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FISHERY STATUS REPORTS 2009

Status of Fish Stocks and Fisheries Managed by the Australian Government

DEPARTMENT OF AGRICULTURE, FISHERIES AND FORESTRY

Australian Government Department of Agriculture, Fisheries and Forestry
Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences

Fishery Status Reports | **2009**

STATUS OF FISH STOCKS AND FISHERIES MANAGED BY THE AUSTRALIAN GOVERNMENT

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Foreword

The 15th edition of the *Fishery status reports* provides an independent evaluation of the biological and economic status of fish stocks and fisheries managed or jointly managed by the Australian Government. The *Fishery status reports* provide trends in stock status and highlight emerging issues that may affect the fishing industry, fisheries management and the broader community.

From a biological perspective, this edition of the reports shows a substantial decrease in the number of stocks classified as uncertain. The number of stocks assessed as not overfished has almost tripled since 2004. However, the number of stocks that are overfished or subject to overfishing remains a cause for concern. This edition of the *Fishery status reports* includes, for the first time, a new minor byproduct section in each fishery chapter. Total catches (landings and reported discards) are included for the most commonly caught byproduct stocks that are not assessed in this years' reports. These minor byproduct stocks will be monitored each year to determine if shifts in targeting practices within the fishery require a formal status assessment process to be undertaken for these stocks.

Alongside the biological assessment, the reports include available indicators of the economic performance of each of the assessed fisheries. The indicators provide a measure of the extent to which economic efficiency is being achieved in Commonwealth-managed fisheries. Monitoring economic efficiency in a fishery context is important to regional communities that rely on fisheries being sustainable and profitable for their livelihood, and to the wider community that expects Australia's natural resources to be managed effectively over time. The value of production of Commonwealth-managed fisheries increased in 2008–09, by five per cent to $314 million, contributing 14 per cent of the gross value of Australia's fishery production.

Historically, only an overview has been provided on fishery-specific environmental issues. However, in this edition, the levels of interaction between fisheries and the ecosystems in which they operate have been explored to a greater degree, with the aim to examine these issues more comprehensively in future editions.

The *Commonwealth Fisheries Harvest Strategy Policy*, released in September 2007, clearly illustrates the importance of sound scientific and economic advice to underpin the development of public policy and decision making in the fisheries sector. The *Fishery status reports* provide a useful reference for fishery managers and other stakeholders in Commonwealth-managed fisheries.

Phillip Glyde

Executive Director

AUSTRALIAN BUREAU OF AGRICULTURAL AND RESOURCE ECONOMICS – BUREAU OF RURAL SCIENCES

Acknowledgments

The 15th edition of the *Fishery status reports* was produced with financial support from the Fisheries Resources Research Fund administered by the Australian Government Department of Agriculture, Fisheries and Forestry. The reports are an outcome of collaboration with fisheries researchers, management and industry throughout Australia. They also draw on a number of unpublished reports from fishery assessment meetings and workshops organised and funded by the Australian Fisheries Management Authority (AFMA). The considerable assistance of officers of AFMA during the preparation of these reports, including the provision of information on management arrangements and fishery data is gratefully acknowledged. Access to the information is appreciated, as is the input of the scientists, industry members, fishery managers and other members of resource assessment groups, including chairs. Contributions from CSIRO Marine Research and the fishery research agencies of Queensland, New South Wales, Victoria, Tasmania, South Australia, Western Australia and the Northern Territory are greatly appreciated. Officers of the Department of Environment, Water, Heritage and the Arts (DEWHA) provided invaluable assistance in the preparation of aspects of the reports.

The status reports covering tuna fisheries required the use of data and assessments compiled by regional fisheries bodies, including the Secretariat of the Pacific Community, the Western and Central Pacific Fisheries Commission, the Indian Ocean Tuna Commission and the Commission for the Conservation of Southern Bluefin Tuna. Staff from each regional fisheries bodies reviewed aspects of respective chapters.

The following data sources used in compiling maps are acknowledged:

- Geoscience Australia: coastline, state boundaries, place names, bathymetric features, Australian Fishing Zone and Exclusive Economic Zone boundaries
- AFMA: Australian Government fisheries logbook data, fisheries management boundaries
- Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR): CCAMLR statistical division boundaries
- DEWHA: marine protected areas boundaries.
- Commission for the Conservation of Southern Bluefin Tuna, Indian Ocean Tuna Commission, Western and Central Pacific Fisheries Commission: catch and effort data.

The Food and Agriculture Organization of the United Nations (FAO) Species Identification and Data Programme (SIDP) kindly gave permission for many line drawings included within the report (www.fao.org/fishery/sidp/en).

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1 Overview

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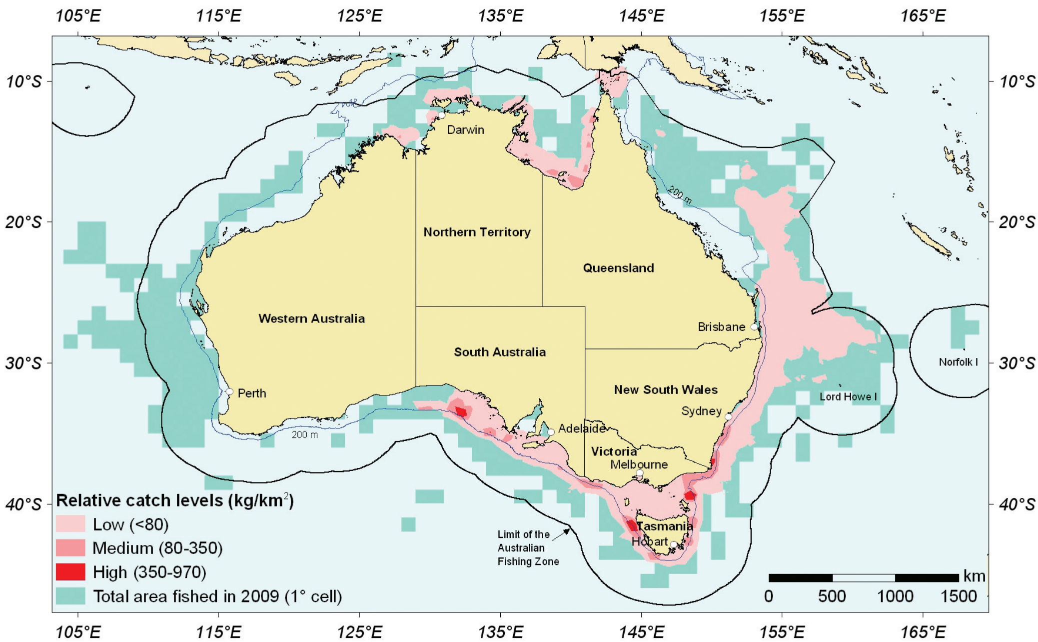

FIGURE 1.1 Relative catch levels of all Commonwealth-managed fisheries in 2009

1.1 BACKGROUND

Scope

The Australian Government's approach to fisheries management aims to 'ensure that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development (ESD) and the exercise of the precautionary principle, in particular the need to have regard to the impact of fishing activities on non-target species and the long term sustainability of the marine environment', as required under the *Fisheries Management Act 1991* (FMA). This requires an understanding of the biological and economic status of stocks, marine ecosystems and the fisheries that depend on them. The Australian Government's directions within the *Commonwealth Fisheries Harvest Strategy: policy and guidelines* (HSP; DAFF 2007), released in September 2007, dictate that Commonwealth fisheries need to be managed in both biological and economic terms.

The *Fishery status reports* provide governments, industry and the community with an independent overview of trends in the biological status of fish stocks and the economic status of fisheries for which the

Australian Government has management responsibility. The reports assess the biological status of the target and key byproduct species in each Commonwealth fishery and review the economic indicators for each fishery. They continue the series of reports produced by the former Bureau of Rural Sciences (BRS) since 1992, when the *Fisheries Management Act 1991* came into effect, and the *Fishery economic status reports* produced by the former Australian Bureau of Agricultural and Resource Economics (ABARE) in 2007 and 2008.

In terms of the biological aspects of fisheries, ESD requires a focus on not just the target species but also the impact of fishing activities on non-target species and the long term sustainability of the marine environment. The *Fishery status reports* will continue to have an increasing emphasis on the non-target and marine environment aspects of Commonwealth fisheries.

The fisheries covered in the reports are all those managed solely by the Australian Fisheries Management Authority (AFMA), those managed through joint authorities with State and Territory governments, and those managed through bilateral international agreements. Some are also subject to broader regional or global international management arrangements. The Australian Government is party to a number of international conventions or agreements for the management of fish stocks, including some that range beyond the Australian Fishing Zone. These stocks are exploited across various Exclusive Economic Zones, as well as on the high seas (Fig. 1.1). AFMA manages more than 20 fisheries on behalf of the Australian Government, all of which are assessed each year. Together, these fisheries—all wild catch—are estimated to account for approximately 14% ($313.8 million) of the gross value of production (GVP) of Australian fisheries in the 2008–09 financial year. The remainder of Australian fisheries production in 2008–09 comprised both wild catch and aquaculture production from state fisheries.

Stocks

Fishery status reports 2009 summarises latest biological and economic information for 101 stocks, species or groups of species (all referred to as 'stocks'). Stocks are usually assessed in the *Fishery status reports* if they meet one or more of the following criteria—or are removed if they fail to meet at least one of these criteria:

- target or key commercial species (as defined in the HSP; DAFF 2007, p54)
- stock managed under a total allowable catch (TAC)
- stock previously classified as 'overfished' that has not yet recovered to a 'not overfished' state
- byproduct stock of ecological and/or economic importance—determined on the basis of whether they meet one or more of the following criteria:
  - for several consecutive years or fishing seasons, the total catch (landings and discards) of a byproduct stock is approximately equal to or greater than that of any other stock currently targeted and/or assessed in that fishery or sector
  - the value of the total catch landed of a byproduct stock is considered to be an important economic component of that fishery or sector
  - a byproduct species or stock is listed as being at high risk from fishing activity in the ecological risk assessment process for that fishery or sector
- a species previously considered as a single stock that has been reclassified as multiple stocks to align with species biology and management, as appropriate
- stock of undifferentiated species managed as a sector within a fishery.

Stock additions to the current (15th) edition of the *Fishery status reports* and the reasons for the additions are:

- Ocean jacket, eastern (*Nelusetta ayraudi*)—substantial recent and historical catches greater than many currently targeted and/or assessed species; important byproduct species within the Commonwealth Trawl Sector (CTS) and Scalefish Hook Sector

(ScHS) of the Southern and Eastern Scalefish and Shark Fishery (SESSF)

- Ocean jacket, western (*Nelusetta ayraudi*)—large recent and historical catches; important byproduct species within the Great Australian Bight Trawl Sector (GABTS) of the SESSF
- Longtail tuna (*Thunnus tonggol*)—listed in the Western Tuna and Billfish Fishery (WTBF) management plan as a primary species; targeted by minor line methods; recent catches comparable to other tuna species targeted and/or assessed within the WTBF.

No stocks were removed from the current edition of the *Fishery status reports*.

Stocks with a modified definition in the current edition of the *Fishery status reports* and the reasons for the changes are:

- Coral Sea Fishery: Lobster and Trochus Sector split into two separate stocks:
  - lobster (*Panulirus ornatus)*—taxonomically distinct stock within the sector
  - trochus (*Trochus niloticus*, possibly *Techtus pyramis)*—taxonomically distinct stock within the sector
- Northern Prawn Fishery: western king prawn and red-spot king prawn (formerly two separate stocks) amalgamated into a single stock—king prawns (two species):
  - western king prawn (*Penaeus latisulcatus*)—combined with red-spot king prawn in logbooks and markets
  - red-spot king prawn (*Melicertus longistylus*)—minor take, combined with western king prawn in logbooks and markets.

As a result of these modifications, 101 stocks are classified in the 15th edition of the *Fishery status reports*, compared with 98 stocks in the previous edition.

Future stock considerations

Minor byproduct stocks, regarded as a lower management priority, and all bycatch species remain unclassified in the *Fishery status reports 2009*. Current research and data collection are expected to enable increased reporting on these stocks in future reports, and increase the potential to assess the status of byproduct stocks. This edition of the *Fishery status reports* includes, for the first time, a new minor byproduct section in each fishery chapter. Where applicable, total catches (landings and reported discards) from logbook records are included for the most commonly caught byproduct stocks that are not assessed in this years' reports—these stocks are referred to as minor byproduct.

It is our intention to monitor these minor byproduct stocks each year to

Sydney fish market PHOTO: FIONA SALMON, DAFF

determine if any shifts in targeting practices within the fishery require a formal status assessment process for these stocks.

In addition to new stocks, those currently assessed will need to be revisited in terms of population structure—specifically, to examine the matching of biologically relevant processes and management units. In assessing and managing Commonwealth fisheries, fish stocks are the fundamental biological unit. The term 'fish stock' is used throughout the *Fishery status reports* to mean a 'functionally discrete population that is largely distinct from other populations of the same species and can be regarded as a separate entity for management or assessment purposes'. In contrast, the definition of the operational management unit (which is usually assessed) is often unclear. As a result, mismatches between the biology and the management action can occur. There is a need for a matching between genetic population structure of a species and the management unit. For a number of Commonwealth-managed stocks, including blue warehou (*Seriolella brama*), jackass morwong (*Nemadactylus macropterus*), ocean perch (*Helicolenus barathi*, *H. percoides*) and pink ling (*Genypterus blacodes*), there is a divergence between population structure and the management unit applied via quotas and other controls. In cases where such a divergence places stocks at unacceptable levels of risk from overexploitation (such as the eastern population of jackass morwong), there is a need for a revision of these management units.

Reporting period

The 15th edition of the *Fishery status reports* was prepared during the first half of 2010 and is based on information available at the time of writing. Most stock assessment information is derived from 2009 or earlier (most recent) assessments, whereas some management information (such as TACs) pertains to the fishing season for a particular stock. Catch information for the majority of stocks extends to the end of 2009; where fishing seasons extend into the first quarter of 2010 (e.g. the SESSF) this information is also added. In some cases, the fishing season aligns with the financial year 2008–09 rather than the 2009 calendar year. Where this occurs, catch and effort information is also aligned with the financial year, and this is clearly indicated in each chapter. Relative catch levels of all Commonwealth-managed fisheries for the 2009 calendar year are provided in Figure 1.1. Economic information is provided for the 2008–09 financial year, where available, or for the financial year for which the most recent information is available. Combined information from all of these sources is used to assess the status of each stock.

Structural adjustment and 2005 Ministerial Direction

From 1992 to 2005 the *Fishery status reports* showed a trend of continued overfishing, increasing numbers of overfished stocks and continued high levels of uncertainty about the biological status of many stocks. In late 2005 the Australian Government responded to this situation by announcing *Securing our Fishing Future*, a $220 million package to cease overfishing and allow overfished stocks to rebuild, and to improve profitability in the fishing industry. The package included a structural adjustment component to reduce the number of fishers competing for fisheries resources and to maximise the opportunities for profitable fishing businesses. The structural adjustment component of the package, which was largely completed during the second half of 2006, included substantial removals of fishing capacity from the SESSF, the Northern Prawn Fishery (NPF) and the Eastern Tuna and Billfish Fishery (ETBF).

Linked to the package was the 2005 Ministerial Direction to AFMA pursuant to Section 91 of the *Fisheries Administration Act 1991*. The direction stated that 'decisive action is needed immediately to halt overfishing and to create the conditions that will give overfished stocks a chance to recover to an acceptable level in the near future'. The direction specified a number of measures to be implemented to improve the management of Commonwealth-managed fish

stocks. In the years immediately following the Ministerial Direction, substantial improvements in the overfishing status of Commonwealth fisheries were observed.

The structural adjustment and Ministerial Direction have led, and will continue to lead, to substantial changes in many key economic indicators for Commonwealth fisheries. The decrease in effort and number of vessels fishing may lead to a higher average catch and profit per vessel. Over time, the reduced pressure on fish stocks is expected to result in growth in biomass. For some species, the amount that can be sustainably harvested may increase with each season as biomass increases. To ensure the long-term profitability of Commonwealth fisheries, it will be important to continue the focus on management measures that allow profits to be maximised from a sustainable stock biomass. Given the common property nature of fisheries resources, market forces alone cannot bring about economic efficiency in Commonwealth fisheries. Instead, management is required to constrain catch and effort to levels that allow maximum economic yield from a sustainable stock biomass. The management arrangements should also allow fishers to choose a combination of inputs that maximise their profits while adhering to sustainable fishing practices.

In response to the increasing number of stocks with an uncertain status, the Australian Government in 2008 committed to addressing this issue and funded an expanded fisheries research program within ABARE–BRS to provide for 'further research to facilitate the classification of Commonwealth-managed species currently classified as uncertain'. Reducing uncertainty in the status of Commonwealth-managed fish stocks is considered critical for providing security to the fishing industry, as well as confidence to the broader Australian community that fish stocks are being sustainably and efficiently managed.

ABARE–BRS, in collaboration with CSIRO, are undertaking the Reducing

Dutch auction, Sydney fish market PHOTO: FIONA SALMON, DAFF

Uncertainty in Stock Status project (discussed below). It is designed to meet the Australian Government's commitment, with strategic research designed to have a long-term impact on reducing uncertainty in Commonwealth-managed fisheries.

The *Commonwealth Fisheries Harvest Strategy Policy*

The Australian Government's HSP (DAFF 2007) has as its core objective:

> *… the sustainable and profitable utilisation of Australia's Commonwealth fisheries in perpetuity through the implementation of harvest strategies that maintain key commercial stocks at ecologically sustainable levels and within this context, maximise the economic returns to the Australian community.*

A key commercial species is defined in the HSP as a species that is, or has been, specifically targeted and is, or has been, a significant component of a fishery.

The HSP provides a framework that allows a more strategic, science-based approach to setting TAC levels in all Commonwealth fisheries on a fishery-by-fishery basis. The implementation guidelines provide practical advice on how to interpret and apply the HSP to Commonwealth fisheries and details of the science behind the fisheries management decisions.

The HSP makes the following observations on what constitutes good fisheries management:

- Fisheries are more efficient, profitable, stable and sustainable when stocks are larger than the stock size (biomass—B) that produces the maximum sustainable yield (MSY), referred to as B_{MSY}.
- Future productivity is at greater risk when stocks are reduced to a level at which the recruitment of young fish relative to the portion of the stock subject to fishing declines precipitously (referred to as 'recruitment failure').
- Fisheries should be managed on a whole-stock basis, and in a way that takes a species' life history characteristics (such as longevity, fecundity and recruitment variability) into account.
- Economic returns can be maximised and, in general, overcapitalisation can be avoided when fish stocks are maintained, on average, at a target adult biomass level that produces the maximum economic yield (MEY), referred to as B_{MEY}.
- If stock size falls below B_{MEY}, the associated increase in fishing costs is greater than the increase in fishing revenue, and fishing is less efficient.

The HSP requires harvest strategies to be developed that pursue MEY from each fishery and ensure that stocks remain above levels at which risk becomes unacceptably high. Specifically, harvest strategies need to have the following aims:

- Seek to maintain fish stocks, on average, at a target biomass (B_{TARG}) equal to B_{MEY}. In cases where B_{MEY} is unknown, a proxy of $1.2B_{MSY}$ (or a level 20% higher than a given proxy for B_{MSY}) is to be used for a single-species fishery; for a multispecies fishery, judgment needs to be exercised. An alternative proxy for B_{MEY} may be used if it can be demonstrated that it is more appropriate.
- Ensure that fish stocks remain above a biomass level below which the risk to the stock is regarded as too high—that is, the limit biomass level (B_{LIM}) or a proxy equal to or greater than $0.5B_{MSY}$.
- Ensure that the stock stays above B_{LIM} at least 90% of the time. For highly variable, abundant species that may naturally breach B_{LIM} (i.e. in the absence of fishing), the harvest strategy for the species must be consistent with the intent of the policy.

A diagrammatic example of a harvest strategy that is consistent with the HSP is shown in Fig. 1.2. In this example, harvest control rules are used to determine a recommended biological catch (RBC). The RBCs reflect the best scientific advice on what the total mortality to maintain or rebuild to B_{TARG} should be for each species or stock. The expected mortality from discards and landings in other jurisdictions is subtracted from these RBCs before advice is provided on

TACs. Recent catch levels relative to RBCs provide an indication of whether overfishing is occurring for a particular stock.

The policy contains further detail and is accompanied by guidelines to support harvest strategy development for Commonwealth-managed fisheries (including input- and output-managed fisheries, single and multispecies fisheries, and large and small fisheries, and in data-rich and data-poor situations). The guidelines also provide contextual information to assist interpretation of the policy and support development and implementation of harvest strategies. The policy has important implications for assessing both the biological and economic status of stocks.

Harvest strategies developed under the policy should set out the management actions necessary to produce the MEY and ensure that fish stocks remain above the biomass levels that pose an unacceptably high risk to the stock. AFMA is responsible for implementing the HSP.

The policy requires that harvest strategies be developed for Commonwealth fisheries, with the exception of those that are managed under the joint authority of the Australian Government and another Australian jurisdiction or under an international management body or arrangement. However, the policy notes that the Australian Government will advocate the principles of the policy within all jointly managed fisheries.

For most Commonwealth-managed fisheries, 2008 and 2009 were trial years for newly developed harvest strategies, which will be reviewed in detail in subsequent editions of the *Fishery status reports*. The trial period is intended to provide time to identify and address issues that restrict effective implementation of the policy.

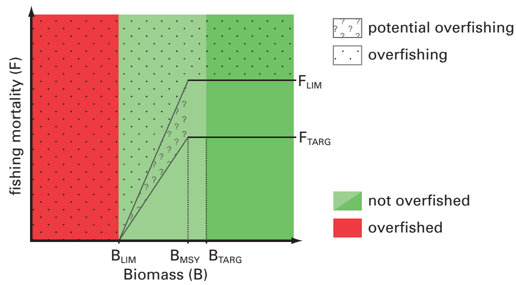

FIGURE 1.2 Example harvest strategy (or harvest control rule) that is consistent with the *Commonwealth Fisheries Harvest Strategy Policy*

B_{LIM} = limit biomass reference point; B_{MSY} = biomass that gives the maximum sustainable yield; B_{TARG} = target biomass, generally B_{MEY}, the biomass required to produce maximum economic yield; F_{LIM} = limit fishing mortality rate; F_{TARG} = target fishing mortality rate

NOTE: In this example, the RBC is calculated by applying the F_{TARG} to the current biomass (assumed to be available from a stock assessment). The control rule specifies that as the biomass reduces below B_{MSY}, F_{TARG} is reduced to zero at B_{LIM}. The dark green area is at or above the target, and the light green area is where management action is required to rebuild the stock to B_{TARG}.

SOURCE: Adapted from DAFF (2007).

Fish bins, Sydney fish market
PHOTO: FIONA SALMON, DAFF

Reference points and indicators

The biological status of a stock depends on its current size (biomass) and the rate of removals from it (known as the exploitation rate or 'fishing mortality'). Reference points, as described in the HSP, commonly define target and limit levels for the stock's biomass (B_{TARG} and B_{LIM}, respectively) and target and limit rates for fishing mortality (F_{TARG} and F_{LIM}, respectively; see Table 1.1). In cases where reference points and/or estimates of current B (biomass) or F (fishing mortality) have not been determined, other indicators are used to determine stock status.

TABLE 1.1 Reference points for fishing mortality and biomass, with associated status implication and actions

	Fishing mortality rate (F)	$F < F_{TARG}$ (fishing mortality is below the target)	$F_{TARG} < F < F_{LIM}$ (fishing mortality is between the limit and the target)	$F > F_{LIM}$ (fishing mortality is above the limit)
Biomass (B)	$B >= B_{TARG}$ (biomass is above the target)	Not overfished Overfishing is not occurring	Not overfished Overfishing is not occurring	Not overfished Overfishing is occurring: note possible planned fish-down
	$B_{TARG} > B > B_{LIM}$ (biomass is between the limit and the target)	Not overfished: rebuild to B_{TARG} Overfishing is not occurring	Not overfished: rebuild to B_{TARG} Overfishing may not be occurring: provided fishing mortality will allow rebuilding towards target	Not overfished: rebuild to B_{TARG} Overfishing is occurring: reduce fishing mortality; no targeted fishing permitted
	$B < B_{LIM}$ (biomass is below the limit)	Overfished: adopt and follow a rebuilding strategy to rebuild biomass above B_{LIM} within a set time Overfishing is not occurring: no targeted fishing permitted	Overfished: adopt and follow a rebuilding strategy to rebuild biomass above B_{LIM} within a set time Overfishing may not be occurring: provided fishing mortality will allow rebuilding towards target; no targeted fishing permitted	Overfished: adopt a rebuilding strategy to rebuild biomass above B_{LIM} within a set time Overfishing is occurring: reduce fishing mortality; no targeted fishing permitted High risk to stock

Biological stock status classifications

Stocks are classified independently in the overfished and overfishing categories. The distinction between overfished stocks and overfishing has practical implications. Management measures might curtail overfishing, but an overfished classification continues to apply until the stock recovers to a level above B_{LIM}, which for some stocks can take many years.

Five classifications of biological stock status are used in this report:

- **Not overfished** refers to the biomass of a fish stock. The biomass is adequate to sustain the stock in the long term and the stock has a biomass above B_{LIM}.
- **Overfished** refers to the biomass of a fish stock. The biomass may be inadequate to sustain the stock in the long term—the stock has a biomass below B_{LIM} . The HSP requires that fish stocks remain above a biomass level at which the risk to the stock is regarded as too high (B_{LIM} or a proxy) at least 90% of the time. Two common proxies for that limit are B_{20} (20% of the unfished biomass) and $0.5B_{MSY}$ (half the biomass required for MSY).
- **Not subject to overfishing** refers to the amount of fishing. The stock is not subject to a level of fishing that would move the stock to an overfished state—the amount of fishing does not exceed the limit reference point (F_{LIM}).
- **Subject to overfishing** refers to the amount of fishing. The stock is subject to a level of fishing that would move the stock to an overfished state, or prevent it from returning to a not overfished state; more technically, the amount of fishing exceeds F_{LIM}. The HSP indicates that any directed (targeted) fishing of an overfished stock is not permitted. The stock is experiencing too much fishing and the removal rate from the stock is unsustainable. Also:
  - Fishing mortality (F) exceeds the limit reference point (F_{LIM}). When stock

levels are at, or above, B_{MSY}, F_{MSY} will be the default level for F_{LIM}.
  - Fishing mortality in excess of F_{LIM} will not be defined as overfishing if a formal 'fish down' or similar strategy is in place for a stock and the stock remains above the target level (B_{TARG}).
  - When the stock is less than B_{MSY} but greater than B_{LIM}, F_{LIM} will decrease in proportion to the level of biomass relative to B_{MSY}.
  - At these stock levels, fishing mortality in excess of the target reference point (F_{TARG}), but less than F_{LIM}, may also be defined as overfishing depending on the harvest strategy in place and/or recent trends in biomass levels.
  - Any fishing mortality will be defined as overfishing if the stock level is below B_{LIM}, unless fishing mortality (not targeted) is below the level that will allow the stock to recover within a period of ten years plus one mean generation time, or three times the mean generation time, whichever is less.
  - Any targeted (directed) fishing of an overfished stock (stock level is below B_{LIM}) will amount to overfishing.
- **Uncertain** refers to the overfished or overfishing status of a fish stock for which there is inadequate information to determine status.

Information on catch rates and trends is used as indicators of a fishery's performance, but the classification of the status of a stock requires consideration of a wider range of factors, as detailed in the individual fishery chapters of this document. The status classifications described above are simplified summary indicators based on these factors.

Reducing uncertainty in biological stock status

The Reducing Uncertainty in Stock Status (RUSS) project is part of an expanded Fisheries Research Program that is facilitating the classification of Commonwealth-managed fish stocks that are currently classified as uncertain. The RUSS project, has three main components:

- information management—compiling data and information to support assessments, and developing systems to maintain research data into the future
- assessments and framework for determining stock status—developing and applying a suite of stock status indicators and models that are then used within a weight-of-evidence stock status decision-making framework
- harvest strategy testing, evaluation and development—examining the fishery harvest strategies that are the basis for controlling harvest levels to assess their capacity to prevent overfishing and stocks becoming overfished.

RUSS has focused primarily on smaller and lower-value Commonwealth fisheries, where there may be less data or limited resources to undertake assessments.

Weight-of-evidence

For some stocks, the *Fishery status reports 2009* have used the weight-of-evidence stock status decision-making framework developed by the RUSS project. The approach allows a broader range of data and information to be included when determining status. Specifically, the framework aims to provide for structured scientific review and interpretation of indicators of biomass and fishing mortality and to arrive at a status determination through the cumulative weight-of-evidence. It is intended to provide a transparent and repeatable process—especially for stocks that are data or information poor.

Types of evidence for each stock are structured as follows:

1. Species and fishery attributes:
   - single species or basket of species
   - biological characteristics (such as productivity and natural mortality)
   - stock structure
   - targeting (target, byproduct or bycatch species)
   - fisheries and sectors taking catch.
2. Empirical indicators—non model-based metrics that respond to stock status (their usefulness for status determination

is improved when they are used in association with reference levels)
  - catch
  - effort
  - catch rate (may be standardised using statistical models and fishing power)
  - spatial distribution of the fishery (e.g. constant, expanding or serial shifting)
  - length and timing of the fishery (e.g. constant or shortening)
  - size-based or age-based indicators, including mean size or age, mean length at age.
3. Risk assessments—from the ecological risk assessment process undertaken by AFMA:
  - Level 2 Productivity Susceptibility Analysis (relative risk score)
  - Level 3 Sustainability Assessment of Fishing Effects (SAFE) (estimates of cumulative fishing mortality relative to reference points).
4. Fishery-independent surveys—including estimates of absolute or relative biomass that can be used to infer the impact of fishing or can be related to reference points equivalent to those defined in the HSP.
5. Quantitative stock assessment models—different from indicators in that they integrate data from more than one source. Complex models generally benefit from a synthesis of more information sources with fewer assumptions, but are highly demanding of data and the skills of the analyst. Less complex models rely on fewer information sources and make more assumptions, but are less demanding of data and so are applicable across a wider range of circumstances. With informative input data, stock status can be reliably estimated by both simple and complex models. Models include:
  - integrated, size/age-based model
  - delay-difference model
  - non-equilibrium surplus production model
  - catch curve analysis
  - fishery-dependent depletion analysis.
6. Harvest strategies—most Commonwealth-managed fisheries now have harvest strategies in place. In principle, status determination should be a straightforward task for a stock fished under a harvest strategy that is fully compliant with the HSP. In practice, this is not always the case, particularly for smaller fisheries and harvest strategies that use simpler or untested approaches. For this reason, one of the key lines of research in the RUSS project is testing and evaluation of harvest strategies. Some important aspects are:
  - target and limit reference points specified and consistent with the HSP
  - control rules specified
  - simulation testing to demonstrate the strategy's effectiveness in achieving targets and avoiding limits
  - implementation occurring.

For most Commonwealth fish stocks, particularly in the smaller fisheries, only a subset of the above information is available and/or useful. Expert judgment has a role, with a strong emphasis on documenting the key evidence and the rationale for the decision. The decision-making process is undertaken separately for biomass (overfished status) and fishing mortality (overfishing status) using the following structure:

- key information used
- interpretation of cumulative evidence, implication for status
- inconsistent information (if any)
- conclusion on status
- key information gaps to resolve status.

Economic considerations

The importance of economics in fisheries management is well documented in the literature and has been discussed at length in previous ABARE reports (for example, Hohnen et al. 2008). The importance of economics in fisheries management is also recognised at a legislative level. Under the *Fisheries Management Act 1991*, AFMA is required to maximise the net economic returns (NER) to the Australian community from the management of Australian fisheries. NER can be thought of as economic profit, or the difference between all fishing revenues earned on fish harvested in a

fishery and all the economic costs incurred to harvest those fish in a given period. These include fuel, crew costs, repairs, the opportunity cost of family and owner labour, fishery management costs, depreciation and the opportunity cost of capital.

The point where NER is maximised is referred to as maximum economic yield (MEY). Relative to MSY (the traditional management target) NER is higher at MEY despite effort and catch levels being lower. This is largely the result of the relationship between fishing costs and stock levels. That is, a given harvest is less costly to catch when fish stocks are more abundant as fish are relatively easier to catch. Additional benefits of MEY are that conservation concerns are more likely to be met under higher stock levels. Also, a more profitable and abundant fishery is more resilient to fluctuations in biological, environmental and economic factors that may negatively impact on the fishery.

An economically efficient fishery (one operating at MEY) will have the following characteristics:

- Total catch and effort are restricted to the point where NER over time is maximised, allowing for the future costs of fishing and the impact of current catch on future stocks and catches. This prevents fishers from expanding their effort until all economic profits are dissipated. This is known as fishery-level efficiency.
- Revenues are maximised and catching costs are minimised for a given quantity of catch. This is known as vessel-level efficiency. While fishers can be relied on to choose the combination of inputs that minimises costs and maximises revenue for their particular operation (given the constraints imposed by fisheries management) the management measures used in a fishery can have a significant impact on the costs and revenues of fishing.
- Fisheries management services are provided effectively and at least cost for the given level of management (not necessarily at lowest cost overall)—this is management efficiency.

The common property characteristic of fisheries implies that market failures will lead to catch and effort levels that are not associated with MEY, but instead result in overfishing. Such an open access scenario results in NER, on average, being close to zero as fishers compete to catch fish and stocks are driven down. This market failure requires government intervention in the form of restricting catch and effort, preferably to a point that is consistent with MEY.

A fishery manager (government) has two broad categories of control available to achieve this:

- input controls—these aim to prevent catch and effort from gravitating to the open-access equilibrium by placing restrictions on fishing gear, limiting the number of vessels operating in a fishery, setting the number of days the fishery is open or controlling other types of fishery inputs.
- output controls—these aim to limit catch and effort, but do so by restricting the size of the harvest. Setting a TAC at an appropriate level can provide biological protection for the fishery—once the predetermined catch level has been reached, the fishery is closed. A TAC system is most effective when the total catch is split among operators through a system of individual transferable quotas (ITQs). In output-controlled fisheries, a mix of input and output controls is usually implemented.

In general, output controls, in the form of ITQs, are preferred to input controls. Input controls often prevent fishers from using the least costly combination of inputs for a given catch. Input controls will often be associated with effort creep whereby fishers substitute unregulated inputs for regulated inputs. This means that management must frequently adjust input controls to limit the amount of effective effort applied in a fishery so as to ensure that catch levels are consistent with targets. This reduces the long term benefits associated with the development of new fishing techniques and technology. The difficulties associated with input controls are outlined in Gooday (2004). However, input controls may be appropriate in small fisheries where the costs of implementing output controls are too high relative to the benefits.

One of the key benefits of ITQs is that they limit catch directly through the TAC and not indirectly through inputs. The transferability characteristic of ITQs also means that quota can move to those operators that are more efficient and profitable, allowing autonomous structural adjustment. Furthermore, they allow operators to use input combinations that minimise costs, and therefore maximise profits.

ITQs work best in high-value, single-species fisheries with relatively stable stock abundance. The efficiency of ITQ management is enhanced if there is good information about fish stocks, fishing costs, revenues, landings and discards. Effective enforcement is also important (Rose 2002). The practicality of ITQs may be limited when stock abundance is highly variable and unpredictable (TAC setting is made difficult), when incentives for high-grading exist (i.e. fishers have an incentive to discard low value fish for higher valued fish) and if implementation costs are excessive (see Squires et al. 1995; Rose 2002).

It should be noted that the benefits of any management control only accrue when control targets are appropriately set. A system of output controls that does not restrict catch will allow a fishery to gravitate to an open-access equilibrium where stocks are low and NER is, on average, close to zero.

In the past, Commonwealth fishery management arrangements often applied catch and effort settings in such a manner. As a result, the historical economic performance of many Commonwealth fisheries has been poor. For example, the SESSF previously exhibited characteristics of an open-access fishery with estimates of NER regularly close to zero or negative. However, in recent years, TACs have been reduced for many species, and economic performance is improving, implying a move away from an open-access situation where NER is close to zero.

A key factor that has influenced this change was the *Securing our Fishing Future* structural adjustment package and the 2005 Ministerial Direction to AFMA. The Direction specifically required AFMA take actions to halt overfishing and bring about the recovery of overfished stocks. The reduction of TACs in the SESSF and the introduction of harvest strategies in all Commonwealth fisheries were examples of these actions. The Direction also required that all fisheries move to ITQ management where it was deemed feasible. These recent events have had some influence on the assessment of the economic status of Commonwealth fisheries in this year's *Fishery status reports*.

Assessing fishery economic status

The *Fishery status reports* provide an assessment of the economic status of each Commonwealth fishery. Economic performance should generally be assessed according to where a fishery is performing relative to its economic optimum or MEY. At MEY, fishing effort, catch and stocks levels are at a point where the difference between discounted revenues and costs are maximised. For most fisheries, it is difficult to provide such an assessment of economic performance without a bio-economic model. However, a range of economic indicators are available to help determine in which direction NER may be moving and, in some specific cases, whether a fishery has moved in the direction of MEY. Some of the key indicators used throughout the report include:

- estimates of NER
- fish prices
- fishing catch and effort
- output to input ratios
- estimates of latent (or unused) fishing rights (quota, licences, etc.)
- value of fishing rights
- the biological status of key species
- other vessel level economic performance indicators.

The reader is referred to Newton et al. (2007) and Vieira et al. (2010) for further explanation of how these indicators can be used to assess fishery economic performance.

For some fisheries, particularly low value fisheries, the available information may be limited to the point that even a simple economic assessment is difficult. However, it should be noted that the potential benefits of

filling information gaps in a low-value fishery are also low and are likely to be outweighed by the costs of doing so.

Over time, with the development of new techniques and indicators, ABARE–BRS will be in a better position to fill such information gaps. Therefore, it will become increasingly possible to assess the performance of all Commonwealth fisheries and their management against economic efficiency criteria. The economic status components of the reports will build on this and provide ongoing monitoring and evaluation of the economic performance of Commonwealth fisheries.

1.2 BIOLOGICAL STATUS

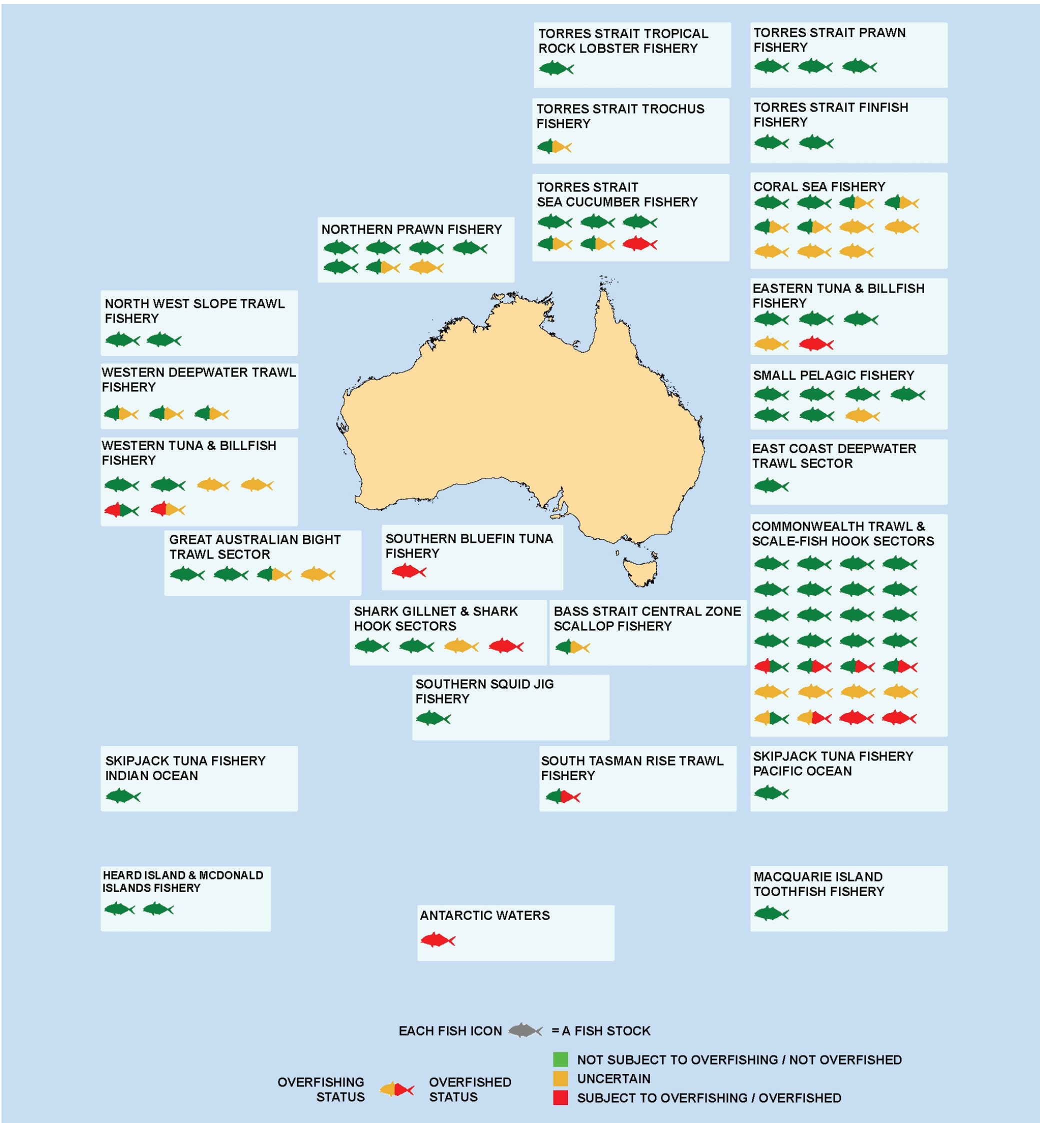

FIGURE 1.3 Biological status of fish stocks in 2009

NOTE: Each fish icon represents a single stock assessed in the *Fishery status reports 2009*, by fishery or sector. The left half of each icon represents the overfishing status, while the right half represents the overfished status of the stock. Colour codes in the key relate to the biological status classifications discussed in this chapter (see also Table 1.2).

Recent trends in *Fishery status reports* (2004 to 2009)

Since the first edition of the *Fishery status reports* was published in 1992, the system used to classify stock status has been modified several times, most recently in 2004 when the 'underfished' and 'fully fished' categories were replaced by a combined category of 'not overfished'. The change was made partly because of the potential confusion about the meaning of 'fully fished'. It was also difficult to classify a stock as 'underfished', because there was often a lack of data for stocks likely to fall into that category. Another change was to make a distinction between a stock that is overfished and one that is subject to overfishing.

Figure 1.3 shows the biological status of each of the 101 stocks assessed in the *Fishery status reports 2009*, by fishery or sector. A time series of biological stock status, since the 2004 change in the classification system, is provided in Figure 1.4.

Table 1.2 shows each biological stock status as a proportion of the total stocks assessed from 2004 to 2009. Table 1.3 lists stocks with a changed status classification between 2008 and 2009. The trends are described in detail below.

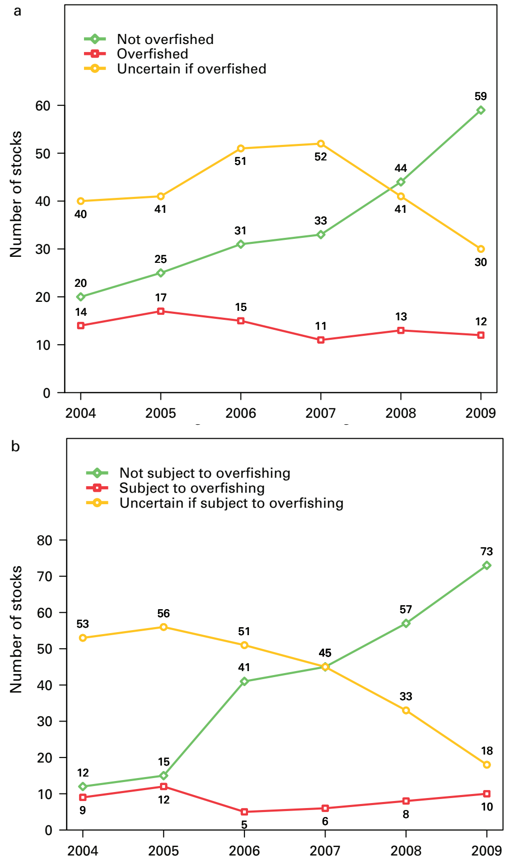

FIGURE 1.4 Biological stock status classification totals (number of stocks) since the classification change in 2004 for a) overfished status and b) overfishing status

TABLE 1.2 Biological stock status classifications as a percentage of the total number of stocks assessed since the classification change in 2004

Biological status		Percentage of stocks assessed 2004	2005	2006	2007	2008	2009
Overfished status	Not overfished	27.0	30.1	31.9	34.4	44.9	58.4
	Overfished	18.9	20.5	15.5	11.4	13.3	11.9
	Uncertain if overfished	54.1	49.4	52.6	54.2	41.8	29.7
Total number of stocks assessed		74	83	97	96	98	101
Overfishing status	Not subject to overfishing	16.2	18.1	42.3	46.9	58.1	72.3
	Subject to overfishing	12.2	14.4	5.1	6.2	8.2	9.9
	Uncertain if overfishing	71.6	67.5	52.6	46.9	33.7	17.8
Total number of stocks assessed		74	83	97	96	98	101

TABLE 1.3 Stocks with a changed biological status classification in 2009

Fishery	Stock common name	2008 status: Overfishing	2008 status: Overfished	2009 status: Overfishing	2009 status: Overfished
Coral Sea Fishery: Sea Cucumber Sector	Other sea cucumber species (11 spp.)	[yellow]	[yellow]	[green]	[yellow]
Coral Sea Fishery: Lobster and Trochus Sector	Tropical rock lobster	[green]	[yellow]	[green]	[green]
Coral Sea Fishery: Lobster and Trochus Sector	Trochus	[green]	[yellow]	[green]	[green]
Coral Sea Fishery: Trawl and Trap Sector	Demersal and midwater fish and crustaceans	[yellow]	[yellow]	[green]	[yellow]
Northern Prawn Fishery	Blue endeavour prawn	[yellow]	[yellow]	[green]	[green]
Northern Prawn Fishery	Western king prawn	[yellow]	[yellow]	[green]	[yellow]
Northern Prawn Fishery	Red-spot king prawn	[yellow]	[yellow]	[green]	[yellow]
North West Slope Trawl Fishery	Deepwater prawns (6 spp.)	[green]	[yellow]	[green]	[green]
North West Slope Trawl Fishery	Scampi (3 spp.)	[yellow]	[yellow]	[green]	[green]
Small Pelagic Fishery	Jack mackerel—east (2 spp.)	[yellow]	[yellow]	[green]	[green]
Small Pelagic Fishery	Jack mackerel—west (2 spp.)	[yellow]	[yellow]	[green]	[green]
SESSF (CTS and ScHS)	Blue warehou	[yellow]	[red]	[red]	[red]
SESSF (CTS and ScHS)	Gemfish, eastern	[green]	[red]	[yellow]	[red]
SESSF (CTS and ScHS)	Jackass morwong	[red]	[red]	[red]	[green]
SESSF (CTS and ScHS)	John dory	[green]	[yellow]	[green]	[green]
SESSF (CTS and ScHS)	Ocean jacket, eastern	[grey]	[grey]	[yellow]	[yellow]
SESSF (CTS and ScHS)	Pink ling	[red]	[green]	[yellow]	[green]
SESSF (CTS)	Redfish (eastern)	[green]	[yellow]	[yellow]	[yellow]
SESSF (CTS and SchS)	Ribaldo	[green]	[green]	[yellow]	[yellow]
SESSF (East Coast Deepwater Trawl Sector)	Alfonsino	[green]	[yellow]	[green]	[green]
SESSF (Great Australian Bight Trawl Sector)	Ocean jacket, western	[grey]	[grey]	[yellow]	[yellow]
SESSF (Shark Hook and Shark Gillnet Sector)	Elephant fish	[yellow]	[yellow]	[green]	[green]
SESSF (Shark Hook and Shark Gillnet Sector)	School shark	[yellow]	[red]	[red]	[red]
Torres Strait Finfish Fishery[a]	Coral trout (multiple spp.)	[green]	[yellow]	[green]	[green]
Torres Strait Prawn Fishery[a]	Blue endeavour prawn	[yellow]	[yellow]	[green]	[green]
Torres Strait Prawn Fishery[a]	Red-spot king prawn	[yellow]	[yellow]	[green]	[green]
Torres Strait Sea Cucumber Fishery[a]	Black teatfish	[yellow]	[red]	[green]	[green]
Torres Strait Sea Cucumber Fishery[a]	Prickly redfish	[yellow]	[yellow]	[green]	[green]
Torres Strait Sea Cucumber Fishery[a]	Sandfish	[yellow]	[red]	[red]	[red]

Table 1.3 continues over the page

TABLE 1.3 Stocks with a changed biological status classification in 2009 CONTINUED

Fishery	Stock common name	2008 status: Overfishing	2008 status: Overfished	2009 status: Overfishing	2009 status: Overfished
Torres Strait Sea Cucumber Fishery[a]	Surf redfish	Uncertain	Overfished	Not subject to overfishing	Uncertain
Torres Strait Sea Cucumber Fishery[a]	White teatfish	Uncertain	Uncertain	Not subject to overfishing	Not overfished
Torres Strait Sea Cucumber Fishery[a]	Other—sea cucumber species	Uncertain	Uncertain	Not subject to overfishing	Uncertain
Torres Strait Trochus Fishery[a]	Trochus	Uncertain	Uncertain	Not subject to overfishing	Uncertain
Eastern Tuna and Billfish Fishery[b]	Tuna, bigeye	Overfishing	Not overfished	Overfishing	Overfished
Eastern Tuna and Billfish Fishery[b]	Tuna, yellowfin	Overfishing	Not overfished	Not subject to overfishing	Not overfished
Western Tuna and Billfish Fishery[b]	Tuna, bigeye	Uncertain	Not overfished	Not subject to overfishing	Not overfished
Western Tuna and Billfish Fishery[b]	Tuna, longtail	Not assessed	Not assessed	Uncertain	Uncertain
Antarctic Waters Fishery[b]	Toothfish (2 spp.)	Uncertain	Uncertain	Overfishing	Overfished

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING OVERFISHED / OVERFISHING UNCERTAIN NOT ASSESSED

CTS = Commonwealth Trawl Sector; ScHS = Scalefish Hook Sector; SESSF = Southern and Eastern Scalefish and Shark Fishery

a Domestic assessments of stocks, but jointly managed with Papua New Guinea

b Domestic assessments are unreliable because interactions with broader regional stocks are uncertain. Ocean-wide assessments of stocks through regional fisheries management organisations were used as the basis for stock status determination.

Not overfished and/or not subject to overfishing. The number of stocks assessed as not overfished has almost tripled since 2004, with the largest yearly increase occurring from 2008 (44 stocks) to 2009 (59 stocks) (Fig. 1.4a; Tables 1.2, 1.3). The improvement in 2009 is largely due to assessments carried out through the RUSS project, an increase in the information available for fish stocks, and an increase in the number and rigour of stock assessments that were carried out by the various fishery resource assessment groups and regional fisheries management organisations.

The number of stocks assessed as not subject to overfishing has also increased substantially, from 12 in 2004 to 73 in 2009 (Fig. 1.4b; Tables 1.2, 1.3). The recent improvement is a direct function of information gathered and assessed through the RUSS project, as well as the 2005 Ministerial Direction that required AFMA to take decisive action to immediately halt overfishing. In the years following the Ministerial Direction, AFMA has implemented additional management measures intended to halt overfishing and bring about recovery of overfished stocks (e.g. TAC reductions, additional area and depth closures).

Overfished and/or subject to overfishing. Of the 15 stocks that are classified as overfished and/or subject to overfishing in 2009 (Table 1.4), 12 are overfished and 10 are subject to overfishing. Seven of these stocks are both overfished and subject to overfishing, up from three stocks in 2008. In 2009, five stocks have been newly classified as either overfished and/or subject to

overfishing (Table 1.4): blue warehou, school shark, sandfish (Torres Strait), bigeye tuna (Pacific) and toothfish (Antarctic waters).

Of the 15 stocks listed in Table 1.4, blue warehou, eastern gemfish, gulper sharks, jackass morwong, orange roughy (eastern, southern and western zones), and school shark are managed by AFMA. The other seven stocks are either jointly managed with Papua New Guinea (Torres Strait stocks) or New Zealand (orange roughy from the South Tasman Rise Trawl Fishery), or are highly migratory tunas and billfishes. These migratory species are harvested by other fleets operating on the high seas or within their Exclusive Economic Zone (EEZ) and are largely managed through regional fisheries management organisations, with Australia's input.

TABLE 1.4 Stocks classified as either overfished and/or subject to overfishing in 2009 and their status in 2008

		2008 status		2009 status	
Fishery	**Stock common name**	**Overfishing**	**Overfished**	**Overfishing**	**Overfished**
SESSF (CTS and Scalefish Hook Sector)	Blue warehou	Uncertain	Overfished / overfishing	Overfished / overfishing	Overfished / overfishing
SESSF (CTS)	Gemfish, eastern	Not overfished / not subject to overfishing	Overfished / overfishing	Uncertain	Overfished / overfishing
SESSF (CTS)	Gulper sharks (3 spp.)	Overfished / overfishing	Overfished / overfishing	Overfished / overfishing	Overfished / overfishing
SESSF (CTS)	Jackass morwong	Overfished / overfishing	Overfished / overfishing	Overfished / overfishing	Not overfished / not subject to overfishing
SESSF (CTS)	Orange roughy, eastern zone	Not overfished / not subject to overfishing	Overfished / overfishing	Not overfished / not subject to overfishing	Overfished / overfishing
SESSF (CTS)	Orange roughy, southern zone	Not overfished / not subject to overfishing	Overfished / overfishing	Not overfished / not subject to overfishing	Overfished / overfishing
SESSF (CTS)	Orange roughy, western zone	Not overfished / not subject to overfishing	Overfished / overfishing	Not overfished / not subject to overfishing	Overfished / overfishing
SESSF (Shark Hook and Shark Gillnet Sector)	School shark	Uncertain	Overfished / overfishing	Overfished / overfishing	Overfished / overfishing
Torres Strait Sea Cucumber Fishery[a]	Sandfish	Uncertain	Overfished / overfishing	Overfished / overfishing	Overfished / overfishing
South Tasman Rise Trawl Fishery[b]	Orange roughy	Not overfished / not subject to overfishing	Overfished / overfishing	Not overfished / not subject to overfishing	Overfished / overfishing
Eastern Tuna and Billfish Fishery[b]	Tuna, bigeye	Overfished / overfishing	Not overfished / not subject to overfishing	Overfished / overfishing	Overfished / overfishing
Southern Bluefin Tuna Fishery[b]	Southern bluefin tuna	Overfished / overfishing	Overfished / overfishing	Overfished / overfishing	Overfished / overfishing
Western Tuna and Billfish Fishery[b]	Swordfish	Overfished / overfishing	Uncertain	Overfished / overfishing	Uncertain
Western Tuna and Billfish Fishery[b]	Tuna, yellowfin	Overfished / overfishing	Not overfished / not subject to overfishing	Overfished / overfishing	Not overfished / not subject to overfishing
Antarctic Waters Fishery[b]	Toothfish (2 spp.)	Uncertain	Uncertain	Overfished / overfishing	Overfished / overfishing

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING   OVERFISHED / OVERFISHING   UNCERTAIN   NOT ASSESSED

CTS = Commonwealth Trawl Sector; SESSF = Southern and Eastern Scalefish and Shark Fishery

a Domestic assessments of stocks, but jointly managed with Papua New Guinea or New Zealand

b Domestic assessments are unreliable because interactions with broader regional stocks are uncertain. Ocean-wide assessments of stocks through regional fisheries management organisations were used as the basis for stock status determination.

Uncertain biological stock status. The number of stocks classified as uncertain (overfished and/or overfishing status) has increased since the inception of the *Fishery status reports*. However, in 2008 and again in 2009, this trend was strongly reversed: in 2009, 15 stocks were reclassified from an uncertain if overfished status in 2008, to either overfished or not overfished (Table 1.3). Similarly, 22 stocks were reclassified in 2009 from a status of 'uncertain if overfishing was occurring' in 2008, to either 'subject to overfishing' or 'not subject to overfishing' (Tables 1.2, 1.3). Much of the historical increase was a consequence of the addition of new stocks not previously considered, for which insufficient information was available. However, in other cases, revised assessments have indicated that less was known about their actual status than was previously thought, or the assessments have become dated, thus moving a stock to an uncertain status (e.g. eastern gemfish, redfish and surf redfish; Table 1.3).

Although there has been a substantial decrease in the number of stocks with an uncertain status in 2009, the high proportion of stocks that remain classified with an uncertain status (29.7% for overfished status and 17.8% for overfishing status; Table 1.2) is a continuing cause for concern, highlighting the importance for AFMA of applying a cautious approach in fisheries management. Uncertainty is often linked to low-value fisheries where there is a lack of funding for data collection and research. Of greater concern however, is when a stock is known to be in an overfished state, but it is uncertain if overfishing is occurring. Eastern gemfish is currently in this situation.

The reduction in the number of stocks classified as uncertain is, in part, attributable to the RUSS project and the continued implementation of the HSP (see page 6). The RUSS project has led to a more rigorous examination of the uncertain classification and how uncertainty can be resolved for some species in the absence of quantitative assessments. Impacts of the project were first observed in the 2008 reports and will continue to accrue over subsequent years.

Historical trends in *Fishery status reports* (1992 to 2009)

To show long-term trends, a summary of the number of stocks in each status category using a previous classification system (pre-2004) is provided in Table 1.5. In Table 1.5, the 'overfished' and 'overfishing' categories are combined, and the 'not overfished' category represents stocks that were previously considered as either 'underfished' or 'fully fished'.

Historically, each stock was given a single status classification based on the worst case scenario, rather than the two-pronged approach now taken. For example, if a stock was considered 'subject to overfishing', it was classified as 'overfished', and no determination of the stock's overfished status was undertaken. In contrast to the current classification system, stocks were only classified in the 'not overfished' category if overfishing was also not occurring. Thus, the numbers in Table 1.5 represent a single classification per stock and are not entirely comparable with the numbers in Table 1.2.

The key elements to note from Table 1.5 are:

- the marked increase in the number of stocks assessed since 1992
- the increase in the number of stocks classified as uncertain since the inception of the *Fishery status reports* up until 2007
- the reversal of this trend in 2008 and again in 2009, with 22 stocks being removed from an uncertain status over the two-year period
- the increasing trend in the number of stocks classified as overfished and/or subject to overfishing up to 2005, with a decrease in subsequent years, to 15 stocks in 2009
- the substantial increase in the number of stocks classified as not overfished since 2005.

TABLE 1.5 Biological stock status classifications by year (1992 to 2009) based on the historical two-class system used in the first *Fishery status reports*

Biological stock status	Number of stocks														
	1992	1993	1994	1996	1997	1998	1999	2000–01	2002–03	2004	2005	2006	2007	2008	2009
Not overfished (fully fished and underfished)	17	29	28	28	20	18	17	19	20	17	19	27	28	39	56
Overfished and/or overfishing	5	5	3	3	4	6	7	11	16	17	24	19	16	18	15
Uncertain	9	9	13	17	31	35	38	34	34	40	40	51	52	41	30
Total stocks assessed	31	43	44	48	55	59	62	64	70	74	83	97	96	98	101

Summary table of biological stock status

The summary table of biological stock status (Table 1.6) presents information from the individual fishery chapters and provides the status classification assigned in each edition of the *Fishery status reports* since 1992. It also gives the main indicators of stock status and reference points against which status was assessed in 2009. This is generally a comparison of stock biomass, catch, effort and/or catch rates, with quotas, permits or licences, trigger catch rates and biological targets as applicable. The fisheries encompassed in the table do not include those for which state or territory government agencies (joint authorities) have primary management responsibility. Primary management responsibility for the fisheries of the Torres Strait, which are also managed under a joint authority (Protected Zone Joint Authority), lies with the Australian Government.

Port of Eden PHOTO: NEIL BENSLEY, ABARE–BRS

Unloading at Eden PHOTO: NEIL BENSLEY, ABARE–BRS

TABLE 1.6 Biological stock status summary

Chapter	Fishery	Common name	Scientific name	Status history: 1992	1993	1994	1996	1997	1998	1999	2001–02	2002–03
2	Bass Strait Central Zone Scallop Fishery	Commercial scallop	*Pecten fumatus*	Not assessed	Not assessed	Not assessed	Uncertain	Uncertain	Uncertain	Overfished / overfishing	Overfished / overfishing	Overfished / overfishing
3	Coral Sea Fishery: Sea Cucumber Sector	Black teatfish	*Holothuria whitmaei*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Overfished / overfishing
3	Coral Sea Fishery: Sea Cucumber Sector	Prickly redfish	*Thelenota ananus*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
3	Coral Sea Fishery: Sea Cucumber Sector	Sandfish	*Holothuria scabra*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
3	Coral Sea Fishery: Sea Cucumber Sector	Surf redfish	*Actinopyga mauritiana*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
3	Coral Sea Fishery: Sea Cucumber Sector	White teatfish	*Holothuria fuscogilva*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
3	Coral Sea Fishery: Sea Cucumber Sector	Other sea cucumber species (11 spp.)	various	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
3	Coral Sea Fishery: Aquarium Sector	Multiple species	various	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
3	Coral Sea Fishery: Lobster and Trochus Sector	Tropical rock lobster	*Panulirus ornatus*, possibly a second species	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
3	Coral Sea Fishery: Lobster and Trochus Sector	Trochus	*Trochus niloticus*, possibly a second species	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
3	Coral Sea Fishery: Line and Trap Sector	Mixed reef fish	various	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
3	Coral Sea Fishery: Trawl and Trap Sector	Demersal and mid-water fish and crustaceans	various	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING — OVERFISHED / OVERFISHING — UNCERTAIN — NOT ASSESSED

2004 Status		2005 Status		2006 Status		2007 Status		2008 Status		2009 Status		Stock status indicators		
Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	**Overfished status**	**Overfishing status**	**Reference points (target, limit)**
												biomass, surveys	fishing mortality (catch)	spatial harvest strategy approach using 'viable' areas
												none specified	none specified	no fishery specific reference points. HSP defaults applied
												none specified	none specified	no fishery specific reference points. HSP defaults applied
												none specified	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												none specified	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												none specified	none specified	no fishery specific reference points. HSP defaults applied
												none specified	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												none specified	none specified	no fishery specific reference points. HSP defaults applied
												fishing mortality (catch)	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												fishing mortality (catch)	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												none specified	none specified	no fishery specific reference points. HSP defaults applied
												none specified	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied

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TABLE 1.6 Biological stock status summary CONTINUED

Chapter	Fishery	Common name	Scientific name	1992	1993	1994	1996	1997	1998	1999	2001–02	2002–03
				Status history								
5	Northern Prawn Fishery	Red-legged banana prawn	*Fenneropenaeus indicus*	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished
5	Northern Prawn Fishery	White banana prawn	*Fenneropenaeus merguiensis*	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished
5	Northern Prawn Fishery	Brown tiger prawn	*Penaeus esculentus*	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Overfished	Overfished	Overfished	Overfished
5	Northern Prawn Fishery	Grooved tiger prawn	*Penaeus semisulcatus*	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Overfished	Overfished	Overfished	Not overfished
5	Northern Prawn Fishery	Blue endeavour prawn	*Metapenaeus endeavouri*	Not assessed	Not assessed	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain
5	Northern Prawn Fishery	Red endeavour prawn	*Metapenaeus ensis*	Not assessed	Not assessed	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain
5	Northern Prawn Fishery	Western king prawn	*Penaeus latisulcatus*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Uncertain	Uncertain	Uncertain	Uncertain
5	Northern Prawn Fishery	Red-spot king prawn	*Melicertus longistylus*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Uncertain	Uncertain	Uncertain	Uncertain
6	North West Slope Trawl Fishery	Deepwater prawns (6 spp.)	multiple species	Not assessed	Not overfished	Not overfished	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain
6	North West Slope Trawl Fishery	Scampi (3 spp.)	*Metanephrops australiensis, M. boschmai, M. velutinus*	Not assessed	Not overfished	Not overfished	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain
7	Small Pelagics Fishery	Australian sardine	*Sardinops sagax*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
7	Small Pelagics Fishery	Blue mackerel—east	*Scomber australasicus*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Uncertain
7	Small Pelagics Fishery	Blue mackerel—west	*Scomber australasicus*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Uncertain

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING · OVERFISHED / OVERFISHING · UNCERTAIN · NOT ASSESSED

2004 Status		2005 Status		2006 Status		2007 Status		2008 Status		2009 Status		Stock status indicators		
Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	**Overfished status**	**Overfishing status**	**Reference points (target, limit)**
												surveys, CPUE	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												surveys, CPUE	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												spawning biomass	fishing effort	target MEY, limit 0.5 B_{MSY}
												spawning biomass	fishing effort	target MEY, limit 0.5 B_{MSY}
												surveys, CPUE	fishing mortality (catch)	target MEY
												surveys	fishing mortality (catch)	target MEY
												surveys, CPUE	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												biomass	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												biomass	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												biomass	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												biomass	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												biomass	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied

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TABLE 1.6 Biological stock status summary CONTINUED

Chapter	Fishery	Common name	Scientific name	1992	1993	1994	1996	1997	1998	1999	2001–02	2002–03
				Status history								
7	Small Pelagics Fishery	Jack mackerel—east (2 spp.)	*Trachurus declivis, T. symmetricus*	Not assessed	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain
7	Small Pelagics Fishery	Jack mackerel—west (2 spp.)	*Trachurus declivis, T. symmetricus*	Not assessed	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain
7	Small Pelagics Fishery	Redbait—east	*Emmelichthys nitidis*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Uncertain
7	Small Pelagics Fishery	Redbait—west	*Emmelichthys nitidis*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Uncertain
9	SESSF (Commonwealth trawl and scalefish-hook)	Blue-eye trevalla	*Hyperoglyphe antarctica*	Uncertain	Uncertain	Not overfished	Not overfished	Not overfished	Not overfished	Uncertain	Uncertain	Uncertain
9	SESSF (Commonwealth trawl)	Blue grenadier	*Macruronus novaezelandiae*	Uncertain	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished
9	SESSF (Commonwealth trawl and scalefish-hook)	Blue warehou	*Seriolella brama*	Uncertain	Uncertain	Not overfished	Not overfished	Uncertain	Not overfished	Not overfished	Overfished	Overfished
9	SESSF (Commonwealth trawl)	Deepwater sharks, eastern (18 spp.)	multiple species	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
9	SESSF (Commonwealth trawl)	Deepwater sharks, western (18 spp.)	multiple species	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
9	SESSF (Commonwealth trawl)	Eastern school whiting	*Sillago flindersi*	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Uncertain	Uncertain	Uncertain	Uncertain
9	SESSF (Commonwealth trawl)	Flathead (5 spp.)	*Neoplatycephalus richardsoni* (plus 4 other spp.)	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished
9	SESSF (Commonwealth trawl)	Gemfish, eastern	*Rexea solandri*	Overfished	Overfished	Overfished	Overfished	Overfished	Overfished	Overfished	Overfished	Overfished
9	SESSF (Commonwealth trawl)	Gemfish, western	*Rexea solandri*	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Uncertain	Uncertain	Uncertain	Uncertain
9	SESSF (Commonwealth trawl)	Gulper sharks (3 spp.)	*Centrophorus harrissoni, C. moluccensis, C. zeehaani*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING | OVERFISHED / OVERFISHING | UNCERTAIN | NOT ASSESSED

2004 Status		2005 Status		2006 Status		2007 Status		2008 Status		2009 Status		Stock status indicators		
Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	**Overfished status**	**Overfishing status**	**Reference points (target, limit)**
												catch	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												catch	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												biomass	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												catch	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												CPUE	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 4 proxies)
												biomass	fishing mortality (catch)	target 48% B_0 & F_{MEY}, limit 20% B_0 (Tier 1)
												CPUE & biomass	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 4 proxies) - Consistent with Tier 1
												CPUE	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 4 proxies)
												CPUE	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 4 proxies)
												biomass	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 1)
												biomass	fishing mortality (catch)	target 41% B_0, limit 20% B_0 (Tier 1)
												biomass	fishing mortality (catch), discarding	target 48% B_0, limit 20% B_0 (Tier 1)
												CPUE		target 48% B_0, limit 20% B_0 (Tier 4 proxies)
												surveys, biomass	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied

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TABLE 1.6 Biological stock status summary CONTINUED

Chapter	Fishery	Common name	Scientific name	1992	1993	1994	1996	1997	1998	1999	2001–02	2002–03
				Status history								
9	SESSF (Commonwealth trawl)	Jackass morwong	*Nemadactylus macropterus*	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Uncertain
9	SESSF (Commonwealth trawl)	John dory	*Zeus faber*	Not overfished	Not overfished	Not overfished	Uncertain	Uncertain	Not overfished	Uncertain	Uncertain	Uncertain
9	SESSF (Commonwealth trawl)	Mirror dory	*Zenopsis nebulosus*	Not overfished	Not overfished	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain
9	SESSF (Commonwealth trawl)	Ocean jacket, eastern	*Nelusetta ayraudi*	Not overfished	Not overfished	Uncertain	Uncertain	Uncertain	Not assessed	Not assessed	Not assessed	Not assessed
9	SESSF (Commonwealth trawl)	Ocean perch (2 spp.)	*Helicolenus* spp.	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Uncertain
9	SESSF (Commonwealth trawl)	Orange roughy (Cascade Plateau)	*Hoplostethus atlanticus*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
9	SESSF (Commonwealth trawl)	Orange roughy, eastern zone	*Hoplostethus atlanticus*	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Overfished	Overfished
9	SESSF (Commonwealth trawl)	Orange roughy, southern zone	*Hoplostethus atlanticus*	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Overfished	Overfished
9	SESSF (Commonwealth trawl)	Orange roughy, western zone	*Hoplostethus atlanticus*	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Overfished	Overfished
9	SESSF (Commonwealth trawl)	Oreo dory: smooth (Cascade Plateau)	*Pseudocyttus maculatus*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
9	SESSF (Commonwealth trawl)	Oreo dory: smooth	*Pseudocyttus maculatus*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
9	SESSF (Commonwealth trawl)	Oreo dory: other	*Neocyttus rhomboidalis, Allocyttus niger, A. verrucosus, Oreosoma atlanticum*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
9	SESSF (Commonwealth trawl and scalefish hook)	Pink ling	*Genypterus blacodes*	Not overfished	Not overfished	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain
9	SESSF (Commonwealth trawl)	Redfish (eastern)	*Centroberyx affinis*	Overfished	Overfished	Uncertain	Not overfished	Not overfished	Not overfished	Not overfished	Overfished	Overfished
9	SESSF (Commonwealth trawl)	Ribaldo	*Mora moro*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING OVERFISHED / OVERFISHING UNCERTAIN NOT ASSESSED

2004 Status		2005 Status		2006 Status		2007 Status		2008 Status		2009 Status		Stock status indicators		
Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	**Overfished status**	**Overfishing status**	**Reference points (target, limit)**
Yellow	Yellow	Green	Green	Green	Yellow	Yellow	Yellow	Red	Red	Red	Green	biomass	catch in relation to RBC	target 48% B_0, limit 20% B_0 (Tier 1)
Yellow	Yellow	Yellow	Yellow	Green	Yellow	Green	Yellow	Green	Yellow	Green	Green	CPUE	recent av. fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 3 & Tier 4 proxies)
Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Yellow	Green	Green	Green	Green	CPUE	recent av. fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 3 & Tier 4 proxies)
Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Yellow	Yellow	catch	fishing mortality (catch)	no formal reference points
Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	CPUE	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 4 proxies)
Yellow	Yellow	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green	biomass	fishing mortality (catch)	limit 60% B_0 (Tier 2)
Red	Red	Red	Red	Green	Red	Green	Red	Green	Red	Green	Red	biomass	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 1)
Red	Red	Red	Red	Green	Red	Green	Red	Green	Red	Green	Red	biomass	fishing mortality (catch)	target 50% B_0, limit 20% B_0 (Tier 2)
Red	Red	Red	Red	Green	Red	Green	Red	Green	Red	Green	Red	biomass	fishing mortality (catch)	target 50% B_0, limit 20% B_0 (Tier 2)
Grey	Grey	Yellow	Yellow	Green	Yellow	Green	Yellow	Green	Green	Green	Green	CPUE	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 4 proxies)
Grey	Grey	Yellow	Red	Green	Red	Green	Red	Green	Green	Green	Green	CPUE	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 4 proxies)
Grey	Grey	Yellow	Red	Green	Red	Green	Yellow	Green	Green	Green	Green	CPUE	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 4 proxies)
Red	Green	Red	Green	Yellow	Yellow	Red	Green	Red	Green	Yellow	Green	biomass	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 1)
Red	Red	Red	Red	Yellow	Red	Yellow	Yellow	Green	Yellow	Yellow	Yellow	CPUE	recent av. fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 3 & Tier 4 proxies)
Grey	Grey	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Yellow	Yellow	CPUE	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 4 proxies)

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TABLE 1.6 Biological stock status summary CONTINUED

Chapter	Fishery	Common name	Scientific name	Status history 1992	1993	1994	1996	1997	1998	1999	2001–02	2002–03
9	SESSF (Commonwealth trawl)	Royal red prawn	*Haliporoides sibogae*	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain
9	SESSF (Commonwealth trawl)	Silver trevally	*Pseudocaranx dentex*	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Overfished / overfishing
9	SESSF (Commonwealth trawl)	Silver warehou	*Seriolella punctata*	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain
10	SESSF (East Coast deepwater)	Alfonsino	*Beryx splendens*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
11	SESSF (Great Australian Bight trawl)	Bight redfish	*Centroberyx gerrardi*	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain
11	SESSF (Great Australian Bight trawl)	Deepwater flathead	*Neoplatycephalus conatus*	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain
11	SESSF (Great Australian Bight trawl)	Ocean jacket, western	*Nelusetta ayraudi*	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Uncertain	Uncertain	Uncertain	Not assessed	Not assessed	Not assessed	Not assessed
11	SESSF (Great Australian Bight trawl)	Orange roughy	*Hoplostethus atlanticus*	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain
12	SESSF (Shark gillnet and hook)	Elephant fish	*Callorhinchus milii*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Uncertain	Uncertain	Uncertain
12	SESSF (Shark gillnet and hook)	Gummy shark	*Mustelus antarcticus*	Overfished / overfishing	Overfished / overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing
12	SESSF (Shark gillnet and hook)	Sawshark	*Pristiophorus* spp.	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Uncertain	Uncertain	Uncertain
12	SESSF (Shark gillnet and hook)	School shark	*Galeorhinus galeus*	Overfished / overfishing	Overfished / overfishing	Overfished / overfishing	Overfished / overfishing	Overfished / overfishing	Overfished / overfishing	Overfished / overfishing	Overfished / overfishing	Overfished / overfishing
13	Southern Squid Jig Fishery	Gould's squid	*Nototodarus gouldi*	Not assessed	Not overfished / not subject to overfishing	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain
15	Torres Strait Finfish Fishery	Coral trout (multiple spp.)	*Plectropomus* spp.	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
15	Torres Strait Finfish Fishery	Spanish mackerel	*Scomberomorus commerson*	Not assessed	Not assessed	Not assessed	Not assessed	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING OVERFISHED / OVERFISHING UNCERTAIN NOT ASSESSED

2004 Status		2005 Status		2006 Status		2007 Status		2008 Status		2009 Status		Stock status indicators		
Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	**Overfished status**	**Overfishing status**	**Reference points (target, limit)**
												CPUE	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 4 proxies)
												CPUE	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 4 proxies)
												biomass	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 1)
													recent av. fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 3 proxies)
												biomass	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 1)
												biomass	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 1)
													fishing mortality (catch)	no formal reference points
												biomass	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 1)
												CPUE	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 4 proxies)
												biomass (pup production)	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 1)
												CPUE	fishing mortality (catch)	target 48% B_0, limit 20% B_0 (Tier 4 proxies)
												biomass (pup production)	fishing mortality (catch); targeting	target 48% B_0, limit 20% B_0 (Tier 1)
												total biomass	fishing mortality (catch), effort	no fishery specific reference points. HSP defaults applied
												spawning biomass	fishing mortality (catch), effort	no fishery specific reference points. HSP defaults applied
												spawning biomass	fishing mortality (catch), effort	no fishery specific reference points. HSP defaults applied

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TABLE 1.6 Biological stock status summary CONTINUED

Chapter	Fishery	Common name	Scientific name	Status history 1992	1993	1994	1996	1997	1998	1999	2001–02	2002–03
16	Torres Strait Lobster Fishery	Tropical rock lobster	*Panulirus ornatus*	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Uncertain	Overfished	Overfished
17	Torres Strait Prawn Fishery	Brown tiger prawn	*Penaeus esculentus*	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished
17	Torres Strait Prawn Fishery	Blue endeavour prawn	*Metapenaeus endeavouri*	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished
17	Torres Strait Prawn Fishery	Red-spot king prawn	*Melicertus longistylus*	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished
18	Torres Strait Sea Cucumber Fishery	Black teatfish	*Holothuria whitmaei*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Overfished
18	Torres Strait Sea Cucumber Fishery	Prickly redfish	*Thelenota ananus*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
18	Torres Strait Sea Cucumber Fishery	Sandfish	*Holothuria scabra*	Not assessed	Not assessed	Not assessed	Not assessed	Overfished	Overfished	Overfished	Overfished	Overfished
18	Torres Strait Sea Cucumber Fishery	Surf redfish	*Actinopyga mauritiana* (likely a mix of *Actinopyga* spp.)	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Overfished
18	Torres Strait Sea Cucumber Fishery	White teatfish	*Holothuria fuscogilva*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
18	Torres Strait Sea Cucumber Fishery	Other species	up to 15 other sea cucumber species	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
18	Torres Strait Trochus Fishery	Trochus	*Trochus niloticus*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
19	Western Deepwater Trawl Fishery	Bugs	*Ibacus* spp.	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
19	Western Deepwater Trawl Fishery	Orange roughy	*Hoplostethus atlanticus*	Not assessed	Not overfished	Not overfished	Not overfished	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING   OVERFISHED / OVERFISHING   UNCERTAIN   NOT ASSESSED

2004 Status		2005 Status		2006 Status		2007 Status		2008 Status		2009 Status		Stock status indicators		
Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfished status	Overfishing status	Reference points (target, limit)
												spawning biomass	fishing mortality (catch), effort	target F_{MSY}, B_{MSY}; limit F_{LIM}, B_{LIM}
												total biomass	fishing mortality (catch), effort	E_{MSY} and B_{MSY}
												total biomass	fishing mortality (catch), effort	E_{MSY} and B_{MSY}
												catch rates	fishing mortality (catch), effort	no fishery specific reference points. HSP defaults applied
												density/biomass, surveys	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												density/biomass, surveys	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												density/biomass, surveys	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												density/biomass, surveys	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												density/biomass, surveys	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												density/biomass, surveys	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												density/biomass, surveys	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												none	fishing mortality (catch), effort	no fishery specific reference points. HSP defaults applied
												none	fishing mortality (catch), effort	no fishery specific reference points. HSP defaults applied

Table 1.6 continues over the page

TABLE 1.6 Biological stock status summary CONTINUED

Chapter	Fishery	Common name	Scientific name	Status history: 1992	1993	1994	1996	1997	1998	1999	2001–02	2002–03
19	Western Deepwater Trawl Fishery	Ruby snapper	*Etelis carbunculus*	Not assessed	Not overfished	Not overfished	Not overfished	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain
20	South Tasman Rise Trawl Fishery	Orange roughy	*Hoplostethus atlanticus*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Uncertain	Uncertain	Overfished
22	Eastern Tuna and Billfish Fishery	Striped marlin	*Tetrapturus audax*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Uncertain	Uncertain
22	Eastern Tuna and Billfish Fishery	Swordfish	*Xiphias gladius*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Uncertain	Uncertain	Uncertain	Uncertain
22	Eastern Tuna and Billfish Fishery	Tuna, albacore	*Thunnus alalunga*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not overfished	Not overfished
22	Eastern Tuna and Billfish Fishery	Tuna, bigeye	*Thunnus obesus*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Uncertain	Uncertain	Not overfished	Not overfished
22	Eastern Tuna and Billfish Fishery	Tuna, yellowfin	*Thunnus albacares*	Not assessed	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished
23	Skipjack Fishery: Pacific Ocean	Tuna, skipjack	*Katsuwonus pelamis*	Not assessed	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished	Not overfished
23	Skipjack Fishery: Indian Ocean	Tuna, skipjack	*Katsuwonus pelamis*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not overfished
24	Southern Bluefin Tuna Fishery	Southern bluefin tuna	*Thunnus maccoyii*	Overfished	Overfished	Overfished	Overfished	Overfished	Overfished	Overfished	Overfished	Overfished
25	Western Tuna and Billfish Fishery	Striped marlin	*Tetrapturus audax*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
25	Western Tuna and Billfish Fishery	Swordfish	*Xiphias gladius*	Not assessed	Not assessed	Not assessed	Not assessed	Uncertain	Uncertain	Uncertain	Not overfished	Not overfished
25	Western Tuna and Billfish Fishery	Tuna, albacore	*Thunnus alalunga*	Not assessed	Not assessed	Not assessed	Not assessed	Uncertain	Uncertain	Uncertain	Not overfished	Not overfished

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING · OVERFISHED / OVERFISHING · UNCERTAIN · NOT ASSESSED

2004 Status		2005 Status		2006 Status		2007 Status		2008 Status		2009 Status		Stock status indicators		
Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	**Overfished status**	**Overfishing status**	**Reference points (target, limit)**
												none	fishing mortality (catch), effort	no fishery specific reference points. HSP defaults applied
												surveys	fishing mortality (catch), effort	no fishery specific reference points. HSP defaults applied
												biomass, CPUE	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												spawning biomass	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												spawning biomass	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												spawning biomass	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												spawning biomass	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												biomass, CPUE	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												biomass, CPUE	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												spawning biomass	fishing mortality (catch)	biomass to rebuild to target level
												CPUE	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												biomass, CPUE	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												biomass, CPUE	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied

Table 1.6 continues over the page

TABLE 1.6 Biological stock status summary CONTINUED

Chapter	Fishery	Common name	Scientific name	Status history 1992	1993	1994	1996	1997	1998	1999	2001–02	2002–03
25	Western Tuna and Billfish Fishery	Tuna, bigeye	*Thunnus obesus*	Not assessed	Not assessed	Not assessed	Not assessed	Uncertain	Uncertain	Uncertain	Uncertain	Overfished / overfishing
25	Western Tuna and Billfish Fishery	Tuna, longtail	*Thunnus tonggol*	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
25	Western Tuna and Billfish Fishery	Tuna, yellowfin	*Thunnus albacares*	Not assessed	Not assessed	Not assessed	Not assessed	Uncertain	Uncertain	Uncertain	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing
26	Antarctic Waters Fishery	Toothfish (2 spp.)	*Dissostichus* spp.	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
27	Heard Island and McDonald Islands Fishery	Mackerel icefish	*Champsocephalus gunnari*	Not assessed	Not assessed	Not assessed	Not overfished / not subject to overfishing	Uncertain	Uncertain	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing
27	Heard Island and McDonald Islands Fishery	Patagonian toothfish	*Dissostichus eleginoides*	Not assessed	Not assessed	Not assessed	Not overfished / not subject to overfishing	Uncertain	Uncertain	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing
28	Macquarie Island Fishery	Patagonian toothfish	*Dissostichus eleginoides*	Not assessed	Not assessed	Not assessed	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Not overfished / not subject to overfishing

n.a. = not available; B_0 = mean equilibrium unfished biomass; CPUE = catch per unit effort; F = fishing mortality; M = natural mortality; TAC = total allowable catch; MEY = maximum economic yield; MSY = maximum sustainable yield; Tiers 1–4 = SESSF assessment and harvest control rule system; SESSF = Southern and Eastern Scalefish and Shark Fishery

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING — OVERFISHED / OVERFISHING — UNCERTAIN — NOT ASSESSED

1.3 ECONOMIC STATUS (2008–09)

Table 1.7 provides a summary of the economic performance of each Commonwealth fishery in the 2008–09 financial year and how this performance differs from when the fishery was last assessed.

The table provides commentary on fishery economic status based on key variables considered in the assessment of fishery economic performance. Changes in gross value of production (GVP) and production volume reveal in which direction a fishery's revenues are moving. Management costs are a key consideration in the context of AFMA's cost effective management objective when compared with fishery GVP. The trend of NER reveals how profitable a fishery has been and whether it is improving or

2004 Status		2005 Status		2006 Status		2007 Status		2008 Status		2009 Status		Stock status indicators		
Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	Overfishing	Overfished	**Overfished status**	**Overfishing status**	**Reference points (target, limit)**
												spawning biomass	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												none	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												spawning biomass	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												surveys, biomass, CPUE	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												biomass	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												biomass	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied
												biomass	fishing mortality (catch)	no fishery specific reference points. HSP defaults applied

deteriorating. The proportion of rights unused allows an assessment of where a fishery is relative to its open access equilibrium—a point where there is no limit on the number of operators or vessels allowed to operate in the fishery. A fishery that is at its open access aquilibrium is associated with low NER (zero on average). A high amount of latent rights in a fishery indicates that effort and catch levels are set beyond the open access equilibrium. Therefore, fishery level NER is likely to be low and there is no profit incentive for all licence holders to activate their rights. The choice of primary management instrument will influence the incentives of operators and overall fishery efficiency.

TABLE 1.7 Summary of economic performance and indicators of Commonwealth fisheries in 2008–09 compared with 2007–08

Fishery	GVP for 2008–09 (and real % change from 2007–08)	Production volumes in 2008–09 (% change from 2007–08)	Management costs for 2008–09 ($ million) (% share of GVP)	Trend of NER	Proportion of rights unused (latency)
LARGE FISHERIES (GVP >$4 million)					
Eastern Tuna and Billfish Fishery	$38.9 million (up 18%)	6 399 tonnes (down 1%)	2.9 (7% of GVP)	Close to zero or negative	High
Heard Island and McDonald Islands Fishery	Confidential[a]	3 069 tonnes (up 27%)	1.1	Not estimated	Low
Northern Prawn Fishery	$74.0 million (down 4%)	6 529 tonnes (down 5%)	2.5 (3% of GVP)	Positive, and increasing	Low
Southern Bluefin Tuna Fishery	$45.3 million (down 1%)[b]	5 062 tonnes (down 3%)	1.9 (4% of GVP)	Not estimated	Low
Southern and Eastern Scalefish and Shark Fishery	$95.5 million[c] (up 7%)	22 610 tonnes (down 5%)	5.7 (6% of GVP)	See individual sectors	See individual sectors
Commonwealth Trawl and Scalefish Hook Sectors	$63.6 million (up 16%)	16 570 tonnes (up 1.3%)	3.4 (6% of GVP)	Positive and increasing	High for a number of species but low for most key species
Great Australian Bight Trawl Sector	$9.0 million (down 30%)	2 505 tonnes (down 33%)	0.6 (7% of GVP)	Not estimated	High
Shark Hook and Shark Gillnet Sector	$22.9 million (up 6%)	3 388 tonnes (down 7%)	1.7 (9% of GVP)	Positive and relatively constant	Low for key species
Torres Strait Prawn Fishery	$6.4 million (down 40%)	704 tonnes (down 29%)	n.a.	Consistently negative	High
Torres Strait Tropical Rock Lobster Fishery	$6.9 million (down 29%)	240 tonnes (down 29%)	n.a.	Not estimated	High
SMALL FISHERIES (GVP <$4 million)					
Antarctic Waters Fishery	Confidential[a]	Confidential[a]	0.1	Not estimated	High
Bass Strait Central Zone Scallop Fishery	$1.2 million (fishery closed 2007–08)	594 tonnes (caught in June 2009 at the start of the 2009 season—June to December 2009)	0.3 (25% of GVP)	Not estimated	Low
Coral Sea Fishery	Confidential[a]	Confidential[a]	0.2	Not estimated	Unknown

Primary management instrument	General comments
Input controls, limited entry	Economic status uncertain, but probably improving. NER has been negative since 2001–02, but was relatively close to zero in 2007–08 (preliminary estimate). Recent restructuring and increased value contributions from bigeye tuna (2007–08) and yellowfin tuna (2008–09) are likely to have increased NER. Status of bigeye tuna stocks is a concern for future economic status. The move to more effective management arrangements will have a positive impact on future economic status.
Output controls, limited entry	Economic status uncertain although NER is likely to be positive given that the TAC for Patagonian toothfish and mackerel icefish was close to being reached in 2008–09.
Input controls, limited entry	Overall economic status has improved given recent structural adjustment, improved tiger prawn stocks and high banana prawn catch rates. NER became positive in 2007–08 and preliminary estimates suggest NER increased further in 2008–09. The move to more effective management arrangements will have a positive impact on future economic status.
Output controls, global TAC	Latency has consistently been very low, indicating positive profits, but falling export unit prices in 2008–09 are likely to have decreased NER. Although NER is positive, the stock's overfished status is a concern.
Output controls, some input controls	While latent effort has historically been an issue in the SESSF, TACs have been reduced for many species and economic performance is improving.
	NER became positive in 2005–06, increased in 2006–07 (due to higher fish prices) and are expected to have increased further in 2007–08. Estimates of NER are not yet available for 2008–09 but are expected to have remained positive. Economic status likely to be improving due to recent stock recoveries and restructuring.
	Economic status uncertain although a MEY study is currently underway. High levels of latent quota indicate that total NER is likely to be low.
	NER for the GHATS (which includes the Shark Gillnet and Shark Hook Sectors) was $5 million in 2007–08 (preliminary estimate) and are expected to have remained positive in 2008–09. Although economic status has recently been positive, evidence suggests that there may be scope to earn additional NER with higher stock levels. However, this would require further research.
Input controls, limited entry	Economic status could probably be improved given that the fishery exibits characteristics associated with open access (low NER and high latent effort). NER has been negative since 2004–05.
Input controls, limited entry	Economic conditions in the fishery have deteriorated. Total NER are likely to be low.
Output controls	Latency high, suggesting NER is low. Australia did not participate in the fishery in 2008–09. Overfished status of toothfish is a concern for future economic performance.
Output controls, some input controls	Improved economic status can be linked to stock recovery. Low level of quota latency in 2009 suggests positive NER.
Combination of input and output controls	Economic status uncertain. There is limited data to undertake an informed assessment of economic performance in this fishery. In the non-aquarium component of the fishery, recent low GVP suggests that potential NER is likely to be low.

Table 1.7 continues over the page

TABLE 1.7 Summary of economic performance and indicators of Commonwealth fisheries in 2008–09 compared with 2007–08 CONTINUED

Fishery	GVP for 2008–09 (and real % change from 2007–08)	Production volumes in 2008–09 (% change from 2007–08)	Management costs for 2008–09 ($ million) (% share of GVP)	Trend of NER	Proportion of rights unused (latency)
East Coast Deepwater Trawl Sector	No fishing effort recorded	No fishing effort recorded	0.1	Not estimated	High
Macquarie Island Toothfish Fishery	Confidential[a]	Confidential[a]	0.2	Not estimated	Low
Norfolk Island Fishery	No fishing offshore, unknown inshore	No fishing offshore, unknown inshore	0.2	Not estimated	Unknown
North West Slope Trawl Fishery	Confidential[a]	Confidential[a]	0.1	Not estimated	Low
Skipjack Fishery	Confidential[a]	Confidential[a]	0.1	Not estimated	High
Small Pelagic Fishery	Confidential[a]	Confidential[a]	0.4	Not estimated	High
Southern Squid Jig Fishery	$0.5 million (up 93%)	308 tonnes (down 70%)	0.2 (40% of GVP)	Estimates for 1997–98 to 2000–01 all negative. No new estimates available.	High
South Tasman Rise Trawl Fishery	Fishery closed	Fishery closed	0.03	Not estimated	High
Torres Strait Finfish Fisheries (Spanish mackerel and reefline)	$1.1 million (down 21%)	90 tonnes (down 45%)	n.a.	Not estimated	High
Torres Strait Hand Collection Fisheries	Not estimated	Not estimated	n.a.	Not estimated	High
Western Deepwater Trawl Fishery	Confidential[a]	Confidential[a]	0.1	Not estimated	High
Western Tuna and Billfish Fishery	Confidential[a]	Confidential[a]	0.4	$1.9 million in 2001–02 (not estimated since 2001–02)	High
TOTAL	**$313.8 million (up 5%)**	**51 416 t (down 2 %)**	**$19.9 million (6% of GVP)**		

GHTS = Gillnet, Hook and Trap Sector; GVP = gross value of production; n.a. = not available; NER = net economic returns; SESSF = Southern and Eastern Scalefish and Shark Fishery; TAC = total allowable catch

a Less than five vessels operating in the fishery
b The majority of Commonwealth production is used as an input to South Australian southern bluefin aquaculture operations.
c Includes Victoria Inshore Trawl and East Coast Deepwater Trawl Sectors

Primary management instrument	General comments
Output and input controls	Economic status uncertain. Catch and fishing effort level very low suggesting that total NER are likely to be low.
Output controls	Economic status uncertain although latent quota falling in Aurora Trough, and very low in Macquarie Ridge. Total NER likely to be positive.
Input controls	Economic status uncertain. Total NER likely to be low given low catch levels and low effort.
Input controls	Economic status uncertain. High latency and low GVP indicate total NER low.
Input controls	Economic status uncertain. Total NER likely to be low with few domestic vessels fishing in either sector in recent years.
Combination of input and output controls	Economic status uncertain. High level of latency suggests total NER low.
Input controls, limited entry	Economic status uncertain. Total NER likely to be low given high level of latency.
Output controls	Latent effort in the form of unfilled quota suggests NER were likely low before the fishery's closure.
Input controls, limited entry	Economic status uncertain. Total NER likely to be low.
Input controls, limited entry	No economic performance indicators available for this fishery.
Input controls	Economic status uncertain. Total NER likely to be low given high latency, low catches and effort.
Input controls (shifting to output controls)	Economic status uncertain. Latent effort remained high in 2009. Catch and effort levels remain low. Total NER likely to be low.

Australian fisheries production

The real value of Australian fisheries production has declined at an average annual rate of 3.8% since the start of this decade, reaching $2.2 billion in 2008–09 (ABARE–BRS 2010) (Fig. 1.5). Most of this fall is attributed to declines in the value of fisheries production in Commonwealth and state wild catch fisheries, which decreased at an average annual rate of 5.8% and 5.3%, respectively, from 1999–2000 to 2008–09. Overall, the real value of aquaculture production fell at an average annual rate of 0.7% over the same period, reaching $861 million in 2008–09.

In recent years, growth in the real value of aquaculture has moderated the overall decline in the real value of Australian fisheries production. Since 2004–05, the real value of aquaculture production grew at an average annual rate of 4.1%.

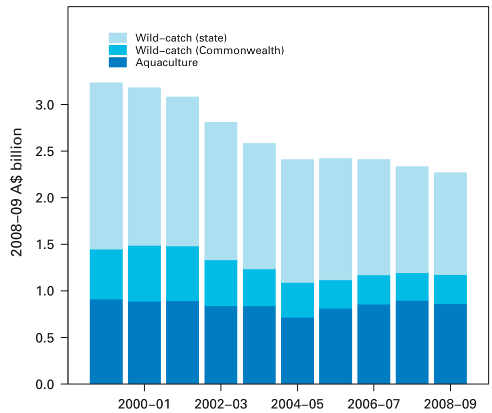

FIGURE 1.5 Real gross value of Australian fisheries production by financial year, 1999–2000 to 2008–09

The real value of production of Commonwealth fisheries increased in 2008–09, by 5% to $314 million, contributing 14% of the gross value of Australia's fishery production. This increase in value follows a substantial decline (48%) from its peak of $600.2 million in 2000–01. This declining trend reflects multiple factors including fishery management changes, rises in the cost of fuel and an appreciating Australian dollar, which has placed downward pressure on domestic and export prices. With increasing costs and a deteriorating competitive position, financial returns from operating in the industry have been negatively affected.

The value of production of major Commonwealth fisheries and key sectors of the SESSF is presented in Figure 1.6. The SESSF generates the highest value of production of all Commonwealth fisheries. This fishery is an amalgamation of the CTS; the Gillnet, Hook and Trap Sector; the GABTS; and the East Coast Deepwater Trawl Sector. Overall, the GVP for the SESSF was $95.5 million in 2008–09 (Fig. 1.6). In the same year, the NPF generated a GVP of $74.0 million, the highest value of production for a single-method fishery. The ETBF is also important in value terms; it generated $38.9 million in 2008–09.

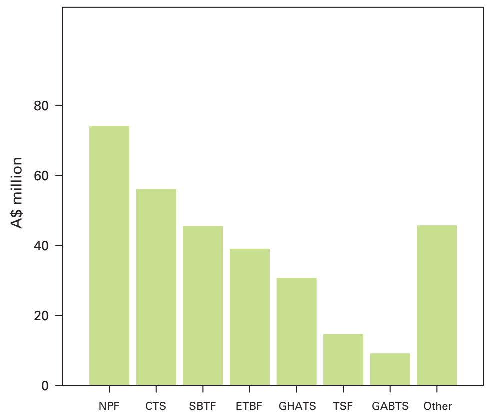

FIGURE 1.6 GVP of major Commonwealth fisheries and sectors by financial year, 2008–09

CTS = Commonwealth Trawl Sector; ETBF = Eastern Tuna and Billfish Fishery; GABTS = Great Australian Bight Trawl Sector; GHTS = Gillnet, Hook and Trap Sector; NPF = Northern Prawn Fishery; SBTF = Southern Bluefin Tuna Fishery; TSF = Torres Strait Fisheries

The Commonwealth Southern Bluefin Tuna Fishery (SBTF) is estimated to have been worth $45.3 million in 2008–09. Post-harvest aquaculture operations in Port Lincoln (South Australia) resulted in that value growing to $192.6 million (including Commonwealth southern bluefin tuna farm input). The method for estimating the GVP of the SBTF is explained in Box 1.

BOX 1 Calculating the gross value of production for the Commonwealth Southern Bluefin Tuna Fishery (SBTF)

Almost all southern bluefin tuna caught in Commonwealth waters are transferred to aquaculture farms off Port Lincoln in South Australia. The price of live juvenile fish at the point of transfer to these farms is not available, largely because many operators are involved in both catching and grow-out operations. Consequently, the GVP for the fishery's output must be estimated indirectly. ABARE–BRS derives the value of the SBTF by adding fishing costs to an estimate of the potential resource rent of wild SBT. This estimate is based on the lease price of the quota, which is obtained through consultation with industry representatives.

Processing facility, Eden PHOTO: NEIL BENSLEY, ABARE–BRS

Employment in commercial fishing, seafood processing and seafood wholesaling

The Australian Bureau of Statistics (ABS) reports two main series relating to employment in the Australian fishing and aquaculture industry. Estimates from the Labour Force Survey (part of the Monthly Population Survey) indicate that employment in this industry was 9215 persons in 2008–09; this is around 52% below the 2000–01 figure (Fig. 1.7).

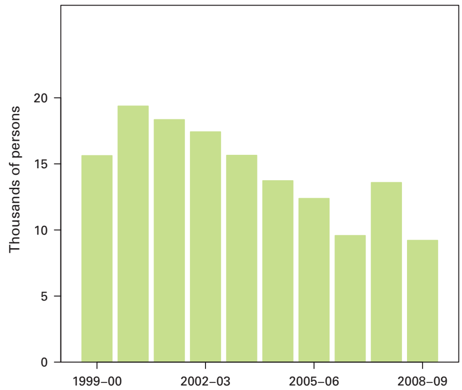

FIGURE 1.7 Employment in the Australian fishing and aquaculture industry by financial year, 1999–2000 to 2008–09

SOURCE: ABS (2009)

ABS census data from 2006 (ABS 2007) show that commercial fishing and aquaculture directly employed 9736 people in Australia (Table 1.8), from an Australian workforce of around 9.1 million. A further 6203 people work in wholesaling and processing of fisheries products, mostly in fish wholesaling. Of the 9736 people employed in the industry in 2006, more than one-third (3628 persons) were employed in aquaculture and 1154 persons were employed in rock lobster fishing, principally in Western Australia and South Australia. Tasmania has the largest employment in aquaculture. The affiliated industries of fish wholesaling and seafood processing employed 4202 and 2001 people, respectively.

TABLE 1.8 Estimated employment in the Australian fishing, hunting, trapping and aquaculture industry by sector in 2006. Australian Bureau of Statistics census data, August 2006[a]

	Number of people employed								
Area of employment	**NSW**	**Vic**	**Qld**	**WA**	**SA**	**Tas**	**NT**	**ACT**	**Australia**
Aquaculture	709	280	551	325	766	935	62	0	**3628**
Finfish trawling	61	52	61	23	53	25	4	0	**278**
Line fishing	7	10	27	15	18	8	0	0	**86**
Prawn fishing	130	4	323	93	78	0	19	0	**648**
Rock lobster fishing	43	93	104	491	227	183	13	0	**1154**
Other fishing, hunting and trapping[b]	865	355	945	530	627	427	186	7	**3942**
Total in commercial fishing	**1815**	**794**	**2011**	**1477**	**1769**	**1578**	**284**	**7**	**9736**
Fish wholesaling	1039	859	1037	452	460	295	43	17	**4202**
Seafood processing	203	259	273	357	509	385	15	0	**2001**
Total in affiliated industries	**1242**	**1118**	**1310**	**809**	**969**	**680**	**58**	**17**	**6203**

a Based on 2006 ANZSIC classification

b Includes fishing, hunting and trapping (not elsewhere specified)

SOURCE: ABS (2007).

The ABS employment data for the Australian fishing industry cover employment in both Commonwealth fishing and in State and Territory fisheries and aquaculture. The employment data do not give a strong indication of where the incomes of those employed in commercial fishing are spent.

The Fisheries Research and Development Corporation (FRDC) has stated that 'data collected by the ABS are not disaggregated in sufficient detail to be useful, and tend to under record employees by allocating them to other industries such as transport and generalised food processing' (FRDC 2004). Hence, the data presented in Figure 1.7 and Table 1.8 provide only a broad indication of employment levels in the Australian fishing industry.

Eden fish processing PHOTO: JAMES LARCOMBE, ABARE–BRS

Exchange rates and Australian fisheries trade

Exchange rates

A large proportion of Australia's fishery production is exported. Consequently, changes in the value of the Australian dollar against the currencies of trading partners affect the value of Commonwealth fisheries production. It is common for the US dollar to be used as the reference price for international trade. An appreciation of the Australian dollar relative to the US dollar reduces the prices received for exports and vice versa. Currency appreciation also increases the foreign currency price of domestic goods and services, rendering them less competitive on world markets.

The relationship between the real value of Commonwealth production and recent movements in the Australian dollar is shown in Figure 1.8. The 30% depreciation of the US dollar relative to the Australian dollar from A$1.90 per US dollar in 2001–02 to A$1.33 per US dollar in 2008–09 is tracked in Figure 1.8, along with the 47% decrease in the real value of production for Commonwealth fisheries. Although changes in the exchange rate are not the only factor contributing to the fall in the value of production, they are likely to have had a substantial impact.

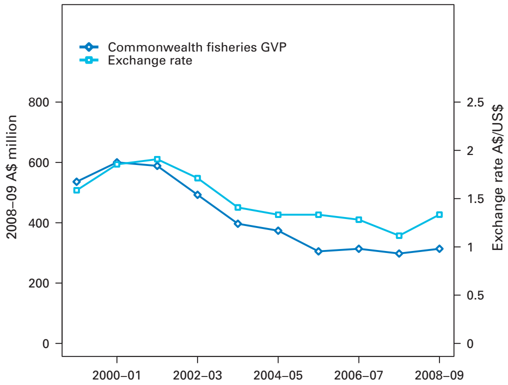

FIGURE 1.8 Real value of Commonwealth fisheries production and the US$–A$ exchange rate, by financial year, 1999–2000 to 2008–09

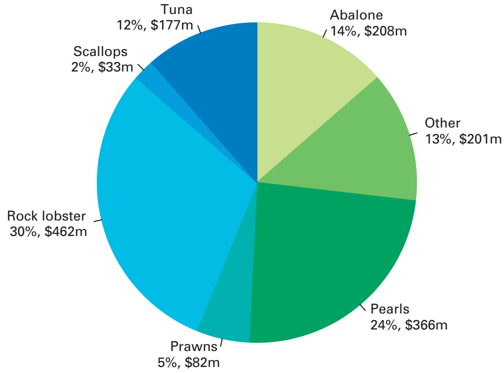

FIGURE 1.9 Proportion and value (A$ million) of Australian fisheries exports, 2008–09

Australian exports of fisheries products

Information about Australian exports of fisheries products is prepared by the ABS. Each product is classified according to the Australian Harmonised Export Commodity Classification system. In most cases, this system records each product's species group and form of processing (such as fresh, chilled or frozen), as well as the originating state or territory and the country of destination. However, using this source of data, it is generally not possible to identify the fishery from which a product was landed. Therefore, in this section, Australian fisheries exports as a whole are discussed; Commonwealth fisheries are not specifically identified.

Around 75% of the total value of Australian exports of fisheries products relates to edible seafood products. Pearls account for 95% of the value of non-edible exports.

In 2008–09 the main exported products in value terms were rock lobster (30% of gross value of exports), pearls (24%), abalone (14%), whole tuna (11%) and prawns (5%) (Fig. 1.9).

Frozen catch PHOTO: MIKE GERNER, AFMA

The real gross value of Australian fisheries exports increased by $146 million to $1.53 billion in 2008–09 (Fig. 1.10). Export values were boosted by the sharp depreciation of the Australian dollar in late 2008 as a result of the global financial crisis. Over the eight years to 2008–09, the total value of exports fell by 44% in real terms, from a peak of $2.7 billion in 2000–01. Both edible (fish, crustaceans and molluscs) and non-edible fisheries exports declined in value over this period, by 47% and 44%, respectively.

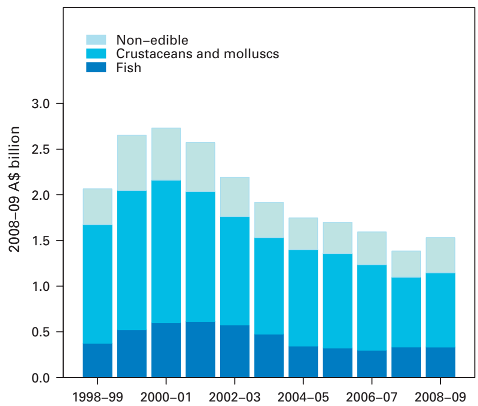

FIGURE 1.10 Real gross value of Australian fisheries exports by financial year, 1998–99 to 2008–09

As a relatively small producer of fisheries products, Australia receives prices for seafood exports that are set predominantly on world markets in foreign currencies. A number

of factors have lowered the export value of Australian fisheries products since 2000–01. First, the volume of exports of edible fisheries products has fallen by 28% since 2000–01 to around 47 000 tonnes in 2008–09. Second, prices of fisheries products on world markets have generally fallen. Third, the appreciation of the Australian dollar against the currencies of major trading partners has further reduced the prices received by Australian exporters. The general decline in the prices of major fisheries commodities exported from Australia to Japan (a major market) since 2000–01 is shown in Figure 1.11. Most of this decline occurred during the period 2000–01 to 2004–05. After 2004–05 prices stabilised for products such as prawns and tuna, and have generally risen for rock lobster.

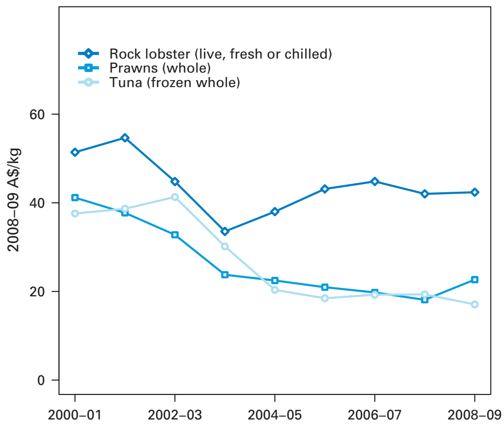

FIGURE 1.11 Real Australian export prices for key species exported to Japan, by financial year, 2000–01 to 2008–09

In 2008–09 Hong Kong continued to be Australia's main export market for edible fisheries products after overtaking Japan in 2005–06 (Fig. 1.12). In value terms, 52% ($525 million) of Australia's edible fisheries products was exported to Hong Kong, and 30% ($302 million) was exported to Japan. The United States is Australia's third largest export destination, followed closely by the Fishing Entity of Taiwan and China. In 2008–09, these five markets accounted for 89% of the value of Australia's exports of edible fisheries products (Fig. 1.12).

Over the eight years to 2008–09, the total value of Australia's seafood exports to Japan fell by 67% in real terms (2008–09 dollars) to $302 million in 2008–09. This was caused largely by substantial reductions in the volume of exports of key products (rock lobster, prawns and other fish) and the appreciation of the Australian dollar relative to the Japanese yen, the effect of which has been compounded by declining yen prices for key export species, particularly prawns. For example, declining yen prices for prawns, combined with the appreciation of the Australian dollar relative to the yen, have resulted in the real price of prawn exports declining by 56% (Fig. 1.11).

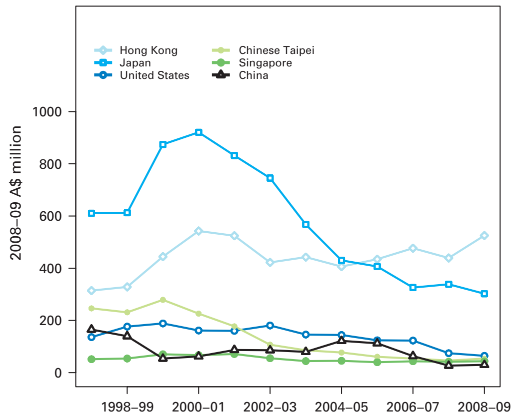

FIGURE 1.12 Value of Australian exports of edible fisheries products (excluding live products) to various destinations, by financial year, 1997–98 to 2008–09

Australian imports of edible fisheries products

Australian fisheries products compete with imported products on the domestic market. The value of Australian imports of edible fisheries products increased by $115 million to $1.3 billion in 2008–09. Around 75% of the gross value of imports was edible fisheries products, with pearls accounting for most non-edible imports. The main edible products imported into Australia were canned fish (26% of the gross value of edible seafood imports); fresh, chilled or frozen finfish fillets (19%); and fresh, chilled or frozen prawns (11%) (Fig. 1.13).

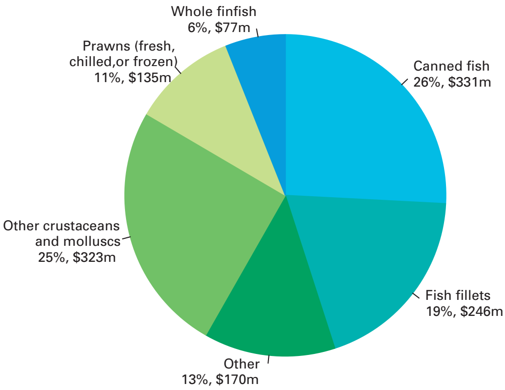

FIGURE 1.13 Proportion and value (A$ million) of Australian imports of edible fisheries products (excluding live products), 2008–09

Thailand, New Zealand, China and Vietnam were the major sources of edible fisheries products imported into Australia. In 2008–09, imports from these four countries accounted for 70% of total edible imports by value (Fig. 1.14). More than 70% of Australia's imports of canned fish, 29% of prawns (fresh, chilled or frozen) and 24% of canned crustaceans and molluscs were sourced from Thailand. New Zealand was the source of 35% of Australia's imports of fresh, chilled or frozen fish products and 28% of fresh, chilled or frozen mollusc imports. In recent years, the gross value of imports from China and Vietnam has grown steadily. China and Vietnam were the source of 27% and 21%, respectively, of fresh, chilled or frozen prawn imports. Also sourced from China were 35% of fresh, chilled or frozen mollusc imports.

Pink ling PHOTO: JAMES LARCOMBE, ABARE–BRS

After a slight decrease in 2007–08, the volume of edible seafood imports continued to increase in 2008–09, by 3% to 193 000 tonnes. The volume of edible seafood imports rose by 34% from 144 000 tonnes in 2000–01. Of particular note was the increase in prawn imports from China and Vietnam and in imports of frozen finfish fillets from Vietnam.

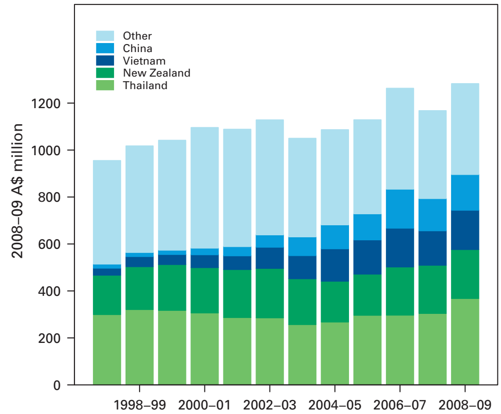

FIGURE 1.14 Real value of Australian imports of edible fisheries products (excluding live products), by source and financial year, 1997–98 to 2008–09

Fuel prices and fishing costs

ABARE–BRS's fishery surveys indicate that fuel is a major cost of fishing, ranging between 10% and 40% of the total costs of operating a vessel, depending on the fishery (Table 1.9). In the NPF and the Torres Strait Prawn Fishery, the proportion is high, at 34% and 40%, respectively. This reflects the longer distances travelled and the relatively fuel-intensive nature of trawling.

Increases in world oil prices in recent years have caused diesel prices to increase. The average wholesale diesel price (see Fig. 1.15) rose from 100 cents per litre in 2002–03 to 141 cents per litre in 2007–08. Despite falling in 2008–09, fuel prices remained high relative to previous years. Fishers are entitled to a rebate on their fuel expense under the Energy Grants Credit Scheme (Commonwealth of Australia 2006). For claims made after early January 2006, the rebate was approximately 38 cents per litre.

TABLE 1.9 Fuel costs as a percentage of total cash costs for selected Commonwealth fisheries and sectors

Fishery or sector	Fuel cost as percentage of total cash cost, 2006–07[a]
Eastern Tuna and Billfish Fishery	17.7
Northern Prawn Fishery[a]	34.4
Commonwealth Trawl Sector	21.5
Gillnet, Hook and Trap Sector	9.6
Torres Strait Prawn Fishery[a]	40.4

a Results for most recent survey year. Results for the Northern Prawn Fishery and Torres Strait Prawn Fishery are for 2007–08.

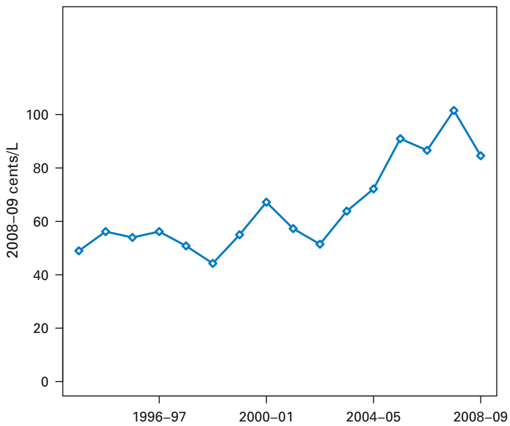

FIGURE 1.15 Real average off-road diesel price, inclusive of farm rebates and subsidies, but excluding GST, by financial year, 1993–94 to 2008–09

1.4 ENVIRONMENTAL STATUS

The Australian Government advocates an ecosystem-based approach to fisheries management. This requires a move away from traditional management, which focuses on target species, to a more holistic approach that considers a wider range of fisheries impacts. An assessment of the environmental status of Commonwealth fisheries has not been a major focus of the *Fishery status reports* in the past. Historically, only an overview has been provided on fishery-specific environmental issues. However, in this edition, we have attempted to explore to a greater degree the levels of interaction between fisheries and the ecosystems in which they operate.

In future editions, it is intended that fisheries will be assessed more rigorously against established performance measures for environmental management; for example, an increasing focus will be placed on assessing fisheries against the specific ecosystem requirements detailed in fisheries management plans, and bycatch and discarding work plans.

The type, significance and frequency of fishing impacts on the ecosystem vary greatly with each fishery, fishing method, and time and area within which fishing operations occur. Some fisheries are also known to interact with threatened, endangered and protected (TEP) species, listed under the EPBC Act. As a consequence, the environmental management of fisheries attracts substantial community scrutiny, and a range of statutory obligations are placed on fishers and management agencies to ensure that fishing practices are sustainable and publicly acceptable.

Management of environmental issues relating to fisheries, such as bycatch and impacts on habitats and the broader ecosystem, is being increasingly incorporated into fisheries management and assessment of Commonwealth-managed fisheries. A legislative and policy basis for this is provided by the ecologically sustainable development objective of the *Fisheries Management Act 1991* (FMA), the Commonwealth Policy on Fisheries Bycatch (DAFF 2000), the assessment of fisheries under the EPBC Act and, more recently, the 2005 Ministerial Direction.

There is a requirement under the FMA to 'ensure that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development (ESD) and the exercise of the precautionary principle, in particular the need to have regard to the impact of

fishing activities on non-target species and the long term sustainability of the marine environment'. The principles of ecologically sustainable development are outlined in both the FMA and the EPBC Act and are part of the objectives that must be pursued by AFMA in managing Commonwealth fisheries.

The following ***principles of ecologically sustainable development*** are stated in the FMA:

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equity considerations.
- If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
- The principle of intergenerational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations—should be observed.
- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision making.
- Improved valuation, pricing and incentive mechanisms should be promoted.

The ***precautionary principle*** has the same meaning as in clause 3.5.1 of the Intergovernmental Agreement on the Environment (www.environment.gov.au):

'Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.' In the application of the precautionary principle, public and private decisions should be guided by:

(a) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment

(b) an assessment of the risk-weighted consequences of various options.

EPBC Act and its interactions with fisheries management

The EPBC Act is the key piece of legislation for conserving the biodiversity of Australian ecosystems and protecting the natural environments that support these ecosystems. The EPBC Act broadly requires that actions taken when fishing do not have a significant impact on the Commonwealth marine environment and its biodiversity, including protected species or ecological communities. This is achieved through the requirement for all Commonwealth fisheries to undergo strategic environmental assessment to determine the extent to which management arrangements will ensure the fishery is managed in an ecologically sustainable way. The fishery assessments are conducted against the *Guidelines for the Ecologically Sustainable Management of Fisheries* (the Guidelines), which outline specific principles and objectives designed to ensure a strategic and transparent way of evaluating the ecological sustainability of fishery management arrangements. The two principles of the Guidelines are:

- A fishery must be conducted in a manner that does not lead to overfishing, or for those stocks that are overfished, the fishery must be conducted such that there is a high degree of probability the stock(s) will recover.
- Fishing operations should be managed to minimise their impact on the structure, productivity, function and biological diversity of the ecosystem.

These assessments determine whether a fishery should be accredited for the purposes of Part 13 (protected species provisions) and Part 13A (wildlife trade provisions) of the EPBC Act. Other more specific actions are controlled through recovery plans, wildlife conservation plans, and threat abatement plans made under the EPBC Act as a result of listing of a protected species or type of fishing activity.

Threatened species and communities

The EPBC Act protects Australia's native species and ecological communities by providing for:

- identification and listing of species and ecological communities as threatened
- development of conservation advice and recovery plans for listed species and ecological communities
- development of a register of critical habitat
- recognition of key threatening processes
- where appropriate, reducing the impacts of these processes through threat abatement plans.

Threatened species are divided into the following categories:

- extinct
- extinct in the wild
- critically endangered
- endangered
- vulnerable
- conservation dependent.

There are some fish species currently taken or interacted with in Commonwealth-managed fisheries that are listed as threatened species under the EPBC Act, although none from the endangered list. Species currently listed as critically endangered are rarely caught by Commonwealth fishers. However, grey nurse sharks (eastern population) are infrequently caught (and released) by hook and net methods. Species listed as critically endangered are:

- Grey nurse shark (*Carcharias taurus*), east coast population—16 October 2001

Species currently listed as vulnerable, such as great white sharks, are infrequently caught (and released) by hook and net methods by Commonwealth fishers. Species listed as vulnerable and infrequently caught are:

- Great white shark (*Carcharodon carcharias*)—effective 16 July 2000
- Freshwater sawfish (*Pristis microdon*)—effective 16 July 2000
- Whale shark (*Rhincodon typus*)—effective 16 October 2001
- Grey nurse shark (*Carcharias taurus*) west coast population—effective 16 October 2001
- Green sawfish (*Pristis zijsron*)—effective 7 March 2008
- Dwarf sawfish (*Pristis clavata*)—effective 20 October 2009.

Species currently listed as conservation dependent are caught by Commonwealth fishers, some in large numbers. However, for a species to remain in the conservation dependent category, fishing for the species can only continue in accordance with a specific plan of management, approved by the Commonwealth environment minister, that provides for management actions necessary to stop the decline and support the recovery of the species, so that its chances of long term survival in nature are maximised. Within Commonwealth fisheries, these plans are managed by AFMA and may also meet the rebuilding strategy requirements of the *Commonwealth Harvest Strategy Policy* (see DAFF 2007). Under this policy, rebuilding strategies must be developed and implemented for stocks that are below their limit reference point and fishing can only consist of unavoidable take. Species currently listed as conservation dependent are:

- Orange roughy (*Hoplostethus atlanticus*)—effective 5 December 2006
- School shark (*Galeorhinus galeus*)—effective 22 January 2009
- Eastern gemfish (*Rexea solandri*), eastern Australian population—effective 22 January 2009.

In addition, a number of species relevant to Commonwealth-managed fisheries are currently being assessed for possible listing as threatened species (southern bluefin tuna, Harrison's dogfish, southern dogfish, endeavour dogfish, dusky whaler shark and shortfin mako shark), the results of which will be made public by DEWHA in 2010 and 2011.

Threatened ecological communities are divided into the following categories:

- critically endangered
- endangered
- vulnerable.

At present no marine ecological communities are listed as threatened under the EPBC Act.

Key threatening processes

A key threatening process is one that threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community. There are currently three key threatening processes listed under the EPBC Act that are relevant to Commonwealth-managed fisheries:

- incidental catch (bycatch) of sea turtles during coastal otter-trawling operations within Australian waters north of 28 degrees South—effective 4 April 2001
- incidental catch (bycatch) of seabirds during oceanic longline fishing operations—effective 16 July 2000
- injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris—effective 13 August 2003.

A threatening process is eligible to be treated as a key threatening process if: (a) it could cause a native species or an ecological community to become eligible for listing in any category, other than conservation dependent; or (b) it could cause a listed threatened species or a listed threatened ecological community to become eligible to be listed in another category representing a higher degree of endangerment; or (c) it adversely affects two or more listed threatened species (other than conservation dependent species) or two or more listed threatened ecological communities. Threat abatement plans (TAPs) are developed for key threatening processes where the development of such a plan is considered to be a feasible, effective and efficient way to abate the threatening process. Two TAPs are currently in force for the above mentioned processes:

- The incidental catch (or bycatch) of seabirds during oceanic longline fishing operations was listed as a key threatening process on 24 July 1995. Under Commonwealth legislation (now the *Environment Protection and Biodiversity Conservation Act 1999*—EPBC Act), a *Threat abatement plan for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations* (AAD 2006) was prepared and approved by the Minister for the Environment on 2 August 1998. A review of the TAP was carried out under subsection 279(2) of the EPBC Act and a new TAP was approved in 2006 (AAD 2006). The provisions of the 2006 TAP apply to all longline fisheries managed by the Commonwealth Government.
- The *Threat abatement plan for the impacts of marine debris on vertebrate marine life* (DEWHA 2009) aims to provide a coordinated national approach to the implementation of measures to prevent and mitigate the impacts of harmful marine debris on vertebrate marine life.

A TAP for the incidental catch (bycatch) of sea turtles during coastal otter-trawling operations within Australian waters north of 28 degrees South, was not developed following a decision from the Threatened Species Scientific Committee (TSSC) that highlighted the widespread uptake of turtle exclusion devices in trawl fisheries. As such, the TSSC recommended that the turtle recovery plan should be used as the coordinating document, rather than developing a TAP.

- The *Recovery Plan for Marine Turtles in Australia* (EA 2003) adopts a threat-based approach. The premise is to reduce the likelihood that current threats will cause mortalities, or to modify activities to reduce the potential for future mortalities at all stages of a marine turtle's life, and to ensure that traditional harvest of marine turtles by indigenous Australians and Torres Strait Islanders is ecologically sustainable. The overall recovery objective is to reduce detrimental impacts on Australian populations of marine turtles and hence promote their recovery in the wild (EA 2003).

DEWHA is currently assessing trawling in the SESSF as a key threatening process, following its inclusion on the priority assessment list in 2007. The results of the review process are due to be made public in 2010 or early 2011.

AFMA's performance against each of the above components of the EPBC Act is discussed in the relevant fishery chapters.

International agreements

Australia is party to a range of international fisheries and conservation agreements that place environmental management obligations on Australian fisheries. Relevant United Nations agreements include:

- International Plan of Actions for the Conservation and Management of Sharks, and Reducing Incidental Catch of Seabirds in Longline Fisheries (FAO 1999)
- Convention on the Conservation of Migratory Species of Wild Animals (CMS 2003), including the Agreement on the Conservation of Albatrosses and Petrels (ACAP 2006)
- Convention on Biological Diversity (CBD 1992)
- Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES 1973).

In addition, the United Nations Food and Agriculture Organization has developed a Code of Conduct for Responsible Fishing that addresses the issue of bycatch and provides a useful blueprint for responsible fisheries management. The United Nations Agreement for the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, ratified by Australia on 23 December 1999, contains a number of obligations regarding the conservation and management of these stocks (see Chapter 21 for further details). Among these obligations are provisions relating to the impact of fishing on non-target species, and the application of the precautionary approach to the management of fisheries.

Convention on the Conservation of Migratory Species (CMS)

The Convention on the Conservation of Migratory Species of Wild Animals aims to conserve terrestrial, marine and avian migratory species throughout their range. It is an intergovernmental treaty, concluded under the aegis of the United Nations Environment Programme, concerned with the conservation of wildlife and habitats on a global scale. Migratory species threatened with extinction are listed in Appendix I of the Convention. CMS Parties strive towards strictly protecting these animals, conserving or restoring the places where they live, mitigating obstacles to migration and controlling other factors that might endanger them. Migratory species that need or would significantly benefit from international co-operation are listed in Appendix II of the Convention. Taxa included in the CMS appendices include whales, dolphins, porpoises, sea turtles, basking shark, great white shark, whale shark, dugong and seals.

United Nations Convention on the Law of the Sea (UNCLOS)

UNCLOS is the international agreement that resulted from the third United Nations Conference on the Law of the Sea (UNCLOS III), which took place from 1973 through 1982. The Law of the Sea Convention defines the rights and responsibilities of nations in their use of the world's oceans, establishing guidelines for businesses, the environment, and the management of marine natural resources. The entry into force of the UNCLOS, to which Australia is a party, means that this Government now has responsibility under international law for 'associated and dependent species' within our EEZ.

Part XII of the Convention (articles 192–237) addresses Protection and Preservation of the Marine Environment and gives basic obligations to prevent, reduce and control pollution from land-based sources; pollution from sea-bed activities subject to national jurisdiction; pollution from activities in the area; pollution by dumping; pollution from vessels; and pollution from or through the atmosphere (articles 207–212).

Convention on Biological Diversity (CBD)

The CBD is an international legally binding treaty that was adopted in Rio de Janeiro in June 1992. The Convention has three main goals: 1) conservation of biological diversity, 2) the sustainable use of its components,

and 3) the fair and equitable sharing of the benefits from the use of genetic resources. The Convention recognises that biodiversity is globally important, intrinsically valuable and vital to human activity and the wellbeing of present and future generations. The Convention has a very wide reach with all but two United Nations member states being a party to it. Importantly, the Convention is legally binding; parties are obliged to implement its provisions.

The Convention emphasises in-situ conservation measures, with ex-situ conservation measures complementing these, and contains measures on:

- the identification and monitoring of important components of biological diversity
- establishment and management of protected areas
- sustainable management of biological resources both within and outside protected areas, rehabilitation and restoration of degraded ecosystems
- recovery of threatened species, control of pest species
- control of threatening processes and activities, involvement of indigenous and local communities, sustainable customary use of biological resources
- research and training.

The main implementation measures for the Convention are national strategies, plans or programs.

Convention on International Trade in Endangered Species (CITES)

Australia is also one of the 175 countries that are a party to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). CITES was established in 1975 as an international convention to prevent international trade from threatening species with extinction.

Under CITES, each party regulates the import and export of an agreed list of species that are endangered, or at risk of becoming endangered, due to inadequate controls over trade in them or their products. CITES became enforceable under Australian law on 27 October 1976.

In Australia, CITES initially was enforced under the Customs (Endangered Species) Regulations and then under the *Wildlife Protection (Regulation of Exports and Imports) Act 1982*. Under amendments effective from 11 January 2002, the legislative basis for Australia's responsibilities under CITES is now provided by Part 13A of the EPBC Act.

The following is a brief summary of the three CITES classification levels:

CITES Appendix I: These are species threatened with extinction that are, or may be, affected by trade. These species attract the strictest controls. Among the marine species listed are great whales and all sea turtles.

CITES Appendix II: These are species that, although not threatened with extinction now, might become so unless trade in them is strictly controlled and monitored. CITES Appendix II also includes some non-threatened species, in order to prevent threatened species from being traded under the guise of non-threatened species that are similar in appearance. Examples include great white sharks and humphead maori wrasse.

CITES Appendix III: These are species that any CITES Party identifies as being subject to regulation within its jurisdiction for the purpose of preventing or restricting exploitation and that require the cooperation of other countries for the control of trade.

Marine taxa currently listed in the CITES Appendices and which are known to interact with Commonwealth-managed fisheries are detailed in Table 1.10.

Marine turtle PHOTO: MIKE GERNER, AFMA

TABLE 1.10 Marine taxa listed under CITES Appendices which are known to interact with Commonwealth fisheries

Common name	Scientific name	CITES Appendix listing
Dugong	*Dugong dugon*	I
Sawfish	Family Pristidae: Genera in this family include *Anoxypristis* and *Pristis* * except *Pristis microdon* that is currently listed in Appendix II, for the exclusive purpose of allowing international trade in live animals to appropriate and acceptable aquaria for primarily conservation purposes	I
Sea turtles	Family Cheloniidae	I
Whales, porpoises, and dolphins	Order Cetacea	I
Black coral	Order Antipatharia	II
Blue corals, Indo-Pacific	Family Helioporidae	II
Fire corals	Family Milleporidae	II
Giant clams	Family Tridacnidae	II
Great white shark	*Carcharodon carcharias*	II
Humphead (maori) wrasse	*Cheilinus undulatus*	II
Seahorses	Genus *Hippocampus*	II
Southern elephant seal	*Mirounga leonina*	II
Southern fur seals	*Arctocephalus* spp.	II
Stony corals	Order Scleractinia	II
Whale shark	*Rhincodon typus*	II

CITIES = Convention on International Trade in Endangered Species of Wild Fauna and Flora

In 2010 the fifteenth Conference of CITES considered a number of marine species for listing. However, the meeting closed without agreement on any listed proposal to protect marine species. Proposals to include four shark species—the scalloped hammerhead, oceanic whitetip, porbeagle and spiny dogfish—in CITES Appendix II were rejected. These species, which are of great commercial value, can therefore continue to be traded without CITES permits.

United Nations Fish Stocks Agreement (UNFSA)

UNFSA establishes a set of rights and obligations for states to conserve and manage fish stocks, associated and dependent species, as well as to protect biodiversity in the marine environment. It sets out mechanisms for international cooperation, and identifies Regional Fisheries Management Organisations (RFMOs) as the mechanism through which States can fulfil their obligations to manage and conserve the stocks. There is a clear linkage between RFMOs and UNFSA (see Chapter 21 for further details).

Bycatch and discarding

The effective implementation of bycatch legislation and policy has been a challenge in the past, and significant opportunities for improvements remain. Identifying environmental management priorities and gaining support for necessary action in the context of other management imperatives will remain a key challenge for both managers and policy makers in the future. The move to an ecosystem-based approach to fisheries management followed the release and adoption of the 1992 *National Strategy for Ecologically Sustainable Development* by all levels of the Australian Government. It is expected that annual assessments of the environmental performance of fisheries will help stakeholders identify where significant progress is being made and where improvements are needed.

A bycatch species is one that is (a) incidentally taken in a fishery and returned

to the sea, or (b) incidentally affected by interacting with fishing equipment in the fishery but not taken. The *Commonwealth Policy on Fisheries Bycatch* (DAFF 2000) recognises that there will be different ways of addressing bycatch issues in different fisheries. Fishery-specific bycatch action plans and, more recently, bycatch and discard workplans, are needed.

Section 17 6(D) of the FMA states that a plan of management for a fishery must contain measures directed at reducing to a minimum:

- the incidental catch of fish not taken under and in accordance with that plan
- the incidental catch of other species.

In accordance with the FMA and government policy, all fishery management plans require the development and implementation of bycatch action plans (BAPs) to ensure that bycatch is reduced to a minimum. While wording differences exist between some fishery management plans, they generally require that BAPs are developed to ensure that:

- information is gathered about the impact of the fishery on bycatch species
- bycatch (excluding protected species) is reduced to, or kept at, a minimum and below a level that might threaten bycatch species
- all reasonable steps are taken to minimise interactions with species listed under Part 13 of the EPBC Act, which include seabirds, marine reptiles, marine mammals and some sharks and bony fish
- the ecological impacts of fishing operations on habitats in the area of the fishery are minimised and kept at an acceptable level.

In 2007 AFMA established a bycatch and discarding program (AFMA 2008a) to provide additional resources and direction for policy and legislative objectives in this area. The program's initial direction has been to mitigate impacts on high-risk and TEP species, and also to reduce discarding of target and quota species 'as far as is practically possible'. A key feature of the program is the development of annual bycatch and discard workplans. The workplan approach is supported by dedicated resources and aims to work more closely with industry and other stakeholders than previous approaches. A more targeted, open and transparent process will greatly assist the development and maintenance of baseline data and the identification of information gaps.

Ecological risk assessment

In the early 2000s, AFMA implemented an ecological risk management (ERM) framework as a key component of its ecosystem-based approach to fisheries management. This approach considers the impact of fisheries on the broader marine environment, not just target species. The ERM framework is informed by the results of ecological risk assessments (ERAs), which consider the direct and indirect impacts of a fishery on all aspects of a marine ecosystem. The intent of the ERAs is to facilitate the sustainable and efficient management of Commonwealth fisheries by helping to identify research priorities, needs for data collection and monitoring, and management priorities for fisheries.

Defining what constitutes 'high-risk' species and determining which species are at risk has been the focus of a joint AFMA and CSIRO project to conduct ERAs on Commonwealth fisheries. The research aims to identify the risk that fisheries pose to target and non-target species and ecosystem components. The project began in the early 2000s, and the first report for a Commonwealth fishery, the GABTS of the SESSF, was released in December 2008.

In order to identify priorities for management, the ERA methodology is hierarchical, moving from a qualitative analysis to a full quantitative ERA. The impacts of fishing activities on ecological components are assessed and categorised. Low-risk activities are screened out during this process, and the higher order analyses focus on activities that were assessed as posing a greater environmental risk. The ecological components assessed are target species, bycatch and byproduct species, TEP species, habitats and communities. As a result of the ERA process, identification of key species in the fishery that require management attention is streamlined and more cost-efficient. The

process allows policies and tools to be more quickly adapted and targeted appropriately across the range of Commonwealth fisheries.

The ERA process begins by scoping the relevant fishery to establish its profile. This involves identifying background issues, objectives and activities or hazards of the fishery, which determine the parameters on which later assessments are based. Stakeholder input is required in determining each of these outputs. The ERA process is outlined in more detail below.

Level 1

After initial scoping, a Level 1 'Scale, Intensity, Consequence Analysis' (SICA) is performed. Fishery-related activities identified in scoping are qualitatively evaluated for their risk to ecological components of the fishery. Activities that may lead to significant impact on any species, habitat or community are identified for further assessment. If a particular activity is considered as having a negligible or low impact, it is screened out and not analysed further. By giving priority to higher risk activities, the ERA facilitates more efficient management of Commonwealth fisheries.

Level 2

A Level 2 'Productivity Susceptibility Analysis' (PSA) follows the SICA. It is a semiquantitative analysis that focuses on the activities identified in Level 1 that were deemed to be of moderate or greater risk to ecological components in the fishery. The PSA prioritises the ecological components in the fishery that are exposed to most risk from fishery activities. Attributes of particular species, habitats and communities are examined and used as proxies to denote their levels of productivity and susceptibility. The resulting information is then used to determine the potential risk each particular unit faces from the hazards identified. This allows research and management to be focused on particular species, habitats or communities that are at most risk from fishing activities.

A Level 2 'Residual Risk Assessment' (RRA) incorporates additional information and management arrangements that were newly introduced or not included in the initial Level 2 PSA. The RRA aims to ensure that the assessment is relevant to the dynamic status and management arrangements that govern each Commonwealth fishery.

Level 3

Level 3 of the ERA is the 'Sustainability Assessment of Fishing Effects' (SAFE). It is a fully quantitative analysis of ecological components categorised as facing moderate or greater risk in the Level 2 PSA. Indicators and reference points are used to determine fish mortality for a species, a measurement of fishing impact. This analysis quantifies the effects of fishing activities on ecological components of the fishery and allows for an accurate assessment of the status of a particular species, habitat or community, thus better informing management arrangements.

Risk assessment management reports

The final risk management reports will be used by AFMA and other agencies to develop or adjust management arrangements for Commonwealth fisheries. Both ERAs and ERM will be periodically reviewed to keep information current and accurate. Ongoing re-evaluations of the ERAs will also ensure that Commonwealth fisheries continue to be managed sustainably and in a way that is consistent with ecosystem-based fisheries management principles.

Management performance

As of June 2010, risk assessments have been completed for 13 Commonwealth fisheries/sectors to the Level 2 ERA, and 12 fisheries/sectors to Level 3. The ERA reports are being released in combination with ecological risk management reports, which identify fishery-specific priority issues for managing the ecological effects of fishing, and managing each species or group of species (AFMA 2008b). After ten years of work on the ERM framework, 15 Commonwealth fisheries have completed risk assessment reports publicly available for review (see

AFMA website: www.afma.gov.au). The outcomes and impacts of this work will be a focus of future *Fishery status reports*.

1.5 OUTLOOK

The improvement in biological stock status seen over the most recent four editions of the *Fishery status reports* is partly a result of management changes following the 2005 Ministerial Direction to AFMA to cease overfishing and recover overfished stocks. This is seen in the substantial increase in the number of stocks assessed as not overfished or not subject to overfishing since 2005. It is best exemplified by the SESSF, where there were substantial reductions in the TAC for a number of stocks following the introduction of a harvest strategy in 2005. In addition, spatial closures have halted overfishing of several stocks, including orange roughy. Some stocks will be quick to rebuild from an overfished status, while others, such as orange roughy and gulper sharks, will take many years or even decades to recover.

Substantial efforts have been made, and continue to be made, to develop and improve harvest strategies for Commonwealth-managed fisheries, particularly for stocks for which there is poor or little information. An unresolved problem is the setting of a single fishery-wide TAC for a species when the fishery exploits more than one stock. In the SESSF, this problem previously resulted in pink ling being classified as subject to overfishing due to high fishing mortality of the eastern stock, which was depleted to below target biomass levels, while the western stock was not subject to overfishing. AFMA should consider separating stocks based on the biology of the species where the risk to the sustainability of the stock is considered high. If this were to occur, stocks such as blue warehou, jackass morwong and pink ling would be split into multiple management units (typically east and west of Tasmania).

The level of fishing effort has fallen in most Commonwealth fisheries over the past several years. This appears to be due to economic and business conditions, such as currency exchange rates, costs of labour and fuel, prices obtained for product and competition from imported product. In some fisheries, the removal of effort through the structural adjustment component of the Australian Government's *Securing our Fishing Future* package is likely to have had a substantial impact on the recovery of some fish stocks. Several smaller fisheries had zero, or close to zero, effort and catch in 2009, resulting in those stocks being assessed as 'not subject to overfishing'.

Like most maritime countries, Australia faces many challenges in managing its fisheries resources, despite being recognised internationally for the sound management practices generally employed. The 2005 Ministerial Direction, structural adjustment package and harvest strategies are likely to continue to improve management performance, with the combined impact of these programs becoming further apparent in coming years. The Australian Government's commitment to reducing uncertainty in Commonwealth-managed fisheries, through the implementation of the RUSS project, will continue to provide additional assurance to the fishing industry and the broader community that most fish stocks are being sustainably and efficiently managed.

Seabirds following trawler
PHOTO: MIKE GERNER, AFMA

1.6 LITERATURE CITED

AAD (Australian Antarctic Division) 2006, *Threat Abatement Plan, for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations*, AAD, Kingston, Tasmania.

ABARE (Australian Bureau of Australian Agricultural and Resource Economics) 2009, *Australian fisheries statistics 2008*, ABARE, Canberra.

ABS (Australian Bureau of Statistics) 2007, *2006 census of population and housing: industry of employment*, cat. no. 20680 (2006 census tables), ABS, Canberra.

——2009, *Labour force, Australia, detailed,* electronic delivery, cat. no. 6291.0, ABS, Canberra.

AFMA (Australian Fishery Management Authority) 2008a, *AFMA's program for addressing bycatch and discarding in Commonwealth fisheries: an implementation strategy*, AFMA, Canberra.

——2008b, *Ecological risk management report for the Great Australian Bight Trawl sub-fishery of the Southern and Eastern Scalefish and Shark Fishery*, AFMA, Canberra.

Commonwealth of Australia 2006, *Energy grants credit scheme*, Australian Government, Canberra.

DAFF (Australian Government Department of Agriculture, Fisheries and Forestry) 2000, *Commonwealth Policy on Fisheries Bycatch*, DAFF, Canberra.

——2007, *Commonwealth Fisheries Harvest Strategy: policy and guidelines*, DAFF, Canberra.

DEWHA (Department of the Environment, Water, Heritage and the Arts) 2009, *Threat Abatement Plan for the impacts of marine debris on vertebrate marine life*, DEWHA, Canberra.

EA (Environment Australia) 2003, *Recovery Plan for Marine Turtles in Australia*, Environment Australia, Canberra.

FRDC (Fisheries Research and Development Corporation) 2004, *Annual report 2003–04*, FRDC, Canberra.

Gooday, P 2004, *Economic aspects of fisheries policy*, ABARE report 04.18, prepared for DAFF, Canberra.

——& Galeano, D 2003, *Fisheries management: a framework for assessing economic performance*, ABARE eReport 037, prepared for the Fisheries Resources Research Fund, ABARE, Canberra.

Hohnen, L, Wood, R, Newton, P, Jahan, N & Vieira, S 2008, *Fishery economic status report 2007*, ABARE report 08.10 prepared for the Fisheries Resources Research Fund, ABARE, Canberra.

Newton, P, Wood, R, Galeano, D, Vieira, S & Perry, R 2007, *Fishery Economic Status Report*, ABARE Report 07.19 Prepared for the Fisheries Resources Research Fund, Canberra, October.

Rose, R 2002, *Efficiency of individual transferable quotas in fisheries management*, ABARE report prepared for the Fisheries Resources Research Fund, ABARE, Canberra.

Squires, D, Kirkley, J & Tisdell, CA 1995, 'Individual transferable quotas as a fisheries management tool', *Reviews in Fisheries Science*, vol. 3, no. 2, pp.141–69.

Vieira, S, Perks, C, Mazur, K, Curtotti, R & Li, M 2010, *Impact of the structural adjustment package on the profitability of Commonwealth fisheries*, ABARE research report 10.01, Canberra.

2 Bass Strait Central Zone Scallop Fishery

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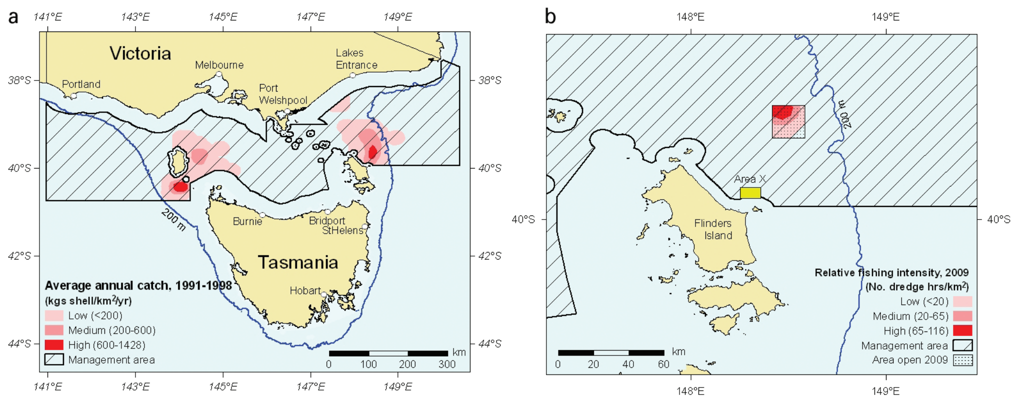


FIGURE 2.1 a) Average annual catch, 1991 to 1998, and b) relative fishing intensity, 2009, in the Bass Strait Central Zone Scallop Fishery

TABLE 2.1 Status of the Bass Strait Central Zone Scallop Fishery

Fishery status	2008		2009		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Commercial scallop (*Pecten fumatus*)					The current level of fishing would not constitute overfishing. The status of the biomass across the BSCZSF remains uncertain.
Economic status Fishery level	Fishery closed		Estimates of net economic returns not available but likely to be positive		Improved economic status can be linked to stock recovery. Low level of quota latency in 2009 suggests positive net economic returns.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING — OVERFISHED / OVERFISHING — UNCERTAIN — NOT ASSESSED

TABLE 2.2 Main features and statistics of the Bass Strait Central Zone Scallop Fishery

Feature	Description	
Key target and byproduct species	Commercial scallop (*Pecten fumatus*)	
Other byproduct species	Doughboy scallop (*Chlamys (Mimachlamys) asperrimus*)—no current market	
Fishing methods	Scallop dredge	
Primary landing ports	Victoria: Lakes Entrance, Port Welshpool, Port Fairy; Tasmania: Bridport, St Helens	
Management methods	Input controls: seasonal and area closures Output controls: TAC allocated as individual transferable quotas, discarding limit (<20% discards of small scallops)	
Management plan	*Bass Strait Central Zone Scallop Fishery Management Plan 2002* (DAFF 2002) (amended 2004)	
Harvest strategy	*Harvest Strategy for the Bass Strait Central Zone Scallop Fishery* (AFMA 2007) Target reference points: not defined Limit reference point: B_{LIM} proxy is one 'viable' area containing at least 500 t estimated biomass	
Consultative forums	Bass Strait Central Zone Scallop Fishery Management Advisory Committee (ScallopMAC), Bass Strait Central Zone Scallop Fishery Resource Assessment Group (ScallopRAG)	
Main markets	Domestic: fresh International: none currently	
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Current accreditation dated 25 May 2009 Current accreditation (Wildlife Trade Operation) expires 21 April 2013	
Ecological risk assessment	Level 1: Scale Intensity Consequence Analysis (SICA) completed on 279 species (Hobday et al. 2007) Level 2: Productivity Susceptibility Analysis (PSA) completed on 142 species (Hobday et al. 2007) Level 2: Residual Risk Assessment completed on 26 species identified as high risk in PSA (AFMA 2009a)	
Bycatch workplans	*Bass Strait Central Zone Scallop Fishery Bycatch and Discarding Work Plan*, June 2009 to 2011 (AFMA 2009b)	
Fishery statistics[a]	**2008 fishing season**	**2009 fishing season**
Fishing season	None—Fishery closed	1 June to 20 December
TAC	0 t (150 t in 2008 for surveys)	2500 t (plus 150 t for surveys)
Catch (shell weight)	82 t from surveys	2423 t
Effort	Zero	3947 dredge hours
Fishing permits	74 quota SFR holders	52 quota SFR holders
Active vessels	0 (8 participated in the survey)	26
Observer coverage	Fishery closed	3.2% of hauls 12 sea days 15 observer days during the surveys
Real gross value of production (2008–09 dollars)	Zero (survey recovered around $150 000 from sale of the catch)	$1.2 million (2008–09 financial year) $4.8 million (preliminary estimate for the 2009 fishing season)
Allocated management costs	$0.2 million (2007–08 financial year)	$0.3 million (2008–09 financial year)

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; SFR = statutory fishing right; TAC = total allowable catch

a Fishery statistics are provided by fishing season unless otherwise indicated.

2.1 BACKGROUND

The Bass Strait Central Zone Scallop Fishery (BSCZSF) targets commercial scallop (*Pecten fumatus*), using dredges to fish areas of dense aggregations (beds) (Table 2.2). The fishery covers the central Bass Strait area between the Victorian and Tasmanian scallop fisheries (generally up to 20 nautical miles (nm) from the coastline) (Fig. 2.1). Although the three fisheries are managed as separate entities, there may be a single stock in Bass Strait or at least connections between the stocks (Woodburn 1990; Haddon et al. 2006). Most fishers have access to multiple jurisdictions.

The fishery has a history of boom and bust, with the peaks (1982–83, 1994, 2003) becoming progressively smaller (Table 2.3) (Haddon et al. 2006). High catches occurred as the fleet found new beds that were then rapidly fished down. Since the 1999–2000 closure, the fishery has focused only on the eastern region of Bass Strait, where there was a single known aggregation of spawning adults. Spatial management was introduced in 2000, with this known bed being closed. However, after 2003 the catch declined rapidly, and surveys suggested that the biomass was low, recruitment was limited and there were no clear signs of recovery (Haddon et al. 2006; Harrington et al. 2009). The fishery was closed under the 2005 Ministerial Direction, with a zero total allowable catch (TAC) for three years (2006 to 2008).

Historically, the level of effort was strongly influenced by economic factors such as market prices, onshore processing capacity and fuel costs. Since 2000 economic constraints have reduced interest in fishing the western area of the fishery. This area was fished extensively during the 1990s, producing more than a third of the catch (up to 5000 t).

Scallops PHOTO: BRADLEY MILIC, AFMA

TABLE 2.3 History of the Bass Strait Central Zone Scallop Fishery

Year	Description
Early 1900s	Dredging started in the Derwent Estuary of south-eastern Tasmania. Up to 16 year-classes were reported in the fishery.
1960s	Scallop beds were found in Port Phillip Bay, Victoria. Seasonal fisheries operated in inshore waters of Tasmania and Victoria.
Late 1970s	Inshore grounds were severely depleted. Commercial fishing began in Bass Strait. Scallop beds were found off Lakes Entrance (Victoria) and northern Tasmania.
Early 1980s	Highest catches (~25 000 t shell weight across the entire Bass Strait, with an estimated 13 864 t from the BSCZSF) were recorded. Rapid increase in the number of vessels and effort, with fishing occurring throughout the year.
1986	Offshore Constitutional Settlement was signed and the BSCZSF was established with 237 operators.
Late 1980s	Seasonal closures (January–March) were introduced. BSCZSF and Tasmanian scallop fishery collapsed.
1990	BSCZSF was closed to fishing to facilitate recovery.
1995–96	GVP of the fishery peaked at $19 million (2007–08 dollars).
1996–97	Catches declined and catch limits increased. GVP fell sharply to around $10 million (2007–08 dollars).
1998	Landed catch declined by 84% from 1997 catch. BSCZSF and Tasmanian scallop fishery showed signs of severe stock depletion and depressed recruitment. GVP for 1998–99 declined to ~$2.3 million (2007–08 dollars).
1999	BSCZSF and Tasmanian scallop fishery closed.
2000	Scientific survey, covering the most productive regions of the BSCZSF, found a single bed of adult scallops near Flinders Island (Area X, Fig. 2.1b). Spatial management was introduced. BSCZSF was opened to exploratory fishing but Area X was closed.
2001–02	All areas in BSCZSF were opened to exploratory fishing, except for Area X. No substantial aggregations of commercial-size scallops were located.
2003	Northern parts of the closed area were opened to fishing, with the TAC set at 5000 t. Effort and catch increased to the highest level since 1998 (~5600 dredge hours and 1453 t shell weight). GVP for 2002–03 was lower than historical averages, at around $0.8 million (2007–08 dollars).
2004	BSCZSF Management Plan came into effect, with 154 vessel SFRs held by 103 holders, and transferable quota SFRs were granted. TAC was set at 2000 t for the season; the catch was only 414 t.
2005	Minimum size was increased to 90 mm shell length. GVP of the fishery remained low (2005–06 GVP was $0.2 million in 2007–08 dollars). Western region was closed to fishing except under scientific permits.
2006	A zero TAC was implemented for three years in line with the 2005 Ministerial Direction. The Australian Government structural adjustment package removed 22 of the 152 concessions (vessel and/or quota SFR packages).
2007	Harvest strategy was adopted by AFMA. Vessel SFRs ceased to exist, and participants only require quota SFRs to fish.
2008	Surveys in the eastern region of the BSCZSF located two viable beds (referred to as the western and eastern beds).
2009	Fishery reopened and harvest strategy was implemented. The western region remained closed to fishing. In the eastern region a commercial TAC was set at 2500 t, with a restricted area (initially 7.5 nm × 10 nm) of the eastern bed open to fishing. Midseason, following an industry request, northern boundary of the fishery was moved 1.5 nm north to maintain high catch rates. Surveys were conducted in eastern and western regions—two new beds were found in the eastern region; no beds were detected in the western region.

AFMA = Australian Fisheries Management Authority; BSCZSF = Bass Strait Central Zone Scallop Fishery; GVP = gross value of production; SFR = statutory fishing right; TAC = total allowable catch

SOURCES: Fairbridge (1953); Sahlqvist (2005); Haddon et al. (2006); Harrington et al. (2009).

2.2 HARVEST STRATEGY

The BSCZSF harvest strategy (HS) uses a spatial management approach in which most of the fishery remains closed while specific areas are opened. Elements of the strategy include the following:

- Surveys, focused on areas known to contain historically fished beds, are used to estimate the biomass and determine areas of high density that have the potential to be fished ('viable' areas). Exploratory fishing may be permitted in other areas to allow the discovery of new beds.
- A TAC is set for the whole fishery. This is the estimated biomass in the beds to be opened to fishing.
- The default fishing season is 1 June to 31 December, subject to review on the basis of survey results.
- Any area to be opened has a maximum discard rate (20% of catch below the minimum size, 90 mm shell length).
- The fishery will remain closed unless the surveys indicate that the following conditions can be met:
  - At least two viable areas (5 nm × 5 nm) are available; 'viable' is defined in terms of scallop size, discard rate and density.
  - At least 40% of viable areas, containing a total biomass of at least 500 t, remain closed to fishing at all times.

Scallop PHOTO: BRADLEY MILIC, AFMA

- When multiple viable areas are available, they will be opened on a rotational or staged basis.
- The HS rules apply separately to the eastern and western regions of the fishery.
- A default TAC of 100 t applies to doughboy scallops.

2.3 THE 2009 FISHERY

Key target and byproduct species

The western region of the fishery remained closed in 2009. A commercial TAC of 2500 t was set for the eastern region. The only area open to fishing was part of the eastern bed (Fig. 2.1) identified in the 2008 survey (7.5 nm × 10 nm), with an option to extend the northern boundary if catch rates dropped below economically viable levels. The size of the area opened was estimated to contain a biomass equivalent to the TAC (ScallopRAG 2009a). The rest of the eastern region was closed to fishing, and the remaining part of the eastern bed and the western bed were closed to navigation, to provide additional protection.

Twenty-six vessels fished in 2009 and, by September, industry was reporting declines in catch rates—by this time, 1508 t of scallop had been landed (ScallopRAG 2009b). Although catch rates had declined throughout the fishing season to a point where industry regarded them as being uneconomical, they remained higher than what had been assumed to be viable (Harrington et al. 2009; ScallopRAG 2009b). This was attributed to the distance from ports and the narrow weather windows that limited fishing time. The northern boundary was moved 1.5 nm north (on 21 September), and catch rates improved (ScallopRAG 2009b). Industry agreed to fish only within the first nautical mile and self-manage the opening of the remaining 0.5 nm, if the quota could not be caught within the open area. The remaining 0.5 nm was opened to fishing in early December 2009.

There was substantial quota trading within the season, with 15 operators holding 80% of the quota by the end of the season.

The number of operators holding the base level of quota (≤19.23 t) had dropped from 48 to 5 through the season (ScallopRAG 2009b). The size and quality of the scallops was regarded as high, and the catch had an estimated gross value of production (GVP) of $4.8 million in the 2009 fishing season (Fig. 2.2). Nearly all product went to domestic markets. Operators reported that the beach price was reasonably steady for the season (ScallopRAG 2009b). Processors indicated that they were unlikely to develop overseas markets unless the TAC was significantly larger.

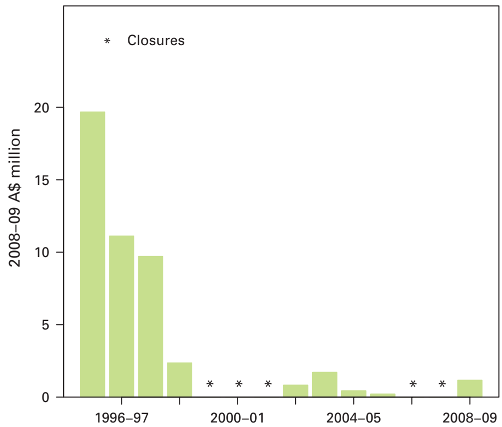


FIGURE 2.2 Gross value of production (GVP) of the BSCZSF, 1995–96 to 2008–09

Minor byproduct species

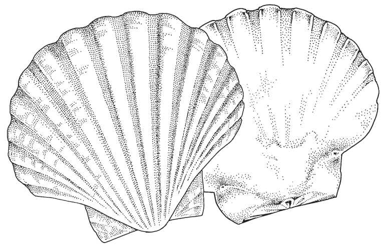
The targeted nature of the fishing, on high density scallop beds, and the limited market for byproduct results in most of the retained catch being the target species. In 2009 a TAC of 100 t for doughboy scallops was set in line with the HS, but none were reported landed or discarded. A total of 12 t of flathead (*Neoplatycephalus richardsoni*) was landed.

Scallop PHOTO: MIKE GERNER, AFMA

2.4 BIOLOGICAL STATUS

COMMERCIAL SCALLOP

(*Pecten fumatus*)



LINE DRAWING: FAO

TABLE 2.4 Biology of commercial scallop

Parameter	Description
Range	**Species:** From central New South Wales south to Tasmania and west to the South Australia – Western Australia border. Patchily distributed on sandy to muddy sediments. **Stock:** Current management treats scallops in the area of the BSCZSF as a single stock. However, there may be structuring within the BSCZSF and connections with the stocks in the Tasmanian and Victorian fisheries, research is underway to examine this issue.
Depth	7–80 m
Longevity	5–9 years (reported to 16 years)
Maturity (50%)	**Age:** 2 years **Size:** ~80 mm shell length, although growth is variable in different areas
Spawning season	August–January. Spat settlement is variable but peaks in mid-October to January.
Size	**Maximum:** 140 mm shell height (narrower shell diameter) **Recruitment into the fishery:** Small scallops may be exposed to fishing within the first three years of life; however, the management approach of not opening areas with >20% discard rate of scallops with <90 mm shell length means that most should recruit into the fishery at 90 mm shell length.

BSCZSF = Bass Strait Central Zone Scallop Fishery

SOURCES: Fairbridge (1953); Woodburn (1990); Young et al. (1999); Haddon et al. (2006).

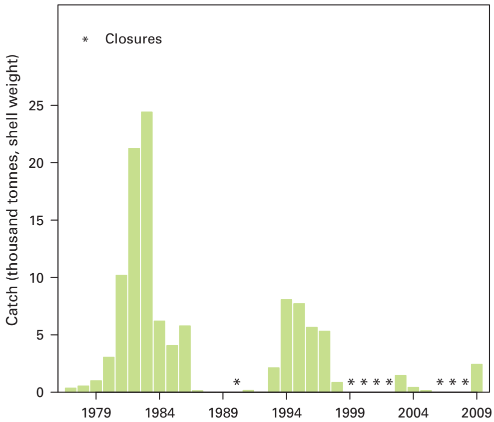


FIGURE 2.3 Commercial scallop catch history, 1977 to 2009

Stock status determination

No formal stock assessment has been undertaken for scallops within the BSCZSF—the state of the stock has been inferred from catch trends and survey data. The stock has been classified as overfished in the *Fishery status reports* since 1998. Between 2000 and 2005, low commercial catches (Fig. 2.3) and the surveys of the historic fishing grounds in the eastern region indicated that the stock was very depleted and recruitment was low (reviewed in Haddon et al. 2006).

Eastern region

The 2008 surveys sampled areas in the eastern region that had been closed in the early 2000s, as well as other historic fishing grounds (Harrington et al. 2009). Very low scallop densities were found in the areas where there had previously been known beds, including those opened to fishing in 2003 and those protected by closures in the early 2000s. The disappearance of the protected beds may be due to their age (approximately seven years; Harrington et al. 2009). However, the areas of the closure that had been fished in 2003 also showed no signs of recruitment.

Two new areas with higher densities of scallops were found in the eastern region, north-east of Flinders Island, to the north of the previously known beds (Area X). These areas had not been surveyed between 2000 and 2005 but were historically fished. In the eastern region, Harrington et al. (2009) identified a western bed and an eastern bed. Both had areas of high density, where the catch rates (28.6–56.5 kg shell weight per 1000 m^2 tow) were considered commercially viable. This rate is estimated as equivalent to a commercial catch rate of 0.343–0.678 t shell weight per hour. The beds appear to contain predominantly a single cohort (3+ and 4+ years), although a second, smaller cohort was apparent in the western bed. The discard rates in the western bed and south part of the eastern bed were less than 20% (Harrington et al. 2009).

Harrington et al. (2009) estimated the average total biomass in the two beds as 4798 t shell weight (assuming 100% dredge efficiency) or 14 542 t shell weight (assuming 33% dredge efficiency). The results suggested that there has been some recovery of biomass in the eastern region.

Two surveys of the eastern region were conducted in October and November 2009 and focused on the known western and eastern beds (identified in the 2008 survey) and data poor regions (Harrington & Semmens 2010). The density of scallops in the unfished areas of the known beds was similar to the 2008 survey. In the areas fished in 2009, there were lower densities of scallops remaining (Harrington & Semmens 2010).

Three new areas of high-density scallops were located—a new bed to the north of the western bed (scallop size range: 80–114 mm), an area that appears to be a commercial extension of the eastern bed (scallop size range: 80–114 mm), and an area north of Babel Island. The latter is in the region of the bed identified in 2005 (referred to as Area 4X, Haddon et al. 2006) and contained high densities of small scallops, 44–62 mm (Harrington & Semmens 2010).

No updated estimate of biomass is available from the 2009 survey, as this was not the aim of the survey. Biomass estimates were generated for areas within the eastern bed, including those closed and open to fishing in 2009. On the basis of these biomass estimates the resource assessment group (RAG) recommended a TAC of 3000 t (plus

150 t for research surveys) for the 2010 fishing season and an open area of 15 nm x 3 nm (ScallopRAG 2009b). The open area would be managed with sequential openings of strips, initially 1.5 nm wide, then 0.5 nm strips (AFMA 2010). The area to be opened in 2010 overlaps with the area opened in the latter part of 2009, as the 2009 survey suggested there were still substantial densities of scallops in these areas.

Western region

A survey conducted in September 2009 focused on historic fishing grounds in the western region (around King Island) (Harrington & Semmens 2010). No viable scallop beds were identified in the western region.

Overall stock status

The stock is assessed as **not subject to overfishing**. This is based on the precautionary implementation of the HS in 2009. The western region remained closed to fishing, and only a restricted area of the eastern bed was opened.

The status of the stock across the BSCZSF remains **uncertain** in terms of whether it is overfished. It is clear the stock was overfished with the biomass significantly reduced by 2005, fewer cohorts in the fishery and impacts on recruitment. Although there is some recovery in the eastern region, no recovery has been detected in the western region (Harrington & Semmens 2010), which remains closed to fishing. The extent of recovery across the fishery area is not yet quantifiable. The 2009 catch from the open area, the high commercial catch rates throughout the season and the fact there are still scallops in the areas opened later in the season indicate that the biomass may be closer to the higher estimates from the 2008 survey, which is a positive outcome. It is also important to note that more areas of high density have been identified in the 2009 surveys, including the area north of Babel Island with a high density of recruits. However, it is not clear that the extent of known beds and signs of recruitment are sufficient to indicate that the stock has rebuilt to a biomass which substantially reduces the risk to the stock (the limit reference point).

Reliability of the assessment/s

There is substantial uncertainty in the 2009 assessment due to the limited information available for the entire historic fishery area. The assessment is constrained by the fact that the recent surveys were not designed to provide biomass estimates, as this was not their key objective. Other key uncertainties include the connectivity among stocks in the three jurisdictions and between beds within the BSCZSF (Table 2.4), and the recruitment and recovery dynamics of beds. Research that is in progress may address these uncertainties.

Scallop catch PHOTO: BRADLEY MILIC, AFMA

Previous assessment/s

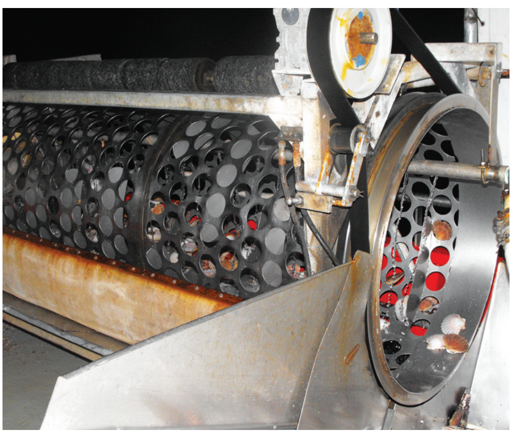
Previous assessments are described above as they are relevant to current status determination.

Future assessment needs

Biomass surveys are critical to the HS and the stock status determination, but there is no long-term strategy to ensure that these occur and provide robust estimates of biomass. Current surveys are part of a targeted research project funded by the Fisheries Research and Development Corporation and the Tasmanian Aquaculture and Fisheries Institute, which will provide information on connectivity and recovery dynamics. This information will be important in assessing the stock status and management, but the fishery needs to consider how it will obtain biomass estimates in the future.

Substantial investment has been made in compiling a historic time series of catch (Sahlquist 2005). Integration of this with the survey data and, if possible, older survey data (Young & Marin 1989) may provide appropriate benchmarks to assess recovery. This data will be used in the management strategy evaluation work currently underway.

The assessment and HS also depend on the definition of a 'viable' area for ensuring biological sustainability. Currently, little information is available on which to base the definition; the importance of self recruitment, high-density beds or particular geographic areas to recruitment is currently not understood. The current strategy assumes that all beds are equally important.



Scallop tumbler PHOTO: BRADLEY MILIC, AFMA

2.5 ECONOMIC STATUS

The former ABARE has previously surveyed the BSCZSF, most recently in 2000 for the 1997–98 and 1998–99 financial years (Galeano et al. 2001). NER were negative in both financial years. Since reopening in June 2009, little economic research has been undertaken on the fishery. However, estimates of fishing latency can provide an indication of whether fishery NER are positive or negative.

Latency

Latency in the BSCZSF was very high between 1993 and 2003 (Table 2.5). In 2003 only 29% of a TAC of 5050 t shell weight was caught. Before the fishery was closed in 1999, only 5% of available bags (management at the time included limitations on the number of scallop bags per permit) was landed (Table 2.5). This latter estimate coincides with ABARE–BRS's most recent estimate of NER for the fishery in 1998–99 when NER were negative.

Latency was low during the 2009 fishing season under the new quota management system. This suggests positive returns are now being made in the fishery. One factor behind this change is the recent *Securing our Fishing Future* structural adjustment package which removed 22 of the 152 concessions in the fishery. The main factor behind this change is the stock recovery that has occurred following the fishery's three year closure. It resulted in higher stock levels and catch rates so that positive NER could be earned from operating in the fishery. As a result, operators now have an incentive to meet their quota entitlements and acquire additional quota through trade. The latter is confirmed through the high amounts of quota trade that occurred in the 2009 fishing season.

TABLE 2.5 Historical latent effort in the Bass Strait Central Zone Fishery

Year	Active vessels	Catch (bags)	Total allowable catch (bags)	Catch in shell weight (tonnes)	Total allowable catch (tonnes)	Latency (%)
1993	n.a.	39 475	418 500	2128	–	91
1994	n.a.	149 588	441 750	8063	–	66
1995	n.a.	139 265	279 000	7711	–	50
1996	81	99 276	271 250	5642	–	63
1997	69	105 829	271 250	5313	–	61
1998	38	14 915	271 250	848	–	95
1999	Closed.					
2000	Fishery reopened, but major beds closed.					
2001	Major beds remained closed.					
2002	Major beds remained closed.					
2003	36	22 354	n.a.	1453	5050	71
2004	14	n.a.	n.a.	415	2000	79
2005	12	n.a.	n.a.	142	1000	86
2006–2008	Closed.					
2009	26	n.a.	n.a.	2404	2500	3.8

– = not applicable; n.a. = not available

SOURCE: Perdrau & Lynch (2004).

Overall economic performance

ABARE's previous survey estimates for the fishery revealed that NER were low and there were high amounts of latent fishing rights. The fishery had been particularly susceptible to effort rising and falling quickly as abundance and market conditions changed because many operators also held endorsements to fish in state waters. Consequently, substantial capital and expertise could be switched quickly from other fisheries to the BSCZSF.

In 2009 the fishery caught 96.2% of the TAC. There was also substantial trading of quota during the season, with quota rights consolidating to relatively few operators, a low number of active vessels and relatively stable beach prices (ScallopRAG 2009b). These factors indicate that the economic conditions in the 2009 fishing season were positive and the fishery's economic status has improved substantially when compared to previous years. Whether the fishery achieved MEY is difficult to assess given the lack of recent economic data on the fishery.

Future considerations

The fishery's HS is strongly linked to economic aspects of the fishery. The 2009 and 2010 TACs, although not based on an economic assessment, have been set at levels thought to be appropriate for maximising economic returns (ScallopRAG 2009b). Management within the season, to open additional areas, was also driven by economic factors with the openings based on industrys' indication that catch rates had become uneconomic in the areas initially opened (ScallopRAG 2009b). The ScallopRAG has identified the collection and inclusion of better economic information as a priority for the review of the HS. This will help ensure that the HS is better able to improve the economic performance of the fishery for the benefit of the Australian community.

2.6 ENVIRONMENTAL STATUS

Surveys in the BSCZSF have collected bycatch data, which contributed to the recently released BSCZSF Bycatch and Discarding Work Plan (AFMA 2009b). The current management approach, with the majority of the fishery closed, means that direct impacts are restricted to the limited open area. Several marine protected areas are located within the BSCZSF; one of these—the Beagle Commonwealth Marine Reserve—closed historic scallop fishing grounds.

Ecological risk assessment

An ecological risk assessment based on the AFMA/CSIRO methodology—Ecological Risk Assessment (ERA) of the Effects of Fishing (Hobday et al. 2007)—was initiated in 2002; 279 species were assessed at Level 1 (Scale Intensity Consequence Analysis). All protected species were excluded from the process at Level 1 due to the very low chance of interaction with the fishery. Of the 142 species assessed at Level 2 (Productivity Susceptibility Analysis), the target species and 25 bycatch species were categorised as high risk (some because of a lack of data). Twenty-eight habitats were also assessed, none were categorised as high risk. The Residual Risk Assessment, which takes into account management measures, suggests that only four taxa may be at high risk: a bivalve, a crab, a sea star and an octopus (AFMA 2009a, c).

Threatened, endangered and protected species

Due to the targeted nature of the fishing and gear, it is highly unlikely there are interactions with threatened, endangered and protected species (Hobday et al. 2007).

Benthic habitats

Haddon et al. (2006) suggest that the habitat impacts from scallop dredges are low at the scale of the fishery, as fishers target areas of high scallop abundance for higher economic return because this reduces the time required to sort catches. The current management approach, with only a restricted area open to fishing, also means that most areas will not be fished in a season. Haddon et al. (2006) were unable to detect a habitat impact. They suggest

Scallop vessel PHOTO: BRADLEY MILIC, AFMA

Scallop dredge PHOTO: MIKE GERNER, AFMA

that this may be due to the naturally dynamic habitat in the region as a result of large tidal currents and heavy seas, or the level of fishing being below that required to adversely impact the habitat.

2.7 HARVEST STRATEGY PERFORMANCE

The 2009 fishing season was the first year of implementation of the HS. The spatial management approach, with most of the fishery closed and selected areas (with estimates of biomass) open, has the potential to result in a biologically sustainable and economically viable fishery. The separate application of the control rules to the eastern and western regions is precautionary, given the lack of information from the west. Retention of the discarding rate rule (with the associated minimum size) and seasonal closures (to protect new recruits) are likely to contribute to the biological sustainability of the stock and improve the value of harvested scallops.

The precautionary manner in which the HS has been implemented in 2009 is warranted, given the previous stock collapses and the uncertainty in stock status. In 2009 and 2010 the economic constraints of the limited domestic market also provide for a precautionary approach to the TAC.

While the current implementation of the HS is in line with the objectives of the *Commonwealth Fisheries Harvest Strategy Policy* (HSP), it has not been demonstrated that the harvest control rules and reference points will ensure long-term biological sustainability or maximise economic returns. If the market situation changed, it is unclear how the HS would perform.

The key issues with the current HS are:

- The closure of at least 40% of 'viable' areas may be an appropriate proxy at high biomass levels, but under this approach, if the biomass in the fishery decreases, the absolute amount of biomass protected by area closures decreases, until the 'limit' is reached and the entire fishery is closed. This approach appears unlikely to facilitate rebuilding.
- The B_{LIM} proxy does not appear sufficiently precautionary or in line with the HSP objectives. The proxy allows the fishery to be fished down to very low levels (a single 5 nm ×5 nm area or estimated 500 t), limiting the potential for recovery. Although a more conservative approach has been taken in implementing the HS in 2009 and 2010, there may be significant pressure to move towards a higher TAC in different economic conditions. ScallopRAG (February 2009) noted that there was no solid scientific basis for the limit of 500 t, and recommended a review of the appropriateness of this limit. At this biomass level or spatial scale, the lack of sufficient beds of dense aggregations of adults is likely to result in recruitment overfishing before the proxy is reached. There are previous indications of depressed recruitment in the fishery, and a review

Scallop processing PHOTO: BRADLEY MILIC, AFMA

of studies of the relationship between spawning stock and recruitment in scallops suggests that pulses of recruitment are less frequent when the spawning stock biomass is low (Orensanz et al. 2006).

- Given the lack of understanding about connectivity and the relationship between density of beds, biomass and recruitment, the definition of 'viable' areas needs further evaluation, and more precaution should be shown in the limit reference point to reflect the uncertainty.
- The surveys and biomass estimates are fundamental to the decision rules. Therefore, the HS should include the survey requirements, the estimation methods, the level of precision required and how uncertainty will be taken into account in the control rules.
- The HS is not explicit about how economic factors are to be incorporated or the economic indicators to be used.

The current review of the HS should address these critical issues and ensure that the strategy meets the HSP objectives. Management strategy evaluation is being undertaken as part of the Reducing Uncertainty in Stock Status project, which should examine how the strategy will perform under different scenarios for connectivity, biomass and the spatial distribution of fishing effort.

2.8 LITERATURE CITED

AFMA (Australian Fisheries Management Authority) 2007, *Harvest Strategy for the Bass Strait Central Zone Scallop Fishery*, AFMA, Canberra.

——2009a, *Residual risk assessment of the level 2 ecological risk assessment species results*, report for the Bass Strait Central Zone Scallop Fishery, AFMA, Canberra.

——2009b, *Bass Strait Central Zone Scallop Fishery Bycatch and Discarding Workplan 1 June 2009 to 31 May 2011*, AFMA, Canberra.

——2009c, *Ecological risk management, report for the Bass Strait Central Zone Scallop Fishery November 2009*, AFMA, Canberra.

——2010, *Bass Strait Central Zone Scallop Fishery Management Arrangements Booklet, 2010*, AFMA, Canberra.

DAFF (Department of Agriculture, Fisheries and Forestry) 2002, *Bass Strait Central Zone Scallop Fishery Management Plan 2002* (amended 2004), Federal Register of Legislative Instruments F2005B01047.

Fairbridge, WS 1953, 'A population study of the Tasmanian 'commercial' scallop, *Notovola meridonalis* (TATE) (Lamellibranchiata, Pectinidae)', *Australian Journal of Marine and Freshwater Research*, vol. 4, pp. 1–40.

Galeano, D, Johnson, C, Levantis, C & Shafron, W 2001, *Australian fisheries surveys report 2000*, ABARE, Canberra.

Haddon, M, Harrington, JJ & Semmens, JM 2006, *Juvenile scallop discard rates and bed dynamics: testing the management rules for scallops in Bass Strait*, report to the FRDC, Canberra.

Harrington, J & Semmens, J 2010, *Bass Strait Central Zone Scallop Fishery 2009 scallop survey report*, report to the FRDC & AFMA, Canberra.

——Semmens, J & Haddon, M 2009, *2008 Commonwealth Bass Strait Central Zone Scallop Fishery survey*, report to the FRDC, Canberra.

Hobday, AJ, Dowdney, J, Bulman, C, Sporcic, M, Fuller, M, Goodspeed, M & Hutchinson, E 2007, *Ecological risk assessment for the effects of fishing: Bass Strait Central Zone Scallop Sub-Fishery*, report for the AFMA, Canberra.

Sorting scallops PHOTO: BRADLEY MILIC, AFMA

Orensanz, JM, Parma, AM, Turk, T & Valero, J 2006, 'Dynamics, assessment and management of exploited natural populations', in SE Shumway & GJ Parsons (eds), *Scallops: biology, ecology and aquaculture*, 2nd edn, Elsevier, Amsterdam, pp. 765–868.

Perdrau, MG & Lynch, AW 2004, *Bass Strait Central Zone Scallop Fishery data summary 2003*, Logbook Program, AFMA, Canberra.

Sahlquist, P 2005, *Consolidation of historic information for assessment of the Bass Strait Central Zone Scallop Fishery,* final report to the AFMA, project no. R02/1087, Canberra.

ScallopRAG (Resource Assessment Group) 2009a, Special meeting of ScallopRAG, 9 September 2009, minutes, AFMA, Canberra.

——2009b, 16th meeting of ScallopRAG, Melbourne, 17 December 2009, minutes, AFMA, Canberra.

Woodburn, L 1990, 'Genetic variation in the southern Australasian Pecten', in MLC Dredge, WF Zacharin & LM Joll (eds), *Proceedings of the Australasian scallop workshop*, Tasmanian Government Printer, Hobart, pp. 226–40.

Young, PC & Martin, RB 1989, 'The scallop fisheries of Australia and their management', *Reviews in Aquatic Sciences*, vol. 1, pp. 615–38.

——West GJ, McLoughlin, RJ & Martin, RB 1999, 'Reproduction of the commercial scallop, *Pecten fumatus,* Reeve, 1852 in Bass Strait, Australia', *Marine and Freshwater Research* vol. 50, pp. 417–25.

3 Coral Sea Fishery

J Woodhams, M Chambers and T Pham

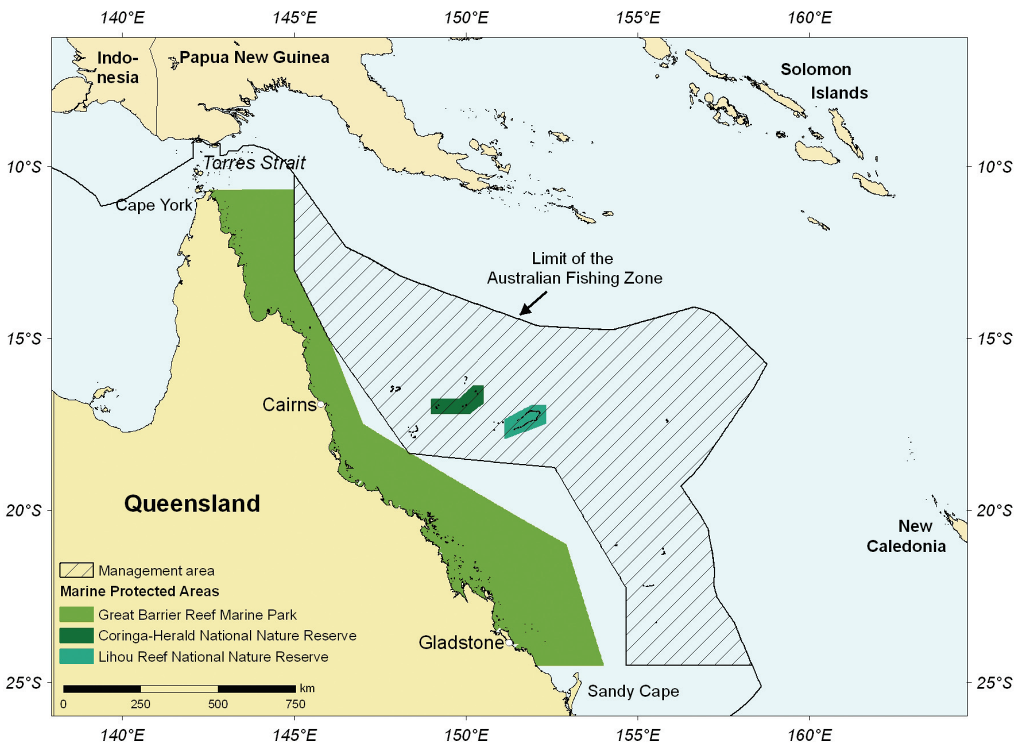


FIGURE 3.1 Area of the Coral Sea Fishery

TABLE 3.1 Status of the Coral Sea Fishery

Fishery status	2008		2009		Comments
Biological status	**Overfishing**	**Overfished**	**Overfishing**	**Overfished**	
Black teatfish (*Holothuria whitmaei*)					No current assessment with which to assess biomass.
Prickly redfish (*Thelenota ananas*)					No current assessment with which to assess biomass.
Sandfish (*Holothuria scabra*)					No take of sandfish in 2008–09. No current assessment with which to assess biomass.
Surf redfish (*Actinopyga mauritiana*)					No take of surf redfish in 2008–09. No current assessment with which to assess biomass.
White teatfish (*Holothuria fuscogilva*)					No current assessment with which to assess biomass.
Other sea cucumber species (~11 species)					Minimal take of other species in 2008–09 season. No current assessment with which to assess biomass.
Aquarium Sector (>500 species)					No current assessment with which to assess biomass.
Tropical rock lobster (*Panulirus ornatus*)					No take of lobster in 2008–09. Historic catch less than plausible sustainable yield.
Trochus (*Trochus niloticus, Tectus pyramis*)					No take of trochus in 2008–09. Historic catch negligible and likely to be less than plausible sustainable yield.
Line and Trap Sector (numerous species)					No current assessment with which to assess biomass.
Trawl and Trap Sector (numerous species)					No fishing in this sector in the 2008–09 season. No current assessment with which to assess biomass.
Economic status Fishery level	Estimates of net economic returns not available				Economic status uncertain. Gross value of production (excluding Aquarium Sector) fell by 71% in 2008–09, following a decrease in volume of production.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING OVERFISHED / OVERFISHING UNCERTAIN NOT ASSESSED

TABLE 3.2 Main features and statistics of the Coral Sea Fishery

Feature	Description
Key target and byproduct species	Sea Cucumber Sector: —black teatfish (*Holothuria whitmaei*) —white teatfish (*Holothuria fuscogilva*) —surf redfish (*Actinopyga mauritiana*) —prickly redfish (*Thelenota ananas*) —sandfish (*Holothuria scabra*) —other sea cucumber species (~11 species), including amberfish (*Thelenota anax*), hairy blackfish (*Actinopyga miliaris*), lollyfish (*Holothuria atra*), greenfish (*Stichopus chloronotus*) Aquarium Sector: >500 species—classes Chondrichthys (cartilaginous fishes) and Osteichthyes (bony fishes), as well as invertebrates and live rock Lobster and Trochus Sector: *Panulirus ornatus* and possibly *Panulirus versicolor, P. pennisiulatus; Trochus niloticus*—possibly *Tectus pyramis* Line and Trap Sector: tropical finfish and sharks (>50 species historically taken) Trawl and Trap Sector: tropical finfish and crustaceans
Other byproduct species	The line, trap and trawl operations take a wide variety of species.
Fishing methods	Hand collection (includes barbless hook and line, scoop, cast and seine nets) with or without the use of breathing apparatus, line (demersal longline, dropline and trotline), trap and trawl (finfish and crustacean)
Primary landing ports	Cairns and Bundaberg
Management methods	Input controls: limited entry, spatial closures, size limits Output controls: TAC for Sea Cucumber Sector, size restrictions, catch triggers Other: prescribed observer coverage levels, move-on provisions
Management plan	For the 2008–09 season, the guiding documentation was *Management arrangements 2008–09—Coral Sea Fishery* (AFMA 2008)
Harvest strategies	Four harvest strategies were introduced on 1 July 2008: – Hand Collection Sector: Sea Cucumber – Hand Collection Sector: Lobster and Trochus – Hand Collection Sector: Aquarium – Line, Trap and Trawl Sector Sub-Fisheries
Consultative forums	CSF stakeholder meeting(s)[a]
Main markets	Domestic: fish products—fresh, frozen; aquarium species—live International: South-East Asia—dried sea cucumber (beche-de-mer); worldwide—live aquarium species
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Current accreditation dated 19 November 2007 Current accreditation (Wildlife Trade Operation) expires 19 November 2010
Ecological risk assessment	Aquarium (hand collection) Level 1: SICA completed on around 660 species (Furlani et al. 2007a) Auto longline, Level 1: SICA completed on 194 species (Furlani et al. 2007b) Demersal longline, Level 1: SICA completed on 131 species (Furlani et al. 2007c) Demersal trawl, Level 1: SICA completed on 152 species (Furlani et al. 2007d) Finfish trap trials, Level 1: SICA completed on 225 species (Furlani et al. 2007e) Lobster and trochus, Level 1: SICA completed on 112 species (Furlani et al. 2007f) Other line, Level 1: SICA completed on 203 species (Furlani et al. 2007g) Sea cucumber, Level 1: SICA completed on 117 species (Furlani et al. 2007h) Coral Sea Fishery Qualitative Risk Analysis. Part 1: Protected (TEP) and Chondichthyan Species (unpublished: AFMA 2009a)
Bycatch workplans	Bycatch and discard workplan in development

Table 3.2 continues over the page

TABLE 3.2 Main features and statistics of the Coral Sea Fishery CONTINUED

Feature	Description	
Fishery statistics[b]	**2007–2008 fishing season**	**2008–2009 fishing season**
Fishing season	1 July 2007 to 30 June 2008	1 July 2008 to 30 June 2009
TAC	White teatfish—4 t Black teatfish—1 t Prickly redfish—20 t Sandfish—10 t Surf redfish—10 t All species combined—150 t Lobster—30 t Trochus—30 t	White teatfish—4 t Black teatfish—1 t Prickly redfish—20 t Sandfish—1 t Surf redfish—10 t Any combination of greenfish and lollyfish—10 t catch limit Any other species—10 t catch limit All species combined—150 t Lobster—30 t catch trigger Trochus—30 t catch trigger
Catch	Entire fishery (excluding Aquarium Sector) about 132 t of fish, crustaceans, molluscs and echinoderms Aquarium sector: not determined	Entire fishery (excluding Aquarium Sector) about 53 t of fish, crustaceans, molluscs and echinoderms Aquarium sector: 45 059 individual fish
Effort	Sea Cucumber: 133 dive hours Lobster and Trochus: zero Aquarium: not determined Line and Trap, and Trap and Trawl: 198 973 hooks, 11 147 trap lifts, zero trawl hours	Sea Cucumber: 138 dive hours Lobster and Trochus: zero Aquarium: not determined Line and Trap, and Trap and Trawl: 63 260 hooks, zero trap lifts, zero trawl hours
Fishing permits	18 fishing permits across the Line and Trap (9), Trawl and Trap (2), Sea Cucumber (2), Aquarium Collection (2), and Lobster and Trochus (3) sectors	18 fishing permits across the Line and Trap (9), Trawl and Trap (2), Sea Cucumber (2), Aquarium Collection (2), and Lobster and Trochus (3) sectors
Active vessels	Sea Cucumber: 1 Lobster: zero Trochus: zero Aquarium: 2 Line and Trap, and Trap and Trawl: 7	Sea Cucumber: 1 Lobster: zero Trochus: zero Aquarium: 2 Line and Trap, and Trap and Trawl: 4
Observer coverage	Sea Cucumber: zero Lobster: zero Trochus: zero Aquarium: zero Line and Trap, and Trap and Trawl: 29% (652 trap sets)	Sea Cucumber: zero Lobster: zero Trochus: zero Aquarium: zero Line and Trap, and Trap and Trawl: 100% (38 days of auto-longline fishing)
Real gross value of production (2008–09 dollars)	$0.58 million (excluding Aquarium Sector—confidential <5 vessels)	$0.17 million (excluding Aquarium Sector—confidential <5 vessels)
Allocated management costs	$0.15 million	$0.18 million

CSF = Coral Sea Fishery; EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; SICA = Scale, Intensity, Consequence Analysis; TAC = total allowable catch

a Queensland Scientific Advisory Groups also act as an information source for this fishery

b Fishery statistics are provided by fishing season unless otherwise indicated.

3.1 BACKGROUND

Fisheries existed in the Coral Sea before their integration into the current Coral Sea Fishery (CSF) (Table 3.3). These fisheries were known by various names, including the East Coast Deepwater Finfish Fishery, the East Coast Deepwater Crustacean Trawl Fishery and the North Eastern Demersal Line Fishery (Table 3.3).

The CSF is a multispecies, multigear fishery extending from Cape York to Sandy Cape, Queensland (Fig. 3.1). It is bounded on the east by the Australian Fishing Zone and on the west by a line 10–100 nautical miles (nm) east of the Great Barrier Reef (AFMA 2008).

The Sea Cucumber Sector targets a range of species which are collected by hand. There are TACs and catch triggers (Table 3.2) in place, along with move-on provisions, which

specify that the primary vessel must move at least 15 nm to a new anchorage after collecting 5 t of sea cucumber (comprising one or more species) (AFMA 2008).

The Aquarium Sector is understood to take more than 500 species (AFMA 2009b). Fish are freighted live to domestic and international markets. Catches are currently recorded in a Queensland fisheries logbook and are then reported to the Australian Fisheries Management Authority (AFMA). A data services contract is currently being negotiated between AFMA and the Queensland Government for management and reporting of the Aquarium Sector data.

Lobster and Trochus Sector permits allow the collection of lobster and trochus by hand, with or without underwater breathing apparatus. Minimum tail length of 125 mm for lobster and a size range of 80–125 mm (basal width) for trochus apply. Move-on provisions are in place for lobster and trochus. When the lobster tail catch at a location reaches 1 t, the primary vessel must move at least 15 nm to a new anchorage; for trochus, the trigger is 1.5 t. In line with the decision rules in the harvest strategy (HS), if the total catch of lobster tails or trochus reaches 30 t, a stock assessment to determine a total allowable catch (TAC) may be undertaken. If an assessment is not completed within 12 months, the lobster catch limit is unchanged; however, the trochus catch limit is reduced by one-third because of the risk of localised depletion for trochus.

The Line and Trap Sector permits allow the use of traps, demersal longlines, trotlines, droplines, setlines and handlines. If prior approval is obtained from AFMA, automatic baiting equipment can also be used. The sector is not permitted to take tuna or tuna-like species. Traps must be constructed of metal, be set and hauled individually, and include in their design a sacrificial anode to minimise the potential for ghost fishing if the trap is lost.

The Trawl and Trap Sector permits allow the use of demersal and midwater trawl gear to target a broad range of finfish and crustaceans, as well as traps. If targeting crustaceans, permit holders are currently required to have turtle excluder devices installed and operational. Traps are subject to the same conditions as for the Line and Trap Sector.

Coral Sea trawl vessel PHOTO: MIKE GERNER, AFMA

TABLE 3.3 History of the Coral Sea Fishery

Year	Description
1988	Development plans established for the East Coast Deepwater Finfish Fishery and the East Coast Deepwater Crustacean Trawl Fishery.
1991	North Eastern Demersal Line Fishery development plan commenced, forming the basis for management of the CSF for many years.
1994	Management of the East Coast Deepwater Trawl fisheries divided into northern and southern fisheries (Sandy Cape being the point of delineation), with finfish and crustacean trawl fisheries north of Sandy Cape forming part of the CSF.
1995	Management arrangements rationalised under an Offshore Constitutional Settlement between the Australian Government and the Queensland Government.
2002	Fishery split into separate sectors for line, trawl, sea cucumber, aquarium, and lobster and trochus.
2004	The first Statement of management arrangements finalised. A two-year trial for demersal traps commenced on 1 July.
2005	Rotational harvesting Memorandum of Understanding (MoU) implemented in the Sea Cucumber Sector, stipulating a rotational harvesting strategy across 21 reefs over three years. The conditions of this MoU now form part of the management arrangements for the sector.
2007	Removal of limit on the number of divers permitted under each permit in the Sea Cucumber, Lobster and Trochus, and Aquarium Sectors; however, limits on the number of tenders, move-on provisions and TACs remain.
2008	Harvest strategies implemented (1 July).
2009	Declaration of the Coral Sea Conservation Zone (May) under the EPBC Act. Commercial fishing operations were not subject to additional regulatory impacts from the declaration.

CSF = Coral Sea Fishery; MoU = memorandum of understanding; TAC = total allowable catch; EPBC Act = *Environmental Protection and Biodiversity Conservation Act 1999*

3.2 HARVEST STRATEGY

Hand collection—Sea Cucumber Sector

The HS employs TACs, spatial closures, move-on provisions and size limits. About 16 species of sea cucumber are available for harvest in the fishery—of these, five have species-specific TACs. The remaining species have catch limits (specified in permit conditions). The sector also employs a rotational harvesting regime that regulates the exploitation of 21 reefs over a three-year period.

Hand collection—Aquarium Sector

The HS regulates the level of exploitation through catch and effort triggers. Upon reaching triggers, further analysis is undertaken before expansion of the sector can occur. As a result of the large number of species harvested in the fishery (>500), the HS uses triggers for the total number of specimens harvested in a fishing season, triggers for the catch of functional groups and catch composition triggers.

Hand collection—Lobster and Trochus Sector

The HS employs catch triggers, spatial closures, move-on provisions and size limits. Catch triggers invoke increased monitoring and analysis.

Line and Trap, and Trawl and Trap Sectors

This HS employs a suite of triggers associated with total catch, total catch of high risk or vulnerable species, changes in catch composition, changes in the spatial extent of the fishery and changes in catch rate.

- Level 1 triggers are designed to detect changes in the fishery, resulting in an investigation to identify the reasons for the change. The investigation may include logbook analysis, industry consultation and a revised risk analysis. If a reasonable justification is made to explain the activation of the Level 1 trigger, the fishery may continue without additional management intervention. In the absence of an explanation, a management response may be invoked. This may include spatial closures, move-on provisions or a downward revision to the Level 2 trigger.
- Level 2 triggers require further investigation. Until the investigation is undertaken, the trigger acts as the cap to exploitation. The assessment may include obtaining age information from otoliths or shark vertebrae collected by an observer program, undertaking catch curves using age and size data, examination of CPUE trends, and examination of spatial and temporal trends in length frequency and age.

3.3 THE 2009 FISHERY (2008–09 FISHING SEASON)

Key target and byproduct species

Some sectors of the CSF benefited from the weak Australian dollar in 2008–09, especially the Aquarium Sector. The depreciation of the Australian dollar resulted in record high prices for some of the species in this sector throughout 2008–09 because a large proportion of Coral Sea species are exported overseas and traded in US dollars.

The total catch for the fishery (excluding the Aquarium Sector) in the 2008–09 fishing season was approximately 53 t (Fig. 3.2). The GVP (excluding the Aquarium Sector) for 2008–09 was estimated at $0.17 million (Fig. 3.3).

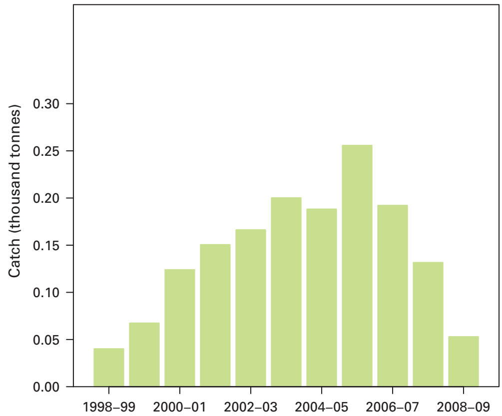


FIGURE 3.2 CSF catch history, 1998–99 to 2008–09, excluding the Aquarium Sector (tonnes)

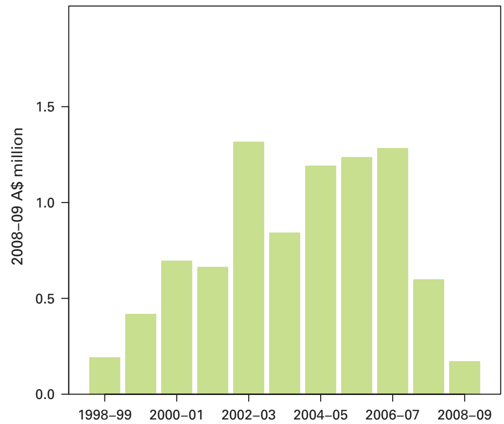


FIGURE 3.3 Real GVP for the CSF, 1998–99 to 2008–09, excluding the Aquarium Sector (2008–09 $m)

Sharks are one of the primary target species of line operations within this fishery. They may also be taken by the Aquarium Sector. Table 3.4 provides a breakdown of species taken in all sectors of the CSF combined.

Minor byproduct species

There were no designated 'target' species in the Line and Trap, and Trawl and Trap Sectors for the 2008–09 season. As such, the term 'byproduct' cannot be applied to the catch of these sectors. Although some species or species groups seem to be more consistently taken, it is not really appropriate to categorise the species caught less frequently or in smaller quantities as byproduct.

TABLE 3.4 Stocks–TACs/Triggers, catches/landings and discards in the Coral Sea Fishery (all sectors combined)

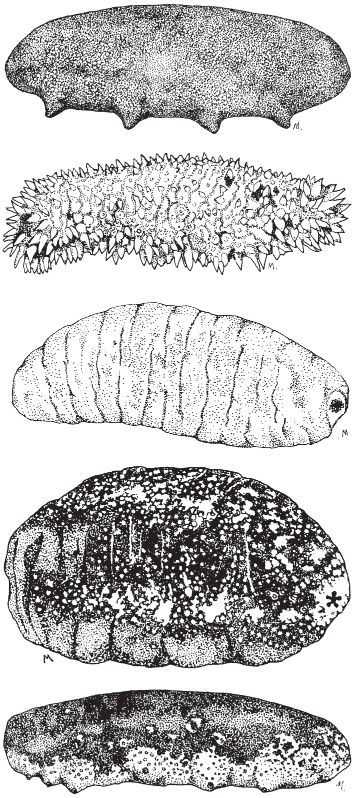
Species	TAC/ Trigger	2007–08 catch (tonnes)	2007-08 discards (number of individuals)	2008-09 catch (tonnes)	2008-09 discards (number of individuals)
Blacktip reef shark (*Carcharhinus melanopterus*)	None	13	11 090	1	910
Paddletail seabream (*Gymnocranius euanus*)	None	13	0	1	0
King snapper (*Pristipomoides filamentosus*)	None	11	0	1	0
Red emperor (*Lutjanus sebae*)	None	11	0	0	0
Redthroat emperor (*Lethrinus miniatus*)	None	6	0	0	0
Flame snapper (*Etelis coruscans*)	None	4	7	1	0
Whaler sharks (*Carcharhinus* spp.)	None	5	1 210	0	410
Tiger shark (*Galeocerdo cuvier*)	None	4	560	0	120
Snappers, other (*Lutjanus* spp.)	None	4	40	0	0
Ruby fish (*Etelis carbunculus*)	None	3	4	0	0
Rockcod, other (*Aethaloperca* spp., *Anyperodon* spp., *Epinephelus* spp.)	None	2	0	1	0
Trevally (Carangidae)	None	2	0	1	0
Scalloped hammerhead shark (*Sphyrna lewini*)	None	2	300	0	90
Bar rockcod (*Epinepbelus ergastularius*, *E. septemfasciatus*)	None	2	0	0	0
Rusty jobfish (*Aphareus rutilans*)	None	0	0	2	0
Grass emperor (*Lethrinus laticaudis*)	None	2	0	0	0
Green jobfish (*Aprion virescens*)	None	1	0	1	0
Amberjack (*Seriola dumerili*)	None	1	0	1	0
Spot-cheek emperor (*Lethrinus rubrioperculatus*)	None	2	0	0	0

NOTE: There is some discrepency between the total seasonal catch figures (Fig. 3.2) derived from catch disposal records, and the catch statistics reported in this table, derived from logbook or operational data.

3.4 BIOLOGICAL STATUS

SEA CUCUMBER SECTOR

(Various species)



LINE DRAWING: FAO

Sea cucumber PHOTO: AFMA

TABLE 3.5 Biology of sea cucumbers

Parameter	Description
General	Wide variety of species with varied life history characteristics. See Torres Strait Sea Cucumber and Trochus chapter (Chapter 18) for further details.
Range	**Species:** Most species available to this fishery have an Indo-Pacific distribution. **Stock:** The area of the fishery.
Depth	0–40+ m (varies depending on species)
Longevity	5 to ~12 years
Maturity (50%)	**Age:** Sandfish: ~2 years. Other species: not well documented. **Size:** Sandfish: ~16 cm; black teatfish: ~26 cm; white teatfish: ~32 cm; prickly redfish: ~30 cm; surf redfish: ~22 cm
Spawning season	Variability exists among species. Usually during the warmer months of the year (with the exception of black teatfish, which is understood to spawn in cooler months) and linked to lunar cycles.
Size	**Maximum:** Sandfish: ~35 cm, ~2.5 kg; black teatfish: ~56 cm, ~4.3 kg; white teatfish: ~57 cm, ~5.2 kg; prickly redfish: ~98 cm, 8 kg; surf redfish: ~35 cm, ~1 kg **Recruitment into the fishery**: a range of minimum size limits from 15 cm to 32 cm

SOURCE: FAO (1990); Conand (1993, 1998); Reichenbach (1999).

Stock status determination

No quantitative stock assessment has been carried out for this sector. The ABARE–BRS acknowledges that TACs have been set for sea cucumbers in the Coral Sea; however, no documentation that establishes the basis for the current suite of TACs has been identified. All sea cucumber stocks in the Coral Sea are therefore assessed as **uncertain if overfished** and **uncertain if subject to overfishing**. The exception is where there has been very low or no reported harvest of the stock in the 2008–09 season. In this case, sandfish, surf redfish and other sea cucumber stocks are assessed as **not subject to overfishing** (Table 3.1).

Reliability of the assessment/s

This is a data-poor fishery (Tables 3.2, 3.5), as such little certainty can be applied to stock status.

Previous assessment/s

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) (Hunter et al. 2002) analysed logbook data from 2000 and 2001 for a number of the target species. This analysis showed a decline in the catch (by weight) of the higher valued black teatfish, prickly redfish and white teatfish. Through CPUE analysis, this work determined that the catch rate of these species had declined at a number of reefs. The ABARE–BRS considers inferences about the abundance of sessile invertebrates, based on CPUE data alone to be potentially unreliable.

Future assessment needs

Quantitative analysis of sea cucumber stocks from catch and effort data alone is difficult, particularly if it is not available at a fine spatial scale. Collecting catch and effort data at the finest possible spatial scale is a high priority for this sector. This would give a clearer indication of whether serial depletion was occurring, and might provide information about the time taken for sub-populations to recover after being harvested.

The ABARE–BRS led Reducing Uncertainty in Stock Status (RUSS) project is currently exploring assessment methods for this sector, aiming to reconcile the status of these stocks.

AQUARIUM SECTOR

Stock status determination

The status of this stock is assessed as **uncertain if overfished** and **uncertain if subject to overfishing**, as there is currently no accepted mechanism to assess the impact of the fishery on the stock (Table 3.1).

Reliability of the assessment/s

Data-poor fishery, as such little certainty can be applied to stock status.

Previous assessment/s

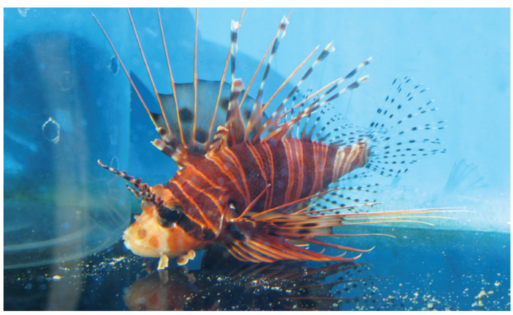
There are no stock assessments for the Aquarium Sector.

Future assessment needs

Detailed analysis of catch and effort data, accounting for location (reef) and targeting behaviour, should be undertaken. ABARE–BRS led RUSS project is currently exploring assessment methods for this sector.

Hand collection on hookah PHOTO: AFMA

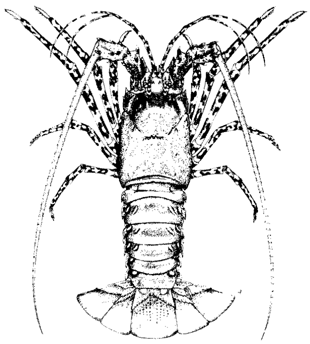
Aquarium fish trade PHOTO: JAMES WOODHAMS, ABARE–BRS



Lionfish PHOTO: AFMA

TROPICAL ROCK LOBSTER

(*Panulirus* spp.)



LINE DRAWING: FAO

TABLE 3.6 Biology of tropical rock lobster (*Panulirus ornatus*)

Parameter	Description
Range	**Species:** Widely distributed throughout the Indian and western Pacific Oceans. In Australia, they are found throughout the tropical northern waters and south to the North West Cape (Ningaloo Reef region) in the west and Sydney in the east. **Stock:** It is likely that the major source of larval recruitment for *P. ornatus* in the Coral Sea is the Gulf of Papua in the Torres Strait. This being the case, the stock most likely includes the reefs of (at least) the western Coral Sea through to Warrior Reef in the Torres Strait and north to the Gulf of Papua (Papua New Guidea) (see Chapter 16 Torres Strait Tropical Rock Lobster Fishery).
Depth	1–200 m; generally found in holes or crevices in shallow reefs to 50 m
Longevity	3–5+ years
Maturity (50%)	**Age:** 2–3 years **Size:** ~10 cm CL
Spawning season	Torres Strait: August–March. Mature females brood 2–4 clutches of 300 000–750 000 eggs. The eggs hatch after about one month. The planktonic larval stage lasts 4–6 months, before recruiting to shallow habitats of the Torres Strait, coastal Queensland and Coral Sea. Dispersal is thought to be largely influenced by the Coral Sea Gyre.
Size	**Maximum:** at least 15 cm CL; weight: tails of 1000 g are often reported **Recruitment into the fishery:** minimum size 12.5 cm (tail length); age 1–2 years

CL = carapace length

SOURCE: MacFarlane & Moore (1986); Kailola et al. (1993); Skewes et al. (1997).

Stock status determination

Due to limited targeting of tropical lobster in the Coral Sea, insufficient information is available from logbook data to accurately estimate the stock size or sustainable yield for this stock. However, consideration of the number of reefs and potential reef area in the Coral Sea and the pattern of catch and effort suggests that none of the major reefs in the Coral Sea have ever been extensively fished. Estimates of lobster density on Coral Sea reefs inferred from catch rates suggest that lobster abundance is likely to be many times larger than would be required to support the total historic catch of less than 10 t.

On this basis, the stock is assessed as **not overfished**. As there was no harvest of lobster in the 2008–09 fishing season, the stock is assessed as **not subject to overfishing** (Table 3.1).

Reliability of the assessment/s

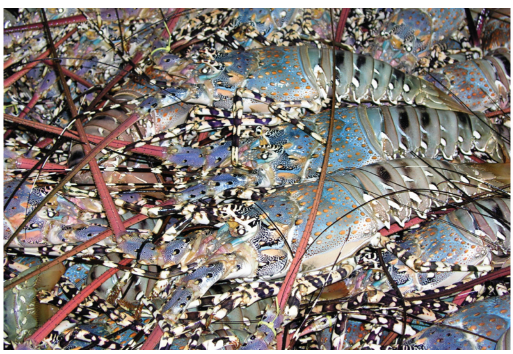
No attempt has been made to conduct a fully quantitative assessment of the stock. However, the status of the stock as not overfished can be considered with a high degree of confidence as the stock has never been heavily exploited.

Previous stock assessment/s

None.

Future assessment needs

If an attempt was made in the future to commercially exploit this stock, careful monitoring of reef-specific catch and effort data should be undertaken.

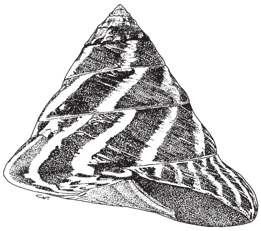


Tropical rock lobsters in tank

PHOTO: JIM PRESCOTT, AFMA

TROCHUS

(*Trochus niloticus; Tectus pyramis*)



LINE DRAWING: FAO

TABLE 3.7 Biology of trochus

Parameter	Description
Range	**Species:** Indo-Pacific distribution **Stock:** The area of the CSF
Depth	*Trochus niloticus*: 0–10 m; *Tectus pyramis*: 0–25 m
Longevity	~15 years
Maturity (50%)	**Age:** 2–3 years **Size:** ~6 cm basal diameter
Spawning season	Year round
Size	**Maximum:** shell length 15 cm, commonly 8 cm in *Trochus niloticus* and 11 cm in *Tectus pyramis* **Recruitment into the fishery:** minimum size 8 cm and maximum size limit of 12.5 cm (for commercial harvest)

CSF = Coral Sea Fishery

SOURCE: Carpenter & Niem (1988); SPC (2008).

Stock status determination

The species of trochus taken in the Coral Sea Fishery is unclear. It is possibly *Tectus pyramis*, which is smaller and has lower value than *Trochus niloticus* (Table 3.7; DEWR 2007). There is insufficient information from the fishery to allow estimation of stock size or potential sustainable yields. Logbook data suggest that no concerted attempt has ever been made to harvest commercial quantities of trochus. Total historic catch of trochus in the Coral Sea amounts to substantially less than 1 tonne, all of which came from a single reef. Furthermore, there has been no reported harvest of trochus since 2001. On this basis, the stock is assessed as **not subject to overfishing** and **not overfished** (Table 3.1).

Reliability of the assessment/s

No attempt has been made to conduct a full quantitative assessment of the stock. The status of the stock as not overfished and not subject to overfishing can be treated with a high degree of confidence because of the negligible quantity of product taken over the history of the fishery.

Previous stock assessment/s

None.

Future assessment needs

If an attempt was made in the future to commercially exploit this stock, careful monitoring of catch-and effort-data that takes account of location (within reef) would be required. Confirmation of the species of trochus occurring in the CSF would be an important step in setting appropriate size limits for the stock.

LINE AND TRAP, AND TRAWL AND TRAP SECTORS

Stock status determination

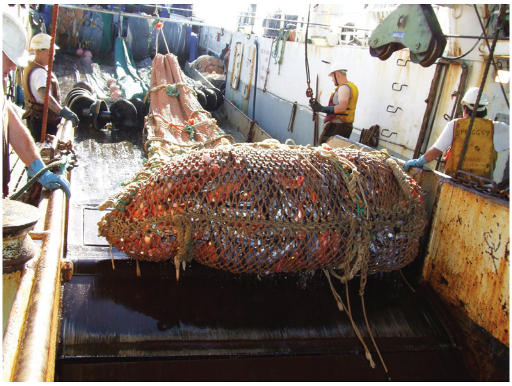
There are no stock assessments or equivalent information for these sectors that would allow comparison of current or historical catches with sustainability indicators. On this basis, the overfished and overfishing classifications of the Line and Trap Sector is assessed as **uncertain**. Similarly, the overfished classification for the Trawl and Trap Sector is assessed as **uncertain**. Since there were no trawl or trap operations during the 2008–09 season, the Trawl and Trap Sector is assessed as **not subject to overfishing** (Table 3.1).

Reliability of the assessment/s

Data-poor fishery, as such little certainty can be applied to stock status.

Previous stock assessment/s

None.



Codend PHOTO: MIKE GERNER, AFMA

Future assessment needs

Detailed analysis of catch-and effort-data that accounts for location (reef) and targeting behaviour is a high priority for this sector. The designation of key commercial or target species, with defensible associated catch triggers, should be progressed in this fishery.

3.5 ECONOMIC STATUS

Overall economic status

The small amount of effort and limited information on the large number of species in the CSF, make it difficult to assess and construct economic performance indicators, such as the level of latent effort for the fishery. Furthermore, no economic surveys of the fishery have been conducted.

Gross value of production for the Aquarium Sector is difficult to estimate since the quantity and value of species in this sector are measured by number and price of individual fish, in contrast to the species caught by the line, trap and trawl sectors, reported by kilogram and price per kilogram. The average price for each species caught in the Aquarium Sector can also vary depending on sex, colour, size and age. A large proportion of the species caught are exported and traded in US dollars; therefore, the value of production is also highly influenced by the Australian dollar exchange rate.

Industry reports that fuel cost makes up a large proportion of the cost of operations, particularly given the remote nature of some of the fishing grounds. This makes fishing less economic in periods of high fuel prices. Another factor that severely affects operations and thus profitability of the fishery is variability in weather conditions, particularly the influence of cyclones and strong winds.

3.6 ENVIRONMENTAL STATUS

Fishing in the CSF occurs using both targeted, hand collection methods and relatively less targeted, multispecies line, trap and trawl methods. For hand collection sectors, the environmental impact is likely to be limited to the removal of target species and the impact their removal may have on the ecosystem.

The Line and Trap, and Trap and Trawl Sectors of the fishery take a wide variety of species, with operations varying both temporally and spatially. These fishing methods are relatively non-selective and take a wide variety of species during the course of fishing operations. Anecdotal reports suggest that trap-caught fish can be released alive if unwanted; however, post-release survival is not well documented for this fishery. Possible ghost fishing from lost traps has been mitigated through the use of sacrificial anodes on trap doors.

Ecological risk assessment

Eight Level 1 Scale, Intensity, Consequence Analysis (SICA) ecological risk assessments have been completed for the CSF (Table 3.2), covering a broad suite of species and associated habitats. A qualitative risk assessment process was undertaken in 2009 for threatened, endangered and protected (TEP) species and Chondricthyans (unpublished; AFMA 2009a). ABARE–BRS understands that a process will be undertaken over the coming years to address the remaining species impacted by the fishery.

Threatened, endangered and protected species

Humphead maori wrasse (*Chelinus undulatus*) is taken in the CSF in low numbers, primarily by the Aquarium Sector. This species is listed under Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and is therefore subject to strict trade regulations. AFMA is in the process of determining species-specific management measures for this species, but no measures are currently in place.

Marine turtles and seabirds

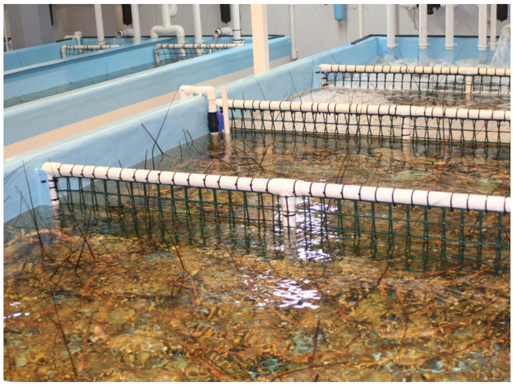
The potential exists for interaction with both turtles and seabirds in the trawl and line sectors; however, no interactions with any TEP species in the CSF has been recorded. When automatic or randomly baited longline equipment is used, operators are required to use tori lines aimed at deterring birds from deployed hooks. Trawl operations are required to use turtle excluder devices when trawling for crustaceans, and trawl nets have a specified minimum mesh diameter (38 mm) to limit bycatch (AFMA–Permit conditions).

Habitats

It is expected that all sectors, with the possible exception of the demersal trawl sector, have minimal impact on habitats. An exception may be the potential for damage caused by anchoring. To mitigate this damage, permanent anchorages have been established at a number of reefs.

3.7 HARVEST STRATEGY PERFORMANCE

Harvest strategies for sectors within the CSF have been developed in light of the developmental nature of the fishery and this should be acknowledged in assessing their performance. The *Commonwealth Fisheries Harvest Strategy Policy* (HSP) states that, in the case of developing fisheries, 'there is a requirement to balance the desire to



Live lobster tanks, Cairns PHOTO: DAVID WILSON, ABARE–BRS

develop a new fishery with the need to ensure any development is sustainable and the stocks are not put at risk' (DAFF 2007). The policy also states that initial catch or effort triggers need to be demonstrably precautionary. In this light, and given the need for a period of implementation and testing in harvest strategy (HS) development, opportunities for strengthening the current strategies are discussed below.

Hand collection sectors: Sea Cucumber, Aquarium, Lobster and Trochus

Sea Cucumber Sector

There are no current stock assessments that establish the long-term sustainable yield for any of the species taken in this sector. The information is currently not available that would demonstrate whether extraction at the prescribed TAC levels are demonstrably precautionary and will ensure the long-term health of these stocks. This is reflected in the uncertain status determinations.

Aquarium Sector

The HS for the Aquarium Sector focuses on functional groups and changes in catch composition of these functional groups. The functional groups were determined with input of industry representatives and scientists

and the use of historical fishing activity. The catch triggers were determined from the relative proportion of the functional group in the historical catch (2001 to 2006). Triggers also exist for live rock. The HS would benefit from further explanation of the suitability and defensibility of the use of proportional catch triggers based on a total specimen trigger.

Lobster and Trochus Sector

There are no current stock assessments that establish a long-term sustainable yield for lobster or trochus. In addition, the species of trochus available to the sector is unclear. It is possible that a number of species of lobster are taken in the fishery.

The basis for the catch triggers is unclear and it is not possible to determine whether the levels are demonstrably precautionary and will ensure the long-term sustainability of these stocks; noting that recent catches have been well below this trigger.

Line and Trap, and Trawl and Trap Sectors

The HS for the Line and Trap, and Trawl and Trap Sectors uses a suite of generic triggers to instigate analysis and assessment, two of which are species specific (white tip reef sharks and grey reef sharks). The HS indicates an intention to designate additional key species in the future.

The decision rules in this strategy raise a number of questions:

- Are generic triggers appropriate to manage a multispecies, multigear fishery?
- Are the levels at which these triggers set demonstrably precautionary for all species harvested?
- Are sufficient data being collected to execute the decision rules in the HS?
- Do management agencies have sufficient resources to implement this iterative HS framework, requiring regular monitoring, analysis and assessment?

It is not clear if the sampling program, intended to be part of the observer program, will collect sufficient biological samples to undertake robust analysis to support triggers in the HS. Furthermore, it is unclear if it is possible to develop a meaningful, standardised index of abundance (CPUE series) for the number of species managed under the HS.

Concluding remarks on harvest strategies

Establishing biologically meaningful targets and limits, derived through a rigorous, quantitative stock assessment process, for this low-GVP, multispecies fisheries is difficult to achieve in practice. However, the HSP requires that catch or effort triggers be ‘demonstrably precautionary’—that is, capable of being demonstrated or proved. If and when the HSs can be established as demonstrably precautionary, adherence to the strategies should be sufficient to determine status.

3.8 LITERATURE CITED

AFMA (Australian Fisheries Management Authority) 2008, *Management arrangements booklet 2008/09—Coral Sea Fishery*, AFMA, Canberra.

——2009a, *Coral Sea Fishery qualitative risk analysis*, part 1, *Protected (TEP) and chondichthyan species*, AFMA, Canberra.

——2009b, *Annual status report—Coral Sea Fishery*, AFMA, Canberra.

Conand, C 1993, ‘Reproductive biology of the holothurians from the major communities of the New Caledonian Lagoon’, *Marine Biology* vol. 116, pp. 439–50.

——1998, ‘Holothurians’, in KE Carpenter & VH Niem (eds), *United Nations Food and Agriculture Organization species identification guide for fishery purposes. The living marine resources of the Western Central Pacific*, vol. 2, *Cephalopods, crustaceans, holothurians and sharks*, FAO, Rome.

DAFF (Australian Government Department of Agriculture, Fisheries and Forestry) 2007, *Commonwealth Fisheries Harvest Strategy: policy and guidelines*, DAFF, Canberra.

DEWR (Australian Government Department of the Environment and Water Resources) 2007, *Assessment of the Coral Sea Fishery*, DEWR, Canberra.

Carpenter, KE & Niem, VH. (eds) 1988, *FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific,* vol. 1. *Seaweeds, corals, bivalves and gastropods,* FAO, Rome, pp. 1–686.

FAO (Food and Agriculture Organization of the United Nations) 1990, *The fishery resources of Pacific island countries*, part 2, *Holothurians*, FAO, Rome.

Furlani, D, Dowdney, J, Bulman, C, Sporcic, M & Fuller, M 2007a, *Ecological risk assessment for the effects of fishing; report for the Aquarium Sub-fishery of the Coral Sea Fishery*, report for the AFMA, Canberra.

——Fuller, M, Dowdney, J, Bulman, C & Sporcic, M 2007b, *Ecological risk assessment for the effects of fishing: report for the Auto Longline Sub-fishery of the Coral Sea Fishery*, report for the AFMA, Canberra.

——Fuller, M, Bulman, C, Dowdney, J & Sporcic, M 2007c, *Ecological risk assessment for the effects of fishing: report for the Demersal Longline Sub-fishery of the Coral Sea Fishery*, report for the AFMA, Canberra.

——Dowdney, J, Bulman, C, Sporcic, M & Fuller, M 2007d, *Ecological risk assessment for the effects of fishing: report for the Demersal Trawl Sub-fishery of the Coral Sea Fishery*, report for the AFMA, Canberra.

——Dowdney, J, Bulman, C, Sporcic, M & Fuller, M 2007e, *Ecological risk assessment for the effects of fishing: report for the Finfish Trap Trials Sub-fishery of the Coral Sea Fishery*, report for the AFMA, Canberra.

——Dowdney, J, Bulman, C, Sporcic, M & Fuller, M 2007f, *Ecological risk assessment for the effects of fishing: report for the Lobster and Trochus Sub-fishery of the Coral Sea Fishery*, report for the AFMA, Canberra.

——Fuller, M, Dowdney, J, Bulman, C & Sporcic, M 2007g, *Ecological risk assessment for the effects of fishing: report for the other line sub-fishery of the Coral Sea Fishery*, report for the AFMA, Canberra.

——Dowdney, J, Bulman, C, Sporcic, M & Fuller, M 2007h, *Ecological risk assessment for the effects of fishing: report for the Sea Cucumber Sub-fishery of the Coral Sea Fishery*, report for the AFMA, Canberra.

Hunter, C, Skewes, T, Burridge, C & Dennis, D 2002, *Research for management of the Coral Sea collector sector (bêche-de-mer)*, CSIRO Division of Marine Research, Cleveland, Queensland.

Kailola, PJ, Williams, MJ, Stewart, PC, Reichelt, RE, McNee, A & Grieve, C 1993, *Australian fisheries resources*, Bureau of Resource Sciences & the FRDC, Canberra.

MacFarlane, JW & Moore, R 1986, 'Reproduction of the ornate rock lobster, *Panulirus ornatus* (Fabricius), in Papua New Guinea', *Australian Journal of Marine and Freshwater Research*, vol. 37, pp. 55–65.

Reichenbach, N 1999, 'Ecology and fishery biology of *Holothuria fuscogilva* (Echinodermata: Holothuroidea) in the Maldives, Indian Ocean', *Bulletin of Marine Science,* vol. 64, no, 1, pp. 103–13.

Skewes, TD, Pitcher, CR & Dennis, DM 1997, 'Growth of ornate rock lobsters, *Panulirus ornatus*, in Torres Strait, Australia', *Marine and Freshwater Research*, vol. 48, pp. 497–501.

SPC (Secretariat of the Pacific Community) 2008, 'Trochus and other marine mollusks', *Trochus Information Bulletin*, issue 14, July 2008.

4 Norfolk Island Fishery

A Leatherbarrow, A Sampaklis and K Mazur

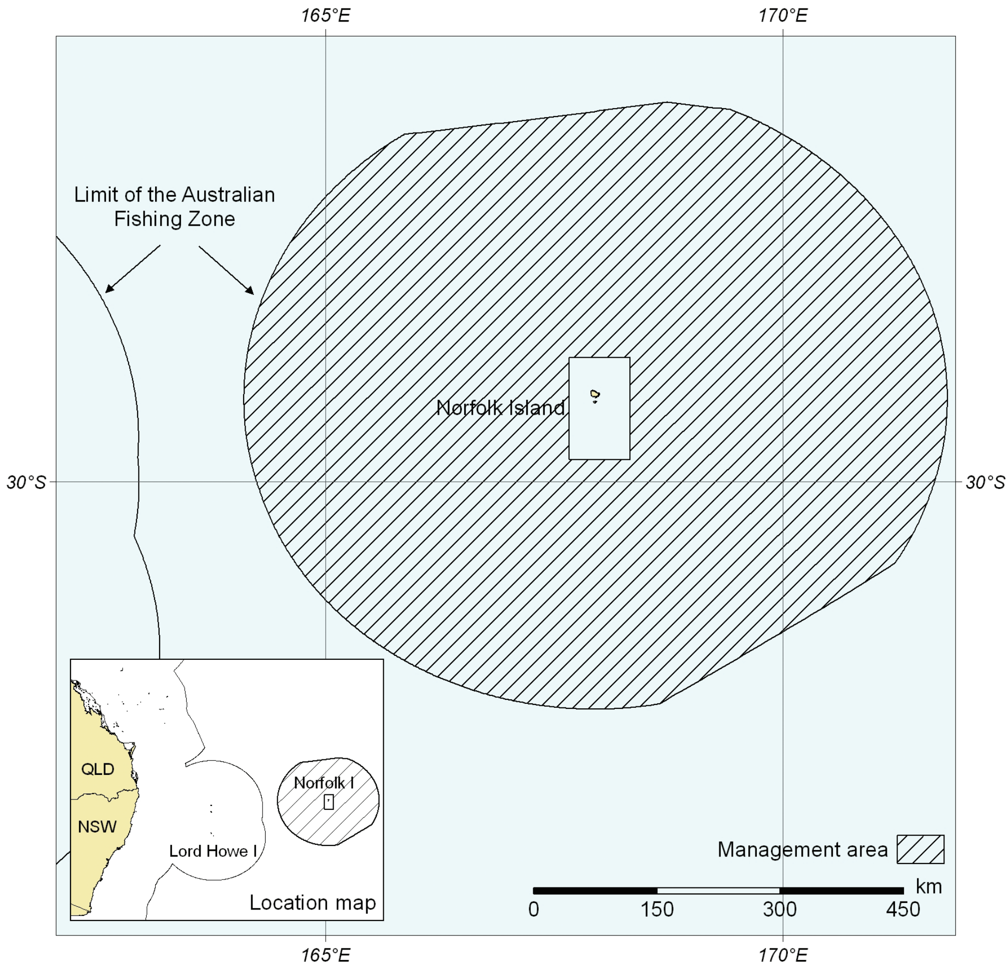


FIGURE 4.1 Area of the Norfolk Island Fishery

TABLE 4.1 Status of the Norfolk Island Fishery

Fishery status	2008		2009		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Inshore fishery					No assessments—recreational fishery with voluntary catch card system.
Offshore fishery					No current fishing concessions and no fishing activity since 2003. Low catch and effort during the exploratory fishing period. No stock assessments or biomass estimates.
Economic status Fishery level	Estimates of net economic returns not available				No effort in the offshore fishery since 2003. Economic status of the inshore fishery uncertain.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING — OVERFISHED / OVERFISHING — UNCERTAIN — NOT ASSESSED

TABLE 4.2 Main features and statistics of the Norfolk Island Fishery

Feature	Description
Key target and byproduct species	Norfolk Island Inshore Recreational and Charter Fishery: no nominated target species; historical catch dominated by redthroat emperor (*Lethrinus miniatus*) Norfolk Island Offshore Demersal Finfish Fishery: exploratory fishery ceased in 2003; there were no nominated target species
Fishing methods	Norfolk Island Inshore Recreational and Charter Fishery: fishing from the shore using poles, rod-and-reels with bait and artificial lures; some fishing from small vessels using deck winches, handlines and rod-and-reels Norfolk Island Offshore Demersal Finfish Fishery: trawl, demersal line
Primary landing ports	Norfolk Island
Management methods	Inshore fishery Output controls; voluntary catch limits on redthroat emperor to align with spawning season (usually from December to January)
Management plan	*AFMA Interim Policy for Inshore Waters Surrounding Norfolk Island* (AFMA 2004) ceased in 2006. A new management policy (the Norfolk Island Inshore Fishery Management Policy 2009) has been developed by the Norfolk Island Government for the management of recreational and charter fishing in the NIIF. The AFMA Commission has endorsed this management policy and entered into a memorandum of understanding with the Norfolk Island Government to maintain a monitoring and advisory role in the fishery. AFMA has also undertaken work to develop a small-scale commercial fishery in the area of the NIIF; the scale and nature of the fishery are yet to be determined. A policy will be developed during 2010 to guide the development of the fishery. Commercial fishing will be managed under the provisions of the *Fisheries Management Act 1991*.
Harvest strategy	No harvest strategy has been developed due to a lack of commercial fishing activity since 2003.
Consultative forums	Norfolk Island Consultative Committee, involving Norfolk Island Government, Norfolk Island Fishing Association, AFMA and other relevant Australian Government representatives
Main markets	Domestic: fresh
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	 Current accreditation: nil Current accreditation: nil
Ecological risk assessment	No ecological risk assessment has been undertaken.
Bycatch workplans	No bycatch workplans have been developed for the offshorefishery due to a lack of fishing activity since 2003.

Table 4.2 continues over the page

TABLE 4.2 Main features and statistics of the Norfolk Island Fishery CONTINUED

Feature	Description	
Fishery statistics[a]	**2008 fishing season**	**2009 fishing season**
Fishing season	No formal fishing season	No formal fishing season
TAC or TAE	No TAC or TAE	No TAC or TAE
Catch	Norfolk Island Inshore Recreational and Charter Fishery: ~30 t recreational and charter catch taken 2006–2009 (reported by fishers) Norfolk Island Offshore Demersal Finfish Fishery: closed since 2003	Norfolk Island Inshore Recreational and Charter Fishery: ~30 t recreational and charter catch taken 2006–2009 (reported by fishers) Norfolk Island Offshore Demersal Finfish Fishery: closed since 2003
Effort	Norfolk Island Inshore Recreational and Charter Fishery: effort not assessed due to unavailability of information on the type and quantities of gear used. Norfolk Island Offshore Demersal Finfish Fishery: zero	Norfolk Island Inshore Recreational and Charter Fishery: effort not assessed due to unavailability of information on the type and quantities of gear used. Norfolk Island Offshore Demersal Finfish Fishery: zero
Fishing permits	Norfolk Island Inshore Recreational and Charter Fishery: no fishing permits currently issued Norfolk Island Offshore Demersal Finfish Fishery: all permits have expired, no valid concessions exist	Norfolk Island Inshore Recreational and Charter Fishery: no fishing permits currently issued Norfolk Island Offshore Demersal Finfish Fishery: all permits have expired, no valid concessions exist
Active vessels	Norfolk Island Inshore Recreational and Charter Fishery: only 12–15 of the ~90 vessels on the island regularly take substantial quantities of fish for domestic consumption. Norfolk Island Offshore Demersal Finfish Fishery: zero	Norfolk Island Inshore Recreational and Charter Fishery: only 12–15 of the ~90 vessels on the island regularly take substantial quantities of fish for domestic consumption. Norfolk Island Offshore Demersal Finfish Fishery: zero
Observer coverage	Zero	Zero
Real gross value of production (2008–09 dollars)	2007–08 Offshore: zero Inshore: unknown	2008–09 Offshore: zero Inshore: unknown
Allocated management costs	2007–08: Norfolk Island Inshore Recreational and Charter Fishery, $0.03 million; Norfolk Island Offshore Demersal Finfish Fishery, $0.25 million	2008–09: Norfolk Island Inshore Recreational and Charter Fishery, $0.08 million; Norfolk Island Offshore Demersal Finfish Fishery, $0.05 million

AFMA = Australian Fisheries Management Authority; EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; NIIF = Norfolk Island Inshore Fishery; TAC = total allowable catch; TAE = total allowable effort

a Fishery statistics are provided by fishing season unless otherwise indicated.

4.1 BACKGROUND

The Norfolk Island Fishery (NIF) comprises an inshore recreational and charter-based fishery and an offshore exploratory commercial fishery that operated between 2000 and 2003 (Tables 4.2 and 4.3).

Norfolk Island Inshore Recreational and Charter Fishery

The Norfolk Island Inshore Recreational and Charter Fishery occurs within a 67 × 40 nautical mile (nm) 'box' covering the shelf and upper-slope waters adjacent to Norfolk Island (Fig. 4.1). The fishery consists of three components:

- a semi-subsistence shore fishery involving rod-and-line fishing for labrids (Labridae), pomacentrids (Pomacentridae) and cods (Serranidae), and the gathering of periwinkles (*Nerita atramentosa*)
- a recreational/semi-commercial small vessel fishery for domestic consumption, comprising approximately 90 fishing vessels that sell surplus catch to restaurants and residents—of these vessels, 12–15 regularly take substantial quantities of fish. Only small vessels are used because of a lack of mooring facilities. Local catches are sporadic, and local demand is supplemented by imported frozen fish
- a recreational charter fishery from rocky shores using modern rod-and-reel gear with lures or bait to take pelagic species, such as yellowtail kingfish (*Seriola lalandi*), trevally (*Pseudocaranx* spp.) and tunas (Thunnidae), and also demersal fish (including Lethrinidae and Serranidae).

Fishing effort in the Norfolk Island Inshore Recreational and Charter Fishery is constrained by weather conditions, which allow for about 50–100 days of fishing per year. Demersal species are primarily targeted on reefs and pinnacles 5–10 nm (but up to 30 nm) offshore, at depths of 20–50 m. Although the catch is dominated by redthroat emperor (*Lethrinus miniatus*), known locally as 'trumpeter', approximately 40 commercial species have been identified

Jetty, Norfolk Island PHOTO: DAVE JOHNSON, AFMA

from the Norfolk Island Inshore Fishery (Table 4.2). Important catch includes grouper and cods (e.g. *Epinephelus rhyncholepis, E. lanceolatus*), snapper (*Pagrus auratus*) and yellowtail kingfish. Pelagic species, particularly yellowfin tuna (*Thunnus albacares*) and skipjack tuna (*Katsuwonus pelanis*), are trolled. The occasional capture of black marlin (*Makaira indica*) indicates scope for sport fishing, if maritime infrastructure (moorings) were improved.

Little specific research has been conducted on the fisheries of Norfolk Island. The Australian Fisheries Management Authority (AFMA) is currently working to release a summary of catch data reported from the Norfolk Island Inshore Recreational and Charter Fishery for 2006–2009.

Norfolk Island Offshore Demersal Finfish Fishery

The work of AFMA around Norfolk Island is focused on the Eastern Tuna and Billfish Fishery (see Chapter 22). The Norfolk Island Offshore Demersal Finfish Fishery has not operated since 2003, when the two trawl and five demersal-line exploratory fishing permits expired (Tables 4.2, 4.3).

There was limited effort in the Norfolk Island Offshore Demersal Finfish Fishery, with permit holders failing to meet the required 50 days of fishing. Low catches of orange roughy (*Hoplosthetus atlanticus*) and alfonsino (*Beryx splendens*) indicate small stock biomass in the Norfolk Island Exclusive Economic Zone. Bass groper (*Polyprion americanus*), hapuka (*P. oxygeneois*) and blue-eye trevalla (*Hyperoglyphe antarctica*) dominated hook catches.

TABLE 4.3 History of the Norfolk Island Fishery

Year	Description
c. 1850s	Fishery resources in shelf waters used by the local island community.
1950s to 1997	Japanese vessels undertook longlining in the Norfolk Island region. Large catches taken from inshore waters in areas that subsequently became unproductive. Annual catch in the fishery estimated to be 80–100 t.
1980s	Common opinion among recreational fishers is that catches of redthroat emperor declined in inshore waters over the decade.
2000	AFMA issued two trawl and five demersal-line 3-year exploratory fishing permits for offshore waters to assess the potential for commercial catches of alfonsino and orange roughy.
2000 to 2003	Over the 3-year exploratory fishing period, 96 t was reported landed, with trawl catch contributing less than 8 t.
2004	Inshore catch estimated to be 6 t. AFMA established an interim management policy for the inshore fishery, which remained in effect until 2006. The policy was endorsed by the Administration of Norfolk Island, and a data-sharing agreement was ratified through an MoU.
2005	Development of a management plan for the inshore fishery under the *Fisheries Management Act 1991* was investigated but found unsuitable; the fishery has been managed under an interim policy since this time.
2008	Development of a draft management policy for recreational and charter fishing by the Norfolk Island Government following discussion with AFMA on future management of the NIIF. The policy, referred to as the Norfolk Island Inshore Fishery Management Policy 2009, is to be administered by the Norfolk Island Government.
2009	The Norfolk Island Inshore Fishery Management Policy 2009 released for public comment by the Norfolk Island Government (March 2009).
2010	The Norfolk Island Inshore Fishery Management Policy 2009 (NIG 2009) for recreational and charter fishing in the inshore fishery was endorsed by AFMA in February 2010. An MoU with the Norfolk Island Government has also been established to allow AFMA to maintain a monitoring and advisory role in the fishery. AFMA has also undertaken work to develop a small-scale commercial fishery in the area of the NIIF.

AFMA = Australian Fisheries Management Authority; NIIF = Norfolk Island Inshore Fishery; MoU = memorandum of understanding

4.2 HARVEST STRATEGY

No harvest strategy (HS) has been developed for the NIF due to the lack of commercial fishing activity in the offshore fishery since 2003. A HS will need to be produced if commercial fishing develops in the NIF.

4.3 THE 2009 FISHERY

Norfolk Island Inshore Recreational and Charter Fishery

The new management policy developed by the Norfolk Island Government for the management of recreational and charter fishing in the Norfolk Island Inshore Fishery (NIIF) will be administered by the Norfolk Island Government. AFMA, through a memorandum of understanding with the Norfolk Island Government, maintains a monitoring and advisory role in the fishery. An informal catch card system is in place.

AFMA has also undertaken work to develop a small-scale commercial fishery in the area of the NIIF; however, the scale and nature of the fishery are yet to be determined. A policy will be developed during 2010 to guide the development of the Norfolk Island Inshore Commercial Fishery.

Redthroat emperor PHOTO: FRASER McEACHAN, AFMA

Norfolk Island Offshore Demersal Finfish Fishery

No fishing has occurred since exploratory permits expired in 2003. In February 2008, AFMA determined that a plan of management was not warranted for the Norfolk Island Offshore Demersal Finfish Fishery, and there are no current plans to develop this fishery.

4.4 BIOLOGICAL STATUS

Stock status determination

Data on catch and effort for the target species in the inshore fishery are limited, although anecdotal reports suggest that catch rates may have declined from historical levels (see Grant 1981). The long-term commercial viability and sustainability of a demersal offshore fishery is uncertain. There have been no stock assessments or biomass estimates for the offshore fishery, and there has been no effort in the offshore fishery since 2003 (Table 4.1).

4.5 ECONOMIC STATUS

Overall economic status

The offshore fishery is currently closed and the low catch levels and inability of vessels to fulfil the required number of fishing days during the exploratory period indicate that net economic returns were likely to be low. No indicators are available of the economic performance of the inshore fishery.

Future considerations

The limited fishing effort during the exploratory period is likely to be related to the significant distances involved and the infrastructure and market constraints. Although the NIF Offshore Fishery is not considered to be commercially viable, if these factors change there may be increased interest. A small-scale commercial inshore fishery is currently being examined.

4.6 ENVIRONMENTAL STATUS

Ecological risk assessment

No ecological risk assessment has been undertaken or is planned for this fishery.

Habitats

The impact of the fishery on marine habitats is likely to be minimal.

Threatened, endangered and protected species

To date, no interactions with threatened, endangered or protected species have been reported. However, as reporting in the fishery has been and is limited, interactions are unlikely to be documented.

4.7 HARVEST STRATEGY PERFORMANCE

Not applicable.

4.8 LITERATURE CITED

AFMA (Australian Fisheries Management Authority) 2004, *AFMA interim policy for inshore waters surrounding Norfolk Island*, AFMA, Canberra.

Grant, C 1981, 'High catch rates in Norfolk Island dropline survey', *Australian Fisheries*, March 1981.

NIG (Norfolk Island Government) 2009, *Norfolk Island Fishery Management Policy 2009*, Norfolk Island Government, Kingston.

5 Northern Prawn Fishery

J Larcombe and C Perks

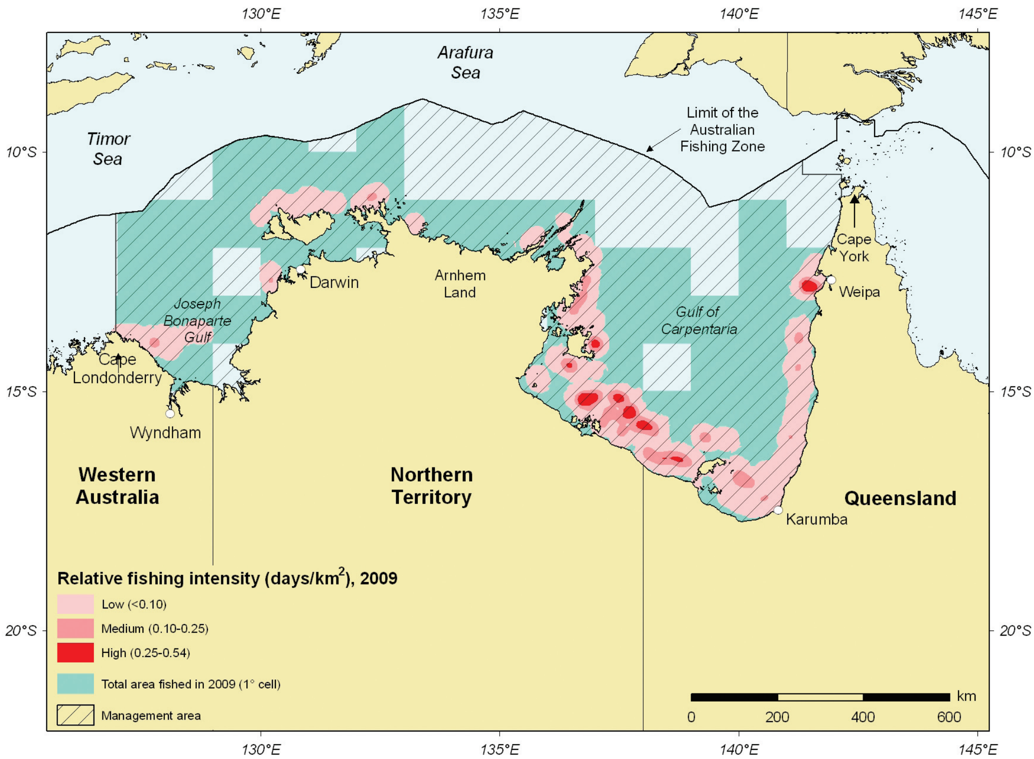


FIGURE 5.1 Relative fishing intensity in the Northern Prawn Fishery, 2009

TABLE 5.1 Status of the Northern Prawn Fishery

Fishery status	2008		2009		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Red-legged banana prawn (*Fenneropenaeus indicus*)	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Stable catches, species biology and preliminary assessment provide no evidence of excessive biomass depletion or overfishing in recent years.
White banana prawn (*Fenneropenaeus merguiensis*)	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	High natural recruitment variability, primarily linked to environmental factors. Reductions in effort.
Brown tiger prawn (*Penaeus esculentus*)	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Spawning biomass not overfished. MEY target applies across multiple species.
Grooved tiger prawn (*Penaeus semisulcatus*)	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Spawning biomass not overfished. MEY target applies across multiple species.
Blue endeavour prawn (*Metapenaeus endeavouri*)	Uncertain	Uncertain	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Three separate preliminary assessments indicate no overfishing and not overfished; biomass appears more depleted (below B_{MSY}) than tiger prawns.
Red endeavour prawn (*Metapenaeus ensis*)	Uncertain	Uncertain	Uncertain	Uncertain	Catches linked to tiger prawn catch. Assessments in development. Contributes to MEY target of tiger prawns.
King prawns (*Melicertus longistylus* and *Melicertus latisulcatus*)	Uncertain	Uncertain	Not overfished / not subject to overfishing	Uncertain	Minor byproduct with catches less than 0.5% of total prawn catches.
Economic status Fishery level (2008–09 dollars)	Net economic returns were $8.1 million in 2007–08		Net economic returns were $11.0 million in 2008–09		Economic status improved following recent structural adjustment, improved tiger prawn biomass and high banana prawn catch rates. The move to more effective management arrangements will have a positive impact on future economic status.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING; OVERFISHED / OVERFISHING; UNCERTAIN; NOT ASSESSED

MEY = maximum economic yield; MSY = maximum sustainable yield

Trawl bycatch

PHOTO: JAMES WOODHAMS, ABARE–BRS

Trawl net with turtle excluder device

PHOTO: MIKE GERNER, AFMA

TABLE 5.2 Main features and statistics of the Northern Prawn Fishery

Feature	Description
Key target and byproduct species	Red-legged banana prawn (*Fenneropenaeus indicus*) White banana prawn (*Fenneropenaeus merguiensis*) Brown tiger prawn (*Penaeus esculentus*) Grooved tiger prawn (*Penaeus semisulcatus*) Blue endeavour prawn (*Metapenaeus endeavouri*) Red endeavour prawn (*Metapenaeus ensis*)
Other byproduct species	Bugs (*Thenus* spp.) Finfish (various) Prawn, red-spot king (*Melicertus longistylus*) Prawn, western king (*M. latisulcatus*) Scallops (*Amusium* spp.) Scampi (*Metanephrops* spp.) Squid (*Photololigo* spp.)
Fishing methods	Otter (prawn) trawl
Primary landing ports	Darwin, Karumba, but much of the catch is offloaded onto motherships at sea
Management methods	Input controls: individual tradable gear units, limited entry, gear restrictions, area closures, seasonal closures and time-of-day closures
Management plan	*Northern Prawn Fishery Management Plan 1995* (DAFF 1995, last amended July 2006)
Harvest strategy	Northern Prawn Fishery (NPF) Harvest Strategy Under Input Controls (Dichmont & Jarrett 2007) **Tiger prawns** Target reference point: MEY from the tiger prawn fishery as a whole (including byproduct of endeavour prawns) Limit reference point: $0.5S_{MSY}$ (half the spawning stock size required for maximum sustainable yield) **Banana prawns** No specific target or limit reference points for banana prawns
Consultative forums	Northern Prawn Fishery Management Advisory Committee (NORMAC), Northern Prawn Resource Assessment Group (NPRAG)
Main markets	International: Japan—frozen Domestic: fresh/frozen
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Current accreditation dated 12 January 2006 Current accreditation (Exempt) expires 9 January 2014
Ecological risk assessment	Level 1: Scale, Intensity, Consequence Analysis (SICA) completed on 788 species (Griffiths et al. 2007) Level 2: Productivity Susceptibility Analysis (PSA) completed on 272 species (Griffiths et al. 2007) Level 3: Sustainability Assessment of Fishing Effects (SAFE) completed on 456 species (Brewer et al. 2007)
Bycatch workplans	*Northern Prawn Fishery Bycatch And Discarding Workplan 1 July 2009 – 30 June 2011* (AFMA 2009)

Table 5.2 continues over the page

TABLE 5.2 Main features and statistics of the Northern Prawn Fishery CONTINUED

Feature	Description			
Fishery statistics[a]	**2008 fishing season**		**2009 fishing season**	
Fishing season	Banana: 27 March 2008–5 June 2008 Tiger: 1 August 2008–28 November 2008		Banana: 8 April 2009–17 June 2009 Tiger: 25 July 2009–5 December 2009	
Total allowable gear	2654 metres of headrope (twin trawl) 2388 metres of headrope (quad trawl)		2654 metres of headrope (twin trawl) 2388 metres of headrope (quad trawl)	
Catch and estimated value by species:	Catch (tonnes)	Real value (2007–08)	Catch (tonnes)	Real value (2008–09)
—banana prawns	5816	$50.2 million	5212	$46.5 million
—tiger prawns	1035	$23.6 million	1278	$24.2 million
—endeavour prawns	217	$1.9 million	357	$2.3 million
—king prawns	7	$0.3 million	6	$0.1 million
Effort	Banana season: 2628 fishing days Tiger season: 5202 fishing days		Banana season: 2146 fishing days Tiger season: 5844 fishing days	
Fishing permits	52		52	
Active vessels	52		55	
Observer coverage	Crew member observers: 2.3% Scientific observers: 2.1% (570 shots)		Crew member observers: 4.9% Scientific observers: 1.2% (353 shots)	
Real gross value of production (2008–09 dollars)	2007–08: $76.8 million		2008–09: $74.0 million	
Allocated management costs	2007–08: $2.3 million		2008–09: $2.5 million	

AFMA = Australian Fisheries Management Authority; EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; MEY = maximum economic yield

a Fishery statistics are provided by fishing season unless otherwise indicated.

5.1 BACKGROUND

The Northern Prawn Fishery (NPF) is a multispecies fishery that targets prawns using otter trawl. The white banana prawn (*Fenneropenaeus merguiensis*) and the two tiger prawns (brown—*Penaeus esculentus* and grooved—*P. semisulcatus*) account for about 80% of the landed catch. Historically, vessels switched to targeting tiger prawns later in the year when the banana prawn catch rates declined (Table 5.3). The fishery has two seasons: a short banana prawn fishery of 6–10 weeks starting around April, and a longer tiger prawn fishery starting July–September (Table 5.2).

White banana prawns are caught mainly during the day in the eastern Gulf of Carpentaria and on isolated grounds along the Arnhem Land coast, whereas red-legged banana prawns are caught in the Joseph Bonaparte Gulf (Fig. 5.1). The white banana prawns form dense aggregations (‘boils’) that are found by spotters in planes, who direct the trawlers. The highest catches are taken offshore from mangrove forests, which are the juvenile nursery areas.

Tiger prawns are taken mainly at night (trawling is banned during the daytime during the tiger prawn fishing season) in the southern and western Gulf of Carpentaria and along the Arnhem Land coast. The tiger prawn fishing grounds are often close to those of banana prawns, but the highest catches are in areas near coastal seagrass beds—the juvenile nursery habitats. Endeavour prawns are caught as a major byproduct in the tiger prawn fishery.

TABLE 5.3 History of the Northern Prawn Fishery

Year	Description
1966	Two vessels operating.
1970	200 vessels operating (Rose & Kompas 2004).
1971	Seasonal closures for banana prawns introduced.
1974	Banana prawn catch peaked at 12 712 t. Total prawn catch peaked at 13 815 t.
1977	First management plan in place, and entry limited to 302 vessels.
1977, 1980	Controls on vessel replacement.
1983	Tiger prawn catch peaked at 5751 t.
1984	Unitisation introduced as a response to concerns about fishing capacity and overcapitalisation. Adoption of A-units as measure of vessel size and power. B-units introduced and served as a right to fish. NORMAC formed.
Mid-1980s	Buyback scheme aimed to reduce A-units to 70 000 by 1990. Plan was for an initial voluntary buyback followed by a compulsory buyback, which later fell through. Voluntary buyback extended to B-units.
1987	Mid-season closure (usually May–August) introduced to reduce effort on tiger prawns before they spawn, in response to decline in tiger prawn recruitment. Daylight trawling during the tiger prawn season banned. Vessels restricted to towing two nets.
1988	Fishery became solely managed by the Commonwealth under Offshore Constitutional Settlement arrangements.
1990	Buyback scheme refinanced, with amended target of 53 844 A-units by early 1993. Licence numbers reduced from 216 to 132 over 1990 to 1993.
1993	Through compulsory (15%) and voluntary surrender, target was met in April. A-units and B-units rolled into class A and B SFRs.
1995	Management plan and SFRs introduced, based on existing effort units in the fishery, to replace class A and B units.
1998	Northern Prawn Resource Assessment Group estimated long-term tiger prawn yield at 4000 t and advised that the effective effort directed at tiger prawns was well above MSY and should be reduced by 25–30%. Bycatch Action Plan developed.
2000	Stock assessment incorporated new fishing power model. Tiger prawn recruitments lowest on record. Fishery moved to gear-based management using headrope length.
2001	AFMA commissioned an international expert review, which confirmed that tiger prawns were overfished and levels of fishing effort were too high to promote recovery. NORMAC established a target of S_{MSY} (spawner biomass that produces MSY) by 2006, with 70% certainty.
2002	40% effort reduction target met through a 25% reduction in total allowable headrope length and shortening of season (to 134 total days in 2002, 2003 and 2004).
2004	NORMAC established MEY as the overall management objective of the fishery. S_{MSY} redefined as limit reference point. NORMAC recommended 25% reduction in gear SFRs.
2005	25% reduction in total allowable headrope length. Second (tiger prawn) season lengthened, with additional measures to minimise tiger prawn catch in the first (banana prawn) season.
2006	Structural adjustment package removed 43 class B SFRs and 18 365 gear SFRs purchased from the fishery (45% and 34% reduction, respectively). A condition of participation was for the fishery to move to output control management (i.e. individual transferable quotas).
2007	NPF Harvest Strategy Under Input Controls introduced, which aims to maximise economic returns (MEY target) by changing effort levels using the results of a bioeconomic assessment of the tiger prawn fishery.
2008	33% increase in total gear in the fishery, resulting in an increase in the value of each gear SFR from 0.5625 cm to 0.7481 cm (headrope length). Extensive research undertaken to assess the advantages and disadvantages of effort control and output control management options for the NPF.
2009	AFMA Commission agreed to implement output controls through an ITQ system for both banana prawns (with an east and west zone) and tiger prawns, subject to redrafting of NPF management plan during 2010. Independent allocation advisory panel formed to advise on ITQ allocation model. New or amended stock assessments developed for banana, tiger and endeavour prawns.

AFMA = Australian Fisheries Management Authority; ITQ = individual transferable quota; MEY = maximum economic yield; MSY = maximum sustainable yield; NORMAC = Northern Prawn Fishery Management Advisory Committee; NPF = Northern Prawn Fishery; SFR = statutory fishing right

5.2 HARVEST STRATEGY

The NPF harvest strategy (HS) includes distinct strategies for the different parts of the fishery and is designed to operate within the current management system of input controls (Dichmont & Jarrett 2007). The tiger prawn strategy has been tested in a simulation environment to assess its performance against the *Commonwealth Fisheries Harvest Strategy Policy* (HSP). The strategy's control rules operated from 2008.

BANANA PRAWNS

Species: Red-legged banana prawn and white banana prawn.

Target: No current specific target.

Limit: No current specific limit.

Control rules:

- The season is limited to 6 weeks, with the possibility of extension to 8 or 10 weeks provided that banana prawn catch rates are maintained (>500 kg/vessel per day) and tiger prawn bycatch is low (<6.6 t/week).
- The rules are read in conjunction with other management measures, including gear controls and spatial closures.
- The rules are based on an analysis of historical fishery records, which indicated that the approach was likely to result in a sustainable fishery.

TIGER AND ENDEAVOUR PRAWNS

Species: Grooved tiger prawn, brown tiger prawn, blue endeavour prawn, red endeavour prawn.

Target: Long-term maximum economic yield (MEY) from a suite of tiger and endeavour prawns (with recognition that some species, when considered in isolation, may be below or above B_{MEY}, but still subject to a limit reference point).

Limit: Half of the spawning stock needed to achieve maximum sustainable yield ($0.5S_{MSY}$), calculated as the moving average over five years (this limit is currently assessed only for tiger prawns).

Control rules:

- The fishing effort for brown and grooved tiger prawn fleets is set for a two-year period to maximise profits over a seven-year moving window, based on the results of a bioeconomic assessment conducted every two years.
- Fishing effort is controlled by modification of gear (headrope length), season length and area fished.
- If the limit reference point is triggered for a species, targeted fishing of that species ceases.
- Standardised fishing effort for the fleet in any one year cannot be less than half of the standardised effort targeted at brown tiger prawns in 2006.
- An early end to the tiger prawn season can be triggered by average nightly prawn catch per vessel falling below a specified level (in 2009, this was 300 kg, measured in the 16th week).

KING PRAWNS

King prawns are monitored through logbooks, surveys and seasonal landings. If a consistent decline in abundance is detected over a three-year period, appropriate management measures (including additional spatial closures) will be implemented to reduce fishing pressure.

Prawn trawler PHOTO: MIKE GERNER, AFMA

SCAMPI

Scampi is monitored through examination of trends in total annual catch, vessel participation, catch rates and size distribution. A catch of 30 t or greater, or participation of eight or more vessels, in a year will trigger a 30 t total allowable catch (TAC) in the following year.

5.3 THE 2009 FISHERY

Key target and byproduct species

A total of 55 vessels fished during 2009 (Table 5.2). The banana prawn season commenced on 8 April and ran for 10 weeks. This comprised a fixed six weeks plus two extensions, each of two weeks, that were triggered according to the HS control rules. There were 2146 vessel days of effort attributed to the 2009 banana prawn season (2628 in 2008). The total reported landing of banana prawns for 2009 was 5212 t (5816 t in 2008) (Fig. 5.2).

Operators regarded the 2009 banana prawn catches and catch rates to be moderately good, although not as good as 2008 and not quite achieving expectations, given the high rainfall. Quality improvements were noted due to fishing practices, but the banana prawns were thought to be smaller on average (and thus less valuable). According to the Northern Prawn Resource Assessment Group (NPRAG), about 90% of banana prawns caught during the 2009 season were sold on the domestic market.

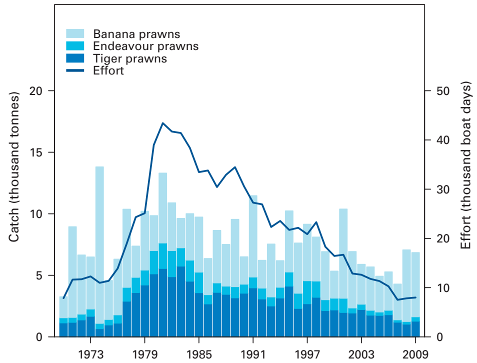


FIGURE 5.2 Prawn catch and effort in the NPF, 1970 to 2009

The tiger prawn season ran from 25 July to 5 December 2009. In accordance with the HS, the season was shortened by two weeks because the average nightly prawn catch per vessel fell below 300 kg in the 16th week. This trigger to close the season is predominantly intended to improve economic performance of the fishery by continuing fishing only when it is profitable. There were 5844 vessel days of effort attributed to the 2009 tiger prawn season (5202 vessel days in 2008). The total reported landings of tiger prawns in 2009 were 1278 t (1035 t in 2008). This was quite low compared with the historical records since the mid-1970s (Fig. 5.2). Prawn byproduct catches were 357 t of endeavour prawns (215 t in 2008) and 6 t of king prawns (7 t in 2008) (Fig. 5.2).

Operators reported an overall improvement in business conditions and profitability in 2009. Fuel prices were lower, but competition from imported prawns (such as farmed black tiger prawns) was strong. In comparison with 2008, a significantly larger proportion of the tiger prawn catch was marketed domestically in 2009.

Gross value of production (GVP) for 2008–09 was $74.0 million (Fig. 5.3). This was 4% lower than in 2007–08, when the fishery achieved $76.8 million worth of production. Both 2007–08 and 2008–09 benefited from above-average catches of

Trawl catch PHOTO: RHYS ARANGIO, AUSTRAL FISHERIES

banana prawns. However, the positive effect of strong banana prawn catches on GVP was partially offset by progressively lower prices for banana prawns in 2007–08 and 2008–09.

Despite falling by 7%, banana prawn catch remained the main contributor to GVP in 2008–09, accounting for $46.5 million and 63% of the total fishery GVP. Tiger prawn GVP increased by 2%, reaching $24.2 million. Together these two species comprised 95% of GVP in the fishery.

Generally, GVP has fluctuated in recent years. Figure 5.3 shows GVP falling and then rising in alternate years every season since 2003–04. Much of this fluctuation can be attributed to external factors that affect either the volume produced or the prices received by producers. Environmental factors, such as rainfall, can effect on the stock of banana prawns. This impact flows through to the volume of banana prawns produced in a season.

Producers have faced increasing competition from imports on domestic markets, and the effect of the appreciation (until 2007–08) of the Australian dollar on domestic and export markets, which have both adversely affected prices received. Prawn prices have halved in real terms since 2000–01, reflecting changes in market conditions. The exception to this has been the 2008–09 tiger prawn season, which saw a 23% increase in the price of tiger prawns, offsetting a decline in the volume of tiger prawns produced relative to 2007–08. This price increase was largely driven by the depreciation of the Australian dollar in 2008–09.

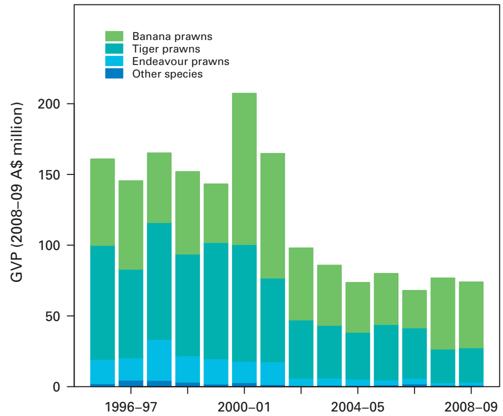


FIGURE 5.3 GVP by species in the NPF by financial year, 1995–96 to 2008–09

SOURCE: ABARE–BRS (unpublished data).

Minor byproduct species

The fishery took 18 t of scampi and 4 t of bugs and slipper lobsters, as well as smaller quantities of other byproduct (Table 5.4). These catches are generally taken as a direct byproduct of fishing for the main prawn targets. Scampi is targeted in much deeper waters on the continental slope, north of Darwin.

TABLE 5.4 Minor byproduct stocks–TACs/triggers, catches/landings and discards in the Northern Prawn Fishery

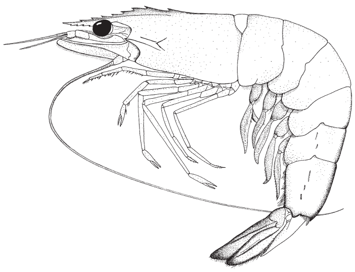
Species	TAC/ trigger/limit	2008 catch (tonnes)	2008 discards (tonnes)	2009 catch (tonnes)	2009 discards (tonnes)
Scampi (*Metanephrops* spp., *Nephropsis* spp.)	30 t	30	n.a.	18	n.a.
Morton bay bugs (*Thenus* spp.)	None	15	n.a.	0	n.a.
Slipper lobster (*Scyllarides* spp.)	Size limit, no female take	8	n.a.	4	n.a.
Whiting (Sillaginidae)	None	5	n.a.	0	n.a.
Squid (Teuthoidea)	500 t	3	n.a.	1	n.a.
Cuttlefish (Sepiidae)	None	3	n.a.	1	n.a.
Spiny lobsters (Palinuridae)	6 *Panulirus ornatus* per trip	2	n.a.	0	n.a.

n.a. = not available; TAC = total allowable catch

5.4 BIOLOGICAL STATUS

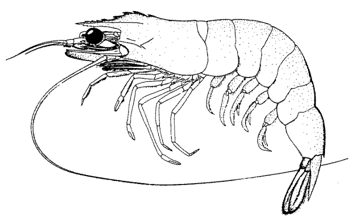
BANANA PRAWNS

Red-legged banana prawn (*Fenneropenaeus indicus*)



LINE DRAWING: FAO

White banana prawn (*F. merguiensis*)



LINE DRAWING: FAO

Prawn trawlers PHOTO: RHYS ARANGIO, AUSTRAL FISHERIES

TABLE 5.5 Biology of banana prawns

Parameter	Description
General	Banana prawns are thought to be resilient to fishing pressure, and recruitment appears to be closely related to seasonal conditions (rainfall) rather than spawning stock size.
Range	**Species:** Northern Australia and tropical Indo-Pacific. Adults inhabit sand or mud bottoms in coastal waters. Mangrove-lined creeks and rivers are nursery habitats. Adult white banana prawns are found mainly on muddy sediments. Larvae of red-legged banana prawns move considerable distances to nursery grounds, and juveniles move large distances back to the deeper fishing grounds. **Stock:** Some evidence indicates that there may be separate stocks of white banana prawns within the NPF, associated with estuaries, and responding independently to seasonal conditions. Red-legged banana prawns in Joseph Bonaparte Gulf are regarded as a single stock for assessment purposes, there is a small amount of catch in adjacent NPF regions to the north-east.
Depth	Red-legged banana prawns tend to inhabit deeper waters of 45–85 m as adults. Adult white banana prawns inhabit waters mainly less than 20 m deep and highly aggregating.
Longevity	1–2 years
Maturity (50%)	**Age:** ~6 months **Size:** >2.5 cm CL
Spawning season	Throughout the year, but the two main spawning periods are March–May and September–November. The later spawning produces most of the prawns in the commercial fishery in April–May the following year.
Size —red-legged banana prawn	**Maximum:** 22 cm total length **Recruitment into the fishery:** at 3–6 months
—white banana prawn	**Maximum:** 24 cm total length **Recruitment into the fishery:** at 3–6 months

CL = carapace length

SOURCES: Yearsley et al. (1999).

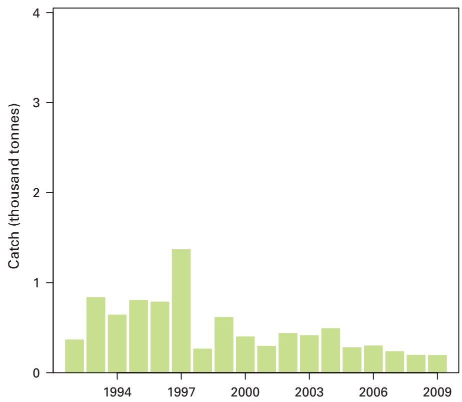


FIGURE 5.4 Red-legged banana prawn catch history, 1992 to 2009

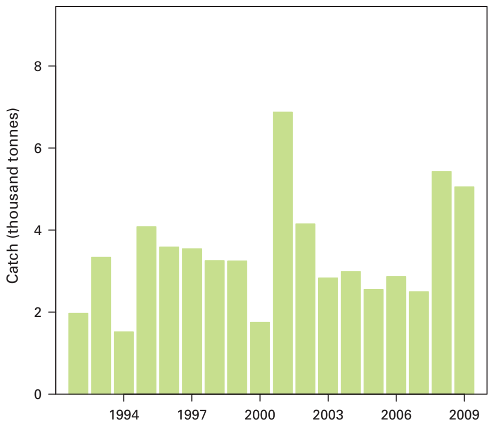


FIGURE 5.5 White banana prawn catch history, 1992 to 2009

Stock status determination

In preparation for the introduction of separate TACs for red-legged banana prawns and white banana prawns, research was undertaken to determine the most appropriate spatial demarcation of the two species (Venables 2009). NPRAG agreed to recommend a boxed area west of longitude 129.3567° and south of latitude 12°S, which separates red-legged banana prawns in the Joseph Bonaparte Gulf (accounting for 80–90 % of the catch) from the balance of the fishery. No white banana prawn catch is taken west of the line in Joseph Bonaparte Gulf.

Two new assessment models were developed for red-legged banana prawns in 2009—a biomass dynamics (production) model (Zhou 2009) and a delay difference model (Plaganyi et al. 2009). The results from these models have not yet been used to make decisions for management purposes and are still being refined. Preliminary results of the delay difference model for the reference case indicate that the spawning biomass had declined in 1999 to as low as 21% of the high 1984–1987 biomass level near the beginning of the fishery, and subsequently increased to some 82% of the initial level. The 2007 depletion was estimated at 60% of unfished levels, with catches remaining low and stable (Fig. 5.4).

There has been no evidence of declining recruitment. Given some of the biological similarities between this species and the

Sorting catch PHOTO: RHYS ARANGIO, AUSTRAL FISHERIES

Sorting catch PHOTO: RHYS ARANGIO, AUSTRAL FISHERIES

white banana prawn (Table 5.5; including the environmental influence on recruitment), the depletion adoption of the HS, lack of evidence for recruitment overfishing and reductions in fleet size, the red-legged banana prawn stock is assessed as **not overfished** and **not subject to overfishing** (Table 5.1).

In recent years, there has been concern over the status of white banana prawns in the Weipa region because of low catches compared with historical levels. That concern has been allayed by better catches in 2008 and 2009 (Fig. 5.5). Fishing mortality is high for white banana prawns but, with the reduction in fleet size, adoption of the HS and lack of evidence of recruitment overfishing, white banana prawn is assessed as **not overfished** and **not subject to overfishing** (Table 5.1).

The HS for banana prawns, developed in 2007, is mainly focused on white banana prawns. The strategy aims to allow enough prawns to escape to ensure an adequate spawning biomass of banana prawns, maximise the economic returns from the fishery and minimise the take of tiger prawns during the banana prawn season. The six week season length is based on an analysis of historical records, which indicates that six weeks of fishing is sustainable. The catch indicator for extending the fishing season, of 500 kg per vessel per day was derived by taking an average of the catches of the fourth fishing week in the most productive banana prawn seasons over a 10-year period and dividing by the number of vessels.

Trawling for prawns PHOTO: RHYS ARANGIO, AUSTRAL FISHERIES

Reliability of the assessment/s

The reliability of the status assessment is moderate for both banana prawn species. There remains a need to monitor and assess banana prawns across the fishery as a set of spatially separate stocks. This may also need to be reflected in the HS for the fishery.

Previous assessment/s

The relationship between spawning stock size and subsequent recruitment levels for banana prawns is weak or at least poorly defined. Because of this, stock assessment of white banana prawns has generally proven difficult, with limited means for estimating yield in the next season. Based on average annual catches, the sustainable long-term annual yield is thought to be around 4000 t. Management of the banana prawn fishery has focused on preventing growth overfishing and providing higher returns by minimising the capture of small prawns.

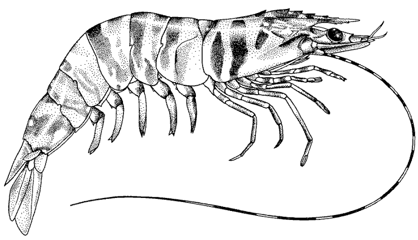
In the mid-1980s, a relationship was found between white banana prawn catches and environmental factors (particularly rainfall) in the south-eastern Gulf of Carpentaria. However, in the late 1990s this relationship appeared to break down, with substantial differences between the predictions and banana prawn catches.

Future assessment needs

Work needs to continue to develop and refine stock assessment of white banana prawns and red-legged banana prawns and understand the impact of fishing on the species. The new stock assessment models of red-legged banana prawns will be important for TAC setting in future. There is a need to further develop a scientifically defendable process for setting TACs for white banana prawns. Investigation of the stock–recruitment relationship for white banana prawns is a continuing priority.

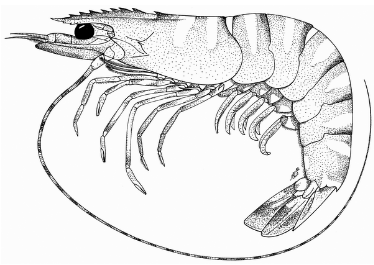
TIGER PRAWNS

Brown tiger prawn (*Penaeus esculentus*)



LINE DRAWING: FAO

Grooved tiger prawn (*Penaeus semisulcatus*)



LINE DRAWING: KARINA HANSEN

Prawn trawlers PHOTO: MIKE GERNER, AFMA

TABLE 5.6 Biology of tiger prawns

Parameter	Description
General	Tiger prawns use coastal and estuarine seagrass beds as nursery habitat. Brown tiger prawns prefer seagrass along exposed coastlines as nursery areas. Grooved tiger prawns prefer more sheltered seagrass beds in estuaries. Though short lived, tiger prawns are only moderately resilient to fishing pressure. There is a relatively good relationship between parental biomass and subsequent recruitment.
Range	**Species:** Northern Australia and tropical Indo-Pacific **Stock:** Primarily southern and western Gulf of Carpentaria, but extending westwards towards Joseph Bonaparte Gulf
Depth	Adult brown tiger prawns occur at 10–20 m over coarse sediments. Grooved tiger prawns mostly occur over fine mud sediments in deeper waters.
Longevity	1–2 years
Maturity (50%)	**Age:** ~6 months **Size:** 32–39 mm CL
Spawning season	August–October and January–February, both of which contribute to the fishery in the following year. Brown tiger prawns move offshore between November and January, whereas grooved tiger prawns do so between January and April.
Size	**Maximum:** 55 mm carapace length **Recruitment into the fishery**: 3–6 months

CL = carapace length

SOURCES: Somers (1987); Yearsley et al. (1999).

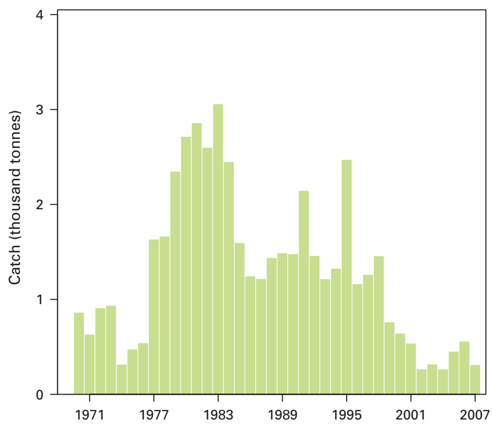


FIGURE 5.6 Brown tiger prawn catch history, 1969 to 2007

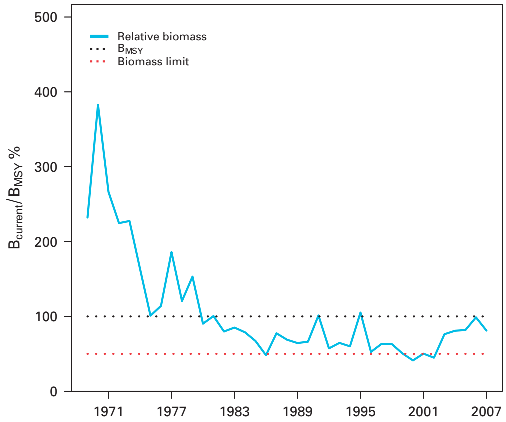


FIGURE 5.7 Brown tiger prawn biomass, 1969 to 2007

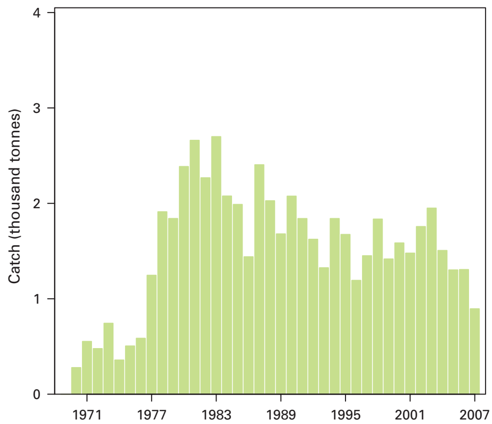


FIGURE 5.8 Grooved tiger prawn catch history, 1969 to 2007

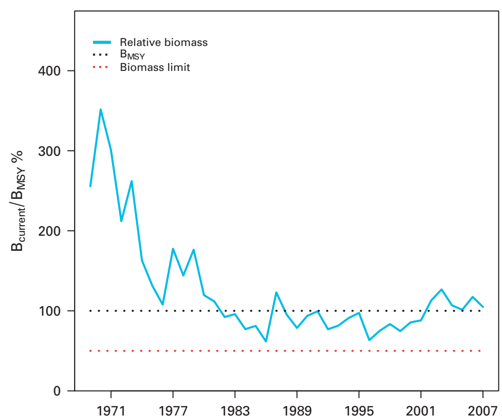


FIGURE 5.9 Grooved tiger prawn biomass, 1969 to 2007

Stock status determination

The most recent assessment of the tiger prawn fishery took place in 2008 and the next assessment is due in 2010. A full bioeconomic assessment (CSIRO 2008) was undertaken that incorporated the stock assessments of the two tiger prawn species, as well as a range of variable costs and projections of future prices. The full bioeconomic assessment also had a preliminary endeavour prawns model, with endeavour prawns treated as an economic byproduct. The model was therefore able to estimate the range of biological and economic management measures referred to in the HS. The abundance indices derived from the fishery independent surveys were incorporated into the assessment as a sensitivity test.

The brown tiger prawn spawning stock biomass was estimated to be 68–80% of SB_{MSY}, (Fig. 5.7) and the 2006 fishing effort was 21–23% of E_{MSY} across four sensitivity scenarios tested (annual catches shown in Fig. 5.6) (CSIRO 2008). The grooved tiger prawn spawning stock biomass was estimated to be 97–117% of SB_{MSY} (Fig. 5.9) and the 2007 fishing effort was 43–44% of E_{MSY} across the four scenarios (annual catches shown in Fig. 5.8). These values represent the central estimates (medians) over the range of scenarios. The biomass estimates are more pessimistic than the previous (2006) estimates, particularly for brown tiger prawns.

The brown tiger prawn spawning stock biomass was estimated to be 74% of B_{MEY}, and the 2007 fishing effort was 24% of E_{MEY} (median of base-case high). The grooved tiger prawn spawning stock biomass was estimated to be 83% of B_{MEY}, and the 2007 fishing effort was 68% of E_{MEY}.

The 2008 assessment suggests that both tiger prawn species are **not overfished** relative to the limit reference point of $0.5SB_{MSY}$ (five-year moving average) specified in the NPF HS. It also suggests that both species are **not subject to overfishing** (Table. 5.1), with effort levels well below E_{MSY}.

Provided that no species is assessed as overfished, the bioeconomic assessment estimates the sequence of future effort levels that will maximise profit over a 50-year

projection period. A meta-rule prevents setting of annual effort at less than half of that directed towards tiger prawns in 2007—effectively to prevent the tiger prawn fishery from closing in a year, purely on economic grounds. The bioeconomic assessment and application of the HS resulted in tiger prawn effort levels of 5142 nominal vessel days for 2008 (no change from 2007) and 6499 for 2009 (an increase of 26.4% on 2008). NPRAG recommended that part of the effort increase could be taken up in 2008 rather than all in 2009. The group proposed an 8% effort increase in 2008, followed by a further effort increase in 2009 calculated at 18.48%, in accordance with the revised MEY trajectory. Under the NPF input control system, changes to fishing effort can be made by changing the total allowed headrope length or by changing the number of days fished (through season lengths). Thus for 2008, the 8% increase in nominal vessel days was brought about by allowing a headrope length increase of 33% (according to an established relationship between days and headrope length). In 2009 the effort increase was given effect by a planned four-week increase in the length of the tiger prawn season. In fact, the season ran for only an additional two weeks because the tiger prawn catch rates fell below the trigger level specified in the HS.

During 2009 there was considerable research into stock assessment methodologies for tiger prawns, including development of a new size-structured population dynamics model for both tiger prawn species. NPRAG has adopted this model as the new assessment approach.

Reliability of the assessment/s

The tiger prawn biological assessment is well developed, incorporating improvements in the modelling of changes in fishing power and the species composition of the catch. A number of assumptions are required for the parameters in the assessment model. The sensitivity of the outputs to those assumptions is examined by modelling a range of scenarios. Fishery-independent surveys are now being used in the stock assessments, helping to overcome reliance on logbook data.

The economic component of the full bioeconomic assessment is quite sensitive to assumptions of future prices for fuel and prawns, as well as the degree to which future profit is discounted. Clearly, such prices are very difficult to predict with any certainty. Moderate changes to these prices can have a marked effect on the sequence of future annual effort levels that are predicted to provide the most profitable pathway to the target of MEY.

The reliability of the tiger prawn biological assessment is regarded as high, and the reliability of the economic assessment is regarded as moderate.

Previous assessment/s

The 2006 assessment incorporated new research to separate catches between grooved and brown tiger prawns, and this had a substantial impact on the assessment results. Under the conservative scenarios, the assessment indicated that both species of tiger prawn were below B_{MSY}. The 2006 bioeconomic model indicated that the fishery's economic yield was 74% of its maximum potential, and that the 'optimal' number of vessels was around 45.

The 2007 assessment used four scenarios for fishing power and catchability and the new tiger prawn species-split method. The grooved tiger prawn spawning stock biomass was estimated to be 111–148% of B_{MSY}, and the 2006 fishing effort was 36–55% of E_{MSY} across the four scenarios tested. The brown tiger prawn spawning stock biomass was estimated to be 96–139% of B_{MSY}, and the 2006 fishing effort was 36–63% of E_{MSY} across the four scenarios.

Future assessment needs

The move to an MEY target for the tiger prawn fishery has put a greater emphasis on obtaining comprehensive financial and economic data from the fishery. The accuracy of those data, along with forecasts of future economic conditions (such as currency exchange rates and fuel prices), is critical to the application of the bioeconomic model. There is a continuing need to develop assessments that can support the change to

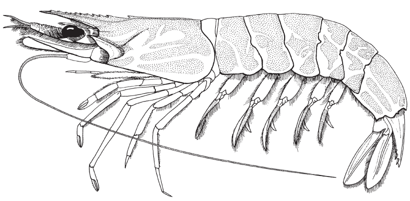
a system of individual transferable quotas, including an ability to forecast the following year's recruitment and a corresponding recommended TAC. There will also be a need to understand the effect of the introduction of TACs on the fleet's functioning, efficiency and effective effort applied to the various species.

High-priority research needs are:

- developing better methods for assessing stock status and setting TACs
- improving the efficiency of fishing gear and techniques to reduce bycatch, increase the survival of bycatch and reduce environmental impacts on the benthos
- increasing the cost-effectiveness of management and making fishing more economically efficient.

ENDEAVOUR PRAWNS

Blue endeavour prawn
(*Metapenaeus endeavouri*)



LINE DRAWING: FAO

Red endeavour prawn
(*Metapenaeus ensis*)

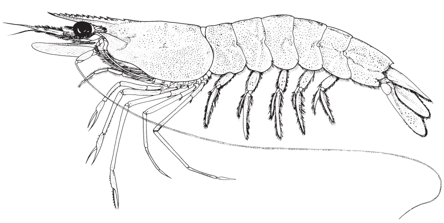


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TABLE 5.7 Biology of endeavour prawns

Parameter	Description
General	Endeavour prawns use coastal and estuarine seagrass beds as nursery habitat. Red endeavour prawn juveniles also use mangrove sand/mud flats. Adult blue endeavour prawns prefer less muddy habitats, whereas adult red endeavour prawns prefer muddier habitats. Endeavour prawns probably have fishing resilience similar to that of tiger prawns.
Species range	**Species:** Blue endeavour prawns are endemic to northern Australia. Red endeavour prawns are distributed across the tropical Indo–west Pacific region. **Stock:** Presumed common stock within Gulf of Carpentaria for assessment purposes.
Depth	Blue endeavour prawns: 10–60 m (but mainly 20–40 m) Red endeavour prawns: 10–60 m (but mainly 30–50 m)
Longevity	1–2 years
Maturity (50%)	**Age:** ~6 months **Size:** ~3 cm CL
Spawning season	Blue endeavour prawns: spawn year round, but major season is August–October. Red endeavour prawns: major spawning is September–December. Both species move offshore to deeper waters (>40 m) to spawn.
Size —Blue endeavour prawn	**Maximum:** 20 cm **Recruitment into the fishery:** not determined
—Red endeavour prawn	**Maximum:** 18 cm **Recruitment into the fishery:** not determined

CL = carapace length

SOURCES: Somers (1987); Yearsley et al. (1999).

Stock status determination

During 2009 there was considerable research and development of new assessment models for blue endeavour prawns. Three stock assessment models have been developed. They are, in order of increasing data usage and complexity, a biomass dynamics model, a delay difference model and a size-based model (see Punt et al. 2009). The biomass dynamics model uses only the catch, effort and an index

of abundance, while the size-structured model uses catch, an index of abundance, surveyed abundance, length composition, and tagging data. The base case of the three models estimated spawning stock biomass to be 57% of B_{MSY} for the biomass dynamics model, 55% of B_{MSY} for the delay difference model and 80% of B_{MSY} for the size model. There is clearly some model uncertainty around relative biomass estimates, and there is no definitive way to identify which model is best. The models use different data sources; in principle, models that use more of the available data and explicitly account for biological processes should lead to more accurate estimates.

The depletion of 55–80% of B_{MSY} from the various models can be compared to a limit reference point of 50% of B_{MSY}, as is used for NPF tiger prawns. A limit reference point is not formally defined for blue endeavour prawns in the NPF HS (Dichmont & Jarrett 2007) and therefore the proxies from the HSP apply. Blue endeavour prawns are therefore assessed as **not overfished** (Table 5.1). Projections of future biomass with fishing according to the HS (Dichmont et al. 2007) indicate that biomass should recover towards and above B_{MSY}. Blue endeavour prawns are therefore assessed as **not subject to overfishing**. The next stock assessment of blue endeavour prawns will be in 2010.

A biomass dynamics model is in development for red endeavour prawns but is not yet ready to be used for determining stock status. The status of red endeavour prawns is **uncertain** with respect to both overfished and overfishing classifications.

Reliability of the assessment/s

Reliability of the assessment is low for red endeavour prawns, and medium for blue endeavour prawns.

Previous assessment/s

The long-term yield estimate for endeavour prawns was previously reported as 500 t, but that figure was not based on a rigorous assessment. Catches were variable but lower from 2000 to 2007 (average 524 t) than in previous decades (1990–99: 1056 t; 1980–89: 1406 t). The gear and fleet reductions, as well as changes in the length and timing of the fishing season or changes in the spatial distribution of fishing effort, may have contributed to the smaller catches.

Future assessment needs

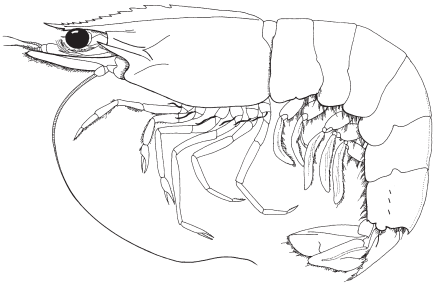
The stock assessments for blue endeavour prawns could be further refined and, when appropriate, reference points for this species should be included in the HS. The information base and stock assessment for red endeavour prawns need further development so that they can be relied upon to provide stock status.

Endeavour prawns PHOTO: MIKE GERNER, AFMA

Processing the catch PHOTO: MIKE GERNER, AFMA

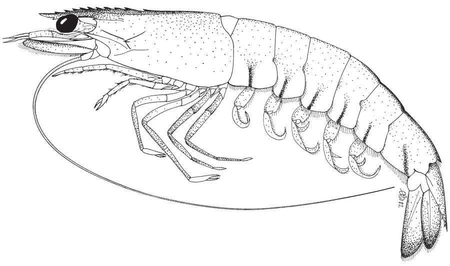
KING PRAWNS

Red-spot king prawn (*Melicertus longistylus*)



LINE DRAWING: FAO

Western king prawn (*Melicertus latisulcatus*)



LINE DRAWING: FAO

Bycatch research PHOTO: MIKE GERNER, AFMA

TABLE 5.8 Biology of king prawns

Parameter	Description
Range —red-spot king prawn	**Species:** Northern Australia and Indo–west Pacific, usually in proximity to coral reefs. Main fisheries and centres of abundance are outside the NPF area. **Stock:** Assumed to be the same as the fishery.
—western king prawn	**Species:** Southern and northern Australia, as well as Indo–west Pacific. Main fisheries and centres of abundance are outside the NPF area. **Stock:** Assumed to be the same as the fishery.
Depth	Adult red-spot king prawns are found to around 60 m on hard sand or mud. Western king prawns are found to a depth of more than 200 m, but mainly less than 80 m, on a wide range of substrates.
Longevity	Red-spot king prawn: 1–2 years Western king prawn: up to 4 years, but likely to be less in NPF
Maturity (50%)	**Age:** ~6 months **Size:** ~3.5 cm CL
Spawning season	Red spot king prawn: autumn and spring Western king prawn: summer in southern Australia, but variable elsewhere
Size —red-spot king prawn	**Maximum:** 21 cm **Recruitment into the fishery:** not determined
—western king prawn	**Maximum:** 20 cm **Recruitment into the fishery:** not determined

CL = carapace length; NPF = Northern Prawn Fishery

SOURCES: Yearsley et al (1999).

Stock status determination

In 2009 the two species of king prawns (Table 5.8) in the NPF are assessed as a basket stock with a combined status. Catches of king prawns peaked in the 1980s, averaging around 100 t—around 1% of the total prawn catch from the NPF. King prawns are not targeted by trawlers and catches have fallen since the late 1990s and are currently less than 20 t—less than 0.5% of the total prawn catch. There was previously concern over king

prawn status following this fall in catches, but the fall has now been attributed to changes in fleet behaviour brought about by management (seasons and closures) or other drivers, as well as variability in the rate of reporting of king prawn catches. Since surveys commenced in 2003, the densities of western king prawn have been somewhat variable (1.11–2.17 prawns/ha, spawner survey), showing occasional spikes but no concerning trends. Surveyed densities of red-spot king prawns have been too low to provide a meaningful index. Both species were given a low risk ranking in the Level 2 ecological risk assessment (AFMA 2008).

King prawns are assessed as **not subject to overfishing** and their overfished status is **uncertain** (Table 5.1). In the next (2010) *Fishery status reports*, king prawns will be treated as a minor byproduct species and not given a formal status, assuming catches of these prawns remains low and fishing practices do not change.

Reliability of the assessment/s

Reliability of the assessment is low for both species of king prawns.

Previous assessments

None.

Future assessment needs

None identified.

5.5 ECONOMIC STATUS

Economic performance

The Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences (ABARE–BRS) has conducted economic surveys of the NPF since the early 1990s. This has allowed the calculation of net economic returns (NER) and financial performance measures. ABARE–BRS's most recent survey of the NPF was released as part of the Australian fisheries surveys report 2009 (see Vieira & Perks 2009). In addition to survey-based estimates of economic performance for 2006–07 and 2007–08, the report also includes non-survey–based forecasts of NER for 2008–09.

Net economic returns

Although NER were negative for the three years between 2004–05 and 2006–07 (Fig. 5.10), they are estimated as positive in 2007–08 and 2008–09. In 2008–09 non-survey based forecasts estimate that NER were $11.0 million. This is a 36% increase on 2007–08, when NER were $8.1 million.

This improved result can be attributed to several factors. The higher catches of banana prawns in 2007–08 and 2008–09 have greatly increased total catch in the fishery. In addition, the removal of less efficient vessels from the sector, through the *Securing our Fishing Future* structural adjustment package, has improved the cost structure of the fishery. This cost effect has potentially been magnified by recent improvements in the tiger prawn stock, ensuring that costs have been reduced for any given catch level. The MEY management target for the fishery and various management decisions that have been made in line with it (see above, under 'History of the NPF') have also contributed to the improved profitability of the fishery.

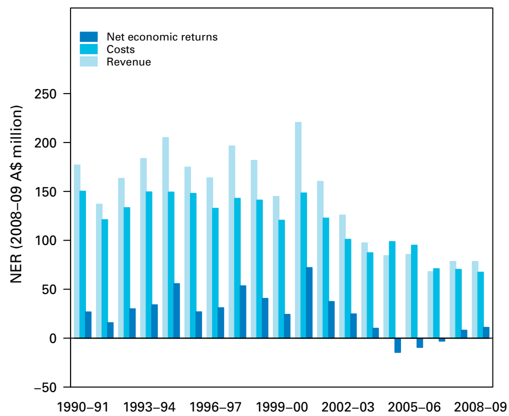


FIGURE 5.10 Net economic returns for the NPF by financial year, 1990–91 to 2008–09 (in 2008–09 dollars)

NOTE: Net economic returns for 2008-09 are estimated using non-survey based methods

SOURCE: Vieira & Perks (2009).

Output-to-input ratio

A fishery level output-to-input ratio can indicate how effectively key fishing inputs have been used to harvest catch over time but also reflects changes in stock abundance. The ratio presented here takes the form of an index that combines time-series indexes of fishery output (fish catch) and key input use (labour, capital, fuel and repairs) (Vieira et al. 2010).

Between 2004–05 and 2008–09, the average annual increase in the output-to-input ratio was 17%. The largest increase occurred in 2007–08, when the ratio increased by 53% (Fig. 5.11). The relatively large increase in the output-to-input ratio between 2006–07 and 2007–08 was partly driven by above-average catches of banana prawns in 2007–08 and 2008–09. These catch levels are attributable to favourable environmental conditions and should be considered an external positive impact on fishery economic performance. In an average year, catches of tiger prawn are the major influence on fishery profitability. Output of tiger prawns was at record lows in 2007–08 and 2008–09.

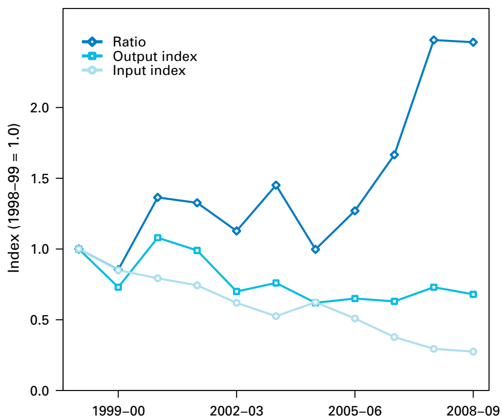


FIGURE 5.11 Output-to-input ratio for the NPF, 1998–99 to 2008–09 (1998–99 base year)

SOURCE: Vieira et al. (2010).

Vessel-level performance

There was a considerable increase in GVP per vessel between 2005–06 and 2008–09 (Fig. 5.12). The increase can be largely attributed to changes in vessel-level catches, but was also affected by prawn prices. Over this period, GVP per vessel increased by 45%, which is significantly less than the 89% increase in catch over the same period. This indicates that the average price per kilogram of catches has fallen. The fall reflects both falling prices for prawns and the increase in the relative proportion of the total catch made up by banana prawns (which receive lower prices relative to tiger prawns).

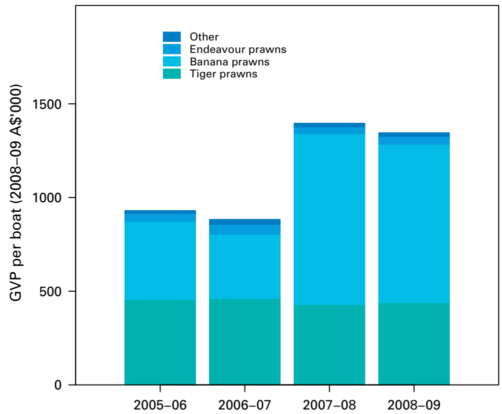


FIGURE 5.12 GVP by species per vessel in the NPF, 2005–06 to 2008–09 (2008–09 dollars)

SOURCE: ABARE–BRS (unpublished data).

Vessel-level costs in the NPF increased between 2005–06 and 2007–08, as can be seen from Fig. 5.13. In 2005–06, vessel-level costs were more than $1.1 million per vessel but by 2008–09, had risen by 11% to more than $1.2 million.

Prawn trawl catch PHOTO: MIKE GERNER, AFMA

Costs, at the vessel level, can largely be explained by changes in effort and catch, both of which affect the key cost items. Between 2005–06 and 2008–09, labour costs, increased by 41%, while other costs—such as freight, marketing and packaging that are linked to catch—increased by 10%. Fuel costs, which are more strongly linked to effort and the price of fuel, fell by 5% over the same period.

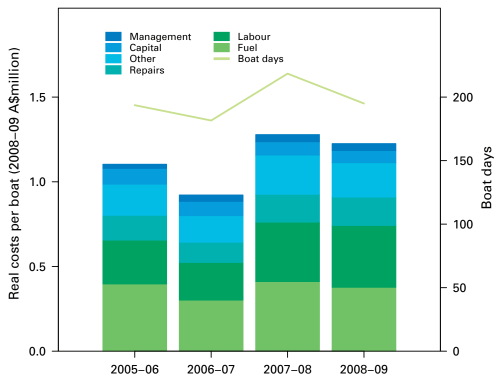


FIGURE 5.13 Real costs per vessel by cost category and vessel days per vessel for the NPF, 2005–06 to 2008–09 (2008–09 dollars)

SOURCE: Vieira et al. (2010).

Overall economic status

Economic conditions in the fishery have improved since 2007–08. The removal in 2006 of fishing concessions through the fisheries structural adjustment component of the *Securing our Fishing Future* package has effected the profitability of the fishery. The removal of operators from the fishery through this package has allowed catch per vessel to increase and lowered operational costs (see Vieira et al. 2010). Combined with the improved economic conditions faced by fishers in 2008–09, this has resulted in the fishery becoming increasingly profitable.

Prices of tiger prawns and the exchange rate between the Yen and Australian dollar have a typically inverse relationship; as the Australian dollar appreciates, prices of tiger prawns typically fall and vice versa (Fig. 5.14). The sharp depreciation of the Australian dollar in 2008–09 benefited producers, as it resulted in a 23% increase in prices received. This helped to offset the decline in tiger prawn production.

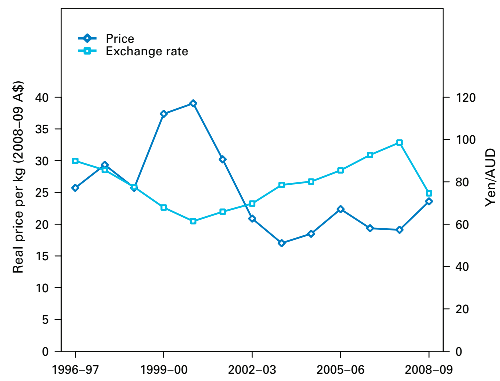


FIGURE 5.14 The Yen/Australian dollar exchange rate and real price of NPF tiger prawns, 1996–97 to 2008–09

SOURCE: ABARE–BRS (unpublished data).

Fuel costs accounted for 34% of total operating costs in the fishery in 2007–08. This was slightly lower than in the previous two years. Figure 5.15 shows that fuel expenditures and the off-road diesel price trend together. Given the slight decline in the off-road diesel price in 2008–09, fishers may have benefited from reduced fuel expenditures. However, the price of off-road diesel is still relatively high.

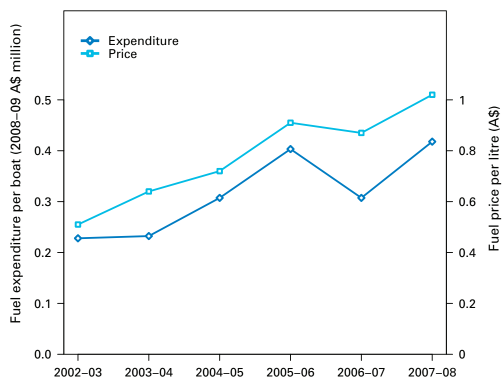


FIGURE 5.15 Off-road diesel price and fuel expenditures in the NPF, 2002–03 to 2007–08

SOURCE: ABARE–BRS (unpublished data).

It is important to note that, while economic conditions improved in 2008–09, environmental conditions were also favourable. The combination of high stock levels

and the aggregating behaviour of banana prawns allowed large catches to be taken at a relatively low cost, as was the case in 2007–08. However, this is not the case in every season. This environmental variability will have a considerable impact on the future economic performance of the NPF. However, the improved profitability in the NPF, in conjunction with improvements in tiger prawn stock biomass, suggests that the fishery is moving toward an effort level that maximises economic returns from the fishery.

Future considerations

A large amount of information exists for this fishery, aiding effective management and informing industry decisions. Vieira et al. (2010) show that profitability in the fishery has improved since the structural adjustment package concluded in late 2006. However, they also note that improved management arrangements will have to be implemented if the benefits of the structural adjustment are to be preserved. Output controls are currently being developed as a replacement for input controls (AFMA 2009b). Such a move, in conjunction with binding TACs, will increase the likelihood of maximising the economic yield from the fishery.

5.6 ENVIRONMENTAL STATUS

Environmental issues within the NPF include the high proportion of bycatch relative to product (Raudzens 2007) and interactions with a diverse array of marine species, including six turtle species, more than 12 sea snake species, some 50 chondricthyan species, and hundreds of species of scalefish and invertebrates. Survival rates after release are variable, but generally low for fishes and higher for some invertebrates (Brewer et al. 2007). There are also potential impacts of trawling on benthic communities as a whole.

The NPF has a long history of research into environmental matters, particularly bycatch. The industry has been involved through crew-member monitoring of bycatch and evaluating the effectiveness of bycatch reduction measures. In the NPF, most of the bycatch comprises small fish and invertebrates. In 2001 mandatory use of bycatch reduction devices (BRDs) was introduced to enable small bycatch to escape. Without BRDs, the ratio of prawn product to bycatch is around 1:10, but the use of a BRD, such as the Popeye Fishbox, can reduce this to around 1:5 (Raudzens 2007). The NPF was the first fishery to develop a bycatch action plan, which has been updated in 2009 as the NPF Bycatch and Discarding Workplan, 1 July 2009 – 30 June 2011 (AFMA 2009b). The plan contains strategies for species with high ecological risk; interactions with threatened, endangered and protected (TEP) species; and minimising overall bycatch and target discarding in the fishery.

Following an AFMA submission in October 2008, the NPF has been granted an exemption from export restrictions under the *Environment Protection and Biodiversity Conservation Act 1999* for a period of five years, until 9 January 2014.

Management of the NPF involves closure of significant areas to trawling to protect prawn nursery grounds (such as seagrass beds) or to improve biological or economic performance of the fishery (for example, by reducing catches of small prawns or targeting of spawning prawns) (Kenyon et al. 2005).

Non-compliance with BRD or other environmental requirements is a serious issue and would change the results of ecological risk assessments that were undertaken on the assumption of compliance. There would also be ramifications for the compliance risk profile of the fishery, with higher levels of compliance and scientific observer action required.

Ecological risk assessment

Ecological risk assessment (ERA) of the NPF has been completed using Level 1, 2 and 2.5 methodologies (see Chapter 1), with higher risk or higher priority taxa assessed at high (more quantitative) levels. Overall, the ecological units assessed include nine target species, 135 byproduct species, 516 discard species

(chondrichthyans and teleosts only), 128 TEP species, 157 habitats and three communities.

Following review of the Level 2 Productivity Susceptibility Analysis (PSA) risk rankings using residual risk guidelines (AFMA 2008), 26 species remained at high risk. During and following the Level 2 PSA work, there were a number of Level 2.5 studies on selected taxonomic groups. Upon completion of all studies in 2009, seven species remained at high risk to fishing. An ecological risk management report has been developed that outlines how AFMA intends to manage the effects of fishing on these seven priority species (see AFMA 2009c).

Threatened, endangered and protected species

Sharks and rays

A total of 51 elasmobranch species have been recorded in NPF catches. Five sawfish species were assessed by the Level 2 ERA as high risk, due to low fecundity and high susceptibility to being caught in nets (see AFMA 2008). Following this, a Level 3 ERA of NPF elasmobranchs (Brewer et al. 2007) found three 'at-risk' elasmobranch species (banded wobbegong—*Orectolobus ornatus*; blotched fantail ray—*Taeniura meyeni*; porcupine ray—*Urogymnus asperrimus*). The Level 3 ERA assessed the vast majority of the NPF elasmobranch bycatch species as sustainable, including sawfish species, but noted that cumulative impacts from other fisheries in the region have not yet been accounted for. Turtle excluder devices (TEDs) have been effective in mitigating bycatch of larger sharks, but less effective for sawsharks because of entanglement.

Marine turtles

TEDs became compulsory in the NPF in 2001, reducing the bycatch of turtles from approximately 5700 animals per year (before 2001) to approximately 30 per year (after 2001) (Griffiths et al. 2007). Coupled with industry education programs, these devices have clearly been effective in reducing marine turtle bycatch and, to some extent, bycatch of other large species. In 2009 logbooks reported that 36 turtles were caught. Of these, 33 were released alive and three were dead. The low catch of turtles has allowed accreditation of the NPF for export of prawns to the United States, which has a strict requirement to limit interactions.

Seabirds

The Level 2 ERA examined interactions with 12 seabird species. One was assessed as medium risk (streaked shearwater—*Calonectris leucomelas*) and 11 as low risk.

Sea snakes

Seven sea snake species were assessed by the Level 2 ERA as high risk, due to low fecundity and a high susceptibility to drowning in trawls (AFMA 2008). Separate research (Milton et al. 2008) developed indices of abundance for 10 sea snake species using sampling during 1976 to 2007. These showed that the abundances of most species, and all sea snake species combined, have been relatively stable over the 30-year period. Two species (*Disteira kingii* and *Hydrophis pacificus*) showed evidence of recent declines in abundance on the fishing grounds, but the fishery was only affecting some 15% of the habitat of these species within the NPF area. Milton et al. (2008) also estimated fishing mortality (F), using trawl swept area versus habitat area methods, and compared it with the reference point (0.5F). This work showed that most species of sea snake were only lightly affected, with highest fishing mortality for all species less than half the level of the reference point. Introduction of newer BRD designs has been shown to be effective in reducing sea snake catch.

In 2009 there were 7369 sea snakes reported caught in logbooks. Of these, 6392 were alive, 652 were dead, 90 were injured and 235 had an unknown life status.

Benthic habitats

A Level 2 PSA analysis was undertaken for 157 habitats within the NPF area (Griffiths et al. 2007). Sixty-five habitats were assessed to be at medium risk, and 92

at low risk. However, with the productivity attribute scoring approach, shallow habitats are assumed to be quite productive, with good recovery rates; therefore, no NPF habitats appear to be at high risk.

5.7 HARVEST STRATEGY PERFORMANCE

Banana prawns

The HS applies to white banana prawns and red-legged banana prawns. No quantitative stock assessment is used in the HS; however, assessments are being developed for red-legged banana prawns.

There are no specific biomass targets and limits (or proxies) for the banana prawn fishery. Instead, historical records have been used to establish that the management regime of gear, season and spatial controls is likely to be sustainable with the current fleet. The pursuit of maximum economic returns is partly achieved by maximising yield (or value) per recruit. The start of the season is timed annually to target larger (and more valuable) banana prawns. The banana prawn HS is designed to perform under conditions of substantial variations in biomass that are thought to be largely independent of fishing. In good years, there is facility to take surplus yield through extension of the fishing season; in poor years, the default four-week season is intended to provide a level of escapement to avoid recruitment overfishing. The control rules are based on historical records and experience in the fishery; however, evidence for the decision rules in the HS would be useful. The HS does not appear to have any mechanism to deal with localised stock concerns (river catchment–associated stocks or substocks), such as that experienced off Weipa several years ago.

Tiger prawns

The objective for the tiger prawn fishery is long-term MEY from the suite of grooved tiger, brown tiger, blue endeavour and red

Prawn trawlers, Darwin harbour PHOTO: MIKE GERNER, AFMA

endeavour prawn stocks. Under the HS, a complete bioeconomic assessment of the tiger prawn fishery is undertaken every two years, using a combination of fishery-dependent and fishery-independent (survey) data. The assessment provides species-specific estimates of spawning biomass (SB) relative to SB_{MSY} and SB_{MEY}, as well as other indicators of stock status and fishery performance. The assessment also provides a pathway to MEY for the tiger prawn fishery as a whole by determining future annual effort levels that maximise profits over a projection period.

The limit reference point for each tiger prawn species is the five-year moving average of $0.5SB_{MSY}$ (half the spawning biomass needed to achieve MSY). If biomass falls below this level, the stock is defined by the HS as overfished, and directed fishing must cease. The five-year averaging is intended to account for short-term changes in biomass that relate to recruitment variability and the short lifespan of tiger prawns. The specific rationale for a five-year average, as opposed to a shorter period, is not detailed. It is conceivable that there could be serious recruitment failure over one or two successive years, so that the moving average limit reference point would not be triggered in a timely manner.

At present, the limit reference point does not apply to endeavour prawns because they have no stock assessment, or assessments are preliminary. Until the limit reference points can be applied to endeavour prawns, it would be preferable for their compliance with the HSP to be demonstrated in some other way.

The tiger prawn HS was subjected to management strategy evaluation (Dichmont et al. 2007). This generally indicated that, under the strategy, the biomass of stocks would be above S_{MSY} at the end of the seven-year projection period. Performance with respect to the actual HS limit reference point of $0.5SB_{MSY}$ has not been reported. However, the testing indicated there was a high probability (>90%) of stocks remaining above SB_{20} (20% of unfished stock size) under a broad range of scenarios and for both tiger prawn species.

5.8 LITERATURE CITED

AFMA (Australian Fisheries Management Authority) 2008, *Residual risk assessment of the level 2 ecological risk assessment species results,* report for the Northern Prawn Fishery.

——2009a, 'Northern Prawn Fishery', extract of register of held statutory fishing rights, AFMA, February 2009.

——2009b, *NPF Bycatch and Discarding Workplan, 1 July 2009 – 30 June 2011*, AFMA, Canberra.

——2009c, *Ecological risk management report for the Northern Prawn Fishery—Tiger and Banana Prawn Sub-Fisheries*, AFMA, Canberra.

Brewer, DT, Griffiths, S, Heales, DS, Zhou, S, Tonks, M, Dell, Q, Taylor, BT, Miller, M, Kuhnert, P, Keys, S, Whitelaw, W, Burke, A & Raudzens, E 2007, *Design, trial and implementation of an integrated, long-term bycatch monitoring program, road tested in the Northern Prawn Fishery,* final report on FRDC project 2002/035, CSIRO, Cleveland.

CSIRO (Commonwealth Scientific and Industrial Research Organisation) 2008, S*tatus of tiger prawn stocks at the end of 2006 in the NPF,* report to NPRAG.

DAFF (Australian Government Department of Agriculture, Fisheries and Forestry) 2006, *Northern Prawn Fishery Management Plan 1995*, DAFF, Canberra, Federal Register of Legislative Instruments F2006C00751.

Dichmont, CM, Deng, AR, Punt, AE, Ye, Y, Venables, WN, Zhou, S, Ellis, N, Kompas, T, Bishop, J & Gooday, P 2007, *Bringing economic analysis and stock assessment together in the NPF: a framework for a biological and economically sustainable fishery,* FRDC report 2004/022, FRDC, Canberra.

——& Jarrett, A 2007, *Northern Prawn Fishery (NPF) harvest strategy under input controls*, AFMA, Canberra.

Griffiths, S, Kenyon, R, Bulman C, Dowdney, J, Williams, A, Sporcic, M. & Fuller, M 2007, *Ecological risk assessment for the effects of fishing: report for the Northern Prawn Fishery*, report for the AFMA, Canberra.

Kenyon, RA, Jarrett, AE, Bishop, JFB, Taranto, TJ, Dichmont, CM & Zhou, S 2005, *Documenting the history of and providing protocols and criteria for changing existing and establishing new closures in the NPF, final report to AFMA (AFMA project R02/0881)*, AFMA, Canberra.

Milton, D, Zhou, S, Fry, G, & Dell, Q 2008, *Risk assessment and mitigation for sea snakes caught in the Northern Prawn Fishery,* final report, FRDC project no. 2005/051, FRDC, Canberra.

Plagányi, E, Bishop, J, Deng, R, Dichmont, CM, Hutton, T, Kenyon, R, Kienzle, M, Miller, M, Pascoe, S, Punt, AE, Venables, WN & Zhou, S 2009, *An assessment model of the NPF Red-legged Banana Prawn* (Penaeus indicus) *Fishery*, draft report to NPRAG.

Punt, AE, Deng, R, Zhou, S, Pascoe, S, Dichmont, CM, Plagányi-Lloyd, ER, Hutton, T, Venables, WN, Kenyon, R & van der Velde, T 2009, *On calculating effort and catch trajectories for species modelled using size, delay-difference and production models*, report to NPRAG.

Raudzens, E 2007, *At sea testing of the popeye fishbox bycatch reduction device onboard the FV* Adelaide Pearl *for approval in Australia's Northern Prawn Fishery*, AFMA, Canberra.

Rose, R & Kompas, T 2004, *Management options for the Australian Northern Prawn Fishery: an economic assessment*, ABARE eReport 04.12 prepared for the Fisheries Resources Research Fund, Canberra.

Somers, IE 1987, 'Sediment type as a factor in the distribution of commercial prawn species in the western Gulf of Carpentaria, Australia', *Australian Journal of Marine and Freshwater Research*, vol. 38, pp. 133–49.

Venables, B 2009, *Partitioning the NPF Banana Prawn Fishery into eastern and western regions for separate TAC allocation,* report to NPRAG.

Vieira, S & Perks, C 2009, *Australian fisheries surveys report 2009: survey results for selected fisheries, 2006-07 and 2007-08, preliminary estimates for 2008-09*, ABARE report prepared for the Fisheries Resources Research Fund, Canberra.

Vieira, S, Perks, C, Mazur, K, Curtotti, R & Li, M 2010, *Impact of the structural adjustment package on the profitability of Commonwealth fisheries*, ABARE research report 10.01, Canberra.

Yearsley, GK, Last, P. & Ward, RD (eds) 1999, *Australian seafood handbook: an identification guide to domestic species*, CSIRO Marine Research, Hobart.

Zhou, S 2009, *Stock assessment of red-legged banana prawns using multi-fleet Bayesian biomass dynamics model*, draft report to NPRAG.

6 North West Slope Trawl Fishery

A Sampaklis, M Chambers and T Pham

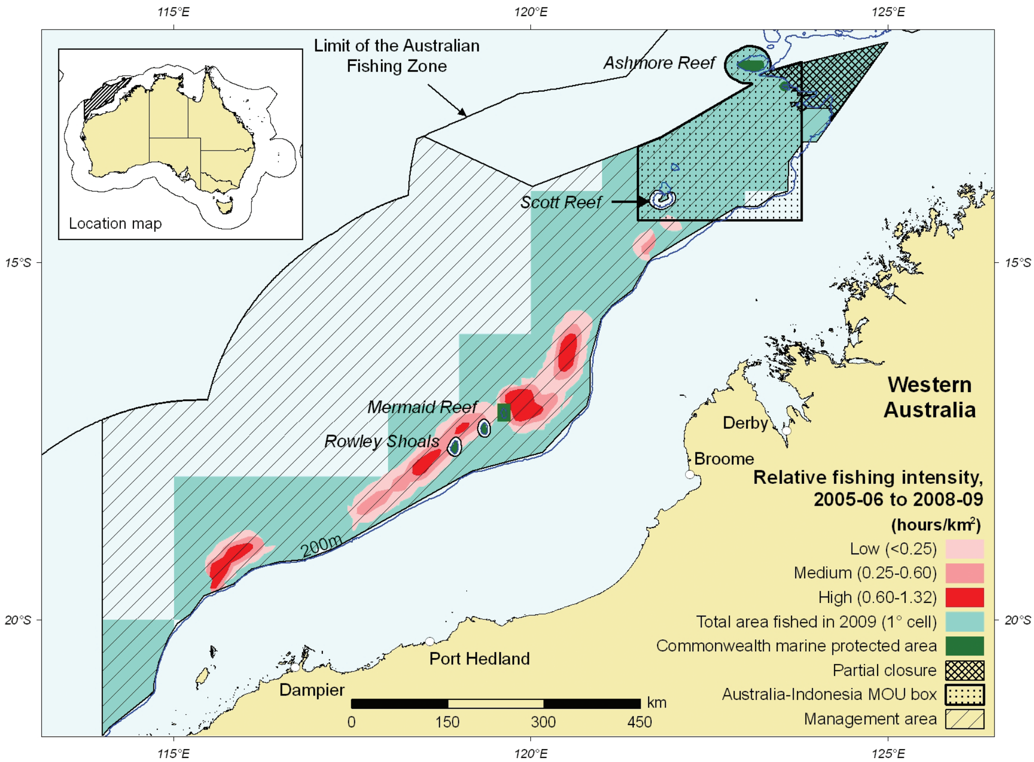


FIGURE 6.1 Relative fishing intensity in the North West Slope Trawl Fishery, 2005–06 to 2008–09

TABLE 6.1 Status of the North West Slope Fishery

Fishery status	2008		2009		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Deepwater prawns (6 spp.)	Not overfished / not subject to overfishing	Uncertain	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Prawn stock modelling indicates a biomass recovery. Fishing mortality was low.
Scampi (*Metanephrops australiensis, M. boschmai, M. velutinus*)	Uncertain	Uncertain	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Non-equilibrium surplus production models indicate stock is not overfished. Catches are considered sustainable.
Economic status Fishery level	Estimates of net economic returns not available				Economic status uncertain. High latency and low gross value of production indicate total net economic returns low.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING · OVERFISHED / OVERFISHING · UNCERTAIN · NOT ASSESSED

TABLE 6.2 Main features and statistics of the North West Slope Trawl Fishery

Feature	Description
Key target and byproduct species	Australian scampi (*Metanephrops australiensis*) Boschma's scampi (*Metanephrops boschmai*) Velvet scampi (*Metanephrops velutinus*) Red prawn (*Aristaeomorpha foliacea*) Royal red prawn (*Haliporoides sibogae*) Giant scarlet prawn (*Aristaeopsis adwardsiana*) Red striped prawn (*Aristeus virilis*) Red carid prawn (*Heterocarpus woodmasoni*) White carid prawn (*Heterocarpus sibogae*)
Other byproduct species	Goldband snapper (*Pristipomoides multidens*) Redspot emperor (*Lethrinus lentjan*) Saddletail snapper (*Lutjanus malabaricus*) See Table 6.4 for a list of other byproduct species.
Fishing methods	Demersal trawl
Primary landing ports	Darwin, Port Hedland, Broome
Management methods	Input controls: limited entry (7 permits), gear restrictions (codend mesh size ≤50 mm)
Management plan	*AFMA statement of management arrangements 2004* (AFMA 2004)
Harvest strategy	*Western Trawl Fisheries Harvest Strategy—North West Slope Trawl Fishery (NWSTF) and Western Deepwater Trawl Fishery (WDTF)* (AFMA 2007)
Consultative forums	The Western Trawl Fisheries Management Advisory Committee was disbanded on 1 July 2009 and replaced by a small consultative panel tasked with focusing on strategic issues in the NWSTF and Western Deepwater Trawl Fishery.
Main markets	Domestic: Perth, Sydney and Brisbane—fresh and frozen International: United States, Spain, China and Japan—frozen
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Current accreditation dated 28 September 2005 Current accreditation (Wildlife Trade Operation) expires 15 November 2010
Ecological risk assessment	Level 1: Scale Intensity Consequence Analysis (SICA) completed on 157 species (AFMA unpublished) Level 2: Productivity Susceptibility Analysis (PSA) completed on 7 species (AFMA unpublished) Level 2.5: REsidual Risk Assessment (AFMA 2010) Level 3: Draft Sustainability Assessment of Fishing Effects (SAFE) assessment completed (Zhou et al. 2009)
Bycatch workplans	*North West Slope Trawl Fishery Bycatch and Discarding Workplan (31 October 2008–1 November 2010)* (AFMA 2008)

Table 6.2 continues over the page

TABLE 6.2 Main features and statistics of the North West Slope Trawl Fishery CONTINUED

Feature	Description	
Fishery statistics[a]	**2007–2008 fishing season**	**2008–2009 fishing season**
Fishing season	1 July 2007–30 June 2008	1 July 2008–30 June 2009
TAC and catch by species —scampi —deepwater prawns	TAC Catch (tonnes) None 14.4 None 3.5	TAC Catch (tonnes) None 33.7 None Zero
Effort	2022 hours of trawling	2449 hours of trawling
Fishing permits	7	7
Active vessels	3	2
Observer coverage	53 trawl hours (2.6%)	0 trawl hours (0%)
Real gross value of production (2008–09 dollars)	Confidential (<5 vessels)	Confidential (<5 vessels)
Allocated management costs	$0.11 million	$0.14 million

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; ERA = ecological risk assessment; NWSTF = North West Slope Trawl Fishery; TAC = total allowable catch

a Fishery statistics are provided by fishing season unless otherwise indicated.

6.1 BACKGROUND

The North West Slope Trawl Fishery (NWSTF) operates off north-western Australia from 114°E to about 125°E, between the 200-metre isobath and the outer boundary of the Australian Fishing Zone, taking into account Australian–Indonesian maritime boundaries (MOU Box; Fig. 6.1). The NWSTF has traditionally targeted scampi and deepwater prawns (Tables 6.2, 6.3).

Offshore Constitutional Settlement (OCS) arrangements between the Commonwealth and Western Australian governments specify management jurisdictions. Under the terms of the OCS, the Commonwealth via the Australian Fisheries Management Authority (AFMA) has management responsibility for all marine species taken by trawl in waters deeper than 200 m, while the Western Australian Government via the Department of Fisheries has responsibility for species taken with non-trawl methods in these waters (except tunas) and for all trawling in inshore waters. The OCS arrangements are currently under review; a temporary area closure implemented in 2007 was considered again in October 2009 and extended until December 2010 while this review takes place.

The *Western Trawl Fisheries statement of management arrangements 2004* (AFMA 2004) aligns fishing seasons with financial years, and specifies a maximum of seven fishing permits, each valid for five years. Different vessels may fish on the same permit, provided that only one vessel is fishing at any time.

Scampi PHOTO: GAVIN KEWAN, AFMA

TABLE 6.3 History of the North West Slope Trawl Fishery

Year	Description
1985	Fishing commenced in the NWSTF.
1987	Management of the Western Trawl Fisheries commenced on 1 July with the first of a series of annual development plans.
1987 to 1990	Fishing effort peaked at 18 600 trawl hours and prawn catch (predominantly red prawn) peaked at 876 t.
1987 to 1992	Substantial decline in scampi and prawn catch rates.
1991 to 1996	Catch comprised largely deepwater prawns (mainly royal red prawns), with squid (mostly Hawaiian flying squid—*Nototodarus hawaiiensis*) an important byproduct. A shift towards targeting of scampi subsequently occurred because markets for deepwater prawns had become less profitable and catch rates had fallen. Since 1993–94, scampi has accounted for more than 70% of the total reported catch by weight in the fishery, and on average the fishery accounts for around 70% of Australia's total scampi production.
1996	Limited entry enforced through the issue of seven fishing permits.
1998	Recovery of scampi stocks confirmed through stock assessment.
2004	*Western Trawl Fisheries statement of management arrangements* (AFMA 2004) commenced in lieu of a management plan.
2005	A stock assessment by Lynch & Garvey (2005) indicated a decline in scampi stocks.
2006 to 2008	Targeted fishing of finfish (tropical snappers) saw the catch of scampi as a proportion of total catch by weight reduce to 33% and 19% from 2006 to 2008, respectively.
2007	Western Trawl Fisheries Harvest strategy adopted by AFMA. AFMA issued a direction that precluded fishing from areas in the north of the fishery <200 m for two years to reduce targeting of finfish such as goldband snapper, saddletail snapper and redspot emperor, and to amend the OCS boundaries.
2009	Western Trawl Fisheries Management Advisory Committee disbanded and replaced by a small consultative panel. The area closure in the north of the fishery extended until 31 December 2010. Consequently, the NWSTF has returned to a scampi-dominated fishery—in 2008–09, approximately 95% of the total reported catch was scampi.

AFMA = Australian Fisheries Management Authority; OCS = Offshore Constitutional Settlement; NWSTF = North West Slope Trawl Fishery

6.2 HARVEST STRATEGY

A combined Western Trawl Fisheries Harvest Strategy (HS), which applies to the NWSTF as well as the Western Deepwater Trawl Fishery (see Chapter 19), reflects the mixed-species composition and opportunistic nature of the two fisheries. The HS acknowledges that there are no target reference points in terms of maximum economic yield (MEY). It aims to strike a balance between precautionary management arrangements and allowing industry to capitalise on fishing opportunities, while emphasising the need to collect biological data.

There are three catch trigger rules to initiate management actions that progressively increase requirements on the fisheries for data collection and analysis (Levels 1 and 2) and establish limit reference points for the target stocks (Level 3). Separate triggers and control rules apply to vulnerable species identified through the ecological risk assessment (ERA) process; the Level 1 and Level 2 ERA results have not yet been published by AFMA.

The HS prescribes species-specific multilevel catch thresholds that initiate alternative management arrangements, such as catch limits and spatial closures. In the absence of other information or assessments, the triggers for target species are based on the highest historical catch. Level 1 is half the highest historical catch, Level 2 is the highest historical catch, and Level 3 is double the highest historical catch. In the case of the NWSTF, zone-specific trigger levels (based on relative historical catch) may in future be applied across three longitudinal areas.

The Level 1 trigger initiates an investigation to reveal why the trigger has been reached. This is undertaken through analysis of logbooks and examination of

standardised catch per unit effort (CPUE) data. It may also result in expert consultation and a possible revision of limit reference points. The Level 2 trigger results in stock assessments using biological parameters, such as size-specific fishing mortality, natural mortality, growth and reproduction. A revision of trigger values is also undertaken. Exceeding the Level 3 trigger results in a cessation of targeted fishing effort, pending a stock assessment and expert consultation.

The trigger values for target species in the NWSTF are:

- Level 1: scampi 50 t, prawns 9 t
- Level 2: scampi 100 t, prawns 18 t
- Level 3: scampi 200 t, prawns 36 t.

The HS also specifies control rules for species identified as high risk under the ERA framework. The measures include 50 animal move-on provisions for high-risk chondrichthyans (sharks). High-risk teleosts (bony fish) and crustaceans have two trigger levels: an intermediate trigger of 2 t (in effect initiating the same management responses as the Level 1 trigger for target species) and a catch limit of 4 t (Level 2).

6.3 THE 2009 FISHERY (2008–09 FISHING SEASON)

Key target and byproduct species

Two vessels were active in the fishery in 2008–09 and predominantly targeted scampi (Table 6.2). A total of 33.7 t of scampi were landed in 2008–09, but no deepwater prawns (Figs. 6.2, 6.3). Fishing effort in 2008–09 was approximately 2400 hours, roughly 20% higher than in 2007–08, but still much less than the peak of 18 600 hours in 1987–88.

In the past, vessels based in the Northern Prawn Fishery (NPF) have fished opportunistically in the NWSTF. This has not been the case in the past two years, and effort in the fishery has been dominated by vessels based in Western Australia, some of which also fish in the Western Deepwater Trawl Fishery and the Western Australian State fisheries (Table 6.3).

Boxed scampi PHOTO: GAVIN KEWAN, AFMA

The closure of the north-east extremity of the fishery in late 2007 (Fig. 6.1) resulted in a reduction in landings of tropical snappers and other finfish to negligible levels (<100 kg).

Deepwater prawns

Deepwater prawns have previously been considered a target in this fishery, with catches in the late 1980s accounting for most of the total landings by weight. It would appear that deepwater prawns have not been seriously targeted since the early 1990s, and these species are now classified as byproduct. Annual reported prawn catch has typically been less than 1 t in recent years, and no catch of deepwater prawns was recorded in 2008–09. Observer reports from the fishery suggest that the quantity of discarded prawn bycatch might be substantially higher than the recorded catch (AFMA pers. comm.).

Scampi

Total scampi catch (33.7 t) in the fishery in 2008–09 was more than double the catch recorded in the previous year. This is likely to be due in part to fishing effort being targeted at scampi rather than finfish. In addition, total trawl effort increased and catch rates were high relative to the previous 10 years.

Minor byproduct species

The combined catch of finfish in 2008–09 (1.5 t) was substantially lower than in 2005–06 and only a small amount of sharks were landed (approximately 0.1 t). A total of 22.6 t of finfish were landed over the period 2005–06 to 2008–09 (Table 6.4). Reductions in catch of goldband snapper (*Pristipomoides multidens*), redspot emperor (*Lethrinus lentjan*) and saddletail snapper (*Lutjanus malabaricus*) were particularly pronounced, owing to the temporary closure of depths below 200 m in the north-east of the fishery (implemented in 2007). Observer reports suggest that total discards might account for a large proportion (perhaps more than 80%) of total catches by weight; however, observer coverage in this fishery is low (zero in the 2008–09 fishing season) (Table 6.2).

Stocks of finfish in the area of the fishery were not assessed in 2009. An assessment of goldband snapper and redspot emperor in 2002 using an age-structured stock assessment model in the Western Australian Northern Demersal Scalefish Managed Fishery, adjacent to the NWSTF, indicated that breeding stock levels of tropical snappers were adequate to maintain the stock above limit reference points; there have been recent concerns about effort levels (Newman & Skepper 2007). The stock assessment is currently under review (Newman & Skepper 2009).

In order to reduce fishing pressure on tropical snapper stocks, AFMA implemented the closure in the north-east of the NWSTF in depths less than 200 m. The area closure lapsed in October 2009 but was renewed to 31 December 2010. Trigger limits for goldband snapper and red emperor were introduced through the HS review process to ensure sustainability of these species. An assessment of the extent and variety of byproduct (notably finfish) is among the most pressing research needs for the NWSTF, together with the collection of biological data for assessment purposes.

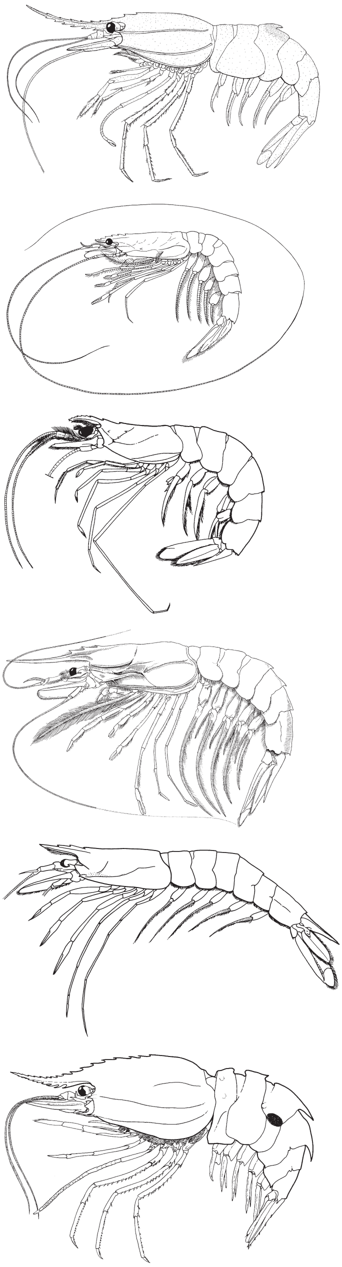
TABLE 6.4 Minor byproduct stocks in the NWSTF

Species	TAC or trigger	2005–06 to 2008–09 catch (tonnes)	2005–06 to 2008–09 discards (tonnes)
Goldband snappers (*Pristipomoides multidens*, *P. typus*)	None	49	1.3
Redspot emperor (*Lethrinus lentjan*)	None	31	0
Saddletail snapper (*Lutjanus malabaricus*)	None	15	0
Mixed fish	None	14	21
Squids (Teuthoidea)	None	3	0
Bigeye seabream (*Gymnocranius grandoculis*)	None	6	0
Red emperor (*Lutjanus sebae*)	None	4	0.3
Crimson snapper (*Lutjanus erythropterus*)	None	4	0
Painted sweetlip (Haemulidae, except *Pomadasys* spp.)	None	3	0
Pearl perch (*Glaucosoma* spp.)	None	2	0
Mangrove jack (*Lutjanus argentimaculatus*)	None	2	0
Spangled emperor (*Lethrinus nebulosus*)	None	2	0
Sweetlips (*Plectorhinchus* spp.)	None	1	0

6.4 BIOLOGICAL STATUS

DEEPWATER PRAWNS

(multiple species)



LINE DRAWINGS: FAO

TABLE 6.5 Biology of deepwater prawns

Parameter	Description
General	Deepwater prawn species vary in their life history traits, but all are found on sandy and/or muddy bottoms, making them susceptible to trawling. They have a low productivity compared with related inshore species.
Range	**Species:** Coastal waters worldwide. In Australia, they are distributed along the north-west, west and east coasts. **Stock:** A basket stock of six species, with red prawn (*Aristaeomorpha foliacea*) dominating historical catches.
Depth	250–800 m
Longevity	~5 years
Maturity (50%)	**Age:** ~1 year **Size:** 20–36 mm CL (for female *Aristaeomorpha foliacea*)
Spawning season	Royal red prawn is known to spawn biannually off New South Wales in February–April and July–August.
Size	**Maximum:** 55 mm CL (*Aristeus virilis*), 60 mm CL (*Aristaeomorpha foliacea*), 40 mm CL (*Heterocarpus sibogae*), 35 mm CL (*Heterocarpus woodmasoni*), 45 mm CL (*Haliporoides sibogae*), 80 mm CL (*Aristaeopsis edwardsiana*) **Recruitment into the fishery:** 1–4 years; size 20 mm CL (*Heterocarpus woodmasoni*, *H. sibogae*, *Haliporoides sibogae*), 30 mm CL (*Aristaeomorpha foliacea*, *Aristeus virilis*;), 40 mm CL (*A. edwardsiana*)

CL = carapace length

SOURCES: Wadley (1992a, b); Baelde (1994)

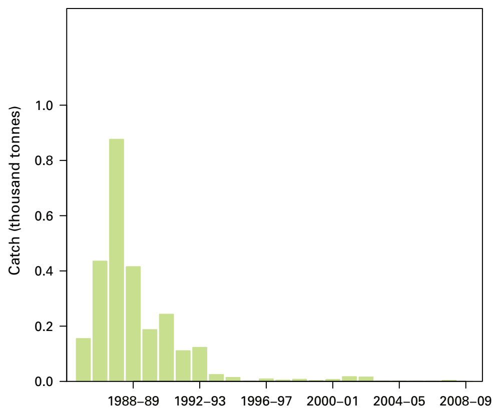


FIGURE 6.2 Deepwater prawn catch history, 1985–86 to 2008–09

Stock status determination

It is believed that deepwater prawns have not been targeted in the NWSTF since 1993 (Fig. 6.2) as the stock was in a highly depleted state (AFMA pers. comm.). The recovery of the prawn stock was modelled by the ABARE–BRS under the RUSS project, using delay difference models incorporating known biological parameters (Table 6.5). Given the maximum observed annual catch, and the fact that the stock was assumed to be in a highly depleted state at the end of 1993, a conservative estimate of the unfished stock biomass of 872 t was used. Given the potential levels of unreported discards the deepwater prawn stock would be expected to recover to a biomass similar to that prior to fishing within five or six years. Based primarily on the results of the delay difference modelling, the stock is assessed as **not overfished**. The negligible reported catch of deepwater prawns, even assuming discards, in recent years indicates that the stock is **not subject to overfishing** (Table 6.1).

Reliability of the assessment/s

Because a full quantitative stock assessment has not been conducted, the current deepwater prawn biomass as a proportion of the unfished biomass is not precisely known. However, the minimal targeting of prawns, the fact that most of the fishing effort is not on prawn grounds, the relatively low effort in the fishery for more than 15 years, and the productivity of prawns means that the status of the stock as not overfished and not subject to overfishing can be regarded with confidence.

Previous stock assessment/s

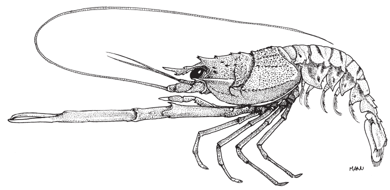
Not previously assessed.

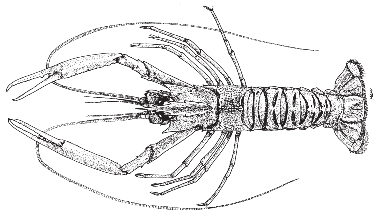
Future assessment needs

Should targeted fishing of deepwater prawns recommence, biological information for each prawn species would need to be collected before the stocks could be assessed. All existing data collected by AFMA observers detailing prawn bycatch should be compiled and examined. Reliable catch data would need to be collected, and deepwater prawn bycatch and discards needs to be recorded in logbooks. Understanding the targeting practice of operators (for prawns rather than scampi) and a summary of changes in fishing gear used over time would assist in interpreting catch and effort data from the fishery.

SCAMPI

(*Metanephrops australiensis, M. boschmai, M. velutinus*)





LINE DRAWING: FAO

TABLE 6.6 Biology of scampi

Parameter	Description
General	Scampi aggregate along muddy bottoms of continental slopes and build extensive burrows. They are relatively slow growing and long lived, with moderately low fecundity.
Range	**Species:** In Australia, scampi occur on the north-west slope in Western Australia up into the Timor Sea, along continental slopes. **Stock:** The stock comprises three species, and most fishing effort is centred on suitable grounds north-east of the Rowley Shoals. A single stock is assumed for management and assessment purposes.
Depth	250–500 m
Longevity	10–12 years (for *M. australiensis*)
Maturity (50%)	**Age:** 3–5 years (for *M. australiensis*) **Size:** ~40 mm CL (for *M. boschmai* and *M. velutinus*), 45 mm CL (for *M. australiensis*)
Spawning season	Timing of spawning unknown, though likely to spawn annually
Size	**Maximum:** ~50 mm CL (for *M. boschmai*), 60 mm CL (for *M. velutinus*), 70 mm CL (for *M. australiensis*) **Recruitment into the fishery:** >3 years; ~45 mm CL (for *M. australiensis*)

CL = carapace length

SOURCES: Davis & Ward (1984); Rainer (1992).

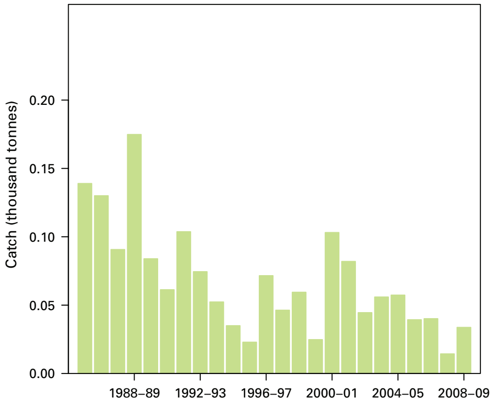


FIGURE 6.3 Scampi catch history, 1985–86 to 2008–09

Stock status determination

An assessment of the scampi stock was conducted under the RUSS project using non-equilibrium surplus production models (ABARE–BRS unpublished). Fox and Schaefer surplus production models (see Polacheck et al. 1993) were fitted to catch and effort data with a stock production model using covariates (ASPIC) (Prager 1994). The analyses suggested that the combined scampi biomass in 2008 was between 1.7 B_{MSY} and 2.2 B_{MSY}, equivalent to 65–85% of the unfished biomass. It is estimated that catch levels in recent years (Fig. 6.3) have been well within sustainable limits. Therefore, the scampi stock has been assessed as **not overfished** and **not subject to overfishing** (Table 6.1).

Reliability of the assessment/s

Surplus production models are relatively simple, incorporating only a time series of annual catch and an index of abundance, which in this case was provided by a standardised CPUE series. Despite their simplicity, surplus production models have been shown to provide more accurate and precise estimates than more complex methods in some situations (Polacheck et al. 1993). Surplus production models are less reliable when the index of abundance used exhibits little contrast or when a continual decline in biomass is suggested. The index of abundance produced for the combined scampi stock suggests that biomass decreased quickly after fishing began in the mid-1980s, before a steady recovery from 1991 to 1996. The model was tested for sensitivity to different assumed stock structures, as well as annual increases in fishing power of 1% and 2%. Both Schaefer and Fox forms of surplus production models were tested. The assessed status of the scampi stock was robust to all sensitivities tested, and general agreement between all models was good, suggesting that the assessment is likely to be reliable.

Previous assessment/s

A 2005 assessment (Lynch & Garvey 2005) examined trends in CPUE in a number of ways and also considered the length–frequency distribution of the scampi data. Although declines in CPUE were observed between 1985 and 2003, in general, the magnitudes of the declines did not raise concerns. No substantial change in size range of scampi was observed. This contrasts with anecdotal evidence from industry suggesting that the size of scampi catch had decreased. The 2005 assessment was not considered sufficiently robust to provide a reliable assessment of stock status.

Future assessment needs

Future assessments would benefit from improved data on biological parameters. A stock assessment of scampi was identified as a priority for the NWSTF by the Western Trawl Fisheries Management Advisory Committee (WestMAC) in 2007–08. The ABARE–BRS assessment referenced in this report should be submitted to the newly formed consultative panel for comment.

6.5 ECONOMIC STATUS

Economic performance

No economic surveys of the fishery have been conducted. Catch is confidential for 2007–08 and 2008–09, and the only readily available indicator of economic performance is the level of latent effort.

Latency

Effort is restricted in the NWSTF by a limit on the number of vessel permits. In 2008–09 seven permits existed in the fishery. Given that only two vessels fished in 2008–09 and three in the previous year, some latent effort is present, possibly indicating low net economic returns from fishing.

Overall economic status

In the past, the vessels operating in the NWSTF tended to be NPF trawlers that fished opportunistically while the NPF was closed. However, none of the vessels that have operated in the NWSTF since 2007 have fished in the NPF in the same period. Despite this development, there is significant latency and a low gross value of production (not generally higher than one million dollars per year), indicating that economic returns for the fishery are not likely to be large.

Future considerations

The fishery is currently managed using input controls, primarily in the form of limited entry. After reviewing the potential to implement individual transferable quotas in the fishery in 2006, WestMAC concluded that these quotas do not appear to be a viable option for the fishery at this time and that the fishery should continue to be managed using input controls (WestMAC 2006).

6.6 ENVIRONMENTAL STATUS

Commercial fishing is excluded in three marine protected areas in the NWSTF: the Cartier Island Marine Reserve, the Ashmore Reef National Nature Reserve and the Mermaid Reef Marine National Nature Reserve (part of the Rowley Shoals). There have been no reports of illegal fishing in the NWSTF.

Ecological risk assessment

AFMA's ERAs provide an inventory of high-risk species, based on their productivity (life history) and susceptibility to fishing. The ERAs consider target, byproduct, and threatened, endangered or protected (TEP) species. Based on the ERA process one high-risk species, giant scarlet prawn, was identified (AFMA 2010). Following completion of the residual risk assessment, giant scarlet prawn remained in the high-risk category and was incorporated into the HS for the fishery. The ERA results will be reviewed in detail in the next *Fishery status reports*.

Threatened, endangered and protected species (sharks, marine turtles and seabirds)

No interactions with TEP species were reported in the NWSTF during 2008–09.

Pt Samson Harbour berths

PHOTO: GAVIN KEWAN, AFMA

Pt Samson Harbour entrance

PHOTO: GAVIN KEWAN, AFMA

Benthic habitats

Demersal trawling can have a significant impact on the sea floor by reducing the structural complexity of the environment, and crushing, burying or exposing marine organisms. The recovery potential of benthic assemblages depends on the growth potential of structure-forming organisms and the period of time between disturbances (Watling & Norse 1998). The most susceptible areas tend to be those that do not experience disturbance, such as shelf and slope habitats, and those that rely on slow-growing organisms for habitat complexity (e.g. coral reefs) (Watling & Norse 1998). Most work on characterising benthic assemblages has focused on the shelf habitat, and there is a paucity of information on the slope habitat.

Demersal trawl gear is used in the NWSTF, with fishing for scampi and prawns occurring over soft, muddy sediments or sandy habitats, typically at depths of 350–600 m on the continental slope. In 2006–07 and 2007–08, some targeting of finfish in shallower waters may have resulted in interactions with reef habitat.

6.7 HARVEST STRATEGY PERFORMANCE

The HS has been implemented and the reported catch levels of scampi and deepwater prawns have not exceeded the first trigger level, and so the control rules have not been enacted. The reference period used in the HS to set the trigger levels appears to be from the recent past and therefore excludes large catches taken in the late 1980s and early 1990s. The result is that prawn triggers may be lower than necessary. At present, the majority of prawn catch is likely to be unreported discards. If prawn discards were considered, it is possible that HS triggers for the deepwater prawn stock would have been activated. However, annual prawn catch of 100 t is most likely sustainable, and prawn discards in the NWSTF are unlikely to approach this level while fishers target scampi (due to the differences in fishing area).

The scampi stock assessment conducted by the ABARE–BRS indicates that an annual scampi catch below the Level 1 trigger of 50 t would be sustainable. However, if annual catches were to regularly exceed 70 t, the stock would need to be carefully reassessed. The limit reference point for scampi of 200 t suggested by the Level 3 trigger is well above the estimated maximum sustainable yield of the stock.

The *Western Trawl Fisheries statement of management arrangements* (AFMA 2004) stipulates a maximum codend mesh size in the NWSTF of 50 mm to discourage the trawling of demersal finfish. An increase in mesh size would be expected to reduce bycatch of prawns and small fish. As an alternative to the current maximum codend mesh size, the targeting of finfish could be discouraged by mandating the use of bycatch reduction devices, such as square mesh windows or Nordmøre sorting grids (e.g. Hartill et al. 2006). The merits of the current strategy compared with alternatives should be considered.

6.8 LITERATURE CITED

AFMA (Australian Fisheries Management Authority) 2004, *Western Trawl Fisheries statement of management arrangements*, AFMA, Canberra.

——2007, *Western trawl fisheries harvest strategy—North West Slope Trawl Fishery (NWSTF) and Western Deepwater Trawl Fishery (WDTF)*, AFMA, Canberra.

——2008, *North West Slope Trawl Fishery Bycatch and Discarding Workplan 31 October 2008–1 November 2010*, AFMA, Canberra.

——2010, Residual risk assessment of Level 2 *Ecological Risk Assessment species results, report for the North West Slope Trawl Fishery*, AFMA, Canberra.

Baelde, P 1994, 'Royal red prawn, *Haliporoides sibogae*', in RJ Tilzey (ed), *The South East Fishery: a scientific review with reference to quota management*, Bureau of Resource Sciences, Canberra, pp. 257–64.

Davis, TLO & Ward, TJ 1994, 'CSIRO finds two new scampi grounds off the North West Shelf', *Australian Fisheries*, vol 43, pp. 41–7.

Hartill, BW, Cryer, M & MacDiarmid, AB 2006, 'Reducing bycatch in New Zealand's scampi trawl fisheries', New Zealand Aquatic Environment and Biodiversity Report no. 4, New Zealand. Ministry of Fisheries, Wellington.

Holloway, PE, Humphries, SE, Atkinson, M & Imberger, J 1985, 'Mechanisms for nutrient supply to the Australian north-west shelf', *Australian Journal of Marine and Freshwater Research*, vol. 36, pp. 753–64.

Lynch, AW & Garvey, JR 2005, *North West Slope Trawl Fishery scampi stock assessment 2004*, AFMA, Canberra.

Newman, SJ & Skepper, C 2007, 'Northern Demersal Scalefish Managed Fishery status report', in WJ Fletcher & K Santoro (eds), *State of the fisheries report 2006/07*, Department of Fisheries, Western Australia, pp. 161–8.

——2009, 'North Coast Demersal Fisheries status report', in WJ Fletcher & K Santoro (eds), *State of the fisheries report 2008/09*, Department of Fisheries, Western Australia, pp. 149–69.

Polacheck, T, Hilborn, R & Punt, AE 1993, 'Fitting surplus production models: comparing methods and measuring uncertainty', *Canadian Journal of Fisheries and Aquatic Science*, vol. 50, pp. 2597–607.

Prager, MH 1994, 'A suite of extensions to a nonequilibrium surplus-production model', *Fisheries Bulletin*, vol. 92, pp. 374–89.

Rainer, SF 1992, 'Growth of the Australian scampi, *Metanephrops australiensis*', in SF Rainer (ed), *The fisheries biology of deepwater crustaceans and finfish on the continental slope of Western Australia*, final report to the FRDC, FRDC project 1988/74.

Wadley, VA 1992a, 'Distribution, growth and reproductive development of giant red prawn, *Aristaeomorpha foliacea* (Risso, 1827), in the North West Slope Trawl Fishery', in SF Rainer (ed), *The fisheries biology of deepwater crustaceans and finfish on the continental slope of Western Australia*, final report to the FRDC, FRDC project 1988/74.

——1992b, 'The Biology of Scampi, Prawns, Carids, Bugs and Crabs Exploited by Deepwater Trawling', in SF Rainer (ed), *The fisheries biology of deepwater crustaceans and finfish on the continental slope of Western Australia*, final report to the FRDC, FRDC project 1988/74.

Watling, L & Norse, EA 1998, 'Disturbance of seabed by mobile fishing gear: a comparison to forest clearcutting', *Conservation Biology*, vol. 12, no. 6, pp. 1180–97.

WestMAC (Western Trawl Fisheries Management Advisory Committee) 2009, *MAC chair's summary, Fremantle, 10 June 2009*, AFMA, Canberra.

Zhou, S, Fuller, M & Smith, T 2009, *Rapid quantitative risk assessment for fish species in seven Commonwealth fisheries*, report for the AFMA, CSIRO, Cleveland.

Emptying the codend PHOTO: GAVIN KEWAN, AFMA

7 Small Pelagic Fishery

P Hobsbawn, J Larcombe and K Mazur

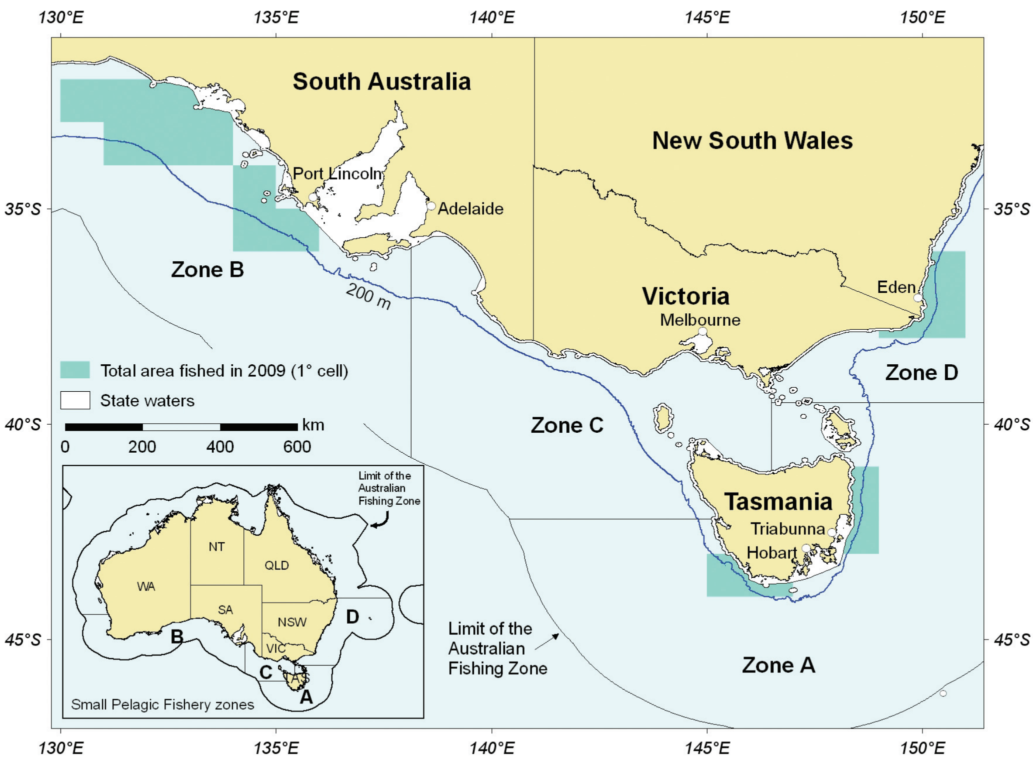


FIGURE 7.1 Approximate area fished in 2009 and management zones in the Small Pelagic Fishery

TABLE 7.1 Status of the Small Pelagic Fishery

Fishery status	**2008**		**2009**		**Comments**
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Australian sardine (*Sardinops sagax*)	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	SPF Tier 1 assessment (DEPM in 2005). Low catches indicate overfishing is not occurring.
Blue mackerel—east (*Scomber australasicus*)	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	SPF Tier 1 assessment (DEPM in 2005). Low catches indicate overfishing is not occurring.
Blue mackerel—west (*Scomber australasicus*)	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	SPF Tier 1 assessment (DEPM in 2005). Low catches indicate overfishing is not occurring.
Jack mackerels—east (*Trachurus declivis, T. murphyi*)	Uncertain	Uncertain	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	High historical catches, predator/prey studies and anecdotal evidence suggest a sizeable stock. Low catches indicate overfishing is not occurring.
Jack mackerels—west (2 species, as above)	Uncertain	Uncertain	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	High historical catches, predator/prey studies and anecdotal evidence suggest a sizeable stock. Low catches indicate overfishing is not occurring.
Redbait—east (*Emmelichthys nitidus*)	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	SPF Tier 1 assessment (DEPM in 2005). Low catches indicate overfishing is not occurring.
Redbait—west (*Emmelichthys nitidus*)	Uncertain	Uncertain	Uncertain	Uncertain	Limited information to assess status.
Economic status Fishery level	Estimates of net economic returns not available				Economic status uncertain. High level of latency suggests total net economic returns low.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING — OVERFISHED / OVERFISHING — UNCERTAIN — NOT ASSESSED

DEPM = Daily Egg Production Model; SPF = Small Pelagic Fishery

TABLE 7.2 Main features and statistics of the Small Pelagic Fishery

Feature	**Description**
Key target and byproduct species	Australian sardine (*Sardinops sagax*) Blue mackerel (*Scomber australasicus*) Jack mackerels (*Trachurus declivis*, *T. murphyi*) Redbait (*Emmelichthys nitidus*)
Other byproduct species	Barracouta (*Thyrsites atun*) Skipjack tuna (*Katsuwonus pelamis*) Spotted warehou (*Seriolella punctata*) Yellowtail scad (*Trachurus novaezelandiae*)
Fishing methods	Purse seine, midwater trawl
Primary landing ports	Triabunna, Port Lincoln, Eden

Table 7.2 continues over the page

TABLE 7.2 Main features and statistics of the Small Pelagic Fishery CONTINUED

Feature	Description	
Management methods	Input controls: limited entry, gear restrictions Output controls: trigger catch limits to 2007–08; recommended biological catches for 2008–09	
Management plan	*Management Policy for the Commonwealth Small Pelagic Fishery* (AFMA 2001; revised 5 December 2007)—in effect for 2009 Small Pelagic Fishery Management Plan 2009 (determined on 2 November 2009, accepted on 30 December 2009)—commencing on 13 January 2010: formal recognition of Australian sardine as a target species, with the merging of IMF with SPF; introduction of statutory fishing rights in the form of individual transferable quotas; recognition of move to set TACs for Eastern sub-area, Western sub-area and Australian sardine sub-area, rather than for Zones A and B (Fig. 7.1)	
Harvest strategy	*Small Pelagic Fishery Harvest Strategy* (AFMA 2008)	
Consultative forums	Small Pelagic Fishery Management Advisory Committee (SPFMAC), Small Pelagic Fishery Resource Assessment Group (SPFRAG)	
Main markets	Domestic: fishmeal production, bait, human consumption	
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Current accreditation dated 5 December 2007 Current accreditation (Exempt) expires 2 November 2014	
Ecological risk assessment	Level 1: Scale Intensity Consequence Analysis (SICA) completed on 235 species (Daley et al. 2007) Level 2: Productivity Susceptibility Analysis (PSA) completed on 235 species (Daley et al. 2007) Level 3: Sustainability Assessment for Fishing Effects (SAFE) completed on 93 and 98 species of teleosts for purse seine and mid-water trawl, respectively—1 high risk species for each method (Zhou et al. 2009)	
Bycatch workplans	Bycatch and Discarding Workplan (AFMA 2009)	
Fishery statistics[a]	**2007–2008 fishing season**	**2008–2009 fishing season**
Fishing season	1 July 2007–30 June 2008	1 July 2008–30 June 2009
TAC or TCL	Zone A: TAC for all species combined 34 000 t (25 000 t individual transferable quotas, 9000 t competitive) Zone B TCL Blue mackerel—5000 t Jack mackerels—4000 t Redbait—1000 t Yellowtail scad—100 t Zone C TCL Blue mackerel—3500 t Jack mackerels—2500 t Redbait—1000 t Yellowtail scad—100 t Zone D TCL Blue mackerel—3500 t Jack mackerels—2500 t Redbait—1000 t Yellowtail scad—100 t	TAC Blue mackerel (east)—5400 t Blue mackerel (west)—8400 t Redbait (east)—14 800 t Redbait (west)—5000 t Jack mackerels (east)—5000 t Jack mackerels (west)—5000 t Australian sardine (east)—2800 t Yellowtail scad (east)—200 t Yellowtail scad (west)—200 t TCL a) 1500 t of any species caught west of 127°50'E; and b) 75% take of any TAC
Catch	Australian sardine—1493 t Blue mackerel—889 t Jack mackerels—356 t Redbait—2325 t Yellowtail scad—0 t	Australian sardine—1147 t Blue mackerel—2149 t Jack mackerels—411 t Redbait—1443 t Yellowtail scad—0 t

Table 7.2 continues over the page

TABLE 7.2 Main features and statistics of the Small Pelagic Fishery CONTINUED

Feature	Description	
Fishery statistics[a]	**2007–2008 fishing season**	**2008–2009 fishing season**
Effort	Purse seine: 655.5 search hours Midwater trawling: 92 shots (736 hours)	Purse seine: 871.2 search hours Midwater trawling: 93 shots (468 hours)
Fishing permits	85	76
Active vessels	Purse seine: 5 Midwater trawl: 1	Purse seine: 3 Midwater trawl: 1
Observer coverage	Purse seine: zero shots Midwater trawl: 122 hours (16.6%)	Purse seine: zero shots (0%) Midwater trawl: 6.1 hours (1.4%)
Real gross value of production (2008–09 dollars)	$1.09 million	Confidential (<5 vessels)
Allocated management costs	$0.61 million	$0.43 million

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; TAC = total allowable catch; TCL = trigger catch limit; IMF = Informally Managed Fishery; n.a. = not available

a Fishery statistics are provided by fishing season unless otherwise indicated.

7.1 BACKGROUND

The Small Pelagic Fishery (SPF) extends from southern Queensland to southern Western Australia. It has historically been divided into four management zones (Fig. 7.1), and the target species are taken in significant volumes within both Commonwealth and adjacent state management jurisdictions. Species targeted in the SPF are also taken in several other Commonwealth-managed and state-managed fisheries, mainly the trawl sectors of the Southern and Eastern Scalefish and Shark Fishery, the Eastern Tuna and Billfish Fishery (where they are purse-seined for bait) and the Western Tuna and Billfish Fishery, and the New South Wales Ocean Hauling Fishery.

Most fishing effort has occurred in Zone A. Historically, most SPF catches have been jack mackerel purse-seined in Zone A within the Tasmania-managed fishery. Purse-seining was the main method historically, but has been replaced by midwater trawling since 2002. Jack mackerel has been replaced by redbait as the main species caught in Zone A within the Commonwealth jurisdiction. In 2006 there was a marked increase in catches in Zone B—a trend that continued into 2007. No catch has been reported from Zone C in recent years, and catches in Zone D have remained low and stable.

A new management plan for the SPF was introduced in late 2009. The plan will replace the permit system with individual transferrable quota statutory fishing rights. Until rights are allocated, the permit and zoning system remains in place; total allowable catches (TACs) will be set for each stock according to an east–west divide at longitude 146°30’.

There is considerable purse-seine capacity in Australia for catching small pelagic species, but rapid development is not expected unless market demand changes.

Small pelagic species are generally characterised by variability in their population size under natural conditions. Expansion of the SPF requires caution because small pelagic fish are at the base of the food chain—preying on phytoplankton and zooplankton—and are themselves prey for many species of fish, birds and marine mammals. Depletion of small pelagic fish stocks elsewhere in the world has dramatically changed the populations of other dependent species (Fréon et al. 2005). However, recent marine ecosystem modelling of south-eastern Australia (Johnson et al. 2009) indicates that the secondary effects on predators of SPF target species may not be as great as previously thought—noting that this work is preliminary and is not resolved to individual predator species.

TABLE 7.3 History of the Small Pelagic Fishery

Year	Description
1936	CSIRO conducted aerial surveys of pelagic fish resources off the east coast of mainland Australia and Tasmania, and off the Western Australian coast. Large numbers of pilchard and mackerel schools were observed along the western edge of the Great Australian Bight.
1938	Government sponsored an investigation into pelagic fish resources off Victoria, Tasmania and New South Wales.
1943 to 1950	Purse-seine nets were used in pelagic fishing trials off New South Wales and eastern Tasmania. The first purse-seine catch in Australia comprised about 4 t of jack mackerel, taken near Hobart.
1960s and 1970s	Southern bluefin tuna pole-and-line fleet typically took about 700–1000 t of live bait from east coast bait grounds (60% yellowtail scad and blue mackerel).
Mid-1970s	Purse-seining trialled near Lakes Entrance, Victoria.
1973	A fishery for jack mackerel commenced by a company operating from Triabunna in Tasmania, where it established a fish-meal processing plant.
1979	The South Eastern Fisheries Committee set a commercial TAC of 30 000 t of mackerel for Australian waters, with 10 000 t reserved for waters off Tasmania.
1984–88	The fishery developed rapidly from an annual catch of 6000 t in 1984–85 to a peak of almost 42 000 t in 1986–87. Large catches of jack mackerel taken off Tasmania (with purse seine), culminating in over 35 000 t in the 1986–87 and 1987–88 fishing seasons.
1989–91	Tasmanian jack mackerel fishery declined because of lower availability of surface schools and economic conditions.
1993–94	Existing management arrangements agreed between the Commonwealth and the states. Zone A established.
1996	Offshore Constitutional Settlement signed by the Tasmanian and Australian Government ministers but not gazetted.
1991 to 2000	Purse-seine fishery in Zone A averaged around 12 000 t per year, with strong interannual and within-season variability.
2000–01	Redbait emerged as the dominant species caught.
2001	BRS released a global review of the state of knowledge of blue mackerel biology and fishery assessment. This highlighted the variability of blue mackerel recruitment and the need to determine stock-abundance indicators by fishery-independent methods, such as aerial surveys or egg-abundance sampling.
2001–02	Large catches of redbait taken by midwater trawl method in Zone A. Zone A TAC reduced proportionally among sectors.
2002	Small Pelagic Research and Assessment Team (SPRAT) formed. Management Policy for the Commonwealth SPF came into effect (applies to Zones B, C and D). SPF formerly known as the Jack Mackerel Fishery. Zone A Small Pelagic Assessment Workshop held to set TACs and develop trigger points (included the Zone A SPF Assessment Group). FRDC and AFMA funded a project led by the SARDI to evaluate egg production as a method of estimating spawning biomass of blue mackerel off the coasts of New South Wales and South Australia. Spawning biomass estimate for Australian sardine off the coast of New South Wales also determined through this project.
2003	SESSF management plan prohibited targeting of small pelagic species.
2004	FRDC and AFMA funded a project led by TAFI to evaluate egg production as a method of estimating spawning biomass of redbait off the coast of Tasmania (see Neira et al. 2008). Foreign fishing interests began to secure fishing rights; AFMA froze all vessel nominations.
2005	*Small Pelagic Fishery Bycatch Action Plan* (AFMA 2005) introduced. Catches of all target species began to decline.
2006	FRDC funded a CSIRO-led project to examine small pelagic fish stock structure in southern Australian waters. Findings from the project strongly suggested the existence of separate eastern and western stocks for all target species (Bulman et al. 2007).

Table 7.3 continues over the page

TABLE 7.3 History of the Small Pelagic Fishery CONTINUED

Year	Description
2008	Informally Managed Fishery was merged into SPF, making Australian sardine a target species of SPF. A study of marine mammal interactions with midwater trawling in fishery (Lyle & Willcox 2008) demonstrated a high level of interactions with fur seals, highlighting the need for well-designed and tested seal exclusion devices.
2008–09	SPF harvest strategy adopted by the AFMA Board. TACs set for the target stocks, for the first time, according to rules in SPF harvest strategy.
2009	FRDC funded a project to determine spawning biomass estimates for jack mackerel in south-eastern Australia. AFMA funded a project led by SARDI, with contributions from TAFI and BRS, to produce an SPF assessment report for 2010 and 2011, to meet minimum requirements for Tier 2 assessment under SPF harvest strategy. SPF management plan determined, which will introduce individual transferable quotas.

AFMA = Australian Fisheries Management Authority; BRS = Bureau of Rural Sciences; CSIRO = Commonwealth Scientific and Industrial Research Organisation; FRDC = Fisheries Research and Development Corporation; SARDI = South Australian Research and Development Institute; SESSF = Southern and Eastern Scalefish and Shark Fishery; SPF = Small Pelagic Fishery; TAC = total allowable catch; TAFI = Tasmanian Aquaculture and Fisheries Institute

SOURCE: Pullen (1994); AFMA (2003).

7.2 HARVEST STRATEGY

The SPF harvest strategy (HS; adopted in 2008–09; Table 7.3) has a three-tier system that applies to each of the target stocks. The tier system is intended to allow for greater levels of catch when there is a better knowledge of stock condition through investment in research. In principle, Tier 1, with the highest level of information (from surveys), should result in the largest allowable catch. Conversely, Tier 3, with relatively poor information, should result in the smallest allowable catch. The tiers are as follows:

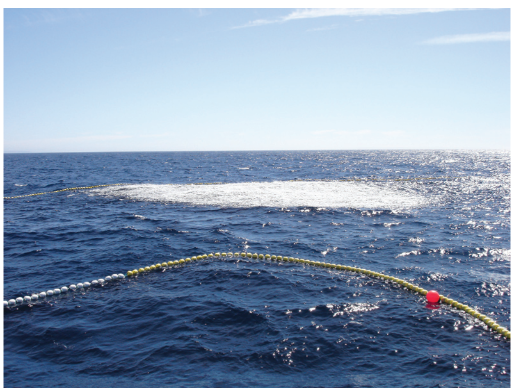
- Tier 1: Recommended biological catches (RBCs) are set as a percentage of the median spawning biomass estimated using a daily egg production method (DEPM) survey. The percentage is determined by the time since the last DEPM assessment and decays from 20% to 10% in the five years following a DEPM survey.
- Tier 2: Assessment is conducted annually using catch and effort data and annual information on the age structure of the catch. The RBC cannot exceed maximum tonnages set out for each stock (see Table 7.4).
- Tier 3: The assessment is based on catch and effort data. The RBC but may not exceed 500 t.

The HS was first used for the 2008–09 fishing season.

TABLE 7.4 Tier 2 maximum catch tonnages for the Small Pelagic Fishery target species under the harvest strategy

	Tier 2 total allowable catch (tonnes)	
Species	West	East
Australian sardine	N/A	3000
Blue mackerel	6500	3000
Jack mackerel	5000	5000
Redbait	5000	5000

N/A = not available



Purse seine PHOTO: BRADLEY MILIC, AFMA

7.3 THE 2009 FISHERY (2008–09 FISHING SEASON)

Total catch in the fishery in the 2008–09 fishing season was 5150 t. The total fishing effort of purse seine vessels increased to 871.2 hours from 655.5 hours in 2007–08 and the single midwater trawl vessel carried out a similar number of shots (93) in 2008–09 to the previous fishing season (92), although average shot duration was decreased (Table 7.2). Real gross value of production (GVP) in the SPF declined to $1.07 million in 2007–08, from $2.68 million in 2006–07 (Fig. 7.2). This decline in GVP is largely in line with the decline in purse-seine effort.

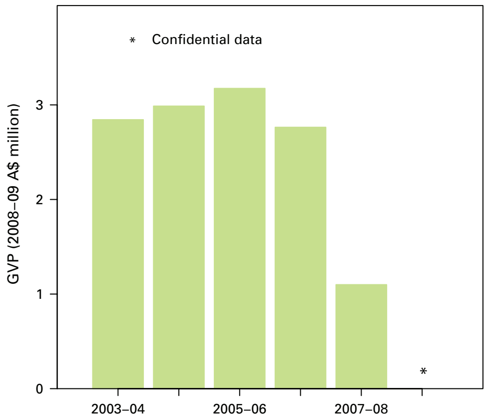


FIGURE 7.2 Real GVP in the SPF by financial year, 2003–04 to 2008–09

Hauling seine net PHOTO: BRADLEY MILIC, AFMA

Minor byproduct species

Species typically caught as byproduct in the SPF include barracouta, skipjack tuna and spotted warehou (Table 7.5).

TABLE 7.5 Minor byproduct stocks in the Small Pelagic Fishery

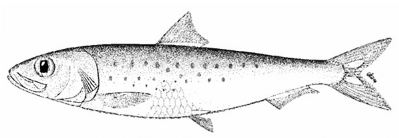
Species	TAC/ trigger	2007-08 catch (tonnes)	2007-08 discards (tonnes)	2008-09 catch (tonnes)	2008-09 discards (tonnes)
Spotted warehou (*Seriolella punctata*)	None	10	0	39	0
Skipjack tuna (*Katsuwonus pelamis*)	None	15	0	0	0
Barracouta (*Thyrsites atun*)	None	10	0	0	0

TAC = total allowable catch

7.4 BIOLOGICAL STATUS

AUSTRALIAN SARDINE

(*Sardinops sagax*)



LINE DRAWING: FAO

TABLE 7.6 Biology of Australian sardine

Parameter	Description
Range	**Species:** Continental shelf waters in southern Australia, throughout the extent of the fishery. **Stock:** Separate stocks have been identified east and west of 146°30'E in Australian waters.
Depth	0–200 m
Longevity	6 years
Maturity (50%)	**Age:** 1–3 years **Size:** 7–13 cm
Spawning season	Summer and autumn in southern New South Wales Autumn to early spring in northern New South Wales
Size	**Maximum:** ~21 cm SL, maximum weight unknown **Recruitment into the fishery:** age: 1.5 years

SL = standard length
SOURCES: Kailola et al. (1993); Bulman et al. (2007).

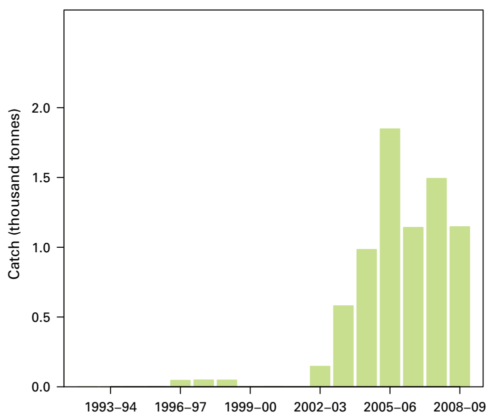


FIGURE 7.3 Australian sardine catch history, 1993–94 to 2008–09

Stock status determination

No formal stock assessment was conducted for the eastern stock of Australian sardine in 2009. RBCs in 2008–09 were set using HS rules: the DEPM survey was conducted in 2005, three years before the RBC was set, so the RBC was set at 4500 t, which is 15% of the biomass estimate. After consideration of state catches, the Commonwealth TAC was set at 2800 t. The spawning biomass estimate determined from the DEPM survey is considered to be between $0.7B_0$ (70% of the unfished biomass) and $0.9B_0$ (90% of the unfished biomass). The stock is therefore assessed as **not overfished** (Table 7.1). State catches increased in 2008–09 to a point where total catches (Fig. 7.3) were around the RBC. The RBC is considered to be conservative, and the stock is assesssed as **not subject to overfishing**.

Reliability of the assessment/s

The biomass estimate from the DEPM survey is imprecise but considered to be conservative. Stock status determination is therefore considered to be reliable within that context.

Previous assessment/s

No formal stock assessments have previously been conducted prior to the 2005 DEPM biomass estimate.

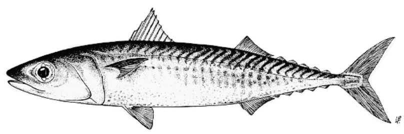
Future assessment needs

The HS requires a DEPM survey at least once every five years for the stock to remain at Tier 1. An assessment report is currently being prepared so that the TAC can be set according to Tier 2 rules.

Australian sardine PHOTO: ANDREW SAMPAKLIS, ABARE–BRS

BLUE MACKEREL

(*Scomber australasicus*)



LINE DRAWING: FAO

TABLE 7.7 Biology of blue mackerel

Parameter	Description
Range	**Species:** Continental shelf waters in southern Australia, throughout the extent of the fishery. **Stock:** Separate stocks have been identified east and west of 146°30'E in Australian waters.
Depth	87–265 m
Longevity	7 years
Maturity (50%)	**Age:** 2 years **Size:** 237–287 mm FL
Spawning season	Autumn to spring off southern Australia; winter and spring off eastern Australia
Size	**Maximum:** ~44 cm FL; 1.36 kg **Recruitment into the fishery:** age: 2 years

FL = fork length

SOURCES: May & Maxwell (1986); Bulman et al. (2007); Ward & Rogers (2008); Froese & Pauly (2009).

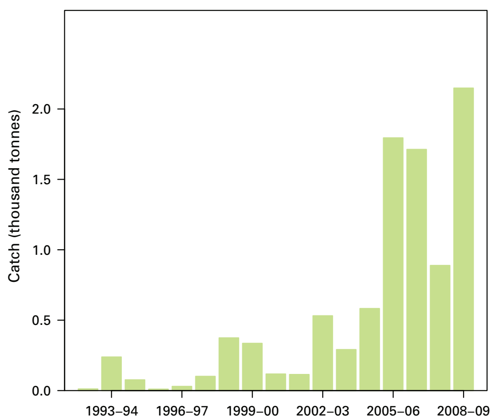


FIGURE 7.4 Blue mackerel catch history, 1992–93 to 2008–09

Stock status determination

No formal stock assessment was conducted for blue mackerel in 2009. RBCs in 2008–09 were set using HS rules and relate to the time since the last DEPM survey (Ward & Rogers 2008). The DEPM survey was conducted in 2005, three years before the RBC was set. The RBC was set at 6000 t in the east and 8400 t in the west, which is 15% of the biomass estimates, and, after consideration of state catches, the Commonwealth TAC was set at 5400 t in the east and left at 8400 t in the west. The spawning biomass estimates determined from the DEPM survey are considered to be between $0.7B_0$ and $0.9B_0$. Both the east and west stocks are therefore assessed as **not overfished** (Table 7.1). Total catches in 2009 (Fig. 7.4) were well below the RBCs for both stocks. The stocks are therefore assessed as **not subject to overfishing**.

Reliability of the assessment/s

Biomass estimates from the DEPM survey are imprecise but considered to be conservative. Stock status determination is therefore considered to be reliable within that context.

Previous assessment/s

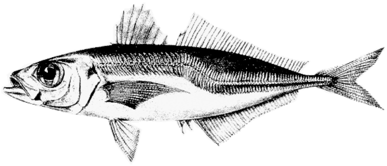
No formal stock assessments have previously been conducted for this species. In 2007–08 the status for these stocks was determined using the DEPM biomass estimate. Although TACs were not set for that season, Commonwealth catches were a small proportion of the estimated biomass.

Future assessment needs

The HS requires a DEPM survey at least once every five years for the stock to remain at Tier 1. An assessment report is currently being prepared so that the TAC can be set according to Tier 2 rules.

JACK MACKERELS

(*Trachurus declivis, T. murphyi*)



LINE DRAWING: FAO

TABLE 7.8 Biology of common jack mackerel (*T. declivis*)

Parameter	Description
Range	**Species:** Continental shelf waters in southern Australia, throughout the extent of the fishery. **Stock:** Separate stocks have been identified east and west of 146°30'E in Australian waters.
Depth	0–460 m
Longevity	16 years
Maturity (50%)	**Age:** 3–4 years **Size:** not determined
Spawning season	December–March
Size	**Maximum:** ~47 cm FL **Recruitment into the fishery:** age: 2 years

FL = fork length

SOURCES: Kailola et al. (1993); Bulman et al. (2007).

TABLE 7.9 Biology of Peruvian jack mackerel (*T. murphyi*)

Parameter	Description
Range	**Species:** Continental shelf waters in southern Australia, throughout the extent of the fishery. **Stock:** Separate stocks have been identified east and west of 146°30' in Australian waters.
Depth	10–306 m
Longevity	30 years
Maturity (50%)	**Age:** 3 years **Size:** not determined
Spawning season	October–December
Size	**Maximum:** ~81 cm TL **Recruitment into the fishery:** age: not determined

TL = total length

SOURCES: Fitch (1956); Hart (1973); Eschmeyer et al. (1983); Knuckey & Koopman (2008); Froese & Pauly (2009).

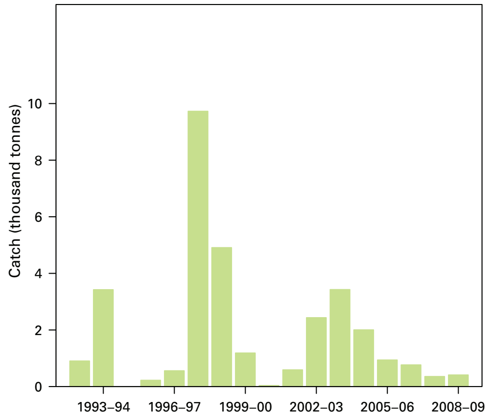


FIGURE 7.5 Jack mackerel catch history, 1992–93 to 2008–09

Stock status determination

No formal quantitative stock assessment (or estimate of spawning biomass) was conducted for jack mackerels. RBCs in 2008–09 were set using the Tier 2 rules, making the RBC and TAC 5000 t for each of the eastern and western stocks. Aerial surveys in the 1970s (Williams 1981) and high catches in the 1980s suggest that biomass was at least 80 000 t in the east. Catches declined in the 1990s, due partly to the lack of surface schools and partly to economic drivers. The absence of surface schools in the early 1990s has been linked to oceanographic factors and low abundance of krill (*Nyctiphanes australis*), the primary prey species for surface schools (Young et al. 1993). Low catches after 1990 would have been sufficient to counteract the effects of the high catches in the 1980s, allowing the stock to rebuild. Several recent studies have shown that jack mackerel constitutes a high proportion of the diets of Australian fur seals (Deagle et al. 2009), Australasian gannets (Pyk et al. 2007), shy albatrosses (Hedd & Gales 2001) and southern bluefin tuna (Young et al. 1993), suggesting that this species remains abundant in southern Australian waters. Also, surface schools of jack mackerel have reappeared in eastern Tasmania, but are not being targeted. Both eastern and western stocks of jack mackerel are therefore assessed as **not overfished** (Table 7.1). Total catches

(Fig. 7.5) in both the eastern and western stocks have been well below the RBC for several years, so it is considered that both stocks are **not subject to overfishing**.

Reliability of the assessment/s

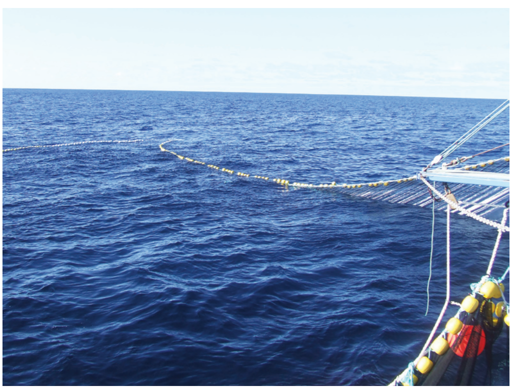
The status determination for jack mackerels is based on a weight-of-evidence approach from diverse fishery, biological and ecological data. It is considered to be moderately reliable, given recent low catches, but would become increasing less reliable under higher catches and in the absence of DEPM surveys.

Previous assessment/s

No formal stock assessments or DEPM surveys have been conducted for this species. The Tasmanian Aquaculture and Fisheries Institute have a project underway to obtain a spawning biomass estimate for jack mackerel (*Trachurus declivis*) using egg samples from the blue mackerel DEPM surveys and historically acquired adult parameters.

Future assessment needs

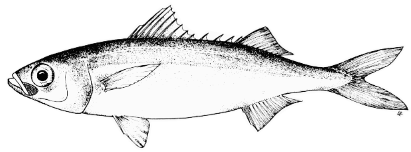
DEPM surveys for each of the eastern and western stocks need to be conducted for the stocks to move to Tier 1 and to confirm stock biomass assumptions. An assessment report is currently being prepared so that TACs can be set according to Tier 2 rules.



Purse seine PHOTO: BRADLEY MILIC, AFMA

REDBAIT

(*Emmelichthys nitidus*)



LINE DRAWING: FAO

TABLE 7.10 Biology of redbait

Parameter	Description
Range	**Species:** Continental shelf waters in southern Australia, throughout the extent of the fishery. **Stock:** Separate stocks have been identified east and west of 146°30'E in Australian waters.
Depth	86–500 m
Longevity	21 years
Maturity (50%)	**Age:** 2–4 years **Size:** 147–244 mm FL
Spawning season	September–November
Size	**Maximum:** ~36 cm FL **Recruitment into the fishery:** age: ~2 years

FL = fork length

SOURCES: Kailola et al. (1993); Bulman et al. (2007); Neira et al. (2008); Froese & Pauly (2009).

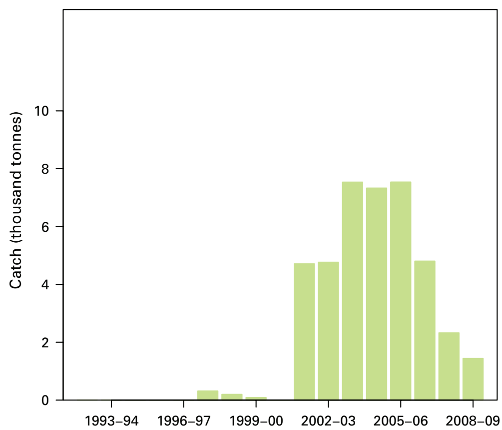


FIGURE 7.6 Redbait catch history, 1992–93 to 2008–09

Stock status determination

No formal stock assessment was conducted for redbait in 2009. For the eastern stock of redbait, RBCs in 2008–09 were set using HS rules and relate to the time since the last DEPM survey (Neira et al. 2008). DEPM surveys were conducted in 2005 and 2006; there were two surveys in three years. The RBC was set at 7000 t, which is 20% of the average of the two biomass estimates. After further analysis of redbait egg samples collected as part of the Ward and Rogers (2008) blue mackerel study, the Commonwealth TAC was set at 14 800 t. The spawning biomass estimate determined from the DEPM survey is considered to be between $0.7B_0$ and $0.9B_0$. The eastern stock is therefore assessed as **not overfished** (Table 7.1). Total catches (Fig. 7.6) are well below the RBC, and therefore the stock is assessed as **not subject to overfishing**.

For the western stock of redbait, no estimates of spawning biomass have been made. Therefore, it is **uncertain** whether overfishing is occurring in the west, or whether the stock is overfished (Table 7.1).

Reliability of the assessment/s

For the redbait eastern stock, the biomass estimate from the DEPM survey is imprecise but considered to be conservative. Stock status determination is therefore considered to be reliable within that context.

Previous assessment/s

No formal stock assessments have previously been conducted for this species. For the redbait eastern stock, the status for the 2007–08 season was determined from the biomass estimate from a DEPM survey, and Commonwealth catches were a small proportion of that biomass estimate.

Future assessment needs

A DEPM survey needs to be conducted at least once every five years for the eastern stock to remain at Tier 1. For the western stock, a DEPM survey needs to be conducted for the stock to move to a Tier 1 assessment. An assessment report is currently being prepared so that TACs can be set according to Tier 2 rules.

7.5 ECONOMIC STATUS

While there were 85 permits available in 2007–08 only six vessels operated in the fishery. The GVP dropped by 64% from $3 million in 2004–05 to $1.09 million in 2007–08. This was mostly a result of a rapid decline in prices and volume of production, which both halved over this period. In 2008–09 the number of permits available fell to 76 and only four vessels were active in the fishery. In the same year, TACs were increased for many species caught in the fishery (see Table 7.2).

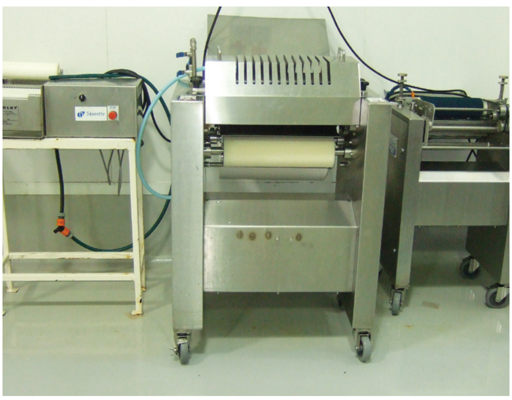
In 2007–08 TACs in Zone A were set at levels far above catch levels for that year, implying high quota latency, or that quotas are non-binding. In addition, the number of permits issued was far greater than the number used, implying high effort latency. If demand for small pelagic species increases over the longer term or alternatively supplies are restricted, a high levels of latency in both quota and effort

Small pelagics fish processing machinery, Eden
PHOTO: FIONA SALMON, DAFF

may result in increased fishing effort and the dissipation of any above-average profits.

It should also be noted that in 2007–08, management costs for the fishery were $0.6 million and were equivalent to 58% of the fishery's GVP. This implies that there was a limited margin for additional fishing costs to be incurred before fishery level NER would become negative. Management costs did decline in 2008–09 (by 31% to $0.4 million) but still remained high relative to the fishery's GVP, indicating that the potential for substantial positive NER remained low in 2008–09.

A statutory management plan was implemented for the fishery in late 2009. The fishery is currently in a transitional phase toward full implementation of this plan. The plan provides for the granting of statutory fishing rights, in the form of individual transferable quotas (ITQs). The move away from setting a global TAC for the fishery as occurred under the previous Management Policy for the Small Pelagic Fishery, is likely to reduce the likelihood of overcapitalisation. ITQs give each fisher a share of the TAC for a species and remove the strong incentive for fishers to compete to maximise their catch by increasing their fishing power. Under the new plan, it will be important that management continue to monitor the level of quota latency in future years to ensure that the fishery improves its economic performance.



Small pelagics fish processing machinery, Eden
PHOTO: FIONA SALMON, DAFF

7.6 ENVIRONMENTAL STATUS

Ecological risk assessment

Ecological risk assessments have been undertaken separately for midwater trawl and purse seine fishing methods: Level 2: Productivity Susceptibility Analysis; Level 2: Residual Risk Assessment, and; Level 3: Sustainability Assessment for Fishing Effects (Table 7.2).

For purse seine, 235 species were assessed at Level 2 and a total of 108 of these species were assessed as high risk, of which 29 remained high risk after applying AFMA's residual risk guidelines (AFMA 2010a, b). The Level 3 analysis examined 93 species of finfish only and found none at high risk from purse seine fishing (Zhou et al. 2009). After application of the residual risk guidelines, 29 species (all marine mammals) remained at high risk and are now listed as high priority in the ecological risk management plan for the SPF purse seine sector.

For midwater trawl, 237 species were assessed at Level 2 and a total of 26 species were assessed at high risk, of which eight remained high risk after applying AFMA's residual risk guidelines (AFMA 2010b). The Level 3 analysis examined 98 species of finfish and found none at high risk from midwater trawl (Zhou et al. 2009). After application of the residual risk guidelines, eight species (all marine mammals) remained at high risk and are now listed as high priority in the ecological risk management plan for SPF midwater trawl.

Threatened, endangered and protected species

Sharks

Interactions between the SPF and the three TEP shark species (white shark, *Carcharodon carcharias*; grey nurse shark, *Carcharias taurus*; whale shark, *Rhincodon typus*) that overlap with the fishery were assessed as low risk.

Seabirds

Interactions with seabirds have not been identified as a significant issue for the SPF. The Level 2 ecological risk assessment found a low or medium risk rating for the 78 seabird species that overlapped with the SPF.

Marine mammals

Interactions with marine mammals (fur seals and dolphins) are a key environmental issue for the fishery when midwater trawls are used. A recent study commissioned by AFMA to quantify the nature and extent of interactions and to evaluate potential mitigation strategies showed that fur seals entered the net in more than 50% of trawl operations (Lyle & Willcox 2008). In contrast, no dolphin interactions were recorded during the study. The study highlights the need for well-designed seal exclusion devices when using this type of gear.

In their ecological risk management plan, AFMA have identified three seal species and 26 whale and dolphin species as being at high risk and high priority within the SPF. AFMA formed the Cetacean Mitigation Working Group to help develop long-term management strategies.

Pelagic habitats

Minimal negative interactions with pelagic habitats have been identified for this fishery, aside from the potential impact of removing the target species from the broader ecosystem.

Small Pelagic Fishery vessel, Eden PHOTO: DAVID WILSON, ABARE–BRS

7.7 HARVEST STRATEGY PERFORMANCE

B_0 and B_{MEY} were not considered appropriate reference points for the SPF, given the high interannual variability in biomass for the target species. Internationally, exploitation rates of 20% of current biomass are considered conservative, so the HS uses exploitation rates between 10% and 20% of estimated spawning biomass from a DEPM survey for a Tier 1 assessment. Testing through management strategy evaluation has indicated that the Tier 1 approach to harvesting is robust for SPF stocks—in most scenarios, it resulted in stock sizes well above 20% of virgin biomass levels ($0.2B_0$) (Giannini et al. 2010). It should be noted, however, that B_{20} is the default limit reference point for Commonwealth fisheries (DAFF 2007) and that other (higher) biomass limit reference points may be more appropriate for small pelagics due to their high productivity. No biomass limit reference point has been set for the fishery, therefore, the HS proxy of $0.5B_{MSY}$ applies. Exploitation rates in Tier 1 assessments have been set at a conservative level to explicitly account for the important trophic role that small pelagic species play in the marine ecosystem.

There has been some confusion between the interpretation and intent of the HS for the fishery. One issue is that the HS indicates that the RBC calculation should drop back to an SPF Tier 3 level if no new assessment has been undertaken after five years since a DEPM survey. However, the SPFRAG has discussed this rule and failed to reach agreement; some members believe that the original intent was for the RBC calculation to drop back to SPF Tier 2.

A second issue is the interpretation of decay in the SPF Tier 1 assessment. Specifically, when more than one DEPM survey has been conducted in a given period (e.g. two in three years or three in five years), it is not clear whether the RBC after this period should be determined using the decay rate from the last of the DEPM surveys (as specified in the HS) or whether decay rates of 2.5% per year should be applied.

7.8 LITERATURE CITED

AFMA (Australian Fisheries Management Authority) 2003, *Draft assessment report, Small Pelagic Fishery*, AFMA, Canberra.

——2005, *Small Pelagic Fishery Bycatch Action Plan*, AFMA, Canberra.

——2007, *Management Policy for the Commonwealth Small Pelagic Fishery*, AFMA, Canberra.

——2008, *Small Pelagic Fishery Harvest Strategy*, AFMA, Canberra.

——2009a, *Small Pelagic Fishery Management Plan 2009, AFMA*, Canberra, Federal Register of Legislative Instruments F2010L00081.

——2009b, *Small Pelagic Fishery Bycatch and Discarding Workplan*, AFMA, Canberra.

——2010a, *Residual Risk Assessment of the Level 2 Ecological Risk Assessment Species Results Report for the Small Pelagic Fishery – Purse Seine*, AFMA, Canberra, March 2010.

——2010b, *Residual Risk Assessment of the Level 2 Ecological Risk Assessment Species Results Report for the Small Pelagic Fishery – Midwater Trawl*, AFMA, Canberra, March 2010.

Bulman, C, Condie, S, Findlay, J, Hender, J, Ward, B & Young, J 2007, 'Management zones from small pelagic fish species stock structure in southern Australian waters', FRDC project no. 2006/076, unpublished report to the FRDC & AFMA, Canberra.

Daley, R, Dowdney, J, Bulman, C, Sporcic, M, Fuller, M, Ling, S, Milton, D & Hobday, A 2007, *Draft ecological risk assessment for the effects of fishing: report for the purse seine sub-fishery of the Small Pelagic Fishery*, report for the AFMA, Canberra.

Deagle, BE, Kirkwood, R & Jarman, SN 2009, 'Analysis of Australian fur seal diet by pyrosequencing prey DNA in faeces', *Molecular Ecology*, vol. 18, no. 9, pp. 2022–38.

Eschmeyer, WN, Herald, ES & Hammann, H 1983, *A field guide to Pacific coast fishes of North America*, Houghton Mifflin Company, Boston.

Fitch, J 1956, 'Jack mackerel', *California Cooperative Oceanic Fisheries Investigations Reports* 1955–1956, pp. 27–8.

Fréon, P, Cury, P, Shannon, L & Roy, C 2005, 'Sustainable exploitation of small pelagic fish stocks challenged by environmental and ecosystem changes: a review', *Bulletin of Marine Science*, vol. 76, pp. 385–462.

Froese, R & Pauly, DE 2009, *FishBase,* version 02/2009, FishBase Consortium, <www.fishbase.org>.

Giannini, F, Hobsbawn, PI, Begg, GA & Chambers, M 2010, *Management Strategy Evaluation (MSE) of the Harvest Strategy for the Small Pelagic Fishery*, BRS and FRDC (FRDC Project 2008/064), Canberra.

Hart, JL 1973, 'Pacific fishes of Canada', *Bulletin of the Fisheries Research Board of Canada*, vol. 180, pp. 1–740.

Hedd, A & Gales, R 2001, 'The diet of shy albatrosses (*Thalassarche cauta*) at Albatross Island, Tasmania', *Journal of Zoology*, vol. 253, no. 1, pp. 69–90.

Johnson, P, Smith, T & Fulton, B 2009, *Forage species management – a report to AFMA.* AFMA, Canberra, September 2009.

Kailola, PJ, Williams, MJ, Stewart, PC, Reichelt, RE, McNee, A & Grieve, C 1993, *Australian fisheries resources*, Bureau of Resource Sciences & the FRDC, Canberra.

Knuckey, I & Koopman, M 2008, *Review of key biological parameters of species from the Small Pelagic Fishery*, AFMA, Canberra.

Lyle, JM & Willcox, ST 2008, *Dolphin and seal interactions with mid-water trawling in the Small Pelagic Fishery, including an assessment of bycatch mitigation strategies*, Tasmanian Aquaculture and Fisheries Institute, University of Tasmania, Hobart.

May, JL & Maxwell, JGH 1986, *Trawl fish from temperate waters of Australia*, CSIRO Division of Fisheries Research, Tasmania.

Neira, FJ, Lyle, JM, Ewing, GP, Keane, JP & Tracey, SR 2008, *Evaluation of egg production as a method of estimating spawning biomass of redbait off the east coast of Tasmania*, final report, FRDC project no. 2004/039, Tasmanian Aquaculture and Fisheries Institute, Hobart.

Pullen, G 1994, *Fishery status report: purse seine* (*the Tasmanian jack mackerel fishery*), internal report no. 13, Department of Primary Industry and Fisheries, Hobart.

Pyk, TM, Bunce, A & Norman, FI 2007, 'The influence of age on reproductive success and diet in Australasian gannets (*Morus serrator*) breeding at Popes Eye, Port Phillip Bay, Victoria', *Australian Journal of Zoology*, vol. 55, no. 5, pp. 267–74.

Ward, TM & Rogers, PJ 2008, *Evaluating the application of egg-based stock assessment methods for blue mackerel,* Scomber australasicus*, in southern Australia*, final report to the FRDC, Canberra.

Williams, K 1981, *Aerial survey of pelagic fish resources off eastern Australia 1973–1977*, CSIRO Division of Fisheries and Oceans Report 130, Hobart.

Young, JW, Jordan, AR, Bobbi, C, Johannes RE, Haskard K & Pullen, G 1993, 'Seasonal and interannual variability in krill (*Nyctiphanes australis*) stocks and their relationship to the fishery for jack mackerel (Trachurus declivis) off eastern Tasmania, Australia', *Marine Biology*, vol. 116, pp. 9–18.

Zhou, S, Fuller, M & Smith, A 2009, *Rapid quantitative risk assessment for fish species in seven Commonwealth fisheries*, AFMA, Canberra, April 2009.

Processed Australian sardine PHOTO: JAMES LARCOMBE, ABARE–BRS

8 Southern and Eastern Scalefish and Shark Fishery overview

I Stobutzki, P Ward, H Patterson and S Vieira

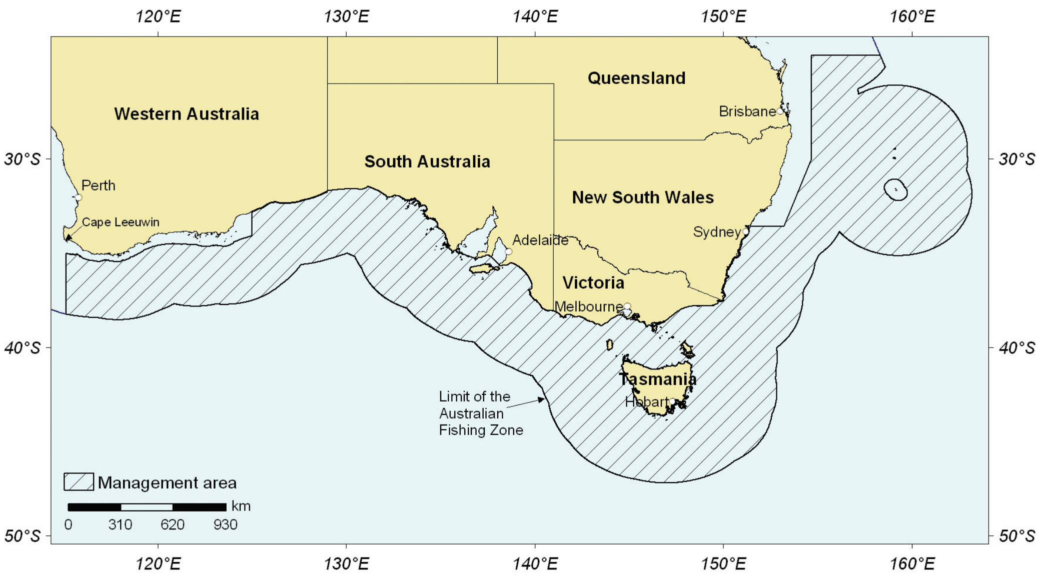


FIGURE 8.1 Area of the Southern and Eastern Scalefish and Shark Fishery

NOTE: Sector-specific areas are provided in following chapters

8.1 BACKGROUND

The Southern and Eastern Scalefish and Shark Fishery (SESSF) is one of the largest Commonwealth-managed fisheries and supplies a large share of the fresh fish for domestic markets. The SESSF covers almost half the area of the Australian Fishing Zone (Fig. 8.1) and spans both Commonwealth and State waters, under Offshore Constitutional Settlement arrangements. It is a multigear fishery that targets a range of scalefish and shark species.

The SESSF was created in 2003 through the amalgamation of four fisheries (South East Trawl, Great Australian Bight Trawl, Southern Shark Non-trawl and South East Non-trawl) under a common set of management objectives; the SESSF Management Plan 2003 came into operation on 1 January 2005. In 2009 the Australian Fisheries Management Authority (AFMA) created the South East Management Advisory Committee (SEMAC) to replace the South East Trawl, and Gillnet Hook and Trap Management Advisory Committees (MACs). The Small Pelagic Fishery MAC and Squid

MAC will become part of SEMAC in 2010. There is currently a separate GABMAC, but its role may be revisited in line with the other amalgamation in the SESSF.

Total SESSF landings have declined from a peak of 37 000 t in 2002 to 20 000 t in 2009, due to reductions in quotas and fishing effort. The gross value of production (GVP) was $95.5 million in 2008–09, accounting for 30% of the GVP of Commonwealth fisheries in that financial year. The SESSF was one of the target fisheries of the 2005 structural adjustment package, which reduced vessel numbers substantially. Although the landings and GVP are lower than historical highs, the net economic returns have improved (Vieira et al. 2010).

8.2 SECTORS OF THE FISHERY AND MANAGEMENT ARRANGEMENTS

Current management arrangements are structured around the different sectors of the fishery:

- Commonwealth Trawl Sector (CTS)
- East Coast Deepwater Trawl Sector (ECDTS)
- Great Australian Bight Trawl Sector (GABTS)
- Gillnet, Hook and Trap Sectors (GHTS).

The specific management areas of the different sectors are shown in subsequent chapters (9, 10, 11 and 12). The GHTS includes the Scalefish Hook Sector (ScHS), the Shark Hook and Shark Gillnet Sector (SHSGS) and two comparatively minor sectors: the Trap Sector (South Australian, Tasmanian and Victorian coastal waters); and the Tasmanian rock lobster sector (SESSF Management Plan—DAFF 2003; as amended in 2009). In this report, the ScHS is reported with the CTS because most of their target species are shared, and the SHSGS is reported as a separate sector. The other minor sectors are not reported in detail because of their low effort and landings. The CTS contributes about 82% of the landed catch (based on 2009–10 fishing season landings) and 59% of the value of the SESSF (2008–09; ABARE 2009).

Management of the SESSF is mainly through annual total allowable catches (TACs) allocated as statutory fishing rights (SFRs). The 34 quota species or stocks comprise around 69% of the total commercial landed catch for the SESSF. The quota species include several byproduct species as well as most target species. Ocean jacket, which is not under quota, is included in this year's report because its catch levels exceed those of many quota species. In addition to TACs, other management arrangements used in the SESSF include limited entry, gear restrictions (e.g. mesh size, net length, setting depth, limits on the number of hooks and trap dimensions), spatial closures, prohibited species (e.g. black cod) and trip limits for certain species (e.g. snapper).

Since 2008 co-management trials have been undertaken in the SESSF. The aim of the trials is to test approaches for AFMA and industry to work cooperatively to increase the efficiency of fisheries management, while still ensuring sustainability. The trials have generally focused on ways in which the day-to-day administration of the fishery can be streamlined and simplified.

8.3 HARVEST STRATEGY FRAMEWORK

Since 2005 a tiered harvest strategy framework (HSF) has been applied in the SESSF. It has evolved over time, particularly after the release of the *Commonwealth Fisheries Harvest Strategy Policy* (HSP; DAFF 2007). The HSF contains four tiers, each of which describes an assessment process and associated harvest control rules. The tiers cater for different levels of certainty (or knowledge) about stocks (AFMA 2009). Each stock is assigned to one of the tier levels, depending on the information available to assess stock status. Tier 1 has the highest

data requirements and represents the most robust assessment, a quantitative, integrated, model-based stock assessment, which provides direct estimates of performance against biomass and fishing mortality target and limit reference points. Tier 4 has the lowest data requirements, with the assessment based on a standardised CPUE series and proxies for the target and limit reference points.

The specific harvest control rules in each tier determine a recommended biological catch (RBC) based on the assessment results. The RBCs are intended to represent the best scientific advice on the total mortality rates (including discards, state and recreational catches) for each stock to achieve the HSF objectives. The harvest control rules also aim to increase the level of precaution in the applied total mortality rates (effectively the TACs) from Tier 1 to Tier 4, reflecting the greater uncertainty in the assessment. Five resource assessment groups (RAGs) provide advice on the appropriate tier level for each stock, review the assessments and determine the RBCs. The overarching SESSF RAG coordinates and reviews this process.

The HSF has undergone management strategy evaluation testing (Wayte 2009) to examine its performance. In 2008 the harvest control rules for Tiers 3 and 4 were altered to ensure that the target and limit reference points reflected those articulated in the HSP, and to address technical performance issues. The Tier 2 is being phased out and is not contained in the most recent description of the HSF (AFMA 2009) that was used to determine RBCs for the 2010–11 fishing year. However, orange roughy (on the Cascade Plateau, southern and western zones) is listed as Tier 2, as this was the classification of the most recent assessment. It is planned that the RBC for this species will be determined under the Tier 1 assessment and harvest control rules.

In summary:

- **Tier 1** uses robust, quantitative, model-based stock assessments, which provide estimates of current biomass levels and fishing mortality relative to the target and

Sorting trawl catch PHOTO: MIKE GERNER, AFMA

limit reference points. The target biomass is the biomass producing maximum economic yield (B_{MEY}) or, if this is not known, 1.2 times the biomass producing maximum sustainable yield (B_{MSY}). The proxy for B_{MSY} is 40% of the unfished biomass (B_0); for B_{MEY} it is $0.48B_0$. The limit reference point for biomass is equal to or greater than $0.5B_{MSY}$ ($0.20B_0$ as a proxy). The target level of fishing mortality is the level that would, on average, maintain the biomass at $0.48B_0$. The Tier 1 harvest control rules specify that if the biomass is below a threshold ($0.35B_0$), the level of fishing mortality is decreased to enable the biomass to rebuild to $0.48B_0$, with fishing mortality reaching zero when the biomass is at or below the limit reference point. The RBC is obtained by applying the appropriate level of fishing mortality to the estimated current biomass.

- **Tier 2** used a preliminary quantitative, model-based assessment, with the target reference point for biomass set at 50% of unfished levels to reflect the uncertainty in the assessment. As noted above, orange roughy (on the Cascade Plateau, southern and western zones) is listed as Tier 2, but this tier level is being phased out.
- **Tier 3** uses estimates of average recent fishing mortality, based on the age structure of the catch, the biology of the species, total catch weight and selectivity of the fishing gear. The limit reference point is the level of fishing mortality that would lead, in the long term, to a spawning biomass equal to $0.48B_{MSY}$ or a proxy. The target reference point is fishing mortality that would lead to a spawning biomass equal to B_{MEY} or its proxies. The RBC is set as a proportion of average recent catch, where the proportion depends on the relationship between the estimate of current fishing mortality and the reference points.
- **Tier 4** uses catch per unit effort (CPUE) reference points as proxies for B_{LIM} and B_{TARG}, assuming that CPUE reflects the trend in biomass of a species (AFMA 2009; Little et al. 2009). The target CPUE is the average for a period of years (the reference period) when CPUE was relatively stable and the fishery was considered to be both profitable and sustainable. For species that do not have a long history of exploitation, the average CPUE for a reference period early in the fishery is considered to represent a relatively unfished state, and the target CPUE is set at half this level (approximating the default proxy for B_{MEY} of $0.48B_0$; AFMA 2009). In both cases, the limit reference point is set at 40% of the target (approximating $0.2B_0$; Little et al. 2009). The RBC is set as a proportion of the average catch in the reference period (or half this value for relatively unfished species), where the proportion depends on the relationship between the current standardised CPUE and the reference points. A maximum level of catch is also set at 1.2 times the average catch in the reference period.

In 2009, 12 SESSF stocks were assessed at the Tier 1 level, 4 at Tier 3 and 14 at Tier 4 (orange roughy in the GABTS is not assessed under the tier structure due to a lack of data). As noted above, three stocks (orange roughy) remain at the Tier 2 level, but will move to Tier 1 assessments the next time they are updated. The Tier 3 and 4 species tend to be of lesser economic value (such as John dory, mirror dory, ocean perch and royal red prawn) or deepwater stocks (with the exception of orange roughy).

The target and limit reference points for Tier 3 and 4 do not include any inherent level of increasing precaution to offset the increasing uncertainty. Therefore, this precaution is introduced through the harvest control rules with a default discount factor that reduces the RBCs slightly for Tier 3 species (5%) and more for Tier 4 species (15%) (AFMA 2009). The RAG can recommend that the discount factors are not required if there is evidence that adequate precaution was already afforded through other management measures (e.g. closures) or that the fishery had exhibited stability at current catch levels. The application of appropriate discount factors for Tier 3 and 4 stocks is needed to ensure that these stocks are not at increased risk as a result of a lack of more sophisticated assessments. Finally, in converting RBCs to TACs, the HSF also takes into account expected mortalities

from discarding and catches in other jurisdictions (including recreational catches).

Post-assessment modifiers

In addition to the above harvest control rules, two additional rules have been developed in response to industry concerns and are applied by AFMA in recommending TACs to the AFMA Commission:

- **Recent catch rate multiplier**. This incorporates the recent CPUE data in recognition of the time lags inherent in the assessment process. TACs are adjusted up or down according to whether the standardised catch rates for the most recent year are higher or lower than the previous year.
- **Minimum and maximum changes**. Changes to TACs are limited to between 10% and 50% to avoid trivial adjustments and large variations in TACs that are difficult for industry to accommodate.

Carryover, bycatch (byproduct) TACs and change to fishing year

Operators can carryover a limited credit of uncaught quota ('undercatch') or debit of overcaught quota ('overcatch') into the following fishing year for most stocks in the SESSF. For the 2009–10 fishing season (1 May 2009 to 30 April 2010), the undercatch and overcatch carryover percentages were set at 10% for all quota stocks except for school shark, gummy shark, sawshark and elephant fish, for which no overcatch carryover was permitted.

For a number of overfished stocks, 'bycatch TACs' are set at low levels to prevent targeted fishing. This is meant to allow retention for sale of a low level of unavoidable catch, taken during targeted fishing for other species. As this catch is retained, it is technically not bycatch, but rather byproduct. However, 'bycatch TAC' is the term used by AFMA to describe these types of TACs. Concern has been raised previously about the carryover of undercatch for these species, which can become a large proportion of the actual bycatch TAC and is inconsistent with the concept of a bycatch TAC and rebuilding of overfished species. In setting TACs for the 2010–11 fishing season, AFMA and the RAGs addressed this issue by examining whether carryover of undercatch was appropriate for each species.

AFMA also sets a 'determined amount', which is the maximum amount, in addition to the percentage of overcatch, that an operator may take under certain conditions without committing an offence. However, twice the quantity of any catch above the quota but below the determined amount that applies for a stock is deducted from the operator's SFR for the following season.

In 2008 the SESSF quota allocation changed from a calendar year to a fishing year, spanning 1 May to 30 April. The TAC, catch and effort values given at the beginning of each sector chapter indicate the TAC for the most recent **fishing years**.

Harvest strategy performance

The implementation of the SESSF HSF has contributed to ensuring that there is at least some form of assessment for most quota species. This, in combination with the fact that the HSF has been tested using mangement strategy evaluation (MSE) techniques, has led to greater certainty about the status of SESSF stocks. This is reflected in a reduction in the number of uncertain species over time and provides a strengthened basis for TAC setting. There are still areas of the HSF which need development/improvement including:

- **Consistency:** a continued focus on consistency in the application of the HSF across species and in the assessment approach across RAGs.
- **Bycatch TACs (byproduct):** the process for establishing the level of bycatch (byproduct) TACs to enable the rebuilding of the stock within the appropriate timeframe.
- **Species at or near the target:** the harvest control rules used for setting TACs for these species. While there is likely to be little risk for species in this situation,

and there is some flexibility for these species, delays in reducing the fishing mortality may result in more significant reductions in subsequent years.

- **Application of discount factors:** the default position in the HSF is the application of the discount factors to Tiers 3 and 4. Specific criteria are needed for determining when these discounts should not be applied (i.e. what evidence demonstrates that sufficient precaution is provided by other management measures).
- **Incorporation of closed areas into assessments:** the effect of closed areas on target catch rates and catches needs to be considered in a consistent way across species, taking into account the mobility of species. If the previous catch from a closed area is included in the target catch, it may not be appropriate to then argue that the closures provide a level of precaution that justifies not applying the discount factor.
- **Target catch levels for Tier 4 stocks without a long catch history:** currently, the average CPUE from the reference period early in the fishery is considered to represent a relatively unfished state, and the target CPUE is set at half this level (approximating the proxy for B_{MEY}). However, the process for identifying the target catch is not consistent. For some stocks, the catch during the reference period is halved to provide the target catch (e.g. non-Cascade smooth oreodory), whereas in others the average catch is used as the target catch.

Other issues that need to be addressed include**:**

- **Standardisation of CPUE for species where fishing practices have changed:** the standardised CPUE time series are critical to both Tier 4 and Tier 1 assessments. In some species, it has been suggested that the fishing practices have changed substantially over time from targeting to avoidance (e.g. pink ling). The approach to standardising CPUE for these species should be examined to see whether it effectively addresses this issue and to confirm that the standardised CPUE provides a robust indicator of biomass.
- **Recent CPUE multiplier rule:** the impact of this rule on the performance of the Tier 3 and 4 assessments needs to be evaluated as recommended by Haddon (2010). The rule is based on a comparison of the CPUE of the two most recent years, while the Tier 4 usually uses an average of four years and the Tier 3 is based on estimates of fishing mortality. Therefore, the implementation of this rule may compromise the intent of the assessments.
- **Stocks for which none of the tier levels is appropriate:** there appear to be stocks (see Chapter 9) for which the RAG has no confidence in the Tier 4 assessment. An alternative approach should be considered to guide RBCs for these species.

8.4 STATUS OF STOCKS

Of the 37 stocks assessed (34 were under quota) from the SESSF in 2009, 23 were not overfished and 25 were not subject to overfishing. However, 7 were overfished and 4 were subject to overfishing and 3 were both overfished and subject to overfishing. Only 9 stocks were uncertain for overfished and/or overfishing status.

The reduction in the number of uncertain stocks has been driven to a large extent by the implementation of the MSE-tested HSF. The SESSF HSF incorporates explicit target and limit reference points consistent with the HSP for each tier. The indicators used in these assessments therefore allow, and have been used in this report to provide, an assessment of stock status. Tier 1 assessments provide a direct estimate of current biomass levels relative to agreed targets and limits, and therefore indicate whether a stock is overfished. Most Tier 1 assessments also provide estimates of fishing mortality. Combined with recent catch levels relative to RBCs, this provides an indication of whether overfishing is occurring. Tier 3 assessments give an estimate of recent average levels of fishing mortality, which provides a basis for assessing whether overfishing has been occurring. Tier 4 assessments provide an indication of whether a stock is overfished, and comparison of the catch with the RBC indicates whether overfishing has been

occurring. For Tier 3 species, the Tier 4 assessment (even though it is not formally used for RBC determination) is used as an indicator of whether a stock is overfished. Where the results from these assessments are inconsistent (e.g. redfish), the assessment from the more robust Tier 3 level has been used. In classifying status, we have also used the weight-of-evidence approach (described in Chapter 1) that considers a wide range of biological and fisheries information in addition to RAG assessments.

8.5 LITERATURE CITED

ABARE (Australian Bureau of Australian Agricultural and Resource Economics) 2009, *Australian fisheries statistics 2008*, ABARE, Canberra.

AFMA (Australian Fishery Management Authority) 2009, *Harvest Strategy Framework for the Southern and Eastern Scalefish and Shark Fishery*, version 1.2 September 2009, AFMA, Canberra.

DAFF (Australian Government Department of Agriculture, Fisheries and Forestry) 2003, *Southern and Eastern Scalefish and Shark Fishery Management Plan 2003* (amended 2006), DAFF, Canberra, Federal Register of Legislative Instruments F2007C00069.

——2007, *Commonwealth Fisheries Harvest Strategy: policy and guidelines*, DAFF, Canberra.

Haddon, M 2010, 'Catch rate standardization updates with data to Nov 2009', in GN Tuck (ed), *Stock assessment for the Southern and Eastern Scalefish and Shark Fishery 2009*, part 2, AFMA & CSIRO Marine and Atmospheric Research, Hobart, pp. 192–228.

Little, LR, Wayte, SE, Tuck, GN, Thomson, RB, Smith, ADM, Klaer, NL, Punt, AE & Haddon M 2009, 'Testing an alternative Tier 4 control rule and CPUE reference points for the SESSF', in SE Wayte (ed), *Evaluation of new harvest strategies for SESSF species*, CSIRO Marine and Atmospheric Research, Hobart & AFMA, Canberra, pp. 98–112.

Vieira, S, Perks, C, Mazur, K, Curtotti, R & Li, M 2010, *Impact of the structural adjustment package on the profitability of Commonwealth fisheries*, ABARE research report 10.01, Canberra.

Wayte, SE (ed) 2009, *Evaluation of new harvest strategies for SESSF species*, CSIRO Marine and Atmospheric Research, Hobart & AFMA, Canberra.

Trawl catch PHOTO: MIKE GERNER, AFMA

9 Commonwealth Trawl and Scalefish Hook Sectors

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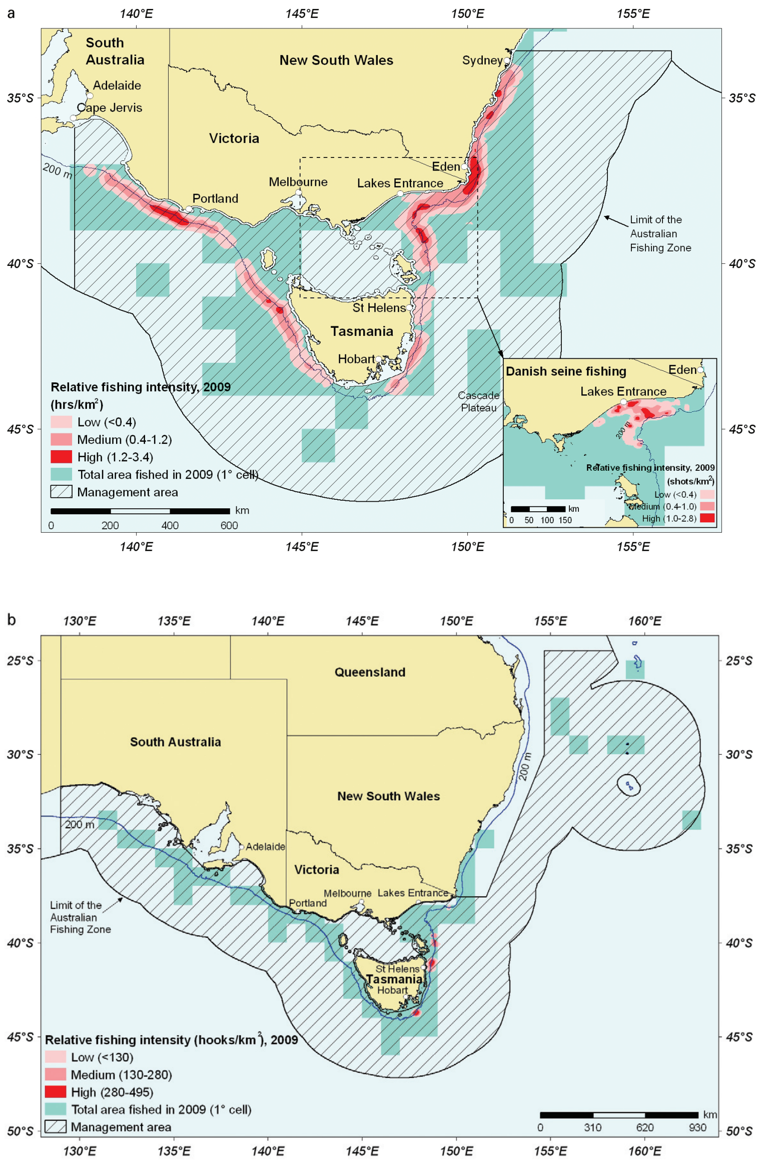


FIGURE 9.1 Relative fishing intensity in the a) Commonwealth Trawl Sector and b) Scalefish Hook Sector, 2009

TABLE 9.1 Status of the Commonwealth Trawl and Scalefish Hook Sectors

Fishery status	2008		2009		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Blue-eye trevalla (*Hyperoglyphe antarctica*)					Tier 4 assessment; CPUE is near the target level; catches in line with the RBC indicate overfishing is not occurring.
Blue grenadier (*Macruronus novaezelandiae*)					Tier 1 assessment; biomass near the target level; catches in line with RBC indicate overfishing is not occurring.
Blue warehou (*Seriolella brama*)					Tier 4 assessment; CPUE is below limit reference point; total fishing mortality is unlikely to facilitate rebuilding.
Deepwater sharks, eastern (18 species)					Tier 4 assessment; low catches indicate overfishing is not occurring.
Deepwater sharks, western (18 species)					Tier 4 assessment; low catches indicate overfishing is not occurring.
Eastern school whiting (*Sillago flindersi*)					Tier 1 assessment; biomass near the target level; catch in line with RBC indicate overfishing is not occurring.
Flathead (5 species)					Tier 1 assessment; biomass above target for past three years in 2009 assessment; catches in line with RBC indicate overfishing is not occurring.
Gemfish, eastern (*Rexea solandri*)					Tier 1 assessment; biomass below limit reference point. Uncertain whether current fishing mortality will enable rebuilding.
Gemfish, western (*Rexea solandri*)					Tier 4 assessment based on CPUE from a minor part of the total fishery.
Gulper sharks (*Centrophorus harrissoni, C. moluccensis, C. zeehaani*) (upper-slope)					Current fishing level constitutes overfishing. Stock reduced by >90% on east coast.
Jackass morwong (*Nemadactylus macropterus*)					Tier 1 assessment; biomass below target level, most of the catch being taken from more depleted eastern stock.
John dory (*Zeus faber*)					Tier 3 and Tier 4 assessments; CPUE trend increasing and just above limit.

Table 9.1 continues over the page

TABLE 9.1 Status of the Commonwealth Trawl and Scalefish Hook Sectors CONTINUED

Fishery status	2008		2009		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Mirror dory (*Zenopsis nebulosus*)					Tier 3 and Tier 4 assessments; CPUE trend increasing and approaching target level.
Ocean jacket, eastern (*Nelusetta ayraudi*)					No formal assessment.
Ocean perch (*Helicolenus barathri, H. percoides*)					Tier 4 assessment; low catches; CPUE trend stable and above limit.
Orange roughy, Cascade Plateau (*Hoplostethus atlanticus*)					Tier 2 assessment; current biomass >60% B_0.
Orange roughy, eastern zone (*Hoplostethus atlanticus*)					Tier 1 assessment; low catches indicate overfishing is not occurring.
Orange roughy, southern zone (*Hoplostethus atlanticus*)					Tier 2 assessment; low catches indicate overfishing is not occurring.
Orange roughy, western zone (*Hoplostethus atlanticus*)					Tier 2 assessment; low catches indicate overfishing is not occurring.
Smooth oreodory, Cascade Plateau (*Pseudocyttus maculatus*)					Tier 4 assessment; CPUE low catches indicate overfishing is not occurring.
Smooth oreodory, other					Tier 4 assessment; low catches indicate overfishing is not occurring.
Other oreodories (4 species)					Tier 4 assessment; low catches indicate overfishing is not occurring.
Pink ling (*Genypterus blacodes*)					Tier 1 assessment; biomass is below target, but above limit reference point; however, it is uncertain whether overfishing is occurring.
Redfish (*Centroberyx affinis*)					Tier 3 and Tier 4 assessments; low biomass with relatively high fishing mortality.
Ribaldo (*Mora moro*)					Tier 4 assessment; limited data.

Table 9.1 continues over the page

TABLE 9.1 Status of the Commonwealth Trawl and Scalefish Hook Sectors CONTINUED

Fishery status	2008		2009		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Royal red prawn (*Haliporoides sibogae*)	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Tier 4 assessment; low catches indicate overfishing is not occurring.
Silver trevally (*Pseudocaranx georgianus*)	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Tier 4 assessment; low catches and catch rates close to target indicate overfishing is not occurring.
Silver warehou (*Seriolella punctata*)	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Tier 1 assessment; low catches and CPUE indicate overfishing is not occurring.
Economic status Fishery level	Net economic returns were $7.1 million in 2007–08		Estimates of net economic returns not available, but likely to be positive in 2008–09		Economic status likely to be improving given recent stock recovery and restructuring.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING — OVERFISHED / OVERFISHING — UNCERTAIN — NOT ASSESSED

CPUE = catch per unit effort; RBC = recommended biological catch

TABLE 9.2 Main features and statistics of the Commonwealth Trawl Sector and Scalefish Hook Sector of the Southern and Eastern Scalefish and Shark Fishery

Feature	Description
Key target and byproduct species	16 individual quota species and 29 species in basket or multispecies quotas (see below for species details); a number of species under TAC that are considered byproduct (e.g. orange roughy); three species of gulper sharks (under trip limits)
Other byproduct species	Numerous species (see Table 9.5)
Fishing methods	Trawl, hook methods (dropline, demersal longline), Danish-seine
Primary landing ports	Ulladulla, Lakes Entrance, Eden, Hobart, Portland
Management methods	Input controls: limited entry, gear restrictions, area closures Output controls: TACs, ITQs, trip limits
Management plan	*Southern and Eastern Scalefish and Shark Fishery Management Plan 2003* (DAFF 2003, amended 2009)
Harvest strategy	*Southern and Eastern Scalefish and Shark Fishery Harvest Strategy Framework* (AFMA 2009a; Smith & Smith 2005)
Consultative forums	South East Management Advisory Committee (SEMAC), Slope Resource Assessment Group (SlopeRAG), Shelf Resource Assessment Group (ShelfRAG), Deepwater Resource Assessment Group (DeepRAG)
Main markets	Domestic: Sydney and Melbourne—fresh, frozen International: minor exports

Table 9.2 continues over the page

TABLE 9.2 Main features and statistics of the Commonwealth Trawl Sector and Scalefish Hook Sector of the Southern and Eastern Scalefish and Shark Fishery CONTINUED

Feature	Description			
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Current accreditation dated 2 February 2010 Current accreditation (Wildlife Trade Operation) expires 30 July 2012			
Ecological risk assessment	Level 1: Scale Intensity Consequence Analysis (SICA) completed on 600 species (Daley et al. 2007; Wayte et al. 2007a,b) Level 2: Productivity Susceptibility Analysis (PSA) completed on 600 species—159 high-risk species (trawl), 1 high-risk (Danish-seine), 56 high-risk (auto-longline) (Daley et al. 2007; Wayte et al 2007a,b) Level 3: Sustainability Assessment for Fishing Effects (SAFE) completed on 440 species—23 high-risk species (trawl), 43 high-risk (auto-longline) (Zhou et al. 2007) Residual risk: 10 high risk (trawl); 1 high risk (Danish seine); 9 high risk (auto-longline) (AFMA 2010a,b,c)			
Bycatch workplans	South East Trawl Fishery Bycatch and Discarding Workplan (1 July 2009–30 June 2011) (AFMA 2009b) Auto Longline Fishery Bycatch and Discarding Workplan (1 July 2009–30 June 2011) (AFMA 2009c)			
Fishery statistics[a]	**2008–2009 fishing season**		**2009–2010 fishing season**	
Fishing season/year	1 May 2008–30 April 2009		1 May 2009–30 April 2010	
TAC and catch by fishing season:	TAC (tonnes)[b]	Catch (trawl, hook) (tonnes)	TAC (tonnes)[b]	Catch (trawl, hook) (tonnes)
blue-eye trevalla	560	439 (38, 400)	560	421 (40, 381)
blue grenadier	4368	3820 (3810,11)	4700	3281 (3270, 11)
blue warehou	365	161 (160, 1)	183	122 (121, 2)
deepwater sharks—mid-slope				
eastern zone	50	30 (30, <1)	75	40 (38, 2)
western zone	50	33 (32, <1)	63	43 (42, 1)
eastern school whiting	750	471 (trawl)	1125	490 (trawl)
flathead	2850	2916 (2915, <1)	2850	2832 (2831, <1)
gemfish, eastern	100	104 (84, 20)	100	87 (71, 16)
gemfish, western	167	99 (88, 11)	125	77 (64, 13)
gulper sharks (upper-slope)[c]	none	6 (5, 1)	none	3 (3, <1)
jackass morwong	560	578 (572, 5)	450	410 (408, 2)
John dory	190	140 (140, <1)	190	97 (97, <1)
mirror dory	634	430 (430, <1)	718	535 (531, 3)
ocean jacket, eastern	none	245 (245, <1)	none	253 (253, <1)
ocean perch	500	231 (182, 49)	400	203 (146, 21)
orange roughy, eastern	25	4 (trawl)	25	9 (trawl)
orange roughy, southern	25	<1 (trawl)	35	17 (trawl)
orange roughy, western	50	6 (trawl)	60	25 (trawl)
orange roughy, Cascade Plateau	700	125 (trawl)	500	465 (trawl)
smooth oreodory, Cascade Plateau	80	1 (trawl)	100	1 (trawl)
smooth oreodory, other	40	1 (trawl)	30	1 (trawl)
oreodory, other	150	103 (trawl)	188	96 (trawl)
pink ling	1080	1109 (645,463)	800	838 (542, 296)
redfish	850	188 (188, <1)	678	190 (190, <1)
ribaldo	165	115 (37, 78)	165	130 (45, 86)
royal red prawn	400	86 (trawl)	400	108 (trawl)
silver trevally	296	128 (127, 1)	360	189 (188, 1)
silver warehou	3227	1544 (1544, <1)	3000	1323 (1321, 2)

Table 9.2 continues over the page

TABLE 9.2 Main features and statistics of the Commonwealth Trawl Sector and Scalefish Hook Sector of the Southern and Eastern Scalefish and Shark Fishery CONTINUED

Feature	Description			
Fishery statistics[a]	**2008–2009 fishing season**		**2009–2010 fishing season**	
TAC and catch by fishing season:	TAC (tonnes)[b]	Catch (trawl, hook) (tonnes)	TAC (tonnes)[b]	Catch (trawl, hook) (tonnes)
Effort	Fishing season 2008–2009	Calendar year 2008	Fishing season 2009–2010 (preliminary[d])	Calendar year 2009
	Otter trawl: 59 823 bottom-time hours Danish-seine: 5685 shots Scalefish hook: 7 151 516 hooks	Otter trawl: 61 240 bottom-time hours Danish-seine: 6520 shots Scalefish hook: 6 745 084 hooks	Otter trawl: 57 066 bottom-time hours Danish-seine: 6381 shots Scalefish hook: 5 387 435 hooks	Otter trawl: 57 160 bottom-time hours Danish-seine: 5980 shots Scalefish hook: 5 946 801 hooks
Fishing permits	59 CTS vessels 22 Victorian coastal waters trawl permits 58 Scalefish hook vessels		59 CTS vessels 22 Victorian coastal waters trawl permits 58 Scalefish hook vessels	
Active vessels	Trawl: 53; non-trawl: 20		Trawl: 51; non-trawl: 21	
Observer coverage	462 trawl shots (3.6% of trawling hours) 15 Danish-seine shots (0.2% of shots) 612 990 auto-longline hooks set (9.1%)		657 trawl shots (3.1% of trawling hours) 32 Danish-seine shots (0.5% of shots) 658 750 auto-longline hooks set (11.1%)	
Real gross value of production (2008–09 dollars)	2007–08: $46.6 million in the CTS and $8.1 million in the ScHS		2008–09: $54.3 million in the CTS and $9.4 million in the ScHS	
Allocated management costs (2008–09 dollars)	2007–08: $3.7 million		2008–09: $3.4 million	

CTS = Commonwealth Trawl Sector; EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; ScHS = Scalefish Hook Sector; TAC = total allowable catch; ITQ = individual transferable quota

a Fishery statistics are provided by fishing season unless otherwise indicated.

b Agreed TAC: TACs for individual quota species set annually by the AFMA Commission; the actual TAC may vary depending on carryover of undercatch and overcatch from the previous year. The TAC shown is for all sectors and fisheries (state and Commonwealth).

c 150 kg trip limit. Catches for gulper sharks are derived from logbooks using the Codes for Australian Aquatic Biota (CAAB) code for 'endeavour dogfish'. This code is generally used to describe the three species in this group, rather than just the true endeavour dogfish. Another CAAB code that may include gulper sharks was excluded, as it also contains sharks from four other families and therefore is not a good indication of gulper shark catch. Thus, reported catches are an underestimate.

d Preliminary effort data as of 27 May 2010.

9.1 BACKGROUND

The Commonwealth Trawl Sector (CTS) of the Southern and Eastern Scalefish and Shark Fishery (SESSF) stretches from Sydney southwards around Tasmania to Cape Jervis in South Australia, where it abuts the Great Australian Bight Trawl Sector (GABTS, Chapter 11) (Fig. 9.1a). To the north, the CTS adjoins the East Coast Deepwater Trawl Sector (Chapter 10), which extends to 24°30´S off Queensland. The Scalefish Hook Sector (ScHS) extends from the same boundary off Queensland to the South Australia–Western Australia border (Fig. 9.1b). The ScHS is managed as part of the Gillnet, Hook and Trap Sector (GHTS) of the SESSF, but is reported here because most target species are shared with the CTS.

Some of the species and stocks extend beyond the fisheries' boundaries and are managed by other jurisdictions. However, under Offshore Constitutional Settlement arrangements, the relevant states have largely ceded control of the SESSF quota-managed species to the Australian Government. Thus, in most instances, the catches in state waters by Commonwealth-endorsed vessels are debited against the respective SESSF total allowable catch (TAC) limits (Table 9.2). However, New South Wales retains jurisdiction over non-trawl fishers out to 80 nautical miles (nm) along its entire coastline, and over trawl fishers for the same distance offshore north of Sydney and out to 3 nm offshore south of Sydney.

TABLE 9.3 History of the Commonwealth Trawl Sector of the SESSF

Year	Description
1915	Fishery started with introduction of three steam trawlers by New South Wales Government.
1920–1928	Steam trawler fleet expanded.
1928–1929	Flathead catches peaked at more than 5000 t.
1933–1947	Danish-seining introduced to New South Wales, then Victorian waters.
Late 1940s	Declines in flathead stocks led to increased catches of redfish and jackass morwong.
1960	Last steam trawler left fishery.
1961–1971	Fleet consisted of Danish-seiners only.
1971–1985	Expansion of otter trawlers into fishery and reduction in the number of Danish-seine vessels by 1979. New South Wales otter trawl fleet expanded the area fished southward and to deeper waters. This fleet was 130 vessels by the early 1980s.
1985	South East Trawl Fishery Management Plan introduced, including limited entry to the fishery, the formation of the South East Trawl Management Advisory Committee and mandatory logbooks.
1988	TAC introduced for eastern gemfish (after catches peaked in the 1980s).
1989	ITQs introduced for eastern gemfish.
1989–1990	TACs introduced for orange roughy off eastern and southern Tasmania.
1992	Sector-wide TACs and ITQs implemented for 16 species and species groups.
1993–1996	Zero TAC implemented for eastern gemfish from 1993 to 1996.
1994	Independent scientific monitoring program initiated to collect data on discards, catch and fishing practices, and port data on the size composition of landings. TAC introduced for blue-eye trevalla in the trawl sector to reduce targeting.
1997	Structural adjustment removed 27 permits from the fishery.
1998	Global TAC[a] introduced for blue-eye trevalla.
2001	Global TACs extended to all 16 quota species/groups.
2002	Eastern gemfish catch reduced to 100 t. Trip limits introduced for Harrisson's, endeavour and southern dogfish.
2003	St Helens Hill closure implemented for orange roughy (all trawl methods prohibited).
2005	Harvest strategy framework adopted by AFMA; TACs introduced for additional six stocks.
2006	Structural adjustment package reduced concessions from 118 to 59. Orange roughy listed as conservation dependent under the EPBC Act. The Orange Roughy Conservation Programme (AFMA 2006) commenced, prohibiting targetted fishing for orange roughy outside the Cascade Plateau.
2007	16-month fishing year (season) from 1 Jan 2007 to 30 April 2008 to enable the fishery to move to a fishing year running from 1 May 2008 to 30 April 2009 (and the same period for all subsequent years). Gulper shark closures implemented: i) endeavour dogfish—waters off Sydney in the area of the submarine cable protection zone closed to all fishing methods; ii) Harrisson's dogfish—eastern Bass Strait closed to all hook and trawl methods. In line with the Orange Roughy Conservation Programme, areas deeper than 700 m were closed to all trawl methods (except those exempt). Tasmanian Seamounts Marine Reserve was declared with all trawl methods prohibited. South-east Commonwealth marine reserve network declared.
2008	Trawling in the SESSF nominated as a key threatening process under the EPBC Act. Three species of gulper sharks (*Centrophorus harrissoni*, *C. moluccensis*, *C. zeehaani*) nominated for listing as threatened under the EPBC Act. Rebuilding strategies commenced for blue warehou (AFMA 2008b), eastern gemfish (AFMA 2008c) and school shark (AFMA 2008d).
2009	Eastern gemfish and school shark listed as conservation dependent under the EPBC Act. Creation of SEMAC with the amalgamation of SETMAC and GHATMAC. SPFMAC and SquidMAC to be included in 2010.

AFMA = Australian Fisheries Management Authority; EPBC Act = *Environment Protection and Biodiversity Conservation Act* 1999; SETMAC = South East Trawl Management Advisory Committee; GHATMAC = Gillnet, Hook and Trap Management Advisory Committee; ITQ = individual transferable quota; SEMAC = South East Management Advisory Committee; SESSF = Southern and Eastern Scalefish and Shark Fishery; SPFMAC = Small Pelagic Fishery Management Advisory Committee; SquidMAC = Southern Squid Fishery Management Advisory Committee; TAC = total allowable catch

a Global TACs encompassed all commercial fishing methods in Commonwealth-managed CTS waters.

SOURCE: Tilzey (1994); www.environment.gov.au; AFMA (2006, 2008b,c,d, 2009b,c); Wilson et al. (2009).

TABLE 9.4 History of the Scalefish Hook Sector of the SESSF

Year	Description
1980s	Non-trawl sector with limited entry, primarily droplining. Targeting of blue-eye trevalla started.
1992	Trip limits introduced for eastern gemfish.
1996	Sector combined with the SESSF.
1997	Mandatory Commonwealth logbooks replaced state reporting. 160 non-trawl endorsed fishers (including gillnet). A TAC of 250 t introduced for blue warehou.
1998	Global TACs introduced for blue-eye trevalla, blue warehou and pink ling.
2001	Global TACs extended to all SESSF quota species and groups.
2002	183 m auto-longline closure: all waters shallower than 183 m closed to auto-longlining.
2002–04	Auto-longlining increased in effort to peak in 2004 (8 504 902 hooks set).
2003	Trip limits introduced for gulper sharks (Harrisson's, endeavour and southern dogfish).
2004	Cascade Plateau closed to hook methods as a precaution for blue-eye trevalla. The auto-longline sector expanded into Great Australian Bight waters.
2005	Harvest strategy framework adopted by AFMA.
2006	Structural adjustment package reduced concessions from 122 to 59.
2007	ScHS gulper shark closure: southern dogfish area closure to hook methods.
2009	Creation of SEMAC with the amalgamation of SETMAC and GHATMAC. SPFMAC and SquidMAC to be included in 2010.

AFMA = Australian Fisheries Management Authority; SETMAC = South East Trawl Management Advisory Committee; GHATMAC = Gillnet, Hook and Trap Management Advisory Committee; ScHS = Scalefish Hook Sector of the SESSF; SEMAC = South East Management Advisory Committee; SESSF = Southern and Eastern Scalefish and Shark Fishery; SPFMAC = Small Pelagic Fishery Management Advisory Committee; SquidMAC = Southern Squid Fishery Management Advisory Committee; TAC = total allowable catch

Source: Tilzey (1994); Wilson et al. (2009).

9.2 THE 2009 FISHERY

The CTS and ScHS continue to be an important component of the Australian fishing industry, particularly as a significant supplier of fresh fish for Sydney and Melbourne fish markets. In 2009–10 fishing season, a total of 19 280 t of quota was agreed upon across the quota species and groups (Table 9.2); the actual total quota available was 20 501 t, once overcatch and undercatch were taken into account. This was a reduction from the total available quota in the 2008–09 fishing season. The majority of the quota (18 877 t) was for target species and groups, while 403 t was allocated as 'bycatch quota' to cover the incidental catch of eastern gemfish, blue warehou and orange roughy (eastern, southern and western regions). The total landings of target quota species in 2009–10 were 11 770 t, and the landings of bycatch quota species were 260 t, both around 61% of the available quota.

The total landings of quota species in the CTS were 11 066 t, decreasing from 12 839 t in the 2008–09 fishing season; of this amount, 242 t was for 'bycatch quota' species. In 2009–10 blue grenadier, flathead and silver warehou remain key species in terms of catch volume; however, all three showed reductions in catches, in line with reduced TACs (Table 9.2). Catches of orange roughy from all sectors with a byproduct TAC increased, and catches on the Cascade Plateau also increased to 465 t from 125 t in 2008–09. Catches of several species—blue warehou, blue grenadier, whiting, western gemfish, jackass morwong, ocean perch, redfish, ribaldo, royal red prawn and silver warehou—declined by more than 10% from 2008–09 (Table 9.2). There were increases (>10%) in the catch of deepwater sharks, mirror dory and silver trevally (Table 9.2).

Annual (calendar year) fishing effort in the CTS (hours of bottom-time) peaked in 2001

at 112 000 hours (Fig. 9.2a). After the removal of fishing concessions by the *Securing our Fishing Future* structural adjustment package, trawl effort declined to 58 000 hours in 2007. Effort decreased by 7% in 2009 to 57 160 hours (61 240 hours in 2008). Effort in the Danish-seine fleet has been more consistent and was 5980 shots in the 2009 calendar year (Fig. 9.2a).

Landings of quota species in the ScHS in 2009–10 fishing season totalled 964 t, 1.7% lower than in 2008–09 (981 t) and 37.0% lower than the peak of 1529 t in 2004 (Fig. 9.2b), noting the change from calendar year to fishing year. Blue-eye trevalla and pink ling remain the key species however, their catches reduced by 30.5% and 38%, respectively, in line with TAC reductions (Table 9.2). Hook effort peaked at around 10 million hooks in 2005 and has since declined; effort was 5 946 801 hooks set in 2009, compared with 6 745 084 hooks sets in 2008.

Scalefish catches in the CTS typically account for more than 85% of the gross value of production (GVP) in the SESSF. In the 2008–09 financial year, GVP in the CTS increased by $8.3 million (18%) to $54.2 million, while GVP in the ScHS increased by $1.3 million (16%) to $9.4 million (in real terms). This resulted in a combined GVP for both sectors of $63.6 million. Blue grenadier and flathead were the most valuable species in 2008–09, valued at $14.8 million and $11.8 million, respectively. Other important species in terms of value included pink ling ($7.8 million), silver warehou ($3.7 million) and blue-eye trevalla ($3.6 million) (Fig. 9.3).

Port of Eden PHOTO: NEIL BENSLEY, ABARE–BRS

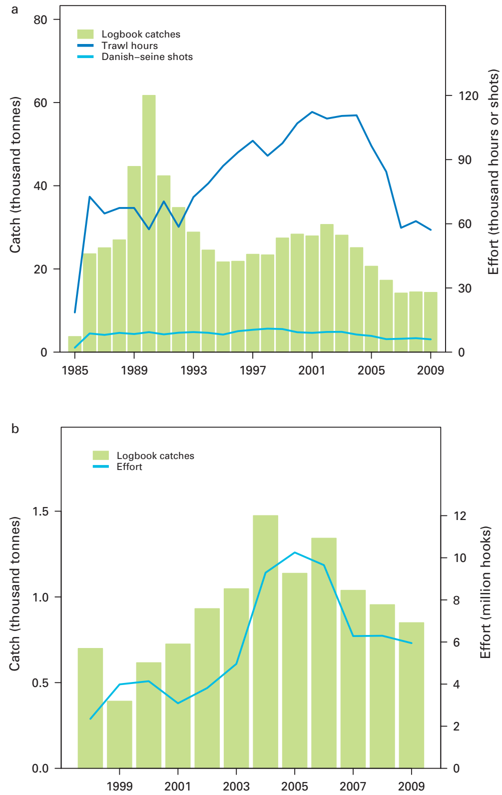


FIGURE 9.2 Total landings and fishing effort in the SESSF for a) the CTS, 1985 to 2009 and b) the ScHS, 1998 to 2009

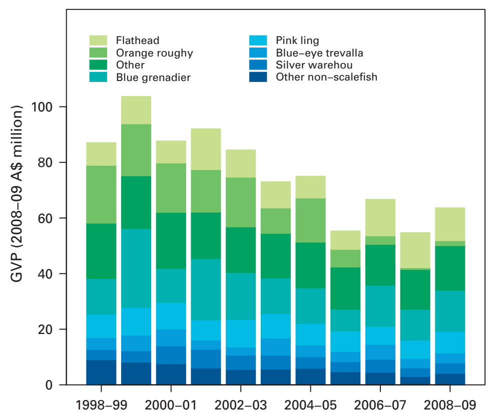


FIGURE 9.3 Real gross value of production (GVP), by key species, of the CTS and ScHS, 1998–99 to 2008–09 financial years

NOTE: Other non-scalefish does not include shark species reported in the Shark Gillnet and Shark Hook sectors but includes other shark species (Chapter 12).

Minor byproduct species

Landings of byproduct (non-TAC) species in the CTS (excluding those of small pelagic species) were 2700 t in 2009–10, a 12% increase from 2400 t in 2008–09. A further 79 t of non-quota species was landed in 2009–10 from the ScHS, compared with 103 t in 2008. These non-quota catches included some byproduct from the Shark Gillnet and Shark Hook sectors (Chapter 12), because a common logbook is used (Table 9.5).

Trawl catch PHOTO: MIKE GERNER, AFMA

TABLE 9.5 Minor byproduct stocks–TACs/triggers, catches/landings and discards in the CTS and ScHS of the SESSF

Species	TAC/ trigger	2008–09 catch (tonnes)	2008–09 discards (tonnes)	2009–10 catch (tonnes)	2009–10 discards (tonnes)
King dory (*Cyttus traversi*)	None	137	0.0	137	0.0
Southern frostfish (*Lepidopus caudatus*)	None	117	60.1	142	34.0
Latchet (*Pterygotrigla polyommata*)	None	71	0.0	98	0.1
Pink snapper (*Pagrus auratus*)	None	63	0.0	104	0.0
Red gurnard (*Chelidonichthys Kumu*)	None	90	7.5	72	8.4
Saw sharks (Pristiophoridae)	See Chapter 12	77	0.3	78	0.3
Gummy shark (*Mustelus antarcticus*)	See Chapter 12	82	0.0	71	0.6
Alfonsino (*Beryx splendens*)	See Chapter 10	50	0.0	89	0.0
Hapuku (*Polyprion oxygeneios*)	None	74	0.0	48	0.0
Stargazer (Uranoscopidae)	None	68	0.0	54	0.0
Boarfish (*Pentacerotidae*)	None	6	0.0	115	0.0
Barracouta (*Thyrsites atun*)	None	58	22.7	57	32.7
Australian angel shark (*Squatina australis*)	None	46	0.0	50	0.0
Silver dory (*Cyttus australis*)	None	37	0.4	30	0.0

Table 9.5 continues over the page

TABLE 9.5 Minor byproduct stocks–TACs/triggers, catches/landings and discards in the CTS and ScHS of the SESSF CONTINUED

Species	TAC/ trigger	2008–09 catch (tonnes)	2008–09 discards (tonnes)	2009–10 catch (tonnes)	2009–10 discards (tonnes)
Cuttlefishes (Sepiidae)	None	31	0.0	32	0.0
Grey morwong (*Nemadactylus douglasi*)	None	27	0.0	31	0.0
Sharkfin guitarfishes—Sand sharks (Rhynchobatidae)	None	28	0.0	25	0.0
Elephantfish (*Callorhinchus milii*)	See Chapter 12	16	0.0	22	0.2
School shark (*Galeorhinus galeus*)	See Chapter 12	13	0.6	19	3.1
Skates (*Rajidae*)	None	17	1.7	14	2.5
Mackerel (*Scomber scombrus*)	None	14	7.0	16	3.0
Bugs—Shovel nosed and slipper lobsters (Scyllaridae)	None	16	0.0	12	0.0
Skates and rays	None	15	2.6	13	2.6
Octopuses (Octopoda)	None	11	0.0	14	0.0
Rudderfish (*Centrolophus niger*)	None	16	0.4	9	0.0
Jack mackerel (*Trachurus declivis*)	None	13	4.7	10	5.2
White trevalla (*Seriolella caerulea*)	None	14	0.0	6	0.0

CTS = Commonwealth Trawl Sector; ScHS = Scalefish Hook Sector; SESSF = Southern and Eastern Scalefish and Shark Fishery; TAC = total allowable catch

Sorting the catch PHOTO: MIKE GERNER, AFMA

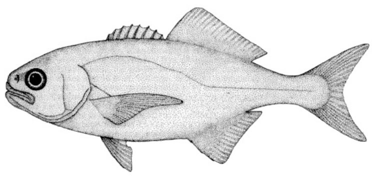
Trawler, Eden PHOTO: FIONA SALMON, DAFF

9.3 BIOLOGICAL STATUS

Copies of assessment reports and background documents are available on the Australian Fisheries Management Authority (AFMA) website (www.afma.gov.au).

BLUE-EYE TREVALLA

(*Hyperoglyphe antarctica*)



LINE DRAWING: FAO

TABLE 9.6 Biology of blue-eye trevalla

Parameter	Description
Range	**Species:** In Australia, known from southern Queensland to south-western Western Australia, including Tasmania; also found in South Africa and New Zealand. **Stock:** No evidence of structuring within the area of the SESSF; regarded as one stock across the SESSF (including the GABTS). Some New South Wales catch is included in assessments, primarily from dropline methods.
Depth	400–600 m
Longevity	39–42 years
Maturity (50%)	**Age:** 8–12 years **Size:** 62–72 cm TL
Spawning season	March–April (Tasmania) and April–June (New South Wales)
Size	**Maximum:** ~140 cm TL; weight: ~40 kg **Recruitment into the fishery:** ~50 cm FL; age: 2–3 years; weight: not determined

GABTS = Great Australian Bight Trawl Sector; SESSF = Southern and Eastern Scalefish and Shark Fishery; TL = total length

SOURCES: Gomon et al. (2008); Robinson et al. (2008).

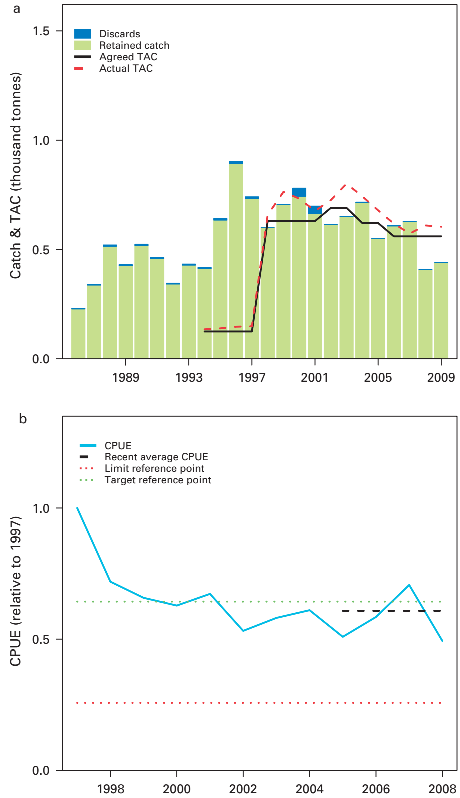


FIGURE 9.4 Blue-eye trevalla a) catch history from the CTS and ScHS, 1986 to 2009 and b) catch per unit effort (CPUE) for the CTS only, 1997 to 2008.

NOTE: that discards and state catch are not included for 2009

Stock status determination

The RBC (global) estimated by the Slope Resource Assessment Group (SlopeRAG) was 612 t for the 2009–10 fishing season, before discards and state catches were taken into account (SlopeRAG 2010). The 2009–10 agreed TAC (global) set by the AFMA Commission was the same as the 2008–09 TAC (560 t) (Table 9.2); however, the actual TAC (global), once carryover of uncaught quota was applied, was 604 t (Fig. 9.4a). A total of 421 t was landed by the CTS and ScHS in the 2009–10 fishing season, with the latter taking most of the catch (381 t). Trawl and dropline catches are mostly of young, immature fish; larger, mature fish become vulnerable to auto-longline fishing when they form seasonal spawning aggregations (Table 9.6).

The 2009 Tier 4 assessment was based on standardised catch rates from the dropline and auto-longline sectors (Fig. 9.4b) (Haddon 2010a). Since 2008, the two time series have been combined with a common unit of catch per shot to provide a longer time series (1997 to 2008). The catch per unit effort (CPUE) series from the trawl sector was not considered to be informative because blue-eye trevalla is a byproduct species and this sector accounts for only a small proportion (<10%) of the total catch (SlopeRAG 2010).

The CPUE standardisation included only shots at depths of 200–600 m and where blue-eye trevalla were caught. The GABTS catches and CPUE are included. Data from the Cascade Plateau and seamounts on the east coast were excluded because they were particularly variable. Discarding is minimal in both sectors. The significant factors in the standardisation model were year, vessel, month, zone, day/night, depth and an interaction between month and zone (Haddon 2010a).

Similar to the 2008 assessment, the 2009 Tier 4 assessment suggests that the stock is **not overfished** (Table 9.1) The standardised CPUE is close to, but slightly below, the target CPUE, based on a reference period of 1997 to 2006, when the stocks were considered to be fully fished (Fig. 9.4b) (Haddon 2010b). The stock is also assessed as **not subject to overfishing** based on the fact that the 2009–10 catch was less than the RBC. However, there are concerns about the potential for localised depletion, so the spatial distribution of the catch should be closely monitored.

Reliability of the assessment/s

The Tier 4 assessment relies solely on CPUE from the hook sector being a reliable index of abundance. There is no incorporation of potential changes in fishing efficiency of vessels over the period. The extent to which changes in area fished—including the expansion to the Great Australian Bight and movements in response to the presence of killer whales—are addressed by the standardisation is not clear.

Previous assessment/s

Tier 3 assessments were applied to blue-eye trevalla in 2006 and 2007. However, a detailed examination of the data in 2008 (Fay 2008) confirmed that the size and age composition of the catch varied annually, seasonally and spatially. Variation in the timing and location of sampling, seasonal movement of fish and differences in the depth distribution of fish of different sizes all contributed to this variation. Variability, combined with reduced selectivity for larger fish, results in more variable and higher estimates of total mortality than would be expected given the biology of the species. Therefore, in 2008, the SlopeRAG rejected the Tier 3 assessment and moved to a Tier 4 assessment as the basis for calculating the RBC.

Several attempts to use conventional stock assessment models have proven unsuccessful, mainly because the available data are inadequate to represent the spatial and temporal structuring evident in the population and the fishery.

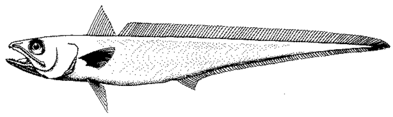
Future assessment needs

The potential for localised depletion and increased fishing efficiency should be examined, particularly given the current reliance on the Tier 4 assessment. Although the trawl sector CPUE has not been used in the assessment, it may still provide an indicator of biomass if the standardisation is appropriate, and could also be considered. Preliminary results from the fishery-independent survey suggest that it may provide a useful index of abundance for blue-eye trevalla in the longer term.

Trawl catch PHOTO: MIKE GERNER, AFMA

BLUE GRENADIER

(*Macruronus novaezelandiae*)



LINE DRAWING: ROSALIND POOLE

TABLE 9.7 Biology of blue grenadier

Parameter	Description
Range	**Species:** Occurs in temperate southern waters, including New Zealand. In Australia, it is found from central New South Wales to south-western Western Australia. **Stock:** Separate stocks are fished by the GABTS and CTS, and there may also be separate stocks between western Tasmania and eastern Bass Strait.
Depth	450–800 m
Longevity	25 years
Maturity (50%)	**Age:** 4–5 years **Size:** females 64 cm; males 57 cm TL
Spawning season	May–September (off western Tasmania); spawning aggregation off eastern Tasmania (observed 2007–2009)
Size	**Maximum:** ~110 cm TL; weight 6 kg **Recruitment into the fishery:** ~55–60 cm TL; age: 3–4 years (non-spawning fishery); weight: not determined

CTS = Commonwealth Trawl Sector; GABTS = Great Australian Bight Trawl Sector; TL = total length

SOURCES: Gomon et al. (2008); Hamer et al. (2009).

Trawl catch PHOTO: MIKE GERNER, AFMA

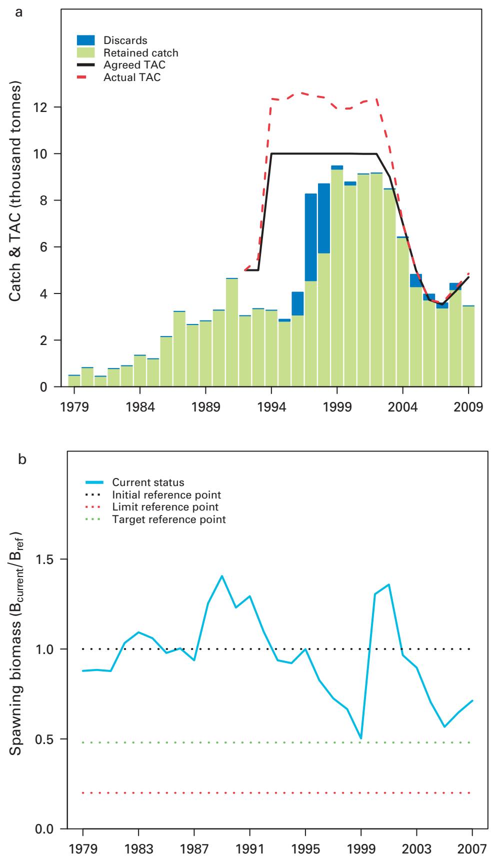


FIGURE 9.5 Blue grenadier a) catch history 1979 to 2009 and b) estimated biomass for the CTS and ScHS, 1979 to 2007.

NOTE: that discards and state catch are not included for 2009

Stock status determination

The long-term RBC estimated by SlopeRAG was 4700 t (SlopeRAG 2010). The 2009–10 fishing season agreed TAC (global) set by the AFMA Commission was 4700 t (Table 9.2); however, the actual TAC (global) was 4851 t once carryover of uncaught quota was taken into account. The 2009–10 total catch from the CTS and ScHS was 3281 t, with 3270 t reported by the CTS. There are two distinct blue grenadier fisheries: a spawning fishery targeting spawning aggregations off western Tasmania between late May and early September and a non-spawning fishery where the catch is caught during general

CTS trawling. In 2008–09 the spawning fishery caught 70% of the CTS catch.

An age-structured, integrated assessment model was last updated in 2008, with data up to 2007. The model focused on the stock in the CTS and incorporated the standardised CPUE from the spawner and non-spawner fisheries, estimates of spawner biomass from acoustic surveys (2003 to 2007) and egg survey estimates of female spawning biomass (1994 to 1995). The model was not updated in 2009, as a three-year TAC of 4700 t had been set (2009–10 to 2011–12 fishing years).

The 2008 model estimated that female spawning biomass was at $0.71B_0$ (71% of the unfished biomass) in 2007 (Fig. 9.5b). This was projected to decline to $0.5B_0$ in 2009 if catches followed the RBC, as the abundance of strong cohorts from the mid-1990s declined and most catch was taken from the relatively less abundant recent cohorts. The model suggested that the long-term RBC would be around 4700 t.

SlopeRAG examined standardised CPUE from the non-spawning fishery (Haddon 2010a), the results of the 2008 acoustic biomass survey (SlopeRAG 2010) and the size and age composition data (Hobsbawn 2009). The standardised CPUE from the non-spawning fishery showed a slight increase back to 2006 levels. The spawning fishery CPUE was regarded as less informative because the fishery targets spawning aggregations and the size of catches is limited by the vessel processing capacity (SlopeRAG 2010). The estimate of biomass from the 2008 acoustic survey was lower than from the 2006 and 2007 surveys, but similar in magnitude to the 2003 survey. This is regarded as a lower bound of the biomass, as it does not account for fish outside the schools or movement of fish into and out of the spawning grounds (SlopeRAG 2010). The size and age composition indicate that a new, relatively strong cohort is starting to enter the fishery. Taken together, these indicators and the projection from the 2008 assessment do not raise concerns. The stock remains assessed as **not overfished** in 2009, and current catch levels (Fig. 9.5a) indicate that the stock is **not subject to overfishing** (Table 9.1).

Reliability of the assessment/s

The greatest uncertainty in the Tier 1 assessment is the potential impact of the stock structure. Hamer et al. (2009) suggest that the GABTS is a separate stock, in line with the current assessment approach, but indicates that separate stocks east and west of Bass Strait may need to be considered. The 2008 assessment had difficulty fitting some of the trends in the two CPUE time series, with the fit to the CPUE for the non-spawning CPUE appearing to be one to two years out of phase with the observed CPUE. The estimated target strength of blue grenadier is an important parameter and source of potential error in acoustic surveys. Experiments were conducted in 2008 to measure target strength of individual blue grenadier, with concurrent optical images giving estimates of length, orientation and species identity. Initial results support the estimates of target strength that had previously been used in the assessment (SlopeRAG 2010).

Previous assessment/s

The spawning biomass (Fig. 9.5b) is estimated to have peaked in 2001, when the strong 1994 and 1995 year classes matured. It declined from 2001 onwards, as the abundance of the two strong cohorts diminished, until 2007 when new strong cohorts began maturing. These new cohorts are estimated to be approximately equal to (in 2003) or twice (in 2004) those predicted by the stock–recruitment relationship, but are not as strong as those of the mid-1990s. The variations in spawning biomass mainly reflect these variations in the strength of recruitment, since fishing mortality levels are estimated to have generally been below 10%.

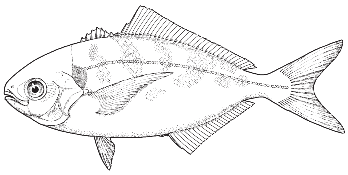
Future assessment needs

The implications of the potential stock structure within the SESSF need to be understood, particularly in terms of the non-spawning and spawning catch rates and integration in the model. Reducing the uncertainty in acoustic biomass estimates

is important to improve their usefulness to the assessment. There is a potential need for a separate assessment of the stock targeted by the GABTS, as the status is unknown.

BLUE WAREHOU

(*Seriolella brama*)



LINE DRAWING: ROSALIND POOLE

TABLE 9.8 Biology of blue warehou

Parameter	Description
Range	**Species:** Typically found in south-eastern Australia (New South Wales, Victoria, Tasmania and South Australia); also New Zealand. **Stock:** There are two stocks targeted in the SESSF, east and west of Bass Strait. Significant catches have been made by Tasmanian fishers, but these have been lower in recent years.
Depth	50–500 m, but most catches from <300 m
Longevity	10–15 years
Maturity (50%)	**Age:** 2–3 years **Size:** 32 cm FL
Spawning season	Winter in various locations
Size	**Maximum:** 76–90 cm TL; weight: 7 kg **Recruitment into the fishery:** 35–45 cm FL; age: not determined; weight: not determined

FL = fork length; SESSF = Southern and Eastern Scalefish and Shark Fishery

SOURCES: Talman et al. (2003); Gomon et al. (2008).

Blue warehou PHOTO: MIKE GERNER, AFMA

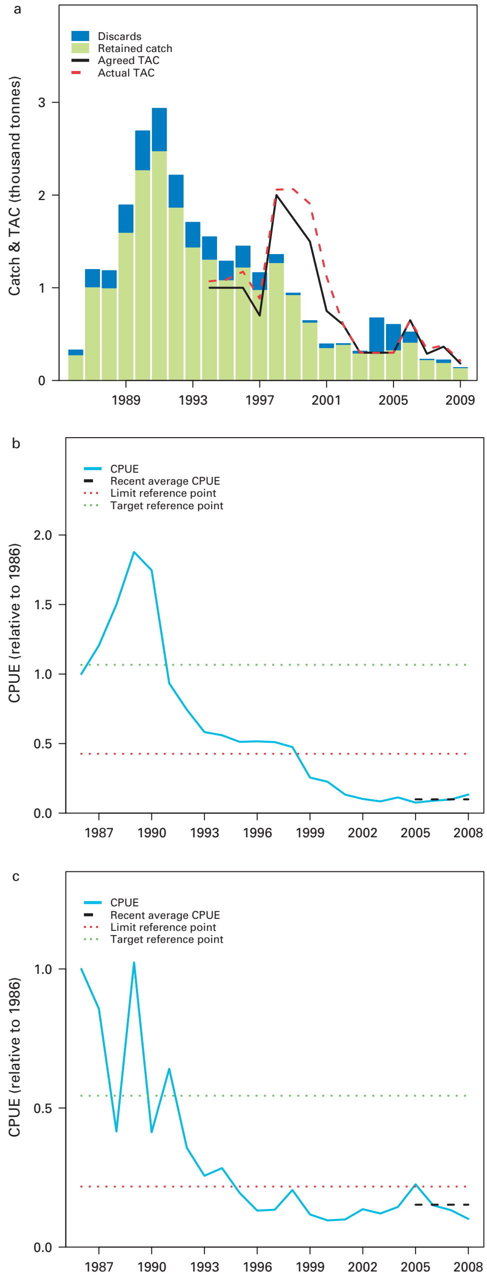


FIGURE 9.6 Blue warehou a) catch history from the CTS and ScHS 1986 to 2009, b) standardised CPUE (east) for the CTS 1986 to 2008 and c) CPUE (west) for the CTS, 1986 to 2008.

NOTE: that discards and state catch are not included for 2009

Stock status determination

The integrated (Tier 1) assessment was updated in 2008, following a substantial effort to explore patterns in the catch and effort data (Punt 2008). In general, this did not lead to substantial changes in the CPUE series. The assessment was regarded as more data poor and less reliable than previous assessments because the sample sizes collected by observers for 2007 were very low, in comparison to previous years (Punt 2008). The lack of data for 2007 for blue warehou presents particular difficulties for the assessment because of the short lifespan of this species. SlopeRAG (2010) did not accept the Tier 1 assessment as a basis for determining the 2009–10 RBC.

The same data issues prevented a Tier 3 assessment being used (SlopeRAG 2010), so the RBC was calculated from a Tier 4 assessment, based on CPUE. The Tier 4 assessment was updated in 2009 (Haddon 2010b). Separate Tier 4 assessments are undertaken for the east and west stocks. The target reference point was the average CPUE from the reference period 1986 to 1995, and the limit reference point was 40% of this target. The recent standardised CPUE series for both east and west stocks was below the limit reference point (B_{LIM}) (Fig. 9.6b,c), indicating (as did the 2008 Tier 1 assessment) that both stocks remain assessed as **overfished** (Table 9.1). In the eastern stock, the standardised CPUE series is lower and has been below the limit reference point since 1998 (Fig. 9.6b). The western stock has been below the limit reference point since 1996, but was close to the limit reference point in 1998 and 2005, with a declining trend since 2005 (Fig. 9.6c).

The 2009–10 RBCs for both eastern and western stocks under the Tier 4 harvest control rules was zero (SlopeRAG 2010). AFMA released the stock rebuilding strategy in late 2008 (AFMA 2008b), with a 2009–10 ‘bycatch TAC’ (global) of 183 t (40 t in the east and 143 t in the west). The basis for the bycatch TAC is unclear; Klaer and Smith (2008) suggested that the TAC could be reduced by 67% (i.e. to ~120 t) without affecting the catch of other species. Punt (2008) suggests that the 2008 exploitation rate was not predicted to lead to recovery for the western stock. There has been no modelling to demonstrate that the bycatch TAC levels will not inhibit rebuilding. The actual 2009–10 TAC (global) was set at 214 t, after carryover of uncaught quota.

The 2009–10 landed catch was reduced to 122 t, down from 160 t in 2008–09. This was made up of 25 t in the east and 97 t in the west (estimated from logbook and catch disposal records). These landed catches are substantially lower than historic values (Fig 9.6a). However, a key issue is the level of discarding. It is estimated that, between 2004 and 2006, 270–380 t were discarded annually, with discarding levels of 40–57% in the west and 13–46% in the east (SlopeRAG 2010). This level of discarding, in conjunction with landed catches, suggests that overfishing was occurring. The reported discard level decreased substantially in 2007, but this estimate is highly uncertain because of the low levels of observer coverage. The level of discarding in 2008 was estimated as 12% overall, but again there is uncertainty in the reliability of this estimate due to the low level of observer coverage and uncertainty whether fishers displayed normal discarding behaviour when observers were present (SlopeRAG 2010). The length frequency information from the discarded and landed catch suggests that high-grading was occurring (Hobsbawn 2009). Limited information is currently available on the level of discarding in 2009. The state catch in the east has been between 17 t and 26 t in recent years.

The reduction in landed catch in 2009–10 is a positive outcome. However, without a robust estimate of discards, it is uncertain whether total mortality has decreased to a level that would facilitate rebuilding. A voluntary closure took place for 10 weeks from mid-August, covering two full moons, to protect historical spawning grounds in the eastern stock. AFMA report that industry was generally compliant with the voluntary closure. The rebuilding strategy’s objective is to rebuild the stocks to B_{20} by 2015 and B_{48} by 2024–26. Given the declining CPUE trend in the western

stock (Haddon 2010b), the projection that the 2008 exploitation rate was unlikely to facilitate rebuilding of the western stock (Punt 2008), the indications of high-grading of the landed catch, and the lack of evidence of rebuilding in the more depleted eastern stock, the stock is assessed as **subject to overfishing** (Table 9.1).

Reliability of the assessment/s

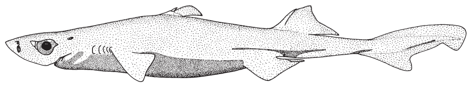
The Tier 1 integrated assessment was not used by SlopeRAG to set the 2009–10 TAC, due to the lack of observer data in 2007, which increased uncertainty; the Tier 4 assessment is also uncertain, given the nature of the approach. SlopeRAG expressed concern that the change to a 'bycatch TAC' may make the commercial CPUE less informative, due to the change in fishing practices (away from targeting). This is a critical issue, as the commercial CPUE is currently the only indicator of recovery. SlopeRAG also identified concerns about the accuracy of state catches, both recent and historical, which may also increase the uncertainty.

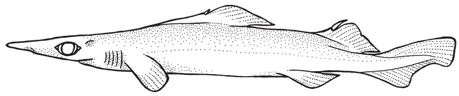
Future assessment needs

The assessment is limited by the lack of representative and recent data from the fishery, particularly in terms of discards. Adequate and representative observer data on the levels of discarding and sizes discarded needs to be collected, so that it can be incorporated into the assessment. The value of standardised CPUE as an index of biomass needs to be examined, including the use of a standardisation that includes the zero data points (Punt 2008). Consideration should also be given to updating the Tier 1 assessment (noting the data limitations in 2007 and 2008), as this would allow projections of recovery trajectories under different catch scenarios to be examined. A fishery-independent survey may provide an improved index of abundance, but this may be difficult given the schooling nature of the fish.

DEEPWATER SHARKS (eastern and western zones)

(*Various species*)





LINE DRAWINGS: FAO, ANNE WAKEFIELD

TABLE 9.9 Biology of deepwater sharks (eastern and western)

Parameter	Description
General	Basket quota species: Portuguese dogfish (*Centroscymnus coelolepis*), golden dogfish (*C. crepidater*), bareskin dogfish (*Centroscyllium kamoharai*), Owston's dogfish (*Centroscymnus owstoni*), Plunket's dogfish (*Centroscymnus plunketi*), black shark (*Dalatias licha*), brier shark (*Deania calcea*), longsnout dogfish (*Deania quadrispinosa*), smooth lanternshark (*Etmopterus bigelowi*), short-tail lanternshark (*E. brachyurus*), pink lanternshark (*E. dianthus*), lined lanternshark (*E. dislineatus*), blackmouth lanternshark (*E. evansi*), pygmy lanternshark (*E. fusus*), southern lanternshark (*E. granulosus*), blackbelly lanternshark (*E. lucifer*), Moller's lanternshark (*E. molleri*), slender lanternshark (*E. pusillus*)
Range	**Species:** Distribution is species dependent, but species are most commonly found within temperate southern Australian waters (Queensland, New South Wales, South Australia, Western Australia and Tasmania). **Stock:** The management assumes there are separate stocks east and west of Tasmania, within the bounds of the CTS.
Depth	50–1800 m
Longevity	Up to 50 years
Maturity (50%)	**Age:** 25–30 years **Size:** various
Spawning season	Unknown
Size	**Maximum:** ~150 cm TL; weight: various **Recruitment into the fishery:** all sizes; age: various; weight: not determined

CTS = Commonwealth Trawl Sector

SOURCES: Froese & Pauly (2009); Last & Stevens (2009).

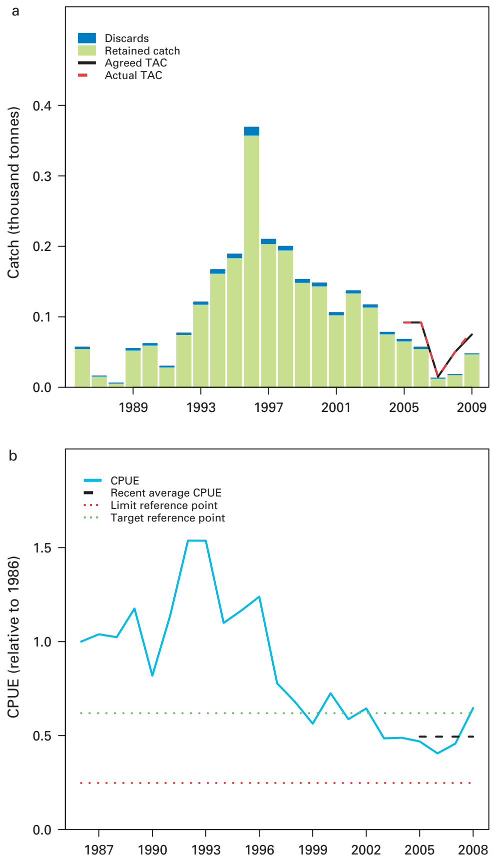


FIGURE 9.7 Deepwater sharks (eastern) a) catch history 1986 to 2009 and b) standardised CPUE for the CTS, 1986 to 2008.

NOTE: that discards are not included for 2009

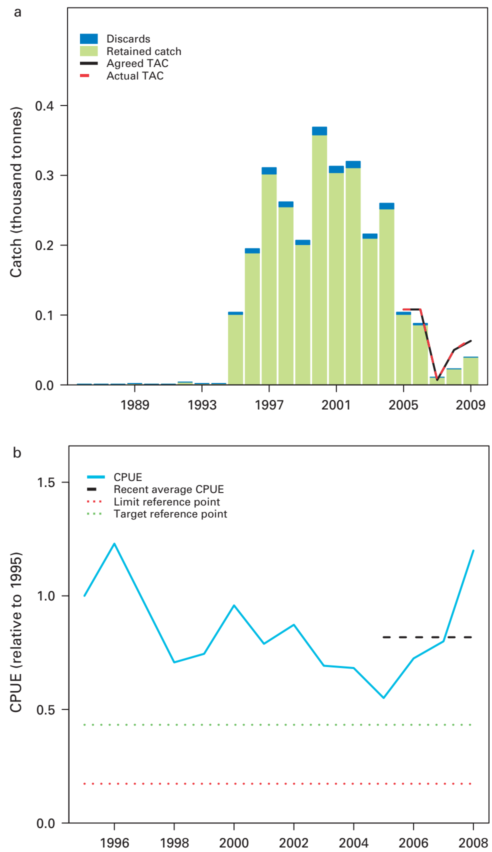


FIGURE 9.8 Deepwater sharks (western) a) catch history 1986 to 2009 and b) standardised CPUE for the CTS, 1995 to 2008.

NOTE: that discards are not included for 2009

Trawl catch PHOTO: MIKE GERNER, AFMA

Stock status determination

The RBC (global) estimated by DeepRAG for the 2009–10 fishing season was 90 t and 121 t for the eastern and western stocks, respectively (DeepRAG 2009). The 2009–10 agreed TAC (global) set by the AFMA Commission was 75 t and 63 t for the east and west stocks, respectively (Table 9.2); however, the actual TAC (global), once carryover of uncaught quota was applied, was 80 t and 66 t. In total the catch for the 2009–10 fishing season was 40 t in the east and 43 t in the west.

Deepwater sharks in the eastern and western zones were assessed in 2009 using the Tier 4 rules for the areas open to fishing (Haddon & Wayte 2010). The reference period for the eastern zone was 1997 to 2004, and

for the western zone 1995 to 2004. As the recent CPUE average for the eastern stock was above the CPUE limit reference point and for the western stock was above the CPUE target reference point (Figs. 9.7b, 9.8b), both stocks are assessed as **not overfished** (Table 9.1). Spatial closures, some of which were specifically designed to afford protection to deepwater sharks, apply in several areas across the fishery. In addition, the closures for orange roughy will afford some protection to mid-slope deepwater shark species. Current biomass, in conjunction with catch levels (Figs. 9.7a, 9.8a) indicate that both stocks of deepwater sharks are **not subject to overfishing**. However, as deepwater sharks are known to be especially vulnerable to overfishing due to their low productivity, and given that these are basket stocks containing a number of species (Table 9.9), CPUE trends should be monitored closely in the future.

Reliability of the assessment/s

The Tier 4 assessment relies solely on CPUE being a reliable index of abundance. It is unclear whether this is the case, particularly given this is a basket stock which may result in changes in species composition going undetected. It is also unclear if a Tier 4 assessment is appropriate for deepwater species, given their longevity and relatively short fishing history.

Previous assessment/s

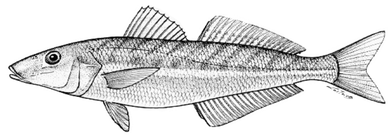
Deepwater sharks were initially taken during trawling for orange roughy. They were largely discarded until the mid-1990s, when the relaxation of mercury laws increased their marketability. Quota management was introduced in 2005 and implemented as a basket quota covering 18 species. A Deepwater Shark Working Group advised that there were potential differences between stocks east and west of Tasmania, so quota was allocated by zone (Figs. 9.7a, 9.8a). In 2007 AFMA recommended that targeted fishing for these species should cease, and the TACs were reduced to low levels to cover incidental catches.

Future assessment needs

For a more robust assessment, more information about these species, and species-specific catch information is needed. Basket quotas can mask depletions of single species and thus need to be assessed and monitored closely. The level of potential protection from the closures should be assessed so that this can be more formally considered in the assessment process.

EASTERN SCHOOL WHITING

(*Sillago flindersi*)



LINE DRAWING: FAO

TABLE 9.10 Biology of eastern school whiting

Parameter	Description
Range	**Species:** Endemic to Australia. Distributed from southern Queensland to eastern South Australia, including New South Wales, Victoria and eastern Tasmania. **Stock:** The assessment assumes that the area of the CTS and ScHS encompasses the stock.
Depth	1–100 m
Longevity	7 years
Maturity (50%)	**Age:** 2 years **Size:** 14–18 cm FL
Spawning season	October–January
Size	**Maximum:** ~32 cm TL; weight: ~280 g **Recruitment into the fishery:** 15–20 cm FL; age: 2–3 years; weight: ~35–85 g

CTS = Commonwealth Trawl Sector; FL = fork length; TL = total length

SOURCES: Kialola et al. (1993); ShelfRAG (2009); Day (2010).

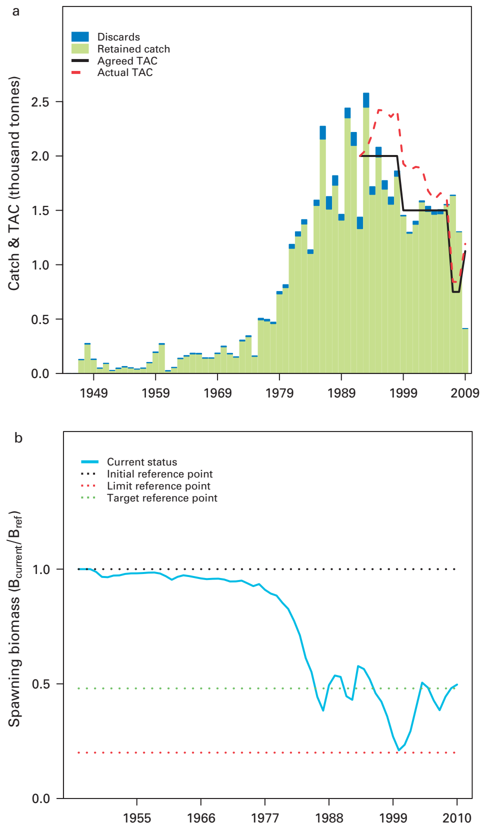


FIGURE 9.9 Eastern school whiting a) catch history (including catches from the SESSF and State fisheries) 1947 to 2009 and b) biomass, 1947 to 2010.

NOTE: that discards and state catch are not included for 2009

Stock status determination

The RBC calculated by ShelfRAG was 3785 t for the 2009–10 fishing season, before discards and state catches were taken into account (ShelfRAG 2009). State catches are also substantial, 1500–1924 t between 2005–2008 (ShelfRAG 2009). The 2009 TAC setting principles (AFMA 2009a) state that TACs for Tier 1 and Tier 2 assessments will not change up or down by more than 50% from the 2008–09 fishing year. Thus, an agreed TAC (global) was set at 1125 t for the 2009–10 fishing season (Table 9.2), while the actual TAC (global), after carryover of uncaught quota was taken into account, was 1192 t. The CTS landed 490 t in the 2009–10 fishing season, with nearly 60% of the quota remaining uncaught. This is similar to the recent years and is suggested to be related to reduced availability of export markets (ShelfRAG 2009).

The 2009 assessment updated the 2008 assessment with length and age data, total catches (Fig. 9.9a) and CPUE, and estimated natural mortality. The base-case assessment estimated that the current spawning stock biomass is $0.5B_0$ (50% of the unfished biomass level), which is close to the 48% target biomass (Day 2010) (Fig. 9.9b). The long term catch under the harvest control rule would be 1660 t per year.

School whiting remains assessed as **not overfished** because biomass is above the $0.2B_0$ limit reference point (Table 9.1). It is **not subject to overfishing** because biomass has been maintained close to or above the target level (Fig. 9.9b).

Reliability of the assessment/s

Estimates of biomass and RBCs in successive assessments have varied considerably, largely due to corrections to historical data and the variability in recruitment for this short-lived species (Table 9.10). The assessment is also strongly influenced by several key parameters, including natural mortality rate, stock-recruitment steepness and size at maturity (Day 2010).

Previous assessment/s

Most SESSF quota catches of school whiting have been taken by the Danish-seine fleet in eastern Bass Strait, although trawlers have taken an increasing proportion of the catch in recent years. Catch rates by Danish-seiners are extremely variable, being influenced by market demand for whiting and the amount of the fleet effort directed at flathead.

In 2004 the spawning biomass of the Jervis Bay–Portland stock was estimated to be well above the 1991 level, with an annual catch of 1500 t considered sustainable in the short to medium term. In 2006 a Tier 3 assessment was undertaken with an RBC of 1280 t and indicated that fishing mortality was less than natural mortality and that overfishing was

not occurring. The TAC for 2007 was set at 750 t and maintained at that level for 2008.

A quantitative model-based assessment was undertaken for the first time in 2007. It estimated the 2007 spawning stock biomass to be $0.35B_0$ (Fig. 9.9b). The 2008 assessment revised the 2007 assessment with updated length frequencies, catches and catch rates, as well as revised historical catch, length and age data for 1994–2006. The base case assessment indicated that current spawning stock biomass was $0.82B_0$ of the unfished level, with an RBC of 3785 t.

Future assessment needs

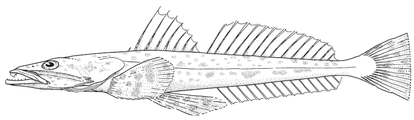
The assessments highlight highly variable recruitment that results in large variations in school whiting biomass and estimated RBCs. This is exacerbated by time lags in data availability. Industry finds it difficult to manage the resultant large fluctuations in annual TACs for this key commercial species. A fishery-independent index of prerecruit abundance, and improvements to age and size data for both the retained and discarded components of the catch would help to reduce the problem of RBC fluctuations. The assessment is also sensitive to the size at maturity function; a relatively small change (1–2 cm) in the size at maturity can substantially affect model outcomes. Review of two separate studies concluded that the current function is appropriate, although the collection and analysis of more recent data from southern areas of the fishery would allay concerns that the size at maturity is too high. The species composition of catches needs to be regularly checked to verify that species other than school whiting do not make a significant contribution to catches.

Flathead being unloaded from trawler

PHOTO: HEATHER PATTERSON, ABARE–BRS

FLATHEAD

(Five species)



LINE DRAWING: ROSALIND POOLE

TABLE 9.11 Biology of flathead

Parameter	Description
General	Blue-spotted flathead (*Platycephalus caeruleopunctatus*), southern blue-spotted flathead (*P. speculator*), southern sand flathead (*P. bassensis*), tiger flathead (*Neoplatycephalus richardsoni*) and toothy flathead (*N. aurimaculatus*) are managed under the flathead group in the SESSF. Almost all the catch is tiger flathead.
Range	**Species:** Temperate southern waters from southern Queensland to Western Australia, including Tasmania. **Stock:** Tiger flathead is assumed to be a single stock in the SESSF for assessment purposes. Some catch from north of the SESSF and in state waters contributes to the assessment.
Depth	30–350 m
Longevity	20 years
Maturity (50%)	**Age**: 4–5 years **Size**: 30–36 cm SL
Spawning season	September–February
Size	**Maximum:** 46–60 cm SL; weight: not determined **Recruitment into the fishery:** 25–30 cm SL; age: not determined; weight: not determined

SESSF = Southern and Eastern Scalefish and Shark Fishery; SL = standard length

SOURCES: Kialola et al. (1993); Gomon et al. (2008).

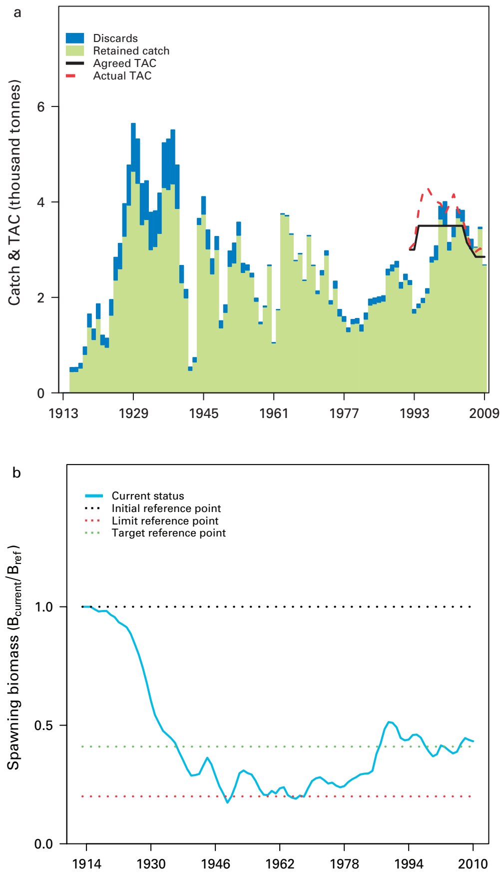


FIGURE 9.10 Flathead a) catch history and b) biomass for the CTS and ScHS, 1915 to 2009.

NOTE: that discards and state catch are not included for 2009

Stock status determination

The RBC calculated by ShelfRAG was 2663 t for the 2009–10 fishing season (ShelfRAG 2009) before discards and state catches were taken into account. The 2009–10 agreed TAC (global) was 2850 t (Table 9.2) and the actual TAC (global) was 2960 t after carryover of uncaught quota was taken into account. The 2009–10 catch was 2832 t, primarily from the CTS. Since 2005 the catch from the SESSF has been between 2698–3197 t and state catches between 180–319 t (ShelfRAG 2009).

A quantitative assessment was conducted for the tiger flathead stock in 2009 (Klaer 2010a), but none of the other species managed under the flathead group were assessed in 2009. The base-case model produced an estimate of depletion to 43.2% of unfished spawning biomass (Fig. 9.10b), which is above the management target of 41% of the unfished spawning biomass. The current assessment updates the previous quantitative assessment (2006) with the addition of age and length data, corrected discard estimates for historic steam trawl fishing, and gear selectivity changes for diesel trawlers and Danish-seiners. The model chosen for the base-case estimated recruitment up until 2005, given that subsequent data were considered insufficient to give reliable recruitment values. Under Tier 1 harvest control rules, the model resulted in an RBC for the 2010–11 fishing season of 2779 t and a long-term RBC of 2623 t.

The current assessment shows that biomass has been above the target reference point for the past three years, so flathead continue to be assessed as **not overfished** (Table 9.1). Although recent annual catches have been above the long-term RBC (Fig. 9.10a), the fact the biomass is above the target reference point means some flexibility can be applied in TAC setting. Flathead therefore remain **not subject to overfishing**.

Reliability of the assessment/s

The flathead assessment is considered a robust assessment that is well accepted by ShelfRAG members. The choice of a base-case model using only pre-2006 recruitment for the most recent assessment may have reduced the resultant RBC, but has been justified by the low selectivity of the trawl gear for small flathead and the poor size sampling in 2007–08.

Previous assessment/s

Historically, the fishery has been unable to sustain annual flathead catches greater than 3000 t for more than a few years. A quantitative assessment model was first developed in the early 1980s, and a revised and updated model was not produced until 2001. Most indicators of stock status across the fishery appeared stable, but a decline in numbers of large fish in catches off New

South Wales was of concern. A quantitative integrated assessment model was developed in 2004–05 and revised in 2006. A full stock assessment was not undertaken in 2007 or 2008, but catch data were updated and RBCs were calculated using the Tier 1 harvest control rule. The 2009 RBC for flathead was calculated using a target biomass of 41% of unfished levels. This change to a slightly higher target (from the target of 40% under the previous SESSF harvest strategy) was based on the adoption of maximum economic yield (MEY) as a target and adjustment using B_{MEY}/B_{MSY} ratio from ABARE–BRS research. B_{MEY}/B_{MSY} is the ratio between the biomass producing MEY and the biomass producing maximum sustainable yield (MSY). It should be noted that the current 41% target biomass is lower than the HSP default target of $0.48B_{MSY}$. The B_{MEY}/B_{MSY} ratio is based on a bioeconomic model that used production models for the biological input, whereas the current stock assessment uses integrated age-structured models. A new bioeconomic model is expected to be produced in 2010.

Measuring fish PHOTO: IAN TOWERS, DAFF

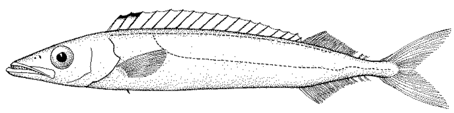
Flathead PHOTO: JAMES LARCOMBE, ABARE–BRS

Future assessment needs

The research needs discussed by the ShelfRAG in 2009 include incorporating historical gear changes and discard rates into the assessment, reviewing catch data before 2001, and improving age composition data. The species composition of the flathead catch needs to be regularly investigated to verify that tiger flathead is the dominant species.

GEMFISH, EASTERN

(*Rexea solandri*)



LINE DRAWING: SHANE WEIDLAND

TABLE 9.12 Biology of gemfish (eastern and western)

Parameter	Description
Range	**Species:** Found from Cape Moreton (Queensland) to Western Australia, including Tasmania; also occurs in New Zealand, but this appears to be a genetically different stock. **Stock:** Two genetically separate stocks, east coast stock and a western Bass Strait to Western Australia stock, with limited mixing off western Tasmania.
Depth	100–800 m
Longevity	17 years females; 13 years males
Maturity (50%)	**Age:** 3–6 years **Size**: 50–75 cm FL
Spawning season	Eastern: winter; western: summer
Size	**Maximum:** ~116 cm FL females; 106 cm FL males; weight: 7–10 kg **Recruitment into the fishery:** ~45–55 cm FL; age: 3–5 years; weight: not determined

FL = fork length

SOURCES: Kialola et al. (1993); Rowling (1994); Ward & Elliot (2001).

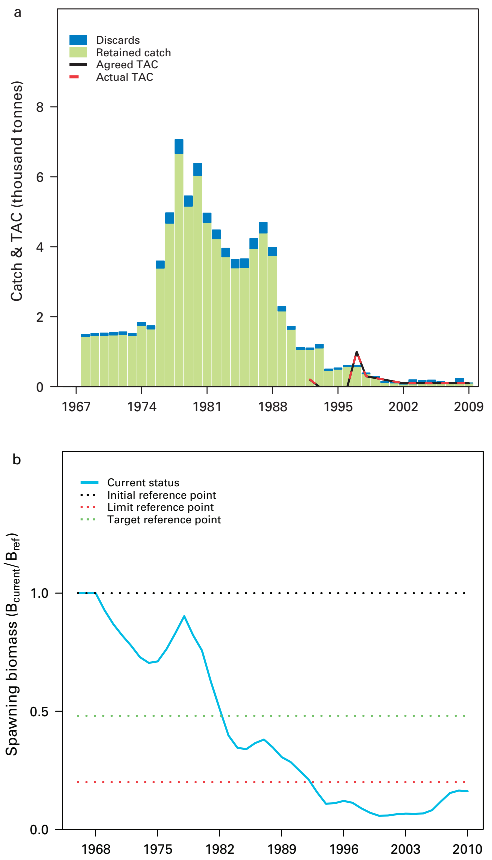


FIGURE 9.11 Eastern gemfish a) catch history 1967 to 2009 and b) estimated biomass for the CTS and ScHS, 1966 to 2010.

NOTE: that discards and state catch are not included for 2009

Stock status determination

In 2009 the assessment was moved to the SS3 modelling framework and updated with 2008 survey data (there was no survey in 2009; Little 2010). The 2008 spawning stock biomass was estimated to be $0.15B_0$ (15% of unexploited levels) (Fig. 9.11b), which was similar to the level estimated by the previous assessment. Eastern gemfish therefore remains assessed as **overfished** (Table 9.1), because the current biomass is below the $0.20B_0$ limit reference point.

Eastern gemfish was assessed as not subject to overfishing in 2008 because the estimated harvest rate (proportion of the estimated biomass caught in a year) was low and the biomass trajectory showed evidence of rebuilding. In 2009 eastern gemfish were listed as conservation dependent under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), which requires the implementation of a rebuilding strategy (AFMA 2008b). To allow stock biomass to rebuild to the limit reference point within approximately nine years, the *Eastern Gemfish Stock Rebuilding Strategy 2008* requires significant reductions in juvenile catches, protection of pre-spawning aggregations and the minimisation of incidental catches and discarding. Since 2002 ShelfRAG has set a zero RBC, with an annual bycatch TAC of 100 t for unavoidable catch. It is unknown whether this level of catch will lead to stock rebuilding, as required by the rebuilding strategy (AFMA 2008b).

The 2008 catch estimate was 233 t, but ShelfRAG doubted the high level of discards (115 t) included in this total because the discard estimate was based on an inadequate sample size from the AFMA observer program. Regardless of the true level of discards, reported landings (118 t) exceeded the bycatch TAC in 2008 (Fig. 9.11a). A reliable estimate of total catch (including discards) is not yet available for 2009, but it is also likely to significantly exceed the bycatch TAC, with 85 t reported for the trawl sector, 10 t for the non-trawl sector, 15 t of state catch plus an unknown level of discards. Estimates of annual discards ranged between 18 and 78 t during 2005–07. Adequate observer coverage must be implemented to demonstrate the true level of discards.

Recent stock assessments do not present projections of future spawning stock biomass beyond 2009 and a reliable estimate of the 2009 harvest rate was not available. A single, stronger-than-average year class was spawned in 2002. It contributed to an upward trend in biomass during 2004–08. However, that year class has now passed through the stock and has not been followed by subsequent strong recruitment. The 2009 biomass estimate is not significantly different to the 2008 estimate. The recruitment time-series shows consistently poor, and lower than expected,

recruitment at low levels of biomass. Recent recruitment is estimated to be very low in absolute terms and below model expectations from the stock-recruitment relationship. It is unclear whether biomass will rebuild to the $0.2B_0$ limit reference point within approximately nine years, as required by the rebuilding strategy (AFMA 2008b).

Management measures to protect spawning aggregations and juvenile gemfish have been implemented as part of the rebuilding strategy. Nevertheless, current catch levels and weak recruitment may be hampering stock rebuilding. There is also concern that the 2009 provisions for overcatch and undercatch of eastern gemfish allow up to 10% of an operator's uncaught quota to be carried over and used in the following fishing year. This is not consistent with the HSP (DAFF 2007), where the intention is that this bycatch quota should only provide for unavoidable catch of this species. The overfishing status of eastern gemfish in 2009 is classified as **uncertain** because it is unclear whether current catch levels will allow the stock to rebuild to the B_{20} limit reference point within the specified timeframe (Table 9.1). To reduce uncertainty in the overfishing status, information is required on current harvest rates and the level of catch and discards that will allow the eastern gemfish stock to rebuild to the limit reference point within the timeframe required by the rebuilding strategy. Evidence that total catch (including discards) is less then the bycatch TAC, and that this level of catch is not hampering rebuilding, is urgently required to prevent this stock from being classified as subject to overfishing.

Reliability of the assessment/s

There are concerns about using the recent survey CPUE values as the main index of abundance. Catch rates of aggregating species could potentially remain high while the biomass declines (hyperstability); this has been observed in analyses of trawl catch and effort data for gemfish in New Zealand. Hyperstability would cause the model to overestimate current spawning biomass levels. There is concern among some RAG members that Stage 1 of the rebuilding strategy is ineffective.

Previous assessment/s

Data from scientific observers indicates significant and increasing discarding (including of juveniles) since 2005 (e.g. 46 t in 2006). Landings were also increasing during this time, leading to industry claims that the stock was recovering. The size composition of the spawning stock showed most fish to be 35–75 cm fork length, with very few fish aged over 5 years; in comparison, a 'recovered' population would contain a greater proportion of fish with lengths of 65–95 cm (aged 5–10 years) during the spawning run.

There was no quantitative assessment from 2001 to 2006, mainly because target TACs of zero were in place and no surveys had been conducted since 1998; thus, there was no recent relative abundance index on which to base an assessment. None of the harvest control rules for any tier level were applied in the 2006 assessment because of the lack of recent data with which to update the model (needed for Tiers 1 or 2), representative age composition data (needed for Tier 3) or representative catch-rate data (needed for Tier 4). An industry trawl survey targeting the spawning stock was again conducted in 2007 to gain a relative abundance index similar to previous years. The revised and updated integrated assessment model estimated the 2007 spawning stock to be $0.165B_0$ of pre-fishery levels; estimates varied between

Sorting trawl catch PHOTO: MIKE GERNER, AFMA

0.14B_0 and 0.28B_0 under different model assumptions. The assessment indicated that the decline in stock biomass had ceased.

Despite greatly reduced catches, the rate of rebuilding has been slow because of low levels of recruitment—estimated to be below average in 17 of the past 24 years. It is not clear whether the failure of recruitment to rebuild the spawning biomass has been the result of bycatch mortality of juveniles, reduced effective reproductive potential from the smaller spawning stock size, changed environmental conditions or some combination of these factors.

Future assessment needs

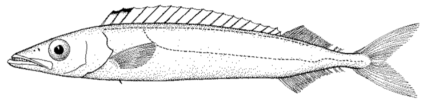
Information is required on the size composition and level of discards, which is a key indicator for determining recruitment and stock rebuilding. Such information is also crucial to resolving the model's inability to fit recent high discard rates. The assessment is also hampered by not having a reliable index of abundance (for aggregating species, catch rates might be maintained while abundance declines). Work is in progress to investigate alternative methods of estimating abundance, including the use of underwater video.

Gemfish and other trawl catch

PHOTO: MIKE GERNER, AFMA

GEMFISH, WESTERN

(*Rexea solandri*)



LINE DRAWING: SHANE WEIDLAND

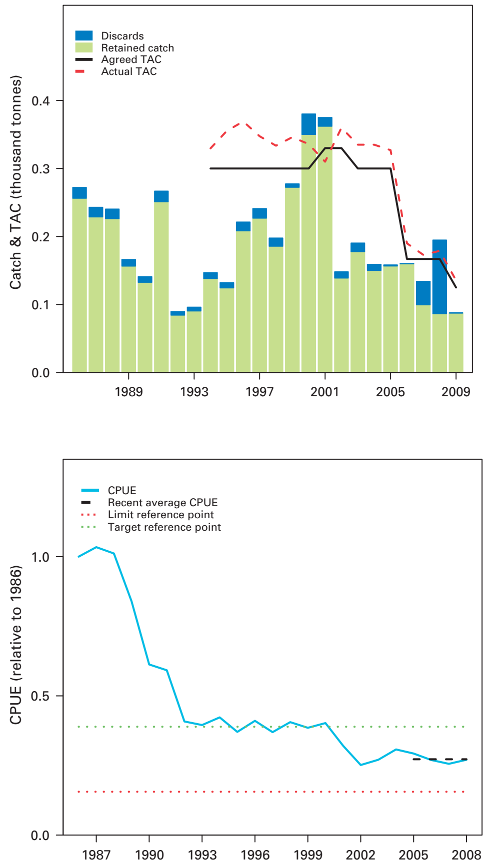


FIGURE 9.12 Western gemfish a) catch history 1989 to 2009 from the CTS and ScHS and b) standardised CPUE for the CTS, 1987 to 2008.

NOTE: that discards and state catch are not included for 2009

Stock status determination

The RBC calculated by SlopeRAG was 102 t for the 2009–10 fishing season (SlopeRAG 2010). The 2009–10 agreed TAC (global) was 125 t (Table 9.2); however, the actual TAC (global) was 135 t after the carryover of uncaught quota was taken into account.

Ongoing attempts are being made to develop an integrated Tier 1 assessment that incorporates data from all sectors (under the RUSS project), but this work is not due for completion until 2010. The catch and CPUE trends for the GABTS differ from those in the CTS, and it will be important to take these differences into consideration during the analysis.

In the 2009–10 fishing season 77 t of western gemfish was landed by the CTS and ScHS, although most catch came from the CTS (Table 9.2). A Tier 4 assessment was used to determine the 2009–10 RBC using trawl CPUE and catch from the CTS and ScHS. A substantial catch of western gemfish is taken within the GABTS (see Chapter 11), 268 t–378 t between 2004–2007. In 2006 and 2007, the GABTS catch was greater than the CTS and ScHS catch. In 2008, the GABTS catch has reduced to ~100 t, which is suggested to be due to a key operator leaving the fishery (SlopeRAG 2010). The level of discarding in the GABTS also appears to be high, based on observer data in recent years (SlopeRAG 2010). Therefore a Tier 4 assessment based only on the CTS data is not ideal; however, this should be addressed in the upcoming Tier 1 assessment.

The Tier 4 assessment suggests that the current CPUE is above the limit reference point and below the target (Fig. 9.12b) (Haddon 2010b). However, given the ongoing conern regarding the fact the GABTS data had not been taken into account in the assessment, western gemfish remain assessed as **uncertain** with regard to whether they are overfished and whether overfishing is occurring (Table 9.1).

Reliability of the assessment/s

The Tier 4 assessment relies solely on CPUE being a reliable index of abundance. It is unclear whether this is the case. As noted above, the fact the GABTS data had not been taken into account, results in a high level of uncertainty. Until the uncertainty is resolved precaution should be shown in setting a TAC.

Previous assessment/s

Landings from SESSF sectors other than the GABTS from 2002 to 2007 have been less than 200 t, and were 77 t in 2009–10 fishing season. The SESSF quota does not apply in the adjacent GABTS, which targets the same stock as the CTS. Separate management controls for the two fisheries increase the risk that total catches will exceed desirable levels for the stock as a whole.

Standardised catch rates of western gemfish (for the CTS) have declined since the late 1980s and have fluctuated in recent years at relatively low levels. Length-frequency distributions are quite variable from year to year and do not provide a robust indicator of the size composition of the stock.

There are no yield estimates for western gemfish; the species was assessed in 2005, 2006, 2007 and 2008 using catch rates under the Tier 4 harvest control rules.

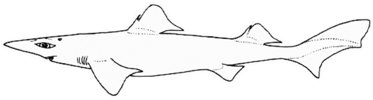
Future assessment needs

Development of the Tier 1 assessment model (as part of the RUSS project) needs to be completed to allow information from all catching sectors to be integrated into the assessment. This will need to be supported by the collection of basic biological information on western gemfish and improved monitoring of the size and age composition of catches, including those from the GABTS.

Mixed trawl catch PHOTO: MIKE GERNER, AFMA

GULPER SHARKS (UPPER-SLOPE)

(*Centrophorus harrissoni*, *C. moluccensis*, *C. zeehaani*)



LINE DRAWING: FAO

TABLE 9.13 Biology of gulper sharks (upper-slope)

Parameter	Description
General	Endeavour dogfish (*Centrophorus moluccensis*), Harrisson's dogfish (*C. harrissoni*) and southern dogfish (*C. zeehaani*)
Range	**Species:** South-eastern Australia, New Zealand and possibly Norfolk Island (*C. harrissoni*); northern New South Wales, across southern Australia to Perth (*C. zeehaani*); east and west coasts of Australia, off southern Africa and some areas of the western Pacific (*C. moluccensis*) **Stock:** The area of the SESSF (CTS, ScHS, GABTS and East Coast Deepwater Trawl Sector)
Depth	Most common in 220–790 m
Longevity	40–50 years
Maturity (50%)	**Age:** 15–34 years **Size:** 61–85 cm
Spawning season	Female cycle continuous and non-seasonal
Size	**Maximum:** ~100–120 cm; weight: 10–15 kg **Recruitment into the fishery:** Size: ~30 cm TL; age: from birth; weight: not determined

CTS = Commonwealth Trawl Sector; GABTS = Great Australian Bight Trawl Sector; ScHS = Scalesfish Hook Sector; SESSF = Southern and Eastern Scalefish and Shark Fishery; TL = total length

SOURCES: White et al. (2008); Last & Stevens (2009).

Gulper shark PHOTO: SALLY WEEKES, AFMA

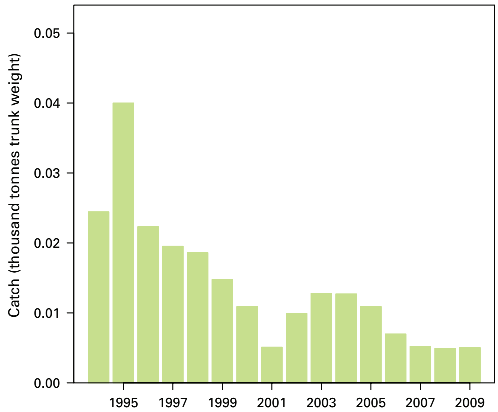


FIGURE 9.13 Gulper shark catch history from the CTS and ScHS, GABTS and ECDTS, 1994 to 2009

Stock status determination

In 2009 and 2010, research surveys carried out by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) confirmed the depleted status of these species off the south coast of NSW (Daley et al. 2009). These surveys confirmed at least two remnant populations of *C. zeehaani* in the south-east, including one in an area closed to Commonwealth fishers. The surveys also located three remnant populations of *C. harrissoni*, one off the northern New South Wales coastline, another on a remote seamount more than 200 nm to the east and a third off Flinders Island. Although these surveys provide a key step in understanding distribution at the species level, population structure remains uncertain, particularly for *C. harrissoni*. As well as the apparent spatial separation of populations, the sexes are spatially segregated but demographically dependent. For example, to the north of Flinders Island, the *C. harrissoni* were dominated by males with very few females caught (CSIRO: R. Daley pers. comm.).

The historical depletion of these species due to targeted fishing is well documented (see Graham et al. 2001; Wilson et al. 2009). Specifically, data indicate that *C. harrissoni* and *C. zeehaani* have undergone significant reductions in numbers throughout much of their restricted geographic ranges.

C. harrissoni is endemic to waters off south-eastern Australia and adjacent seamounts (north of New Zealand), while *C. zeehaani* is endemic to southern Australian waters largely or wholly within the SESSF management area (Last & Stevens 2009; White et al. 2008). Graham et al. (1997, 2001) report declines in catches of more than 99% for both species on the New South Wales upper-slope from 1976–77 to 1996–97.

The viability of these two species is at risk, as indicated by the confirmed declines in catches in scientific trawl surveys from 1976–77 to 1996–97; continued low catches (Walker et al. 2008; Daley et al. 2009; Wilson et al. 2009); the low numbers of mature individuals being caught by fishery-dependent and fishery-independent studies; and their life history strategy of slow growth, late age at maturity (Table 9.13), low fecundity and low natural mortality.

Graham et al. (2001) also indicate that endeavour dogfish (*C. moluccensis*) has undergone a significant reduction in numbers (in excess of 95%) throughout the upper slope of the SESSF.

This group of three gulper shark species therefore remains assessed as **overfished** and **subject to overfishing** in 2009 (Table 9.1). Based on the biology of the species and the current catch (~5 t reported in logbooks in 2008 and 2009, Fig. 9.13), little evidence of recovery is expected for several decades. Indeed, the fishing mortality occurring in the SESSF in 2009 is considered too high to enable species within this stock to rebuild.

Strategies are needed to prevent further depletion of populations on the upper slope and, where possible, to begin to rebuild local populations. Given that historical fishing on these shark species was carried out in a targeted manner, with large catches leading to significant declines (overfished status), we conclude that the HSP is applicable to these species. Therefore, a rebuilding strategy is required to reduce the mortality of these species to a level that will stop further decline and support the recovery of populations within the area of the SESSF.

Reliability of the assessment/s

The information on the decline of these species provided by Graham et al. (2001) and other sources is considered to be reliable, as are the recent survey data provided by CSIRO. It is well documented that deepwater shark species, particularly sharks within the family Centrophoridae, are vulnerable to overfishing (e.g. Garcia et al. 2008; Forrest & Walters 2009; Patterson & Tudman 2009). It has been concluded that fishing in the SESSF is the primary cause of the marked declines in these species (Graham et al. 2001), and this has been confirmed by other reports (Wilson et al. 2009).

Previous assessment/s

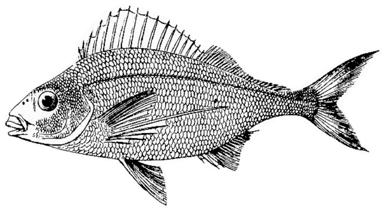
Gulper sharks were targeted throughout the 1990s for the oil in their livers (squalene). Targeting effectively ceased in 2002 due to declining catch rates; however, various sectors of the SESSF continue to take these species as byproduct at levels considered unsustainable (Daley et al. 2002; Wilson et al. 2009). Of the three species in this group, *C. harrissoni*, a species considered endemic to south-eastern Australia and adjacent seamounts, is the most vulnerable. The three species have been nominated for listing as threatened species under the EPBC Act, and a decision by the Minister for Environment Protection, Heritage and the Arts is expected by 30 September 2010. Although the species are not formally assessed under the SESSF HSF, all available information indicates that these species are overfished.

Future assessment needs

Historically, identification to species level has been a problem and has hindered the collection of reliable fishery data. Levels of discarding also need to be closely monitored to provide robust estimates of catch levels. In addition, further CSIRO surveys should improve our understanding of the level of depletion of this group and the potential level of connectivity between depleted areas and remnant populations. AFMA is currently developing a gulper shark management strategy to address some of these issues.

JACKASS MORWONG

(*Nemadactylus macropterus*)



LINE DRAWING: FAO

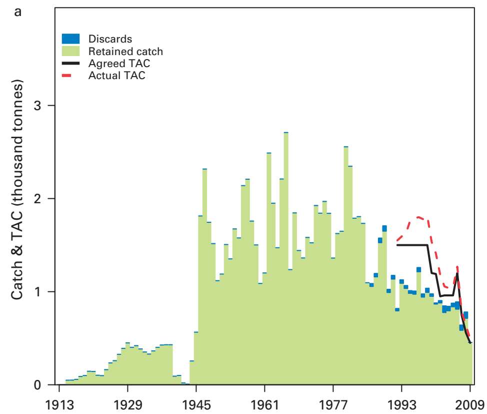
TABLE 9.14 Biology of jackass morwong

Parameter	Description
General	Managed as a single stock, but assessment assumes separate stocks east and west of Bass Strait.
Range	**Species:** Occurs in the southern waters of Australia from New South Wales (NSW) to Western Australia, including Tasmania; it also occurs in other areas of the southern hemisphere, including New Zealand. **Stock:** The assessment assumes separate stocks east and west of Bass Strait. Otolith microstructure studies found differences between southern Tasmania and NSW/Victoria but it is unclear if these indicate separate stocks. Catches of jackass morwong from the GABTS are currently not included in the stock assessments.
Depth	10–450 m, but most abundant in 100–200 m
Longevity	20–35 years
Maturity (50%)	**Age:** 3 years **Size:** 23–27 cm FL
Spawning season	Late summer and early autumn
Size	Maximum: ~70 cm TL; weight: ~ 5 kg Recruitment into the fishery: 25–30 cm FL; age: 4–6 years; weight: ~0.4 kg

FL = fork length; GABTS = Great Australian Bight Trawl Sector; TL = total length

SOURCES: Kailola et al. (1993); Ward & Elliot (2001).

Jackass morwong PHOTO: ABARE–BRS



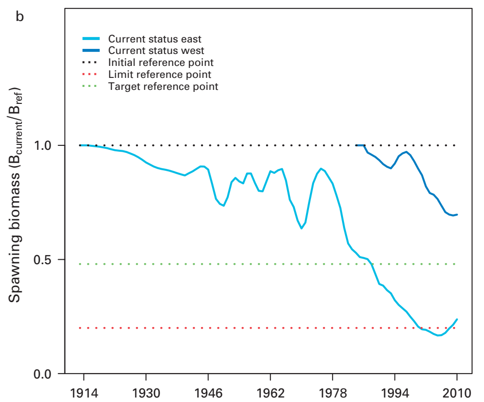


FIGURE 9.14 Jackass morwong a) catch history 1913 to 2009 and b) biomass (east and west) for the CTS and ScHS, 1914 to 2010.

NOTE: that discards and state catch are not included for 2009

Stock status determination

The status of jackass morwong was determined using the 2009 Tier 1 stock assessments, which consists of separate assessments of the eastern stock (southern New South Wales to east coast of Tasmania) and the western stock (western Tasmania to western Victoria; Wayte 2010). As in 2008, most of the catch was taken from the east in 2009 despite the RAG recommending a zero RBC (Wayte 2010). This occurs because both stocks are managed through a single TAC (Fig. 9.14a). Jackass morwong is also caught in the GABTS in high numbers. Without evidence to suggest otherwise, Great Australian Bight morwong must be assumed to be part of the western stock.

Jackass morwong was classified as overfished in 2008 because the spawning biomass of the eastern stock was below the B_{20} limit reference point. Model projections from the 2009 assessment show increasing biomass (Fig. 9.14b). The base case estimate of depletion for the beginning of 2010 was 24% of unfished levels. The assessment of the western stock (not including catches from the GABTS) indicated a spawning biomass at 70% of unfished levels. As a result, ShelfRAG recommended 2010–11 RBCs of 143 t for the eastern stock and 367 t for the western stock.

Jackass morwong is assessed as **not overfished** (Table 9.1). Regardless, the eastern stock is likely to be well below the target reference point; eastern catches should be restricted to the eastern RBC to allow stock rebuilding (143 t for the 2010–11 fishing season).

The combined 2009–10 TAC was set at 450 t, with deductions for state catch (10 t), discards (22 t) and the application of the CPUE multiplier rule. The high proportion of catch from the more depleted eastern stock persisted in 2009–10, highlighting the need for separate management arrangements for the two stocks. Jackass morwong remains assessed as **subject to overfishing** because catches in the east exceeded both the 2009–10 fishing season RBC of zero, and the proposed RBC of 143 t for the 2010–11 fishing season (which assumes a biomass of $0.24B_0$ at the end of 2009). The overfishing determination might seem to contradict the increased biomass estimated by the end of 2009. By definition, however, stocks are assessed to be subject to overfishing where catches significantly exceed the RBC and the biomass is near the limit reference point.

Reliability of the assessment/s

Although jackass morwong is classified as not overfished in 2009, there was a strong case for an uncertain classification. The western assessment was considered preliminary; and it was not reviewed in detail by the RAG. GABTS catches are significant, but were not included in the stock assessment or deducted from the RBC. Annual GABTS catches of jackass morwong averaged more than 100 t during 2003–08, while western catches were 167 t per year over the same period. It is unclear how the inclusion of GABTS catches would affect conclusions of the western assessment. Furthermore, independent research surveys in the GABTS (Knuckey et al. 2009) suggest a 36% reduction in morwong biomass from 2007 to 2009 (25% averaged over 2005–09).

There is also uncertainty in the assessment of the eastern stock. It was sensitive to the last year of recruitment estimation and stock–recruitment steepness, with a range of scenarios producing depletion estimates of 14–38% of unfished levels. In previous assessments, recruitment was estimated from catch and discard sampling up until two years before the end of the data series, with subsequent years set at average levels. The 2009 assessment of jackass morwong (and several other Tier 1 stocks) estimated recruitment up until four years before the end of the data series. This modification to the base case is justified by the low selectivity of the gear for small-sized jackass morwong and the poor standard of data collection in 2007–08.

The 2009 stock assessment also depended on assumptions about stock structure. Like other Tier 1 stocks, there were concerns about

Jackass morwong PHOTO: HEATHER PATTERSON, ABARE–BRS

a lack of recent data, including discards, size composition and age composition. For jackass morwong, those problems may have reduced the assessment's ability to reflect possible stock rebuilding in the east.

Previous assessment/s

Jackass morwong is caught mainly by the CTS, with the bulk of the catch taken off southern New South Wales, eastern Bass Strait and the east coast of Tasmania. The TAC remained steady from 1992 to 1999 at 1500 t, but the maximum annual catch in this period was 1200 t (Fig. 9.14a). The TAC was partly based on yield estimates derived from erroneously high estimates of natural mortality. It was reduced to 1200 t in 2000, following improved estimates of natural mortality that indicated a less productive resource requiring lower fishing rates.

The TAC was reduced to 960 t from 2002 to 2005 and increased to 1200 t in 2006. The 2006 quantitative assessment for the eastern fishery was highly sensitive to the standardised CPUE time series used as an index of abundance, and biomass estimates varied between 15% and 35% of the unfished biomass. As a result, the more precautionary assessment of stock status was adopted as the base case and used for calculation of the RBC. Since 2006, TACs have consequently declined markedly, from 1268 t to 493 t.

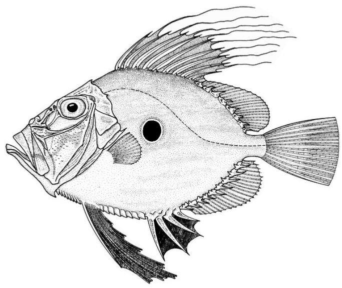
Annual landings were comparatively stable at around 800 t since 1997, until 2007 (643 t) and 2008 (721 t). Catch rates generally declined during the late 1980s and 1990s, but have stabilised in recent years.

Future assessment needs

The most pressing assessment needs are improvements to sampling of the catch to provide reliable estimates of recruitment, stock–recruitment dynamics, and the relationship between eastern and western stocks and between the Great Australian Bight and the western stock (Table 9.14). For many CTS stocks, including jackass morwong, the influence of zero catches on the CPUE standardisation requires further consideration.

JOHN DORY

(*Zeus faber*)



LINE DRAWING: ROSALIND POOLE

TABLE 9.15 Biology of John dory

Parameter	Description
Range	**Species:** Distributed in the east Atlantic, west Indian and Pacific Oceans. In Australia, it is found in temperate waters from southern Queensland to Western Australia, including Tasmania. **Stock:** The assessment assumes that the stock is the area of the CTS sector of the SESSF. The SESSF catch is taken mostly off New South Wales and Victoria, with limited catches taken off eastern Bass Strait. State catches are included in the assessment. John dory is largely a byproduct of trawlers that target other shelf species, such as redfish and flathead.
Depth	5–400 m; usually in 50–150 m
Longevity	20 years
Maturity (50%)	**Age:** 3–5 years **Size:** 25–30 cm SL
Spawning season	Summer (December–March)
Size	**Maximum:** ~ 66 cm SL; weight: 3 kg **Recruitment into the fishery:** ~20–30 cm TL; age: 3–5 years; weight: not determined

CTS = Commonwealth Trawl Sector; SESSF = Southern and Eastern Scalefish and Shark Fishery; SL = standard length

SOURCES: Klaer (2010b).

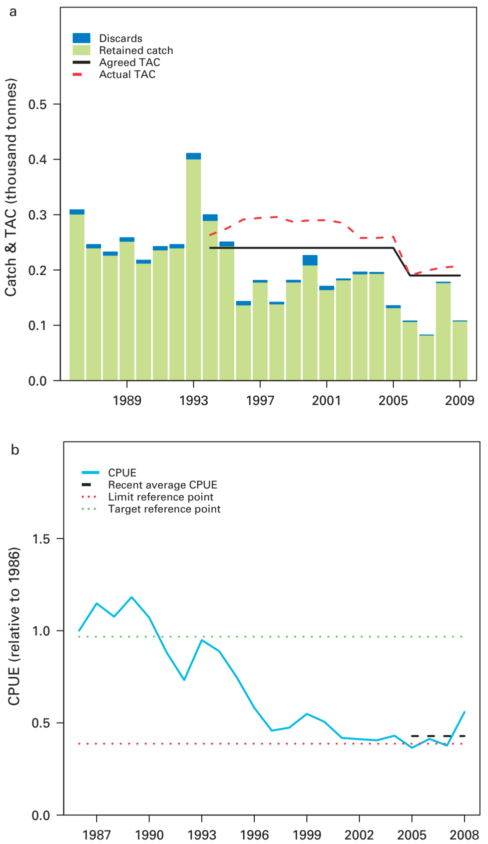


FIGURE 9.15 John dory a) catch history from the CTS and ScHS and b) standardised CPUE for the CTS, 1986 to 2009.

NOTE: discards and state catch are not included for 2009

Stock status determination

John dory was assessed using a Tier 3 assessment model, which involves catch-curve analyses providing estimates of fishing mortality (Klaer 2010b). The 2009 assessment used new harvest control rules that are more robust and overcome several of the problems associated with the previous Tier 3 approach.

The RBC calculated by ShelfRAG was 233 t for the 2009–10 fishing season (ShelfRAG 2009) (Table 9.2). However, AFMA had previously set an agreed TAC of 190 t for three fishing seasons (2007–08 to 2009–10). The actual TAC (global) set by the AFMA Commission was 207 t for 2009–10 fishing season, following undercatch provisions.

The Tier 3 assessment indicates that current fishing mortality rates are near the target reference point of 48% of unfished levels (Klaer 2010b). Since the average fishing mortality rate from the Tier 3 catch-curve analysis is well below the limit reference point, John dory was assessed as **not subject to overfishing** (Table 9.1).

The Tier 4 assessment was used as an indicator of biomass levels. The 2009 assessment changed the Tier 4 reference period to 1986–95, which is considered to more accurately reflect catches that can reasonably be expected by the current fishery (Haddon 2010b). In two of the past four years, CPUE has been below the CPUE limit (Fig. 9.15b; Haddon 2010b). However, the four-year average CPUE series is above the limit and the most recent

John dory PHOTO: ANDREW SAMPAKLIS, ABARE–BRS

Sorting the catch PHOTO: MIKE GERNER, AFMA

estimate was considerably higher than in the preceding decade (Fig. 9.15b). John dory is consequently assessed as **not overfished**.

The three-year annual TAC of 190 t lapsed at the end of the 2009–10 fishing season leading to the resumption of TACs based on current RBCs. The 2010–11 RBC is 284 t, which is similar to reference period catches (Klaer 2010b). The default 5% discount factor was not applied to John dory because of the bycatch nature of this species, and stability in catches and size composition.

Reliability of the assessment/s

Tier 3 assessments are moderately reliable and use yield-per-recruit calculations to determine mortality rates. Tier 4 assessments rely solely on CPUE being a reliable index of abundance. It is not certain that this is the case. However, the high upturn in CPUE in 2009 provides some confidence in classifying John dory as not overfished.

Previous assessment/s

John dory is largely taken as byproduct while fishing for other shelf species. As a result, the size of the catch depends on how much fishing effort is directed at the depth strata occupied by John dory. Consequently, it is unlikely that changing the TAC would affect the fishing mortality, as landings have not approached the TAC in the past 10 years (Fig. 9.15a). Also, a significant portion of the John dory landings come from non-SESSF fisheries, particularly the trawl fishery north of Sydney.

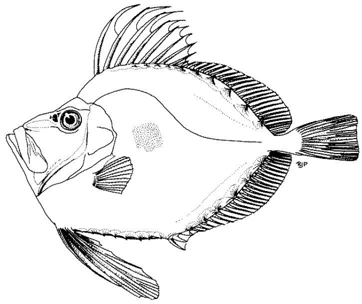
Catch-curve analyses in 2006 indicated that fishing mortality rates were lower than previously estimated and less than natural mortality rates. No long-term trends in the size structure of the catch were apparent. The assessment was not updated in 2007 because it was recognised that it was not advisable to apply the previous Tier 3 harvest control rules each year (see Chapter 8). This is no longer the case with the revised Tier 3 rules.

Future assessment needs

Comparison of Tier 3 and Tier 4 results has yielded some inconsistencies. Therefore, a collection of age data would be useful to support the current Tier 3 results.

MIRROR DORY

(*Zenopsis nebulosa*)



LINE DRAWING: FAO

TABLE 9.16 Biology of mirror dory

Parameter	Description
Range	**Species:** Widespread on the continental margins of the Pacific Ocean; in Australia, it is widespread except for northern Queensland, Northern Territory and northern Western Australia. **Stock:** Stock structure is uncertain, although two stocks, east and west of Bass Strait, are likely. A single stock is assumed for management purposes. Mirror dory is predominantly taken from the CTS, with minor catches (typically <2 t) from the GABTS.
Depth	50–600 m, but most catches in 300–600 m
Longevity	12 years
Maturity (50%)	**Age:** 4–7 years **Size:** ~35 cm TL
Spawning season	May–September off New South Wales
Size	**Maximum:** ~70 cm SL; weight: ~3 kg **Recruitment into the fishery:** ~30–35 cm TL; age: 3–4 years; weight: ~1 kg

CTS = Commonwealth Trawl Sector; GABTS = Great Australian Bight Trawl Sector; TL = total length

SOURCES: Parin et al. (1988); Gomon et al. (2008)

Stock status determination

The RBC calculated by SlopeRAG was 906 t for the 2009–10 fishing season (SlopeRAG 2010). The 2009–10 agreed TAC (global) was 718 t (Table 9.1); however, the actual TAC (global) set by the AFMA Commission was 761 t.

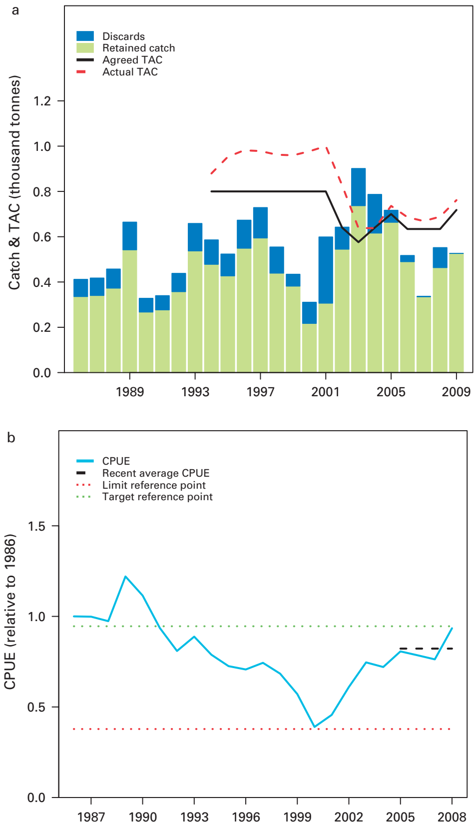


FIGURE 9.16 Mirror dory a) catch history, 1986 to 2009 from the CTS and ScHS and b) CPUE for the CTS, 1986 to 2008.

NOTE: that discards and state catch are not included for 2009

In 2009 the availability of mirror dory data was investigated with the view to a Tier 1 assessment of the stock. However, because of concerns about the spatial and temporal representativeness of sampling and an imbalance with respect to sex (lacking male samples), the Tier 3 assessment was updated instead. The Tier 3 assessment indicated that the average mortality rate was lower than the rate that would reduce the stock to the target level (Klaer 2010b). Therefore, mirror dory remains assessed as **not subject to overfishing** (Table 9.1). The Tier 4 assessment was also used as an indicator of biomass levels and showed that the recent CPUE is near the target CPUE, with an increasing trend since 2000 (Fig. 9.16b) (Haddon 2010b). Thus, the mirror dory stock status remains assessed as **not overfished**.

A RBC was calculated for the 2010–11 fishing season using the new harvest control rules (Klaer 2010b). The resulting RBC for the 2010–11 fishing season of 1196 t, almost 300 t greater than for the 2009–10 fishing season (906 t). However, the AFMA Commission maintained the actual TAC at 761 t so that the data concerns could be addressed.

Mirror dory PHOTO: MIKE GERNER, AFMA

Reliability of the assessment/s

Tier 3 assessments are moderately reliable and use yield-per-recruit calculations to determine mortality values. The Tier 4 assessments rely solely on CPUE being a reliable index of abundance. It is unclear whether this is the case.

There are concerns with the representativeness of biological sampling of mirror dory, notably the limited ageing samples, and inconsistency in the spatial and temporal collection of size composition data. Consequently, there is a lack of confidence in the 2010 RBC, although recent stability in catches and the upward trend in CPUE are positive.

Previous assessment/s

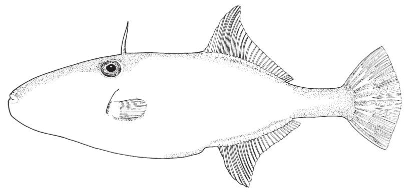
The availability of data on age composition has allowed for assessment of mirror dory under Tier 3 harvest control rules since 2005. Catch-curve analyses have previously indicated fishing mortality to be less than natural mortality. Recent assessments of the available information on catches (Fig. 9.16), catch rates and size composition of mirror dory showed no changes in these indicators, resulting in a consistent RBC since 2006 (Haddon 2010b; Klaer 2010b).

Future assessment needs

An updated direct estimate of the age composition of the catch of mirror dory from otoliths would provide a more robust estimate of the current level of fishing mortality than the length-based approach currently used. It is essential that samples for size and age are collected from both the eastern and western parts of the fishery. These data would also assist with updating estimates of selectivity, which are now incorporated into the revised Tier 3 harvest control rule. Investigating the stock structure of mirror dory would also be useful.

OCEAN JACKET (eastern)

(*Nelusetta ayraudi*)



LINE DRAWING: FAO

TABLE 9.17 Biology of ocean jacket

Parameter	Description
Range	**Species:** Subtropical waters, 20°S–32°28'S and 114°02'E–114°59'E. This species is considered to be endemic to Australia, although a single specimen has been reported from New Zealand. **Stock:** Inhabit waters of southern Australia from Cape Moreton in Queensland to North West Cape in Western Australia, but excluding Tasmania. Also occur in CTS and ScHS. Stock from the eastern Great Australian Bight and the south-east of South Australia are a common stock.
Depth	0–360 m, usually 0–200 m. Adults are found on the continental shelf and slope, while juveniles school seasonally in inshore waters.
Longevity	<9 years
Maturity (50%)	**Age:** 2.5 years **Size:** ~35 cm TL
Spawning season	Spawning occurs from July to September, with a peak in spawning during August in northern New South Wales. In South Australia, ocean jackets spawn between late April and early May in waters 85–200 m deep several hundred kilometres offshore. Spawning probably occurs more than once during this brief period.
Size	**Maximum:** 100 cm TL; weight: 3.5 kg **Recruitment into the fishery:** 22 cm TL; age: 2 years (fully recruited); weight: not determined

CTS = Commonwealth Trawl Sector; ScHS = Scalesfish Hook Sector; TL = total length

SOURCES: Kailola et al. (1993); Miller (2007); Froese & Pauly (2009); Miller & Stewart (2009).

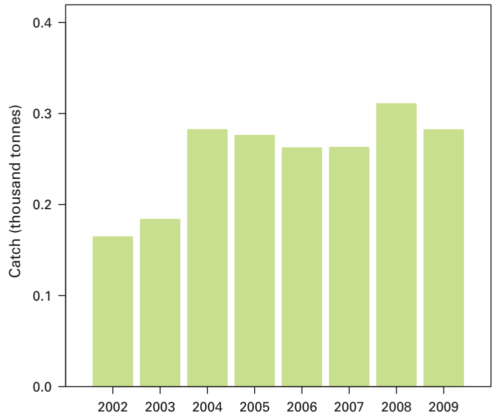


FIGURE 9.17 Ocean jacket catch history for the CTS and ScHS, 2002 to 2009

Stock status determination

Ocean jacket, which is not under quota, is included in this year's report because its catch levels (Fig. 9.17) exceed those of many quota species and may therefore warrant formal stock assessment and/or additional stock specific management measures. The criteria for inclusion in the *Fishery status reports* are outlined in the overview chapter (Chapter 1). In the case of ocean jacket, they are considered an important byproduct stock from both an ecological and economic position. The total catch (landings and discards) of ocean jacket has been greater than that of many other stocks currently targeted and assessed in the CTS and ScHS of the SESSF and the value of the total catch landed is considered to be an important economic component of the fishery, and continues to increase.

There is currently no quantitative stock assessment for ocean jacket taken in the CTS and ScHS. Trends in the unstandardised CPUE series for ocean jacket in the CTS and ScHS have remained relatively stable. As there is no formal stock assessment for ocean jacket, and the CPUE series has not yet been standardised, the status for overfished and overfishing is **uncertain** (Table 9.1).

Reliability of the assessment/s

There is no formal assessment of the ocean jacket stock fished by the CTS and ScHS.

Previous assessment/s

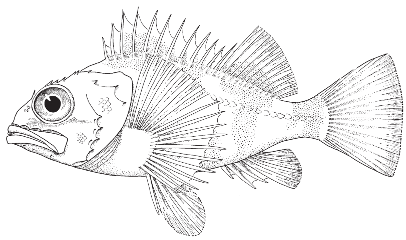
None.

Future assessment needs

A formal Tier 4 assessment for ocean jacket in the CTS and ScHS is required to provide information for determining the stock status in the future.

OCEAN PERCH

(*Helicolenus barathi, H. percoides*)



LINE DRAWING: FAO

TABLE 9.18 Biology of ocean perch

Parameter	Description
General	Bigeye ocean perch (*Helicolenus barathri*), reef ocean perch (*H. percoides*)
Range	**Species:** Occupies southern Australian temperate waters from New South Wales to Western Australia, including Tasmania; also found in New Zealand. **Stock:** Area of the SESSF.
Depth	50–800 m
Longevity	30–60 years
Maturity (50%)	**Age:** not determined **Size:** 30 cm FL
Spawning season	Late winter to early spring
Size	**Maximum:** 30–40 cm FL; weight: 1.5 kg **Recruitment into the fishery:** ~20–25 cm FL; age: ~7–10 years; weight: not determined

SESSF = Southern and Eastern Scalefish and Shark Fishery

SOURCES: Kailola et al. (1993); Park (1994); Paul & Horn (2009).

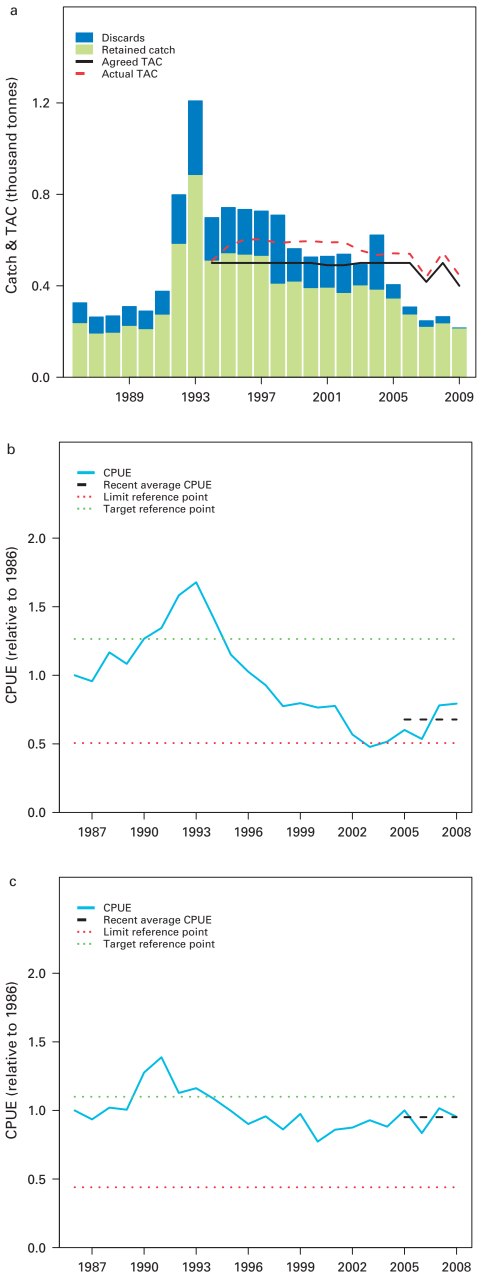


FIGURE 9.18 Ocean perch a) catch history from the CTS and ScHS 1986 to 2009, CPUE for the CTS b) inshore and c) offshore species, 1986 to 2008.

NOTE: that discards and state catch are not included for 2009

Stock status determination

The RBC calculated by SlopeRAG was 280 t for the 2009–10 fishing season (SlopeRAG 2010). The 2009–10 agreed TAC (global) was 400 t (Table 9.2); however, the actual TAC (global) set by the AFMA Commission was 446 t.

In 2009 inshore (*H. barathri)* and offshore (*H. percoides)* species of the ocean perch stock were assessed separately using Tier 4 assessments (Haddon 2010b). The default reference period, 1986 to 1995, was used (SlopeRAG 2010). The Tier 4 assessment for offshore species suggests that the standardised CPUE is fairly constant, displaying no concerning trends (Fig. 9.18c). The standardised CPUE for the inshore species (Fig. 9.18b) shows substantially more variation, with a peak in the mid-1990s, decreasing to a low in the early 2000s. However, the trend has since been positive. The catch for the 2009–10 fishing season was 203 t, which is 51% of the agreed global TAC of 400 t. Both species of ocean perch are assessed as **not overfished** (Table 9.1). Given the low level of catch in recent years relative to the RBC, they are also assessed as **not subject to overfishing**.

The RBC for the 2010–11 fishing season was calculated as 244 t, comprising 25 t for the inshore species (*H. barathri)* and 219 t for the offshore species (*H. percoides)*. These two species will be considered for status determination as two separate stocks in the next fishery status reports.

Reliability of the assessment/s

The Tier 4 assessment relies solely on CPUE being a reliable index of abundance. It is unclear whether this is the case.

Previous assessment/s

Decreases in abundance and length composition of ocean perch occurred between 1976–77 and 1996–97. However, recent Integrated Scientific Monitoring Program (ISMP) data show little evidence of a decrease in the size of bigeye ocean perch in recent commercial catches. Catch rates for reef ocean perch have declined

steadily over the past decade (Fig. 9.18a), and ISMP data indicate a decrease in size over recent years. About 90% of reef ocean perch caught are too small to market and are discarded. This high level of discarding has been a concern. However, the discard rate appears to be declining; it was 10% across both species in 2007 and 7% in 2008.

No formal quantitative assessments have been conducted. Assessments in 2005 and 2006 applied the previous form of the Tier 4 harvest control rules and assessed both species combined. No indicators in the 2007 assessment suggested any cause for concern about the status of ocean perch. However, the old Tier 4 assessments did not provide clear guidance on current stock size.

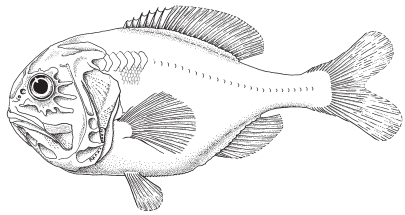
Future assessment needs

Better information on the level of discarding and on the possible decline in the abundance of larger length groups could be influential in the assessment. In addition, data that would allow a more robust assessment, such as age-class data, would provide more confidence in the assessment of these species.

Ocean perch PHOTO: FIONA SALMON, DAFF

ORANGE ROUGHY (Cascade Plateau)

(*Hoplostethus atlanticus*)



LINE DRAWING: ROSALIND POOLE

TABLE 9.19 Biology of orange roughy

Parameter	Description
General	The stock structure of orange roughy in the SESSF remains unclear, despite considerable research. New research using genetic techniques may elucidate the stock structure of orange roughy in south-eastern Australia on a finer spatial scale.
Range	**Species:** Occurs in all temperate oceans except the north Pacific; in Australia, it occurs across the south coast from Sydney to Perth and is found in continental slope and seamount areas. **Stock:** Orange roughy on the Cascade Plateau is considered to be a distinct stock, based on geographic and biological information. For management purposes, the remaining area of the CTS is divided into zones (eastern, western and southern), which are assessed separately.
Depth	180–1800 m, but usually found at 400–1000 m
Longevity	90–150 years
Maturity (50%)	**Age:** ~30 years **Size:** ~29–32 cm SL
Spawning season	July–August
Size	**Maximum:** 50–60 cm SL; weight: ~3–4 kg **Recruitment into the fishery:** ~30 cm SL; age: 24–42 years; weight: not determined

CTS = Commonwealth Trawl Sector; ScHS = Scalesfish Hook Sector; SL = standard length

SOURCES: Clark et al. (2000); Gomon et al. (2008).

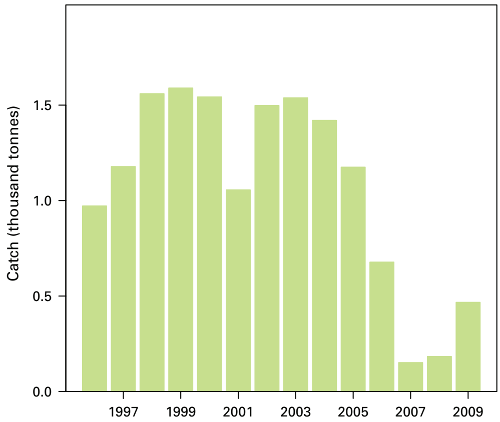


FIGURE 9.19 Orange roughy catch history on the Cascade Plateau, 1996 to 2009

Stock status determination

The assessment was updated in 2009 based on new information about the biomass estimate from the 2005 survey. When the biomass estimate was re-evaluated, it was found to include acoustic marks that were probably not orange roughy, which resulted in an over-estimate of biomass. The new estimate of biomass in 2005 is 18 000 t (down from 31 000 t), which results in an RBC of 315 t. However, the assessment also indicated that the stock is at 64% of unfished levels, which is above the limit reference point required under the Orange Roughy Conservation Programme (ORCP) (AFMA 2006). In addition, and in contrast to the past two years, the acoustic survey showed defined spawning marks of orange roughy on the Cascade Plateau.

As it has been determined that the stock is above the limit reference point, and 2009 catches are below the RBC (465 t), Cascade Plateau orange roughy remains assessed as **not overfished** and **not subject to overfishing** (Table 9.1).

Reliability of the assessment/s

The assessment method is generally robust and has a high level of reliability. However, the assessment relies on biomass estimates from acoustic surveys, which can be problematic. In 2009 a new method (acoustic-optical system; AOS) was trialled that provides a means to visually verify the acoustic signature and may improve the accuracy of the biomass estimates (Ryan et al. 2009).

Previous assessment/s

There was no formal stock assessment for this fishery before 2004 because of inadequate data, although acoustic surveys using commercial vessels have been conducted since 1999 and the area has been fished since 1996 (Fig. 9.19). An integrated assessment model with an age- and sex-structured population dynamics component was used for an assessment in 2004 and was updated in 2006 using results of acoustic surveys in 2003, 2004 and 2005. Inconsistencies in the biomass estimates from the surveys led the Deepwater Resource Assessment Group (DeepRAG) to run the assessment using only the 2005 survey results (which produced the highest biomass estimate) and to treat them as an estimate of absolute abundance. The pre-fishery (1989) female spawning biomass was not estimated to be large (between 20 000 t and 38 000 t), and in 2005 was estimated to be at 73% (62–82%) of the average unfished biomass. In response to the listing of orange roughy as conservation dependent, it has been determined that TACs should be set at a level such that the stock should not be depleted below 60% of unfished levels.

Future assessment needs

Orange roughy assessments and monitoring arrangements will be reviewed in 2011, as required by the ORCP. There is also a need for a review of the assessment, as potential biases from a range of sources—including sampling design, uncertain target strength and species composition—have been identified. Given the newly calculated RBC of 315 t, an updated biomass estimate will need to be considered if the TAC is to remain at 500 t in future years given the constraints of the ORCP. In addition, a recent review of the orange roughy stock assessment process, as required by the ORCP, provided comments and suggestions that will need to be considered and incorporated during the next formal assessment. Finally, a better understanding of the stock structure of orange roughy in south-east Australia and the level of connectivity of the Cascade Plateau stock with other stocks is important for making management decisions.

ORANGE ROUGHY (eastern, southern and western zones)

(*Hoplostethus atlanticus*)

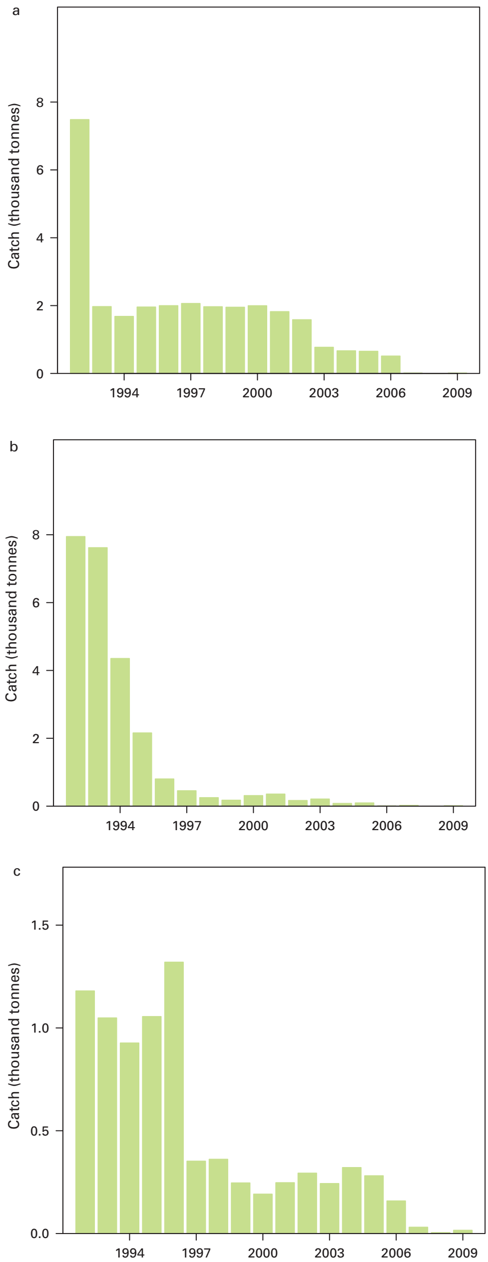


FIGURE 9.20 Orange roughy catch history a) eastern, b) southern and c) western from the CTS and ScHS, 1992 to 2009

Stock status determination

The assessments for orange roughy in the eastern, southern and western zones were not formally updated in 2009. There is no targeted fishing for orange roughy in these zones. Given the low recent catches (TACs only reflect incidental catch or catch taken under scientific permits; Figs. 9.20a,b,c) and the closures that have been introduced, all the zones remain assessed as **overfished** but **not subject to overfishing** (Table 9.1).

Reliability of the assessment/s

The assessments are generally robust with a high degree of reliability.

Previous assessment/s

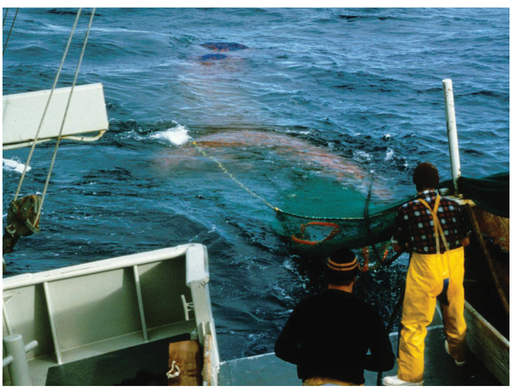
Assessments in the eastern zone have been made annually since 1993. The results of the major 1997, 2000 and 2001 assessments were not consistent, but all indicated the need to reduce catches. Results from a 2006 acoustic survey were used to provide an updated assessment and to calculate an RBC under Tier 1 harvest control rules. The current biomass was estimated to be at either 13% or 24% of the unfished biomass, depending on whether the annual level of recruitment was estimated from the age composition data or assumed to be at an average level. This indicated that it was likely that the biomass was still below the limit reference point. A 2007 update showed there had been a small but consistent increase in the spawning biomass since 1993.

The assessment for the southern zone has not been updated since 2000, when the stock was assessed as being overfished. Standardised catch-per-shot abundance indices, using only data from vessels that had regularly fished this zone, estimated the abundance in 2001 to be about 7% of that in 1989. The 2004 update of abundance indices, incorporating limited 2003 catch data, was more optimistic. The assessment was considered to be at Tier 2, and in 2005 a zero TAC was recommended. Based on fishing catches, CPUE and acoustic marks observed on the fishing grounds, the stocks still appeared to be rebuilding in 2006.

The first assessment for the western zone was made in 1999, and there have been no updates since 2002. The probability that the 2004 biomass was less than 30% of the 1985 biomass was estimated to be greater than 90%, even with a zero catch. The establishment of a spatial closure in a possible spawning area was used to justify the 2005 TAC remaining at 450 t. However, no significant spawning is known to occur in the region. A comparison of the age composition in 1994–1996 with that in 2006 showed a marked change in modal age, which is indicative of a heavily fished stock, but it is uncertain whether all the otolith samples used for this analysis came from the same stock of fish. In 2005 the RBC was zero; the TAC was reduced in 2007 to low levels to cover incidental catches.

Future assessment needs

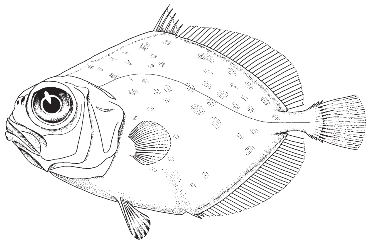
There will be a review of orange roughy assessments and monitoring arrangements in 2011, as required by the ORCP. In addition, a recent review of the orange roughy stock assessment process, as required by the ORCP, provided comments and suggestions that will need to be considered and incorporated during the next formal assessment. An acoustic survey of spawning aggregations at St Helens Hill and St Patricks Head in the eastern zone, trialling the new AOS, was successful, and indicated that spawning aggregations were present at both locations. Further development of the AOS will likely provide valuable information that can be incorporated into future assessments.



Bringing in orange roughy PHOTO: AFMA

SMOOTH OREODORY (Cascade Plateau and non-Cascade Plateau)

(*Pseudocyttus maculatus*)



LINE DRAWING: FAO

TABLE 9.20 Biology of smooth oreodory

Parameter	Description
Range	**Species:** Common in southern oceans and also found in the north-west Atlantic. In Australia, it is found across the south, from New South Wales to Western Australia, including Tasmania. **Stock:** Cascade oreodories are considered to be a distinct stock. The remaining area of the CTS comprises the non-Cascade Plateau stock.
Depth	650–1500 m
Longevity	85–100 years
Maturity (50%)	**Age:** ~25 years **Size:** ~32–41 cm TL
Spawning season	Unknown
Size	**Maximum:** ~68 cm TL; **weight:** ~5 kg **Recruitment into the fishery:** ~34 cm TL; age and weight: not determined

CTS = Commonwealth Trawl Sector; ScHS = Scalesfish Hook Sector; TL = total length

SOURCE: Gomon et al. (2008).

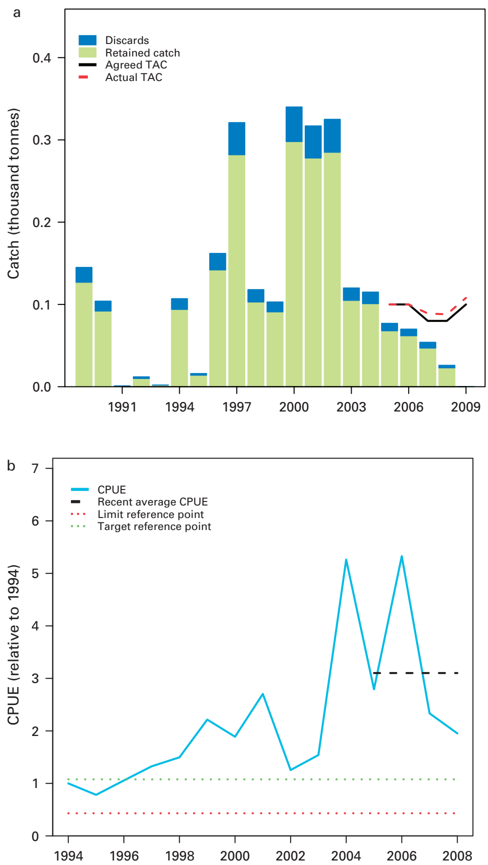


FIGURE 9.21 Smooth oreodory (Cascade Plateau) a) catch history, 1989 to 2009 and b) CPUE for the CTS, 1994 to 2008

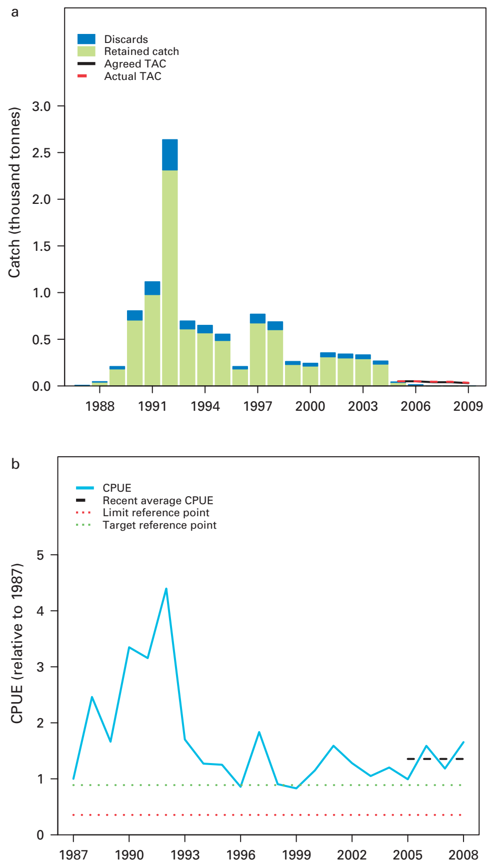


FIGURE 9.22 Smooth oreodory (non-Cascade Plateau) a) catch history, 1987 to 2009 and b) CPUE for the CTS, 1987 to 2008

Stock status determination

The RBC (global) estimated by DeepRAG for the 2009–10 fishing season was 121 t and 154 t for the Cascade Plateau and non-Cascade Plateau stocks, respectively (DeepRAG 2009). The 2009–10 agreed TAC (global) set by the AFMA Commission was 100 t and 30 t for the Cascade Plateau and non-Cascade Plateau stocks, respectively (Table 9.1); however, the actual TAC (global), once carryover of uncaught quota was applied was 108 t and 34 t respectively.

Smooth oreodory (Cascade Plateau) was assessed under the Tier 4 rules in 2009, using the reference period 1996 to 2005 (Haddon & Wayte 2010). Non-Cascade Plateau smooth oreodory was assessed for the areas open to fishing, using the reference period 1989 to 1998 (excluding 1992, which is thought to be in error). Recent CPUE averages for both Cascade Plateau and non-Cascade Plateau fish are well above the target CPUE (Figs. 9.21b, 9.22b) and indicate that smooth oreodory is **not overfished** in all areas (Table 9.1). Given recent low catches (<1 t in the 2009–10 fishing season for Cascade Plateau and non-Cascade Plateau oreodory, respectively; Figs. 9.21a, 9.22a), smooth oreodory also remains assessed as **not subject to overfishing** in all areas.

Reliability of the assessment/s

The Tier 4 assessment relies solely on CPUE being a reliable index of abundance. It is unclear whether this is the case. It is also unclear if a Tier 4 assessment is appropriate for deepwater species, given

their longevity and relatively short fishing history. In addition, it is currently difficult to distinguish targeted catch of oreodories from bycatch taken while targeting orange roughy. To rectify this and improve the assessments, industry representatives have agreed to provide more information to help distinguish between targeted and non-targeted shots in future assessments.

Previous assessment/s

Oreodories are usually caught as a byproduct of fishing for orange roughy, but have been targeted in some localities. Although there have been marked reductions in landings and catch rates in some areas in the past, catches and catch rates on the Cascade Plateau have remained relatively stable (Figs. 9.21a, 9.22a). Closures of areas (except the Cascade Plateau) to all trawling at depths greater than 700 m were introduced in mid-2007.

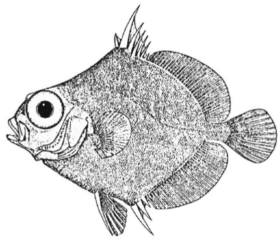
Future assessment needs

Smooth oreodory is an important byproduct species and is targeted in some cases. More information on stock structure and targeting practices would be useful in determining RBCs and reducing uncertainty of the assessments.

Trawl net on drum
PHOTO: NEIL BENSLEY, ABARE–BRS

OTHER OREODORIES (black, spikey, warty, other)

(*Allocyttus niger*, *Neocyttus rhomboidalis*, *A. verrucosus, N.* spp.)



LINE DRAWING: FAO

TABLE 9.21 Biology of other oreodories

Parameter	Description
Range	**Species:** Generally found in cold waters of all southern oceans; black oreodories are found in the south-west Atlantic and Indian Oceans. **Stock:** Stock structure is generally unknown. For management purposes, a single stock is considered in the CTS, outside of the Cascade Plateau.
Depth	290–1520 m
Longevity	100–140 years
Maturity (50%)	**Age:** 27 years **Size:** ~20–35 cm TL
Spawning season	September–October
Size	**Maximum:** 22–49 cm TL; weight: not determined **Recruitment into the fishery:** not determined

ScHS = Scalesfish Hook Sector; TL = total length

SOURCE: Gomon et al. (2008).

Stock status determination

The RBC (global) estimated by DeepRAG for the 2009–10 fishing season was 211 t (DeepRAG 2009). The 2009–10 agreed TAC (global) set by the AFMA Commission was 188 t (Table 9.2); however, the actual TAC (global), once carryover of uncaught quota was applied, was 202 t.

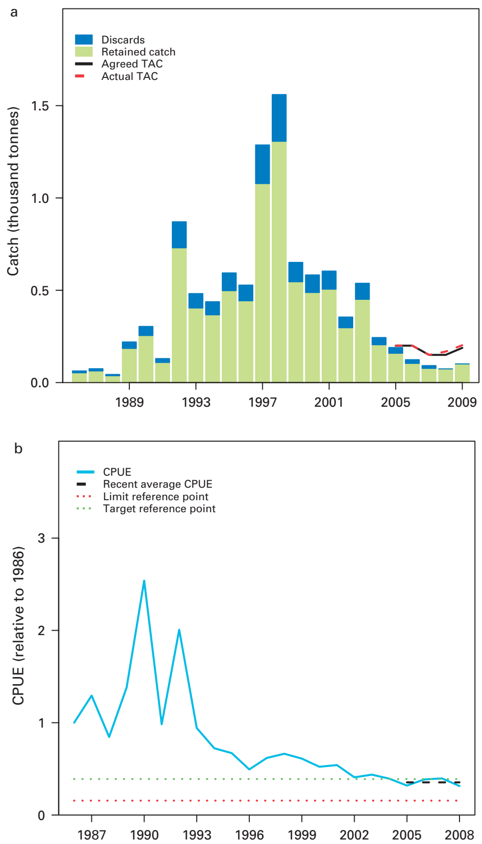


FIGURE 9.23 Oreodories a) catch history, 1986 to 2009 and b) CPUE for the CTS, 1986 to 2008.

NOTE: that discards are not included for 2009

The basket of other oreodories was assessed in 2009 under the Tier 4 rules for areas open to fishing, using the reference period of 1992 to 2001 (Haddon & Wayte 2010). The average CPUE for recent years is just below the target reference point, but well above the limit reference point (Fig. 9.23b). The status of other oreodories is therefore assessed as **not overfished** (Table 9.1) Given recent catch levels (96 t; Fig. 9.23a), they are also assessed as **not subject to overfishing**.

Reliability of the assessment/s

The Tier 4 assessment relies solely on CPUE being a reliable index of abundance. It is unclear whether this is the case. It is also unclear if a Tier 4 assessment is appropriate for deepwater species, given their longevity and relatively short fishing history.

Previous assessment/s

Catches of other oreodories have been dominated by spikey oreodory, with small landings of the three other species. There are no biomass estimates of Australian stocks of spikey oreodory, but there have been marked reductions in recent landings and catch rates. Although catch rates from the Cascade Plateau have remained relatively stable, only a small proportion of the catch is taken there. In the eastern and southern orange roughy management zones, substantial but unquantified discarding of oreodories occurred during the orange roughy 'boom' period from 1989 to 1992. The basket stock of other oreodories has previously been classified as overfished, based on a large decline in unstandardised catch rates after 1992. However, the analysis in 2007, using geometric mean catch rates and data back to 1986, did not indicate such a substantial decline.

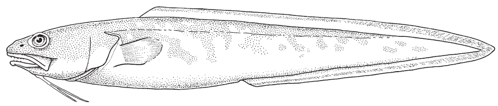
Future assessment needs

Other oreodory species, particularly spikey oreodory, are important byproduct species and are targeted in some cases. More information on Australian stocks would be useful in determining RBCs and in reducing uncertainty of the assessments.

Sorting trawl catch PHOTO: MIKE GERNER, AFMA

PINK LING

(*Genypterus blacodes*)



LINE DRAWING: ROSALIND POOLE

TABLE 9.22 Biology of pink ling

Parameter	Description
General	Managed as a single stock, but the assessment is based on separate stocks east and west of Bass Strait. A genetic and morphometric study was unable to identify any stock structuring, so a common stock was assumed until 2005. However, clear and persistent differences in the catch composition between east and west Bass Strait led to the assumption of separate stocks.
Range	**Species:** Central New South Wales (NSW) to Western Australia, including New Zealand; also found in South America. **Stock:** Separate stocks are assumed east and west of Bass Strait; the stock in the Great Australian Bight is assumed to be part of the western stock. Some catch is taken in NSW.
Depth	200–900 m
Longevity	28 years
Maturity (50%)	Age: 4–5 years Size: 72 cm
Spawning season	August–October
Size	**Maximum:** ~200 cm SL; weight: not determined **Recruitment into the fishery:** ~40 cm TL; weight: not determined ; age: 3–4 years

SL = standard length

SOURCES: Ward & Elliot (2001); Taylor (2010); SlopeRAG (2010).

Pink ling PHOTO: HEATHER PATTERSON, ABARE–BRS

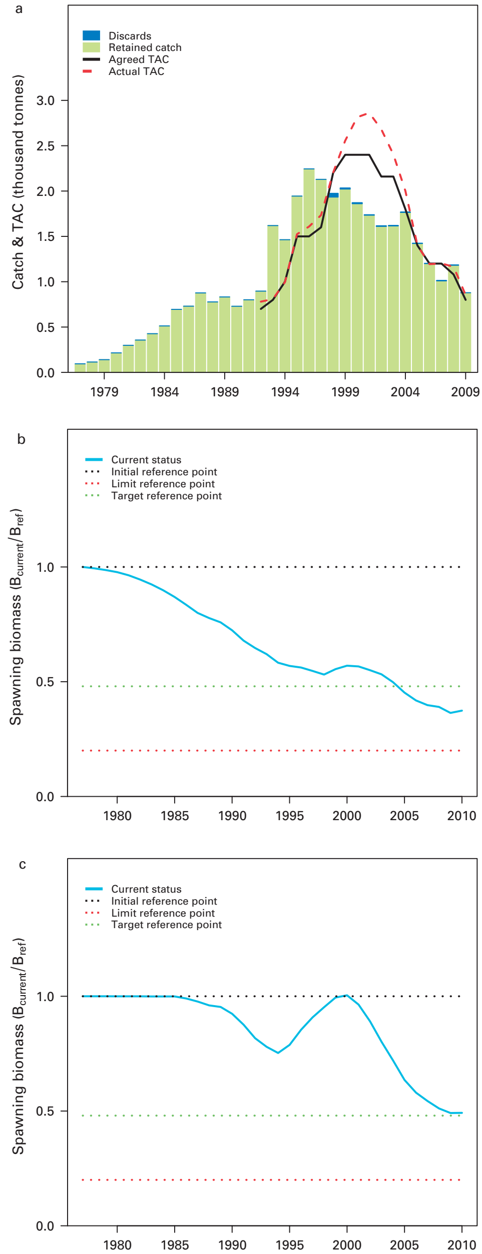


FIGURE 9.24 Pink ling a) catch history, 1977 to 2009 b) biomass (east) and c) biomass (west) for the CTS and ScHS, 1977 to 2010.

NOTE: that discards and state catch are not included for 2009

Stock status determination

The age-structured, integrated stock assessment model was updated in 2009 with data up to 2008 (Taylor 2010). The model assumes separate stocks east and west of Bass Strait and incorporates the standardised CPUE series from the trawl sector (Haddon 2010a) and non-trawl sector (2003–2008 in the east, 2002–2008 in the west) and the fisheries research vessel (FRV) Kapala surveys (Graham et al. 2001). The GABTS catches are included in the assessment of the western stock. Historically, very low levels of discarding of ling have been observed (Fig. 9.24a). However, industry reports that the reduced TACs in recent years have created the incentive to high-grade, and so an estimate of discarding is included in recent years (Taylor 2010). The model incorporates the changes in net design in the CTS since 2006 as a change in gear selectivity.

The non-trawl sector has taken an increasing proportion of the catch in both regions since 2000. However, the total catch from the CTS has remained larger than for the non-trawl sector in the east. In the west, the non-trawl catch was larger in 2004 and 2005, but since then trawl has caught more than 50% of the total catch. The 2009 assessment incorporates some significant changes—in particular, depth was included as a factor in the CPUE standardisation (Haddon 2010), and the year up to which recruits were estimated by the model was changed from five years before the latest assessment to three years (east) and four years (west), based on the age at which 50% of the population is selected by the gear (Taylor 2010).

The 2009 assessment also used a different approach to capture suggested changes in targeting behaviour by trawlers that may have affected the trawl CPUE. The trawl CPUE declined by more than 56% between 1999 and 2002. This is faster than would be expected by stock reduction, particularly as it occurred when the trawl catches declined from 1209 t in 1999 to 529 t in 2002. Industry suggests that the reduction in ling quota resulted in ling being increasingly seen as a byproduct species for trawlers, particularly in the east. They suggest that fishers changed their fishing practices to avoid ling, leading to concern that this was not captured by the standardisation (SlopeRAG 2010). The 2009 model incorporates this change in practices in the east, by assuming there was a change in catchability in 2000, effectively breaking the trawl CPUE series into two—before and after 2000 (Taylor 2010). This was accepted as the base case for estimating the 2010–11 RBC (SlopeRAG 2010). The approach means that the decline in trawl CPUE is attributed to changes in catchability, not biomass decline.

The 2009 assessment is more optimistic than the 2008 assessment, estimating the spawning biomass at the start of 2008 to be $0.37B_0$ in the east (Fig. 9.24b) and $0.49B_0$ in the west (Fig. 9.24c) (Taylor 2010), compared with $0.28B_0$ in the east and $0.33B_0$ in the west from the 2008 assessment. A substantial part of the change in estimate of depletion in the east is due to the assumption of a change in catchability; the sensitivity test without this change estimates the biomass as $0.29B_0$ (Taylor 2010). The changes in the estimates in the west are driven by the changes in trawl CPUE standardisation and in the year to which recruitment is estimated and updated length-frequency data (Taylor 2010).

The most recent assessments (2008 and 2009) do not suggest that the biomass in either region has declined below the limit reference point. Both stocks are therefore assessed as **not overfished** (Table 9.1), although the eastern stock requires some rebuilding to the target biomass.

The issue of whether the stocks are subject to overfishing is **uncertain**, due to the sensitivity of the assessment to key assumptions, particularly the treatment of the trawl CPUE. In recent years, most of the catches of pink ling have come from the eastern stock, despite this stock being more depleted. This resulted in the eastern stock being classified as subject to overfishing based on the 2008 assessment. The 2009–10 fishing season RBC, based on the 2008 assessment, suggested that the catch needed to be reduced to 350 t for the east and 407 t for the west, a total of 858 t. Along with the

TAC reduction, two areas of historically high catch in eastern Bass Strait were closed, and AFMA indicated that there was the potential for trip limits if catches from the east approached the RBC for that stock. In addition, voluntary measures were agreed by industry; under these measures, trawlers would avoid targeted shots for pink ling in the east, and the auto-longline sector would shift effort directed at pink ling to the west.

Fishery-independent surveys by the FRV Kapala off southern New South Wales indicated that pink ling abundance had not decreased between 1976–77 and 1996–97. At this time, the standardised catch rates from the commercial fleet were similar to those observed in the mid-1980s. However, the length-frequency data from the Kapala surveys showed a significant truncation in the size frequency, with a decline in the mean size of fish caught. Catch rates in the east have since declined.

The updated 2009 assessment results in a RBC for the 2010–11 fishing season of 656 t in the east and 813 t in the west (noting that the assessment assumed that the 2009 catch was limited to 350 t in the east and 407 t in the west).

In the 2009–10 fishing season, the total landed catch was 838 t—405 t in the east and 434 t in the west. No estimate of discards is available at the time of writing of this report. The landed catch is significantly lower in the east than historic levels, which is a positive outcome. While the catch is above the 2009–10 RBC, it is below the level suggested by the updated 2009 assessment. This fact, combined with the sensitivities in the assessment, make it uncertain whether overfishing is occurring.

Reliability of the assessment/s

The Tier 1 assessments have been sensitive to changes in the assumptions and updated data. In the east, a key assumption is the change in catchability. As noted by SlopeRAG (2010), a more detailed investigation of the changes in fishing practices in the east around 2000 is needed, as allowing catchability to change has a substantial impact on the assessment. The current approach assumes that all vessels changed behaviour, which is not necessarily the case. The available data should be examined to document the nature of these changes and determine the best way to represent them in the assessment model. The declining CPUE trend in the non-trawl sector also needs to be examined. The assessment uses length-frequency data from port sampling, which is of concern if discarding continues. Given that the CTS still accounts for most of the catch and has the longest CPUE series, it is a key driver in the model.

Previous assessment/s

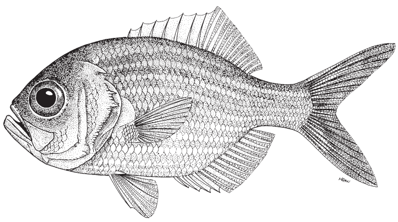
Early stock assessments could not reconcile the standardised CPUE series with the catch-at-age and length-frequency data. The size–age data indicated heavy fishing mortality, but catch rates were relatively stable. Since those assessments, the catch rates have declined. The fishery has had a greater impact on the eastern populations, where the mean size of fish caught has declined. An integrated assessment for separate east and west stocks, including both trawl and non-trawl fleets, has been under development since 2006. As discussed above, the outcomes of the assessments have been sensitive to changes in the models and data inputs.

Future assessment needs

Investigation and quantification of the reported changes in fishing practices and gear since 2000 are a priority to validate the changes made to the assessment model. SlopeRAG (2009, 2010) has repeatedly identified the importance of this work. Industry reports of continued expansion of the non-trawl fishery westward, also with high catch rates, warrant closer examination. The stock structure, particularly the relationship with Great Australian Bight stocks, should be further assessed.

REDFISH

(*Centroberyx affinis*)



LINE DRAWING: FAO

TABLE 9.23 Biology of redfish

Parameter	Description
Range	**Species:** Northern New South Wales (NSW) to eastern Bass Strait. Studies indicate that there is a single redfish stock off NSW, although variation in length-at-age and sex ratios suggests north–south stock structuring. **Stock:** No formal stock differentiation studies have been carried out. Previously, a single stock was assumed, based on tagging studies. However, recent studies of mean length at age suggest different growth rates between northern and southern (south of Montague Island) sectors of the fishery.
Depth	10–450 m
Longevity	~35 years
Maturity (50%)	**Age:** 4–7 years **Size:** 15–20 cm FL
Spawning season	February–May
Size	**Maximum:** ~40 cm SL; weight: 1 kg **Recruitment into the fishery:** 20–25 cm FL; age: 3–5 years; weight: not determined

FL = fork length; SL = standard length

SOURCES: Morison & Rowling (2001); Gomon et al. 2008

Stock status determination

The RBC calculated by ShelfRAG (using a Tier 3 analysis) was 788 t for the 2009–10 fishing season (ShelfRAG 2009). The 2009–10 agreed TAC (global) was 678 t (Table 9.2); however, the actual TAC (global) was 756 t after the carryover of uncaught quota. The landed catch was 190 t (Table 9.2), mostly taken by trawl in the waters off NSW.

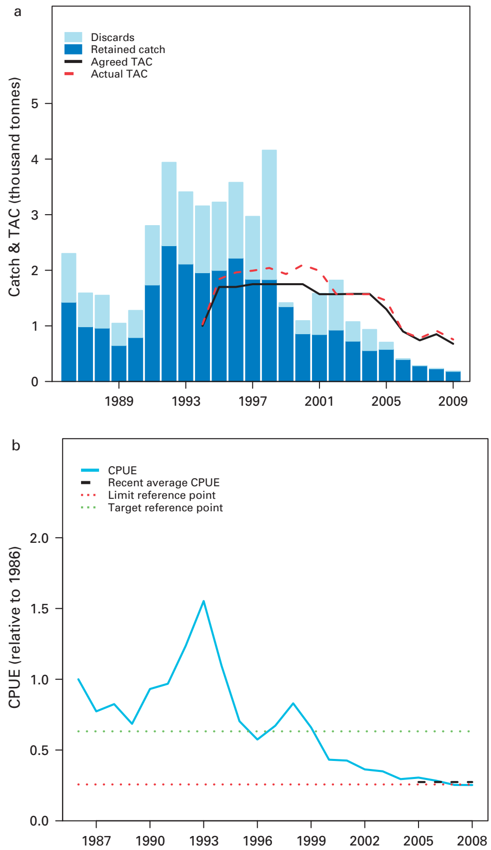


FIGURE 9.25 Redfish a) catch history from the CTS and ScHS 1986 to 2009 and b) standardised CPUE for the CTS, 1986 to 2008.

NOTE: that discards and state catch are not included for 2009

In 2009 redfish underwent updated assessments using Tier 3 and Tier 4. Tier 3 provides an estimate of fishing mortality (Klaer 2010b), while Tier 4 (Haddon 2010b) makes inferences about biomass using catch rates that are compared to an historical reference period (see Chapter 8). The TAC for redfish is set using the Tier 3 approach; however, the status determination here uses both the Tier 3 and Tier 4 results.

The Tier 4 assessment (Haddon 2010b) indicated that catch rates have been declining for more than a decade, reaching their lowest level in 2008 (Fig. 9.25b). This is a cause for concern as it may indicate a steady and

continuous decline in stock biomass. The 2009 Tier 4 assessment used a revised reference period, 1986–2003 but excluding 1987–1995, because of changes in the fleet behaviour in these years – a lot of small fish were retained for surimi. The ShelfRAG had not reviewed the Tier 4 previously as the Tier 3 has been used to set the TAC since 2006. The 2009 Tier 4 indicated that the recent four-year CPUE average (2005 to 2008) was just above the limit reference point, suggesting an RBC of 62 t (Haddon 2010b). However, the CPUE for the past two years was estimated to be below the limit reference point (Fig. 9.25b). The Tier 4 harvest control rules use the recent four-year CPUE average (see Chapter 8). These results suggest that the stock is depleted and well below the target biomass. The Tier 4 assessment relies solely on CPUE being a reliable index of stock abundance; it is unclear if this is the case for redfish for the following reasons: 1) interpreting CPUE patterns is constrained by changes in discarding practices over time (over 50% in some years, down to 4% in 2006) and 2) suggested changes in availability of the stock, with periods of low catches, followed by periods of high catches of fish across a broad size range. The overfished status of redfish is therefore assessed as **uncertain**, noting that the stock is likely to be depleted with no signs of rebuilding.

The Tier 3 assessment (Klaer 2010b) indicates that the recent (15–20 year) average level of fishing mortality for redfish was 0.14, which was above the target of 0.074 (F_{Sspr48}) but below the limit of 0.213 (F_{Sspr20}). Despite reductions in the TAC since 2005, the actual catch has remained substantially below the TAC—the 2009–10 fishing season TAC was 756 t while only 190 t was landed (Table 9.2). Noting that catches in excess of 4000 t were taken in the 1990s, albeit with a larger fleet. Along with the declining CPUE, the recent catches would suggest a stock that is depleted more than is suggested by the Tier 3 assessment. The results from the Tier 3 and Tier 4 are, to some extent, at odds. It may be that recruitment has been poorer than predicted in the Tier 3 analysis over the last decade or abundance/availability has been affected in some other way. ShelfRAG suggested that caution needed to be applied to the harvest of redfish at the present time. Given the above uncertainties and inconsistencies redfish is classified as **uncertain** if subject to overfishing.

Under the Tier 3 harvest control rules, the assessment indicates that fishing mortality needs to be further reduced to allow stock rebuilding. This resulted in an RBC of 700 t for the 2010–11 fishing season. The 2009 Tier 4 indicated that the recent four-year CPUE average (2005 to 2008) was just above the limit reference point, suggesting an RBC of 62 t for the 2010–11 fishing season (Haddon 2010b).

Reliability of the assessment/s

Redfish was assessed by ShelfRAG using the revised Tier 3 method in 2009 (Klaer 2010), which is considered to be more robust than the earlier Tier 3 assessment. ShelfRAG also examined the Tier 4 as an indicator of biomass. ShelfRAG have raised concerns about both the Tier 3 and Tier 4 assessments that need to be more fully explored. In particular, it has been suggested that due to the longevity of this species (~35 years) the Tier 3 should be MSE tested and non-equilibrium methods investigated. The Tier 4 assessment relies solely on CPUE being a reliable index of abundance; it is unclear if this is the case, particularly given changes in discarding practices and mesh size over time.

Previous assessment/s

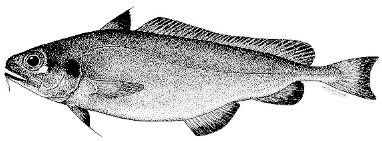
Previous efforts to develop a quantitative assessment model for redfish have been plagued by uncertainties in the model structure and assumptions and the accuracy and consistency of the data on which they were based. The availability of redfish to the fishery may fluctuate among years. Previous modelling has consistently indicated that stocks of redfish have been depleted to some degree. The previous Tier 4 assessment was more pessimistic; however ShelfRAG had not evaluated it or considered the appropriateness of the reference period, as they did in 2009.

Future assessment needs

The assessment of redfish requires strengthening, particularly given the uncertainties noted above. The apparent inconsistencies between the Tier 3 TAC, low landed catch and biomass decline need to be closely examined. Specifically, the ShelfRAG's recommendations regarding testing non-equilibrium methods and MSE-testing of the Tier 3 and whether CPUE is an appropriate index of abundance should be investigated further. There is a clear need for a better understanding of the level of depletion of the stock and the suggested availability issues.

RIBALDO

(*Mora moro*)



LINE DRAWING: FAO

TABLE 9.24 Biology of ribaldo

Parameter	Description
Range	**Species:** Widespread in temperate waters; in Australia, it occurs from Queensland to Western Australia, including Tasmania. **Stock:** A single stock of ribaldo is assumed. Early catches were largely opportunistic or byproduct of fishing for orange roughy in deeper waters. More recently, targeted fishing has occurred over shallower depths (less than 600 m).
Depth	450–2500 m, but most abundant at 500–1000 m
Longevity	~50 years
Maturity (50%)	**Age:** males ~8 years; females ~14 years **Size:** 36–45 cm TL
Spawning season	June and July
Size	**Maximum:** ~75 cm FL; weight: not determined **Recruitment into the fishery:** size not determined; age: ~17 years; weight: not determined

FL = fork length; TL = total length

SOURCES: Gomon et al. 2008.

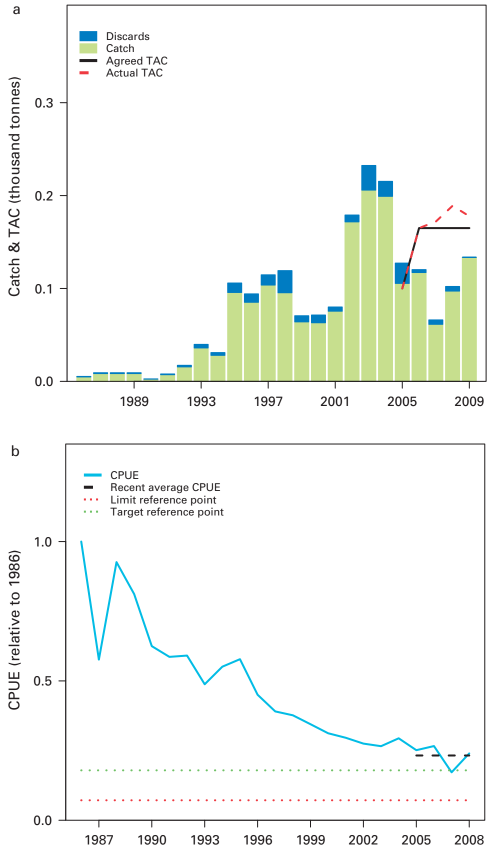


FIGURE 9.26 Ribaldo a) catch history from the CTS and ScHS, 1986 to 2009 and b) standardised CPUE for the CTS, 1986 to 2008.

NOTE: that discards are not included for 2009

Stock status determination

The RBC calculated by SlopeRAG was 209 t for the 2009–10 fishing season (SlopeRAG 2010). The 2009–10 agreed TAC (global) was 165 t (Table 9.2), however the actual TAC (global) set by the AFMA Commission was 178 t.

Ribaldo was assessed in 2009 using a Tier 4 assessment, which indicated that the current average CPUE is above the target CPUE; the catch was also below the TAC (Haddon 2010b; Fig. 9.26a,b). However, there were concerns that the standardised CPUE series did not adequately reflect changes in ribaldo biomass due to the history of the fishery. Ribaldo was previously assessed using a Tier 3 assessment. Under new

harvest controls, it is no longer a candidate for such an assessment without additional biological and fishery-dependent data.

The implementation of closed areas for orange roughy may offer some protection to the ribaldo stock from trawling. However, a preliminary analysis of ribaldo catch by depth could not detect any notable shift away from targeting fish in deeper waters (using auto-longline). As a result of the lack of formal assessments and other information, the status of ribaldo is assessed as **uncertain** for both overfishing and the overfished status (Table 9.1).

Reliability of the assessment/s

The Tier 4 assessment relies solely on CPUE being a reliable index of abundance. It is unclear whether this is the case. This is particularly true of ribaldo as changes in the history of the fishery and the fact that the stock was only lightly fished during the reference period of 1995 to 2004 meant that SlopeRAG had no confidence that the standardised CPUE series reflected changes in abundance. The reliability of this assessment is therefore low.

The precautionary TAC level should prevent the fishery from expanding too quickly and overfishing the stock before overfishing becomes apparent in the assessments. Annual assessments to monitor the effect of fishing on the stock will be important.

Previous assessment/s

Ribaldo was previously assessed under the Tier 3 harvest control rules, with assessments from 2006 to 2008 indicating that fishing mortality was much less than the estimate of natural mortality. Under the new rules for Tier 3 assessment, the reference period must be the same as that used for calculating the current catch. In addition, all the age classes included in the assessment must have been exposed to that level of fishing mortality from the age at first recruitment. Ribaldo does not meet these requirements, as the fish do not recruit to the fishery until about 17 years of age (Table 9.24), and catches have been at very low levels for 10 years. Consequently, most age classes in the fishery have been subject to fishing for only part of their life, and their relative abundance does not provide a good estimate of the current level of fishing mortality.

Future assessment needs

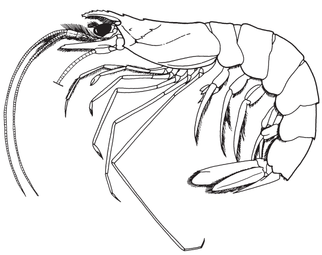
Given the concerns with the current assessment, it may be possible to apply Tier 3 harvest control rules to this species and provide a more robust assessment once the stock has been fished for a longer period and includes more age classes. Estimates of age composition of the ribaldo population not subject to significant fishing pressure would improve estimates of fishing mortality. Understanding the impact of closed areas on CPUE and the level of protection provided to the ribaldo stock is an additional research need.

Trawler, Eden PHOTO: HEATHER PATTERSON, ABARE–BRS

Trawl nets PHOTO: HEATHER PATTERSON, ABARE–BRS

ROYAL RED PRAWN

(*Haliporoides sibogae*)



LINE DRAWING: FAO

TABLE 9.25 Biology of royal red prawn

Parameter	Description
Range	**Species:** West coast of Australia, from Perth northwards to Indonesia; east coast from south-east Queensland to north-west Victoria, as well as the Queensland Plateau in the Coral Sea. **Stock**: Unknown—a single stock is assumed for assessments in the SESSF, including catch from New South Wales–managed waters north of Barranjoey Point.
Depth	230–825 m, but most abundant in 400–550 m
Longevity	3–4 years
Maturity (50%)	**Age**: 2–3 years **Size**: females 3.1 cm CL; males 2.6 cm CL
Spawning season	March–April, July–August
Size	**Maximum:** females ~5 cm CL; weight: ~40 g **Recruitment into the fishery:** ~2 cm CL

CL = carapace length

SOURCES: Kailola et al. (1993); Haddon (2010b).

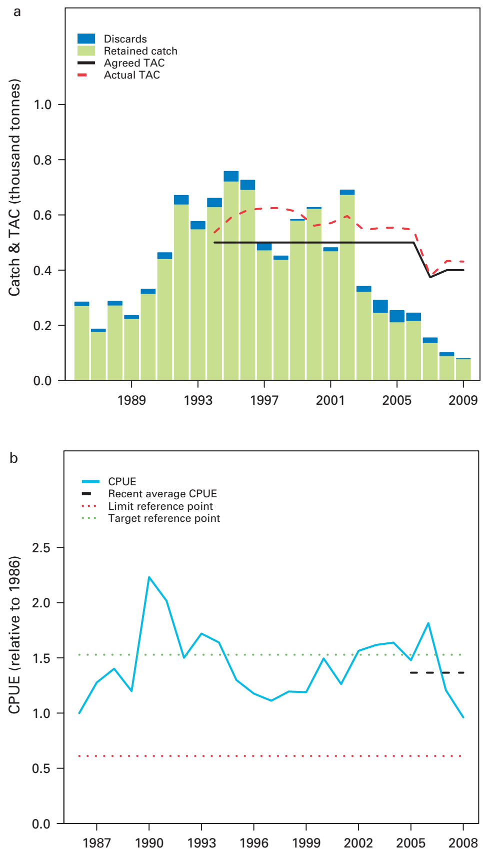


FIGURE 9.27 Royal red prawn a) catch history from the CTS and ScHS, 1986 to 2009 and b) CPUE for the CTS, 1986 to 2008.

NOTE: that discards and state catch are not included for 2009

Stock status determination

The RBC calculated by ShelfRAG was 466 t for the 2009–10 fishing season (ShelfRAG 2009). The 2009–10 agreed TAC (global) was 400 t (Table 9.2); however, the actual TAC (global) set by the AFMA Commission was 431 t.

The total catch used in the latest assessment was 101 t (2008 calendar year; Fig. 9.27a), comprising 88 t reported from the CTS, 2 t from state fisheries and an estimated 11 t of discards. The catch is the lowest in the fishery's history, continuing the trend of catches well below TACs since 2003. Limited processing facilities and low market demand have been the main reasons for low catches of royal red prawns. The total SESSF catch reported in the AFMA catch disposal records for the 2009–10 season was 108 t, well below the agreed TAC of 400 t and only 25% of the actual TAC (431 t) for that season.

The 2009 assessment again used the revised Tier 4 harvest control rules that were introduced in 2008. The Tier 4 assessment indicated that the average CPUE for the past four years was just below the target level

(Haddon 2010b). Catch rates showed an increasing trend from 1997 to 2006, then a decline in 2007 and again in 2008 (Fig. 9.27b), to below the Tier 4 target catch rate. These data contradict the catch size composition during 1998 to 2007 and the recent low catches. The size structure of the catch has been relatively stable during those years, but poor sampling of the fishery in 2008 means that there are no recent size data to assist interpretation of CPUE trends. The ShelfRAG had concerns that current fishing practices may be driving catch rates downward and application of the HCR may result in unnecessary reductions in the TAC. As a result, the ShelfRAG intends to give priority to detailed analysis of catch and effort data in 2010, including identification of target shots. Observer data indicated an increase in discarding rates for 2007 and 2008 to 11%, but the ShelfRAG considered the estimates to be unreliable due to poor sampling. Historically, discarding of royal red prawns has been low, around 1–4%.

The results of the Tier 4 assessment and the low current catches mean that royal red prawn is assessed as **not overfished** and **not subject to overfishing** (Table 9.1).

An RBC of 336 t was recommended for 2010–11, which would give a Commonwealth TAC of 284 t. ShelfRAG members decided not to waive the 15% precautionary discount factor in view of the low catch rates and absence of 2008 size data. The SEMAC subsequently recommended rollover of the past year's TAC for 2010–11 (400 t), after considering the uncertainty related to the CPUE series.

Reliability of the assessment/s

It is unclear whether CPUE is a reliable index of abundance for royal red prawn. Fluctuating market demand and industry constraints on landings may also influence the validity of catch rate data. Lack of biological information, particularly recent size data, also reduces the reliability of the assessment.

Previous assessment/s

An assessment was undertaken in 2008 using the new Tier 4 harvest control rules. The new rule was determined to be more appropriate for royal red prawns because it relied on a longer reference period for CPUE, rather than recent values that tended to reinforce the market limitations in calculating the RBC. The Tier 4 analysis was restricted to records from vessels that had a history of targeting prawns. At that time, the RAG considered the stock to be healthy and concluded that a TAC of 500 t could be sustained, at least in the short term.

An attempt to use catch-curve analysis in 2006 did not yield valid results, so a Tier 3 analysis has not been possible. However, carapace length distributions, which were stable in the period up to 2007, have provided some confidence that the stock is not being overfished.

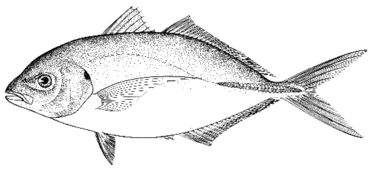
Future assessment needs

Stock boundaries within the SESSF and nearby areas need to be defined. Length-frequency data and discard estimates need to be improved and extended into the fishery north of the SESSF management boundary in New South Wales. Cooperation of fishers in identifying prawn target shots in logbooks will improve future CPUE standardisation and assessments.

Trawl catch PHOTO: MIKE GERNER, AFMA

SILVER TREVALLY

(*Pseudocaranx georgianus*)



LINE DRAWING: FAO

TABLE 9.26 Biology of silver trevally

Parameter	Description
Range	**Species:** Distributed across southern Australia from New South Wales to Western Australia, including Tasmania. Also inhabits New Zealand waters. **Stock:** Considered to be a single stock in the SESSF, separate from the New Zealand stock. Also caught by state commercial and recreational fishers outside the SESSF.
Depth	10–238 m, but most commonly found at 10–25 m
Longevity	30 years
Maturity (50%)	**Age:** 2 years **Size:** ~35 cm FL
Spawning season	October–December
Size	**Maximum:** ~80 cm TL; weight: 4 kg **Recruitment into the fishery:** 20–25 cm TL; age: 3–5 years; weight: <1 kg

FL = fork length; SESSF = Southern and Eastern Scalefish and Shark Fishery; TL = total length

SOURCES: Kailola et al. (1993); Gomon et al. (2008); Haddon (2010b).

Net rolling PHOTO: ABARE–BRS

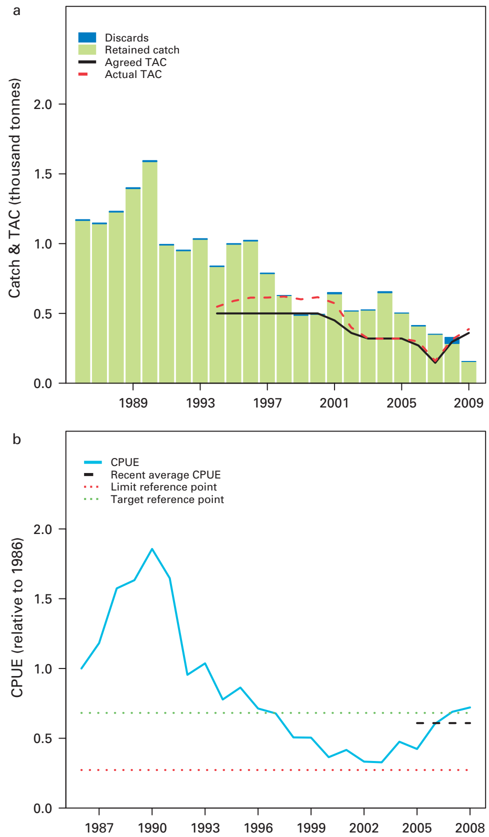


FIGURE 9.28 Silver trevally a) catch history from the CTS and ScHS, 1986 to 2009 and b) CPUE for the CTS, 1986 to 2008.

NOTE: that discards and state catch are not included for 2009

Stock status determination

The RBC calculated by ShelfRAG was 624 t for the 2009–10 fishing season (ShelfRAG 2009). The 2009–10 agreed TAC (global) was 360 t (Table 9.2); however, the actual TAC (global) set by the AFMA Commission was 388 t.

A Tier 4 assessment was carried out in 2009, using the same reference period as the previous year's assessment (Haddon 2010b). The most recent total catch used in the assessment was 328 t for the 2008 calendar year, comprising 111 t landed from the CTS, 174 t from state fisheries and an estimated 43 t of discards (Fig. 9.28a). The total SESSF catch reported in the AFMA catch disposal records for the 2009–10 fishing season was

189 t, well below the agreed TAC of 360 t. Most of the CTS catch is taken from waters off southern New South Wales. The majority of the silver trevally catch (61% in 2008) is taken outside the SESSF. Estimates for the recreational catch in New South Wales are between 100 t and 210 t (Scandol et al. 2008).

Catch rate data for fishing operations within the Batemans Marine Park area before 2007 were again excluded from the assessment. The 2009 Tier 4 assessment indicated that the average CPUE for the past four years was just below the target level. Catch rates showed an increasing trend after 2003, when the historical low value was recorded (Fig 9.28b), and the 2008 standardised catch rate was just above the Tier 4 target. Given the continuing positive catch rate trend from the Tier 4 assessment and the low level of recent catches, the status of silver trevally continues to be assessed as **not overfished** and **not subject to overfishing** (Table 9.1).

An RBC of 649 t was recommended for 2010–11, and ShelfRAG members recommended that the 15% precautionary discount factor should not be applied to silver trevally as significant protection is now provided to the stock by the Batemans Marine Park.

Reliability of the assessment/s

The Tier 4 assessment relies solely on CPUE being a reliable index of abundance. It is unclear whether this is the case. In addition, earlier problems with reliability of the quantitative model mean a level of uncertainty about the extent of depletion in silver trevally stocks. The waiving of the default 15% discount factor for Tier 4 assessments is inconsistent with the level of uncertainty associated with this tier level and the inclusion in the RBC calculation of past catches from the Batemans Marine Park. The inclusion of Batemans Marine Park catches in RBC calculations implies that silver trevally in those areas are fully available to fisheries outside the park. However, this contradicts the argument that the discount factor should be waived because the Park acts as a refuge for the stock. This highlights a need to develop a scientifically defensible approach to incorporating the effects of closures, such as marine parks, into harvest strategies for silver trevally and other stocks.

Previous assessment/s

A formal quantitative assessment was conducted in 2006, updating a preliminary 2005 model with new data and new assessment software. However, the levels of stock depletion produced were not considered reliable enough for a valid Tier 1 assessment. Estimates of total mortality from catch-curve analysis could not be used to apply the Tier 3 harvest control rules because of uncertainty about gear selectivity and the potential for older fish to be under-represented in the catch. A Tier 4 assessment was used to determine the RBC for 2007–08. The assessment was not updated until 2008, when the reference period for calculation of the RBC was changed to 1992 to 2001 from the default of 1986 to 1995. This change was agreed to because elevated catch and catch rate levels were observed during 1988 to 1991; these were attributed to concentrated targeting of trevally by some trawl operators that were unlikely to be repeated. The 2008 assessment also excluded from the catch rate standardisation the logbook catch and effort records for the Batemans Marine Park area. Twenty-nine fishing businesses that caught silver trevally in the marine park were bought out by the New South Wales Government before June 2007. Between 127 t and 218 t of silver trevally was landed annually from the closed grounds between 2003 and 2005.

Analysis of catch and size data in the New South Wales commercial and recreational fisheries since the late 1980s shows a significant reduction in mean size of silver trevally. Yield-per-recruit analyses (Rowling & Raines 2000) also indicate that fish are being caught below the size that would optimise yield. This is particularly applicable to the trawl fishery, but market preferences for 'plate-sized' fish tend to counteract the economic effect of growth overfishing. The most recent stock status assigned by New South Wales was 'growth overfished', based on the apparent loss of potential yield described above (Scandol et al. 2008). The Tier 4 assessment method

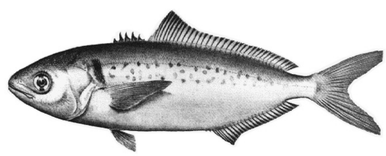
used in the SESSF does not accommodate estimates of yield-per-recruit as carried out in New South Wales, but has considered more recent fishery indicators, such as standardised catch rate and size composition.

Future assessment needs

More data on the size distribution of silver trevally for all fishing methods and ongoing ageing are needed if a Tier 1 assessment is to be undertaken in the future. Regular collection of recreational catch data should also be considered so that changes in the relative exploitation rates by the commercial and recreational fisheries can be analysed. The role of spatial closures, such as the Batemans Marine Park, in providing refuges or nursery areas needs investigation.

SILVER WAREHOU

(*Seriolella punctata*)



LINE DRAWING: FAO

TABLE 9.27 Biology of silver warehou

Parameter	Description
Range	**Species:** Found on both coasts of South America and also New Zealand. **Stock:** Southern coast of Australia from South Australia to Victoria, including Tasmania. A recent study did not indicate the existence of separate stocks east and west of Bass Strait; a single stock is assumed for management purposes.
Depth	25–500 m
Longevity	15 years
Maturity (50%)	**Age:** 3–4 years **Size:** ~40 cm FL
Spawning season	September–October
Size	**Maximum:** ~66 cm TL; weight: not determined **Recruitment into the fishery:** ~45 cm FL; age: not determined; weight: not determined

FL = fork length; TL = total length

SOURCES: Gomon et al. (2008).

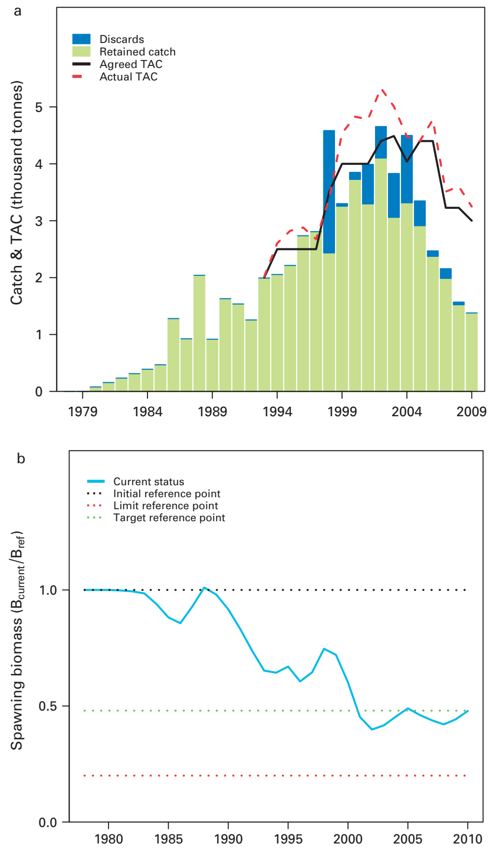


FIGURE 9.29 Silver warehou a) catch history, 1978 to 2009 and b) biomass for the CTS and ScHS, 1978 to 2010.

NOTE: that discards and state catch are not included for 2009

Stock status determination

The RBC calculated by SlopeRAG was 2488 t for the 2009–10 fishing season (SlopeRAG 2010). The 2009–10 agreed TAC (global) was 3000 t (Table 9.2), however the actual TAC (global) set by the AFMA Commission was 3249 t.

In 2009 a fully updated Tier 1 assessment was undertaken, which included updated catch and discard data such (Tuck & Fay 2010). These data were grouped by calendar year to ensure a complete 2008 dataset. Catch data were also updated to reflect total landings, rather than just logbook catches (Fig. 9.29a).

The 2009 assessment indicated that the spawning stock biomass was 44% of unfished levels (Fig. 9.29b); it is estimated to increase

to 48% in 2010. Since the model indicates that the biomass is close to the target stock biomass of 48% of the unfished biomass and the levels of catch have been low, silver warehou remains assessed as **not overfished** and **not subject to overfishing** (Table 9.1).

An RBC of 2660 t was recommended for the 2010–11 fishing season by ShelfRAG (ShelfRAG 2010).

Reliability of the assessment/s

Tier 1 assessments are robust stock assessments and thus have a high degree of reliability.

Previous assessment/s

An age-structured integrated assessment model for silver warehou was developed in 2001–02. The biomass trend estimated by the base case model indicated a decline since 1997 (Fig. 9.29b). Strong year-classes entered the fishery in 1993 and 1994, and a biomass decline would have occurred even in the absence of fishing as these two cohorts passed through the fishery. The model estimated that the female spawning biomass in 2001 was about 50% of the unfished biomass. Other modelling results in 2004 indicated that the fishery was now having a greater impact on the stock, but that current biomass levels were still approximately 60% of the unfished biomass.

The assessment model was revised and updated in 2007. The new assessment indicated that the data supported a higher value for natural mortality than previously estimated. This revised value was used in estimating the spawning stock biomass to be at 54% of unfished levels. The 2008 assessment was an update of the 2007 assessment and indicated a spawning stock biomass of 53% of unfished levels.

Future assessment needs

Discarding in the fishery sometimes appears to be market driven, although there is no clear pattern. Further information on the mechanisms driving discarding would be useful for a better understanding and assessment of discarding. In addition, future stock assessments should explore raw data, and potential changes in selectivity and growth. Further analysis of catch and effort data would also assist in understanding the impact of other variables (e.g. depth) on the fishery and interactions with other species (particularly blue grenadier).

9.4 ECONOMIC STATUS

ABARE–BRS has surveyed the CTS since the mid-1990s as part of its annual fisheries survey program. The information collected from these surveys has been used to calculate annual net economic returns (NER), productivity indices and other financial performance indicators for the fishery. It has also assisted in the development of a bioeconomic model to determine optimal harvest strategies for key species. The ScHS is surveyed as part of the Gillnet, Hook and Trap Sector. These survey results are reported in Chapter 12.

Latent quota

Previously, high levels of latent or unused quota typically prevailed in the SESSF, particularly for species targeted in the CTS. Catches that consistently fall short of TAC limits for key target species generally suggest that effort in a fishery is at a point associated with open-access equilibrium. As a result, NER will be low, possibly even negative. Non-binding TACs also negatively affect the rate of autonomous adjustment in a fishery—the rate at which fishing rights gravitate to the most efficient operators. This impact occurs because non-binding TACs result in relatively low quota prices, so that the returns to trading quota are low. Consequently, quota trade and autonomous adjustment are slower than they could otherwise be. Evidence suggests that this has been an issue in the CTS in the past (Elliston et al. 2004; FERM 2004).

Recent TAC reductions may be addressing such issues. For the 2009–10 fishing season, more than 80% of TACs were caught for five species: pink ling, flathead, orange roughy (Cascade Plateau), gemfish (eastern) and jackass morwong (Fig. 9.30). Tiger flathead and pink ling are key species in terms of GVP,

accounting for 19% and 12% of scalefish GVP in the 2009–10 financial year. However, blue grenadier, which accounted for 23% of scalefish GVP in the 2009–10 financial year, only had 68% of its TAC caught in the 2009–10 fishing season, given a decline in the catch of this species. This may indicate a decline in the profitability of this species, but without additional information for the 2009–10 fishing season (prices in particular) it is difficult to draw any strong conclusions.

It is not expected that all TACs will be filled every season in a multispecies fishery, given that bycatch of less profitable species cannot be avoided when targeting more profitable species. Increasingly over recent years, there have been low levels of latent quota for key species that account for relatively high amounts of scalefish GVP, suggesting that economic performance has been improving in the sector.

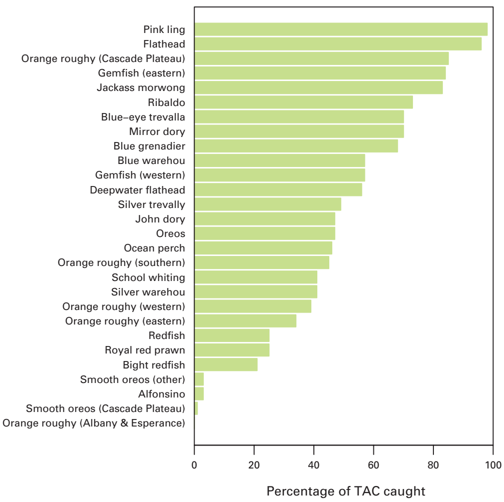


FIGURE 9.30 Catch as a percentage of total allowable catch for scalefish species in the SESSF, 2009–10 fishing season (1 May 2009 to 30 April 2010)

SOURCE: AFMA (2009a).

Effort

Before 2003–04, fishing effort in the CTS, measured in hours trawled, was increasing over time. At the same time, production volume and value were declining. As a result, catch per hour trawled declined in both volume and value terms.

Since 2003–04, total hours trawled in the fishery have declined substantially, by 46% (Fig. 9.31). However, real GVP in 2008–09 ($55.9 million) was only 12% lower than in 2003–04 ($63.3 million). The relatively more rapid decline in hours trawled over this period suggests that economic performance has improved.

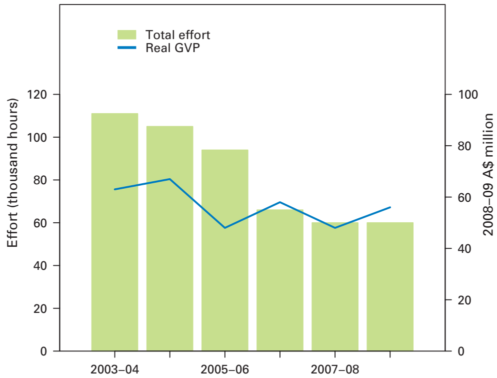


FIGURE 9.31 Trawl effort and real GVP in the CTS, 2003–04 to 2008–09 financial years

NOTE: Trawl hours relate only to trawl vessels in the CTS.

Net economic returns

The most recent survey-based estimates of NER for the CTS are available for 2006–07. The sector was surveyed by ABARE–BRS in early 2010 for the 2007–08 and 2008–09 financial years. Results from this survey will not be available until late 2010. However, non-survey–based preliminary estimates of NER are available for the sector for 2007–08. These preliminary estimates have been calculated using the method outlined by Vieira & Perks (2009).

Given the size of the CTS in terms of vessel numbers, NER have historically been low. The highest estimate before 2007–08 was $6 million (in 2008–09 dollars), recorded in 1997–98. More recently, following negative NER in 2003–04 and 2004–05, NER became positive in 2005–06 ($1.6 million) and 2006–07 ($3.6 million). Preliminary

estimates of NER for 2007–08 suggest that this positive trend has continued, with NER increasing to $7.1 million (Fig. 9.32).

These recent improvements can largely be attributed to a decline in fishery level operating costs, which occurred at the same time as a sharp fall in the number of active vessels operating in the fishery. The number of vessels decreased from 91 in 2004–05 to 52 in 2007–08; this was largely attributable to the *Securing our Fishing Future* structural adjustment package. Although TAC reductions have resulted in lower fishery revenues, costs have fallen by a greater amount with these reductions in vessel numbers.

Although no estimates of NER are available for 2008–09, a 17% increase in GVP, relatively constant effort levels (a decrease of 1% in otter trawling hours) and a decline in fuel prices in 2008–09 suggest that the positive trend in NER may have continued.

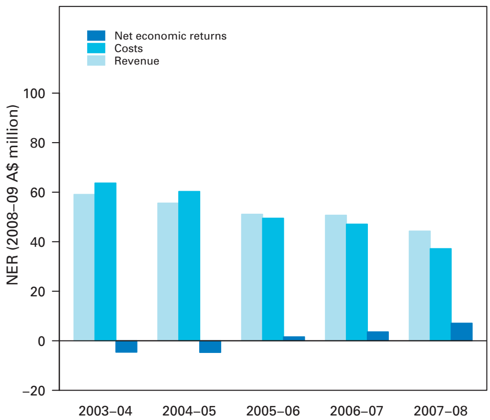


FIGURE 9.32 Revenue, costs and net economic returns for the CTS by financial year, 2003–04 to 2007–08.

NOTE: Results for 2007–08 are preliminary non-survey-based estimates

SOURCE: Vieira et al. (2008).

Output-to-input ratio

A fishery level output-to-input ratio can indicate how effectively key fishing inputs have been used to harvest catch over time, but also reflects changes in stock abundance. The ratio presented here takes the form of an index that combines time-series indexes of fishery output (fish catch) and key input use (labour, capital, fuel and repairs) (Vieira et al. 2010).

Aggregate input use in the CTS has followed a downward trend since 2003–04 (Fig. 9.33), in line with a decline in vessel numbers. This decline was initially driven by vessel operators choosing to exit the sector (a likely response to low profits), and then by the removal of active vessels through the *Securing our Fishing Future* package. Following the conclusion of the buyback package, vessel numbers fell by 33% between 2006–07 and 2007–08. The aggregated input index fell by 32% over the same period.

Output followed a downward trend over the same period. However, the rate of decline slowed considerably between 2006–07 and 2007–08, with only a 5% fall in the output index, because of increased catches of flathead and ling. Despite the large reduction in vessels in 2007–08, output levels have therefore been less affected; the output index stayed relatively constant in 2008–09, increasing by 2%.

The combined effect of these changes is an increasing trend in the output-to-input ratio. Between 2003–04 and 2006–07, the ratio increased by 6%, compared with a much larger (39%) increase between 2006–07 and 2007–08. This suggests that key inputs were being used more effectively in 2007–08 than previously, indicating an improvement in economic performance.

Silver warehou PHOTO: HEATHER PATTERSON, ABARE–BRS

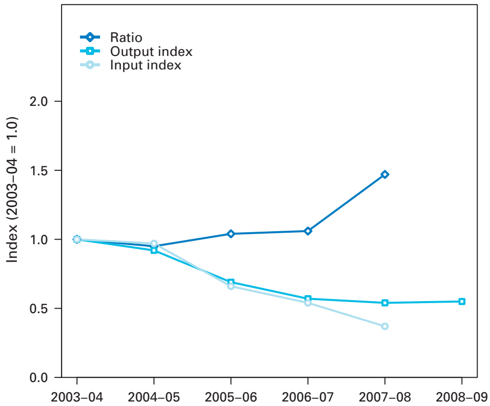


FIGURE 9.33 Output-to-input ratio for the Commonwealth trawl sector, 2003–04 to 2008–09 (2003–04 base year)

NOTE: Estimates for 2008–09 are non-survey-based extrapolation estimates.

Although survey estimates of input costs are not yet available for 2008–09, some broad conclusions can be drawn about expected movements in input use and the output to input ratio in that year. Active vessel numbers in the fishery remained constant in 2008–09, at 52 vessels, while total effort levels (in terms of hours trawled) were also stable. This suggests that input use is likely to have also remained constant in 2008–09. Given that output was relatively constant in 2008–09, it can be concluded that the output-to-input ratio is likely to have exhibited little change.

Vessel-level performance

On average, real beach prices increased by 15% between 2007–08 and 2008–09, while total catch remained relatively stable over the same period, increasing by 2%. Since vessel numbers remained constant, real GVP per vessel increased substantially, by 17%, from $920 000 to $1.1 million (Fig. 9.34). These values are much higher than in 2005–06, when GVP per vessel was $590 000. The main drivers of the increase in 2008–09 were GVP increases associated with blue grenadier and other species.

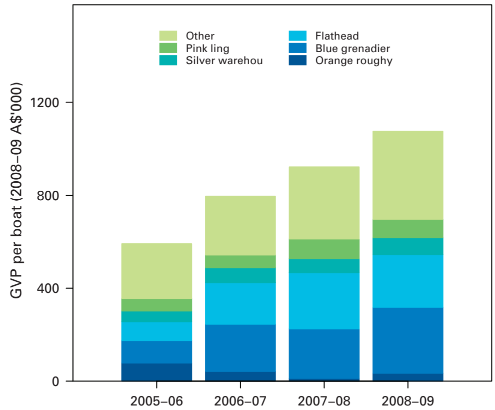


FIGURE 9.34 Real GVP by species per vessel in the CTS, 2005–06 to 2008–09 (2008–09 dollars)

Vessel-level costs (Fig. 9.35) increased from 2005–06 to 2007–08, although most of this increase occurred in 2007–08, the year following the recently completed buyback. These changes are broadly consistent with increases in effort per vessel. Key changes in 2007–08 were a 35% increase in labour costs due to higher catch receipts (crew are generally paid a proportion of catch revenue), and a 29% increase in fuel costs due to an increase in fuel use and a 17% increase in the real offroad price of diesel. Cost estimates for 2008–09 are not yet available, but stable effort levels and a decline in the price of fuel suggest that costs at the vessel level may have fallen slightly.

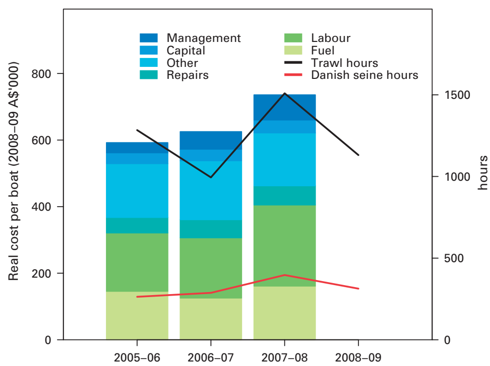


FIGURE 9.35 Real costs per vessel by cost category for the CTS and hours trawled per vessel by method, 2005–06 to 2008–09 (2008–09 dollars)

NOTE: Cost estimates for 2007–08 are non-survey-based extrapolation estimates. Estimates for 2008–09 are not yet available.

Overall economic performance

A bioeconomic model of the CTS, based on the 2004 fishing season, indicated that larger stocks are a key component to maximising NER because any given level of harvest becomes cheaper to catch (Kompas & Che 2006). The bioeconomic model also provided estimates of steady-state MEY harvests and optimal initial harvests to allow for stocks to rebuild while maximising long-term NER. In all cases, the model indicated that TACs needed to be reduced from 2004 levels to maximise NER. Also, the benefits of reducing catches would be realised in the future when, for almost all species, a TAC could be set that results in larger catches than were being made in 2004.

Recent lower TACs and effort levels in the SESSF are likely to have benefited the long-term economic performance of both the CTS and the ScHS, in line with the predictions of Kompas & Che (2006). Lower TACs for key species are likely to have restricted catches of these species to a greater degree and assisted in stock rebuilding. A time lag would normally be expected for higher profits to eventuate from such changes, due to the time taken for fish stocks to rebuild to a level that allows the cost per unit of catch to fall. However, recent indicators for the fishery suggest that NER and vessel level profitability have already improved, although this could be the result of natural short-term variability in stock levels.

The *Securing our Fishing Future* structural adjustment package removed a significant number of vessels from the fishery. As a result of the buyout, fewer resources (notably fuel and capital) are now expended in the fishery, and total economic costs at the fishery level are lower. The positive trend in NER that has prevailed since 2004–05 is expected to have been maintained in 2008–09. These trends and key changes suggest that the fishery is closer to MEY than in the period before the buyout. With a continued management focus on setting TAC limits for key species that are consistent with maximising NER and further stock rebuilding, economic performance should continue to improve.

9.5 ENVIRONMENTAL STATUS

The SESSF has a significant level of bycatch, particularly in the trawl sectors. ISMP data from 2004 indicated that 30% by weight of the catch of non-quota species in the CTS was discarded, as was 9% of the catch of non-quota species in the hook sector. In 2006 new mandatory gear requirements for otter trawls were introduced to reduce the catch of small species and juvenile fish. The requirements specified a range of codend options, including larger mesh and escape panels and minimum mesh size in the trawl wings and trawl mouth. The impact of these changes is yet to be evaluated. AFMA has introduced a bycatch and discarding program, which includes annual bycatch and discarding workplans, to address bycatch issues more effectively. It is intended that priority setting under the workplan will draw heavily on the outcomes of AFMA's ecological risk assessment and ecological risk management approaches.

In 2007, 13 marine protected areas were introduced in the South-east Marine Region, where the SESSF occurs. This is the first region to undergo the marine bioregional planning process. The boundaries of the marine protected area network were designed largely to avoid impacts on commercial fisheries, including the SESSF. Most of the area covered is off the continental shelf and over deeper waters, outside key fishing areas. The zoning system permits some forms of commercial fishing to continue in some zones.

In 2008 a variation was made to the declaration of the approved Wildlife Trade Operation for the SESSF, issued by the Minister for the Environment, Heritage and the Arts. This variation includes provisions to develop and implement rebuilding strategies for all SESSF species below the limit reference point (B_{20}), including eastern gemfish and blue warehou. As well, AFMA is to develop and implement effective mitigation measures for Harrisson's dogfish. AFMA is also to ensure that robust levels of observer effort are maintained to validate logbook data and

assess the significance of bycatch issues, such as seabird warp strike in the trawl fishery.

Orange roughy is listed as conservation dependent under the EPBC Act. AFMA has implemented the ORCP (AFMA 2006), which requires that the spawning biomass of orange roughy is maintained above 60% of the unfished biomass on the Cascade Plateau, the take of orange roughy is reduced in overfished areas, and future development is ecologically sustainable in areas where the status of orange roughy is unknown. As part of this program, all SESSF waters deeper than 700 m were closed to trawling in 2007. The South East Trawl Fishing Industry Association (SETFIA) proposed that some areas deeper than 700 m be opened to fishing, based on logbook information (Knuckey et al. 2008), and this change was implemented in early 2009. The remaining closed areas encompass 89% and 54% of the historical orange roughy and deepwater shark catch, respectively.

Fishing activities in the SESSF interact with a number of species listed as protected or conservation dependent under the EPBC Act, including marine mammals (cetaceans and pinnipeds), seabirds, some shark species, syngnathids (seahorses and pipefish) and orange roughy. Fisheries are required to avoid interactions with threatened, endangered and protected (TEP) species, and all interactions are to be reported in logbooks; however, logbooks are known to under-report the levels of interactions with some species.

Ecological risk assessment

The SESSF has undergone ecological risk assessments for several gear types—otter trawl, auto-longline, Danish-seine and gillnet—that are used across the SESSF sectors (Table 9.2). Gillnet results are discussed in Chapter 12. For otter trawl, 600 species were assessed at the Level 2 (Productivity and Susceptibility Analysis; PSA) stage. Of these 600, 159 species were classified as high risk; the majority of the high-risk species were chondrichthyans or teleosts. The Level 3 (Susceptibility Assessment of Fishing Effects; SAFE) assessment was then applied, which reduced the number of high-risk species to 23. During the residual risk process, new information was identified that allowed the total number of high-risk species to be reduced to 10. These species include several low-productivity, deepwater sharks (including Harrisson's dogfish and southern dogfish), several seabirds and the Australian fur seal.

For Danish-seine, 204 species (198 of which were TEP species) were assessed at Level 2. Of these species, only the Australian fur seal was classified as high risk, and remained at high risk after the residual risk process. Overall, the Danish-seine fishery is a low-risk fishery.

For auto-longline, 306 species were assessed at Level 2, and 56 were found to be high risk. Of these, the majority were seabirds and chondrichthyans. The number of low-productivity chondrichthyans found to be high risk was a concern, as many are endemic to the area of the fishery. Thirteen of the chondrichthyan and teleost species were removed from the high-risk list when the Level 3 analyses were used; this is not applied to seabirds or mammals. For these thirteen species, the other residual risk rules were applied, and the total number of high-risk species was reduced to nine. Seven of these are chondrichthyans, including five deepwater sharks, and two are teleosts (blue-eye trevalla and hapuka).

Threatened, endangered and protected species

Seals and sea lions

The areas fished by the SESSF overlap with the distributions of Australian and New Zealand fur seals (*Arctocephalus pusillus doriferus* and *A. fosteri*, respectively) and the Australian sea lion (*Neophoca cinera*, which is listed as vulnerable under the EPBC Act) (Goldsworthy et al. 2010). The CTS, in particular, is known to interact with these species (primarily the Australian fur seal). Interactions with the hook sector are much fewer. Between 1993 and 2000, the ISMP and its precursor (the Scientific Monitoring Program) suggested that an average of 720 fur seals are caught

incidentally by wet-vessels each year (Knuckey et al. 2002). Wet-vessels are smaller trawl vessels operating in the CTS that do not have the industrial freezer capacity of the larger vessels that target blue grenadier and other species. Due to the smaller vessel size, it is proving more difficult to apply mitigation methods such as seal exclusion devices (SEDs) on wet-vessels. Recent trials of a flexible SED design have been relatively successful, but reliably estimating and reducing the level of interactions between seals and wet-vessels remains an issue. A monitoring program is in progress to assess the extent of seal interactions, and trials of SEDs are continuing. Many fur seal populations are now recovering, and increasing seal numbers in some areas have created the potential for more frequent interactions. In these areas, the concern is not about depletion but rather how to minimise interactions with a protected species.

Seal interactions are also a significant issue in the winter trawl fishery for blue grenadier off western Tasmania. SEDs are compulsory for this component of the SESSF. The amended fishing practices appear to have substantially reduced the incidence of seal bycatch in the midwater nets of factory vessels; however, limited observer data are available to verify bycatch rates (Tilzey et al. 2006).

Yellow-nosed albatross PHOTO MIKE GERNER, AFMA

During 2007 SETFIA released an updated trawl industry code of conduct for responsible fishing, and the industry code of practice to minimise interactions with seals. The codes aim to address the environmental impacts of the fishery, as well as interactions between the trawl fishery and seals more specifically.

Seabirds

Seabirds are known to interact with a number of forms of fishing activity, particularly longlining and trawl. In 1998 in accordance with the EPBC Act requirements, the Australian Government developed the Threat Abatement Plan for the Incidental Catch (or bycatch) of Seabirds during Oceanic Longline Fishing Operations. The plan, which was revised in 2006, applies to longline operations in the SESSF. The levels of seabird bycatch recorded by auto-longline, demersal longline, dropline and trotline operators in the SESSF are regarded as low, compared with the bycatch in pelagic longline operations, but data and observer coverage on seabird interactions in the SESSF are limited.

Seabirds also interact with trawling activities—for example, they are vulnerable to warp strike, predominantly during hauling. Analysis of observer data suggests that levels of interactions are potentially significant (Phillips et al. 2010). Further work is needed to understand the scale and significance of these interactions.

Sharks

There have been rare interactions in the CTS and ScHS with two protected shark species: great white sharks (*Carcharodon carcharias*) and grey nurse sharks (*Carcharias taurus*). In 2006 AFMA responded to concerns over declines in the abundance of some deepwater shark species taken as byproduct by the SESSF; a number of these species have been nominated for listing under the EPBC Act. Spatial closures, some of which were specifically designed to afford some protection to deepwater sharks, apply in several areas across the fishery. In addition, the closure to fishing for orange roughy in waters deeper

than 700 m (750 m in the Great Australian Bight) will provide some protection to mid-slope sharks. Finally, school shark were listed as conservation dependent under the EPBC Act in February 2009. The listing does not prevent the take of school shark as bycatch, which is covered by a bycatch quota.

Syngnathids

Syngnathids are taken as bycatch within the SESSF. The ISMP and logbook data suggest that Danish-seining has the greatest potential for impact, because seiners operate in relatively shallow waters and use nets with a small mesh size. This sector reported a catch of more than 1000 syngnathids in 2000 to 2002. Reported catches have decreased substantially since then, and no syngnathid interactions were recorded in logbooks in 2007 or 2008. However, the decrease is thought to be associated more with under-reporting of interactions than with altered fishing practices or changes in the abundance or distribution of syngnathids. It is unclear if the fishery poses an ecological risk to syngnathids, but the Level 2 ecological risk assessment for the fishery indicated that the spiny pipehorse (which was identified in the Level 1 scoping assessment as being at possible risk) was at low risk, as the fishery overlaps with only a small portion of its range.

Benthic habitats

The potential for practices such as demersal trawling to damage marine benthos within the SESSF is of concern. The lack of regulations governing the size of footrope gear such as rollers may result in damage to benthic habitats, particularly as fishers move to previously inaccessible areas. A voluntary industry code of conduct does place restrictions on rollers. Available information on the spatial distribution of trawl effort indicates that most of it is confined to historic, established fishing grounds. The extent and nature of possible habitat damage within the SESSF has not been quantified, although CSIRO is currently conducting some research in this area. As a precautionary measure, AFMA and the Department of the Environment, Water, Heritage and the Arts have designated a fishing closure to protect a group of seamounts off southern Tasmania from demersal trawling.

9.6 HARVEST STRATEGY PERFORMANCE

Following the adoption of the SESSF HSF in 2005, particularly the development of explicit harvest control rules, the basis for establishing TACs has improved. Similarly, the revision of the Tier 3 and 4 rules has resulted in the harvest control rules being more likely to meet the objectives of the HSP (Wayte 2009). The reduction in the number of stocks for which status was uncertain has clearly resulted from the introduction of the MSE tested HSF.

The adoption of MEY (or its proxy) as the target for all species should aid both sustainability and profitability; however, its estimation in such a multispecies fishery is difficult. The use of proxies is needed in the short-term, although proxies are contentious as there are no agreed criteria for developing or selecting alternatives.

There are still some remaining issues to be resolved in the SESSF HSF, as discussed in Chapter 8. There are several cases where more guidance/criteria are needed, such as when a fish-down is occurring, closed areas have been implemented or what constitutes sufficient precaution to justify not applying a discount factor for Tier 3 and Tier 4 stocks.

An early improvement that is evident from the adoption of the revised rules is the increased number of stocks for which status could be assigned.

The HSF is a path for improvement in management, but even a well-designed harvest strategy cannot address all management issues. For example, an issue concerning the management of pink ling is a spatial mismatch between management arrangements and stock structure and an inability to control the catch independently for each of the stocks. Ideally, there should be separate

management and TACs for separate stocks. However, there are clearly legal difficulties where statutory fishing rights have already been granted. If the legal impediments to resolving such situations remain, there are few options other than reductions in TACs. However, as an example of these other options, extended closures have been introduced for pink ling, and the non-trawl industry has voluntarily agreed to shift fishing effort away from the more depleted eastern stock.

The HSF also does not address the need to collect data and undertake assessments of commercially valuable non-quota species; this has been an ongoing issue since individual transferable quotas were introduced in 1992. Quotas, and therefore stock assessments, have been introduced for deepwater shark species, ribaldo and oreodories, but other non-quota species are still being actively targeted.

The issue of carryover allowances has been re-examined and the RAGs are now providing direct advice on this. This has previously been a concern for species with a 'bycatch TAC' for incidental catch, where increases in the actual quota due to carryover of uncaught quota from the previous year is inappropriate and counter to the reason for setting a TAC that reflects incidental catch only. For such overfished stocks, there are also often insufficient data or analyses to determine whether these reduced catches will allow stocks to rebuild within acceptable timeframes.

Finally, the reliability of the decisions made under the harvest strategy depends partly on the quality of the assessments that support it. The observer and port-sampling programs collect data that is critical to the assessments, and if these are compromised it can have a substantial impact on the assessment (e.g. blue warehou). AFMA recently commissioned a review of the ISMP (Bergh et al. 2009) and is implementing the recommendations from this review. The various SESSF RAGs should regularly provide feedback and assist in coordinating priorities for the ISMP to ensure data needs for assessments are met.

9.7 LITERATURE CITED

AFMA (Australian Fisheries Management Authority) 2006, *Orange Roughy Conservation Programme*, AFMA, Canberra, <www.afma.gov.au/fisheries/sess/sess/notices/2006/n20061207.pdf>.

——2008a, *AFMA CatchWatch, a report from the Australian Fisheries Management Authority on 9 May, 2008*, AFMA, Canberra, <www.afma.gov.au/fisheries/sess/sess/publications/catchwatch/2008/20080509_catchwatch.pdf>.

——2008b, *Blue warehou stock rebuilding strategy 2008*, AFMA, Canberra.

——2008c, *Eastern gemfish stock rebuilding strategy 2008*, AFMA, Canberra, <www.afma.gov.au/fisheries/sess/sess/notices/2009/eastern_gemfish_rebuild.pdf>.

——2008d, *School shark stock rebuilding strategy 2008*, AFMA, Canberra, <www.afma.gov.au/fisheries/sess/sess/notices/2009/school_shark_rebuild.pdf>.

——2009a, *AFMA CatchWatch—a report from the Australian Fisheries Management Authority, 19 May 2009*, AFMA, Canberra, <www.afma.gov.au/fisheries/sess/sess/publications/catchwatch/2009/20090520_catchwatch.pdf>.

——2009b, *South East Trawl Fishery* (*Board Trawl & Danish Seine*) *Bycatch and Discarding Workplan 1 July 2009 to 30 June 2011*, AFMA, Canberra.

——2009c, *Automatic Longline Fishery Bycatch and Discarding Workplan 1 July 2009 to 30 June 2011*, AFMA, Canberra.

——2010a, *Residual risk assessment of the Level 2 ecological risk assessment species results: Report for the Danish seine fishery*, AFMA, Canberra.

——2010b *Residual risk assessment of the Level 2 ecological risk assessment species results: Report for the auto-longline sector of the Gillnet Hook and Trap Fishery*, AFMA, Canberra.

——2010c *Residual risk assessment of the Level 2 ecological risk assessment species results: Report for the Commonwealth Trawl Fishery*, AFMA, Canberra.

Bergh, M, Knuckey, I, Gaylard, J, Martens, K & Koopman, M 2009, *A revised sampling regime for the Southern and Eastern Scalefish and Shark Fishery*, Final Report to the AFMA, AFMA Project F2008/0627. OLRAC and Fishwell Consulting

Clark, MR, Anderson, OF, Francis, RICC & Tracey, DM 2000, 'The effects of commercial exploitation on orange roughy (*Hoplostethus atlanticus*) from the continental slope of the Chatham Rise, New Zealand, from 1979 to 1997', *Fisheries Research*, vol. 45, pp. 217–38.

DAFF (Australian Government Department of Agriculture, Fisheries and Forestry) 2003, *Southern and Eastern Scalefish and Shark Fishery Management Plan 2003* (amended 2006), DAFF, Canberra, Federal Register of Legislative Instruments F2007C00069.

——2007, *Commonwealth Fisheries Harvest Strategy: policy and guidelines*, DAFF, Canberra.

Daley, RK, Stevens, JD & Graham, KJ 2002, *Catch analysis and productivity of the deepwater dogfish resource in southern Australia*, FRDC final report 1998/108, FRDC, Canberra.

——Webb, H, Hobday, A, Timmiss, T, Walker, T, Smith, T, Dowdney, J & Williams, A 2007, *Ecological risk assessment for the effects of fishing: Report for the automatic longline sub-fishery of the Southern and Eastern Scalefish and Shark Fishery,* report for the AFMA, Canberra.

——Green, M, Barker, B & Williams, A 2009, *Mapping the distribution and movement of gulper sharks, and developing a non-extractive monitoring technique, to mitigate the risk to the species within a multi-sector fishery region off southern and eastern Australia—Interim report on exploratory survey*, 8 October 2009, CSIRO Marine and Atmospheric Research, Hobart.

Day, J 2010, 'School whiting (*Sillago flindersi*) stock assessment based on data up to 2008', in *Stock assessment for the Southern and Eastern Scalefish and Shark Fishery 2009*, part 1, GN Tuck (ed), AFMA & CSIRO Marine and Atmospheric Research, Hobart, pp. 190–249.

DeepRAG (Deepwater Resource Assessment Group) 2009, *2009 Deepwater RAG species stock assessment report*, report to AFMA, Canberra.

Elliston, L, Newton, P, Galeano, D, Gooday, P, Kompas, T & Newby, J 2004, *Economic efficiency in the South East Trawl Fishery*, ABARE eReport 0421 prepared for the Fisheries Resources Research Fund, Canberra.

FERM (Fisheries Economics, Research and Management) 2004, *ITQs, ageing boats and the price of fish: profitability and autonomous adjustment in the South East Trawl Fishery*, funded by the Fisheries Resources Research Fund & Fisheries Economics Research and Management Pty Ltd, Canberra.

Fay, G 2008, *Tier 3 Calculations for Blue eye trevalla using data up to and including 2007*, SlopeRAG discussion paper 2008–12, AFMA, Canberra.

Forrest, RE & Walters, CJ 2009, 'Estimating thresholds to optimal harvest rate for long-lived, low-fecundity sharks accounting for selectivity and density dependence in recruitment', *Canadian Journal of Fisheries and Aquatic Sciences*, vol. 66, pp. 2062–80.

Froese, R & Pauly, DE 2009, *FishBase,* version 02/2009, FishBase Consortium, <www.fishbase.org>,

Garcia, VB, Lucifora, LO & Myers RA 2008, 'The importance of habitat and life history to extinction risk in sharks, skates, rays and chimaeras', *Proceedings of the Royal Society B: Biological Sciences*, vol. 275, pp. 83–9.

Goldsworthy, SD, Page, B, Shaughnessy, PD & Linnane, A 2010, *Mitigating seal interatctions in the SRLF and the gillnet sector SESSF in South Australia*. SARDI Aquatic Sciences Publication Number F2009/000613-1. SARDI Research Report Series No. 405.

Gomon, M, Bray, D & Kuiter, R 2008, *Fishes of Australia's south coast*, New Holland Publishers, Sydney.

Graham, KJ, Wood, BR & Andrew, NL 1997, *The 1996–97 survey of upper slope trawling grounds between Sydney and Gabo Island (and comparisons with the 1976–77 survey)*, Kapala Cruise Report No. 117. Fisheries Research Institute, NSW Fisheries.

——Andrew, NL & Hodgson, KE 2001, 'Changes in relative abundance of sharks and rays on Australian South East Fishery trawl grounds after twenty years of fishing', *Marine and Freshwater Research*, vol. 52, pp. 549–61.

Haddon, M 2010a, 'Catch rate standardizations for data 1986–2008', in GN Tuck (ed), *Stock assessment for the Southern and Eastern Scalefish and Shark Fishery 2009,* part 2, AFMA & CSIRO Marine and Atmospheric Research, Hobart, pp. 21–191.

Haddon, M 2010b, 'Tier 4 analyses 1986–2008', in GN Tuck (ed), *Stock assessment for the Southern and Eastern Scalefish and Shark Fishery 2009,* part 2, AFMA & CSIRO Marine and Atmospheric Research, Hobart, pp. 318–368.

——Wayte, S 2010, 'Deep water catch rate standardizations and Tier 4 analyses for data 1986–2008, in GN Tuck (ed), *Stock assessment for the Southern and Eastern Scalefish and Shark Fishery 2009,* part 2, AFMA & CSIRO Marine and Atmospheric Research, Hobart, pp. 370–421.

Hamer, P, Kemp, J, Robertson, S & Hindell, J 2009, *Use of otolith chemistry and shape to assess the stock structure of blue grenadier (*Macruronus novaezelandiae*) in the Commonwealth Trawl and Great Australian Bight fisheries*, final report to the FRDC, project no.2007/030, Fisheries Research Branch, Queenscliff.

Hobsbawn, PI 2009, *Data summaries for SESSF quota species 1994–2008*, Bureau of Rural Sciences, Canberra.

Kailola, PJ, Williams, MJ, Stewart, PC, Riechelt, RE, McNee, A & Grieve, C 1993, *Australian fisheries resources,* Bureau of Resource Sciences & the FRDC, Canberra.

Klaer, N 2010a, 'Tiger flathead (*Neoplatycephalus richardsoni*) stock assessment based on data up to 2008, in GN Tuck (ed), *Stock assessment for the Southern and Eastern Scalefish and Shark Fishery 2009,* part 1, AFMA & CSIRO Marine and Atmospheric Research, Hobart, pp. 164–189.

Klaer, N 2010b, 'Yield, total mortality values and Tier 3 estimates for selected shelf and slope species in the SESSF 2009', in GN Tuck (ed), *Stock assessment for the Southern and Eastern Scalefish and Shark Fishery 2009,* part 2, AFMA & CSIRO Marine and Atmospheric Research, Hobart, pp. 275–318.

Klaer, NL & Smith, DC 2008, *Species associations and companion TACs in the SESSF*, report for the Australian Fisheries Management Authority, Canberra.

Knuckey IA, Eayrs S & Bosschietter B 2002, *Options for reducing incidental catch of seals on wet-boats in the SETF: a preliminary report*, MFRI report to the AFMA. ARF Project R01/0887. 89p.

Knuckey, I, Fuller, M, Moore, J & Daley, R 2008, *Empowering industry R & D: redefining deepwater closures in the SESSF to reduce the impact on the commercial deepwater fishery and maintain adequate protection for orange roughy*, draft final report, AFMA project R2008/836, AFMA, Canberra.

——Koopman, M, & Hudson, M 2009, *Resource survey of the Great Australian Bight Trawl Fishery – 2009*, AFMA Project 2008–848, AFMA, Canberra.

Kompas, T & Che, N 2006, *A stochastic bioeconomic model of a multi-species and multi-fleet fishery: an application to the South East Trawl Fishery*, ABARE report to the Fisheries Resources Research Fund, Canberra.

Last, PR & Stevens, JD 2009, *Sharks and rays of Australia*, CSIRO Publishing, Collingwood.

Little, LR 2010, 'Moving the eastern gemfish (*Rexea solandri*) stock assessment to SS3', in GN Tuck (ed), *Stock assessment for the Southern and Eastern Scalefish and Shark Fishery 2009,* part 1, AFMA & CSIRO Marine and Atmospheric Research, Hobart, pp. 76–98.

Miller, ME 2007, *Key biological parameters and commercial fishery for ocean leatherjackets `Nelusetta ayraudi' (Monacanthidae) off the coast of New South Wales*, Australia, MEnvSc thesis, School of Biological Sciences, University of Wollongong.

——& Stewart, J 2009, The commercial fishery for ocean leatherjackets (*Nelusetta ayraudi*, Monacanthidae) in New South Wales, Australia. *Asian Fisheries Science*, vol.22, pp. 257–264.

Morison, AK & Rowling, KR 2001, 'Age, growth and mortality of redfish *Centroberyx affinis*', *Marine and Freshwater Research*, vol. 52, pp. 637–49.

Parin, NV, Pavlov, YP & Andrianov, DP 1988, 'Ecology of the mirror dory, *Zenopsis nebulosus*, of the submarine Nascus Ridge', *Journal of Ichthyology*, vol. 25, pp. 106–15.

Park, T 1994, *Ocean perch Helicolenus sp. in The South East Fishery; a scientific review with particular reference to quota management* (RDJ, Tilzey, ed), Bureau or Resource Sciences, Canberra.

Patterson, HM & Tudman, MJ 2009, *Chondrichthyan guide for fisheries managers: a practical guide for mitigating chondrichthyan bycatch*, BRS & AFMA, Canberra.

Phillips, K, Giannini, F, Lawrence, E & Bensley, N 2010, *Cumulative assessment of the catch of non-target species in Commonwealth fisheries: a scoping study*, Bureau of Rural Sciences, Canberra.

Paul, LJ & Horn, PL 2009, Age and growth of sea perch (*Helicolenus percoides*) from two adjacent areas off the east coast of South Island, New Zealand, *Fisheries Research* vol. 95, pp. 169–180.

Punt, AE 2008, *Data analysis and preliminary updated stock assessment of blue warehou (*Seriolella brama*) based on data up to 2008*, report to SlopeRAG, CSIRO Marine and Atmospheric Research, Hobart.

Ryan, TE, Kloser, RJ, & Macaulay, GJ 2009, 'Measurement and visual verification of fish target strength using an acoustic-optical system attached to a trawlnet', *ICES Journal of Marine Science*, vol. 66, pp. 1238–44.

Robinson, N, Skinner A, Sethuraman, L, McPartlan H, Murray N, Knuckey I, Smith DC, Hindell J & Talman S 2008, 'Genetic stock structure of blue-eye trevalla (*Hyperoglyphe antarctica*) and warehous (*Seriolella brama* and *Seriolella punctata*) in south-eastern Australian waters', *Marine and Freshwater Research* vol. 59(6), pp. 502–514.

Rowling, K 1994, 'Gemfish (*Rexea solandri*)', in R.D.J. Tilzey (ed), *The south east fishery: a scientific review with particular reference to quota management,* Bureau of Resource Sciences, Canberra.

——& Raines, LP 2000, *Description of the biology and an assessment of the fishery of Silver Trevally (Pseudocaranx dentex) off New South Wales*. Final Report to Fisheries Research and Development Corporation. Project No. 97/125. NSW Fisheries Final Report Series No. 24. ISSN 1440–3544.

Scandol, J, Rowling, K & Graham, K (eds) 2008, 'Redfish' in *Status of Fisheries Resources in NSW 2006/07*, NSW Department of Primary Industries, Cronulla, pp. 213–16.

ShelfRAG 2009, *2009 ShelfRAG stock assessment summaries*, report to the AFMA, Canberra,

SlopeRAG 2010, *SlopeRAG assessment Report – 2009 Stock Assessment Report for SESSF species assessed by SlopeRAG*, report to the AFMA, Canberra.

Smith, ADM & Smith, DC 2005, *A harvest strategy framework for the SESSF*, report to the AFMA, Canberra.

Talman, S, Hamer, P, Robertson, S, Robinson, N, Skinner, A & Smith, D 2003, *Stock structure and spatial dynamics of the warehous: a pilot study*, report to the Fisheries Research and Development Corporation. Project No. 2001/004.

Taylor, B 2010, 'Stock assessment of pink ling (*Genypterus blacodes*) in the south east fishery, December 2009', in GN Tuck (ed), *Stock assessment for the Southern and Eastern Scalefish and Shark Fishery 2009,* part 1, AFMA & CSIRO Marine and Atmospheric Research, Hobart, pp. 14–49.

Tilzey, RDJ 1994, 'Introduction', in RDJ Tilzey (ed), *The South East Fishery: a scientific review with reference to quota management*, Bureau of Resource Sciences, Canberra, pp.15–40.

Tilzey RDJ, Goldsworthy SD, Cawthorn M, Calvert N, Hamer DJ, Russell S, Shaughnessy PD, Wise B & Stewardson CL 2006, *Assessment of seal-fishery interactions in the winter blue grenadier fishery off west Tasmania and the development of fishing practices and Seal Exlusion Devices to mitigate seal bycatch by factory trawlers*, Final Report to FRDC. Project no. 2001/008, Canberra.

Tuck, GN & Fay, G 2010, 'Silver warehou (*Seriolella punctata*) stock assessment based on data up to 2008', in GN Tuck (ed), *Stock assessment for the Southern and Eastern Scalefish and Shark Fishery 2009,* part 1, AFMA & CSIRO Marine and Atmospheric Research, Hobart, pp. 50–75.

Vieira, S, & Perks, C 2009, *Australian fisheries surveys report 2009: survey results for selected fisheries, 2006-07 and 2007-08, preliminary estimates for 2008-09*, ABARE report prepared for the Fisheries Resources Research Fund, Canberra.

——Perks, C, Mazur, K, Curtotti, R & Li, M 2010, *Impact of the structural adjustment package on the profitability of Commonwealth fisheries*, ABARE research report 10.01, Canberra.

——Wood, R & Causer, T 2008, *Australian fisheries surveys report 2008, results for selected fisheries 2005–06 and 2006–07*, ABARE report prepared for the Fisheries Resources Research Fund, Canberra.

Ward, RD & Elliott, NG 2001 Genetic population structure of species in the South East Fishery of Australia, *Marine and Freshwater Research,* vol. 52(4), pp. 563–573.

Walker, TI, Stevens, JD, Braccini, JM, Daley, RK, Huveneers, Irvine, SB, Bell, JD, Tovar Ávila, J, Trinnie, FI, Phillips, DT, Treloar, MA, Awruck, CA, Gason, AS, Salini, J & Hamlett, WC 2008, *Rapid assessment of sustainability for ecological risk of shark and other chondrichthyan bycatch species taken in the Southern and Eastern Scalefish and Shark Fishery*, Final report to Fisheries Research and Development Corporation Project No. 2002/033. 354 + v pp. (Fisheries Research Brand: Queenscliff, Victoria, Australia).

Wayte, S, Bulman, C, Dowdney, J, Sporcic, M, Williams, A, Fuller, M & Smith, T 2007a, *Ecological risk assessment for the effects of fishing: Report for the Danish seine sub-fishery of the Commonwealth Trawl Sector of the Southern and Eastern Scalefish and Shark Fishery*, report to the AFMA, Canberra.

——Dowdney, J, Williams, A, Bulman, C, Sporcic, M, Fuller, M & Smith, T 2007b, *Ecological risk assessment for the effects of fishing: Report for the otter trawl sub-fishery of the Commonwealth Trawl Sector of the Southern and Eastern Scalefish and Shark Fishery*, report to the AFMA, Canberra.

——(ed) 2009, *Evaluation of new harvest strategies for SESSF species*, CSIRO Marine and Atmospheric Research, Hobart and AFMA, Canberra.

——2010, 'Jackass morwong (*Nemadactylus macropterus*) stock assessment based on data up to 2008', in GN Tuck (ed), *Stock assessment for the Southern and Eastern Scalefish and Shark Fishery 2009,* part 1, AFMA & CSIRO Marine and Atmospheric Research, Hobart, Hobart, pp.99–145.

White, WT, Ebert, DA & Compagno, LJV 2008, 'Description of two new species of gulper sharks, genus *Centrophorus* (Chondrichthyes: Squaliformes: Centrophoridae) from Australia', in PR Last, WT White & JJ Pogonoski (eds), *Descriptions of new Australian chondrichthyans*, CSIRO Marine and Atmospheric Research Paper 022, Hobart.

Wilson, DT, Patterson, HM, Summerson, R & Hobsbawn, PI 2009, *Information to support management options for upper-slope gulper sharks (including Harrisson's dogfish and southern dogfish)*, final report to the FRDC, project no. 2008/65, Bureau of Rural Sciences, Canberra.

Zhou, S, Smith, T & Fuller, M 2007, *Rapid quantitative risk assessment for fish species in selected Commonwealth fisheries*, report for the AFMA, Canberra.

Greeneye dogfish PHOTO: MIKE GERNER, AFMA

Processed ocean jacket PHOTO: JAMES LARCOMBE, ABARE–BRS

10 East Coast Deepwater Trawl Sector

H Patterson and T Pham

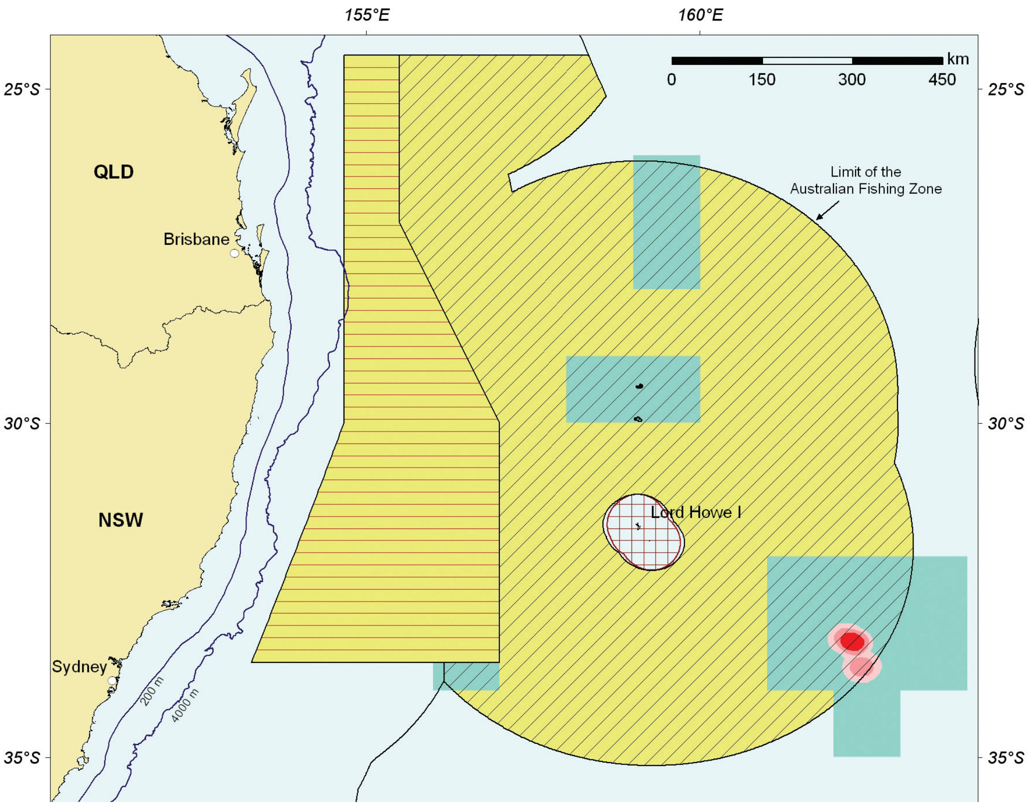


FIGURE 10.1 Relative fishing intensity in the East Coast Deepwater Trawl Sector of the SESSF

TABLE 10.1 Status of the East Coast Deepwater Trawl Sector

Fishery status	2008		2009		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Alfonsino (*Beryx splendens*)	Not overfished / not subject to overfishing	Uncertain	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Tier 3 assessment indicates no overfishing over history of the fishery. Very low effort in recent years.
Economic status Fishery level	Estimates of net economic returns not available				Economic status uncertain. Catch and fishing effort level very low so total net economic returns likely to be very low.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING — OVERFISHED / OVERFISHING — UNCERTAIN — NOT ASSESSED

TABLE 10.2 Main features and statistics of the East Coast Deepwater Trawl Sector of the SESSF

Feature	Description			
Key target and byproduct species	Alfonsino (*Beryx splendens*)			
Other byproduct species	Blue-eye trevalla (*Hyperoglyphe antarctica*) Boarfish (*Pentacerotidae* spp.) Orange roughy (*Hoplostethus atlanticus*)			
Fishing methods	Demersal and midwater trawl			
Primary landing ports	Brisbane, Eden			
Management methods	Input controls: SFRs (alfonsino), area closures, gear restrictions Output controls: TACs (alfonsino, orange roughy and boarfish). Catches of SESSF quota species taken in the sector are decremented from quota.			
Management plan	*Southern and Eastern Scalefish and Shark Fishery Management Plan 2003* (DAFF 2003); amended 2006			
Harvest strategy	*Southern and Eastern Scalefish and Shark Fishery Harvest Strategy Framework* (Smith & Smith 2005)			
Consultative forums	South East Management Advisory Committee (SouthEastMAC), Deepwater Resource Assessment Group (DeepRAG)			
Main markets	Domestic: frozen/chilled			
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Current accreditation dated 2 February 2010 Current accreditation (Wildlife Trade Operation) expires 30 July 2012			
Ecological risk assessment	Level 1: Scale Intensity Consequence Analysis (SICA) completed on 600 species (Wayte et al. 2007) Level 2: Productivity Susceptibility Analysis (PSA) completed on 600 species—159 high-risk species (trawl) (Wayte et al. 2007) Level 3: Sustainability Assessment for Fishing Effects (SAFE) completed on 440 species—23 high-risk species (trawl) (Zhou et al. 2007) Residual risk: 10 high risk (trawl)			
Bycatch workplans	South East Trawl Fishery (Board Trawl & Danish Seine) Bycatch and Discarding Workplan (1 July 2009 – 30 June 2011) (AFMA 2009)			
Fishery statistics[a]	**2008–2009 fishing season**		**2009–2010 fishing season**	
Fishing season	1 May 2008–30 April 2009		1 May 2009–30 April 2010	
TAC and catch:	TAC (tonnes)	Catch (tonnes)	TAC (tonnes)	Catch (tonnes)
Alfonsino	500	0	500	14
Boarfish	200	0	200	0
Orange roughy	50	0	50	0
Effort	Zero		1 trip	
Fishing permits	10		10	
Active vessels	Zero		1	
Observer coverage	Zero		6.8 trawl hours (100%)	
Real gross value of production (2008–09 dollars)	Zero		Confidential (< 5 vessels)	
Allocated management costs	2007–08: $0.06 million		2008–09: $0.05 million	

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; SESSF = Southern and Eastern Scalefish and Shark Fishery; SFR = statutory fishing right; TAC = total allowable catch

a Fishery statistics are provided by fishing season unless otherwise indicated.

10.1 BACKGROUND

The East Coast Deepwater Trawl Sector (ECDTS; Fig. 10.1) began as a separate fishery, which was then split into sections and amalgamated with other fisheries (Table 10.3). The southern portion joined with the Southern and Eastern Scalefish and Shark Fishery (SESSF). At that time, the Australian Fisheries Management Authority (AFMA) established a permanent trawl exclusion area to protect the eastern Australian seamounts, which lie within the ECDTS. Trawling is also prohibited within 25 nautical miles (nm) of Lord Howe Island and Ball's Pyramid. Fishers must have statutory fishing rights for the Commonwealth Trawl Sector to be granted permits to operate in the fishery. Alfonsino is the main target species, although fishing effort in the sector over recent years has been extremely low (Table 10.2).

TABLE 10.3 History of the East Coast Deepwater Trawl Sector of the SESSF

Year	Description
1990s	Most fishing for orange roughy around the Lord Howe Rise.
1994	Northern sector of the fishery transferred to the Coral Sea Fishery.
2000	Fishery integrated with the former South East Trawl Fishery.
2003	Fishery amalgamated into the SESSF and became the ECDTS.
2005	Alfonsino the main target species for several years.
2006	Orange roughy declared conservation dependent; TAC reduced to bycatch levels. Alfonsino TAC introduced. No fishing.
2007	SFRs for alfonsino granted.
2008	No fishing occurred.
2009	A single trip undertaken in the fishery.

ECDTS = East Coast Deepwater Trawl Sector; SESSF = Southern and Eastern Scalefish and Shark Fishery; SFR = statutory fishing right; TAC = total allowable catch

10.2 HARVEST STRATEGY

The harvest strategy is the Southern and Eastern Scalefish and Shark Fishery Harvest Strategy Framework (2005) (see Chapter 8).

10.3 THE 2009 FISHERY

Key target and byproduct species

One fishing trip occurred in the ECDTS in 2009. The highest volume and gross value of production of the fishery occurred in 2000–01. Alfonsino has historically accounted for about two-thirds of the fishery's total catch.

Minor byproduct species

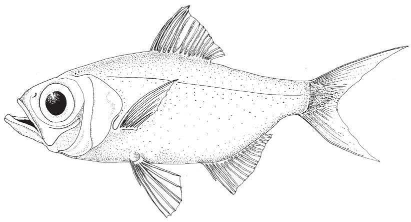
Although the ECDTS mainly targets alfonsino, some byproduct species are associated with the fishery, including blue-eye trevalla (*Hyperoglyphe antarctica*) and boarfish (*Pseudopentaceros richardsoni*). However, catches of these byproduct species have historically been low and therefore stock status has not been determined.

Research PHOTO: AFMA

10.4 BIOLOGICAL STATUS

ALFONSINO

(*Beryx splendens*)



LINE DRAWING: WILLIAM MURRAY

TABLE 10.4 Biology of alfonsino

Parameter	Description
Range	**Species:** Worldwide except in the north-east Pacific; in Australia, it occupies the temperate waters from Western Australia to central Queensland, including Tasmania. **Stock:** The area of the ECDTS. The primary area fished is a small section south-east of Lord Howe Island; this is the only area in the fishery from which data have been collected.
Depth	25–1200 m
Longevity	20 years
Maturity (50%)	**Age:** 4–6 years **Size:** ~35 cm FL
Spawning season	Spawning activity has not been recorded in the Australian Fishing Zone. July–August spawning recorded in New Zealand waters.
Size	**Maximum:** ~50 cm SL **Recruitment into the fishery:** 28–31 cm FL; age: ~5 years (fully recruited)

ECDTS = East Coast Deepwater Trawl Sector; FL = fork length; SL = standard length

SOURCES: Gomon et al. (2008); Lehodey et al. (1997).

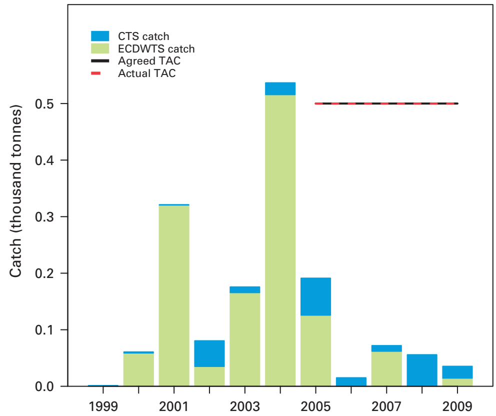


FIGURE 10.2 Alfonsino catch history, from the CTS and ECDTS, 1999 to 2009

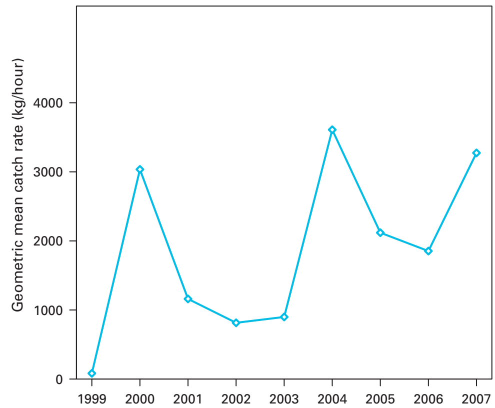


FIGURE 10.3 Alfonsino geometric mean catch rate, for the ECDTS, 1999 to 2007

Stock status determination

The RBC calculated by the Deepwater Resource Assessment Group (DeepRAG) for the area south-east of Lord Howe Island was 82 t for the 2009–10 fishing season (DeepRAG 2009). The 2009–10 agreed TAC (global) was 500 t (Table 9.2), with a limit of 100 t in the defined south-east area; the actual TAC (global) set by the AFMA Commission was 550 t after the carryover of uncaught quota was included.

The 2008 Tier 3 assessment for alfonsino remains current (Klaer 2009) as there were little data available in 2009 with which to update the assessment. This assessment, based

on age data (otoliths) from 2003 and 2007, indicates that the current fishing mortality rate is between the default target and limit reference points. Therefore, the stock is assessed as **not subject to overfishing** (Table 10.1). This is supported by the very low levels of fishing in recent years (Figs. 10.2, 10.3). The RBC calculated from the Tier 3 assessment was 82 t. Generally, Tier 3 assessments cannot be used to provide a measure of biomass. However, the Tier 3 assessment in this case includes the entire history of the fishery (since 2000) and has otolith samples both before and after the major fishing peak in 2005. As the Tier 3 assessment determined that fishing mortality was not large enough to be considered overfishing, and this has been the case for the entire history of the fishery, the stock is assessed as **not overfished**. This determination is supported by the very low effort and catch in recent years.

DeepRAG recommended an RBC of 82 t for the area south-east of Lord Howe Island for the 2010–11 fishing season (DeepRAG 2009).

Reliability of the assessment/s

Although only two years of data and a limited number of otoliths were used for the Tier 3 assessment, the distribution of age frequencies was consistent across the two years. However, as the otoliths used were from fish collected from the small area south-east of Lord Howe Island, this assessment does not apply to the larger area of the fishery. Data from other areas are required to obtain a comprehensive assessment for the fishery.

Previous assessment/s

Assessment of alfonsino has proven problematic due to a lack of fishing effort in the sector and a lack of associated data. Preliminary Tier 4 assessments were regarded by the DeepRAG as inconclusive and were rejected.

Future assessment needs

There is a need for more comprehensive data for a future alfonsino assessment, particularly if the fishing effort increases. Greater sampling over a wider area of the sector is required to provide a better understanding of the status of this species, but this will be difficult while the fishing effort remains low.

10.5 ECONOMIC STATUS

Economic surveys of the fishery have not been conducted. Fishing costs would be expected to be high, given the large distance of fishing grounds from ports. Given the low level of fishing effort and catch in recent years, it is unlikely that profits in the fishery are positive.

10.6 ENVIRONMENTAL STATUS

Orange roughy was listed as conservation dependent in 2006. Therefore, there is no targeted fishing for orange roughy in the SESSF, except on the Cascade Plateau. A review of orange roughy assessments and monitoring arrangements will take place in 2011, as required by the Orange Roughy Conservation Programme (AFMA 2006). See Chapter 9 for more information on environmental issues in the trawl sectors of the SESSF.

Ecological risk assessment

The ECDTS was not assessed separately under the ecological risk assessment (ERA) process, but was included in the assessment of the Commonwealth Trawl Sector. See Chapter 9 for more information on the ERA, including the outcomes.

Threatened, endangered and protected species

Sharks, marine turtles and seabirds

Due to the limited effort in the fishery in recent years, interactions with sharks, seabirds and marine turtles is not considered a problem at this stage. However, if effort increases in the fishery, these issues will need to be considered.

Benthic habitats

Most shelf trawls are on soft, sandy substrates with little sessile fauna or flora, but some 'exploratory' shots near the established grounds contained substantial benthos. There is potential for substantial impact if effort were to increase.

10.7 HARVEST STRATEGY PERFORMANCE

The ECDTS is included in the SESSF harvest strategy, discussed in Chapters 8 and 9.

10.8 LITERATURE CITED

AFMA (Australian Fisheries Management Authority) 2006, *Orange Roughy Conservation Programme*, AFMA, Canberra, <www.afma.gov.au/fisheries/sess/sess/notices/2006/n20061207.pdf>.

——2009, *South East Trawl Fishery (Board Trawl & Danish Seine) Bycatch and Discarding Workplan 1 July 2009 – 30 June 2011*, AFMA, Canberra, <www.afma.gov.au/fisheries/sess/sess/publications/set_bwp_2009_06_16.pdf>.

DAFF (Australian Government Department of Agriculture, Fisheries and Forestry) 2003, *Southern and Eastern Scalefish and Shark Fishery Management Plan 2003* (amended 2006), DAFF, Canberra, Federal Register of Legislative Instruments F2007C00069.

DeepRAG (Deepwater Resource Assessment Group) 2009, *2009 Deepwater RAG species stock assessment report*, report to AFMA, Canberra.

Gomon, M, Bray, D & Kuiter, R 2008, *Fishes of Australia's south coast*, New Holland Publishers, Sydney.

Klaer, N 2009, 'Yields and total mortality values and Tier 3 estimates for selected shelf and slope species in the SESSF', in GN Tuck (ed), *Stock assessment for the Southern and Eastern Scalefish and Shark Fishery 2008*, part 2, Australian Fisheries Management Authority & CSIRO Marine and Atmospheric Research, pp. 275–318.

Lehodey, P, Grandperrin, R & Marchal, P 1997, 'Reproductive biology and ecology of a deep demersal fish, alfonsino *Beryx splendens*, over the seamounts off New Caledonia', *Marine Biology*, vol. 128, pp. 17–27.

Smith, ADM & Smith, DC 2005, *A harvest strategy framework for the SESSF*, report to the AFMA, Canberra.

Wayte, S, Dowdney, J, Williams, A, Bulman, C, Sporcic, M, Fuller, M & Smith, T 2007, *Ecological risk assessment for the effects of fishing: Report for the otter trawl sub-fishery of the Commonwealth Trawl Sector of the Southern and Eastern Scalefish and Shark Fishery*, report to the AFMA, Canberra.

Zhou, S, Smith, T & Fuller, M 2007, *Rapid quantitative risk assessment for fish species in selected Commonwealth fisheries*, report to the AFMA, Canberra.

11 Great Australian Bight Trawl Sector

A Moore, H Patterson and T Pham

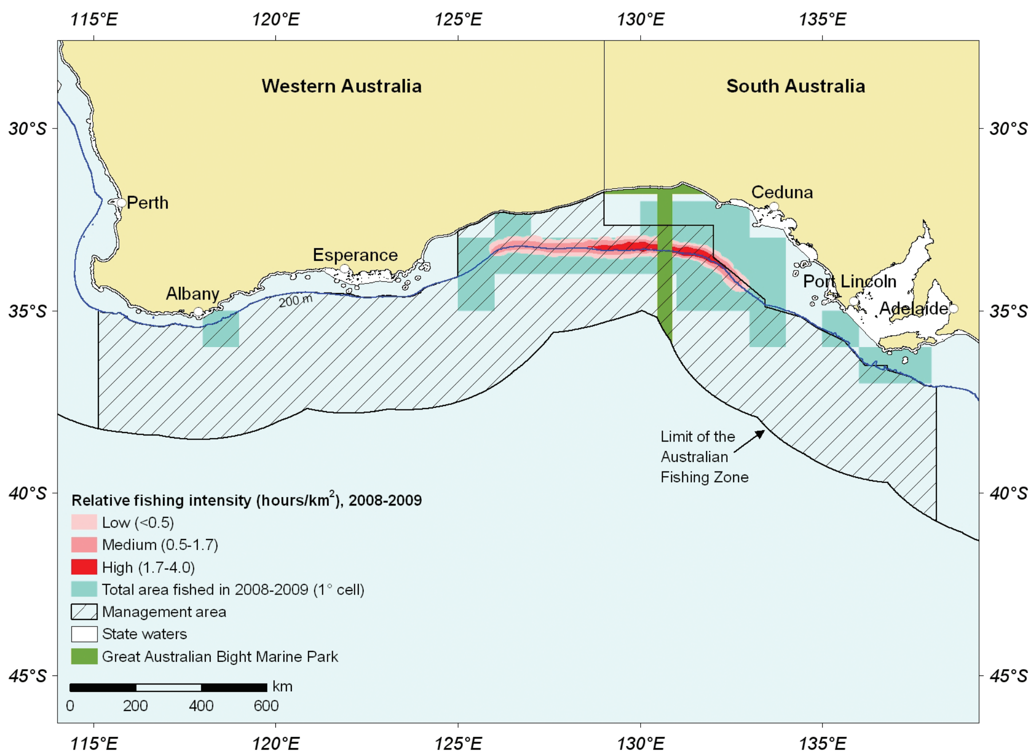


FIGURE 11.1 Relative fishing intensity in the Great Australian Bight Trawl Sector of the SESSF, 2008 and 2009

TABLE 11.1 Status of the Great Australian Bight Trawl Sector

Fishery status	2008		2009		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Bight redfish (*Centroberyx gerrardi*)	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Tier 1 assessment. Low catches indicate overfishing is not occurring.
Deepwater flathead (*Neoplatycephalus conatus*)	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Tier 1 assessment. Low catches indicate overfishing is not occurring.
Ocean jacket, western (*Nelusetta ayraudi*)	Not assessed	Not assessed	Uncertain	Uncertain	No formal assessment.
Orange roughy (*Hoplostethus atlanticus*)	Not overfished / not subject to overfishing	Uncertain	Not overfished / not subject to overfishing	Uncertain	No formal assessment of biomass. Zero catch in 2009.
Economic status Fishery level	Estimates of net economic returns not available				Economic status uncertain although a MEY study is currently underway. High levels of latent quota indicate that total net economic returns are likely to be low.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING — OVERFISHED / OVERFISHING — UNCERTAIN — NOT ASSESSED

MEY = maximum economic yeild

TABLE 11.2 Main features and statistics of the Great Australian Bight Trawl Sector of the SESSF

Feature	Description
Key target and byproduct species	Bight redfish (*Centroberyx gerrardi*) Blue grenadier (*Macruronus novaezelandiae*)—assessed in Chapter 9 Deepwater flathead (*Neoplatycephalus conatus*) Jackass morwong (*Nemadactylus macropterus*)—assessed in Chapter 9 Ocean jacket (*Nelusetta ayraudi*) Orange roughy (*Hoplostethus atlanticus*) Gemfish (*Rexea solandri*)—assessed in Chapter 9
Other byproduct species	Blue morwong (*Nemadactylus valenciennesi*) Elephant fish (*Callorhinchus milii*)—assessed in Chapter 12 Gould's squid (*Nototodarus gouldi*) Gummy shark (*Mustelus antarcticus*)—assessed in Chapter 12 Knifejaw (*Oplegnathus woodwardi*) Latchet (*Pterygotrigla polyommata*) Ornate angel shark (*Squatina tergocellata*) Pink ling (*Genypterus blacodes*) Red gurnard (*Chelidonichthys kumu*) Saw sharks (*Pristiophorus* spp.)—assessed in Chapter 12 School shark (*Galeorhinus galeus*)—assessed in Chapter 12 Yellow-spotted boarfish (*Paristiopterus gallipavo*)
Fishing methods	Demersal trawl
Primary landing ports	Port Lincoln
Management methods	Input controls: limited entry, area closures, gear restrictions Output controls: TAC distributed as individual transferable quotas for deepwater flathead and bight redfish. There is a 'bycatch' TAC for orange roughy in the Esperance and Albany zones
Management plan	*Southern and Eastern Scalefish and Shark Fishery Management Plan 2003* (DAFF 2003), amended 2006
Harvest strategy	*Southern and Eastern Scalefish and Shark Fishery Harvest Strategy Framework* (Smith & Smith 2005)

Table 11.2 continues over the page

TABLE 11.2 Main features and statistics of the Great Australian Bight Trawl Sector of the SESSF CONTINUED

Feature	Description			
Consultative forums	Great Australian Bight Management Advisory Committee (GABMAC), Great Australian Bight Resource Assessment Group (GABRAG)			
Main markets	Domestic: fresh, frozen International: Europe—frozen			
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Current accreditation dated 2 February 2010 Current accreditation (Wildlife Trade Operation) expires 30 July 2012			
Ecological risk assessment	Level 1: Scale Intensity Consequence Analysis (SICA) completed on 307 species (Daley et al. 2007) Level 2: Productivity Susceptibility Analysis (PSA) completed on 307 species (AFMA 2008b; Daley et al. 2007) Level 3: Sustainability Assessment for Fishing Effects (SAFE) completed on 204 species (Zhou et al. 2007)			
Bycatch workplans	*Great Australian Bight Bycatch and Discarding Workplan (November 2008 to October 2010)* (AFMA 2008a)			
Fishery statistics[a]	**2008–2009 fishing season**		**2009–2010 fishing season**	
Fishing season/year	1 May 2008–30 April 2009		1 May 2009–30 April 2010	
TAC, catch and estimated value:	TAC (t)[b]	Catch (t)	TAC (t)[b]	Catch (t)
—Bight redfish	2000	656	2000	472
—Deepwater flathead	1400	817	1300	855
—Ocean jacket	None	157 (+85 discard)	None	229 (+211 discard)
—Orange roughy	25	0	50	0
Effort	Fishing season 2008-09	Calendar year 2008	Fishing season 2009-10 (preliminary)	Calendar year 2009
	16 205 bottom-time hours	17 901 bottom-time hours	15 413 bottom-time hours	16 870 bottom-time hours
Fishing permits	10		10	
Active vessels	7		4	
Observer coverage	718 trawl hours (4.0%)		0 trawl hours (0%)	
Real gross value of production (2008–09 dollars)	2007–08: $12.8 million		2008–09: $9.0 million	
Allocated management costs	2007–08: $0.5 million		2008–09: $0.6 million	

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; TAC = total allowable catch

a Fishery statistics are provided by fishing season unless otherwise indicated

b Agreed TAC: TACs for individual quota species set annually by the AFMA Commission; the actual TAC may vary depending on carryover of undercatch and overcatch from the previous year.

SOURCES: AFMA (2008a, b, 2009)

11.1 BACKGROUND

The former Great Australian Bight Trawl Fishery (GABTF) is now referred to as the Great Australian Bight Trawl Sector (GABTS) of the Southern and Eastern Scalefish and Shark Fishery (SESSF). The GABTS (Fig. 11.1) can be divided into a continental shelf sub-fishery, in depths of 200 m or less, an upper continental slope sub-fishery (approximately 200–700 m), and a deepwater sub-fishery (on the mid- to lower slope, 700–1000 m).

In shelf waters, the trawlers usually fish at 120–160 m, targeting mainly deepwater flathead (*Neoplatycephalus conatus*) and Bight redfish (*Centroberyx gerrardi*) (Table 11.2). The shelf fishery operates year round, but deepwater flathead catches and catch rates peak in October–December and those of Bight redfish in February–April. Trawlers fishing the upper continental slope primarily target blue grenadier (*Macruronus novaezelandiae*), gemfish (*Rexea solandri*) and pink ling (*Genypterus blacodes*) (Tables 11.2, 11.3). The deepwater fishery historically targeted orange roughy (*Hoplostethus atlanticus*)—in 1988, 68% of the fishery's total effort was on the continental slope. However, apart from research surveys, there is now little effort at these depths, following the 2007 closure of most of the historical orange roughy fishing grounds (>750 m depth). Orange roughy is now a byproduct species with a 'bycatch' total allowable catch (TAC). Byproduct species from historical targeted orange roughy fishing include spikey oreodory (*Neocyttus rhomboidalis*), smooth oreodory (*Pseudocyttus maculatus*), warty oreodory (*Allocyttus verrucosus*) and dogfish (Squalidae). Gulper sharks (Centrophoridae) are also taken as a minor byproduct in the GABTS (see Chapter 9 for more information on gulper sharks).

TABLE 11.3 History of the GABTS of the SESSF

Year	Description
1912	Trawling first took place.
1977 to 1979	British United Trawlers and Southern Ocean Trawlers operated in the Great Australian Bight
1980s	Orange roughy fishery developed in the Commonwealth Trawl Sector and renewed interest in the Great Australian Bight.
1987	Commercial quantities of orange roughy discovered in the Great Australian Bight.
1988	Developmental management plan implemented, including a logbook program.
1989	Orange roughy catches peaked at 3757 t, but then significantly declined.
1992	Initial assessment for Bight redfish, with dominant age classes 12–24 years, compared with 20–40 years in the 1980s.
1993	First fishery to be managed under the *Fisheries Management Act 1991*.
1998	Great Australian Bight Marine Park established to preserve a representative sample of the unique sea floor plants, animals and sediments of the area.
2000	Onboard sampling program initiated to assess catch composition and discarding.
2001	Shark Gillnet and Shark Hook Sector species caught as trawl bycatch subject to management by individual transferable quotas.
2003	Management plan determined.
2005	Harvest strategy adopted by Australian Fisheries Management Authority (AFMA). Annual fishery-independent trawl surveys initiated.
2006	TACs introduced for deepwater flathead, Bight redfish and orange roughy (Albany and Esperance zones). Orange roughy listed as conservation dependent under the EPBC Act. The Orange Roughy Conservation Programme (AFMA 2006) commenced, prohibiting targetted fishing for orange roughy outside the Cascade Plateau (see Chapter 9).
2007	Deepwater Management Strategy implemented for orange roughy and deepwater habitats. Sixteen-month fishing year (season) to run from 1 January 2007 to 30 April 2008.
2008	Fishing year (season) to run from 1 May 2008 to 30 April 2009, and for all subsequent years.
2009	Co-management arrangement between AFMA and the Great Australian Bight Industry Association Inc. trialled.

AFMA = Australian Fisheries Management Authority; GABTS = Great Australian Bight Trawl Sector; SESSF = Southern and Eastern Scalefish and Shark Fishery

11.2 HARVEST STRATEGY

The GABTS uses the same four-tier harvest strategy framework (HSF) as the other sectors of the SESSF (see Chapter 8). Each tier has its own harvest control rule that is used to determine a recommended biological catch (RBC). The RBCs provide the best scientific advice on what the total mortality (landings plus discards) should be for each species or stock and are used to advise on TACs. Revisions to the HSF that were adopted in 2008 for the other sectors of the SESSF (see Chapter 8) have yet to be applied to the GABTS.

The RBCs calculated in 2007 were based on a target reference point of 40% of unfished biomass. The revised default target reference point is 48% of the unfished biomass, as a proxy for the biomass producing maximum economic yield (B_{MEY}). No species in the GABTS are assessed under the Tier 3 or Tier 4 harvest control rules.

In addition to applying the SESSF HSF for deepwater flathead and Bight redfish, the GABTS has implemented a streamlined TAC-setting and research strategy, which sets annual default TACs over two and three years for Bight redfish and deepwater flathead, respectively, so that annual assessments are not needed and costs are reduced. As part of this process, decision rules have been developed for deepwater flathead based on the results of the annual fishery-independent surveys, or where these are not available, based on CPUE indicator rules. These rules set the conditions under which a full stock assessment would be required earlier than the preset interval. The rules appear to be precautionary, but are yet to be formally evaluated.

The GABTS has a development strategy for species not currently under a TAC, with specified actions to occur at specified 'trigger' catch levels. This strategy is designed to improve assessments of species as the size of the catch increases, through an increasingly stringent tiered data collection and assessment process. Firstly, ongoing collection of biological data at specified catch levels. The initial catch trigger—set at 400 t for blue grenadier and gemfish and 100 t for pink ling, blue-eye trevalla, ribaldo and hapuku—requires the initiation of data collection, analysis and the development of an assessment plan. The second trigger level—set at 500 t for blue grenadier and gemfish, 250 t for pink ling, blue-eye trevalla, ribaldo and hapuku, and 2 t for gulper sharks—requires that fishing for that species cease in that year. The third trigger level applies to total catches across the three most recent years and requires a stock assessment to be undertaken; this trigger level is 1000 t (over three years) for blue grenadier and gemfish and 250 t for pink ling. Catches of gemfish (991 t for 2004 to 2006 and 985 t for 2005 to 2007) have come close to the levels that require formal assessments to be undertaken, and an assessment of gemfish (across both the GABTS and the CTS and ScHS) is being undertaken by the RUSS project in 2010.

11.3 THE 2009 FISHERY

Total fishing effort was relatively stable, with 15 413 trawl bottom-time hours in the 2009–10 fishing season, compared with 16 205 hours in 2008–09; a peak of 31 921 bottom-time hours occurred in 2005 (Fig. 11.2a, 11.2b). Vessel numbers decreased from 7 in 2008 to 4 in 2009, from a peak of 12 in 2006. Fishing effort on the shelf in 2009 represented 96% of the total effort, a slight increase from the 2008 shelf effort figure of 94% (Fig. 11.2a). Total landings in 2009 declined from the 2008 level by 13% to 2262 t and were down by 62% from the peak landings of 5933 t in 2004.

Bight redfish trawl catch PHOTO: MIKE GERNER, AFMA

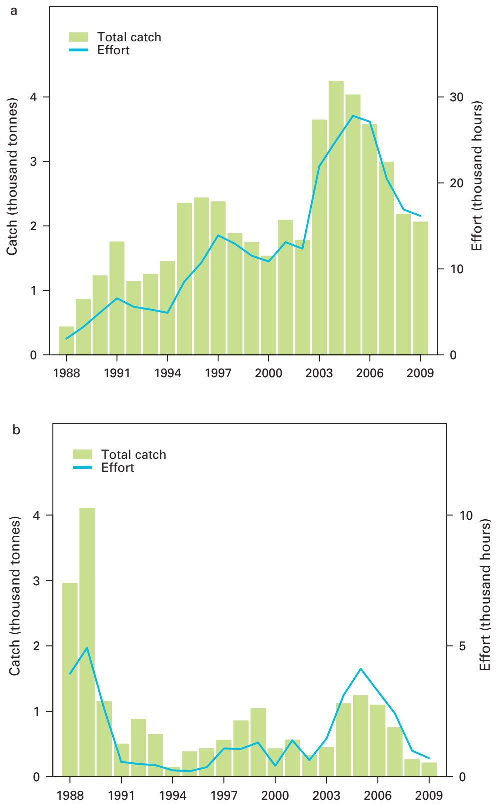


FIGURE 11.2 Catch and effort on the continental a) shelf and b) slope in the GABTS, 1988 to 2009

Key target and byproduct species

The GABTS catch declined by 15% in 2009–10 to 2200 t, partly reflecting slightly lower effort. In recent years the catches of deepwater flathead and Bight redfish have been greater than 60% of landings, and so significantly influence overall catches. In comparision, these species contributed 53% of the catch from 2001 to 2006. The 2009–10 deepwater flathead catch (855 t) was 4% higher than the 2008–09 catch, and the 2009–10 Bight redfish catch (472 t) was 28% lower than the 2008–09 catch. Both catches were well below the RBC and TAC for 2009–10. Catches of orange roughy in 2009–10 were zero, the same as 2008–09.

Landings in the GABTS of scalefish species that are under quota elsewhere in the SESSF (blue grenadier, blue-eye trevalla, jackass morwong, pink ling and gemfish) totalled 126 t and comprised just 6% of the total GABTS landings. This is a decline from 213 t in 2008–09 and 684 t in 2007–08 (Fig. 11.3), due to substantially decreased catches of gemfish and blue grenadier. Landings for all major species declined in 2009–10 (e.g. decline of 12% for angel shark, 97% for blue grenadier, 100% for blue-eye trevalla and 75% for pink ling). Landings of gemfish in 2009–10 were 56 t, with an estimated 2 t discarded, the same amount as reported in 2008–09. Landings of jackass morwong were 72 t with minimal reported discards, down from 2008–09 landings (100 t). Discard levels are from logbook data only and have not been verified by observer data, which was zero in the 2009–10 fishing season. Ocean jacket is included this year for the first time with total landings of 229 t in the 2009–10 fishing season, up from 157 in the previous season (Table 11.2). Discards of this species are typically high with 211 t discarded in 2009–10, bringing the total reported catch to 440 t in 2009–10.

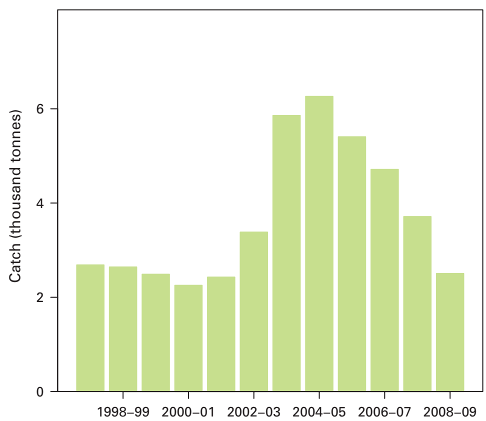


FIGURE 11.3 Catch in the GABTS by financial year, 1997–98 to 2008–09

In 2008–09 the real gross value of production (GVP) of the fishery (Fig. 11.4) decreased by 32% ($4.2 million) to $9 million. This fall was driven by the decline in the catch (landings), despite the increase in the average unit value of the sector. In 2008–09 the average beach price of Bight redfish and deepwater

flathead increased by 3% and 4%, respectively. Despite the price increase, a 16% decline in the catch resulted in a 13% decrease in the GVP of Bight redfish, to $2.4 million, from 2007–08 to 2008–09. The GVP of deepwater flathead fell by 18% to $4.1 million over the same period.

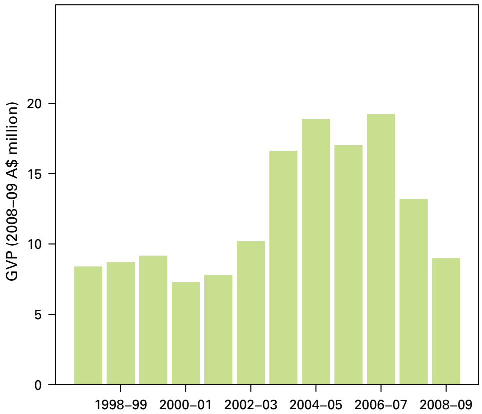


FIGURE 11.4 Real GVP in the GABTS by financial year, 1997–98 to 2008–09

Recent catch totals of TAC species are derived from landing data rather than logbook data; logbook data are sometimes used for non-TAC species. Comparisons across the 2002 to 2004 datasets indicate that logbook data understate catch weights by about 12%, although the difference has been declining in recent years, and the discrepancy varies between species. However, this discrepancy must be taken into account when time series of catch weights are compared.

Minor byproduct species

The main species of byproduct taken and discarded in the GABTS are shown in Table 11.4. Gummy shark and saw shark catches are included in the assessments described in Chapter 12. If catches of angel shark, boarfish and knifejaw increase, these species may require assessment and targeted management arrangements.

TABLE 11.4 Byproduct TACs/triggers, catches/landings and discards in the GABTS

Species	TAC/trigger (tonnes)	2008–09 catch (tonnes)	2008–09 discards (tonnes)	2009–10 catch (tonnes)	2009–10 discards (tonnes)
Angel sharks (*Squatina* spp.)	None	77	0	104	0
Blue grenadier (*Macruronus novaezelandiae*)[a]	400	3	0	1	0
Knifejaw (*Oplegnathus woodwardi*)	None	39	2	36	2
Gemfish (*Rexea solandri*)[a]	400	56	2	56	2
Gould's squid (*Nototodarus gouldi*)[a]	None	40	1	14	<1
Pink ling (*Genypterus blacodes*)[a]	100	2	0	<1	0
Latchet (*Pterygotrigla polyommata*)	None	61	257	43	189
Jackass morwong (*Nemadactylus macropterus*)[a]	None	81	0	63	<1
Blue morwong (*Nemadactylus valenciennesi*)	None	25	0	24	0

Table 11.4 continues over the page

TABLE 11.4 Byproduct TACs/triggers, catches/landings and discards in the GABTS CONTINUED

Species	TAC/trigger (tonnes)	2008–09 catch (tonnes)	2008–09 discards (tonnes)	2009–10 catch (tonnes)	2009–10 discards (tonnes)
Yellow-spotted boarfish (*Paristiopterus gallipavo)*	None	29	0	51	<1
Gummy shark (*Mustelus antarcticus*)[a]	None	29	0	42	0
Red gurnard (*Chelidonichthys kumu*)	None	12	<1	20	0
Saw shark (*Pristiophorus* spp.)[a]	None	22	<1	14	<1
Tuskfish (*Choerodon* spp.)	None	16	0	15	0
Silver trevally (*Pseudocaranx dentex*)	None	10	0	22	<1

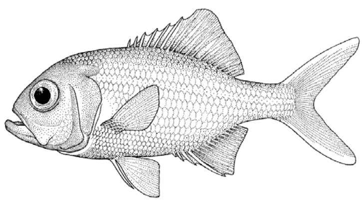
GABTS = Great Australian Bight Trawl Sector; TAC = total allowable catch

a Catches are included in assessments described in other chapters.

11.4 BIOLOGICAL STATUS

BIGHT REDFISH

(*Centroberyx gerrardi*)



LINE DRAWING: FAO

Bight redfish PHOTO: MIKE GERNER, AFMA

TABLE 11.5 Biology of Bight redfish

Parameter	Description
Range	**Species:** Endemic to southern Australia from Western Australia to Bass Strait. **Stock:** The assessment assumes that the stock is the area of the GABTS. Catches from the area of the Commonwealth Trawl Sector and Scalefish Hook Sector of the SESSF are not included in the assessment. State catches are also not included.
Depth	10–500 m
Longevity	64 years
Maturity (50%)	**Size:** 28 cm SL **Age:** not determined
Spawning season	February–April
Size	**Maximum:** ~49 cm FL **Recruitment into the fishery:** age: 15–17 years; size: 24 cm

FL = fork length; GABTS = Great Australian Bight Trawl Sector; SESSF = Southern and Eastern Scalefish and Shark Fishery; SL = standard length

SOURCES: Stokie (2004); Stokie & Krusic-Golub (2005); Knuckey et al. (2009).

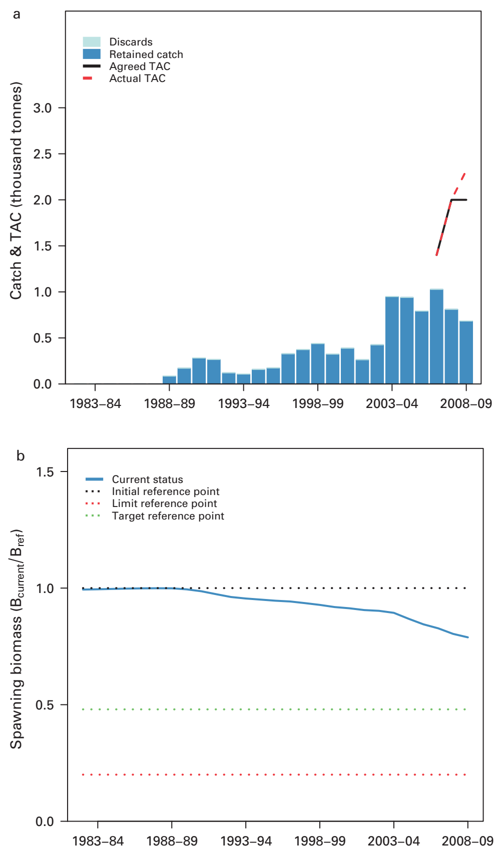


FIGURE 11.5 Bight redfish a) catch history, 1982–83 to 2008–09 and b) estimated spawning stock biomass, 1982–83 to 2008–09

Stock status determination

The RBC calculated by the Great Australian Bight Resource Assessment Group (GABRAG) was 3590 t for the 2009–10 fishing season (GABRAG 2009) with a long-term RBC of 1700 t. The 2009–10 agreed TAC (global) was 2000 t (Table 9.2), however the actual TAC (global) set by the AFMA Commission was 2200 t after the carryover of uncaught quota.

The Bight redfish RBC was estimated from a Tier 1 assessment. The most recent update to previous data includes data up until late 2009, and includes two years of additional data in comparison to the previous assessment (Klaer 2010). The stock assessment undertaken in 2009 used a new version of the stock assessment software Stock Synthesis SS3. The 2009 assessment also includes fishery-independent survey data for 2007–08 and 2008–09 fishing seasons, as an additional index of relative abundance and greater use of empirically derived biological parameters rather than estimates of such parameters. The fishery is currently undergoing a fish-down, with the population estimated at 77.1% of unfished biomass (77.1% B_0) (Fig. 11.5b). The relative biomass (23 410 t) estimated from the 2008 fishery-independent survey (Knuckey et al. 2009) was 62% higher than the previous estimate (14 591 t) and 12% higher than in 2005 (20 887 t). However, the fishery-independent survey noted a progressive step-down in modal length measured yearly from 2005 to 2009 (Knuckey et al. 2009). This may reflect the recent fishing mortality affecting the size structure of the stock. The landed catch of Bight redfish in the 2009–10 fishing season was 472 t (Table 11.2; excluding scientific catch), which was substantially less than the TAC and the long-term RBC. Given the level of depletion estimated by the Tier 1 assessment and the information from the fishery-independent survey, Bight redfish is classified as **not overfished** (Table 11.1). The recent catches have been well below the RBC, and the 2009–10 catch was below both the current and long-term RBC, therefore Bight redfish is assessed as **not subject to overfishing**.

Reliability of the assessment/s

The biomass estimates for Bight redfish have wide confidence limits and have varied substantially as assessments have improved. However, all the assessments have indicated that biomass is well above the target level. Some of the assumptions and values were derived from parameters estimated for similar species. An independent age-determination study of Bight redfish has provided confidence in the aging data (Stokie 2004).

There are large uncertainties about the biomass estimates from the initial trawl surveys, which are sensitive to assumptions about catchability and swept area (Tilzey & Wise 1999). Therefore, the inclusion of that information in assessment models has increased the variability in biomass estimates, especially for Bight redfish.

The trawl survey was designed to provide a time series of relative-abundance indices, rather than to calculate absolute biomass estimates. With the small number of surveys and uncertainties about the extrapolation of survey data to the biomass across the fishery, the estimates of absolute biomass remain highly uncertain; however, the estimates of the extent of depletion have been less variable. Inter-year variability in biomass estimates from the trawl survey is becoming evident. At this stage, the relative contribution to that variability from population changes, seasonal variability and a range of potential sources of measurement error is unclear.

Previous assessment/s

The initial fish-down changed the age structure of the population from predominantly 20–40-year-old fish in the 1980s to 14–24-year-old fish in the early 1990s (Tilzey & Wise 1999). Previous assessments estimated the unfished biomass to be 51 884 t in 2005, 29 763 t in 2006 and 18 685 t in 2007 (Klaer 2005, 2006; Wise & Klaer 2005). The 2007 assessment for Bight redfish estimated that the unfished biomass was 18 685 t (37% lower than the 2006 estimate), with biomass 82% of that level. The RBC for 2007 was 5383 t, with a long-term RBC of 1730 t for a target reference point of 40% of unfished biomass (Klaer 2007).

Future assessment needs

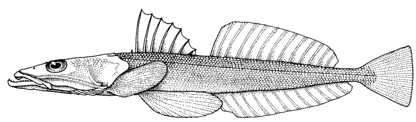
The assessment models for Bight redfish would benefit from ongoing refinements, including the incorporation of discard rates, and further investigation of appropriate ways to weight survey values relative to other data from the fishery. A bioeconomic model for the fishery has been funded to determine B_{MEY} for the Bight redfish and deepwater flathead; this model is due to be completed in October 2010.

Periodic fishery-independent, stratified trawl resource surveys remain a high priority as the most reliable way to obtain a relative index of abundance. They are scheduled for a review to determine whether they should be undertaken annually or less frequently. The need to refine biomass and yield estimates remains, despite the recent decrease in fishing effort.

The onboard scientific observer program gathers valuable information on GABTS bycatch and discarding practices and collecting specific biological material, which is collected biannually. The program, which is industry funded, is needed to provide onboard catch-composition data and biological data. It has recently been complemented by an industry-based catch sampling program for a range of species, but should remain as an important mechanism for catch verification.

DEEPWATER FLATHEAD

(*Neoplatycephalus conatus*)



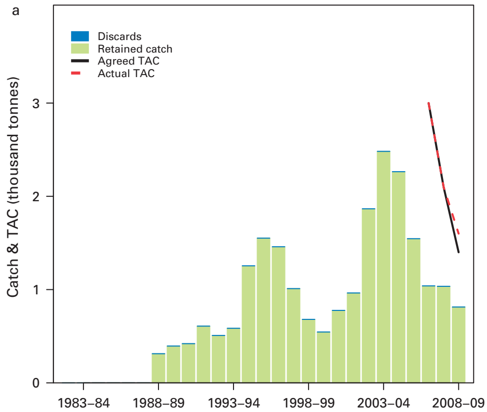
LINE DRAWING: KARINA HANSEN

TABLE 11.6 Biology of deepwater flathead

Parameter	Description
Range	**Species:** Occurs in southern temperate Australian waters from central Victoria to central Western Australia (28°53'S – 33°24'S; 113°41'E – 114°31'E). **Stock:** No data on stock structure. The majority of the catch is taken in the GABTS, and the assessment assumes that the stock is the area of the GABTS. Catches from the area of the Commonwealth Trawl Sector and Scalefish Hook Sector of the SESSF are not included in the assessment.
Depth	70–490 m (demersal)
Longevity	Females ~26 years; males ~19 years
Maturity (50%)	**Age:** females 5–6 years; males 4–5 years **Size:** 43 cm TL; 33 cm SL
Spawning season	October–February
Size	**Maximum:** 94 cm TL; ~4 kg **Recruitment into the fishery:** females ~5 years, males 4 years; size: 33 cm

Great Australian Bight Trawl Sector; SESSF = Southern and Eastern Scalefish and Shark Fishery; SL = standard length; TL = total length

SOURCES: Kailola et al. (1993); Stokie & Talman (2003); Stokie & Krusic-Golub (2005); Klaer (2010); Knuckey et al. (2009).



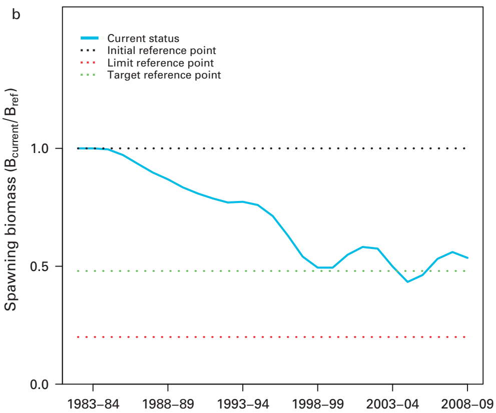


FIGURE 11.6 Deepwater flathead a) catch history, 1982–83 to 2008–09 and b) estimated spawning stock biomass, 1982–83 to 2008–09

Stock status determination

The RBC calculated by GABRAG was 1205 t for the 2009–10 fishing season (GABRAG 2009). The 2009–10 agreed TAC (global) was 1300 t (Table 9.2); however, the actual TAC (global) set by the AFMA Commission was 1519 t after the carryover of uncaught quota.

The RBC for deepwater flathead was estimated from a Tier 1 assessment. The 2009 assessment includes two years of additional catch data and used a new version of the stock assessment software Stock Synthesis SS3 (Klaer 2010). The assessment now includes fishery-independent survey data as an index of relative abundance and greater use of empirically derived biological parameters rather than estimates of these parameters. The fishery is currently undergoing a fish-down, with the population estimated at 49% of unfished biomass ($B_{current}/B_0 = 0.49$) (Fig. 11.6b). As estimated biomass is close to the default B_{MEY} target of B_{48} ($B_{MSY} \times 1.2$), the fishery will need to cease fish-down operations and monitor and control catch and effort to ensure that stock biomass is maintained at or around the levels necessary to pursue MEY. The landed catch of deepwater flathead in the 2009–10 fishing season was 855 t. The relative biomass estimated from the results of the fishery-independent survey (10 181 t) was 25% higher in 2009 than in 2008 and 17% lower than the 2005 estimate of 12 152 t. Recent catches have been well below both the current and long-term RBC (Fig. 11.6a) so deepwater flathead is assessed as **not subject to overfishing** (Table 11.1). The estimated biomass in 2009 indicates that deepwater flathead is **not overfished**.

Reliability of the assessment/s

The biomass estimates for deepwater flathead have wide confidence limits and have varied substantially as assessments have improved. However, the estimates indicate the biomass is near the target level. Some of the assumptions and values were derived from parameters estimated for similar species (i.e. steepness of the stock recruitment relationship). Nevertheless, the need for caution remains because assessments for deepwater flathead are not yet considered to provide robust estimates of biomass or sustainable yield as they tend to rely on estimated parameters.

Previous assessment/s

The initial 1992 estimate of unfished biomass was 32 000 t, with a sustainable yield of 1500–3000 t (Tilzey & Wise 1999). In the mid-to-late 1990s, the catch and catch rates increased, and the proportion of fish over nine years old declined. The 2004–05 assessment, incorporating data from a 2005 trawl survey, produced a higher estimate of the unfished biomass of 27 398 t, with a maximum sustainable yield (MSY) of 2000 t per year. The estimates were lower (19 260 t and an MSY of 1660 t) if the survey data were not used. The 2006 catch was 1155 t. The 2006

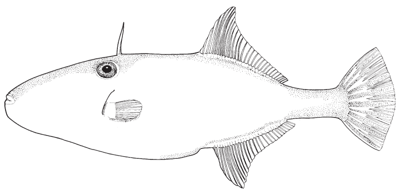
assessment estimated the unfished biomass as 10 087 t and the 2007 assessment estimated unfished biomass as 8836 t (Fig. 11.6b).

Future assessment needs

These are similar to the needs identified above for Bight redfish.

OCEAN JACKET (western)

(*Nelusetta ayraudi*)



LINE DRAWING: FAO

TABLE 11.7 Biology of ocean jacket

Parameter	Description
Range	**Species:** Occurs in southern Australia from Cape Moreton in Queensland to North West Cape in Western Australia, but excluding Tasmania. This species is considered to be endemic to Australia, although a single specimen has been reported from New Zealand. **Stock:** Also occurs in Commonwealth Trawl Sector and Scalefish Hook Sector. Stock from the eastern Great Australian Bight and the south-east of South Australia are considered a common stock.
Depth	0–360 m, usually 0–200 m. Adults are found on the continental shelf and slope, while juveniles school seasonally in inshore waters.
Longevity	<9 years
Maturity (50%)	**Age:** 2.5 years **Size:** ~35 cm TL
Spawning season	Spawning occurs from July to September, with a peak during August in northern New South Wales. In South Australia, ocean jackets spawn between late April and early May in waters 85–200 m deep, several hundred kilometres offshore.
Size	**Maximum:** 100 cm TL; 3.5 kg. **Recruitment into the fishery:** 22 cm TL; fully recruited at 2 years

TL = total length

SOURCES: Kailola et al. (1993); Miller (2007); Froese & Pauly (2009); Miller & Stewart (2009).

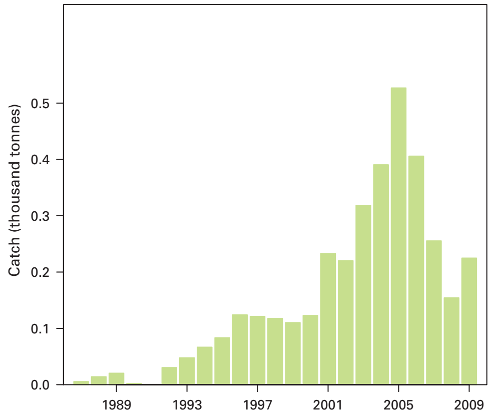


FIGURE 11.7 Ocean jacket catch history, 1987 to 2009

Stock status determination

Ocean jacket, which is not under quota, is included in this years report because its catch levels are the third highest in the sector and may therefore warrant formal stock assessment and/or additional stock-specific management arrangements. In the case of ocean jacket, they are considered an important byproduct stock from both an ecological and economic position. The total catch (landings and discards) of ocean jacket has been in the top four most commonly caught and landed stocks in the GABTS over the past five years and the value of the total catch landed is considered to be an important economic component of the fishery, and continues to increase.

There is currently no quantitative stock assessment for ocean jacket. As there is no formal stock assessment for ocean jacket in the GABTS, stock status is **uncertain** for both the overfished and overfishing categories (Table 11.1). Our preliminary review of trends in CPUE (unstandardised) in the GABTS suggest that there is no cause for immediate concern. However, with total catch increasing from 14 t in 1988 to 526 t in 2005, and then decreasing to only 154 t in 2008 (Fig. 11.7), it may warrant further examination. This could reflect changes in effort levels, spatial distribution, or the biomass. During the 2009–10 fishing season, a total of 224 t of ocean jacket were landed.

Reliability of the assessment/s

There is no formal assessment of the ocean jacket stock fished by the GABTS operators.

Previous assessment/s

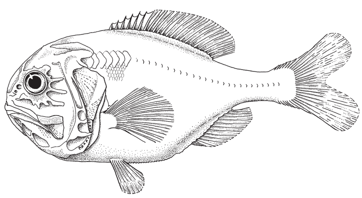
None.

Future assessment needs

A formal Tier 4 assessment for ocean jacket in the GABTS based on standardized CPUE would provide clearer information for stock status determination. Given the level of catch and value of the species a greater understanding of the stock status is required.

ORANGE ROUGHY

(*Hoplostethus atlanticus*)



LINE DRAWING: ROSALIND MURRAY

TABLE 11.8 Biology of orange roughy

Parameter	Description
Range	**Species:** Occurs in all temperate oceans except the north Pacific; in Australia, it occurs across the south coast from Sydney to Perth and is found in continental slope and seamount areas. **Stock:** For management purposes, orange roughy in the GABTS is considered a separate stock.
Depth	Ranges between 180–1800 m, but usually found at 400–1000 m
Longevity	90–150 years
Maturity (50%)	**Age:** 20–30 years **Size:** ~25–30 cm SL
Spawning season	July–August
Size	**Maximum:** ~50–60 cm SL; weight: 3–4 kg **Recruitment into the fishery:** 24–42 years; size: ~30 cm SL

GABTS = Great Australian Bight Trawl Sector; SL = standard length

SOURCES: Gomon et al. (2008).

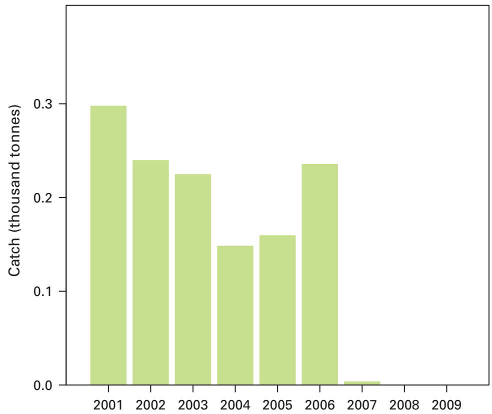


FIGURE 11.8 Orange roughy catch history, 2001 to 2009

Stock status determination

There was no assessment of orange roughy in 2009, and the overfished status remains **uncertain** (Table 11.1). No quantitative assessment has been conducted because the data are both sporadic and spatially scattered. The TAC in 2009 remained at bycatch levels (50 t) for the Albany/Esperance Zone, and a zero commercial catch for orange roughy was reported in 2009 (Fig. 11.8). A deepwater management strategy has been developed and implemented to address the requirements of the Orange Roughy Conservation Programme (ORCP). The strategy identifies orange roughy 'research zones' that include the areas of the Bight from which more than 96% of the catch of orange roughy has historically been taken (1988 to 2005) and from which more than 99% of the more recent catch was taken (2001 to 2005). Until sustainable harvest levels can be determined, fishing will only be allowed in these zones if conducted under a research program that has been approved by the Australian Fisheries Management Authority (AFMA). Given the low catch levels and the deepwater management strategy, orange roughy remains assessed as **not subject to overfishing**.

Reliability of the assessment/s

There is no formal assessment of the orange roughy stock fished by the GABTS.

Previous assessment/s

See ORCP discussed above.

Future assessment needs

A review of orange roughy assessments and monitoring arrangements will take place in 2011, as required by the ORCP. In addition, a recent review of the stock assessment process, also required by the ORCP, provided comments and suggestions that will need to be considered and incorporated during any future formal assessments. Size–age data collected from the Albany/Esperance zone, to where the catches are now confined, would be useful for conducting future assessments.

11.5 ECONOMIC STATUS

The key species targeted in the GABTS are being caught under quota, and quota has remained unfilled in recent years. In the 2008 SESSF fishing season, only 10% of the Bight redfish TAC and 26% of the deepwater flathead TAC were caught. This was a substantial decline from the 2007 SESSF fishing season, when 41% of the Bight redfish TAC and 57% of the deepwater flathead TAC were caught (Tables 11.9, 11.10). In the 2009 SESSF fishing seasons, the percentage of TAC caught for Bight redfish was 8% and for deepwater flathead was 32%. These two species contributed to 72% of the GVP of the fishery in 2008–09. A high level of latency in the fishery is indicative of low profitability, and net economic returns of the fishery are likely to be low. Profitability in the GABTS, as a trawl fishery, is particularly susceptible to sharp rises in fuel costs, and higher fuel prices in 2007–08 are likely to have adversely affected profitability in that year. Lower fuel prices and improved prices for the key species caught in the fishery in 2009 indicate that profitability may have improved in 2008–09.

TABLE 11.9 Latency for Bight redfish by SESSF fishing season, 2006 to 2009

	2006	2007	2008	2009
Agreed TAC	1400 t	3338 t	2000 t	2000 t
Catch	912 t	1047 t	222 t	171 t
% TAC caught	65%	41%	10%	8%

SOURCE: AFMA Catchwatch (2007–2009).

TABLE 11.10 Latency for deepwater flathead by SESSF fishing season, 2006 to 2009

	2006	2007	2008	2009
Agreed TAC	3000 t	2129 t	1400 t	1400 t
Catch	1266 t	1370 t	415 t	481 t
% TAC caught	42%	57%	26%	32%

SOURCE: AFMA Catchwatch (2007–2009).

11.6 ENVIRONMENTAL STATUS

Information gathered by the onboard observer program has shown modest discarding of commercial species, but substantial discarding (about 44% by weight of the overall catch) of non-commercial species in continental-shelf waters. Discarding during the 2009–10 fishing season is not available due to zero observer coverage in that year. The discards include large quantities of fish with potential, but little current, commercial value. Comparatively few juvenile deepwater flathead and Bight redfish are caught and discarded, probably because trawling is rare in waters shallower than 100 m, where juveniles reside. However, latchets, for which there is currently only a small market, have been discarded in large numbers. Historically, bycatch and discarding by trawlers operating on the mid- to lower continental-slope and targeting orange roughy, were very low (about 4% by weight). The onboard observer program reported no bycatch of marine mammals and birds.

There is developing interest in the potential for midwater trawling in the Great Australian Bight for small pelagic species such as jack mackerel (*Trachurus declivis*), blue mackerel (*Scomber australasicus*) and Gould's squid (*Nototodarus gouldi*). If commercial operations start, the bycatch will need to be closely monitored. Should large catches of the target species be taken, consideration should also be given to the trophic implications of harvesting key prey species of predators such as southern bluefin tuna (*Thunnus maccoyii*), marine mammals and seabirds—particularly as the Australian sardine (*Sardinops neopilchardus*) catch has increased sharply in recent years.

Fishing in the Great Australian Bight
PHOTO: MIKE GERNER, AFMA

Four new areas have been closed to fishing in response to the needs of the ORCP and to protect deepwater habitats and species. The closures complement existing closures in the Great Australian Bight Marine Park and the Murray Marine Protected Area, and the gulper shark closure. There is potential for further marine protected areas to result from the South-west Marine Bioregional Planning process of the Department of the Environment, Water, Heritage and the Arts.

The GABTS is trialling co-management to streamline TAC-setting processes and research, improve data collection programs (e.g. electronic logbooks, reporting of bycatch, biological data), enhance management advisory procedures, and introduce vessel-specific operational procedure manuals, and training of crew. Vessel-specific management plans are intended to assist in reducing the risk of interactions with threatened, endangered and protected species.

Ecological risk assessment

In 2008 AFMA released the ecological risk management report for the GABTS (AFMA 2008b). The report identifies two byproduct invertebrate species groups that have been assessed as being at high risk (Level 2 residual risk assessment), primarily due to a lack of data: cuttlefish (various species) and octopods (various species). A Level 3 Sustainability Assessment for Fishing Effects indicated that none of the 204 assessed species had a fishing mortality level greater than the reference point (Zhou et al. 2007). AFMA is currently developing a policy to address any gaps in the management of byproduct species in Commonwealth fisheries.

Threatened, endangered and protected species

Sharks

Limited interactions with protected shark species are currently reported in logbooks.

Seabirds

Seabirds are known to interact with trawling activities and are vulnerable to warp strike, predominantly during hauling (Phillips et al. 2010). The Great Australian Bight Industry Association has been supportive of action under the bycatch workplan to design and implement vessel-specific management plans to reduce the risk to seabirds, including at-sea independent observer assessment of fishing practices and observations of seabird behaviour. As part of the export accreditation requirements for the SESSF, AFMA has been directed to investigate the extent and nature of seabird interactions in the trawl sectors of the SESSF and, where necessary, to develop and implement effective seabird mitigation measures.

Benthic habitats

Most shelf trawls are on soft, sandy substrates with little sessile fauna or flora, but some 'exploratory' shots near the established grounds contain substantial benthos. The current FRDC project 2006/036 'Supporting sustainable fishery development in the GAB with interpreted multi-scale seabed maps based on fishing industry knowledge and scientific survey data' may provide useful information and tools to better understand benthic habitats and sustainable management of the GABTS.

11.7 HARVEST STRATEGY PERFORMANCE

Only deepwater flathead and Bight redfish have been managed by specific objectives within the broad ecologically sustainable development and economic objectives of the Fisheries Management Act. Target and limit reference points have now been developed for the two species as part of the harvest strategy being implemented for the SESSF, and these have been used to determine the species' biological status.

Assessments are also supported by the results of annual fishery-independent surveys that provide indices of abundance. These measures, if fully implemented and maintained, should help to ensure that catches remain sustainable and do not increase without appropriate consideration of the impacts on stocks. This should constrain effort to levels that are appropriate for the fishery. If future TACs are set in accord with the agreed harvest control rules, the fishery should be demonstrably within sustainable limits. Nevertheless, the need for caution remains because assessments for deepwater flathead and Bight redfish

Trawl catch PHOTO: MIKE GERNER, AFMA

are not yet considered to provide robust estimates of biomass or sustainable yield as they tend to rely on estimated parameters. Proposals for refinements to the harvest strategy, particularly for the implementation of multiyear TACs and less frequent assessments, require careful evaluation to reduce the risk of indicators exceeding reference points.

A strategy implemented in 2006 requires increased data collection and assessment if catch levels increase to specified trigger levels for each of the main non-quota target species in the GABTS. The GABTS lands some species that appear to be part of single stocks common to the GABTS and other SESSF sectors. Joint management arrangements or global TACs for these species are needed. For example, the catch of gemfish in recent years has exceeded the Commonwealth Trawl Sector's total for the species and has been well in excess of that sector's TAC.

The small number of operators and their continued willingness to support a range of voluntary conservation and management measures are also positive indicators for the sector.

Unloading catch PHOTO: MIKE GERNER, AFMA

11.8 LITERATURE CITED

AFMA (Australian Fisheries Management Authority) 2006, *Orange Roughy Conservation Programme*, AFMA, Canberra, <www.afma.gov.au/fisheries/sess/sess/notices/2006/n20061207.pdf>.

AFMA (Australian Fisheries Management Authority) 2008a, *Great Australian Bight Bycatch and Discarding Workplan, 1 November 2008 to 31 October 2010*, AFMA, Canberra, ACT.

——2008b, *Residual risk assessment of the level 2 ecological risk assessment species results: report for the Great Australian Bight trawl sub-fishery of the Southern and Eastern Scalefish and Shark Fishery*, AFMA, Canberra.

——2009, *Southern and Eastern Scalefish and Shark Fishery—Great Australian Bight Trawl Sector management arrangements booklet*, AFMA, Canberra, <www.afma.gov.au/fisheries/sess/sess/publications/GABTS_man_plan_09.pdf>.

AFMA Catchwatch 2007–2009, *TAC and catch data available for the 2007 to 2009 SESSF fishing season*, AFMA, Canberra, <afma.gov.au/fisheries/sess/sess/publications/catchwatch>.

DAFF (Australian Government Department of Agriculture, Fisheries and Forestry) 2003, *Southern and Eastern Scalefish and Shark Fishery Management Plan 2003* (amended 2006), DAFF, Canberra, Federal Register of Legislative Instruments F2007C00069.

Daley, R, Knuckey, I, Dowdney, J, Williams, A, Bulma, C, Sporcic, M, Fuller, M & Smith, T 2007, *Draft ecological risk assessment for the effects of fishing: report for the Great Australian Bight trawl sub-fishery of the Southern and Eastern Scalefish and Shark Fishery*, report for the AFMA, Canberra.

Froese, R & Pauly, DE 2009, *FishBase*, version 02/2010, FishBase Consortium, <www.fishbase.org>.

Gomon, M, Bray, D & Kuiter, R 2008, *Fishes of Australia's south coast,* New Holland Publishers, Sydney.

Kailola, PJ, Williams, MJ, Stewart, PC, Reichelt, RE, McNee, A & Grieve, C 1993, *Australian fisheries resources*, Bureau of Resource Sciences & the FRDC, Canberra.

Klaer, N 2005, *Modified base case for Bight redfish (Centroberyx gerrardi) in the Great Australian Bight Trawl Fishery (GABTF) September 2005,* report to the AFMA, Canberra.

——2006, *Updated stock assessment for deepwater flathead (Neoplatycephalus conatus) and Bight redfish (Centroberyx gerrardi) in the Great Australian Bight Trawl Fishery using data to June 2006,* report to the AFMA, Canberra.

——2007, *Updated stock assessment for deepwater flathead (Neoplatycephalus conatus) and Bight redfish (Centroberyx gerrardi) in the Great Australian Bight Trawl Fishery using data to June 2007,* report to the AFMA, Canberra.

——2010, 'Stock assessment for Bight redfish (*Centroberyx gerrardi*) and projection for deepwater flathead (*Neoplatycephalus conatus*) in the Great Australian Bight trawl fishery using data to June 2009' in Tuck, G.N. (ed.) 2010. *Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery 2009*. Part 1. AFMA and CSIRO Marine and Atmospheric Research, Hobart, pp 312–333.

Knuckey, I, Koopman, M & Hudson, R 2009, *Resource survey of the Great Australian Bight Trawl Fishery*, report to the AFMA, Canberra.

Miller, ME 2007, 'Key biological parameters and commercial fishery for ocean leatherjackets *Nelusetta ayraudi* (Monacanthidae) off the coast of New South Wales, Australia', MEnvSc thesis, School of Biological Sciences, University of Wollongong, <ro.uow.edu.au/theses/26>.

——& Stewart, J 2009, 'The commercial fishery for ocean leatherjackets (*Nelusetta ayraudi*, Monacanthidae) in New South Wales, Australia', *Asian Fisheries Science*, vol. 22, no. 1, pp. 257–64.

Phillips, K, Giannini, F, Lawrence, E & Bensley, N 2010, *Cumulative assessment of the catch of non-target species in Commonwealth fisheries: a scoping study*, Bureau of Rural Sciences, Canberra.

Smith, ADM & Smith, DC 2005, *A harvest strategy framework for the SESSF*, report to the AFMA, Canberra.

Stokie, TK 2004, *Age estimation of Bight redfish (Centroberyx gerrardi)*, report to the AFMA, Canberra.

——& Talman, S 2003, *Age estimation of deepwater flathead (Neoplatycephalus conatus)*, report to the AFMA, Canberra.

——& Krusic-Golub, K, 2005, Age estimation of Bight redfish and deepwater flathead in the Great Australian Bight Trawl Fishery, 2004/05, AFMA, Canberra.

Tilzey, RDJ & Wise, B 1999, *Fishery Assessment Report: The Great Australian Bight Trawl Fishery 1998, Stock Assessment Report*, Bureau of Rural Sciences, Canberra.

Wise, B & Klaer, N 2005, *Updated stock assessment for deepwater flathead (Neoplatycephalus conatus) and Bight redfish (Centroberyx gerrardi) in the Great Australian Bight Trawl Fishery (GABTF) September 2005,* report to the AFMA, Canberra.

Zhou, S, Smith, T, & Fuller, M 2007, *Rapid quantitative risk assessment for bycatch species in selected Commonwealth fisheries*, report to the AFMA, Canberra.

12 Shark Gillnet and Shark Hook sectors

I Stobutzki, A Moore and C Perks

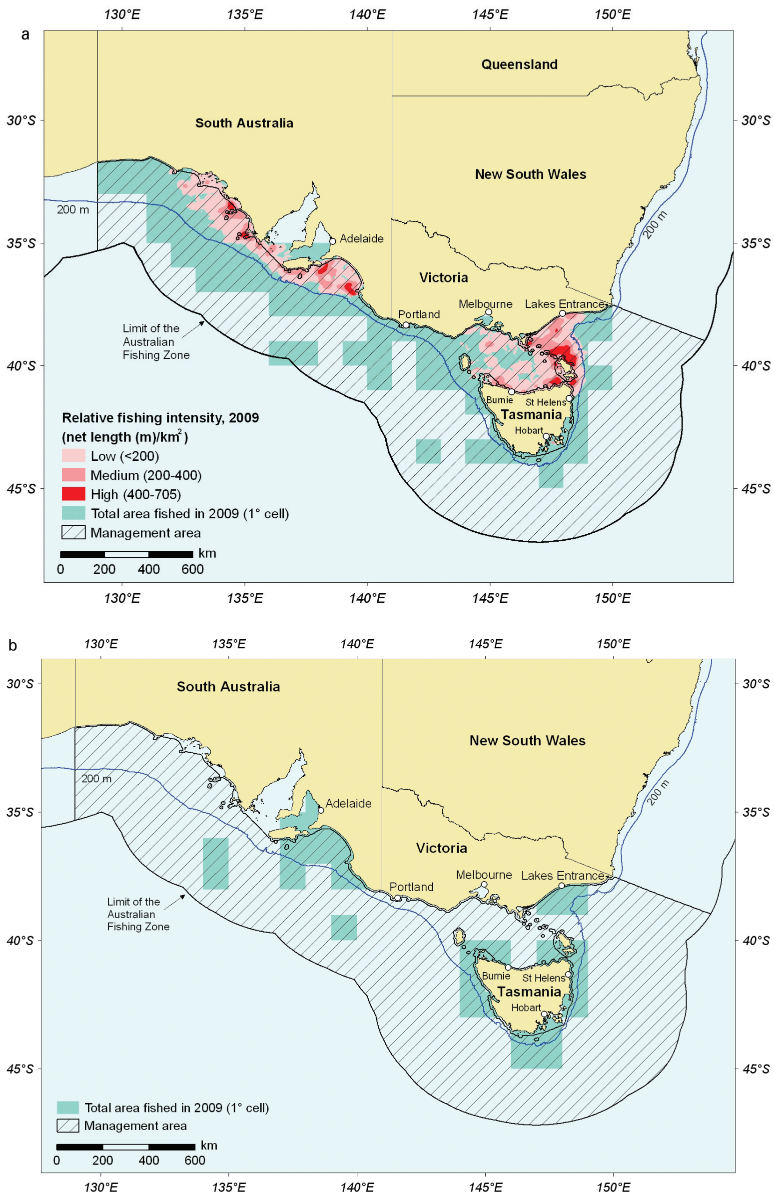


FIGURE 12.1 Relative fishing intensity in the a) Shark Gillnet Sector and b) Shark Hook Sector of the SESSF, 2009

TABLE 12.1 Status of the Shark Gillnet and Shark Hook sectors

Fishery status	2008		2009		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Elephant fish (*Callorhinchus milii*)	Uncertain	Uncertain	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Tier 4 assessment suggests close to CPUE target; current catch is in line with assessment.
Gummy shark (*Mustelus antarcticus*)	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	No recent stock assessment. 2006 assessment estimated pup production at 40% unexploited levels. Catch and CPUE indicators are positive.
Sawshark (*Pristiophorus cirratus*, *P. nudipinnis*)	Uncertain	Uncertain	Uncertain	Uncertain	Tier 4 assessment, but a multi-species stock. Decreasing trend in standardised CPUE.
School shark (*Galeorhinus galeus*)	Uncertain	Overfished / overfishing	Overfished / overfishing	Overfished / overfishing	Tier 1 assessment estimates pup production is below 20% of unexploited levels. Targeted fishing occurring, and catch levels are unlikely to facilitate recovery.
Economic status Fishery level	Net economic returns were $5.0 million in 2007–08 (preliminary estimate)		Estimates of net economic returns not available for 2008–09 but likely to still be positive		Although net economic returns have been positive, evidence suggests that economic status could be further improved, however, more research is required.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING — OVERFISHED / OVERFISHING — UNCERTAIN — NOT ASSESSED

CPUE = catch per unit effort

TABLE 12.2 Main features and statistics of the Shark Gillnet and Shark Hook Sectors of the SESSF

Feature	Description
Key target and byproduct species	Elephant fish (*Callorhinchus milii*) Gummy shark (*Mustelus antarcticus*) Sawsharks (predominantly *Pristiophorus cirratus* and *P. nudipinnis*) School shark (*Galeorhinus galeus*)
Other byproduct species	Other sharks (whiskery, broadnose sevengill) and some finfish (boarfish)
Fishing methods	Demersal gillnet, demersal longline
Primary landing ports	Lakes Entrance, San Remo, Port Welshpool, Devonport
Management methods	Input controls: SFRs (granted in 2010), gear restrictions, closed areas Output controls: individual transferable quotas for the four main species; legal minimum lengths
Management plan	*Southern Scalefish and Shark Management Plan 2003* (DAFF 2003) (amended 2006)
Harvest strategy	*Southern and Eastern Scalefish and Shark Fishery Harvest Strategy Framework* (Smith & Smith 2005)
Consultative forums	South East Management Advisory Committee (SEMAC), Shark Resource Assessment Group (SharkRAG)
Main markets	Domestic: Melbourne—fresh, frozen
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Current accreditation dated 2 February 2010 Current accreditation (Wildlife Trade Operation) expires 30 July 2012

Table 12.2 continues over the page

TABLE 12.2 Main features and statistics of the Shark Gillnet and Shark Hook sectors of the SESSF CONTINUED

Feature	Description			
Ecological risk assessment	Level 1: Scale, Intensity, Consequence Analysis (SICA) completed on 329 species (Walker et al. 2007) Level 2: Productivity Susceptibility Analysis (PSA) completed on 329 species—21 high risk species (Walker et al. 2007) Level 3: Sustainability Assessment for Fishing Effects (SAFE) completed on 195 species (40 chondrichthyans and 155 teleosts)—13 high risk species (Zhou et al. 2007) Residual risk assessment—9 high risk species (AFMA 2010a)			
Bycatch workplans	Shark Gillnet Bycatch and Discarding Workplan, 1 July 2009 to 30 June 2011 (AFMA 2009a)			
Fishery statistics[a]	**2008–2009 fishing season**		**2009–2010 fishing season**	
Fishing season/year	1 May 2008–30 April 2009		1 May 2009–30 April 2010	
TAC and catch by species (carcase weight; Commonwealth fishers):	TAC[b] (tonnes)	Catch (SHSGS, non-SHSGS) (tonnes)	TAC[a] (tonnes)	Catch (SHSGS, non-SHSGS) (tonnes)
—elephant fish	94	87 (58, 29)	94	91 (51, 40)
—gummy shark	1717	1764 (1670, 95)	1717	1565 (1483, 82)
—sawshark	312	230 (132, 98)	312	192 (90, 102)
—school shark	240	228 (215, 12)	240	204 (187, 17)
Effort	Gillnet: 35 516 km lifts Hook: 434 329 hooks		Gillnet: 37 135 km lifts Hook: 609 760 hooks	
Fishing permits	Gillnet: 62 Hook: 13		Gillnet: 62 Hook: 13	
Active vessels	62		44	
Observer coverage	Gillnet: 155.4 km lifts (0.44%) Hook: zero		Gillnet: 214.2 km lifts (0.58%) Hook: zero	
Real gross value of production (2008–09 dollars)	2007–08: $20.7 million		2008–09: $21.5 million	
Allocated management costs	2007–08: $2.2 million (GHTS)		2008–09: $1.7 million (GHTS)	

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; GHTS = Gillnet, Hook and Trap Sectors; SESSF = Southern and Eastern Scalefish and Shark Fishery; SHSGS = Shark Hook and Shark Gillnet Sector; TAC = total allowable catch

a Fishery statistics are provided by fishing season unless otherwise indicated

b Agreed TAC: TACs for individual quota species set annually by the AFMA Commission; the actual TAC may vary depending on carryover of undercatch and overcatch from the previous year. The TAC shown is for all sectors and fisheries (State and Commonwealth)

12.1 BACKGROUND

The Southern Shark Fishery began as a longline fishery, targeting school shark, which were marketed domestically. The move to monofilament gillnets and concern over mercury content in large sharks saw gummy shark become the principal species in the catch (Table 12.2). Gummy shark has been the main species in Bass Strait catches since the early 1970s, but the transition from targeting school shark to gummy shark came later in South Australia and Tasmania. Sawshark, elephant fish and several other shark species also became more important with the gear changes.

Following the introduction of individual transferable quotas (ITQs) as the major management control for school and gummy shark in 2001 (Table 12.3), input controls for the fishery were amended to remove previous hook restrictions and allow all permit holders to use up to 4200 m of gillnet. These changes had the potential to increase effort, but monitoring since 2001 has not shown a marked increase in gillnet effort—gillnet effort since 2001 has been less than half

the 1987 peak (99 000 km gillnet lifts). The main gear in the current fishery is gillnets with 6-inch mesh size. The size selectivity of gillnets strongly influences the size composition of the catches and is an important factor in management of these stocks.

The Shark Gillnet Sector and the Shark Hook Sector (Fig. 12.1) were formerly managed as the Southern Shark Fishery. They are now part of the Gillnet, Hook and Trap Sector of the larger Southern and Eastern Scalefish and Shark Fishery (SESSF).

TABLE 12.3 History of the Shark Hook and Shark Gillnet sectors of the SESSF

Year	Description
1927	Shark fishing first recorded in southern Australia.
1930s	Catches of 400–500 t per year sold through Melbourne fish markets (mainly school shark).
1940s	Fishery expanded due to demand for vitamin A from shark liver oil.
1960	Demand for shark meat grew in Victoria, and catches increased to more than 3000 t. Gillnets introduced to the fishery.
1970s	Concern over mercury in shark led to decreased demand and lower catches (large school shark banned from sale from 1972 to 1985). Gillnets dominant fishing method and gummy shark the main species in the catch.
1980s	Fishery open access until 1984. Commonwealth began endorsing Commonwealth fishing vessel licences, allowing operators to take shark with gillnets of mesh size exceeding 150 mm. Fishing effort for shark peaked in the late 1980s.
1987	Total shark catch peaked at 4226 t (carcass weight).
1988	Southern Shark Fishery Management Plan (1988) established under the *Fisheries Act 1952*. Creation of a limited-entry gillnet fishery that reduced nominal gillnet-fishing capacity. This led to a restructuring of the fishing fleet, fishing capacity restrictions and issuing of net units to operators based on catch history. Each net unit permitted use of a standard gillnet with a headline length of 6000 m, 20 meshes deep and mesh size of not less than 150 mm. Victoria banned targeted shark fishing in coastal waters (out to 3 nm).
1990 to 1993	Amalgamation of endorsements and interim net reductions introduced to reduce overall fishing capacity. Each net unit reduced from 6000 m to 4200 m. School shark assessment raised concern over overfished status of stock.
1994	Hook permits introduced based on shark catch history.
1997	An upper mesh size limit of 165 mm introduced to protect adult school shark.
2000	Offshore Constitutional Settlement arrangements signed between the Commonwealth and Tasmania and South Australia, giving the Commonwealth jurisdiction from the low water mark to the boundary of the Australian Fishing Zone. The Commonwealth conducted a buyout of 40 operators from the fishery.
2001	Jurisdiction over school shark and gummy shark in Victorian coastal waters ceded to the Commonwealth under Offshore Constitutional Settlement. Individual transferable quotas (based on catch history, 1994–1997) introduced for school and gummy shark as the main management control.
2002	Individual transferable quotas introduced for sawshark and elephant fish. Quota can be traded across methods in the SESSF.
2003	Southern and Eastern Scalefish and Shark Fishery Management Plan 2003 established under the *Fisheries Management Act 1991*. Consequently, the former Southern Shark Fishery is managed as part of the GHTS of the SESSF.
2004	Coastal waters closed to protect school shark pupping areas: all waters within 3 nm of Victorian coast and identified pupping areas in Tasmanian waters.
2006	Structural adjustment package removed 26 gillnet vessel SFRs (leaving 62) and 17 shark hook vessel SFRs (leaving 13).
2007	An interim 16-month fishing season ran from 1 January 2007 to 30 April 2008, with quotas pro-rated to account for this extended season. South-east network of marine protected areas declared under EPBC Act. Gulper shark closure for Harrisson's dogfish (eastern Bass Strait). Gillnet 183 m depth closure: most areas deeper than 183 m closed to shark gillnet. West coast Tasmania shark hook and gillnet depth closure: areas deeper than 130 m closed to shark hook and gillnet. Auto-longline closure: areas shallower than 183 m closed to auto-longline. Kangaroo Island and Pages Islands closures to protect Australian sea lions.

Table 12.3 continues over the page

TABLE 12.3 History of the Shark Hook and Shark Gillnet Sector of the SESSF CONTINUED

Year	Description
2008	Fishing year over which quotas apply changed to 1 May to 20 April. Areas important to sharks in Bass Strait and inshore western Victoria and eastern South Australia closed to trawling. School Shark Rebuilding Strategy released.
2009	School shark listed as conservation dependent under EPBC Act. Interim management measures, voluntary closures (4 nm around colonies) and increased observer coverage implemented, while long-term management measures to mitigate gillnet fishery interactions with Australian sea lions are developed by 20 June 2010.
2010	SFRs granted 1 May. ERAEF reports released, along with residual risk assessment and ecological risk management report.

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; SESSF = Southern and Eastern Scalefish and Shark Fishery; ERAEF = ecological risk assessment of the effects of fishing; GHTS = Gillnet, Hook and Trap Sectors; SFR = statutory fishing right

SOURCES: Punt & Pribac (2001); Wilson et al. (2009); AFMA (2009b)

12.2 HARVEST STRATEGY

See Chapter 8.

12.3 THE 2009 FISHERY

The Australian Fisheries Management Authority (AFMA) sets 'global' total allowable catches (TACs) for gummy shark, sawshark and elephant fish that apply across all sectors of the SESSF (Table 12.2) and a 'bycatch TAC' for school shark. The total landed shark catch in the Shark Hook and Shark Gillnet sectors (SHSGS) of the SESSF was 1811 t in 2009–10, consistent with the catches of 1900–2000 t over the past six years (Fig. 12.2). During this time, effort levels have declined (Fig. 12.2), leading to an overall improvement in catch rates for the fishery.

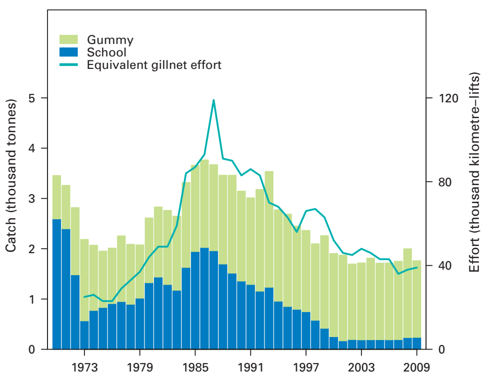


FIGURE 12.2 Catch and effort in the Shark Hook and Shark Gillnet Sector, 1970 to 2009

In the 2009–10 fishing season, gummy shark reported landings were 1565 t (approximately 1483 t by shark hook and gillnet (Fig. 12.2) and 82 t by the trawl fisheries). The landings of sawshark have been declining since 2004 (208 t), with 192 t landed in the 2009–10 fishing season, but the TAC has not been filled in recent years. The landings of elephant fish increased to 91 t in the 2009–10 fishing season, but again the TAC was not filled (Table 12.2). Substantial proportions of the catch of these species were taken in the trawl sectors, as well as the SHSGS.

The school shark rebuilding strategy set a 'bycatch TAC' of 240 t, which became an actual TAC of 255 t after the carryover of uncaught quota from the 2008–09 fishing season. A total of 204 t was landed, 187 t by the SHSGS and 17 t by other sectors.

The real gross value of production (GVP) in the SHSGS rose by $1.3 million (6%) to $22.9 million in the 2008–09 financial year (Fig. 12.3). The main contributor to this increase was a $1.0 million rise in the value of gummy shark production, to $19.1 million. This resulted from a 16% increase in real average unit price, offsetting a 10% decrease in production volume. Other important shark species included school shark and sawshark, valued at $2.3 million and $1.1 million, respectively, in the 2008–09 financial year.

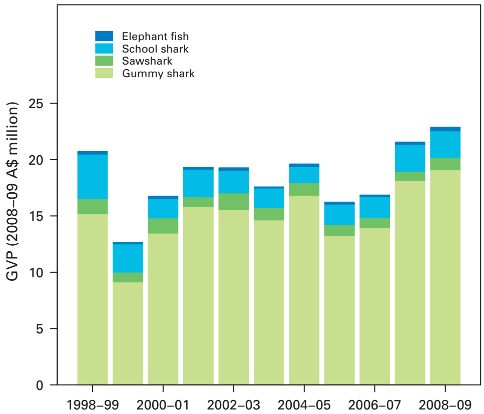
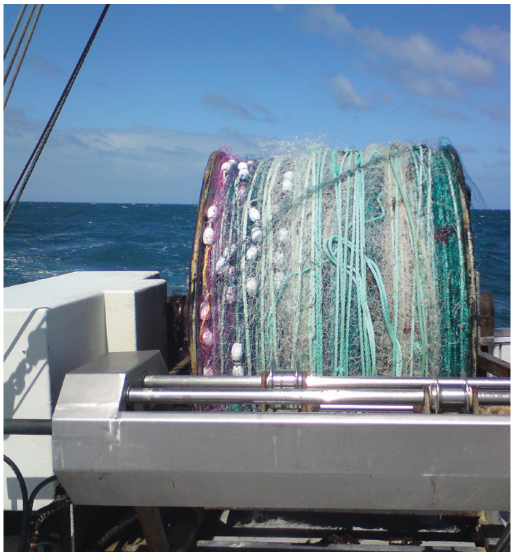


FIGURE 12.3 Real GVP in the Shark Hook and Shark Gillnet Sector by financial year, 1998–99 to 2008–09

SOURCE: ABARE–BRS (unpublished data).



Gillnet PHOTO: MIKE GERNER, AFMA

Other byproduct

There are low levels of retained catch of byproduct, primarily other shark species (Table 12.4).

TABLE 12.4 Minor byproduct stocks—TACs/triggers, catches/landings and discards in the SHSGS of the SESSF

Species	TAC/ trigger (tonnes)	2008–09 catch (tonnes)	2008–09 discards (tonnes)	2009–10 catch (tonnes)	2009–10 discards (tonnes)
Pink snapper *Pagrus auratus*	None	37	0.8	27	1.9
Whiskery shark *Furgaleus macki*	60	30	0.0	30	0.0
Broadnose sevengill shark *Notorynchus cepedianus*	20, 70[a]	27	0.0	27	0.0
Bronze whaler *Carcharhinus brachyurus*	10, 35[a]	17	0.0	34	0.0
Boarfish Pentacerotidae	15, 25[a]	18	0.0	17	0.0
Spotted swellshark *Cephaloscyllium laticeps*	None	14	24.3	17	28.0
Queen snapper *Nemadactylus valenciennesi*	None	17	0.0	14	0.0

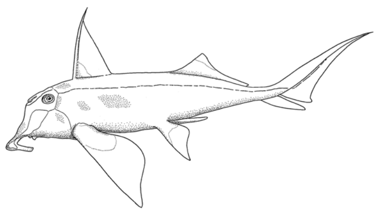
SESSF = Southern and Eastern Scalefish and Shark Fishery; SHSGS = Shark Hook and Shark Gillnet sector; TAC = total allowable catch

a lower and upper triggers.

12.4 BIOLOGICAL STATUS

ELEPHANT FISH

(*Callorhinchus milii*)



LINE DRAWING: KARINA HANSEN

TABLE 12.5 Biology of elephant fish

Parameter	Description
Range	**Species:** Southern waters of Australia from New South Wales to Western Australia, including Tasmania, as well as New Zealand waters. **Stock:** New Zealand stocks are considered genetically separate from the population in southern Australia. Potential for regional management of stock based on biology. Westernport Bay is the only confirmed egg-laying area, although industry accounts suggest egg-laying may also occur around Tasmania.
Depth	50–200 m
Longevity	6 years
Maturity (50%)	**Age:** 2–3 years **Size:** 70 cm
Spawning season	Spring and summer
Size	**Maximum:** females ~105 cm TL; males ~77 cm; 7.2 kg **Recruitment into the fishery:** all age and size classes taken by the fishery

SOURCES: Kailola et al. (1994); Last & Stevens (2009).

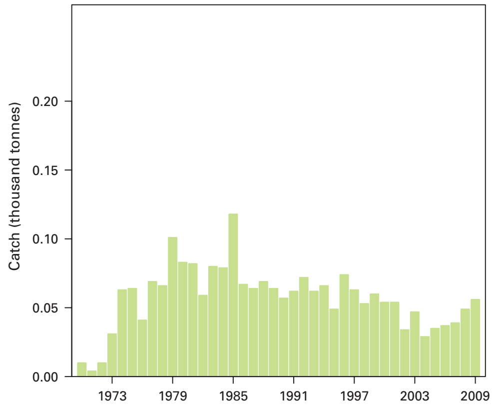


FIGURE 12.4 Elephant fish catch history, from the Shark Hook and Shark Gillnet Sector, 1970 to 2009

Current assessment

The Shark Resource Assessment Group (SharkRAG) suggested a recommended biological catch (RBC) of 94 t for the 2009–10 fishing season (SharkRAG 2009), although there was no assessment. The 2009–10 agreed TAC (global) was also 94 t (Table 12.2); however, the actual TAC (global) set by the AFMA Commission was 100 t, after the carryover of uncaught quota.

Total catch in the SHSGS in 2009–10 was 51 t; but, across the SESSF, 91 t in total was landed (Fig. 12.4). There was no accepted assessment in 2008, and SharkRAG recommended that the TAC remain at 94 t, the level since 2007. A catch per unit effort (CPUE) standardisation and Tier 4 assessment were completed in 2009 as part of the RUSS project (Rodriguez & McLoughlin 2009a) and accepted by SharkRAG as the basis for the 2010–11 RBC. The standardisation used a two-stage model; modelling the likelihood of catching elephant fish and then, for positive catches, modelling the catch size. The most significant factor in the standardisation was vessel, followed by area, month and gear; depth was found to be non-significant. The Tier 4 assessment based on this CPUE standardisation suggests that the current CPUE is close to the target CPUE (reference period 1998–2004), and so elephant fish are assessed as **not overfished** (Table 12.1). While there is no clear basis for the 2009–10 TAC because no assessment was made, and the recreational catch was not taken into account (this has been rectified in the 2010–11 TAC), the current catch and increasing CPUE trend suggest that the stock is **not subject to overfishing**.

An RBC of 123 t was recommended by SharkRAG for the 2010–11 fishing season based on the 2009 Tier 4 assessment (SharkRAG 2010a).

Reliability of the assessment

There was no reliable assessment for elephant fish before the recent Tier 4 assessment, and the 2010–11 fishing season will be the first in which the SESSF harvest strategy framework (HSF) has applied to this species. The 94 t TAC for 2009–10 was based on the average catch between 2002–05, when catches were regarded as stable, and weighted by 1.25% (SharkRAG 2010a). The current Tier 4 assessment has some uncertainties, particularly due to a lack of data on catch and discards from the trawl sector in the earlier years, unknown levels of discarding in the SHSGS (GHTS discards were estimated at 7.3 t in 2008, SharkRAG 2010a) and the size of recreational catches over time (estimated at 48 t in 2007; SharkRAG 2010a).

Previous assessment/s

For 2004–06 the agreed TACs covered all holocephalans. However, since 2007, only elephant fish has been included in the TAC. Elephant fish is a byproduct of the gummy shark fishery, but has a shallower distribution and so is potentially protected by shallow water closures (Table 12.2).

An initial assessment conducted in 2004 for Bass Strait suggested that pup production was around 20% of the 1950 level. However, SharkRAG considered the assessment highly uncertain, due to the lack of data on length and age composition of the historical catches, and insufficient tagging data to estimate mortality rates. A deterministic assessment model (Braccini et al. 2008) was used to examine alternative harvest strategies for elephant fish. The model uses available population parameters such as growth, reproduction and selectivity. Commercial catch and effort data for 1970 to 1994 are used in the fitting of the model; later data are excluded because of the commencement of the recreational fishery for elephant fish around the mid-1990s.

Future assessment needs

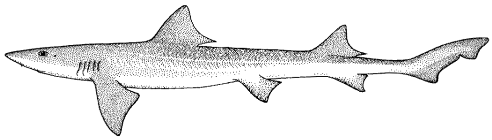
An agreed historic catch series should be established, or the impact on the assessment of different assumptions regarding historic catch should be considered. The outcomes of the fishery-independent surveys (Braccini et al. 2009) may assist in determining status. Ongoing reliable estimates of the recreational fishing catch are also needed.

Gillnet catch PHOTO: MIKE GERNER, AFMA

Hauling the catch PHOTO: MIKE GERNER, AFMA

GUMMY SHARK

(*Mustelus antarcticus*)



LINE DRAWING: KARINA HANSEN

TABLE 12.6 Biology of gummy shark

Parameter	Description
Range	**Species:** Endemic to southern Australia, below ~30°S. **Stock:** Three genetic stocks have been identified in Australia, one of which occurs in the SESSF (Bunbury in Western Australia to Jervis Bay in New South Wales). However, relatively low rates of movement, indicated by tagging studies, and different CPUE trends among regions suggest that there are separate Bass Strait, Tasmanian, South Australia and Western Australian stocks. Some catches in New South Wales are accounted for in the assessment; the Western Australian stock is assessed by Western Australia.
Depth	Recorded to 350 m, but generally found on the shelf from near shore to 80 m
Longevity	16 years
Maturity (50%)	**Age:** females 5 years; males ~4 years **Size:** females ~85 cm TL; males ~80 cm TL
Spawning season	November–December; ~12-month gestation period; litters of 1–57 pups, with litter size increasing with maternal length (average ~14 pups)
Size	**Maximum:** ~175 cm TL; weight: not determined **Recruitment to the fishery:** Peak selectivity for the mesh size used is ~115 cm TL. Few gummy sharks smaller than 75 cm TL are taken by the mesh sizes used.

TL = total length

SOURCES: Kirkwood & Walker (1986); Gardner & Ward (1998, 2002); Walker (2007); Last & Stevens (2009); SharkRAG (2010b).

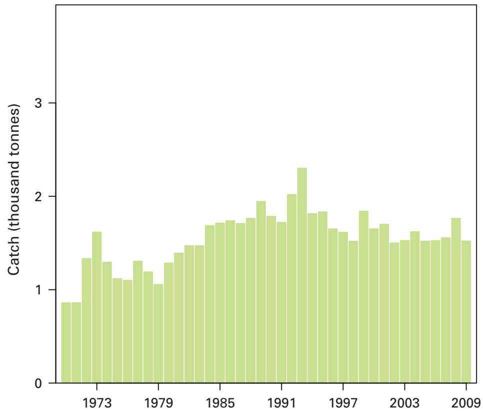


FIGURE 12.5 Gummy shark catch history, 1970 to 2009

Current assessment

The SharkRAG recommended an RBC of 1682 t for the 2009–10 fishing season, carried over from the previous fishing season (SharkRAG 2009) as there was no updated assessment in 2008 or 2009. The 2009–10 agreed TAC (global) was 1717 t (Table 12.2); however, the actual TAC (global) set by the AFMA Commission was 1771 t after the carryover of uncaught quota.

In the 2009–10 fishing season, 1565 t was landed, 1483 t from the SGSHS, the remainder from other SESSF sectors, a decrease from 1764 t in 2008–09. The size selectivity of the gillnets means that the catch is primarily of 4–7 year-old subadults, with young juveniles and breeding adults relatively unfished (Table 12.6; Kirkwood & Walker 1986; Walker 1989).

The spatially structured and age-based stock assessment was last updated in 2006, using data to 2005 (Punt et al. 2006). The assessment includes tagging data, length-frequency and age-composition data, and CPUE series from the different gillnet mesh sizes and hook sectors. The 2006 base-case assessment indicated that pup production in 2005 was above 48% of the 1927 level in Tasmania, between 40% and 48% in Bass Strait, and below 40% in South Australia (Punt 2006). The RBC from this assessment was calculated using simulations of future harvest

strategies. The most optimistic of these was an RBC of 1632 t with a target pup production of 40% of the 1927 level, and with the exploitation rate being reduced when pup production falls below 40% of the 1927 level (Punt 2006; SlopeRAG 2010). This RBC did not include an allowance for trawl catches taken by the Great Australian Bight Trawl Sector in waters off Western Australia and the Commonwealth Trawl Sector (CTS) off New South Wales (historically around 50 t per year combined).

Industry-based fishery-independent surveys were undertaken in 1973–76, 1986–87, 1998–01 and 2007–08 (Braccini et al. 2009). While the objectives of the surveys have changed, with the 2007–08 survey primarily focused on providing a baseline to measure school shark recovery, they provide indications of trends in gummy shark abundance. Comparisons with earlier surveys suggested that gummy shark had been depleted in the early years of the fishery but that there had been subsequent recovery (Braccini et al. 2009).

In the absence of an updated formal assessment, SharkRAG (2009) considered information from trends in fishery data in advising AFMA that retaining the current TAC was appropriate. In addition to the apparent long-term stability of catches (Fig. 12.5) and recruitment to the fishery, there has been an increase in CPUE, and industry has indicated that there has been an increase in the average carcass weight of gummy shark in recent catches.

On the basis of the 2006 assessment (which estimated that the stocks were close to the target level), the relatively stable recruitment throughout the history of the fishery suggested by the assessments to date (SlopeRAG 2010b), the current trend in CPUE and the fishery-independent surveys, the stock is assessed as **not overfished** (Table 12.1). The level of recent catches and reductions in effort would suggest the stock is **not subject to overfishing**.

An RBC of 1800 t was recommended for the 2010–11 fishing season by SharkRAG (SharkRAG 2010b).

Reliability of the assessment

The assessment is becoming dated, and the current TAC was based on a lower target reference point ($0.4B_0$) than in the *Commonwealth Fisheries Harvest Strategy Policy* (HSP) and SESSF harvest strategy framework (Chapter 8), and so the status is becoming less certain.

There are significant uncertainties about the spatial structure of both school shark and gummy shark populations. The gummy shark assessment model treats stocks in Bass Strait, South Australia and Tasmania separately. However, there is most likely a finer scale population structure that cannot be examined because of the lack of fine-scale spatial data. The 2006 assessment was sensitive to assumptions about density dependence and the effect of gear saturation, which is used to model the functional response between effort and catch.

Previous assessment/s

Gummy shark catches from the gillnet sector have been relatively stable since 1972, despite marked changes in effort levels over this period. Tier 1 assessments have been undertaken since 1994 (Punt et al. 2006).

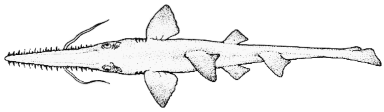
Future assessment needs

Gummy shark is the mainstay of this fishery and a significant contributor to the overall value of the SESSF, and it is critical that the assessment is updated to provide confidence in future TAC setting. This is planned to occur in 2010. The SESSF HSF needs to be applied to the updated assessment, as this has not been done to date. The model incorporates a number of structural assumptions that require further consideration in view of current information. The 2007 and 2008 survey information will be important for incorporation into an updated assessment.

After ITQs were introduced, AFMA revised the input controls for the fishery. Monitoring fishing effort levels in the fishery and assessing the impact of that effort will continue to be an important research area.

SAWSHARK

(*Pristiophorus cirratus*, *P. nudipinnis*)



LINE DRAWING: FAO

TABLE 12.7 Biology of sawshark

Parameter	Description
Range	**Species:** Common sawshark: Jurien Bay in Western Australia to Eden in New South Wales; southern sawshark: typically found within Bass Strait and in Tasmanian waters. **Stock:** TAC applies to catch of both species, with no finer scale spatial structuring assumed.
Depth	Usually found to 300 m
Longevity	15 years
Maturity (50%)	**Age:** not determined **Size:** females: ~113 cm; males ~97 cm
Spawning season	Winter
Size	**Maximum:** ~150 cm TL for female common sawshark, 118 cm for males; 105 cm for female southern sawshark, 97 cm for males **Recruitment into the fishery:** all size and age classes taken by the fishery

TL = total length
SOURCE: Last & Stevens (2009).

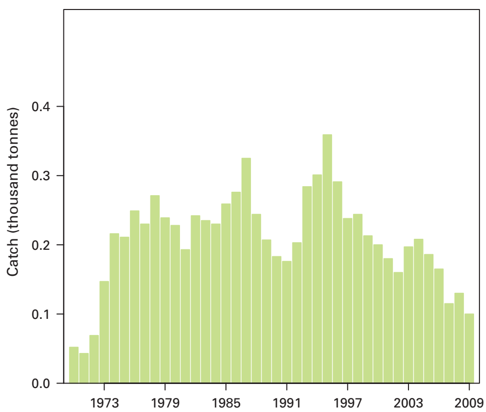


FIGURE 12.6 Sawshark catch history, from the Shark Hook and Shark Gillnet Sector, 1970 to 2009

Current assessment

The RBC recommended by SharkRAG was 312 t for the 2009–10 fishing season, although there was no accepted assessment (SharkRAG 2009). The 2009–10 agreed TAC (global) was 312 t (Table 12.2); however, the actual TAC (global) set by the AFMA Commission was 335 t after the carryover of uncaught quota.

Total catch in the SESSF in 2009–10 was 192 t, with 102 t from the SHSGS. This represents two-thirds of the TAC (Fig. 12.6), which has not been filled in recent years. There was no accepted assessment in 2008, and the TAC has been set at 312 t since 2007. In 2009 a CPUE standardisation and Tier 4 assessment (Rodriguez & McLoughlin 2009b) were undertaken. The standardisation was a two-part model, modelling the likelihood of catching sawshark and then, for positive catches, the size of the catch. The factor that explained the highest proportion of the variability in the size of catch was area, closely followed by vessel and then, in order of importance, month, depth and gear. SharkRAG recommended that the peak in catches (1992–1996) be removed from the analysis as it was regarded as artificially inflated (SharkRAG 2010c). The CPUE data show a decreasing trend, with approximately a 50% reduction in CPUE during 1980 to 2008. The Tier 4 assessment suggests that the CPUE is slightly below the target (reference period 2002–08) and resulted in an RBC for 2010–11 of 370 t, before state catches and discards are taken into account.

The CPUE series is highly variable. Although a reference period was selected, there is no clear time period with stable CPUE and catch. There is also a lack of data on trawl catches in the early period of the fishery and discarding by the different sectors, increasing the level of uncertainty for this species. It is not possible to separate the species in the catch, and so changes in relative abundance may be masked. Given the fact it is a basket stock with a highly variable CPUE, sawshark is assessed as **uncertain** as to whether the stock is overfished and **uncertain** as to whether it is subject to overfishing (Table 12.1).

Reliability of the assessment

There was no reliable assessment for sawshark before the recent Tier 4 assessment and the 2010–11 fishing season will be the first in which the SESSF HSF has applied to this species. The Tier 4 assessment is regarded as uncertain, due to the lack of species-specific catch data, variable catch and CPUE data and significant uncertainties in the historic catches and discard levels.

Previous assessment/s

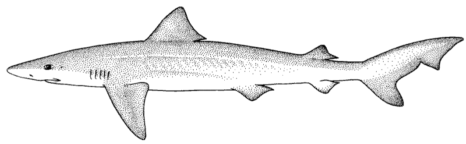
A preliminary quantitative assessment was undertaken in 2004 for sawshark south of the Victoria – New South Wales border (Punt et al. 2004). This assessment suggested that pup production was around 30% of the 1950 level. SharkRAG considered that the assessment is too uncertain for use in recommending an RBC, due to the lack of data on length and age composition of the historical catches, insufficient tagging data and lack of species breakdown of the catch.

Future assessment needs

The lack of species separation in the catch will remain a significant cause of uncertainty. An agreed historic catch series should be established, or the impact on the assessment of different assumptions regarding historic catch should be considered. The outcomes of the fishery-independent surveys (Braccini et al. 2009) may assist in determining status.

SCHOOL SHARK

(*Galeorhinus galeus*)



LINE DRAWING: KARINA HANSEN

TABLE 12.8 Biology of school shark

Parameter	Description
Range	**Species:** 20°S–58°S, 37°E–111°E; it is known in the southern waters of Australia from Queensland to Western Australia, including Tasmania, as well as in New Zealand. Tagging studies have shown some mixing between southern Australia and New Zealand, but genetic studies suggest these populations are not interbreeding. **Stock:** There are assumed to be separate stocks east and west of Bass Strait and in South Australia. Catch from Western Australian fisheries is included in the assessment.
Depth	100–500 m
Longevity	50 years
Maturity (50%)	**Age:** 10–12 years **Size:** not determined
Spawning season	Winter
Size	**Maximum:** ~175 cm TL; weight: not determined **Recruitment to the fishery:** Peak selectivity for the mesh size used is ~110 cm TL.

TL = total length

SOURCE: Last & Stevens (2009).

Hauling the gillnet PHOTO: MIKE GERNER, AFMA

School shark PHOTO: AFMA

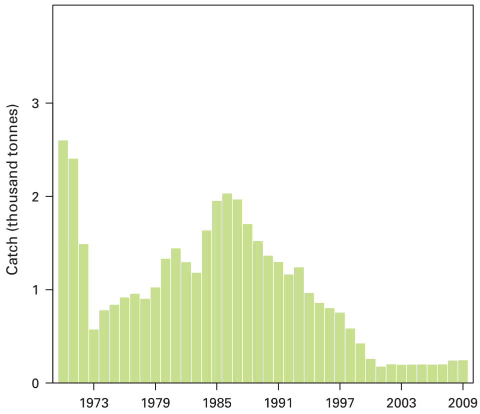


FIGURE 12.7 School shark catch history, from the Shark Hook and Shark Gillnet Sector, 1970 to 2009

Current assessment

In 2009–10, 204 t of school shark were landed under the 'bycatch TAC' of 240 t (actual TAC 255 t; RBC of zero). The landed catch has been increasing since 2004 (188 t; Fig. 12.7) but declined in 2009–10 in comparison to 2008–09 landings (SharkRAG 2010d). The age-structured, integrated assessment was updated in 2009 (Thompson & Punt 2009). The model incorporates CPUE series from fleets using different gillnet mesh sizes, fishery-independent survey data (Braccini et al. 2009), observer data on the catch from the CTS, size frequency and sex ratio of the catch, and tagging data. Catch data from the Western Australian fishery in 2001–08 were also included. Previous assessments had not included recent CPUE data because of changes in the management regulations, which were assumed to have changed targeting behaviour by fisheries. The CPUE series has been truncated at 1996 or 1999 (depending on the region). In 2009 the assessment incorporated an additional standardised CPUE series for 2001–08. It is assumed that this series represents non-targeted CPUE.

The 2009 assessment estimates that the level of pup production is 8% to 17% of the unfished levels, with the base case giving an estimate of 12% of unfished levels (Thompson & Punt 2009). Pup production is estimated to have been less than the limit reference point (20% unfished levels) since around 1990—possibly since 1980 for the eastern Bass Strait stock. School shark therefore continues to be assessed as **overfished** (Table 12.1).

Projections were run on the 2009 assessment to estimate the largest catches that would allow recovery to the limit reference point within the required timeframe (Thompson & Punt 2009). The base-case model suggests that catches of 26 t or less are required to rebuild the stock to 20% of pristine pup production, within a generation plus 10 years (32 years). The projections suggest that rebuilding to 40% of pristine pup production cannot be achieved within the timeframe, even if no catches are taken. The estimate of MSY from the assessment is at least 49% of pristine pup production, higher than the HSP proxy of 40% (Thompson & Punt 2009).

The 2007–08 fishery-independent survey was designed to establish a baseline for monitoring school shark recovery. Comparisons with earlier surveys suggest that the 2007–08 survey catch rates were higher than previous ones; however, the 1973 to 1976 survey did not adequately survey school shark in Bass Strait. The surveys suggest that fishing mortality was about four times natural mortality during 1986–87 for age classes up to 10 years, suggesting severe stock depletion in the 1980s (Braccini et al. 2009).

Following industry reports in 2009 that some targeted fishing was occurring, SharkRAG (2009; 2010d) examined analyses of the extent of targeting. One analysis was based on the approach taken in Klaer & Smith (2008), which aims to identify targeted and non-targeted catch, and the other was a detailed examination of the ratio of school shark to gummy shark catch at the operator level. The first analysis estimated that 35% of the catch might be targeted. The second suggested that targeting was occurring by some fishers. Some fishers were catching more school shark than gummy, or similar numbers (SharkRAG 2010d).

In light of the fact that catches exceed levels that are predicted to enable rebuilding and that targeted fishing has occurred, school shark is assessed as **subject to overfishing**.

Reliability of the assessment

Significant resources have been invested in refining the Tier 1 assessment. However, there is uncertainty about the productivity estimates and whether these may be lower than expected, which influences the recovery projections. There is also concern that the commercial CPUE is a less robust indicator of biomass since the management changes. However, recent CPUEs have shown indications of stability in some areas (although small declines or increases are unlikely to be detected). The treatment of the CPUE series in the assessment has some similarities to the approach taken for pink ling (Chapter 9), further investigation on the ability of the standardisation to detect targetting is required. There is also uncertainty in the historic catch data; catches were possibly under-reported during the mid-1970s because of the ban due to mercury levels, and over-reported in the years before the start of ITQs. There are currently no robust estimates of discards.

Previous assessment/s

Concerns over declines in CPUE for this fishery were expressed as early as 1959, when school shark was the primary target species. In the mid-1980s, the fishery was assessed as overfished, and the managers agreed that fishing effort should be reduced to the 1982 level (when the total fishery catch was around 2800 t for all species combined). Failure to cap fishing effort in subsequent years led to further depletion of the school shark stocks.

Stock assessments for school shark conducted since 1990 have consistently shown the stock to be overfished (Thompson 2010). Projections by Punt and Pribac (2001) suggested that catches of 200 t or more would result in continued depletion, and only catches of 100 t or less showed recovery.

Future assessment needs

There is an ongoing need for fishery-independent surveys, particularly given the concern over commercial CPUE as an index of abundance. These are essential for monitoring the effectiveness of strategies to rebuild the school shark stock.

There appears to have been some ongoing targeting of school shark. If stocks are recovering, there will also be increased interaction and discarding, which will need to be monitored. It is possible that a sustainable and economically viable gummy shark fishery might prevent school shark from rebuilding to target levels recommended by the HSP; however, it is important that adequate information is obtained to assess whether recovery is occurring.

12.5 ECONOMIC STATUS

The former Australian Bureau of Agricultural and Resource Economics undertook a survey of the Gillnet, Hook and Trap Sector (GHTS)—which is comprised of the SHSGS and the Scalefish Hook Sector— every year since the mid-1990s as part of its annual fisheries survey program. The results give a good indication of the economic performance of the SHSGS, given that this sector accounted for 72% of GVP in the GHTS in 2008–09.

Net economic returns

Unlike many other Australian fisheries, the GHTS has enjoyed consistently positive economic returns over time. From 1998–99 to 2007–08, net economic returns (NER) in the GHTS averaged around $1.35 million in 2008–09 dollars (Fig. 12.8). It is estimated that NER in the GHTS reached almost $5 million in 2007–08 (Vieira et al. 2010), a significant improvement.

The improved result can be attributed to several factors. The removal of less efficient vessels from the sector, through the *Securing our Fishing Future* structural adjustment package, has positively affected the cost

structure of the fishery, allowing a given catch to be taken at a lower cost. While costs have fallen, revenues for a given catch increased in 2007–08 as the average real price per kilogram in the fishery increased from $5.94 to $6.78. The combined effect of a decrease in costs and an increase in revenues has been an increase in profit.

Other factors, such as management changes and environmental variability, may have also contributed to the increased profitability.

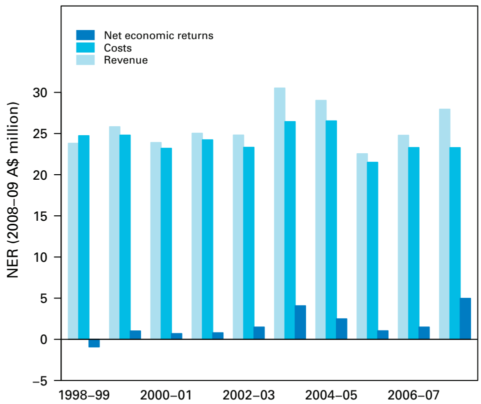


FIGURE 12.8 Net economic returns for the GHTS by financial year, 1998–99 to 2007–08 (in 2008–09 dollars)

NOTE: Net economic returns for 2007–08 are estimated using non-survey based methods

SOURCE: Vieira et al (2010).

Output-to-input ratio

A fishery level output-to-input ratio can indicate how effectively key fishing inputs have been used to harvest catch over time but also reflect changes in stock abundance. The ratio presented here takes the form of an index that combines time series indexes of fishery output (fish catch) and key input use (labour, capital, fuel and repairs) (Vieira et al. 2010).

Between 1998–99 and 2006–07, the average increase in the output-to-input ratio was 5%. However, in 2007–08, the ratio increased by 22%. As shown in Fig. 12.9, the input and output indexes previously tended to trend together. However, in 2007–08, the indexes have diverged; the input index decreased while the output index remained relatively constant, indicating that fewer inputs were being used to produce a given level of output. The 11% reduction in inputs is attributable to fewer vessels remaining in the fishery after the recent structural adjustment package. Because the buyback targeted the less efficient operators in the sector, not only has total input use fallen, but also the costs of a given level of catch.

Estimates of input use for 2008–09 are not yet available; however, consistent with the decrease in total catch, the output index declined by 5% in 2008–09. For the increasing trend in the output-to-input ratio to continue in 2008–09, input usage will have to have fallen by a similar proportion.

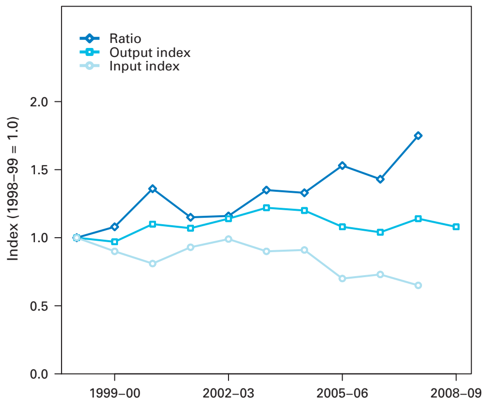


FIGURE 12.9 Output-to-input ratio for the Gillnet, Hook and Trap Sector, 1998–99 to 2008–09

NOTE: Estimates for 2007–08 are non-survey based extrapolation estimates.

SOURCE: Vieira et al. (2010).

Vessel-level performance

GVP per vessel in the GHTS increased from almost $203 000 to just over $336 000 between 2005–06 and 2008–09 (Fig. 12.10). A large proportion of this increase occurred in 2007–08 and is attributable to the increase in gummy shark revenue, from $177 000 in 2006–07 to $271 000 in 2007–08 (an increase of 53%). School shark and elephant fish also rose considerably in 2007–08, increasing by 51% and 78%, respectively, while sawshark increased by 9%. Most of these increases were maintained in 2008–09.

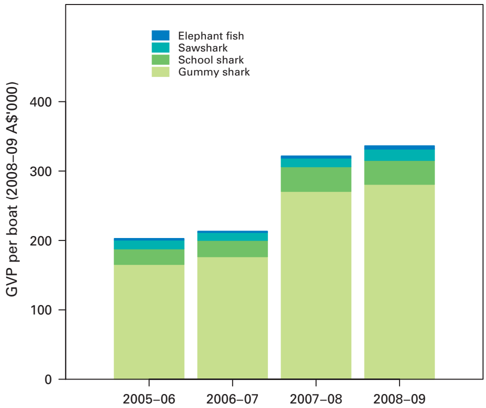


FIGURE 12.10 Real GVP by species per vessel in the SHSGS, 2005–06 to 2008–09 (2008–09 dollars)

SOURCE: ABARE–BRS (unpublished data)

Vessel-level costs in the GHTS increased between 2005–06 and 2007–08, as can be seen from Fig. 12.11. This is due to increases in catch and effort per vessel, indicated by the increase in average net length used per gillnet vessel.

In recent years, the declining fleet size (from 118 in 2003–04 to 68 in 2008–09) has resulted in each vessel claiming a larger proportion of the relatively constant total sector catch. While vessel-level catches have increased, vessel-level effort has also increased as each vessel works harder to land the larger catch. Effort levels have remained relatively constant from 2007–08 to 2008–09.

Gillnet boat at sunset PHOTO: MIKE GERNER, AFMA

Although both of these have an impact on vessel-level costs, catch levels have strongly contributed to increases in labour costs and other costs per vessel. Between 2005–06 and 2007–08, labour costs rose by 42% and other costs by 37%.

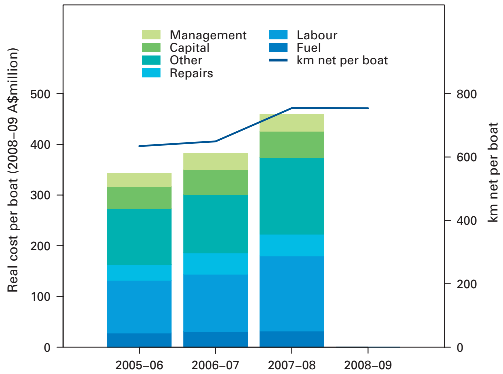


FIGURE 12.11 Real costs per vessel by cost category and effort per vessel for the GHTS, 2005–06 to 2008–09 (2008–09 dollars)

SOURCE: Vieira et al. (2010).

Overall economic performance

It is estimated that NER in the GHTS reached almost $5 million in 2007–08 (Vieira et al. 2010), significantly more than the average NER estimated for previous years (Vieira et al. 2008).

Survey results for the GHTS for 2007–08 and 2008–09 will not be available until later in 2010. However, the available data suggest that there has been a 6% decrease in total catch and an increase of 14% in the sector's average per kilogram price. These factors, in combination, have resulted in a mild increase in revenue of 5% in 2008–09. Given the decrease in the price of off-road diesel, historically one of the major cost components, and the relatively constant effort levels between 2007–08 and 2008–09, it follows that the sector is most likely to have benefited from a second year of positive profits in 2008–09.

Where the fishery performed relative to its economic potential is difficult to determine with the information currently available for the fishery. Kompas and Che (2008) provided estimates of B_{MEY} and the optimal harvest that

would achieve MEY (following rebuilding to B_{MEY}) for six key species in the SESSF including gummy shark. Their preliminary estimates indicated a B_{MEY}/B_{MSY} value for gummy shark of 1.22 and a MEY harvest level (or TAC) of 1500 t. This compares to the current TAC for the species of 1717 t. Although preliminary, these estimates suggest that higher NER could potentially be earned from at least this species.

Future considerations

Active management of key species by AFMA through the setting of TACs is a key factor affecting economic performance. If TACs can be set at levels consistent with moving stocks towards B_{MEY} and then maintaining stocks at B_{MEY}, then the benefits that have emerged through recent management changes and since the structural adjustment package will be preserved. Planned stock assessment updates in 2010 for gummy shark combined with further economic research could better inform the HS for this fishery.

12.6 ENVIRONMENTAL STATUS

Research surveys of school shark nursery areas in eastern Tasmania and central Victoria in the early 1990s indicated a much lower abundance of pups than in the same areas in the 1950s. Urbanisation near these areas and subsequent pollution and environmental degradation are likely to have affected pup abundance. Therefore, the relative importance of the effects of fishing is not known.

Victoria has maintained a closure to targeted school and gummy shark fishing in its coastal waters (to 3 nm offshore) for more than 10 years, and Tasmania maintains closures in known nursery areas. AFMA held a workshop in May 2003 to identify additional areas that would afford protection to school shark if they were closed. Several additional closures have since been adopted to protect mature females and juveniles.

A bycatch and discarding work plan for the gillnet sector was released in 2009. A Level 3 risk assessment (Zhou et al. 2009) has also been undertaken for the fishery, the outcomes of which need to be taken into account in future management.

Ecological risk assessment

Gillnets were assessed for the SESSF using the ecological risk assessment process. At the Level 2 assessment phase, 329 species were assessed, with 21 being assessed as high risk (16 chondrichthyans and 5 marine mammals) (Walker et al. 2007). After the application of the Level 3 assessment to chondrichthyan and teleost species, eight species were removed from the high-risk list (Zhou et al. 2009). A further four were removed during the residual risk assessment process (AFMA 2010a). The remaining nine species considered high risk comprise six sharks (white shark, shortfin mako, smooth hammerhead, bronze whaler, dusky whaler and broadnose sevengill shark) and three marine mammals (Australian fur seal, Australian sea lion and New Zealand fur seal).

Threatened, endangered and protected species

Sharks

Catches are dominated by gummy and school shark. However, southern sawshark, common sawshark, elephant fish and other shark species constitute about 12% of the total catch. Most shark and scalefish species are marketed, and most discards—notably draughtboard shark (*Cephaloscyllium laticeps*), Port Jackson shark (*Heterodontus portusjacksoni*) and piked spurdog (*Squalus megalops*)—are released live. Only 3% of the commercial chondrichthyan catch and 2% of the scalefish catch are discarded dead (Walker et al. 2005). Demersal gillnets also take small numbers of protected species, including great white shark (*Carcharodon carcharias*). As noted above, six shark species were regarded as high risk (AFMA 2010). Trigger limits have been

implemented for non-quota shark species, with the intention that, if the catch reaches the trigger level, there will be a detailed assessment of catch and other available data.

Sea lions

There is particular concern about interactions with Australian sea lions, which are listed as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*. The sea lion's apparent high fidelity for natal sites for females suggests that animals lost from a colony are unlikely to be replaced by immigrants. The small colony sizes mean that the loss of just a few breeding females from a population can significantly reduce the long-term prospects for that population (Goldsworthy et al. 2010). Research projects (Goldsworthy et al. 2007, 2010) have placed observers on vessels to monitor sea lion interactions in the waters off South Australia, where most of the sea lion colonies occur. Goldsworthy et al. (2010) used sea lion foraging data and fine-scale fishing effort to identify areas of risk of interactions. Based on the observer data (12 sea lion mortalities were observed in 145 sea days on 10 trips, observing 234 sets), Goldsworthy et al. (2010) estimated that more than 300 sea lions were caught as bycatch each breeding cycle (17.5 months).

Closures were introduced in 2003 around the Pages Islands (the largest sea lion colony) and around Kangaroo Island. In December 2009, interim voluntary closures of 4 nm around all colonies were introduced. AFMA implemented a sealion management strategy in July 2010. The strategy includes formal closures around colonies, increased observer coverage and a trigger system, where observed levels of bycatch result in the closure of larger areas (AFMA 2010b). The increased observer coverage is critical for obtaining robust data on the bycatch rates.

12.7 HARVEST STRATEGY PERFORMANCE

The HSF for the SESSF is well established, but there are still areas that need review or development (see Chapter 8). Management strategy evaluation of the HSF has focused on finfish species. In the SHSGS, full implementation of the HSF has been limited to date; 2010–11 will be the first time the sawshark and elephant fish TACs will be based on the Tier 4 approach. The gummy shark Tier 1 assessment has not been updated since 2006, and RBCs have effectively been rolled over from previous years. There is no information on the current estimate of gummy shark biomass or how the fishery is performing in relation to a maximum economic yield target. It is important that the formal assessment for gummy shark is updated in the coming year and the HSF is applied.

12.8 LITERATURE CITED

AFMA (Australian Fisheries Management Authority) 2009a, *Shark Gillnet Fishery Bycatch and Discarding Workplan 1 July, 2009 to 30 June, 2011*, AFMA, Canberra.

——2009b, *Southern and Eastern Scalefish and Shark Fishery wildlife trade operation re-assessment 2009*, AFMA, Canberra.

——2010a, *Residual risk assessment of the Level 2 ecological risk assessment species results*, report for the gillnet sector of the Gillnet Hook and Trap Fishery, AFMA, Canberra.

——2010b, *Australian sea lion management strategy, Southern and Eastern Scalefish and Shark Fishery (SESSF)*, AFMA, Canberra.

Braccini, JM, Walker, TI & Conron, S 2008, *Evaluation of the effects of targeting breeding elephant fish by recreational fishers in Western Port*, draft final report to the Fisheries Revenue Allocation Committee, Department of Primary Industries, Victoria.

——, ——& Gason, AS 2009, *GHATF shark survey of population abundance and population size composition for target, byproduct and bycatch species*, final report to the AFMA and the Fisheries Research Branch, Department of Primary Industries, Queenscliff, Victoria.

DAFF (Australian Government Department of Agriculture, Fisheries and Forestry) 2003, *Southern and Eastern Scalefish and Shark Fishery Management Plan 2003* (amended 2006), DAFF, Canberra, Federal Register of Legislative Instruments F2007C00069.

Gardner, MG & Ward, RD 1998, Population structure of the Australian gummy shark (*Mustelus antarcticus* Gunther) inferred from allozymes, mitochondrial DNA and vertebrae counts. *Marine and Freshwater Research*, vol 49, pp. 733–745.

——& Ward, RD 2002, Taxonomic affinities within Australian and New Zealand *Mustelus* sharks (Chondrichthyes : Triakidae) inferred from allozymes, mitochondrial DNA and precaudal vertebrae counts. *Copeia*, pp. 356–363.

Goldsworthy, SD, Hamer, D & Page, B 2007, *Assessment of the implications of interactions between fur seals and sea lions and the southern rock lobster and gillnet sector of the Southern and Eastern Scalefish and Shark Fishery (SESSF) in South Australia*, rinal report to the FRDC, SARDI Aquatic Sciences, Adelaide.

——Page, B, Shaughnessy, PD & Linnane, A 2010, *Mitigating seal interactions in the SRLF and the Gillnet Sector SESSF in South Australia*, report to the Fisheries Research and Development Institute, SARDI Research Report Series no. 405, SARDI Aquatic Sciences, Adelaide.

Kailola, PJ, Williams, MJ, Stewart, PC, Reichelt, RE, McNee, A & Grieve, C 1993, *Australian fisheries resources*, Bureau of Resource Sciences & the FRDC, Canberra.

Kirkwood, GP & Walker, TI 1986, ‘Gill net mesh selectivities for gummy shark, *Mustelus antarcticus* Gunther, taken in south-eastern Australian waters’, *Marine and Freshwater Research*, vol. 37, pp. 689–97.

Klaer, NL & Smith, DC 2008, *Species associations and companion species in the SESSF*, report to the AFMA Slope Resource Assessment Group, CSIRO Marine Research, Hobart.

Kompas, T and Che, N 2008, *Maximum Economic Yield in the Southern and Eastern Scalefish and Shark Fishery*, ABARE Report to the Fisheries Resources Research Fund, Canberra.

Last, PR & Stevens, JD 2009, *Sharks and rays of Australia*, CSIRO Publishing, Collingwood.

Punt, AE & Pribac, F 2001, *An assessment of school shark for 2001*, prepared for SharkFAG, SharkFAG/01/D03 (final), CSIRO, Hobart.

——, ——& Fay, G 2004, ‘A revised approach for conducting assessments of gummy shark, elephantfish, and sawshark off southern Australia’, prepared for the 2 March 2004 meeting of SharkFAG.

——, ——Walker, T & Gason, AS 2006, ‘Updated stock assessment of gummy shark (*Mustelus antarcticus*) based on data up to 2005’, prepared for the SharkRAG, SharkRAG/06/D21, CSIRO, Hobart.

Rodriguez, V & McLoughlin, K 2009a, *Elephant fish CPUE standardisation and Tier 4 assessment, 2009*, Bureau of Rural Sciences, DAFF, Canberra.

——2009b, *Saw shark CPUE standardisation and Tier 4 assessment, 2009*, Bureau of Rural Sciences, DAFF, Canberra.

SharkRAG 2009, Minutes of the SharkRAG meeting, 17–18 November 2009, Hobart, AFMA, Canberra.

——2010a, *2009 stock assessment report for elephantfish (Callorhinchus milii)*, prepared by the Shark Resource Assessment Group (SharkRAG) for the South East Management Advisory Committee, AFMA, Canberra.

——2010b, *2009 stock assessment report for gummy shark (Mustelus antarcticus)*, prepared by the Shark Resource Assessment Group (SharkRAG) for the South East Management Advisory Committee, AFMA, Canberra.

——2010c, *2009 stock assessment report for sawfish (Pristiophorus spp.)*, prepared by the Shark Resource Assessment Group (SharkRAG) for the South East Management Advisory Committee, AFMA, Canberra.

——2010d, *2009 stock assessment report for school shark (Galeorhinus galeus)*, prepared by the Shark Resource Assessment Group (SharkRAG) for the South East Management Advisory Committee, AFMA, Canberra.

SlopeRAG 2010, *SlopeRAG assessment Report – 2009 Stock Assessment Report for SESSF species assessed by SlopeRAG*, report to the AFMA, Canberra.

Smith, ADM & Smith, DC 2005, *A harvest strategy framework for the SESSF*, report to the AFMA, Canberra.

Thompson, RB 2010, 'Summary of quantitative stock assessments conducted for school shark for the SharkRAG and its predecesors, from 1991 onwards' prepared for the SharkRAG meeting Melbourne, 8 January 2009, CSIRO Marine and Atmospheric Research, Hobart.

——& Punt, AE 2009, 'Stock assessment update for school shark *Galeorhinus galeus* based on data to 2008', presented to the SharkRAG meeting 17–18 November, CSIRO Marine and Atmospheric Research, Hobart

Vieira, S, Wood, R & Causer, T 2008, *Australian fisheries survey report 2008, results for selected fisheries 2005–06 and 2006–07*, ABARE report prepared for the Fisheries Resources Research Fund, Australian Bureau of Agricultural and Resource Economics, Canberra.

Vieira, S, Perks, C, Mazur, K, Curtotti, R & Li, M 2010, *Impact of the structural adjustment package on the profitability of Commonwealth fisheries*, ABARE research report 10.01, Canberra.

Walker, TI 1989, Can shark resources be harvested sustainably? A question revisited with a review of shark fisheries. *Marine and Freshwater Research* vol. 49, pp. 533–572.

——2007, 'Spatial and temporal variation in the reproductive biology of gummy shark *Mustelus antarcticus* harvested off southern Australia', *Marine and Freshwater Research*, vol. 58, pp. 67–97.

——Dowdney, J, Williams, A, Fuller, M, Webb, H, Bulman, C, Sporcic, M & Wayte, S, 2007, *Ecological risk assessment for the effects of fishing: report for the shark gillnet component of the Gillnet Hook and Trap Sector of the Southern and Eastern Scalefish and Shark Fishery*, report for the AFMA, Canberra.

——Hudson, RJ & Gason, AS 2005, 'Catch evaluation of target, by-product and by-catch species taken with gillnets and longlines in the shark fishery off south-eastern Australia, *Journal of Northwest Atlantic Fisheries Science*, vol. 35, pp. 505–30.

Wilson, DT, Patterson, HM, Summerson, R & Hobsbawn, PI 2009, *Information to support management options for upper-slope gulper sharks (including Harrisson's dogfish and southern dogfish)*, final report to the FRDC, project no. 2008/65, BRS, Canberra.

Zhou, S, Smith, ADM & Fuller, M 2007, *Rapid quantitative risk assessment for fish species in major Commonwealth fisheries*, report for the AFMA, Canberra.

13 Southern Squid Jig Fishery

P Sahlqvist, P Hobsbawn and R Curtotti

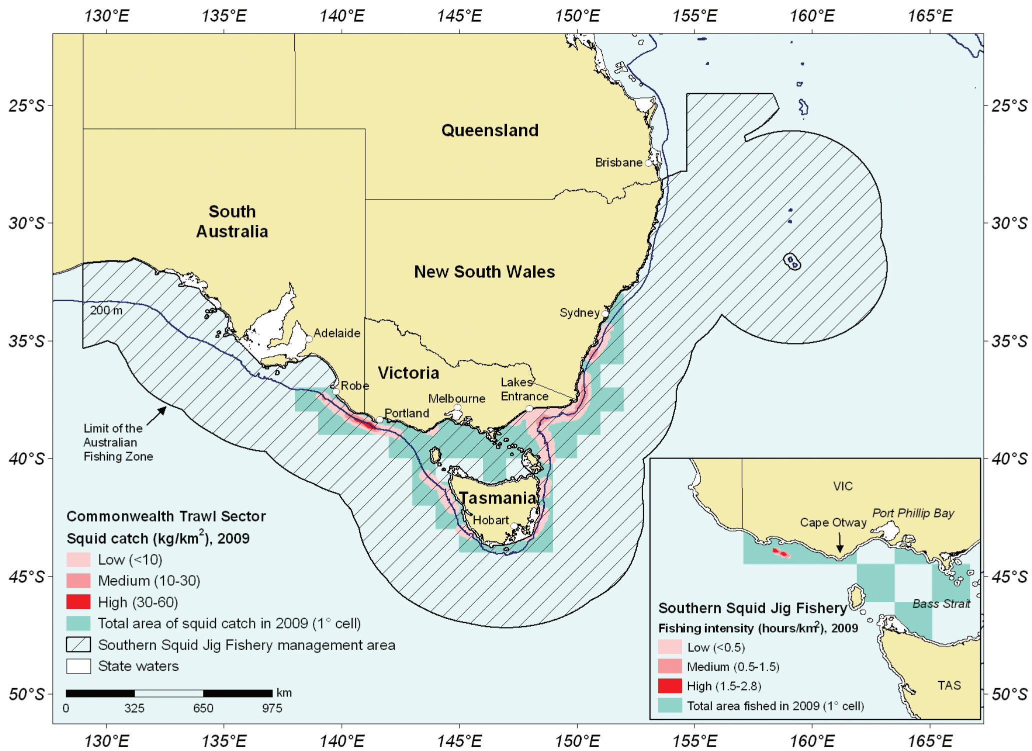


FIGURE 13.1 Relative fishing intensity in the Southern Squid Jig Fishery and distribution of Commonwealth Trawl Sector squid catch, 2009

TABLE 13.1 Status of the Southern Squid Jig Fishery

Fishery status	2008		2009		Comments
Biological status	Overfished	Overfishing	Overfished	Overfishing	
Gould's squid (*Nototodarus gouldi*)	Not overfished	Not subject to overfishing	Not overfished	Not subject to overfishing	No formal assessment. Recent low annual catches. High reproductive potential.
Economic status Fishery level	Estimates of net economic returns not available				Economic status uncertain. Total net economic returns low given high level of latency.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING · OVERFISHED / OVERFISHING · UNCERTAIN · NOT ASSESSED

TABLE 13.2 Main features and statistics of the Southern Squid Jig Fishery

Feature	Description	
Key target and byproduct species	Gould's squid (*Nototodarus gouldi*)	
Other byproduct species	None reported in recent fishing seasons	
Fishing methods	Squid jigging: jig vessels operate at night using high-powered lamps to attract squid. Up to 10 automatic jig machines are used on each vessel, each machine having two spools of heavy line with 20–25 jigs attached. SSJF gear SFRs only allow the capture of squid, and operators must have appropriate line endorsements for targeting scalefish or shark species.	
Primary landing ports	Portland, Queenscliff	
Management methods	Input controls: gear-based SFRs; annual total allowable effort	
Management plan	*Southern Squid Jig Fishery Management Plan 2005* (DAFF 2005)	
Harvest strategy	*Southern Squid Jig Fishery Harvest Strategy* (AFMA 2007)	
Consultative forums	Southern Squid Jig Fishery Management Advisory Committee (SquidMAC), Southern Squid Jig Fishery Resource Assessment Group (SquidRAG)	
Main markets	Domestic: fresh International: frozen—China, Canada, Hong Kong	
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Current accreditation dated 22 April 2010 Current accreditation (Wildlife Trade Operation) expires 30 April 2015	
Ecological risk assessment	Level 1: Scale, Intensity, Consequence, Analysis (SICA) completed on 225 species (Furlani et al. 2007)	
Bycatch workplans	*Southern Squid Jig Fishery Bycatch Action Plan 2004* (AFMA 2004)	
Fishery statistics[a]	**2008 fishing season**	**2009 fishing season**
Fishing season/year	1 January–31 December	1 January–31 December
Total allowable effort	640 standard squid jigging machines	580 standard squid jigging machines
Catch of Gould's squid	882 t (SSJF: 179 t, CTS: 641 t, GABTS: 62 t)	910 t (SSJF: 308 t, CTS: 573 t, GABTS: 29 t)
Effort	883 hours of squid jigging	1229 hours of squid jigging
Fishing permits	64	58
Active vessels	8	8
Observer coverage	Zero	Zero
Real gross value of production (2008–09 dollars)	2007–08: $0.2 million	2008–09: $0.5 million
Allocated management costs	2007–08: $0.19 million	2008–09: $0.18 million

CTS = Commonwealth Trawl Sector; EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999;* GABTS = Great Australian Bight Trawl Sector; SFR = statutory fishing right; SSJF = Southern Squid Jig Fishery

a Fishery statistics are provided by fishing season unless otherwise indicated.

13.1 BACKGROUND

The Southern Squid Jig Fishery (SSJF) is managed by the Australian Government in waters beyond the coastal waters of New South Wales, Victoria, Tasmania and South Australia, and in a small area of oceanic water off southern Queensland. Within coastal waters (inside the 3 nautical mile [nm] limit), squid jigging is managed by state governments.

Jig vessels operate at night using high-powered lamps to attract squid. The squid attack the jigs as they are retrieved, and the squid tentacles become hooked by rows of barbless hooks on the jigs. Fishing is carried out in continental-shelf waters, where depths range between 60 m and 120 m. Jig vessels are able to target aggregations for a few weeks or even months on the fishing grounds off Portland (Fig. 13.1). The success of squid jigging is greatly affected by weather; heavy winds and swells in Bass Strait in winter, effectively halt the jig fishery. Moon phase also influences the catchability of Gould's squid, with lower catch rates close to the full moon. The catch is chilled with ice and normally landed the next morning for direct sale to processors.

Squid jigging vessel PHOTO: AFMA

In the SSJF, Gould's squid is caught solely by squid-jigging operations. However, it is also caught in other Commonwealth fisheries, mostly by the trawl method, and particularly in the Southern and Eastern Scalefish and Shark Fishery (SESSF) (Fig. 13.1; Table 13.2). In the Commonwealth Trawl Sector (CTS) of the SESSF, the annual catch of squid has ranged between 440 t and 900 t over the past 10 years. In the Great Australian Bight Trawl Sector (GABTS), the annual catch peaked in 2006 at 262 t, but has been much less in recent years. The main trawl catches are taken in depths of 100–200 m, from areas off New South Wales and the Victoria – South Australia border. In some years, large amounts of Gould's squid are caught by jigging in Tasmanian waters, especially in Storm Bay and nearby locations (Table 13.3). In northern New South Wales waters, squid is taken as a small component of byproduct in the Ocean Prawn Trawl Fishery. These squid are mainly species of *Photololigo*, but some Gould's squid is also caught. Trawl fishers maintain their interest in Gould's squid as an alternative target species.

Waters outside Port Phillip Bay are usually fished in February and early March, and those in western Victoria from March to June. A very small proportion of fishing effort is directed outside these traditional fishing grounds. The Australian Fisheries Management Authority (AFMA) has provided for the issuing of scientific permits to target squid in the GABTS using midwater trawl gear. No applications have been received to date.

Catch disposal record forms (which record landing quantities) have been required from jig operators since January 2005, and from trawl operators since 2003 (Table 13.3). There were 20 days of observer activity on board SSJF vessels in 2005, and another six days of observer activity in 2007, but none in 2008 or 2009. The observers validate the quality of reporting of catch, bycatch and wildlife interaction, and collect sample data for estimating Gould's squid population parameters.

TABLE 13.3 History of the Southern Squid Jig Fishery

Year	Description
Pre-1978	Australian catch of Gould's squid less than 100 t annually, and largely a byproduct of demersal trawling and Danish-seining off south-eastern Australia. Attempts to develop a Gould's squid jig fishery, particularly in Tasmanian waters—small scale, using improvised fishing gear and unsuitable fishing vessels.
1978 to 1980	Japanese commercial squid jig vessels carried out feasibility fishing in southern waters under a joint venture with Australian companies. Nineteen vessels caught 3387 t in the first year, and 64 vessels caught 7914 t in the second year, mostly off South Australia, Victoria and Tasmania.
1983 to 1988	Vessels from Fishing Entity of Taiwan and the Republic of Korea fished in Bass Strait. Annual catches ranged from 13 t to 2309 t.
1986	Fishers in the Commonwealth Trawl Sector required to complete daily catch and effort logbooks.
1987	One local vessel actively fished Bass Strait Gould's squid using jig gear. Fishers in the Great Australian Bight Trawl Sector required to complete daily catch and effort logbooks.
1988 to 1995	Fishing effort increased slowly until 1995, fleet size fluctuating between 7 and 17 vessels. Annual Gould's squid catches did not exceed 400 t until the 1995 season, when 1260 t was landed.
1996, 1997	Success of the 1995 season generated increased interest from fishers holding jig endorsements; as a result, approximately 40 vessels fished. Commonwealth squid jig daily catch and effort logbook introduced.
1997	Gould's squid catch (about 2000 t) the highest taken by domestic jig vessels.
Post-1997	In the 10 years since 1997, there were seven seasons in which the total catch was above 1000 t, and three years that yielded much less. Unpredictability of the jig fishery and low prices caused a gradual reduction in the number of active vessels.
2002	Jig catch (663 t) less than half the 2001 catch of 1838 t.
2003 to 2005	Consistent annual catches ranged from 1239 t to 1668 t. From 2003, catch disposal record forms were required from trawl and jig operators.
2005	Southern Squid Jig Fishery Management Plan commenced. From January, catch disposal record forms (which record landing quantities) were required from jig operators.
2006	SFRs granted to all SSJF permit holders in January 2006. TAE for 2006 and 2007 was set at 800 standard jig machines. Catch declined to 619 t in 2006.
2007	Jig season provided better catch rates on the main fishing grounds off western Victoria, but overall catch was affected by some fishers choosing to take advantage of high catch rates in Tasmanian State waters. 1600 SFRs surrendered in the voluntary fishing concession buyback scheme (only one active fisher). Harvest strategy adopted by AFMA.
2008	TAE reduced to 640 standard jig machines for the 2008 season. Lowest catch recorded since logbooks were introduced for the SSJF.
2009	TAE reduced to 580 standard jig machines following surrender of six SFR packages.

AFMA = Australian Fisheries Management Authority; SFR = statutory fishing right; SSJF = Southern Squid Jig Fishery; TAE = total allowable effort

13.2 HARVEST STRATEGY

The *Southern Squid Jig Fishery Harvest Strategy* (HS) (AFMA 2007) uses a system of within-season monitoring against catch triggers for the jig and trawl sectors. It includes catch, effort, and catch per unit effort (CPUE) triggers that signal the need for assessment and review of management arrangements. Target and limit reference points are not defined.

The HS includes the following elements:

Jig fishery

- 3000 t intermediate catch trigger or 30 standard vessel effort trigger—requires a depletion analysis and increased investment in fishery monitoring and biological data collection. If there is no indication of impact (level of depletion is not defined in the HS), fishing may continue up to the next trigger limit. If there is an impact, the trigger values may be revised.
- 5000 t limit catch trigger—further catches are suspended pending another depletion

analysis. If there is no indication of impact, a further (higher) trigger limit may be considered. If there is impact, catch or effort may be capped. Fishing beyond this trigger will require more rapid, real-time monitoring of the fishery.

The limit trigger may be overridden when there is a 'boom' year—defined in terms of catch rates, as well as the time of day and time of month that catches are taken.

There are also criteria that signal excessive fishing effort during periods of low squid availability, and similar decision rules to the intermediate catch trigger apply in that case.

Trawl fishery

- 2000 t combined trawl sector (CTS and GABTS) catch limit trigger—control rules require depletion analyses equivalent to those required for the jig fishery rules. Catch trip limits may be set, depending on the outcome of the analyses.

Combined jig and trawl fishery

- 4000 t intermediate combined jig and trawl catch trigger—control rules are equivalent to those applying to the 3000 t intermediate jig catch trigger. However, assessment will involve depletion analysis that uses data for both fisheries.
- 6000 t combined jig and trawl limit catch trigger—control rules are equivalent to those applying to the 5000 t jig catch limit trigger. However, assessment will involve depletion analysis using data for both fisheries, and any changes to catch triggers will require agreement by both the SSJF and the SESSF resource assessment groups.

Squid PHOTO: ANDREW SAMPAKLIS, ABARE–BRS

13.3 THE 2009 FISHERY

In 2009, 308 t of squid were caught in the SSJF. Most of the catch (167 t) was taken in April from the fishing grounds near Portland, where 93% of total jig effort was located. Fishing effort (1229 hours) was greater than in the previous fishing season but still much less than in any season from 1996 to 2007. The ongoing effects of high costs and low domestic prices influenced fishers' decision to avoid fishing for squid.

Landing prices paid for Gould's squid increased in 2009 by around 17%, to $1.50/kg, and operators experienced lower fuel prices, helping to improve profitability. Despite this, profitability in the SSJF continues to be severely affected by the increased availability of squid product on the global market and the high levels of imported squid used by processors. The availability of local trawl-caught squid has also affected prices paid to SSJF operators, despite the generally poorer quality of squid from the trawl fisheries.

Catches of squid in other Commonwealth fisheries

The trawl catch of Gould's squid in 2009 was 602 t, comprising 573 t from the CTS and 29 t from the GABTS (Table 13.2). The CTS Gould's squid landings and catch rates in 2009 were highest in February–June. Logbooks for CTS fishers record that a large amount (234 t) of the Gould's squid catch came from the waters west of Bass Strait (west of longitude 144°E) in 2008.

As is the case with the volume of squid caught, there is considerable seasonal variability in gross value of production (GVP) in the fishery (Fig. 13.2), reflecting mainly changes in catch levels and, to a lesser extent,

changes in the per unit price received by fishers for squid. In 2008–09 the GVP of the fishery doubled to $461 000. This increase is primarily attributed to higher effort by fishers, which resulted in higher catch and higher prices. In 2008–09, eight active vessels were operating in the fishery, the same number as in 2007–08.

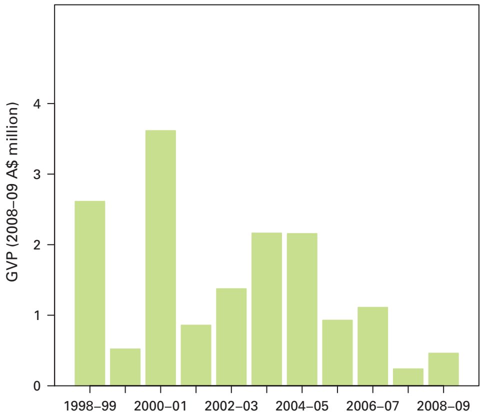


FIGURE 13.2 GVP of the SSJF by financial year, 1998–99 to 2008–09

Generally, operators in the SSJF service domestic markets, where they compete with large volumes of imports, the value of which is many times greater than the value of the fishery. For 2008–09, the Australian Bureau of Statistics estimated the value of squid and cuttlefish imports as $47.2 million (Fig. 13.3). Principal sources are China, New Zealand and Thailand. The value of Australian cuttlefish and squid exports is very low. In 2008–09, $0.4 million worth of cuttlefish and squid was exported, mostly to China, Canada and Hong Kong.

The prospect of replacing some of the imported squid with high-quality, jig-caught Gould's squid has continued to maintain the interest of fishers wishing to diversify their operations. However, the generally lower prices of squid on the world market, and consequently on the Australian market, in recent years have discouraged fishers from investing further in the fishery.

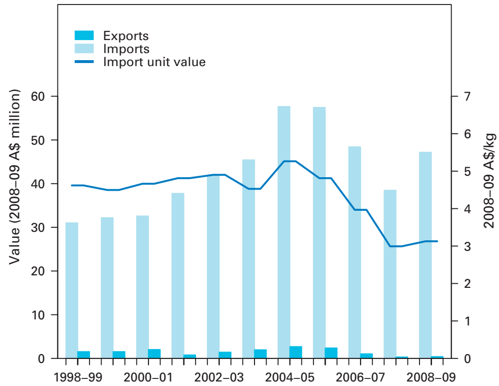


FIGURE 13.3 Real value of squid and cuttlefish exports, imports and import unit value by financial year, 1998–99 to 2008–09

Minor byproduct species

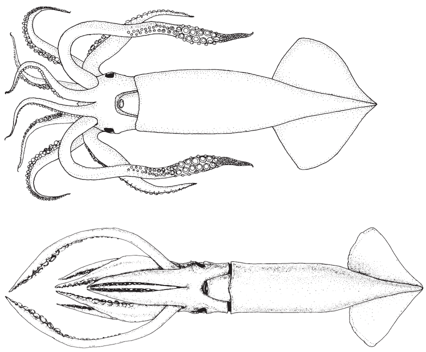
No squid species other than Gould's squid are reported in squid jigging logbooks. However, scientific sampling indicates that species other than Gould's squid do form a very small byproduct of jigging (Dunning & Brandt 1985). In the deeper shelf waters, Southern Ocean arrow squid (*Todarodes filippovae*) and red ocean squid (*Ommastrephes bartrami*) constitute less than 1% of the catch. Some finfish, especially barracouta and blue shark, were reported in earlier years, but they were caught using line methods not covered by the *Southern Squid Jig Fishery Management Plan* (DAFF 2005).

Squid jigs PHOTO: MIKE GERNER, AFMA

13.4 BIOLOGICAL STATUS

GOULD'S SQUID

(*Nototodarus gouldi*)



LINE DRAWINGS: FAO

Squid PHOTO: HEATHER PATTERSON, ABARE–BRS

Gould's squid PHOTO: STEVE HALL, AFMA

TABLE 13.4 Biology of Gould's squid

Parameter	Description
General	Growth rates variable among years, seasons and locations. Rapid stock regeneration during periods of favourable environmental conditions, resulting in large seasonal variations in stock abundance. Feed mainly at night, eating pelagic crustaceans, fish and smaller squid.
Range	**Species:** Southern Australian waters south of latitude 27°S, and waters of the New Zealand Exclusive Economic Zone. **Stock:** Genetics of Gould's squid support the existence of a single stock over most of the species' Australian distribution, although there has been no sampling in Bass Strait. For stock assessment purposes, all catches from within the SSJF management area are used in analysis (SSJF, CTS, GABTS). There is no information on movement of squid within the fishery.
Depth	Continental shelf, but have been recorded over the continental slope to 500 m depth. Aggregate in large schools near the seabed during the day, and then disperse to some extent into the water column at night.
Longevity	1 year
Maturity (50%)	**Age:** varies according to season and location (171–275 days) **Size:** varies with season, location and sex, but may be less than 300 g live weight
Spawning season	Year round, with peak periods of activity. Larval distribution indicates that spawning occurs throughout the continental shelf waters of southern Australia. Up to four cohorts per year. Continue to grow during the spawning phase, and females release a number of batches of fertilised eggs.
Size	**Maximum:** females 40 cm mantle length; males 35 cm mantle length **Recruitment into the fishery:** ~10 cm mantle length; weight and age: not determined

CTS = Commonwealth Trawl Sector; GABTS = Great Australian Bight Trawl Sector; SSJF = Southern Squid Jig Fishery

SOURCES: Jackson & McGrath–Steer (2003).

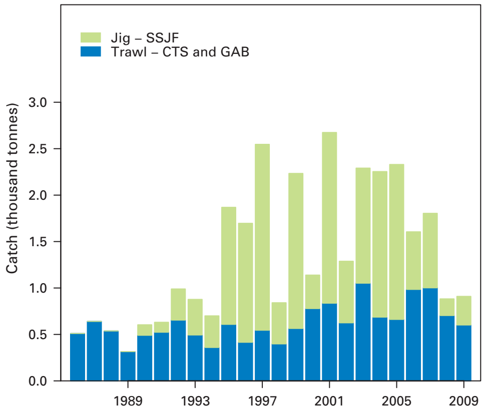


FIGURE 13.4 Gould's squid catch history for the SSJF, CTS and GABTS, 1986 to 2009

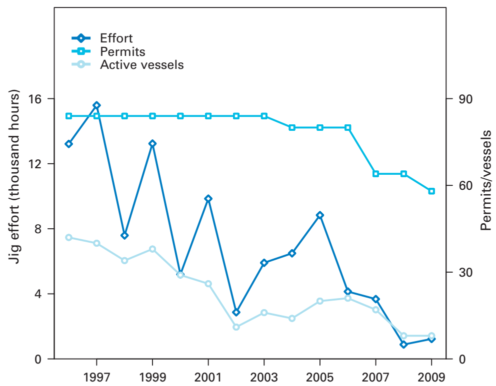


FIGURE 13.5 Gould's squid effort history for the SSJF, 1996 to 2009

Stock status determination

No formal stock assessment was carried out in 2009. Analysis of catch (Fig. 13.4), effort (Fig. 13.5) and catch rates since 2000 for four regions in the SSJF showed that only one region (the central region from Cape Otway in Victoria to Robe in South Australia) had levels of fishing that could cause substantial depletion. A preliminary depletion analysis for the central region was conducted by the Southern Squid Jig Fishery Resource Assessment Group (SquidRAG) using jig catch and effort data for the 2001 fishing season. High catch rates were reported in that season, and the total jig fishery catch was the second highest on record (Fig. 13.4). The results of the analysis indicated that the stock was not overfished in that region for that year as only half the biomass present at the start of the season was removed by the fleet. The ABARE–BRS is also investigating the reliability of depletion models for assessing the Gould's squid stock under the project Reducing Uncertainty in Stock Status. Results of these analyses are expected by 2010.

Decision rules for the SSJF HS relate to trigger points for initiation of assessment and research. In the absence of reference points for determination of stock status, particular care must be taken in assessing the fishery. Even so, the historically low catches in recent years (caused by economic factors rather than availability of squid), maintenance of good jig catch rates when fishing has been undertaken, and the known ability of squid species to thrive when environmental conditions are favourable mean that the stock is assessed as **not overfished** and **not subject to overfishing** (Table 13.1).

Reliability of the assessment/s

No formal agreed assessment is provided by SquidRAG. Investigation of depletion analysis has been preliminary, and the operational aspects of this assessment tool within the HS are yet to be finalised, particularly the feasibility of conducting the assessments within the current fishing season. The work being undertaken by the ABARE–BRS and CSIRO will provide some guidance on the reliability of depletion analyses for assessing the status of Gould's squid.

Previous assessment/s

No formal stock assessments are available.

Future assessment needs

Confirmation of population structure and patterns of squid movement (Table 13.4) within the fishery will be necessary to determine whether stock assessment and management should be divided geographically. Consideration should be given to the

implementation of real-time monitoring of jig catch and effort so that the SSJF HS can function effectively. The introduction of electronic logbooks and reporting via wireless technology from fishing vessels may provide the most economical solution. Routine sampling of the catch at regular time intervals during the season is also desirable to determine size composition. Catch and effort for State waters, especially the Tasmanian Jig Fishery, should also be obtained by SquidRAG and included in any future assessment, in addition to catches from the CTS and GABTS. Further testing of the depletion analysis method on data from past seasons should be conducted, and the impact of trawl fishing in the same region and time should be considered.

13.5 ECONOMIC STATUS

The SSJF has not been recently surveyed by the ABARE–BRS. Hence, no estimates of recent net economic returns exist for the fishery. The only readily available economic performance indicator for the fishery is latent effort.

Level of latency

In recent years, there has been high latent effort in the SSJF (Table 13.5). In 2008–09, 58 Commonwealth entitlements were issued for the fishery, but only eight vessels operated, and at least six entitlements were voluntarily surrendered during the year. The existence of latent effort in the fishery is a reliable indicator that total effort is not being restricted and that economic returns are likely to be low.

TABLE 13.5 Active and inactive permits in the SSJF

Year	Active vessels	Concessions	Latency (%)
1997–98	32	84	62
1998–99	36	84	57
1999–2000	30	84	64
2000–01	26	84	69
2001–02	11	84	87
2002–03	16	83	81
2003–04	14	83	83
2004–05	20	80	75
2005–06	21	80	74
2006–07	17	80	79
2007–08	8	64	88
2008–09	8	58	86

SSJF = Southern Squid Jig Fishery

A number of factors have contributed to low participation numbers and investment in the fishery. These include relatively high set-up and running costs for squid jigging operations, and possibly consumer preference for southern calamari (*Sepioteuthis australis*). The most significant factors, however, have been the low market price received by fishers for squid, which can be attributed to competition from low-cost imports.

The tendency for squid abundance levels to fluctuate from season to season also influences participation in the jig sector, and the lack of a reliable supply for the domestic market has limited the development of processing facilities. Currently, the majority of vessels operating in the fishery have no onboard refrigeration or processing equipment. The catch is chilled on board but must be returned to port each morning for processing or freezing. Most of the vessels are also not equipped to operate in extreme weather conditions, and heavy winds and swells in Bass Strait halt activity in the fishery during the winter months.

Management costs

In the 2007–08 and 2008–09 financial years, the fishery's allocated management costs remained a high proportion of overall GVP of the fishery, in excess of 35%. Management costs for the fishery are therefore likely to be greater than profits.

Management costs relative to GVP in 2007–08 and 2008–09 were significantly higher than the average over the period 1998–99 to 2006–07, which was around 16%. The significant rise in this proportion is attributed to the sharp fall in GVP in 2007–08 and only modest recovery in 2008–09 (Table 13.2).

13.6 ENVIRONMENTAL STATUS

Only minimal environmental effects have been reported for the SSJF. The current bycatch action plan for the SSJF was finalised in 2004 (AFMA 2004), in conjunction with the strategic assessment process and the ecological risk assessment (ERA) project (Furlani et al. 2007). The bycatch action plan expired in November 2008, according to the provisions of the *Southern Squid Jig Fishery Management Plan*, but will continue to operate until a bycatch and discarding workplan is produced under new guidelines developed by AFMA. Progress towards achieving the current plan's objectives will continue to be reported every six months by AFMA.

Ecological risk assessment

The ERA of the fishery completed did not identify any indicators of threat to the environment from jig fishing (Furlani et al. 2007; AFMA 2009).

Threatened, endangered and protected species

No wildlife interactions have been reported to date. The occurrence of seals in the vicinity of working jig vessels has been raised as a concern in the past. However, observers on jig vessels have found no evidence of negative effects on seals from jig fishing, noting that there has been no observer coverage in recent years.

Pelagic habitats

The ERA project did not identify significant habitat effects from jig fishing. Occasionally, schools of pelagic sharks, especially blue shark (*Prionace glauca*), are attracted by the schooling squid, and barracouta (*Thyrsites atun*) frequently attack squid jigs and cause loss of jigs and lines. Operators usually move on to another area when this occurs.

13.7 HARVEST STRATEGY PERFORMANCE

None of the control rules have been triggered, and they are unlikely to be triggered in the SSJF HS unless the economics of the fishery change. Some recommendations for research in the strategy have been followed, including a review of historic values for CPUE and the feasibility of using depletion analyses.

The control rules are designed to manage fishing seasons that are exceptional compared with fishery history. No biomass estimates are available at present and, although it may be possible to set escapement targets to limit the percentage of biomass removed in a season, the current HS is not sophisticated enough to achieve this. It is also likely that SquidRAG will need to consider application of separate triggers for the main fishing grounds off western Victoria or more complex geographic triggers. This is because the total 3000 t trigger could be applied to a single fishing ground, with increased risk of overfishing and localised depletion before control rules are enacted.

The current systems for monitoring catch and effort are not suitable for the real-time reporting required by the HS, so there is a lag of up to one month in updating landings statistics, and longer for catch and effort logbooks. Catch and effort reporting could

be improved to meet the needs of the HS if electronic logbooks were introduced, together with protocols for electronic transmission.

It is unlikely that the total allowable effort will be limiting on jig fishers for the next few years. AFMA has a policy on the apportionment of the squid total allowable catch (TAC) that could come into effect if the jig catch were to exceed a trigger limit of 4000 t or the trawl catch were to exceed a trigger limit of 2000 t in a season. The policy requires review of the stock status and a decision by SquidMAC on the need for the introduction of a TAC. It would also require decisions on the apportionment of a squid TAC between the jig and trawl fisheries. The policy on apportionment will continue in parallel with the HS.

Although the catch triggers in the policy and the strategy differ, both instruments have similar objectives and require consideration of stock status before the operational aspects of fishery management are reviewed. Given the catch rates achieved by SSJF vessels in some years, a catch far greater than the 4000 t trigger is possible if all statutory fishing rights are allocated to vessels and the catch is realised.

13.8 LITERATURE CITED

AFMA (Australian Fisheries Management Authority) 2004, *Southern Squid Jig Fishery Bycatch Action Plan 2004*, AFMA, Canberra.

——2007, *Southern Squid Jig Fishery Harvest Strategy*, AFMA, Canberra.

——2009, Ecological risk management, report for the Southern Squid Jig Fishery, April 2009, AFMA, Canberra.

DAFF (Australian Government Department of Agriculture, Fisheries and Forestry) 2005, *Southern Squid Jig Fishery Management Plan 2005*, DAFF, Canberra, Federal Register of Legislative Instruments F2005L00964.

Dunning, M & Brandt, SB 1985, 'Distribution and life history of deep-water squid of commercial interest from Australia', *Australian Journal of Marine and Freshwater Research*, vol. 36, pp. 343–59.

Furlani, D, Ling, S, Hobday, A, Dowdney, J, Bulman, C, Sporcic, M & Fuller, M 2007, Ecological Risk Assessment for the effects of fishing: Southern Squid Jig Sub-Fishery, report to the AFMA, Canberra.

Jackson, GD & McGrath–Steer, BL 2003, *Arrow squid in southern Australian waters—supplying management needs through biological investigations*, final report to the FRDC, project no. 1999/112, Institute of Antarctic and Southern Ocean Studies, University of Tasmania, Hobart.

14 Torres Strait Fisheries overview

P Ward, J Woodhams, M Rodgers, N Marton and S Vieira

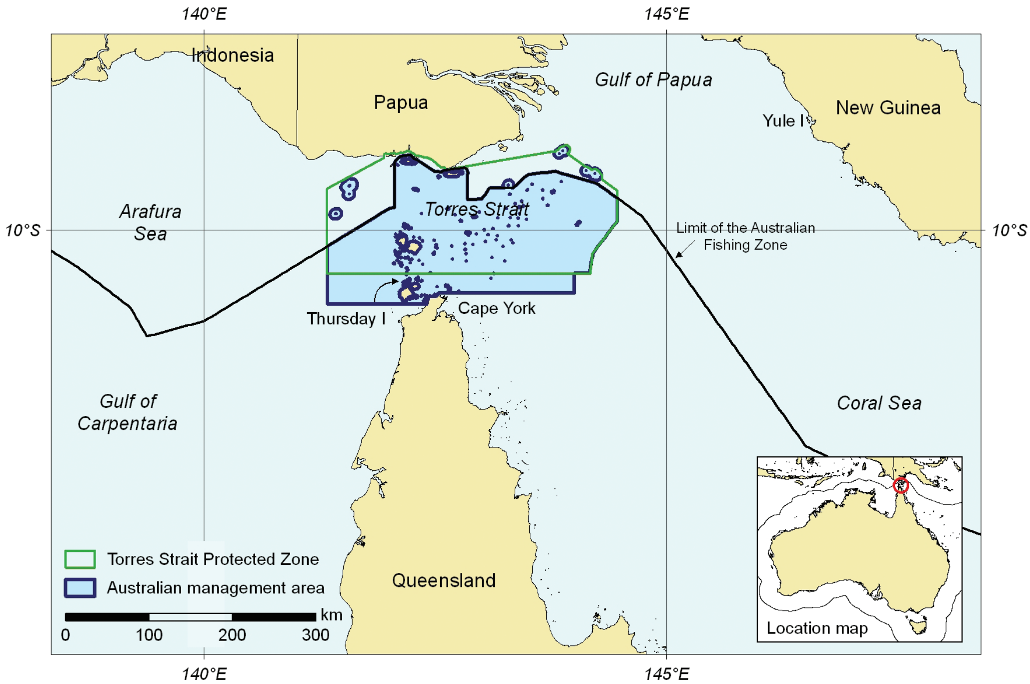


FIGURE 14.1 The Torres Strait Protected Zone and Australian management area

14.1 BACKGROUND

The Torres Strait is located between Cape York Peninsula in far north Queensland and Papua New Guinea (PNG) (Fig. 14.1). It connects the Arafura and Coral Seas and is an important shipping route. There are hundreds of islands and reefs in the Torres Strait, with 18 islands currently inhabited. The area is biologically productive, producing large amounts of seafood for local consumption and for sale in Australia and overseas. Marine resources are a staple in the diet of Torres Strait Islanders, as well as being central to traditional island culture.

The 1985 *Torres Strait Treaty* between Australia and PNG describes the boundaries between the two countries and how the sea area and its shared resources are managed. The Treaty is concerned with sovereignty and maritime boundaries, the protection of the marine environment and the optimum

utilisation of commercial resources in the region. It also establishes the Torres Strait Protected Zone (TSPZ), in which each country exercises sovereign jurisdiction for migratory fish and sedentary species in their waters. The principal purpose of the TSPZ is to acknowledge and protect the way of life and livelihood of the Traditional Inhabitants of the area. This includes protecting traditional fishing methods and rights of free movement.

Under the Treaty, Australia and PNG are required to cooperate in the conservation and management of the commercial fisheries of the TSPZ. This occurs through regular bilateral discussions between the two countries. One of the more tangible aspects of this cooperation is the fishery catch-sharing provisions, set out under Article 23 of the Treaty, which require Australia and PNG to negotiate an agreed share of the catch for a number of Torres Strait fisheries. Catch sharing also includes the development of subsidiary conservation and management arrangements under Article 22 of the Treaty.

In the Australian area of the TSPZ, traditional fishing and commercial fisheries are managed by the Torres Strait Protected Zone Joint Authority (PZJA; www.pzja.gov.au). The PZJA, established under the *Torres Strait Fisheries Act 1984*, comprises the Australian Government and Queensland ministers responsible for fisheries and the Chair of the Torres Strait Regional Authority (TSRA). The TSRA, an Australian Government statutory authority, was established in 1994 under the then *Aboriginal and Torres Strait Islander Commission Act 1989* (now the *Aboriginal and Torres Strait Islander Act 2005*).

In 2008 the Torres Strait Scientific Advisory Committee was re-formed after a two-year hiatus. The committee provides a forum for the expert consideration of scientific issues in the Torres Strait. This includes identifying research needs and priorities for consideration by the PZJA and reviewing research proposals.

14.2 FISHERIES WITHIN THE PROTECTED ZONE

The fisheries currently managed by the PZJA are prawn, tropical rock lobster, Spanish mackerel, reef line, sea cucumber, trochus, pearl shell, crab, barramundi and traditional fishing (including turtle and dugong). Recreational fishing in the Torres Strait is managed under Queensland legislation.

Five of these fisheries—prawn, tropical rock lobster, pearl shell, Spanish mackerel, and turtle and dugong—are Article 22 fisheries and are jointly managed by PNG and Australia. The Torres Strait Prawn Fishery (TSPF) is the largest commercial fishery in the Torres Strait in terms of catch, followed by the Torres Strait Tropical Rock Lobster Fishery (TSTRLF). However, in 2008–09, the TSTRLF was the most economically valuable of the two fisheries, with a gross value of production of $6.9 million, compared with $6.4 million for the TSPF.

Two commercial sectors operate within the Torres Strait: the Traditional Inhabitant Boat (TIB) Sector and the Transferable Vessel Holder (TVH) Sector (non-Islanders). TIB licences are available to fishers who satisfy the Traditional Inhabitant requirements under the *Torres Strait Fisheries Act 1984*. TVH licences are issued to other commercial fishers.

Logbook-style reporting is the main method of monitoring commercial catches in the Torres Strait. Logbooks are mandatory in the TVH Sector, whereas a voluntary docket-book system is used by Torres Strait fish receivers for recording the commercial catch from TIB fishers.

Formal stock assessments exist for brown tiger prawn (*Penaeus esculentus*), blue endeavour prawn (*Metapenaeus endeavouri*), tropical rock lobster (*Panulirus ornatus*) and Spanish mackerel (*Scomberomorus commerson*). A management strategy evaluation has been developed for coral trout

Fishing vessel and dories PHOTO: JAMES WOODHAMS, ABARE–BRS

(*Plectropomus* spp.) in the Reef Line Fishery. Abundance surveys for sea cucumbers and trochus have also been undertaken across the Torres Strait. Pearl shells have been surveyed on a number of occasions throughout the history of the fishery and are still counted during tropical rock lobster surveys.

Marine turtles and dugong

Marine turtles and dugong are taken in accordance with traditional fishing rights, provided for under the Treaty. The Treaty defines traditional fishing as 'the taking, by Traditional Inhabitants for their own or their dependants' consumption or for use in the course of other traditional activities, of the living natural resources of the sea, seabed, estuaries and coastal tidal areas, including turtle and dugong. As traditional fisheries are not commercial, the biological and economic status of these fisheries is not assessed as part of this report. A brief overview of these traditional fisheries can be found in the PZJA annual reports, the most recent of which was published in 2008 (PZJA 2008).

14.3 HARVEST STRATEGIES

The *Commonwealth Fisheries Harvest Strategy Policy* (HSP) does not prescribe management arrangements for fisheries jointly managed by the Australian Government and other management agencies (domestic or international), such as the fisheries in the Torres Strait. However, the PZJA has asked its management forums to provide advice on the application of the HSP to the Torres Strait fisheries. Harvest strategies are being developed for the TSTRLF and the TSPF.

14.4 LITERATURE CITED

PZJA (Protected Zone Joint Authority) 2008, *Torres Strait Protected Zone Joint Authority annual report 2007–08*, PZJA, Canberra.

15 Torres Strait Finfish Fisheries (Spanish mackerel and reef line)

N Marton, J Woodhams and K Mazur

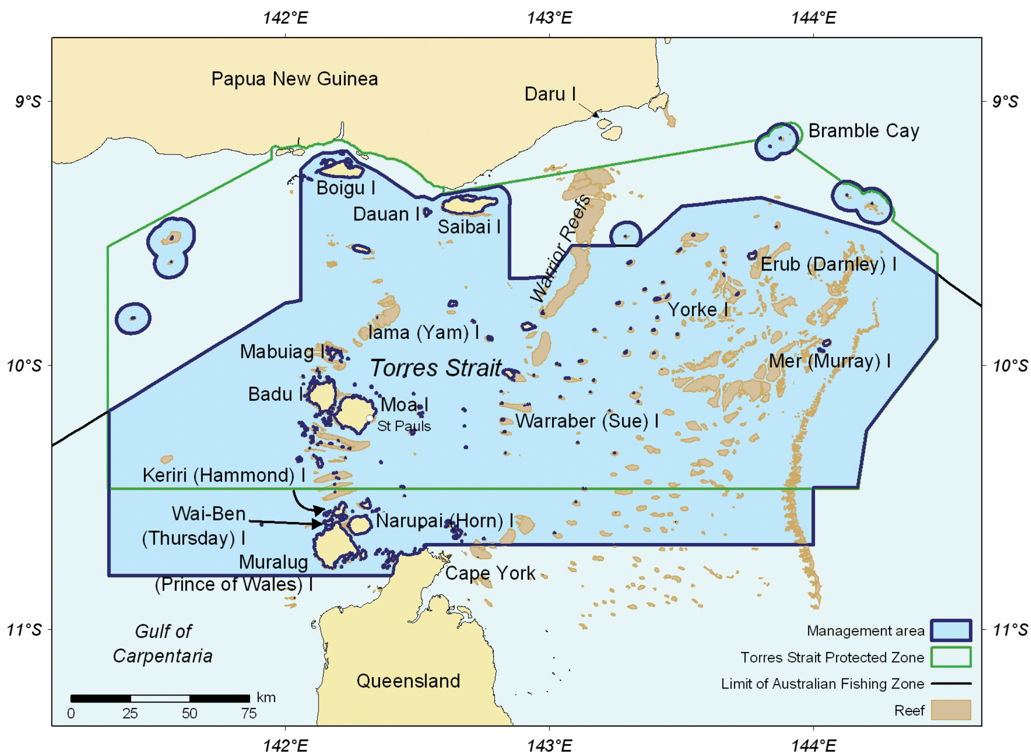


FIGURE 15.1 Area of the Torres Strait Finfish Fisheries (TSFF) (comprising the Torres Strait Spanish Mackerel Fishery [TSSMF] and the Torres Strait Reef Line Fishery [TSRLF])

TABLE 15.1 Status of the Torres Strait Finfish Fisheries

Fishery status	2008		2009		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Coral trout (*Plectropomus* spp., *Variola* spp.)					2009 catch below all total allowable catch scenarios run in recent management strategy evaluation.
Spanish mackerel (*Scomberomorus commerson*)					Catch for 2008 and 2009 below base-case model estimate of maximum sustainable yield and lower risk simulations in management strategy evaluation.
Economic status Fishery level	Estimates of net economic returns not available				Economic status uncertain. Total net economic returns are likely to be low.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING — OVERFISHED / OVERFISHING — UNCERTAIN — NOT ASSESSED

TABLE 15.2 Main features and statistics of the Torres Strait Finfish Fisheries

Feature	Description
Key target and byproduct species	Coral trout (*Plectropomus* spp., *Variola* spp.) —common coral trout (*P. leopardus*) —blue-spotted coral trout (*P. laevis*) —passionfruit coral trout (*P. areolatus*) —barcheek coral trout (*P. maculatus*) —white-edge coronation trout (*V. albimarginata*) —yellowedge coronation trout (*V. louti*) Spanish mackerel (*Scomberomorus commerson*)
Other byproduct species	Mixed reef species; predominately snappers (*Lutjanus* spp.), emperors (*Lethrinus* spp.) and rock cods (*Epinephelus* spp.) School mackerel (*Scomberomorus queenslandicus*), grey mackerel (*S. semifasciatus*), spotted mackerel (*S. munroi*) and double-lined or shark mackerel (*Grammatorcynus bicarinatus*)
Fishing methods	Coral trout and mixed reef species: handline Spanish mackerel: trolled baits and lures, handlines and droplines
Primary landing ports	Cairns; Torres Strait Island fish receivers on Darnley, Murray and Yorke islands
Management methods	Input controls: limited entry, vessel restrictions, prohibited species Output controls: size limits
Management plan	No formal plan of management. A management plan is being developed.
Harvest strategy	None
Consultative forums	Torres Strait Fisheries Management Advisory Committee (TSFMAC), Torres Strait Scientific Advisory Committee (TSSAC), Torres Strait Finfish Fishery Working Group (TSFFWG)
Main markets	Domestic: frozen
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Current accreditation dated 18 November 2008. Current accreditation (Wildlife Trade Operation) expires 25 November 2011.
Ecological risk assessment	None
Bycatch workplans	*Torres Strait Finfish Bycatch Action Plan 2005* (AFMA 2005a)

Table 15.2 continues over the page

TABLE 15.2 Main features and statistics of the Torres Strait Finfish Fisheries CONTINUED

Feature	Description			
Fishery statistics[a]	**2008 fishing season**		**2009 fishing season**	
Fishing season	1 January 2008–31 December 2008		1 January 2009–31 December 2009	
TAC and catch by species	TAC	Catch (tonnes)	TAC	Catch (tonnes)
—coral trout	None	25	None	27
—Spanish mackerel	None	90	None	101
Effort	Not available		Not available	
Fishing permits/licences	In June 2008: 166 TIB licences with line endorsements 184 TIB licences with mackerel endorsements 11 TVH licences with mackerel and/or line endorsements		In June 2009: 13 TIB licences with line endorsements 4 TIB licences with mackerel endorsements 6 TVH licences with mackerel and/or line endorsements	
Active vessels	35 TIB line fishers 24 TIB mackerel fishers 9 TVH line and/or mackerel fishers		17 TIB line and mackerel fishers 6 TVH line and mackerel fishers	
Observer coverage	Zero		Zero	
Real gross value of production (2008–09 dollars)	2007–08: $0.73 million (TSRLF), $0.70 million (TSSMF)		2008–09: $0.83 million (TSRLF), $0.30 million (TSSMF)	
Allocated management costs	n.a.		n.a.	

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; TIB = Traditional Inhabitant Boat; TSRLF = Torres Strait Reef Line Fishery; TSSMF = Torres Strait Spanish Mackerel Fishery; TVH = transferable vessel holder; n.a. = not available

a Fishery statistics are provided by fishing season unless otherwise indicated.

15.1 BACKGROUND

In July 2005 the Torres Strait Protected Zone Joint Authority (PZJA) approved a voluntary surrender process for all non-Traditional Inhabitant commercial operators in the Torres Strait Finfish Fisheries (TSFF). The surrender process covered the Transferable Vessel Holder (TVH) Sector and included both the reef line and mackerel fisheries. The aims were:

- to facilitate a 50:50 split of the Australian share of the resource between the TVH Sector and the Traditional Inhabitant Boat (TIB) Sector (for Traditional Inhabitant fishers)
- to allow for at least 50% ownership of Australia's share of the finfish resource by Traditional Inhabitants
- to meet Australia's catch-sharing obligations to Papua New Guinea under the *Torres Strait Treaty*.

Mediations initiated by TVH fishers and the Australian Government Department of Agriculture, Fisheries and Forestry resulted in agreement on a voluntary 100% buyout of all TVH fishing licences in the finfish fisheries. All TVH endorsements were surrendered to the PZJA by 30 June 2008 (Table 15.3). Since the surrender of TVH licences, there has been limited leasing of licences to non-traditional fishers.

Reef line

The Torres Strait Reef Line Fishery (TSRLF) is a multispecies fishery targeting mainly coral trout, with a smaller harvest of tropical snappers, emperors and rock cods (Table 15.2). Most commercial fishing activity takes place in the north-eastern region of the Torres Strait (Fig. 15.1). A large area of the fishery west of 142°32'E is closed to commercial fishing. Commercial operations are subject to many of the size limits that apply to species in Queensland's east-coast commercial reef line fishery (the Coral Reef Fin Fish

Fishery); however, red bass (*Lutjanus bohar*) and barramundi cod (*Cromileptes altivelis*), which are no-take species on the east coast, may be harvested in the Torres Strait.

A management plan for the TSRLF is under development and is expected to be implemented during 2011. New management arrangements may include a total allowable commercial catch for finfish species.

Spanish mackerel

The Torres Strait Spanish Mackerel Fishery (TSSMF) targets the Spanish mackerel, primarily by trolling (Table 15.2). The catch is highly seasonal, and the majority is taken around Bramble Cay in the far north-east of the Torres Strait (Fig. 15.1). A management plan for the fishery is under development and is expected to be implemented during 2011. New management arrangements may include a total allowable commercial catch for Spanish mackerel.

Thursday Island moored vessels
PHOTO: JAMES WOODHAMS, ABARE–BRS

TABLE 15.3 History of the Torres Strait Finfish Fisheries

Year	Description
Pre-1939	A troll fishery for Spanish mackerel existed; vessels based on Thursday Island.
1939 to 1945	Army unit stationed at Thursday Island to provide fish for army hospitals and troops.
1950	The first Cairns-based vessel began fishing for Spanish mackerel in the Torres Strait. Commercial fishing for reef fish began, with fishers travelling from southern ports.
1953	Other vessels from the Queensland east coast began to work in the Torres Strait.
1979 to 1983	Small-scale tagging projects for Spanish mackerel in effect.
1980	Commercial fishing by Traditional Inhabitants began for reef fish after the establishment of processing facilities and freezers on some islands.
1985	Introduction of the *Torres Strait Treaty*.
1988	Logbooks introduced for non-traditional fishers.
1990	~20 vessels licensed to fish in the Torres Strait for Spanish mackerel.
1998	Fishing methods for Spanish mackerel restricted to trolling, handlines and droplines. Possession limit of no more than 50 kg of other finfish. Minimum legal size of 45 cm total length for all mackerel.
2003	Logbooks introduced.
2004	Islander docket-book system introduced. Minimum legal size for Spanish mackerel set to 75 cm total length.
2008	Removal of transferable vessel holder endorsements from the fishery and commencement of leasing arrangements.
2009	Timeline for implementation of new management plan established. Management plan is expected to commence in July 2011.

SOURCES: Williams (1994); Begg et al. (2006).

15.2 HARVEST STRATEGY

The *Commonwealth Fisheries Harvest Strategy Policy* (HSP) is not prescribed for fisheries jointly managed by the Australian Government and other management agencies (domestic or international), such as the fisheries in the Torres Strait. Although the PZJA has asked its management forums to provide advice on the application of the HSP to the Torres Strait fisheries, currently no formal harvest strategies are in effect for the TSFF.

15.3 THE 2009 FISHERY

Key target and byproduct species

In 2009 the reported catch was approximately 27 t of coral trout and 101 t of Spanish mackerel (Table 15.2). Reporting of TIB catch is not mandatory, and catch records for July–December 2009 from Mer (Murray) Island were not available. The catch of Spanish mackerel and coral trout in 2009 was similar to the levels in 2008. The reduction in catch from previous years is understood to be a result of the voluntary surrender process for TVH operators.

Minor byproduct species

A recent survey of byproduct and bycatch in the TSRLF by Williams et al. (2008) found that coral trout made up more than 65% of retained catch by weight for both the TIB and TVH sectors, with mackerel and snapper making up an additional 23% for both sectors. The TIB Sector retains a wider range of species as byproduct than the TVH Sector.

Byproduct makes up a relatively minor component of catch in the TSSMF. Other mackerel species—including grey, school, spotted and shark mackerel—make up the majority of byproduct species; however, small quantities of reef fish such as coral trout may also be retained (AFMA 2005b; Begg et al. 2006). Table 15.4 lists the most abundantly caught byproduct species in the TSFF.

A recent study of Islander subsistence catch found that subsistence fishing yielded similar quantities of fish to the TIB and TVH sectors combined (Busilacchi 2010). However, the species composition of the subsistence and commercial catches differed: traditional subsistence fishing took predominantly Carangids (31% by weight) and Mugilids (20% by weight), whereas the commercial sector predominantly caught Serranids (19% by weight) and Carangids (18% by weight). Since traditional subsistence fishing is not targeting the same families as commercial subsistence fishing (with the exception of Carangids), it is unlikely that traditional subsistence fishing has a large impact on the more commercially valuable species such as coral trout and Spanish mackerel.

TABLE 15.4 Minor byproduct species—TACs/triggers, catches/landings and discards in the Torres Strait Finfish Fisheries

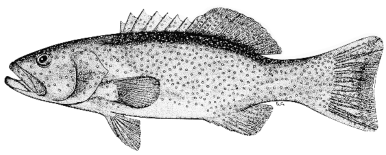
Species	TAC/ trigger	2008 catch (tonnes)	2008 discards	2009 catch (tonnes)	2009 discards
Barramundi cod (*Cromileptes altivelis*)	None	<1	n.a.	<1	n.a.
Cod, other (Serranidae)	None	<1	n.a.	<1	n.a.
Emperors (*Lethrinus* spp.)	None	<1	n.a.	1.7	n.a.
Sharks (Carcharhinidae)	None	0	n.a.	0	n.a.
Snappers (Lutjanidae)	None	0	n.a.	0	n.a.
Trevally (Carangidae)	None	<1	n.a.	1	n.a.
Wrasse (Labridae)	None	0	n.a.	0	n.a.

TAC = total allowable catch

15.4 BIOLOGICAL STATUS

CORAL TROUT

(*Plectropomus leopardus, P. laevis, P. areolatus, P. maculatus, Variola albimarginata, V. louti*)



LINE DRAWING: FAO

TABLE 15.5 Biology of coral trout

Parameter	Description[a]
Range	**Species:** Tropical waters of the Indian and Pacific Oceans. **Stock:** The area of the TSFF.
Depth	Relatively shallow water—to about 100 m—often associated with coral reefs. On the nearby Great Barrier Reef, inhabit mid-shelf reefs.
Longevity	~17 years
Maturity (50%)	**Age:** females 3–4 years; males 2 years. Species are protogynous hermaphrodites, functioning first as females and later as males. **Size:** 280 mm FL
Spawning season	August–December
Size	**Maximum:** ~65 cm for all species other than blue-spotted coral trout (~130 cm). **Recruitment into the fishery:** 38 cm TL for all species other than blue-spotted coral trout, which has a minimum legal size of 50 cm and a maximum of 80 cm.

FL = fork length; TL = total length; TSFF = Torres Strait Finfish Fisheries

a As approximately 80% of the catch of coral trout in the Torres Strait (by number) is common coral trout (*Plectropomus leopardus*), the information presented is for common coral trout, unless otherwise indicated.

SOURCES: Kailola et al. (1993); Samoilys (1997); Williams et al. (2007).

Barcheek coral trout PHOTO: MIKE GERNER, AFMA

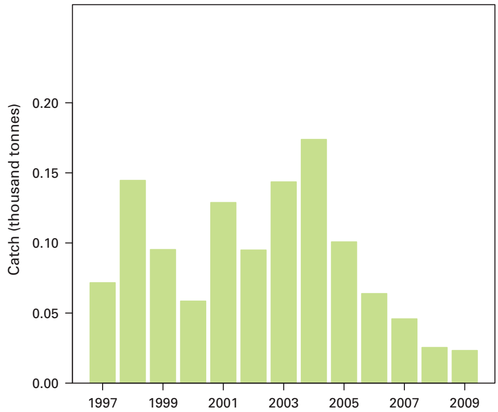


FIGURE 15.2 Coral trout catch history, 1997 to 2009

Stock status determination

The data presented in Williams et al. (2007), combined with a comparison of the 2009 catch with the historical catch record (Fig. 15.2), form the basis of the classification of this stock. This work estimated the spawning biomass to be greater than 60% of pre-fished levels in 2004. Catch in recent years has been below historic catch levels and well below the lowest catch level simulated in the management strategy evaluation (MSE) (80 t per year). This simulation saw the stock reach greater than 80% of the unfished spawning biomass within 20 years (Williams et al. 2007). On this basis, the stock is assessed as **not overfished** and **not subject to overfishing** (Table 15.1).

Reliability of the assessment/s

Although the TSRLF MSE (Williams et al. 2007) is not a stock assessment, the information presented by the authors is founded in well-tested methodology. The results of this work can be considered sound.

Previous assessment/s

An MSE has recently been undertaken for the TSRLF and should prove valuable in the development of future management arrangements (Williams et al. 2007). All four total allowable catch (TAC) simulations, ranging from 80 t to 170 t, achieved a spawning biomass greater than 70% of the

assumed unfished levels by 2025. Seasonal closures, minimum size limits (Table 15.5) and effort reductions were also tested in the MSE. Although additional management measures are probably not needed at current fishing levels, the results of these simulations indicated that a seasonal closure would be a good measure for addressing conservation, stock and economic objectives.

Future assessment needs

A formal stock assessment for coral trout would be a valuable addition to the management tools available to this fishery, providing useful information for any future TAC setting.

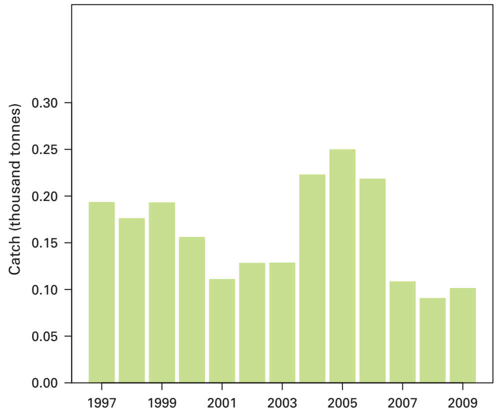
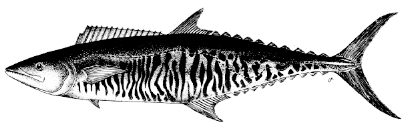


FIGURE 15.3 Spanish mackerel catch history, 1997 to 2009

SPANISH MACKEREL

(*Scomberomorus commerson*)



LINE DRAWING: FAO

TABLE 15.6 Biology of Spanish mackerel

Parameter	Description
General	Relatively fast-growing pelagic fish
Range	**Species:** Widely distributed throughout tropical and subtropical waters. In Australia, they are distributed from Geographe Bay in Western Australia to St Helens in Tasmania. **Stock:** The area of the TSFF.
Depth	Range from near the edge of the continental shelf to shallow coastal waters. Adults are commonly associated with coral reefs, rocky shoals and current lines on outer reef areas and offshore.
Longevity	22 years
Maturity (50%)	**Age:** ~2 years **Size:** 90 cm TL
Spawning season	Multiple spawning events between August and March
Size	**Maximum:** 240 cm FL; weight: 70 kg **Recruitment into the fishery:** 75 cm TL; weight: <5 kg; age: <2 years

FL = fork length; TL = total length; TSFF = Torres Strait Finfish Fisheries

SOURCES: McPherson (1992, 1993); Kailola et al. (1993); Begg et al. (2006).

Stock status determination

The most recent assessment of Spanish mackerel in the Torres Strait was released in 2006, incorporating data up to 2003. Based on the estimates of maximum sustainable yield (MSY) in the stock assessment and catch information for 2008 and 2009 (Fig. 15.3), this stock is assessed as **not subject to overfishing** (Table 15.1). Catches in 2008 and 2009 were below both the base case and lower risk MSY estimates (Begg et al. 2006).

Although the authors of the 2006 assessment acknowledged the significant uncertainty in the models, none of the model runs saw the biomass fall below $0.2B_0$; the base case predicted the exploitable biomass at $0.37B_0$. On this basis, the stock is assessed as **not overfished**. However, the more pessimistic of these models indicated that some rebuilding of the stock may be required, acknowledging that targets have not been set for this fishery. The low levels of harvest in recent years may have resulted in some rebuilding of the stock.

Reliability of the assessment/s

Uncertainty associated with the 2006 Spanish mackerel assessment and with the management advice and reference points derived from the analysis is largely a result of the quality and extent of the input data. The assessment used all available data, including the non-Islander commercial catch from logbooks,

Islander commercial catches from island council fish receivers, and AFMA docket books (1989–2003). Average total catch for years when no data were available (1940 to 1988) was modelled with both a non-linear model and a linear regression model. The modelling of catches for this period introduces further uncertainty in the biomass predictions. Although logbooks have been compulsory for non-traditional commercial fishers since 1988, the voluntary recording of commercial catch from traditional fishers through the docket-book system has only been in place since 2004. Therefore, it is highly likely that not all commercial harvest of Spanish mackerel was available for use in the assessment (Begg et al. 2006).

Previous assessment/s

The first formal stock assessment of Spanish mackerel in the Torres Strait was published in 2006 (Begg et al. 2006), informed by data to 2003 (inclusive). This found that catch rates declined from 1989 to 1999, and then increased from 2000 to 2003. The assessment concluded that Spanish mackerel was probably being harvested at levels near or exceeding maximum sustainable levels (up to 2003).

An MSE suggested that annual catches of around 150 t per year or less would achieve a better risk outcome and meet a fishing mortality target of half natural mortality. Noting that no target or limit reference points have been set for this fishery. The 2006 assessment noted that catches for 12 of the 15 years from 1989 to 2003 were above the base-case MSY of 169 t.

The potential for hyperstability of catch rates in the TSSMF was discussed by Begg et al. (2006). Hyperstability, in this case, is the maintenance of catch or catch rates, primarily due to the fishing operations focusing on spawning aggregations around Bramble Cay.

Future assessment needs

The most recent assessment of Spanish mackerel is now more than three years old, and an additional six years of catch and effort data are now available. An update to this assessment would be a valuable addition to the management tools available to the fishery, providing useful information for any future TAC setting.

15.5 ECONOMIC STATUS

Historically, the TSFF has been managed under a licensing system, combined with input and output controls. The fishery is currently developing a management plan that allows for setting of TACs. If the shift to a TAC management system occurs, input controls currently in place such as area closures, gear controls and minimum fish size limits will still have an important role to play in allowing sustainability and environmental objectives to be met.

In 2008–09 the GVP of the TSSMF was approximately $301 000. Since 2003–04 the real GVP in the fishery has fallen by $0.77 million (72%) (Fig. 15.4). This decline is largely the result of a 76% decrease in volume over this period.

In 2008–09 the gross value of production (GVP) of the TSRLF was approximately $826 000. Since 2003–04 the real GVP in the TSRLF has fallen by $1.7 million (67%) (Fig. 15.5). The main factor contributing to this decline has been a 73% fall in the volume of coral trout caught (Fig. 15.2).

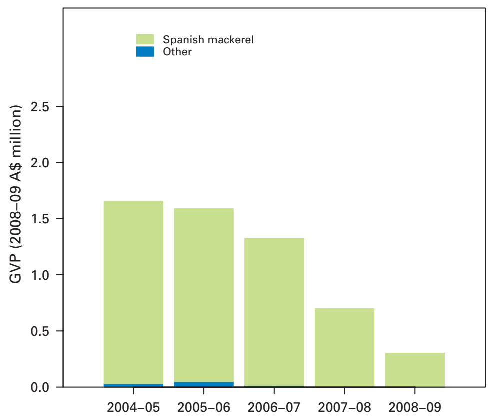


FIGURE 15.4 Real GVP in the TSSMF by financial year, 2004–05 to 2008–09

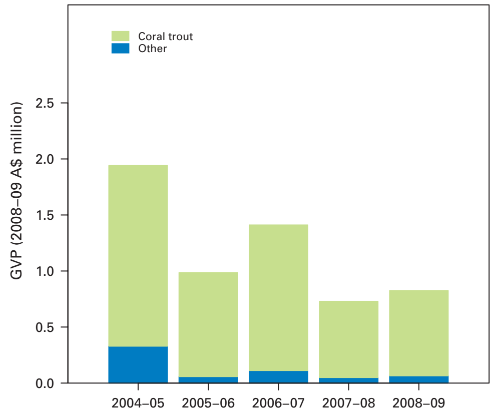


FIGURE 15.5 Real GVP in the TSRLF by financial year, 2004–05 to 2008–09

Leasing first occurred in 2008–09. In that year, 30 t of coral trout and 90 t of Spanish mackerel quota were leased (TSFMAC 2009); quantities that are significantly lower than catches achieved in recent years. For the 2009–10 season, there was a general lack of interest in leasing coral trout quota. A range of factors have been suggested by fishers for this, including low whole/fillet prices, difficulties in employing crew, remoteness of fishing locations and high fuel costs. All of these factors indicate that the expected economic returns from targeting coral trout were low. However, for Spanish mackerel in 2009–10, 105 t of quota was made available, all of which was taken up by fishers. This indicates that there has been an increase in the expected economic returns from catching this species in 2008–09.

Revenue from leasing quota to non-traditional fishers amounted to around $170 000 in 2008–09 (TSFMAC 2009) and approximately $110 000 in 2009–10 (sourced from the Torres Strait Regional Authority via S. Hall, pers. comm., July 2010). Revenue from leasing activity is invested in capacity building for Traditional Inhabitant fishers (TSFMAC 2009). These leasing revenues also represent a lower bound estimate of the NER (excluding management costs) generated from the fishery in each year as leasing costs represent a transfer of NER from operators to another entity (in this case, the TIB sector). Provided operators cover their leasing costs, then NER is at least equal to the leasing transfer.

To help increase leasing activity, longer term leases—for up to three years—are now also offered in the fishery, to provide longer term security to TVH fishing operators investing in the fishery. It is expected that these capacity-building projects will boost the economic performance of the fishery in the longer term, and increase the participation in the fishery by Traditional Inhabitant fishers.

15.6 ENVIRONMENTAL STATUS

The fishing methods employed in both fisheries typically result in the landing of live fish, allowing for the release of any unwanted or undersize fish. Therefore, provided that post-release mortality is not high, the impact on discarded fish is likely to be low. Results of post-release mortality studies in Queensland indicate that post-release survival of coral trout is quite high (>75%). Williams et al. (2007) report bycatch as a significant component of catch in the TSRLF. The number of species that were not kept was greater for non-Indigenous fishers (59.6%) than for Islander fishers (38.9%). The proportion of catch (by number of individual fish) discarded was similar between Islander fishers (57.8%) and non-Indigenous fishers (54.9%) (Williams et al. 2007).

Ecological risk assessment

No ecological risk assessment (ERA) has been completed to date.

Habitats

No studies have been undertaken to date on the impact of the fishery on habitat. However, due to the methods used and the selective nature of the fishery, it is expected that any impact is minimal. Completion of an ERA will provide valuable information on this

aspect of the fishery. Anchoring of vessels potentially has some impact on habitat.

Threatened, endangered and protected species

Sharks

Grey reef, white tip and unidentified shark are caught by Indigenous and non-Indigenous fishers. However, they make up less than 5% of the total catch in the TSRLF, and neither sector harvested them (Williams et al. 2008).

Marine turtles

A recent survey on the TSRFL by Williams et al. (2008) did not list marine turtles in the list of species caught. A previous assessment by the AFMA suggested that, based on anecdotal evidence, incidental capture of marine turtles is rare (AFMA 2005b).

15.7 HARVEST STRATEGY PERFORMANCE

Not applicable.

15.8 LITERATURE CITED

AFMA (Australian Fisheries Management Authority) 2005a, *Torres Strait Finfish Bycatch Action Plan 2005*, AFMA, Canberra.

——2005b, *Torres Strait Finfish Fishery draft assessment report*, AFMA, Canberra.

Begg, GA, Chen, CCM, O'Neill, MF & Rose, DB 2006, *Stock assessment of the Torres Strait Spanish Mackerel Fishery*, technical report no. 66, CRC Reef Research Centre, Townsville.

Busilacchi, S 2010, 'Monitoring and assessment of the subsistence fisheries in the eastern Torres Strait islands, Australia', PhD thesis, James Cook University, Townsville.

Kailola, PJ, Williams, MJ, Stewart, PC, Reichelt, RE, McNee, A & Grieve, C 1993, *Australian fisheries resources*, Bureau of Resource Sciences & the FRDC, Canberra.

McPherson, GR 1992, 'Age and growth of the narrow-barred Spanish mackerel (*Scomberomorus commerson* Lacepède, 1800) in north-eastern Queensland waters', *Australian Journal of Marine and Freshwater Research*, vol. 43, no. 5, pp. 1269–82.

——1993, 'Reproductive biology of the narrow-barred Spanish mackerel (*Scomberomorus commerson* Lacepède, 1800) in Queensland waters', *Asian Fisheries Science*, vol. 6, pp. 169–82.

Samoilys, MA 1997, 'Periodicity of spawning aggregations of coral trout, *Plectropomus leopardus* (Pisces: Serranidae) on the northern Great Barrier Reef', *Marine Ecology Progress Series*, vol. 160, pp. 149–59

TSFMAC (Torres Strait Fisheries Management Advisory Committee) (2009), 'Update to finfish leasing arrangements for 2009/2010', presented at meeting no. 11, 11–12 November, agenda item no. 7.3, <www.pzja.gov.au/committees/macs/tsfmac11_20091111/item_7.pdf>.

Williams, G 1994, *Fisheries and marine research in the Torres Strait*, Bureau of Resource Sciences, Department of Primary Industries and Energy, Canberra.

Williams, AJ, Begg, GA, Little, LR, Currey, LM, Ballagh, AC & Murchie, CD 2007, *Evaluation of the eastern Torres Strait reef line fishery*, Fishing and Fisheries Research Centre technical report no. 1, James Cook University, Townsville.

——Ballagh, AC, Begg, GA, Murchie, CD & Currey, LM 2008, 'Harvest patterns and effort dynamics of Indigenous and non-Indigenous commercial sectors of the eastern Torres Strait reef line fishery', *Continental Shelf Research*, vol. 28, pp. 2117–28.

16 Torres Strait Tropical Rock Lobster Fishery

P Ward, M Rodgers and C Perks

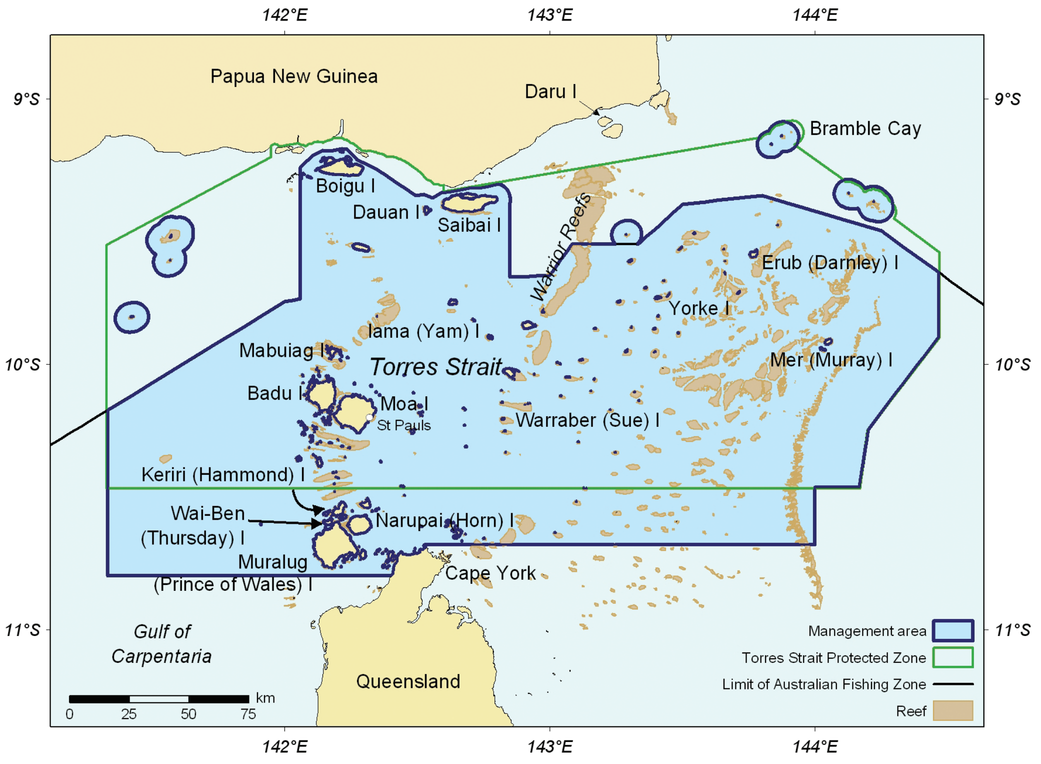


FIGURE 16.1 Management area of the Torres Strait Tropical Rock Lobster Fishery

TABLE 16.1 Status of the Torres Strait Tropical Rock Lobster Fishery

Fishery status	2008		2009		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Tropical rock lobster (*Panulirus ornatus*)	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Spawning stock biomass above target level. Fishing mortality rate well below the target. Poor fishing and economic conditions contributed to reduced fishing effort and catches in 2009.
Economic status Fishery level	Estimates of net economic returns not available				Economic conditions in the fishery have worsened. Total net economic returns are likely to be low.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING | OVERFISHED / OVERFISHING | UNCERTAIN | NOT ASSESSED

TABLE 16.2 Main features and statistics of the Torres Strait Tropical Rock Lobster Fishery

Feature	Description
Key target and byproduct species	Tropical rock lobster (*Panulirus ornatus*)
Other byproduct species	Other tropical rock lobsters (*Panulirus* spp.). Less than 1% of the catch comprises other lobster species, mainly *P. versicolor*. Pearl oysters (*Pinctada* spp.)
Fishing methods	Hand-held implement (snare, net or spear) on shallow reef flats at night; free-diving or with the use of hookah gear during the day
Primary landing ports	Thursday Island, Cairns, Daru Island (PNG), Yule Island (PNG)
Management methods	Input controls: hookah-gear ban (December–January), commercial fishing ban (October–November), and spring-tide hookah closures for a week around either the full or new moon each month (whichever has the highest tidal range) Output controls: minimum size limit (≥115 mm tail length or ≥90 mm carapace length) to protect pre-recruits and newly recruited lobsters; a bag limit of three lobsters per person or six lobsters per dinghy for traditional and recreational fishers; nominal TAC
Management plan	A management plan is being developed and the PZJA Standing Committee is reviewing interim management arrangements.
Harvest strategy	A harvest strategy approach is being trialled.
Consultative forums	Torres Strait Fisheries Management Advisory Committee (TSFMAC), Torres Strait Scientific Advisory Committee (TSSAC), Tropical Rock Lobster Resource Assessment Group (TRLRAG), Tropical Rock Lobster Working Group (TRLWG)
Main markets	Domestic: live lobsters and frozen tails International: United States (frozen tails), China (live lobsters)
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	 Current accreditation dated 22 November 2007 Current accreditation (Wildlife Trade Operation) expires 23 November 2010
Ecological risk assessment	Level 1: Scale, Intensity, Consequence Analysis (SICA) completed on 91 species (Furlani et al. 2007) Level 2: Productivity Susceptibility Analysis (PSA)—none Level 3: Sustainability Assessment for Fishing Effects (SAFE)—none Ecological risk management report (AFMA 2009)
Bycatch workplans	None

Table 16.2 continues over the page

TABLE 16.2 Main features and statistics of the Torres Strait Tropical Rock Lobster Fishery CONTINUED

Feature	Description	
Fishery statistics[a]	**2008 fishing season**	**2009 fishing season**
Fishing season	1 December 2007–30 September 2008 (commercial)	1 December 2008–30 September 2009 (commercial)
TAC	Nominal TAC of 751 t live weight	Nominal TAC of 484 t live weight (304 t for the Australian sector)
Catch (live weight): —Australia —PNG	 297 t (TVH—111 t, TIB—186 t) 352 t	 228 t (TVH— 99 t, TIB—129 t) 114 t[b]
Effort:	Australia TVH: 1323 tender days 809 operation days TIB: 4564 tender days PNG: 1232 tender days	Australia TVH: 1281 tender days 719 operation days TIB: 3146 tender days PNG: 1415 tender days
Fishing licences	12 TVH licences (with 25 tenders), 333 TIB licences, 8 PNG freezer vessel licences Hundreds of PNG dinghies and canoes fish unrestricted from coastal villages	13 TVH licences (with 34 tenders), TIB licences = n.a., 6 PNG freezer vessel licences Hundreds of PNG dinghies and canoes fish unrestricted from coastal villages
Active vessels	TVH: 13 TIB: 357 PNG: 6	TVH: 10 TIB: 279 PNG: 3
Observer coverage	Zero	Zero
Real gross value of production (2008–09 dollars)	2007–08: $9.72 million	2008–09: $6.94 million
Allocated management costs	n.a.	n.a.

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; PNG = Papua New Guinea; PZJA = Torres Strait Protected Zone Joint Authority; TAC = total allowable catch; TIB = Traditional Inhabitant boat; TVH = transferable vessel holder; n.a. not available

a Fishery statistics are provided by fishing season unless otherwise indicated

b This figure will be reviewed in 2010.

16.1 BACKGROUND

The Torres Strait Tropical Rock Lobster Fishery (TSTRLF) was the most valuable fishery in the Torres Strait in 2009 and provides significant economic opportunities for Torres Strait Islanders. Torres Strait Islanders fish traditionally and commercially (Traditional Inhabitant boat—TIB—licences) on local reefs and on more distant reefs. Their fishing trips usually last one day. Growth of the non-Islander sector of the fishery has been capped for more than two decades (Table 16.3). A small fleet of non-Islander freezer vessels (transferable vessel holder—TVH—licences) travels to the fishing grounds. Their trips last from a few days to several weeks. Lobsters from the Torres Strait stock are also fished in the Papua New Guinea (PNG) area of jurisdiction in the Torres Strait and to the north-east around Yule Island. The southern extension of the stock is fished commercially off north-east Queensland as far south as 14°S (Fig. 16.1).

Unlike temperate and subtropical rock lobsters (*P. cygnus* and *Jasus* spp.), tropical rock lobsters do not enter baited traps. Most lobsters are caught by divers with spears, or are caught alive by hand or with snares during the day. Divers usually work in pairs from dinghies (tenders or service vessels) that are about five metres long. They either free-dive or use hookah gear, which supplies the diver with compressed air through a hose from the vessel (Table 16.2). Free-divers work in waters to about four metres deep; hookah

divers work in waters to about 20 metres deep. However, some fishers take lobster by hand-held net or spear while pulling their dinghies across shallow reef flats at night in areas where lobsters emerge to forage.

The majority of product is marketed as frozen tails. There is some trade in live lobsters, which began in the mid-1990s to service lucrative export markets and a small domestic market. Handling and shipping of live lobsters require more sophisticated transport infrastructure than handling frozen tails, and there is always a risk of lobsters dying between the point of harvest and the market. There is increasing interest among the TIB and TVH sectors in using alternative methods to shipboard tanks, such as submerged cages, to hold live lobsters at sea.

TABLE 16.3 History of the Torres Strait Tropical Rock Lobster Fishery

Year	Description
1960s	Commercial fishing for tropical rock lobster began in the Torres Strait.
1970s to 1980s	Some trawl catches of tropical rock lobster, with most catch taken in PNG waters.
1984	*Torres Strait Fisheries Act 1984* determined. Trawling for lobsters banned to protect the breeding migration.
1985	*Torres Strait Treaty* ratified by Australia and PNG.
1986	Australian catches peaked at 914 t live weight.
1988	Minimum size implemented (100 mm tail length).
1989	Baseline abundance and age-composition survey of tropical rock lobster conducted.
1990	Beginning of annual mid-season fishery-independent surveys.
1990s	Introduction of a closure from October to November to prevent fishing using hookah gear.
1997	Logbooks made compulsory for TVH operators.
2001	Australia reported a catch of 116 t, the lowest on record. Minimum legal length of lobsters increased from 100 mm to 115 mm tail length. Hookah closure extended from October to January.
2002	October–November hookah closure extended to all methods of commercial fishing.
2003	30% tender reduction on TVH vessels implemented; this measure has been reintroduced annually. Moon-tide hookah closure introduced for one week during peak spring tide each month as an interim arrangement; this measure has been reintroduced annually.
2005	TRLRAG established. Fishery-independent pre-season survey introduced to support the development of a proposed quota-based management system.
2007	13 TVH vessel licences and 29 associated non-Islander licence tenders voluntarily surrendered in an open-tender process to meet Australia's obligations under the *Torres Strait Treaty*.
2008	TRLRAG agreed to a new weight-conversion factor of 2.677 for converting lobster tail weight to live weight.
2009	New stock assessment model introduced. PNG cross-endorsed vessels took up option under the *Torres Strait Treaty* to fish in Australian waters for the first time since 2002.

PNG = Papua New Guinea; TRLRAG = Torres Strait Tropical Rock Lobster Resource Assessment Group; TVH = transferable vessel holder

16.2 HARVEST STRATEGY

The *Commonwealth Fisheries Harvest Strategy Policy* (HSP; DAFF 2007) is not prescribed for fisheries jointly managed by the Australian Government and other management agencies (domestic or international). Although the Torres Strait Protected Zone Joint Authority (PZJA) has asked its management forums to provide advice on the application of the HSP to Torres Strait fisheries, there is currently no formal harvest strategy in effect for the TSTRLF. However, one is currently in development and is expected to be completed during 2010. The four fishery-specific parameters—B_{LIM}, B_{TARG}, F_{LIM} and F_{TARG}—have been defined. The harvest control rule consists of a constant exploitation rate (F_{TARG} = 0.15 per year) while the stock size is above B_{TARG} (= SB_{MSY}), and an exploitation rate that falls linearly to zero as the stock declines to the 0.2SB limit. The limit fishing mortality was set at F_{MSY}. In addition, a maximum total allowable catch (TAC) of 1200 t was defined as a precautionary measure to prevent extremely high fishing pressure.

With the introduction of the new stock assessment model, and its inherent assumptions and estimates of uncertainty, the proposed harvest strategy would benefit from a management strategy evaluation.

16.3 THE 2009 FISHERY

Key target and byproduct species

Catches in 2009 were below those recorded in 2008 (Table 16.2), following the decreasing catch trend since 2007. The Australian fishery recorded a preliminary catch of 228 t, 25% below the nominal Australian TAC of 304 t. The TIB Sector reported a greater catch than the TVH Sector, by approximately 30 t. Lower stock abundance and economic conditions contributed to reduced fishing effort and catches in 2009. Uncertainty about future management arrangements, as discussions on the management plan continue, may have also affected effort. Economic drivers such as high fuel prices and a downturn in the export market are also likely to contribute to reduced effort.

PNG reported a catch of 114 t, or 33% of the total reported catch for the fishery, which is within the normal range (PNG catch represents, on average, 20–35% of the total Torres Strait catch). The PNG fishery had a nominal TAC of 180 t. Following discussions at the 2009 resource assessment group meeting, the 2008 PNG catch was revised to 352 t (up from initial reports of 41 t). PNG fishers are not obliged to provide records of catch and effort, although catch data are recorded by fish receivers, and some operators do provide catch records. As for the Australian fleet, PNG fishers may be constrained by poor fishing and economic conditions.

PNG was granted cross-endorsement for six primary vessels to fish in Australian waters during the 2009 fishing season. They took up this option and fished in Australian waters for the first time since 2002. PNG is proposing to review its lobster fishery management plan, which was introduced in 2002, but this review did not occur in 2009.

The PZJA has agreed that the existing 2009 management arrangements be carried over into 2010. It has also agreed to a 30% tender reduction for TVH fishers for 2010.

There was no pre-season survey in 2009; therefore, no final TAC (which is based on the pre-season survey) will be calculated for 2010. However, the provisional TAC for 2010 will be the same as for 2009. Mid-season surveys are again proposed for the 2010 fishing season.

Tropical rock lobster production in the fishery fell in 2008–09 for the fourth consecutive year, to 240 t, a 29% reduction from 2007–08 production. Real gross value of production (GVP) also decreased for the fourth consecutive year, to $6.9 million (Fig. 16.2). After three years of consecutive rises, real prices remained steady in 2008–09 averaging $27.79 per kilogram.

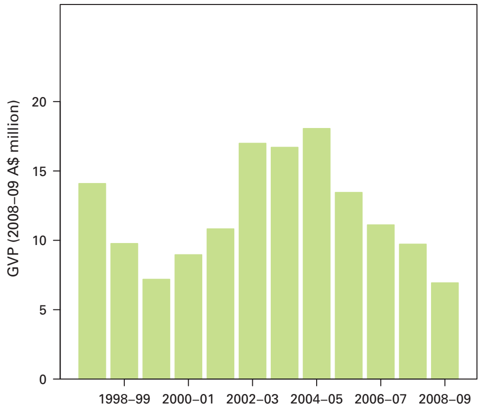


FIGURE 16.2 TSTRLF real GVP, by financial year, 1997–98 to 2008–09

SOURCE: ABARE–BRS (unpublished data).

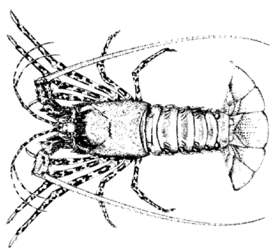
Minor byproduct species

Other lobster species, mainly *P. versicolor*, and pearl oysters (*Pinctada* spp.) are a minor byproduct of the TSTRLF. Pearl oysters have been reported in catches in recent years.

16.4 BIOLOGICAL STATUS

TROPICAL ROCK LOBSTER

(*Panulirus ornatus*)



LINE DRAWING: KARINA HANSEN

TABLE 16.4 Biology of tropical rock lobster

Parameter	Description
General	In spring each year, 2–3 year-old lobsters emigrate from the Torres Strait to breed. Tagging shows that some lobsters move north-east into the Gulf of Papua while they are becoming sexually mature. Some move as far as the eastern Gulf of Papua where, for a few months each summer, they are targeted in a seasonal fishery around Yule Island. Studies have concluded that nearly all post-emigration lobsters would die at the end of the summer breeding season from the combined stresses of emigration and breeding.
Range	**Species:** Widely distributed throughout the Indian and western Pacific Oceans. In Australia, they are found throughout tropical northern waters and generally as far south as North West Cape (Ningaloo Reef region) and Sydney. **Stock:** The assessment covers the main Australian and PNG fishing grounds—waters less than 25 m deep, in the area west of 142°E to Warrior Reef and 142.9°E in the east, from the southern PNG coastline southwards along the Queensland coastline to 10.8°S.
Depth	Generally found in seabed holes or crevices in shallow reefs or the deeper areas between reefs to depths of about 50 m, but occasionally reported from deeper waters.
Longevity	3–5+ years, although individuals older than 3 years are rare in the Torres Strait, due to the annual emigration of 2–3-year-old lobsters to breeding grounds.
Maturity (50%)	**Age:** 2–3 years **Size:** ~100 mm CL
Spawning season	Eastern Torres Strait and eastern Gulf of Papua: November–March. Mature females brood 2–4 clutches of 300 000–750 000 eggs. The eggs hatch after about one month. The planktonic larval stage lasts 4–6 months, before recruiting to shallow habitats of the Torres Strait and coastal Queensland. Dispersal is thought to be largely influenced by the Coral Sea Gyre.
Size	**Maximum:** At least 150 mm CL. Fast growing, attaining 40–60 mm CL at 1 year of age. **Recruitment into the fishery:** The minimum legal size is 90 mm CL or 115 mm tail length. Lobsters typically reach this size in the Torres Strait between 1 and 2 years of age. Most lobsters taken in the fishery have tails weighing 250–450 g, corresponding to a whole-lobster weight of about 625–1100 g. Some lobsters remain in the Torres Strait for an additional year, and tails of 1000 g are often reported.

CL = carapace length

SOURCE: MacFarlane & Moore (1986); Kailola et al. (1993); Skewes et al. (1997).

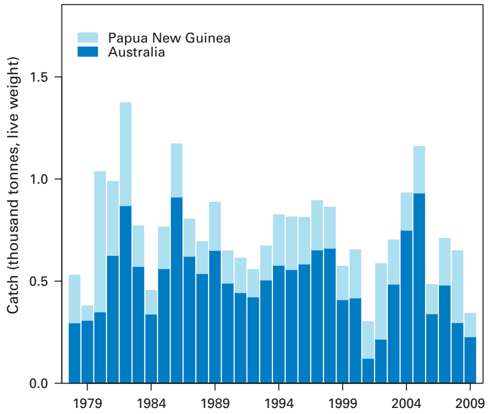


FIGURE 16.3 Tropical rock lobster catch history, 1978 to 2009

Stock status determination

The 2009 assessment involved a new, integrated, age-structured stock assessment model (Plagányi et al. 2009). It used annual fishery-independent survey data (including the 2008 mid-year and pre-season surveys) and commercial catch data, which extended back to 1973. Abundance indices derived from surveys were checked against catch rates reported by the non-Islander sector since 1989. The new model used a Beverton–Holt stock–recruitment relationship, with an estimated low steepness value.

The model estimated a preliminary TAC of 450 t for the fishery, which was substantially lower than the final TAC for 2007 (835 t) and 2008 (751 t). However, this was not unexpected because the preliminary TAC must be conservative and because of low stock abundance in 2006 and subsequent poor recruitment. The 2008 mid-year and pre-season surveys showed a low abundance of recruiting (1+ year-old) and fished (2+ year-old) lobsters. The abundance of recently settled (0+ year-old) lobsters was slightly higher than in the previous year, suggesting prospects for improved recruitment after 2009.

The fishery recorded a catch of 342 t in 2009 (Fig. 16.3), which was about 100 t less than the preliminary final TAC. The PNG catch may be underestimated. Catch levels will be close to the preliminary final TAC if the PNG reported catch is at levels similar to those in 2008.

In 2009 the stock is assessed as **not overfished** (Table 16.1) because the spawning stock biomass is estimated to be at 56% of the initial (1973) level, which is well above the 20% biomass limit. The fishery is assessed as **not subject to overfishing** because the average fishing mortality rate is 6% per year, which is less than half the 13% limit (Plagányi et al. 2009). Fishing effort is at historically low levels due to factors other than stock abundance.

Reliability of the assessment/s

Plagányi et al. (2009) considered the estimates of reference points to be preliminary because the new model requires further testing and development. The base-case estimate of depletion (current spawning biomass at 56% of the initial biomass) had 90% confidence intervals of 39–72% of the initial biomass. Depletion estimates ranged from 50% to 94% for various sensitivity runs, which included non-reporting of catches, stock–recruitment variability and length-at-age scenarios. Model estimates of stock–recruitment steepness (0.27–0.31) seem low for this short-lived species, but are similar to steepness estimates for prawns in the Northern Prawn Fishery. Low steepness suggests that management should maintain a larger spawning biomass with low yields (Plagányi et al. 2009).

The proportion of 0+ year-old lobsters that settle in PNG waters and the proportion that migrate from Australian to PNG as they get older are uncertain. This information is necessary for estimating the percentage of the Torres Strait stock originating in PNG waters. Queensland catches are not included in the assessment. Incorrect assumptions on mixing, stock relationships and catch levels may lead to under- or over-estimation of biomass. Concerns remain, over illegal, unregulated and unreported fishing, and localised depletion in PNG waters due to unconstrained artisanal fishing effort (Table 16.2).

Previous assessment/s

A baseline survey of the population was conducted in 1989. Subsequent annual surveys of abundance and age composition have provided fishery-independent estimates of stock size, of the relative abundance of recruits that would comprise target stocks in the following year, and of potential yield. The annual surveys are conducted in May–June (mid-season) to measure the abundance of recruiting (1+ year-old) and fished (2+ year-old) lobsters in the Torres Strait. To support the introduction of a quota-based management system, an additional fishery-independent, pre-season survey was introduced in 2005. The trials over the past four years show that the pre-season survey provided the most reliable information for the setting of a TAC. The running of the mid-season and pre-season surveys are subject to ongoing review.

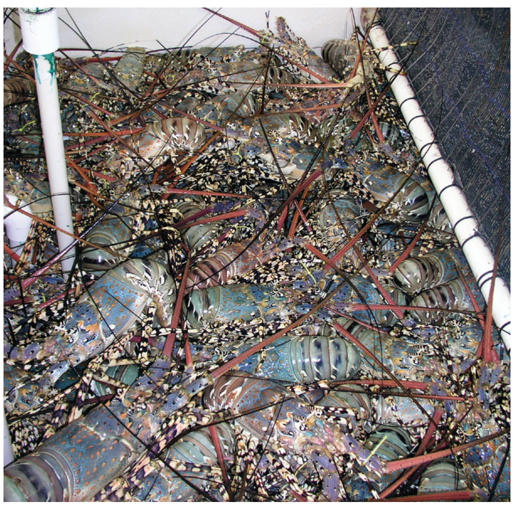
The surveys highlight a poor stock–recruitment relationship and variability in adult abundance. Annual recruitment varies both temporally and spatially. Analyses of size-frequency data have shown that growth rates can differ by more than 10% between years, and up to 40% between different areas of the Torres Strait. For example, lobsters in the north-western Torres Strait grow faster and are significantly larger than those in the south-east and south-west (Table 16.4).

The 2007 stock assessment estimated the maximum sustainable yield (MSY) to be 700 t (live weight). This was an increase of 60 t on the estimate provided in 2006. At the close of the 2007 fishing season, the spawning stock biomass was estimated to be above the level required to support MSY. Overall, the results of the 2007 stock assessment indicated that the 2007 spawning stock and the number of 2+ year-old lobsters were higher than in 2006.

Future assessment needs

Current data deficiencies in the assessment include uncertainties in catch data for the TIB sector and PNG. Catch reporting is voluntary in the TIB sector (although fish receivers may keep records through the voluntary docket book system), and little is known about the level and location of TIB fishing effort. The PNG catch and effort data are provided mainly by two companies and therefore represent only part of the catch. Records from PNG fish receivers are also used to help estimate the PNG catch. The accuracy of the catch and effort data directly influences the reliability of the stock assessment and the subsequent estimation of TACs.

Tropical rock lobster tails on ice
PHOTO: KATE DUNKERLEY, AFMA



Tropical rock lobsters PHOTO: AFMA

In addition to catch reporting, there is uncertainty about the natural mortality rates of 1+ and 2+ year-old lobsters (Plagányi et al. 2009). The high variability in recruitment since 1989 highlights the need for accurate monitoring of the lobster population to ensure that sustainable TACs are set each year under the proposed quota-management system.

Extending the pre- and mid-season surveys to the area from the southern boundary of the TSTRLF to the northern boundary of the Queensland East Coast Tropical Rock Lobster Fishery would provide information on movement between Queensland and the TSTRLF, and perhaps provide insights into the size of the spawning stock outside the Torres Strait (Ye et al. 2007).

These issues highlight challenges to the successful introduction of the proposed quota-management system. TAC forecasts will need to provide sufficient notice for fishers and management agencies to plan appropriately. Another challenge is how to monitor, and potentially restrict, catches during the season to ensure that they remain within limits. Annual variations in lobster abundance will result in significant fluctuations in TACs from year to year, presenting some fishing businesses with cash-flow and marketing problems.

16.5 ECONOMIC STATUS

In 2007 ABARE surveyed the fishers in the TSTRLF and Torres Strait Finfish Fishery (see Fairhead & Hohnen 2007). Between 2004–05 and 2005–06, total cash receipts and total cash costs declined by 43% and 33%, respectively, in the TSTRLF. Because of the larger relative decrease in total cash receipts than in total cash costs, vessel business profit declined by 65% between the two years (Fairhead & Hohnen 2007). The partial buy-back of non-Islander (TVH) licences in 2007 (TSSAC 2009), which was initiated by the Australian Government, may have had an impact on economic performance by decreasing the fixed capital costs associated with the fishery.

Overall economic performance

Little information is available on the TSTRLF. However, Figure 16.4 shows the price per kilogram of tropical rock lobster and the quantity caught. Prices have increased by 28% since 2005–06, but quantities caught have fallen by 60%, and the result is a 48% decrease in revenues. Unless operating costs have fallen by more than 48%, it would appear that economic conditions in the TSTRLF have deteriorated since the last survey.

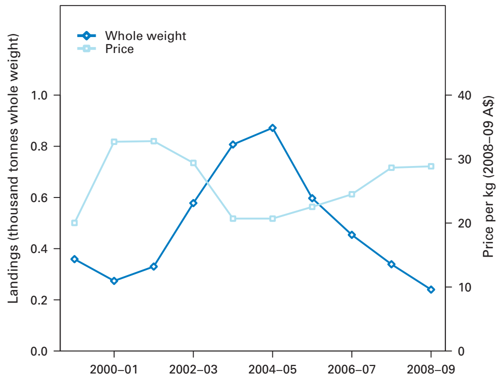


FIGURE 16.4 Quantity landed and real price per kilogram of Torres Strait tropical rock lobster, 1999–00 to 2008–09

SOURCE: ABARE–BRS (unpublished data).

Future considerations

With the exception of the 2007 ABARE survey, there is little information on the economic performance of the TSTRLF. Since it is a single-species fishery, information about stocks and revenues is relatively accessible. It is possible that the fishery may move from the current system of input controls to a management system based on individual transferable quotas (ITQs). If the move to an ITQ system were to occur, issues such as high-grading and the monitoring of landings would need to be considered further.

16.6 ENVIRONMENTAL STATUS

The fishery has little direct impact on the marine environment or other fish species because hand-collection fishing methods allow careful selection of catch.

Ecological risk assessment

The Level 1 ecological risk assessment did not identify any species with a medium or high risk associated with TSTRLF fishing activities (Furlani et al. 2007; AFMA 2009).

Threatened, endangered and protected species

TIB operators may opportunistically take dugong or turtles while fishing in the TSTRLF.

Benthic habitats

Damage to the marine benthos might occur through vessel anchors, fishers walking on emergent reefs and divers damaging corals. The extent of such damage has not been estimated in the Torres Strait.

16.7 HARVEST STRATEGY PERFORMANCE

Not applicable.

16.8 LITERATURE CITED

AFMA (Australian Fisheries Management Authority) 2009, *Ecological risk management report for the Torres Strait Tropical Rock Lobster Fishery,* AFMA, Canberra.

DAFF (Australian Government Department of Agriculture, Fisheries and Forestry) 2007, *Commonwealth Fisheries Harvest Strategy: policy and guidelines*, DAFF, Canberra.

Fairhead, L & Hohnen, L 2007, *Torres Strait islanders: improving their economic benefits from fishing*, ABARE research report 07.21, prepared for the Fisheries Resources Research Fund, Canberra.

Furlani, D, Dennis, D, Dowdney, J, Butler, A & Mason, F 2007, *Ecological risk assessment for the effects of fishing: report for the Torres Strait Rock Lobster Fishery*, report for the AFMA, Canberra.

Kailola, PJ, Williams, M, Stewart, P, Riechelt, R, McNee, A & Grieve, C 1993, *Australian fisheries resources,* Bureau of Resource Sciences & the FRDC, Canberra, pp. 64–67.

MacFarlane, JW & Moore, R 1986, 'Reproduction of the ornate rock lobster, *Panulirus ornatus* (Fabricius), in Papua New Guinea', *Australian Journal of Marine and Freshwater Research*, vol. 37, pp. 55–65.

Plagányi, É, Dennis, D, Kienzle, M, Ye, Y, Haywood, M, Mcleod, I, Wassenberg, T, Pillans, R, Dell, Catchability, Coman, G, Tonks, M & Murphy, N 2009, *TAC estimation and relative lobster abundance surveys 2008/09*, final report to the AFMA, project no. 2008/837, CSIRO Marine and Atmospheric Research, Cleveland, Queensland.

Skewes, TD, Pitcher, CR & Dennis, DM 1997, 'Growth of ornate rock lobsters, *Panulirus ornatus*, in Torres Strait, Australia', *Marine and Freshwater Research*', vol. 48, pp. 497–501.

TSSAC (Torres Strait Scientific Advisory Committee) 2009, *Strategic Research Plan for Torres Strait Fisheries*, July, <www.pzja.gov.au/resources/publications/Stratplan_TSF_Jul09.pdf>.

Ye, Y, Dennis, D, Skewes, T, Polon, P, Pantus, F, Brewer, D, Haywood, M, McLeod, I, Wassenberg, T, Pillans, R, Chetwynd, D & Sheils, J 2007, *2006 relative abundance and preseason surveys, assessment of the Torres Strait Lobster Fishery and TAC estimation,* CSIRO Marine and Atmospheric Research, Cleveland, Queensland & AFMA, Canberra.

17 Torres Strait Prawn Fishery

J Woodhams, M Rodgers and C Perks

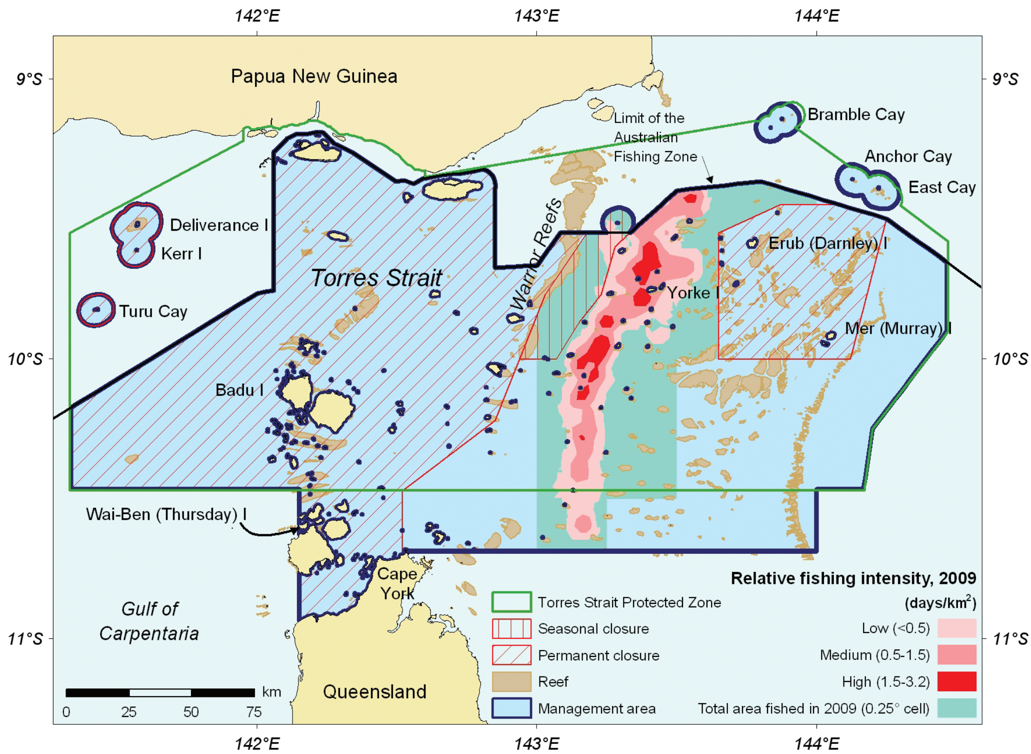


FIGURE 17.1 Relative fishing intensity in the Torres Strait Prawn Fishery, 2009

TABLE 17.1 Status of the Torres Strait Prawn Fishery

Fishery status	2008		2009		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Brown tiger prawn (*Penaeus esculentus*)	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Catch in recent years is below estimate of MSY. Most recent estimate of $B_{CURRENT}$ is above B_{MSY}.
Blue endeavour prawn (*Metapenaeus endeavouri*)	Uncertain	Uncertain	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Catch in recent years is below estimate of MSY. Most recent estimate of $B_{CURRENT}$ is above B_{MSY}.
Red-spot king prawn (*Melicertus longistylus*)	Uncertain	Uncertain	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Recent catches historically low. 2009 catch rates close to historical average. Low activation of effort. Catch below historical MCY estimates.
Economic status Fishery level	Net economic returns –$2.7 million in 2007–08		Net economic returns were –$3.3 million in 2008–09 (preliminary estimate)		Economic status could be improved: exhibits characteristics associated with open access and low profits.

MCY = maximum constant yield; MSY = maximum sustainable yield

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING — OVERFISHED / OVERFISHING — UNCERTAIN — NOT ASSESSED

TABLE 17.2 Main features and statistics of the Torres Strait Prawn Fishery

Feature	Description
Key target and byproduct species	Brown tiger prawn (*Penaeus esculentus*) Blue endeavour prawn (*Metapenaeus endeavouri*) Red-spot king prawn (*Melicertus longistylus*)
Other byproduct species	Moreton bay bug (*Thenus orientalis*) Scallops (*Amusium* spp.) Slipper lobster (*Ibacus* spp.) Squid (*Photololigo* spp.)
Fishing methods	Prawn trawl; predominately quad gear (four nets)
Primary landing ports	Cairns, Innisfail
Management methods	Input controls: limited entry, TAE, gear restrictions, time and area closures. The combined head rope and foot rope length of all the gear (for a single vessel) may not exceed 88 m. Maximum vessel length of 20 m
Management plan	*Torres Strait Prawn Fishery Management Plan 2009* (DAFF 2009)
Harvest strategy	None (harvest strategy in development)
Consultative forums	Torres Strait Prawn Management Advisory Committee (TSPMAC), Torres Strait Scientific Advisory Committee (TSSAC)
Main markets	Predominately domestic; some export to United States, Japan, Europe
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Current accreditation dated 25 February 2009 Current accreditation (Wildlife Trade Operation) expires 25 February 2012
Ecological risk assessment	Level 1: Scale Intensity Consequence Analysis (SICA) completed on 612 species (Turnbull et al. unpublished)

Table 17.2 continues over the page

TABLE 17.2 Main features and statistics of the Torres Strait Prawn Fishery CONTINUED

Feature	Description					
Bycatch workplans	*Torres Strait Prawn Fishery Bycatch Action Plan 2005* (AFMA 2005)					
Fishery statistics[a]	**2008 fishing season**			**2009 fishing season**		
Fishing season	1 March 2008–30 November 2008			1 March 2009–30 November 2009		
TAE, catch and estimated value by species:	TAE (days/nights)[b]	Catch (tonnes)	Real value (2007–08)	TAE (days/nights)	Catch (tonnes)	Real value (2008–09)
—all prawns	9200: 6867 (Australia) 2070 (PNG) 263 (reserved)	940	$10.4 million	12 325:[c] 9200 (Australia) 3125 (PNG)	505	$6.1 million
—tiger prawn	–	472	$6.8 million	–	322	$4.2 million
—blue endeavour prawn[d]	–	420	$2.8 million	–	167	$1.3 million
—red-spot king prawn[d]	–	48	$0.5 million	–	16	$0.2 million
—other catch	–	n.a	$0.3 million	–	n.a.	$0.4 million
Effort applied	3479 days/nights			1776 days/nights		
Fishing permits/licences	61 (10 licences not attached to vessels)			61 (8 licences not attached to vessels)		
Active vessels	38			26		
Observer coverage	155 days (4.52% of activated effort)			86 days (4.84% of activated effort)		
Real gross value of production (2008–09 dollars)	2007–08: $10.8 million			2008–09: $6.4 million		
Allocated management costs[e]	2007–08: $0.65 million			2008–09: $0.60 million		

– = not applicable; EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; TAE = total allowable effort

a Fishery statistics are provided by fishing season unless otherwise indicated

b The terms ‘nights’ and ‘days’ are used interchangeably throughout the text where they refer to effort in the fishery. This is because licences are allocated fishing ‘days’ to operate in the fishery, whereas the actual fishing activity occurs at night

c Although TAE was set at 12 325, only 9200 nights were available to the fishery

d Includes catches of other endeavour and king prawn species

e Includes Australian Fisheries Management Authority, Queensland Department of Employment, Economic Development and Innovation.

17.1 BACKGROUND

The Torres Strait Prawn Fishery (TSPF) (Fig. 17.1) operates in both Queensland and Commonwealth waters and is managed by the Torres Strait Protected Zone Joint Authority (PZJA), established under the *Torres Strait Fisheries Act 1984*. The area fished is about 8000 km^2, covering approximately 20% of the Torres Strait Protected Zone (Turnbull & Rose 2007).

Under the *Torres Strait Treaty*, Papua New Guinea (PNG) is entitled to 25% of the TSPF resource in the Australian jurisdiction (Table 17.2). Similarly, Australia is entitled to 25% of the fishery in the PNG jurisdiction. PNG operators have sporadically activated their entitlements in the past; however, the majority of PNG activity has been confined to PNG waters (north of the Australian Fishing Zone).

The trawl fleet is highly mobile, with many of the licensed vessels endorsed to operate in the East Coast Otter Trawl Fishery and/or the Northern Prawn Fishery. Australian-licensed trawlers can remain on the Torres Strait fishing grounds for extended periods, with support from mother ships, fuel barges and the delivery of spare parts via aircraft.

The fishery has a number of permanent, spatial and temporal closures (Fig. 17.1). The permanent closure to the west of Warrior

Reef was implemented in 1981 (Table 17.3) at the request of industry, to prevent large catches of non-commercial-sized tiger prawns (Watson & Mellors 1990). The closure around Darnley Island was introduced in response to Traditional Inhabitants' concerns about the possible impact of trawling on pearl shell beds. An area east of the Warrior Reefs is closed from December to August, again to protect small, non-commercial prawn. The seas surrounding Turu Cay and Deliverance and Kerr Islands were excluded from trawling operations when the management plan for the fishery was introduced in 2009, with the aim of protecting breeding populations of marine turtles.

The efficiency of vessels within the fishery has increased over the years. Efficiencies have been gained in average engine horsepower, gearbox ratios, trawl speed, fuel capacity and consumption, and adoption of propeller nozzles. The adoption of computer-based technologies—such as mapping applications, sonar and global positioning systems—has also helped fishers to more effectively target their operations (O'Neill & Turnbull 2006; Turnbull et al. 2009).

The fishery is managed in light of the sustainable yield of the tiger prawn stock, as this species is considered the most vulnerable to exploitation. The take of prawns in the TSPF is regulated through the pro-rata allocation of effort to operators, capped at a total allowable effort (TAE) to achieve maximum sustainable yield (MSY) of tiger prawns, as determined through stock assessment. The TAE in recent years has been set at 9200 days, based on fishing effort needed to harvest the tiger prawn stock at MSY (E_{MSY}). The E_{MSY} estimate of 9197 days is from the most recent stock assessment for tiger prawns, using the Beverton–Holt stock–recruitment relationship (O'Neill & Turnbull 2006). In 2009 the TAE was set at 12 325 days; however, only 9200 were made available to the fishery.

Under the management plan for the fishery (DAFF 2009), the TAE (9200 units) is split between Australia and PNG according to the catch-sharing arrangements set out in the *Torres Strait Treaty*. This amounts to 6867 units for Australian-licensed vessels and 2333 units for PNG-licensed vessels.

TABLE 17.3 History of the Torres Strait Prawn Fishery

Year	Description
1970	TSPF began. All Queensland east-coast and Northern Prawn Fishery prawn trawlers were entitled to fish in the Torres Strait.
1974	Five vessels based at Thursday Island. Approximately 70 east-coast prawn trawlers, from about 1200, took up the option to fish.
1981	Ban on daylight trawling to protect migrating lobsters. In October, the fishing grounds to the west of the Warrior Reef were closed to trawling under Commonwealth legislation, at industry request. 1980s saw the arrival of mother ships and fuel barges to the Torres Strait, resulting in the closure of processing facilities on Thursday Island.
1984	A total ban on trawling for lobsters legislated.
1985	*Torres Strait Treaty* ratified, resulting in management of TSPF as a separate and distinct fishery from the NPF and ECOTF. Torres Strait Treaty provides for catch-sharing arrangements with PNG.
1989	Introduction of compulsory logbooks. Three licences allocated for Torres Strait Islander participation in the fishery.
1993	Arrangements introduced to allocate a quota of access days to operators to limit the total effort allocated in the fishery.
2005	Torres Strait Islander licences were given back to the PZJA. A total effort cap of 9197 days (rounded to 9200 for administrative purposes) for TSPF introduced, reducing allocated days from around 13 450 days. The decision followed stock assessment estimates of MSY and E_{MSY} for tiger prawns.

Table 17.3 continues over the page

TABLE 17.3 History of the Torres Strait Prawn Fishery CONTINUED

Year	Description
2006	Vessel-replacement policy suspended, which previously required a 20% reduction in allocated fishing days for operators wishing to introduce a more powerful vessel into the fishery. Minimum number of days to participate in the fishery reduced from 50 to 34 to accommodate the reduction in fishing effort imposed by the 9200 fishing-day effort cap. Effort buy-back to allow for cross-border fishing by PNG vessels.
2007	In June, PNG agreed to allow its allocation of effort in the Australian jurisdiction to be used by Australian operators. In August, PZJA agreed to allow internal leasing of effort units in TSPF under a management plan. At the 2007 Bilateral Fisheries Meeting between Australian and PNG, it was agreed to roll over the 2007 arrangements for the 2008 fishing season.
2008	Management plan endorsed by PZJA, to be in place for the 2009 fishing season.
2009	Torres Strait Prawn Fishery Management Plan 2009 (DAFF) introduced. This plan caps the number of licences to 61, with the PZJA required to set a TAE each year.

ECOTF = East Coast Otter Trawl Fishery; E_{MSY} = effort producing maximum sustainable yield; MSY = maximum sustainable yield; NPF = Northern Prawn Fishery; PNG = Papua New Guinea; PZJA = Protected Zone Joint Authority; TSPF = Torres Strait Prawn Fishery; TAE = total allowable effort

SOURCES: Turnbull & Watson (1995); Taylor et al. (2007); Cocking et al. (2008); Wallis et al. (2009).

17.2 HARVEST STRATEGY

The *Commonwealth Fisheries Harvest Strategy Policy* (HSP; DAFF 2007) is not prescribed for fisheries jointly managed by the Australian Government and other management agencies (domestic or international). Although the PZJA has asked specific management forums to provide advice on the application of the HSP to Torres Strait fisheries, there is currently no formal harvest strategy in effect for the TSPF. A harvest strategy is in development and is expected to be completed during 2010.

17.3 THE 2009 FISHERY

A number of days equivalent to the full TAE for the 2009 fishing season (9200) was made available to Australian operators, under PNG's guarantee that it would not seek to activate its effort allocation in the 2009 season (which would push the potential activated effort above the current E_{MSY}). This was achieved by multiplying the effort units in the fishery, introduced through the management plan (DAFF 2009), by ~1.34, resulting in a TAE for the fishery of 12 325 days, as shown in the following calculations:

Total fishery TAE = 9200 units × ~1.34 = 12 325 units

Australian operator TAE: 6867 units × ~1.34 = 9200 fishing days

PNG TAE: 2333 units × 1.34 = 3125 units

Key target and byproduct species

The 2009 prawn harvest for the TSPF was 505 t, comprising 322 t of tiger prawns, 167 t of endeavour prawns and 16 t of king prawns (Table 17.2). There were 1776 days fished in 2009, down from 3479 in 2008 (Fig. 17.2a).

Gross value of production (GVP) for 2008–09 was $6.4 million (Fig. 17.2b). This was considerably lower than in 2007–08, when the fishery was responsible for $10.8 million worth of production. GVP in real dollar terms has fallen in the fishery every year since 1998–99. This negative trend is consistent with declining catches over the same period. Several other factors have also contributed to the decline in GVP. Over the past decade, prawn fishers have experienced increased competition in domestic markets from imports and the Australian dollar has strengthened, putting downward pressure on prices in both domestic and export markets.

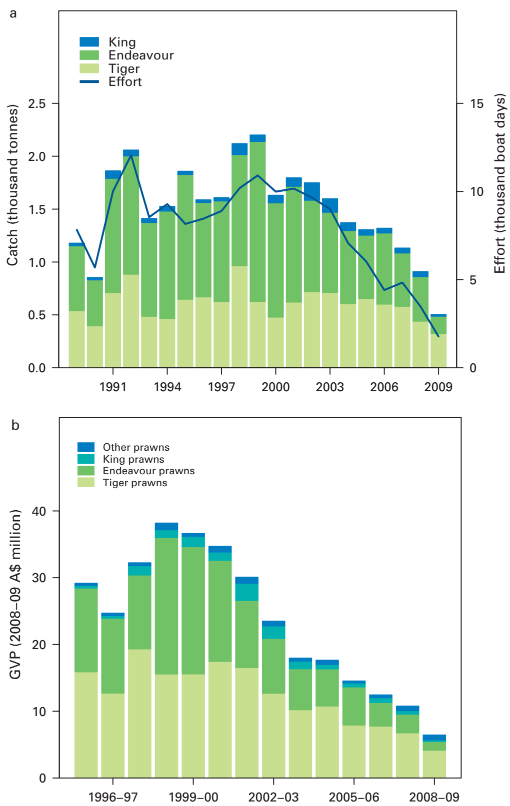


FIGURE 17.2 TSPF a) Catch and effort, 1989 to 2009 and b) GVP by species and financial year, 1995–96 to 2008–09

SOURCE: ABARE–BRS (unpublished data).

Brown tiger prawn PHOTO: FISHERIES QUEENSLAND

Measuring tiger prawn carapace length
PHOTO: FISHERIES QUEENSLAND

Minor byproduct species

Minor byproduct species in the TSPF typically include Moreton Bay bugs (*Thenus orientalis*), cuttlefish (Sepiidae), slipper lobsters (*Ibacus* spp.) and squid (*Photololigo* spp.) (Table 17.4). There are no TACs or triggers for byproduct species in the TSPF.

TABLE 17.4 Minor byproduct species—TACs/triggers, catches/landings and discards in the TSPF

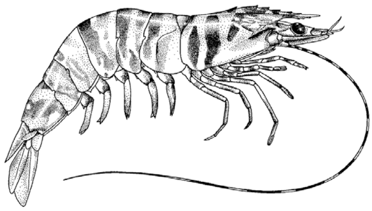
Species	TAC/ trigger	2008 catch (tonnes)	2008 discards	2009 catch (tonnes)	2009 discards
Cuttlefish (Sepiidae)	None	1.2	n.a.	0.9	n.a.
Moreton bay bugs (*Thenus* spp.), slipper lobsters (Scyllaridae)	None	23.5	n.a.	11.8	n.a.
Other prawn catch	None	1.8	n.a.	0.9	n.a.
Squid (Teuthoidea)	None	2.5	n.a.	0.9	n.a.

n.a. = not available, TAC = total allowable catch; TSPF = Torres Strait Prawn Fishery

17.4 BIOLOGICAL STATUS

BROWN TIGER PRAWN

(*Penaeus esculentus*)



LINE DRAWING: FAO

TABLE 17.5 Biology of tiger prawn

Parameter	Description
General	The life cycle of prawns in the Torres Strait begins with adults spawning in the deep waters of the fishery. Fertilised eggs sink to the bottom after release, where they hatch into larvae within about 24 hours. Less than 1% of these offspring survive the 2–4 week planktonic larval phase to reach nursery habitats (seagrass beds), where they settle. After 1–3 months on the nursery grounds, the young prawns begin to migrate into deeper waters surrounding reefs. Tagging studies and length-frequency analyses indicate that the prawns typically migrate from around the Warrior Reef complex to the east and south-east.
Range	**Species:** Broad tropical Indo-Pacific distribution **Stock:** Area of the Torres Strait Protected Zone
Depth	10–50 m
Longevity	1–2 years
Maturity (50%)	**Age:** ~6 months **Size:** ~26 mm CL
Spawning season	Spawning occurs multiple times throughout the year, with peaks in summer and winter.
Size	**Maximum:** up to 30 cm (total length) **Recruitment into the fishery:** Many sizes of prawn are encountered in the fishery; however, larger prawns are typically preferred for greater economic returns.

CL = carapace length

SOURCES: Somers (1987); Somers et al. (1987); Kailola et al. (1993); Turnbull & Watson (1995); AFMA (2007).

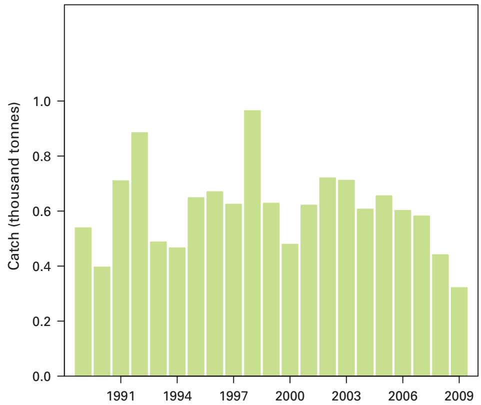


FIGURE 17.3 Brown tiger prawn catch history, 1989 to 2009

NOTE: May contain catches of other tiger prawn species

Stock status determination

There was no update of the tiger prawn stock assessment in 2009. The most recent stock assessment was in 2006, incorporating catch and effort data to 2003 (O'Neill & Turnbull 2006). The 2009 stock status assessment for this stock is based on a comparison of recent catches (Fig. 17.3) with estimates of MSY, recent catch rates (unstandardised), a comparison of activated effort with estimates of E_{MSY} and the most recent estimates of biomass.

The tiger prawn catch has been below the estimate of MSY for both spawner-recruitment relationships (Ricker and Beverton–Holt) for the past four seasons. The effort applied to the fishery has been below the mean estimate of E_{MSY} for both spawner-recruitment relationships for the last six seasons and below the lower 90% confidence intervals of both relationships for E_{MSY} for the past four seasons.

The most recent estimate of biomass was presented in the 2007 Torres Strait Prawn Fishery Handbook (Taylor et al. 2007). To support this publication, some of the 2006 assessment models (O'Neill & Turnbull 2006) were run with additional catch and effort data for 2004–2006. The mean biomass estimate for the stock was on an upward trajectory, between 0.6 and $0.8B_{current}/B_0$. This was considerably higher than B_{MSY} levels, estimated to be around 28–38% of the unfished level.

On this evidence, the Torres Strait tiger prawn stock is assessed as **not subject to overfishing** and **not overfished** in 2009 (Table 17.1).

Reliability of the assessment/s

Variability in recruitment, linked to environmental influences on these short-lived species (Table 17.5), may affect the accuracy of stock assessment projections. Natural mortality, an important parameter in estimating sustainable yield, is also difficult to determine. The 2006 assessment tested the sensitivity of the models to natural mortality rates between 0.16 and 0.24 and provided management reference points (MSY and E_{MSY}) for these.

In October 2003, an independent stock assessment expert reviewed the 2002 Torres Strait tiger prawn assessment (Die 2003). The review provided a number of recommendations aimed at improving the stock assessment. Where possible, recommendations were addressed in the 2006 assessment (O'Neill & Turnbull 2006). Die (2003) remarked that the scientific advice produced by the assessment was of high quality, sustained by state-of-the-art statistical analysis and simulation modelling. The 2006 tiger prawn stock assessment is considered reliable.

Research vessel, Gwendoline May
PHOTO: FISHERIES QUEENSLAND

Previous assessment/s

The 2006 tiger prawn assessment used data to the end of the 2003 fishing season and three modelling approaches: a monthly delay-difference model (Deriso–Schnute) and two types of surplus production models (Schaefer and Fox forms). The delay-difference model using the Ricker stock–recruitment relationship estimated MSY (90% CI) for tiger prawns at 606 t (436–722 t), with an E_{MSY} of 8245 (5932–9823) nights (with a natural mortality rate of 0.2). The corresponding Beverton–Holt model estimates were 676 t (523–899 t) and 9197 (7116–12 231) nights. The fishing power of the fleet was estimated to have increased by 21–25% between 1980 and 2003.

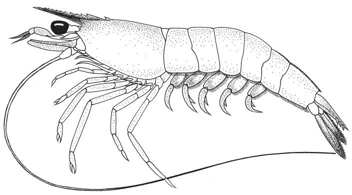
The surplus production models estimated MSY (90% CI) for tiger prawns at between 601 t (349–659 t) and 643 t (478–688 t) for the Schaefer model, and between 661 t (495–734 t) and 681 t (584–748 t) for the Fox model. The estimates of E_{MSY} were between 9600 (7348–11 250) nights and 9830 (7920–11 500) nights for the Schaefer model, and between 12 400 (9950–15 400) nights and 13 400 (1150–18 100) nights for the Fox model. The delay-difference models were thought to better reflect the dynamics of the data (such as seasonal changes in the catch and effort data) and were used to make management recommendations (MSY and E_{MSY}).

Future assessment needs

The 2006 assessment is still being used to inform management decisions in the fishery. Although some of the models have been run since 2006 (Taylor et al. 2007), a full assessment has not been undertaken. An updated assessment should be developed for this fishery as a priority.

BLUE ENDEAVOUR PRAWN

(*Metapenaeus endeavouri*)



LINE DRAWING: PETER MALONEY

TABLE 17.6 Biology of endeavour prawns

Parameter	Description
General	The fishery predominately targets the blue endeavour prawn (*Metapenaeus endeavouri*). This species is understood to use seagrass beds as nursery habitat.
Species range	**Species:** Endemic to northern Australia. **Stock:** The extent of the Torres Strait Protected Zone.
Depth	10–60 m
Longevity	1–2 years
Maturity (50%)	**Age:** ~6 months **Size:** ~18 mm CL
Spawning season	Spawn year round, but major spawning time is August–October. These prawns move into deeper waters to spawn.
Size	**Maximum:** ~20 cm TL **Recruitment into the fishery:** variable size classes impacted by fishing

CL = carapace length

SOURCES: Somers (1987); Somers et al. (1987); Kailola et al. (1993); Yearsley et al. (1999).

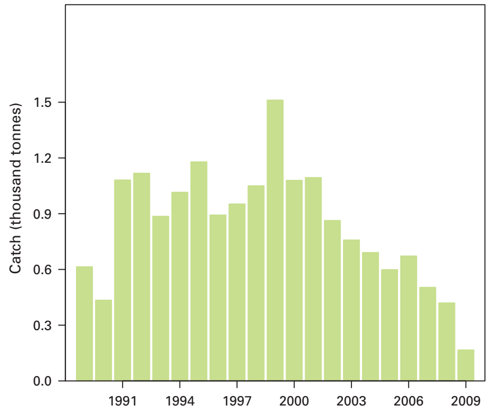


FIGURE 17.4 Blue endeavour prawn catch history, 1989 to 2009

NOTE: May contain catches of other endeavour prawn species

TABLE 17.7 Model estimates from the initial attempts at delay-difference models for endeavour prawns, restricted to catch and effort data between 1989 and 2006

	Ricker (90% CI)	Beverton–Holt (90% CI)
Steepness	0.44 (0.31–0.79)	0.47 (0.3–0.64)
MSY (tonnes)	901 (666–1022)	938 (775–1622)
E_{MSY} (days)	8810 (3314–14 938)	8186 (3427–23 437)

E_{MSY} = effort producing maximum sustainable yield; MSY = maximum sustainable yield

SOURCE: Turnbull et al. (2009).

Stock status determination

The most recent stock assessment for the endeavour prawn stock was completed in 2009 (Table 17.7, Turnbull et al. 2009). The authors originally set out to adapt the existing tiger prawn delay-difference assessment model to the endeavour prawn stock. Although this approach fit the catch rate series well, it was abandoned due to the poor (uncertain) fit of the spawner-recruitment relationship to the annual estimates of spawning stock.

The authors then developed a number of size- and age-structured models. These models follow cohorts (age and sex) of the stock, enabling tracking of the size-related variability in productivity. Two models were developed: a stochastic model that allowed in-model estimation of recruitment error around the two fixed means for the steepness of the spawner-recruitment relationship (0.5 and 0.7), and a deterministic model that restricted variability around the two fixed

means for the steepness of the spawner-recruitment relationship. The models were implemented into a Bayesian framework that allowed parameters to be estimated through a Markov Chain Monte Carlo algorithm. The stochastic models were unable to estimate realistic ranges for the steepness of the spawner-recruitment relationship and experienced difficulty in converging due to the large number of parameters estimated.

These assessments estimated the mean MSY for endeavour prawns at between 899 t and 1368 t (see Table 17.8), depending on the type of model chosen (stochastic or deterministic recruitment variation). The lower end of this range was similar to the estimates of MSY from the delay-difference model initially attempted.

Shot sample ready for processing
PHOTO: FISHERIES QUEENSLAND

TABLE 17.8 Model estimates and steepness parameters for the age-structured models

	Stochastic model (90% CI)	Stochastic model (90% CI)	Deterministic model (90% CI)	Deterministic model (90% CI)
Steepness	0.5	0.7	0.5	0.7
MSY (tonnes)	899 (745–1208)	989 (817–1402)	1105 (1060–1184)	1368 (1287–1531)
E_{MSY} (days)	8198 (6791–11 012)	9022 (7450–12 786)	10 079 (9667–10 800)	12 476 (11 733–13 962)

SOURCE: Turnbull et al. (2009).

The authors note that it was difficult to fit the stock assessment models to the catch and effort data for endeavour prawns in the fishery, largely because of the nature of the data collected in the fishery and the direct overlap in species distribution. With endeavour prawns currently being a 'secondary target species' as a result of their relatively low price, catch rates are difficult to standardise and therefore may be less reliable as an index of abundance.

The 2009 stock status classifications for the blue endeavour prawn stock are based on a comparison of recent catches (Fig. 17.4) with estimates of MSY, comparison of activated effort with estimates of E_{MSY}, and the most recent estimates of biomass. The model preferred by the authors from the 2009 assessment estimates MSY (90% CI) at 1105 (1060–1184 t). Catch has been below the lower 90% confidence interval of this estimate since 2002. Biomass estimates from the 2009 assessment range between $0.71B_{current}/B_0$ for the stochastic model with a fixed steepness value of 0.5 and $0.85B_{current}/B_0$ for the deterministic model with the steepness fixed at 0.7. This would put the stock above the respective B_{MSY} levels of $0.43B_0$ and $0.38B_0$.

Based on the evidence presented above, the Torres Strait endeavour prawn stock is assessed as **not overfished** and **not subject to overfishing** in 2009 (Table 17.1).

Reliability of the assessment/s

This assessment was developed by stock assessment scientists at the Queensland Department of Employment, Economic Development and Innovation (DEEDI) using the latest analytical techniques. The assessment methods used in this publication can be considered reliable.

Previous assessment/s

Estimates of MCY for prawns in the TSPF were first attempted in 1991 by the Queensland Department of Primary Industries (QDPI). This assessment used research trawl data between 1986 and 1989 to estimate prawn numbers by species, sex and length class for select areas of the fishery. These numbers were then transformed into a biomass estimate, using a length–weight relationship, previously estimated by Watson & Mellors (1990). The estimates of weight were applied to the area of the fishery, producing an average biomass estimate for the fishery. MCY estimates were then calculated, using the following formula (Mace 1988):

$$MCY = 0.5 \times F_{0.1} \times B_{AVG}$$

where $F_{0.1}$ is the value of fishing mortality (F), for a slope of the yield-per-recruit function of 0.1, and B_{AVG} is the average exploited biomass estimate. An annual $F_{0.1}$ was estimated for each sex and species separately from estimates of age vectors of weight, selectivity and natural mortality.

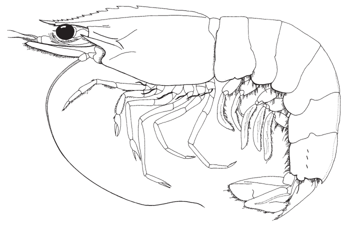
Turnbull and Watson (1995) adapted the work undertaken by the QDPI (1991), using logbook data to define the extent of the fishery area.

Future assessment needs

The models in the 2009 endeavour prawn assessment (Turnbull et al. 2009) had difficulties in estimating the steepness parameter of the spawner-recruitment relationship. The model preferred by the authors uses a fixed steepness parameter of 0.5. For prawns in the Northern Prawn Fishery, a preliminary assessment estimated the steepness parameter of the spawner-recruitment relationship as 0.378 (0.358–0.405) (AFMA 2008). A sensitivity test for a lower value of steepness would be informative.

RED-SPOT KING PRAWN

(*Melicertus longistylus*)



LINE DRAWING: FAO

TABLE 17.9 Biology of red-spot king prawns

Parameter	Description
General	King prawns taken in this fishery are predominately red-spot king prawns. The ABARE–BRS understands that king prawns are not currently being targeted and should probably be considered as a byproduct species.
Range	**Species:** Indo-west Pacific **Stock:** Area of the Torres Strait Protected Zone.
Depth	Adult red-spot king prawns are found to a depth of around 60 m, typically on coarser sediments.
Longevity	1–2 years
Maturity (50%)	**Age:** ~6 months **Size:** 15–20 mm CL
Spawning season	Autumn and spring
Size	**Maximum:** 21 cm (total length) **Recruitment into the fishery:** variable size classes impacted by fishing

CL = carapace length

SOURCES: Somers (1987); Kailola et al. (1993); Yearsley et al. (1999).

Red-spot king prawn PHOTO: JAMES WOODHAMS, ABARE–BRS

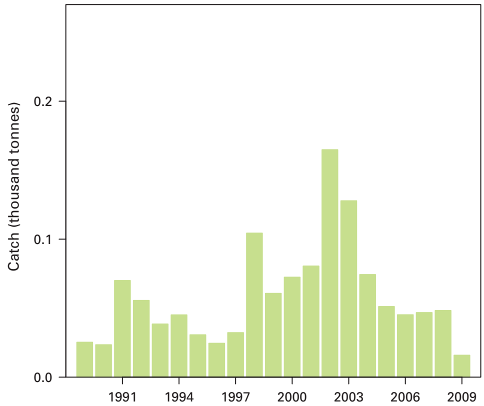


FIGURE 17.5 Red-spot king prawn catch history, 1989 to 2009

NOTE: May contain catches of other king prawn species

Stock status determination

The overfishing and overfished classifications of the red-spot king prawn stock have historically been uncertain, primarily because of the absence of recent estimates of biomass, MSY or E_{MSY}. However, a number of attempts have been made to estimate a long-term harvest level (maximum constant yield—MCY) for king prawns for this fishery. These estimates placed the MCY at between 99 t and 186 t (QDPI 1991; Turnbull & Watson 1995).

Although there is still no estimate of the current biomass of red-spot king prawns in the Torres Strait, or a more recent estimate of sustainable harvest level, the ABARE–BRS has used a 'weight-of-evidence' approach to estimate status in 2009. In the absence of a fully quantitative assessment, all available lines of evidence are brought together to determine status. In the case of the red-spot king prawn stock, these lines of evidence are stable catch rates (unstandardised), catch and effort levels in the fishery for 2009 (and preceding seasons) and the MCY estimates undertaken in the early and mid-1990s. Additionally, the absence of changing targeting practices and the low level of effort in the fishery also provide some evidence that red-spot king prawns in the fishery are currently not heavily fished.

The catch of king prawns in the 2009 season (16 t) is the lowest recorded since logbooks became mandatory in 1989 (Fig. 17.5). The fishery has supported an average king prawn harvest over the period 2004–2008 of 53 t (Kertesz et al. 2010) and an average over the preceding five years (1998–2002) of 110 t. At 16 t, the 2009 catch is substantially lower than that historically taken by the fishery. As well, effort in the fishery has been below the current E_{MSY} estimate (for tiger prawns) for the past six seasons and has been less than half the current E_{MSY} for the past two seasons. On this basis, the stock is assessed as **not subject to overfishing** (Table 17.1).

King prawn catch rates (unstandardised) have been close to the long-term average (1989 to 2007) for the past two seasons (2008 and 2009), with the exception of the last two months of each season (October and November). In these two months, fishing operations are understood to have moved out of areas of the fishery where king prawns are typically taken, leading to a reduction in catch rates. If catch rates provide a reliable index of abundance for this species, a stable catch rate series may indicate a stable biomass. Furthermore, since catches have been below the lower estimate of MCY (99 t) since 2003, the likelihood of the stock being reduced to an overfished state is low. On this basis, the status of king prawns is assessed as **not overfished** (Table 17.1).

Previous assessment/s

See text under endeavour prawns for discussion of previous assessments.

Reliability of the assessment/s

There have been many changes in the fishery since the MCY models were developed, including changes to gear, vessel efficiency and the use of bycatch reduction devices. The impact of these changes on the application of the MCY estimates is unknown.

In the absence of any other indicators, the MCY estimation methods and catch history are probably sufficient to give an indication of sustainable harvest levels. As previously stated, the MCY models have not been used for status determination in the previous

editions of the *Fishery status reports*. However, since the catch for the 2009 season is so low relative to the history of the fishery, the results of these models provide evidence that the 2009 fishery is probably not over-exploiting red-spot king prawns at 2009 catch levels.

Future assessment needs

An updated assessment of the MCY for king prawns would be of benefit to management decisions for this fishery. The data collected as part of Turnbull et al. (2009) may be a potential data source.

17.5 ECONOMIC STATUS

Economic performance

The former Australian Bureau of Agricultural and Resource Economics (ABARE) first surveyed the TSPF in the early 1990s. Subsequent surveys have allowed the calculation of net economic returns (NER) and financial performance measures. ABARE's most recent survey of the TSPF was released as part of the *Australian Fisheries Surveys Report 2009.* In addition to survey-based estimates of economic performance for 2006–07 and 2007–08, the report also includes non-survey based forecasts of NER for 2008–09.

Net economic returns

Profitability in the TSPF has remained negative over the past five years. It is estimated that NER improved slightly, from –$4.1 million to –$2.7 million, from 2006–07 to 2007–08. However, profits declined again in 2008–09, with NER were forecast at –$3.3 million (Vieira & Perks 2009; see Fig. 17.6).

With the exception of 2006–07, fishing receipts in the TSPF have fallen every year since 1998–99. Costs have also exhibited a negative trend, but with more variability than total receipts. The decrease in profitability between 2007–08 and 2008–09 can be largely attributed to the estimated 35% decrease in cash receipts between the two years. Although this decrease was partially mitigated by decreases in all cost categories, these declines were not of the same magnitude, resulting in lower NER.

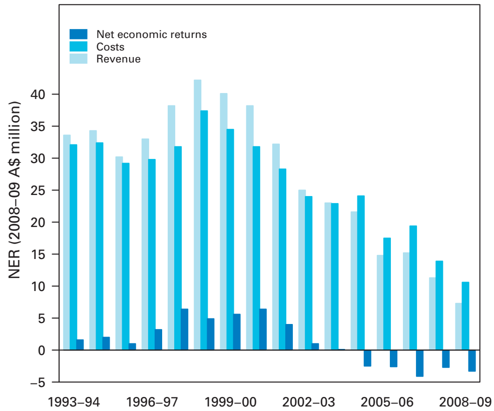


FIGURE 17.6 Real economic returns for the TSPF by financial year, 1993–94 to 2008–09

NOTE: Net economic returns for 2008–09 are estimated using non-survey based methods

SOURCE: Vieira & Perks (2009).

Latency

The low NER in the TSPF are consistent with the high levels of latent effort. Latent effort in the TSPF is the number of nights not used by fishers as a proportion of the total allocation. The percentage of unused nights in the 2008 and 2009 fishing seasons was 62.2% and 80.7%, respectively. The high level of latent effort in 2009 can be attributed to both the increase in fishing nights available to Australian operators and unwillingness of operators to take up those nights.

Low or negative NER tend to be inversely linked with the level of latency in the fishery. Consistently high levels of latent effort are indicative of non-binding controls. This implies that profits in the fishery are too low to justify fishers using their entire effort allocation. It also means that, in the event of increased profitability, any new profits may be quickly eroded once previously latent effort activates.

Overall economic status

ABARE's *Australian Fisheries Surveys Report 2009* estimated that profitability, as represented by NER, was low in the TSPF in both 2006–07 and 2007–08. Recently, external factors have played an increased role in the reduced profitability of the fishery. The prices received by producers have been adversely affected by increasing competition from imports on domestic markets, and the gradual appreciation of the Australian dollar on domestic and export markets.

Prices of tiger prawns sourced from the Torres Strait and the Yen/Australian dollar exchange rate have had a typically inverse relationship. As the Australian dollar appreciates, prices of tiger prawns typically fall and vice versa (Fig. 17.7). However, atypical global economic conditions in 2008–09 caused the relationship to break down, and the industry experienced falling tiger prawn prices in a year when the Australian dollar depreciated.

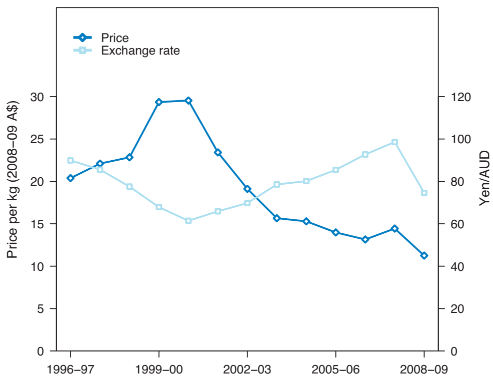


FIGURE 17.7 The Yen/AUD exchange rate and real price of Torres Strait tiger prawns, 1996–97 to 2008–09

SOURCE: ABARE–BRS (unpublished data).

With regard to costs, prawn trawling is highly fuel intensive. As a result, the industry is exposed to fluctuations in the price of off-road diesel. Off-road diesel prices have been rising steadily for several years, although they declined slightly in 2008–09. Despite this decrease, prices are still relatively high. Fuel accounted for 40.4% of operating costs in 2007–08, with increases in the off-road diesel price driving up total fuel costs, as shown in Fig. 17.8.

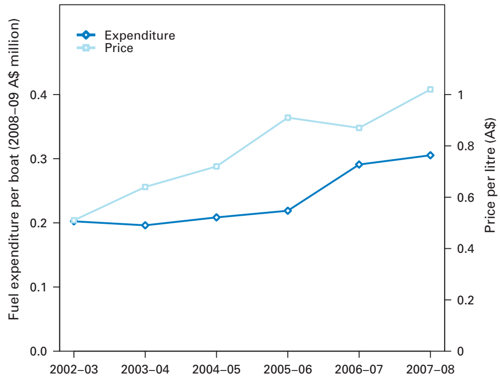


FIGURE 17.8 Off-road diesel price and fuel expenditures in the Torres Strait prawn fishery, 2002–03 to 2007–08

SOURCE: ABARE–BRS (unpublished data).

Future considerations

The TSPF management plan provides for internal leasing arrangements, whereby only license holders are able to trade fishing nights. Extending these arrangements to provide for external leasing may also be an option. With binding controls, an efficient effort-leasing mechanism would allow autonomous adjustment in the fishery. As a result, the fishery would likely reallocate effort to the more efficient producers, with a positive impact on NER.

17.6 ENVIRONMENTAL STATUS

Trawling for prawns is a relatively non-selective fishing method that typically takes a broad range of target, byproduct and bycatch species. Bycatch can include fish, cephalopods, crabs, lobsters, scallops, sharks and rays. Trawling can also impact upon protected species, such as turtles, sygnathids (seahorses and pipefish) and sea snakes, as well as benthic communities. The PZJA has required operators to use turtle excluder

devices (TEDs) in trawl gear since the start of the 2002 fishing season. In 2004 the use of bycatch reduction devices became mandatory.

An observer program was initiated in 2005 to provide information on catch, effort and fishing practices in the fishery. This program observed 86 nights of fishing—4.84% of the activated effort—on two vessels in 2009 (Table 17.2).

Research surveys between 2004 and 2006 collected independent information on the weight, composition and distribution of bycatch in the TSPF (Turnbull & Rose 2007). The surveys were conducted within the main prawn trawling grounds and also within adjacent areas that are seasonally or fully closed to trawling. The analysis concluded that bycatch for the TSPF was typical of tropical prawn trawl bycatch, in that it was highly diverse and mainly consisted of fish and invertebrates. The surveys found no major differences in the bycatch community structure between areas open, partially closed and entirely closed to trawling; however, there was some difference in dominance in bycatch species between open and closed areas. The dominant fish species and families have changed little from those identified in studies in the mid-1980s.

Ecological risk assessment

This fishery has been assessed up to Level 1 (Scale, Intensity, Consequence Analysis—SICA), but this assessment remains unpublished (Turnbull et al. unpublished). The Australian Fisheries Management Authority is currently determining whether to progress the TSPF through the ecological risk assessment process. In 2007 Pitcher et al. (2007) released their publication 'Mapping and characterisation of key biotic and physical attributes of the Torres Strait ecosystem'. This publication contains comprehensive data on the seabed habitats of the Torres Strait and associated biodiversity. It catalogues more than 3600 species of benthos, bycatch and fish of the Torres Strait. Examination of the likely extent of past effects of trawling on the benthos and bycatch over the TSPZ indicated that trawling had a significant effect on the biomass of 21 of the 256 species analysed. Of the 21 species, 9 were likely to have a negative response to trawling and 12 a positive response.

Threatened, endangered and protected species

A number of threatened, endangered and protected (TEP) species are potentially impacted by prawn trawling activities. These include turtles, sygnathids, sea snakes and sawfish. Fishers are required to record any interaction with TEPs in their logbooks, as well as the condition of the animal upon release.

Sharks

Although the fishery still takes small sharks and rays as bycatch, larger specimens are likely to be ejected by the TED. Three sawfish interactions were reported in 2008; of these, one was reported as alive upon release. No sawfish interactions were reported for 2009.

Marine turtles

In May 2008 the PZJA agreed to implement exclusion zones around Deliverance Island, Kerr Islet and Turu Cay to protect important nesting areas for green and flatback turtles. One interaction with a flatback turtle and two with green turtles were reported in the TSPF in 2008. The flatback turtle was reported as being released alive, whereas the fate of the green turtles was reported as 'unknown'. One flatback turtle interaction was reported in 2009. This animal is reported as having been released alive.

Seabirds

Although some seabirds are attracted to vessels and some interaction between the seabirds and the vessel or fishing operations is possible, seabirds are not understood to be a typical part of the bycatch of this fishery.

Sygnathids and sea snakes

Sygnathids and sea snakes are taken during the course of prawn trawling. In 2008 there were 1089 sea snake interactions; of these, 521 were reported as alive when released. In 2009, 634 sea snake interactions were reported; of these, 176 were reported as having been released alive.

Benthic habitats

The TSPF occupies about 20% of the area of the TSPZ (Turnbull & Rose 2007). Fishing operations are undertaken largely on sandy or muddy substrates, where operators know from previous experience that they are likely to encounter the target species.

17.7 HARVEST STRATEGY PERFORMANCE

Although the HSP is not prescribed for fisheries jointly managed by the Australian Government and other management agencies (domestic or international), a long-term harvest strategy for the TSPF is currently in development and is expected to be completed during 2010.

17.8 LITERATURE CITED

AFMA (Australian Fisheries Management Authority) 2005, *Torres Strait Prawn Fishery Bycatch Action Plan 2005*, AFMA, Canberra.

——2007, *Draft fishery assessment report, Torres Strait Prawn Fishery*, AFMA, Canberra.

——2008, NPF RAG Assessment 2007/8. *Bio-economic Model; Status of Tiger Prawn Stocks at the End of 2007 in the NPF*, AFMA, Canberra.

Cocking, L, Turnbull, C, Gaddes, S & Wilson D (eds) 2008, *Torres Strait prawn handbook 2008*, AFMA, Canberra.

DAFF (Australian Government Department of Agriculture, Fisheries and Forestry) 2007, *Commonwealth Fisheries Harvest Strategy: policy and guidelines*, DAFF, Canberra.

——2009, *Torres Strait Prawn Fishery Management Plan 2009*, DAFF, Canberra, Federal Register of Legislative Instruments F2009L00505.

Die, DJ 2003, *Review of the stock assessment of the Torres Strait Prawn Fishery*, report to the AFMA, Canberra.

Kailola, PJ, Williams, MJ, Stewart, PC, Reichelt, RE, McNee, A & Grieve, C 1993, *Australian fisheries resources*, Bureau of Resource Sciences & the FRDC, Canberra.

Kertesz, M, Cocking, L, Turnbull, C, Jacobson, I, Hall, S & Lui, S 2010, *Torres Strait Prawn Fishery handbook 2010*, AFMA, Canberra.

Mace, PM 1988, 'The relevance of MSY and other biological reference points to stock assessment in New Zealand', New Zealand Fisheries Assessment Research Document 88/30,

O'Neill, MF & Turnbull, CT 2006, *Stock assessment of the Torres Strait tiger prawn fishery (Peneaus esculentus)*, Department of Primary Industries and Fisheries, Brisbane.

Pitcher, CR, Haywood, M, Hooper, J, Coles, R, Bartlett, C, Browne, M, Cannard, T, Carini, G, Carter, A, Cheers, S, Chetwynd, D, Colefax, A, Cook, S, Davie, P, Ellis, N, Fellegara, I, Forcey, K, Furey, M, Gledhill, D, Hendriks, P, Jacobsen, I, Jacobson, J, Jones, M, Last, P, Marks, S, McLeod, I, Sheils, J, Sheppard, J, Smith, G, Strickland, C, Van der Geest, C, Venables, W, Wassenberg, T & Yearsley, G 2007, *Mapping and characterisation of key biotic and physical attributes of the Torres Strait ecosystem*, CSIRO/QM/QDPI CRC Torres Strait Task final report.

QDPI (Queensland Department of Primary Industries) 1991, 'Northern fisheries centre', in C Turnbull,& R Watson, 1995, *Torres Strait prawns 1994, stock assessment report*, Torres Strait Fisheries Assessment Group, AFMA, Canberra.

Somers, IE 1987, 'Sediment type as a factor in the distribution of commercial prawn species in the western Gulf of Carpentaria, Australia', *Australian Journal of Marine and Freshwater Research*, vol. 38, pp. 133–49.

——Poiner, IR & Harris, AN 1987, 'A study of the species composition and distribution of commercial penaeid prawns of Torres Strait', *Australian Journal of Marine and Freshwater Research*, vol. 38, pp. 47–61.

Taylor, S, Turnbull, C, Marrington, J & George, M (eds) 2007, *Torres Strait prawn handbook 2007*, AFMA, Canberra.

Turnbull, C, Furlani, D, Bulman, C & Dowdney, J unpublished, *Ecological risk assessment for the effects of fishing: report for the Torres Strait Prawn Fishery*, report for the AFMA, Canberra.

——& Rose, CL 2007, *Towards ecologically sustainable management of the Torres Strait Prawn Fishery*, CRC Torres Strait Task T1.5 final report, Department of Primary Industries and Fisheries, Queensland.

——Tanimoto, M, O'Neill, MF, Campbell, A & Fairweather, CL 2009, *Torres Strait spatial management research project 2007–09*, final report for DAFF consultancy DAFF83/06, Department of Employment, Economic Development and Innovation, Brisbane.

——& Watson, R 1995, *Torres Strait prawns 1994, stock assessment report*, Torres Strait Fisheries Assessment Group, AFMA, Canberra.

Vieira, S & Perks, C 2009, *Australian fisheries surveys report 2009: results for selected fisheries, 2006–07 and 2007–08, preliminary estimates for 2008–09*, ABARE report, Canberra.

Wallis, D, Cocking, L, Turnbull, C, Zunic, Y & Fava, S 2009, *Torres Strait prawn handbook 2009*, AFMA, Canberra.

Watson, RA & Mellors, JE 1990, 'General introduction', in JE Mellors (ed), *Torres Strait prawn project: a review of research 1986–1988*, Queensland Department of Primary Industries Information Series, Queensland Department of Primary Industries, Brisbane.

Yearsley, GK, Last, PR & Ward, RD 1999, *Australian seafood handbook: domestic species*, FRDC, Canberra..

18 Torres Strait Sea Cucumber and Trochus Fisheries

J Woodhams and M Rodgers

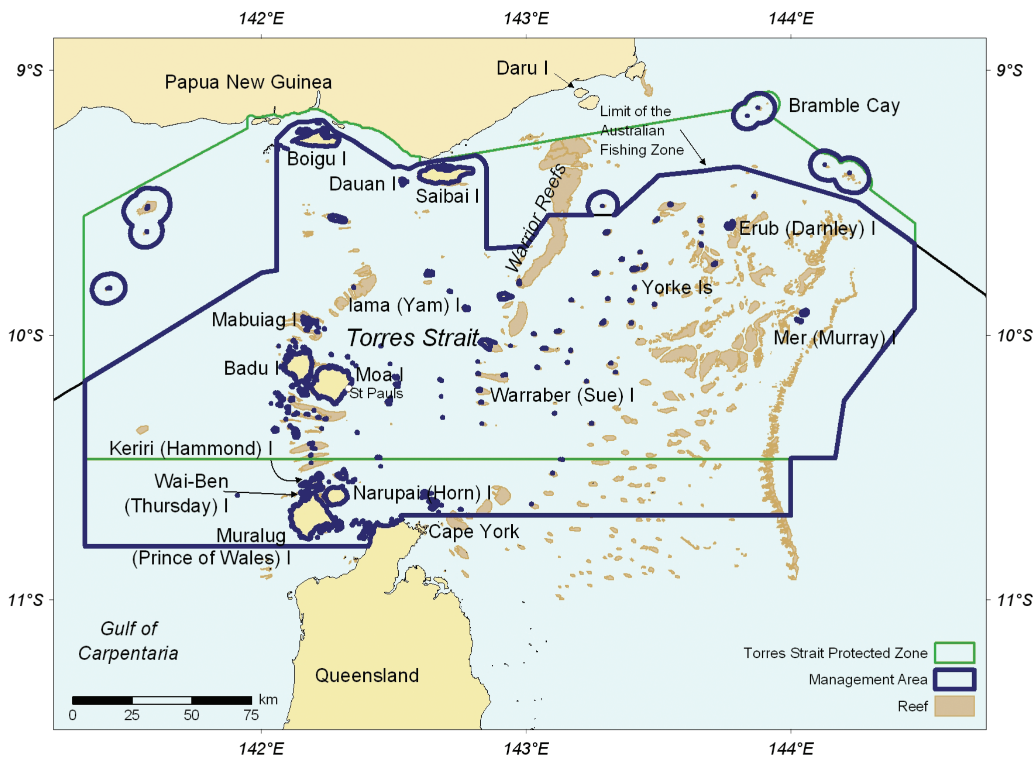


FIGURE 18.1 Area of the Torres Strait Sea Cucumber and Trochus Fisheries—Torres Strait Protected Zone (TSPZ)

TABLE 18.1 Status of the Torres Strait Sea Cucumber and Trocus Fisheries

Fishery status	2008		2009		Comment
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Black teatfish (*Holothuria whitmaei*)	Uncertain	Overfished	Not subject to overfishing	Not overfished	Understood to be no domestic fishery in 2009. Most recent survey estimates indicate a recovering stock.
Prickly redfish (*Thelenota ananas*)	Uncertain	Uncertain	Not subject to overfishing	Not overfished	Understood to be no domestic fishery in 2009. Relatively stable densities through recent history of fishery
Sandfish (*Holothuria scabra*)	Uncertain	Overfished	Overfishing	Overfished	Most recent published density well below pre-exploitation estimate. Confirmed illegal, unregulated or unreported harvest on Warrior Reef in early 2009.
Surf redfish (*Actinopyga mauritiana*)	Uncertain	Overfished	Not subject to overfishing	Uncertain	Understood to be no domestic fishery in 2009. Density estimates are uncertain, and exploitation levels require further clarification.
White teatfish (*Holothuria fuscogilva*)	Uncertain	Uncertain	Not subject to overfishing	Not overfished	Understood to be no domestic fishery in 2009. Relatively stable densities through recent history.
Other sea cucumber species (18 species)	Uncertain	Uncertain	Not subject to overfishing	Uncertain	Understood to be no domestic fishery in 2009. Catch composition difficult to discern. Number of species inhibits certainty.
Trochus (*Trochus niloticus*)	Uncertain	Uncertain	Not subject to overfishing	Uncertain	Reported take in 2009 below historic levels and plausible sustainable extraction rates. Uncertainty in survey results.
Economic status Fishery level	Estimates of net economic returns not available				n.a.

n.a. = not available

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING — OVERFISHED / OVERFISHING — UNCERTAIN — NOT ASSESSED

TABLE 18.2 Main features and statistics of the Torres Strait Sea Cucumber and Trochus Fisheries

Feature	Description
Key target and byproduct species	Black teatfish (*Holothuria whitmaei*) Prickly redfish (*Thelenota ananas*) Sandfish (*Holothuria scabra*) Surf redfish (*Actinopyga mauritiana*) White teatfish (*Holothuria fuscogilva*) Other sea cucumbers (up to 18 other species) Trochus (*Trochus niloticus*)
Other byproduct species	Nil
Fishing methods	Hand collection: free-dive, reef walking; breathing apparatus permitted when fishing for trochus
Primary landing ports	Island processors

Table 18.2 continues over the page

TABLE 18.2 Main features and statistics of the Torres Strait Sea Cucumber and Trochus Fisheries CONTINUED

Feature	Description			
Management methods:	Sea cucumber: —Input controls: limited entry, gear restrictions —Output controls: competitive TAC, size limits Trochus: —Input controls: limited entry, gear restrictions —Output controls: competitive TAC, size limits			
Management plan	No formal plans of management			
Harvest strategy	No formal harvest strategies			
Consultative forums	Torres Strait Fisheries Management Advisory Committee (TSFMAC), Torres Strait Scientific Advisory Committee (TSSAC), Torres Strait Hand Collectables Working Group (TSHCWG)			
Main markets:	Sea cucumber: —International: China—predominately as a dried product, small amounts frozen or salted —Domestic: minimal Trochus: —International: Historically, markets have included France, Germany, Italy, Spain, Japan, United Kingdom, United States, Thailand, Philippines and China. —Domestic: minimal			
EPBC Act assessments: Sea Cucumber Fishery: —listed species (Part 13) —international movement of wildlife specimens (Part 13A) Trochus Fishery: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	 Current accreditation dated 10 June 2008 Current accreditation (Wildlife Trade Operation) expires 20 June 2011 Current accreditation dated 8 November 2008 Current accreditation (Wildlife Trade Operation) expires 25 November 2011			
Ecological risk assessment	None			
Bycatch workplans	None			
Fishery statistics[a]	**2008 fishing season**		**2009 fishing season**	
Fishing season	Calendar year		Calendar year	
TAC and catch by species:	TAC (tonnes)	Catch (tonnes)	TAC (tonnes)	Catch (tonnes)
—sandfish	Zero	n.a	Zero	None reported (IUU)
—black teatfish	Zero	n.a	Zero	Zero
—surf redfish	Zero	n.a	Zero	Zero
—prickly redfish	20	n.a	20	Zero
—white teatfish	15	n.a	15	Zero
—other sea cucumbers (combined)	80	n.a	80	Zero
—trochus	150	8	150	1.5
Effort	Sea cucumber: no reported effort in 2008 Trochus: 16 sellers		Sea cucumber: no reported effort in 2009 Trochus: 7 sellers	
Fishing licences	Sea cucumber: 76 Trochus: 110		Sea cucumber: 49 Trochus: 110	
Active vessels	Sea cucumber: 0 Trochus: 16		Sea cucumber: 0 Trochus: 7	
Observer coverage	Zero		Zero	
Real gross value of production (2008–09 dollars)	2007–08: not available		2008–09: not available	
Allocated management costs	n.a.		n.a.	

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; TAC = total allowable catch; n.a. = not available; IUU = Illegal, unreported and unregulated (fishing)

a Fishery statistics are provided by fishing season unless otherwise indicated.

SOURCES: Raudzens (2007); Skewes et al. (2010).

18.1 BACKGROUND

Sea cucumber fishery

Fishing for sea cucumbers in the Torres Strait is a highly selective fishing activity, conducted either through reef-top walking or free-diving from dinghies (Table 18.2). Twenty-three species of sea cucumber have been recorded in the Torres Strait. They are of variable commercial value, and not all are targeted by fishers for commercial purposes (Skewes et al. 2010).

Participation in the Sea Cucumber Fishery is largely limited to the Torres Strait Traditional Inhabitants, with the exception of one long-term, non-traditional licence holder who was active in the fishery before the introduction of limited entry in April 1999. Traditional fishers who wish to harvest sea cucumber commercially are required to hold a Traditional Inhabitant Boat (TIB) licence. Fishers are not permitted to use breathing apparatus (hookah or scuba) in their fishing operations for sea cucumbers. After harvesting, the sea cucumber goes through a number of processing stages, typically reaching the market as the gutted, boiled and dried product, bêche-de-mer.

Sandfish have traditionally been a primary target species in the Torres Strait, with the majority of fishing for this species taking place on the Warrior Reef complex (Fig. 18.1). Fishing pressure led to a marked decline in the stock, resulting in the introduction of a zero total allowable catch (TAC) for the species in 1998 (Table 18.3). Fishers then switched to targeting black teatfish and what is now understood to be a suite of redfish and blackfish species (*Actinopyga* spp.), previously reported as surf redfish. The TACs for black teatfish and surf redfish were set to zero in 2003 (Table 18.3). As a result of zero TACs for these higher value species, fishing activity is understood to have been relatively low in recent years.

Sea cucumber research PHOTO: P. SEDEN, AFMA

Trochus fishery

The fishery for trochus in the Torres Strait is a small, single-species commercial fishery. Participation in the fishery is restricted to Traditional Inhabitants, for some of whom it can be an important source of income. The shell is used mainly for buttons, jewellery and fashion accessories, while the byproduct (trochus meat) may be consumed. Current participation in the fishery is understood to be relatively low, largely as a result of the low price paid for product (Murphy et al. 2009). A minimum (80 mm) and maximum (125 mm) size limit (basal diameter) applies to commercial fishing. The TAC for 2009 was 150 t.

Trochus are typically found on high-energy areas of reefs, on substrates dominated by stony or coral pavements, associated with turf algae. They are not typically found in environments with high concentrations of sand and/or mud (Murphy et al. 2009).

TABLE 18.3 History of the Torres Strait Sea Cucumber and Trochus Fisheries

Year	Description
1700s	Macassans from south-west corner of Sulawesi (formally South Celebes) fished northern Australia.
1839	Presence of traders and processing facilities in the Northern Territory.
1912	Commercial collection of trochus in Australia began, with the shell exported to Japan, United Kingdom and Europe, primarily for use in making buttons and jewellery. The Australian trochus fishery continued until about 1950, when plastics were developed for button production.
1916 to 1917	124 vessels registered solely for the collection of sea cucumber; 558 t (dry weight) exported from Thursday Island, although the exact source of this catch is unknown.
1917 to 1939	Continual fishery expansion until 1928. By World War II, the fishery had contracted significantly.
1977 to 1980	Over this entire period, 6 t of sea cucumber was reportedly exported, primarily from PNG.
1984–85	1.7 t of sea cucumber harvested.
1990 to 1993	The PNG catch between 1990 and 1993 reportedly ranged between 109 t and 192 t of processed beche-de-mer (nearly all sandfish)—equivalent to approximately 1160 t and 2040 t of gutted weight (Skewes et al. 2006). There was a brief resurgence in the trochus fishery in the 1990s for use in ceramics.
1993	Fishing on the PNG side of Warrior Reef for sandfish was closed as a result of concerns about overfishing. The closure remained in effect until 1995, when the fishery was reopened under a management plan, including an annual 40 t (dry weight) TAC.
1994 to 1996	Resurgence of the Sea Cucumber Fishery in the Australian area of the TSPZ; catch in 1995 estimated between 1200 t and 1400 t (wet weight), with all but about 50 t being sandfish. Competitive TACs of 260 t per species (wet weight) for sandfish, black teatfish, white teatfish and prickly redfish and a collective quota of 80 t for the remainder of species were implemented in 1995, along with minimum size limits.
1998	Zero TAC introduced for sandfish in the TSPZ.
1999	Management responsibilities for the Torres Strait fisheries transferred from the (then) Queensland Fisheries Management Authority to the Torres Strait Protected Zone Joint Authority.
2003	Zero TAC introduced for black teatfish and surf redfish in the TSPZ. Reduction in TAC for white teatfish and prickly redfish to 15 t and 20 t, respectively.
2005	Recent trochus catches peaked at 96 t.
2009	PNG Sea Cucumber Fishery closed for three years from 1 October 2009. Survey of sea cucumbers and trochus in eastern Torres Strait indicated recovery of the black teatfish population (Skewes et al. 2010).

PNG = Papua New Guinea; TAC = total allowable catch; TSPZ = Torres Strait Protected Zone

SOURCES: Conand and Byrne (1993); Stutterd & Williams (2003); Skewes et al. (2004, 2006).

18.2 HARVEST STRATEGY

The *Commonwealth Fisheries Harvest Strategy Policy* (HSP) (DAFF 2007) is not prescribed for fisheries jointly managed by the Australian Government and other management agencies (domestic or international), including the fisheries of the Torres Strait. Although the Torres Strait Protected Zone Joint Authority has asked its management forums to provide advice on the application of the HSP to Torres Strait fisheries, there are currently no formal harvest strategies for the Torres Strait Sea Cucumber and Trochus Fisheries.

A number of communities have expressed interest in developing community-based management plans for hand collection fisheries, and a number may be in the process of doing so.

18.3 THE 2009 FISHERY

Sea Cucumber Fishery

There was no fishing for sea cucumbers by Traditional Inhabitants (or the one non-traditional license holder) in 2009. This has been confirmed by staff of the Australian Fisheries Management Authority (AFMA) and the Queensland Boating and Fisheries Patrol. Skewes et al. (2010) also indicate that the Sea Cucumber Fishery was inactive in 2009, informed by conversations with Islander processors.

In early 2009, a number of apprehensions were made of Papua New Guinea (PNG) nationals fishing illegally for sea cucumbers on the Warrior Reef complex. With the closure of the PNG Sea Cucumber Fishery on 1 October 2009, the incidence of PNG nationals fishing illegally in the Australian area of the Torres Stratit Protected Zone (TSPZ) is understood to have ceased (AFMA pers. com.).

Trochus Fishery

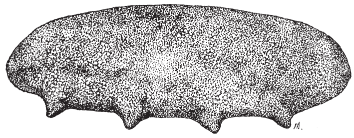
The Torres Strait Trochus Fishery in 2009 experienced low effort, with a reported harvest of approximately 1.5 t (Table 18.2). The stock was surveyed in early 2009.

18.4 BIOLOGICAL STATUS

Status determination of a number of stocks in the Torres Strait Sea Cucumber and Trochus Fisheries has been undertaken using a weight-of-evidence approach. In the absence of resource-intensive, fully quantitative stock assessment models, a process for determining biological status has been formed through the accumulation of all available quantitative and qualitative evidence. This approach has been particularly important for white teatfish and prickly redfish in 2009.

BLACK TEATFISH

(*Holothuria whitmaei*)



LINE DRAWING: FAO

TABLE 18.4 Biology of black teatfish

Parameter	Description
General	Medium to large sea cucumber that typically inhabits shallower reef-flat and reef-edge habitats. May be found associated with seagrass habitats.
Range	**Species:** Likely to have a broad distribution throughout the fishery, particularly in the east Torres Strait **Stock:** The area of the Torres Strait Protected Zone
Depth	Relatively shallow range, down to ~20 m
Longevity	Not known. White teatfish, a similar species, has been estimated at 12+ years.
Maturity (50%)	**Age:** Not determined **Size:** 800 g; 260 mm TL
Spawning season	Cooler months of the year (June–August)
Size	**Maximum:** 560 mm TL; 4.3 kg whole weight **Recruitment into the fishery:** minimum size limit 250 mm TL

TL = total length

NOTE: Statistics presented in this and other biology tables for sea cumbers may not necessarily have been from research on Australian stocks.

SOURCES: Conand (1989, 1998); Kinch (2008); www.pzja.gov.au.

Stock status determination

The most recent survey of sea cucumbers in the Torres Strait was undertaken in 2009 (Skewes et al. 2010). Preliminary results from the 2009 survey indicate a substantial increase in the mean density of black teatfish from the survey in 2005. Results also indicate increases in mean length and mean weight of black teatfish. It is important to note, however, that all these estimates come with considerable uncertainty around the mean estimates. Skewes et al. (2010) recommend

reopening the fishery for black teatfish, with a TAC of 25 t. This amounts to an extraction rate of about 4% of the lower 90th percentile of the standing stock estimate of 624.5 t.

Black teatfish is assessed as **not overfished**, based on the data presented in the latest survey report (Skewes et al. 2010). These data appear to show a substantial recovery of the stock since closure of the fishery in 2003.

Although reporting of catch of sea cucumbers by TIB fishers in the Torres Strait is not mandatory, it is understood that there has been no domestic fishery for sea cucumbers in the Torres Strait in 2009. On this basis, black teatfish is assessed as **not subject to overfishing** (Table 18.1).

The Torres Strait Sea Cucumber Fishery is understood to have been inactive in recent years. Issuing of a TAC for a high-value species such as black teatfish is likely to have a stimulating effect on the fishery. Mechanisms to effectively monitor catch and stop the harvesting of stocks when TACs have been reached will be important for long-term sustainability of this fishery. The fishery should also consider scheduling further surveys of sea cucumber stocks to detect the stock response to harvesting.

Reliability of the assessment/s

The TAC estimate from the latest assessment can be considered reasonable and conservative (Skewes et a. 2010). Uthicke et al. (2003) indicate that a harvest rate of less than 5% of the virgin biomass estimate for black teatfish on the Great Barrier Reef would be appropriate.

The abundance estimates derived from the surveys undertaken in 2002, 2005 and 2009 can be considered reliable, given the established and repeated methodology. A survey conducted in 1995 concluded that there were substantial populations of a number of species of sea cucumber in the east of the Torres Strait, but that further survey work was required to reliably estimate abundance (Long et al. 1996).

Previous assessment/s

Prior to the 2009 survey (Skewes et al. 2010), the next most recent assessment of Torres Strait sea cucumbers was published in 2006 (Skewes et al. 2006), based on survey data collected in 2005. This survey found that black teatfish were less abundant than in 2002. The assessment recommended maintaining the zero TAC for this species.

In 2002 surveys of the eastern Torres Strait and the Warrior Reef complex were conducted (Skewes et al. 2004). The surveys of the eastern Torres Strait aimed to estimate abundance, length and weight of all commercial sea cucumbers. Outputs of this work included estimation of the level of exploitation of each species, biomass estimates, estimates of maximum sustainable yield (MSY) and a TACs for each species.

Black teatfish and surf redfish were considered overexploited, resulting in the recommendation of zero TAC for these species (implemented in 2003). Other species, such as white teatfish and prickly redfish, were thought to have historically been subject to harvesting, but their populations did not appear to have been severely depleted. TACs for white teatfish and prickly redfish were estimated at 15 t and 20 t, respectively. Several other species were found to have relatively large standing stocks.

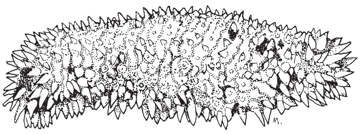
Sea cucumber PHOTO: MIKE GERNER, AFMA

Future assessment needs

Future assessment needs are the same as for sandfish.

PRICKLY REDFISH

(*Thelonota ananas*)



LINE DRAWING: FAO

TABLE 18.5 Biology of prickly redfish

Parameter	Description
General	A relatively large sea cucumber, typically found on harder, broken coral or rubble-based substrates on the reef edge/slope.
Range	**Species:** Likely to have a broad distribution throughout the fishery, particularly in the east **Stock:** The area of the Torres Strait Protected Zone.
Depth	Down to ~25 m
Longevity	Not known
Maturity (50%)	**Age:** not determined **Size:** 1230 g; 300 mm TL
Spawning season	Warmer months of the year (November–February)
Size	**Maximum:** 980 mm; 8 kg whole weight **Recruitment into the fishery:** minimum size limit 300 mm TL

TL = total length

SOURCES: Conand (1989, 1998); Kinch (2008); www.pzja.gov.au.

Stock status determination

In 2009 prickly redfish is assessed as **not overfished** and **not subject to overfishing** (Table 18.1). This is based on preliminary results from the 2009 survey (Skewes et al. 2010), which presents re-estimated values for density, length and weight of sea cucumbers for the four surveys undertaken between 1995 and 2009 in eastern Torres Strait. The mean density of prickly redfish has been relatively stable over the period 1995 to 2009, at between 1.42 individuals/ha to 2.15 individuals/ha, increasing from 1.44/ha to 1.99/ha from 2005 to 2009. The mean weight of prickly redfish has also been relatively stable over the period 2002 to 2009, at 2652 g (2002), 2147 g (2005) and 2812 g (2009), also increasing from 2005 to 2009. Although these means are accompanied by considerable uncertainty around the mean estimate, the estimation methodology can be considered sound. The stability in density estimates and increases in size and weight indicate that the stock is probably not being significantly impacted by fishing at current levels and is the basis for the **not overfished** status determination.

After the 2002 survey of eastern Torres Strait, Skewes et al. (2004) classified prickly redfish as 'exploited' and proposed a TAC of 20 t. Whilst the ABARE–BRS has been unable to clarify the comparative and qualitative nature of this 'exploitation' assessment process, the status and the fact that a TAC was proposed for this stock may act as another line of evidence to support the 2009 classification. Additionally the 20 t TAC was calculated using the lower 90% confidence interval of the biomass estimate (342.5 t), amounting to a conservative approach.

Although reporting of catch of sea cucumbers in the Torres Strait is not mandatory, it is understood that there was no domestic fishery for sea cucumbers in the Torres Strait in 2009. On this basis, prickly redfish is assessed as **not subject to overfishing** (Table 18.1).

Reliability of the assessment/s

Reliability of the assessments is the same as for white teatfish.

Previous assessment/s

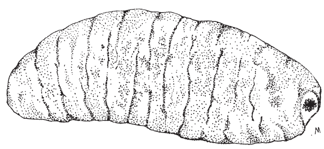
The same as for white teatfish.

Future assessment needs

Future assessment needs are the same as for sandfish.

SANDFISH

(*Holothuria scabra*)



LINE DRAWING: FAO

TABLE 18.6 Biology of sandfish

Parameter	Description
General	Small to medium-sized sea cucumber, typically found on inner reef flats and lagoons. Often associated with seagrass habitats.
Range	**Species:** In the Torres Strait, sandfish is understood to be largely restricted to the Warrior Reef complex and likely to be a shared stock with PNG. **Stock:** The area of the Torres Strait Protected Zone.
Depth	Relatively shallow: <10 m
Longevity	6+ years
Maturity (50%)	**Age:** 2 years **Size:** 184 g; 160 mm TL
Spawning season	Warmer months of the year
Size	**Maximum recorded:** 350 mm TL; 1 kg whole weight **Recruitment into the fishery:** minimum size limit 180 mm TL

TL = total length

SOURCES: Conand (1989, 1998); Kinch (2008); www.pzja.gov.au.

Stock status determination

The most recent survey of sandfish was undertaken in early 2010, but the results of this survey were not available at the time of publication. As a result, the 2009 status determination is based on the 2006 assessment of sandfish in the Torres Strait (Skewes et al. 2006), supported by survey data collected in 2004. The assessment found that the density of sandfish had decreased by 40% since the previous survey in 2002, when the stocks were already understood to be overfished. The assessment recommended maintaining a zero TAC for this species. Sandfish is assessed as **overfished** (Table 18.1), based on the information presented in the 2006 assessment and the data in previous assessments in 2002, 2000, 1998 and 1995.

A back-calculation of the density required to support the 1995 catch of sandfish is presented in the 2006 assessment. This estimated the density of sandfish in 1992 to be around 1600 individuals per hectare. The mean estimate from the 2004 survey in the Torres Strait was 88 (standard error of 21) individuals per hectare. This would indicate a substantially depleted stock.

The sandfish fishery in Australian waters has been closed since 1998. However, the ABARE–BRS has confirmed that a number of apprehensions were made of PNG nationals for sea cucumber related offences on the Warrior Reef complex over the past couple of years, including some in early 2009.

Although the HSP is not prescribed for fisheries jointly managed by the Australian Government and other management agencies, in the absence of an established harvest strategy, the HSP was used by ABARE–BRS to inform the status determination process for these stocks.

The directive from the HSP is that:

> *Any fishing mortality will be defined as overfishing if the stock is below* B_{LIM}*, unless the fishing mortality is below the level that will allow the stock to recover within a period of 10 years plus one generation time, or three times the mean generation time, which ever is less.*

As ABARE–BRS has confirmation of targeted illegal fishing of this overfished stock in early 2009, and there is evidence from surveys (since 1998) that the stock is not rebuilding, sandfish is assessed as **subject to overfishing** (Table 18.1) The HSP indicates that any directed (targeted) fishing on an overfished stock is not permitted and therefore amounts to overfishing.

The change in the overfishing status from 2008 (uncertain) to 2009 (subject to overfishing) is based on the examination of data provided by the Foreign Surveillance & Response Section of AFMA, relating to the

apprehension of illegal fishers in the area of the Torres Strait Protected Zone (TSPZ) in 2009. As part of the drafting process for the 2009 *Fishery status reports,* ABARE–BRS sought data from AFMA on the number, location and associated catch of illegal fishers taking sea cucumber in the TSPZ. These data confirmed the existence and extent of the illegal harvest of sandfish by Papua New Guinea nationals on the Australian side of the Warrior Reef complex in the Torres Strait in the 2009 fishing season. Whilst the number of apprehensions and the recorded catch associated with these apprehensions is less than that recorded for 2008, 2009 is the first year ABARE–BRS has sought evidence of these activities and therefore been able to support the assertion that there is illegal take of sandfish in the TSPZ. This investigation has led to a change in stock status.

ABARE–BRS understands that illegal fishing on the Australian side of Warrior Reef complex by Papua New Guinea nationals ended in mid 2009. This is understood to have resulted from the close of the Papua New Guinea sea cucumber fishery (implemented 1 October 2009) and may also be the result of an increase in compliance activity in 2008 (AFMA pers. comm.).

Reliability of the assessment/s

The abundance estimates derived from the surveys undertaken between 1998 and 2004 can be considered reliable, given the established and repeated methodology. The general survey of marine resources that resulted in the 1995 assessment (Long et al. 1996) for sandfish is considered less reliable, due to the untargeted nature of the survey design and the low precision of results.

The back-calculation of densities required to support the catch taken in 1995 is a relatively coarse estimation method (Skewes et al. 2006). However, it is sufficient to provide an indication of the density of sandfish on the Warrior Reef complex before the recent exploitation period, starting in about 1995.

Previous assessment/s

A survey conducted in 1995 concluded that the breeding year-class of sandfish on Warrior Reef was depleted (Long et al. 1996). In 1998 a survey of sandfish on Warrior Reef found that the standing stock was 77.5% (63–86%) lower than in the 1995 surveys and that the stock was considered overexploited (Skewes et al. 1998). This led to a reduction of the TAC in the fishery to zero.

In 2000 a survey of sandfish revealed that the stock was still severely depleted; it was estimated as 69.7% (53–81%) smaller than in 1995 (Skewes et al. 2000). In 2002 surveys of the eastern Torres Strait and the Warrior Reef complex (Skewes et al. 2004) found that, although abundance at sites repeated in 2002 was 21.4% greater than in 2000, it was still less than half that observed in 1995. The bulk of the sandfish observed were larger, two-year-old animals, giving potential for good recruitment. As the sandfish population was considered overexploited in 1995, it was also considered overexploited in 2002.

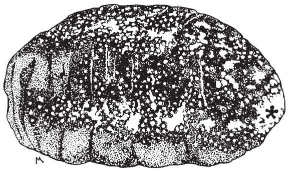
Future assessment needs

The reporting of sea cucumber catch in this fishery is not mandatory for TIB fishers. Understanding catches is an important component of the management of stocks, ensuring sustainability and maximising economic return to fishers. The analysis of catch and effort data is also an important component of the assessment of the status of stocks. Effective reporting of catch and effort data should be addressed as a priority. Some validation of catch composition would also be a valuable addition to the management of this fishery.

The data from the 2010 survey of the Warrior Reef are currently being analysed. The results of this work are likely to inform the status determination process in subsequent *Fishery status reports*.

SURF REDFISH

(*Actinopyga maurtiania*)



LINE DRAWING: FAO

TABLE 18.7 Biology of surf redfish

Parameter	Description
General	A relatively small sea cucumber, typically found in shallower habitats on outer or fringing reefs. Thought to be most abundant in high-energy environments. Can reach relatively high densities (>1 individual/m^2).
Range	**Species:** Recent survey report indicates distribution in eastern Torres Strait. **Stock:** The area of the Torres Strait Protected Zone.
Depth	Relatively shallow: <20 m
Longevity	Not known
Maturity (50%)	**Age:** not determined **Size:** 370 g; 220 mm TL
Spawning season	Warmer months of the year
Size	**Maximum:** 350 mm; 1 kg whole weight **Recruitment into the fishery:** minimum size limit 220 mm TL

TL = total length

SOURCES: Conand (1989, 1998); Kinch (2008); www.pzja.gov.au.

Stock status determination

Surf redfish has previously been determined as overfished and uncertain with regard to the overfishing classification. The overfished determination was made using the information presented in the previous two assessment reports (Skewes et al. 2004; 2006). These indicated that surf redfish was overexploited and recommended a zero TAC for this species. The uncertain classification for overfishing in recent years was made on the basis that the extent of illegal, unregulated and unreported (IUU) fishing could not be confirmed.

Preliminary indications from the most recent survey report of sea cucumbers in the east Torres Strait (Skewes et al. 2010) suggest that surf redfish has never been a significant part of the commercial catch of sea cucumbers in the Torres Strait and has probably always occurred at low densities. The authors suggest that the catch reported as surf redfish was more likely to be deepwater redfish (*Actinopyga echinites*) and a suite of blackfish species (*Actinopyga* spp.).

Skewes et al. (2010) indicate that most of the reported historical catch of 'redfish' has come from the shallow banks on, or adjacent to, the Warrior Reef complex and Great North East Channel (GNEC). The authors estimate the distribution of surf redfish to be predominately in the eastern Torres Strait. However, given that the density estimates of surf redfish and the quantity of catch of this species through the history of the fishery are both uncertain, the stock is assessed as **uncertain** with regard to the overfished status. The Warrior Reef complex was resurveyed (primarily for sandfish) in early 2010. The results of this work may also inform the status determination for surf redfish when they are available.

Although reporting of sea cucumber catch of in the Torres Strait is not mandatory, it is understood that there was no domestic fishery for sea cucumbers in the Torres Strait in 2009. On this basis, surf redfish is assessed as **not subject to overfishing** (Table 18.1).

Reliability of the assessment/s

Reliability of the assessments is the same as for black teatfish.

Previous assessment/s

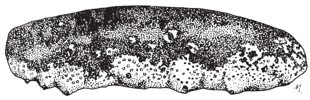
Previous assessments are the same as for black teatfish.

Future assessment needs

Future assessment needs are the same as for sandfish. Additionally, reconciliation of the prevalence of surf redfish in the historical catch records for this fishery should be undertaken as a matter of priority.

WHITE TEATFISH

(*Holothuria fuscogilva*)



LINE DRAWING: FAO

TABLE 18.8 Biology of white teatfish

Parameter	Description
General	A relatively large sea cucumber, typically found on reef edge or slope, and outer barrier reef habitats
Range	**Species:** Likely to have a broad distribution throughout the fishery, particularly in the east **Stock:** The area of the Torres Strait Protected Zone
Depth	10–40+ m
Longevity	12+ years
Maturity (50%)	**Age:** not determined **Size:** 1175 g; 320 mm TL
Spawning season	Warmer months of the year (November–February)
Size	**Maximum:** 570 mm; 5.2 kg whole weight **Recruitment into the fishery:** minimum size limit 320 mm TL

TL = total length

SOURCES: Conand (1989, 1998); Kinch (2008); www.pzja.gov.au.

Stock status determination

The most recent survey of sea cucumbers in the Torres Strait was undertaken in 2009 (Skewes et al. 2010). Preliminary data from this survey indicate that the mean density of white teatfish had increased from the previous survey in 2005 (Skewes et al. 2010). Mean length and weight had also increased. However, there is considerable uncertainty around these mean estimates.

In 2009 white teatfish is assessed as **not overfished** on the basis that the stock has maintained relatively stable and low densities (<1 individual/ha) over the past four surveys (1995 to 2009), during which time there has been some fishing of the species. This suggests that white teatfish are naturally found at low densities in the Torres Strait and that the level of fishing that was applied between 1995 to 2005 did not adversely affect the stock. Additionally, white teatfish, which spans a relatively broad range of depths (10–40+ m), is probably protected to some extent at greater depths by the prohibition on use of breathing apparatus when fishing for sea cucumbers in the Torres Strait. Although the proportion of the stock that is protected is unknown, there is some inbuilt protection in the management arrangements of the fishery. It is also possible, given this broad depth range of the species, that surveys in the Torres Strait (limited to maximum depth of 20 m) may underestimate the density of the stock and, as a result, the biomass.

Although reporting of catch of sea cucumbers by TIB fishers in the Torres Strait is not mandatory, it is understood that there was no domestic fishery for sea cucumbers in the Torres Strait in 2009. On this basis, white teatfish is assessed as **not subject to overfishing** (Table 18.1).

Reliability of the assessment/s

The abundance estimates derived from the surveys undertaken in 2002, 2005 and 2009 can be considered reliable, given the established and repeated methodology. A survey conducted in 1995 concluded that there were substantial populations of a number of species of sea cucumber in the east of the Torres Strait, but that further survey work was required to reliably estimate abundance (Long et al. 1996).

Previous assessment/s

In 2008 white teatfish was classified as uncertain with regard to both the overfished and overfishing classification because:

- there was insufficient information to ascertain the health of the biomass, other than the 'exploitation' classification (Skewes et al. 2004), which was poorly understood
- the extent of IUU fishing was not known.

Previous stock assessments are detailed under black teatfish.

Future assessment needs

Future assessment needs are the same as for sandfish.

OTHER SEA CUCUMBERS

Stock status determination

The ‘other sea cucumber’ stock in the Torres Strait comprises as many as 18 species. Results from the 2009 survey (Skewes et al. 2010) indicate that the densities of deepwater redfish (*Actinopyga echinites*) and hairy blackfish (*A. miliaris*) have increased since the previous survey in 2005. Skewes et al. (2010) also indicate that deepwater redfish and a suite of blackfish species are likely to have made up what was historically reported as surf redfish catch. It is therefore difficult to know what the observed densities in 2009 imply for the health of these stocks.

The 2004 assessment (Skewes et al. 2004) provided an exploitation classification for a number of other sea cucumber species that are contained within this basket stock. None of these species were found to be overexploited.

Species-specific catch for this ‘stock’ (group of species) is not well understood. The Australian catch of sea cucumbers in the Torres Strait between 1996 and 2005 was variable (Skewes et al. 2010). Blackfish catch peaked at 28.5 t (gutted weight) in 2001. The total catch of other species peaked at 14.5 t in 2002.

Given the number of species that comprise this stock, it is difficult to determine a suitable status classification. On this basis, the ‘other’ sea cucumber stock is assessed as **uncertain** with regard to the overfished status.

Although reporting of catch of sea cucumbers in the Torres Strait is not mandatory, it is understood that there was no domestic fishery for sea cucumbers in the Torres Strait in 2009. On this basis, other sea cucumbers are assessed as **not subject to overfishing** (Table 18.1).

Reliability of the assessment/s

Reliability of the assessments is the same as for black teatfish.

Previous assessment/s

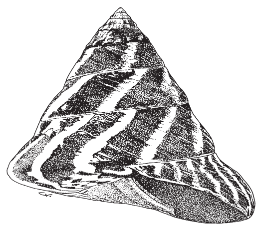
Previous assessments are the same as for white teatfish.

Future assessment needs

Future assessment needs are the same as for sandfish.

TROCHUS

(*Trochus niloticus*)



LINE DRAWING: FAO

TABLE 18.9 Biology of trochus

Parameter	Description
General	Asynchronous spawners that may form loose aggregations to spawn. The short planktonic duration of trochus larvae before settlement (~3 days) is understood to limit the dispersal range of this species. Recruitment may be limited by suitable juvenile habitat.
Range	**Species:** Indo-Pacific distribution **Stock:** The area of the Torres Strait Protected Zone.
Depth	Most common range 0–10 m
Longevity	12–15 years
Maturity (50%)	**Age:** 2–3 years **Size:** 55–77 mm basal diameter
Spawning season	Year round
Size	**Maximum:** ~170 mm (basal diameter) **Recruitment into the fishery:** minimum (80 mm basal diameter) and maximum (125 mm basal diameter) size limits for commercial harvest

SOURCES: FAO (1998); SPC (2008); Murphy et al. (2009).

Stock status determination

The most recent broad-scale survey of trochus stocks in the Torres Strait was undertaken in 2009 (Murphy et al. 2009), combined with the survey of sea cucumbers. The survey covered 113 sites over 10 days. Preliminary results of this work indicate that a total of 62 trochus were found at 12 of the 113 sites. Although survey transects went down to a depth of 20 m, trochus was only found down to 3 m.

A geographic information system was used to estimate habitat area, and the survey data provided estimates of density and size (basal width). Trochus weight was estimated through a length–weight relationship previously established for Torres Strait trochus (Long et al. 1993).

A total of 1.5 t of trochus was reportedly taken in the Torres Strait in 2009. This is the smallest reported catch since 1987 (Murphy et al. 2009). Given the low levels of catch in 2009, relative to historical levels, the stock is assessed as **not subject to overfishing** (Table 18.1). Preliminary results from Murphy et al. (2009) propose a catch trigger of 75 t for this fishery (20% of the standing biomass estimate).

Given the small number of sites where trochus was found (12 of 113), there is considerable uncertainty in the survey results. The authors conclude that densities of trochus in 'trochus habitat' are similar to healthy populations outside of Australia. Mean densities across the Torres Strait are higher than the mean estimate from the 1995 reef resources inventory (when the GNEC is included in the analysis). However, since the fishery was active before this survey, the health of the population in 1995 is unknown. Although valuable information is provided by this work, the level of uncertainty in the preliminary results is too great to resolve the overfished status for 2009. On this basis, Torres Strait trochus is assessed as **uncertain** with regard to the overfished classification (Table 18.1).

Reliability of the assessment/s

Considerable uncertainty is associated with the preliminary results of the 2009 survey, stemming from the survey design and the small number of sites where trochus was found.

Previous assessment/s

There are no previous, full-scale targeted assessments of trochus in the Torres Strait. A general reef resources survey was undertaken in 1995 (Long et al. 1996), but the results for trochus were not published.

Future assessment needs

Reporting of trochus catch in the fishery is not currently mandatory for TIB fishers; however, understanding catches is important for assessment of the status of stocks. This should be addressed as a priority for the fishery.

18.5 ECONOMIC STATUS

No economic information is available for this fishery.

18.6 ENVIRONMENTAL STATUS

Because of the selective nature of these hand collection fisheries, there is understood to be relatively little direct impact on the benthos or other marine species.

The sessile nature of both sea cucumbers and trochus and their relatively restricted mobility make them inherently vulnerable to localised depletion.

Threatened, endangered and protected species

The selective nature of the fishery minimises any direct effects of fishing on threatened, endangered or protected species.

Benthic habitats

Fishing for sea cucumbers and trochus in the Torres Strait is conducted either through reef-top walking or free-diving. The impact of these collection methods is unquantified, however they are suspected to be low.

18.7 HARVEST STRATEGY PERFORMANCE

Not applicable.

Dried sea cucumber trade PHOTO: DAVID WILSON, ABARE–BRS

Dried sea cucumber
PHOTO: KATHRYN READ, DEWHA

18.8 LITERATURE CITED

Conand, C 1989, *The Fishery Resources of Pacific Island Countries: Part 2. Holothurians*. FAO Fisheries Technical Paper, No. 272.2. FAO, Rome.

——1998, 'Holothurians', in KE Carpenter & VH Niem (eds), *United Nations Food and Agriculture Organization species identification guide for fishery purposes. The living marine resources of the Western Central Pacific*, vol. 2, *Cephalopods, crustaceans, holothurians and sharks*, FAO, Rome.

DAFF (Australian Government Department of Agriculture, Fisheries and Forestry) 2007, *Commonwealth Fisheries Harvest Strategy, policy and guidelines*, DAFF, Canberra.

FAO (Food and Agriculture Organization of the United Nations) 1998, 'Seaweeds, corals, bivalves and gastropods', in KE Carpenter & VH Niem (eds), *United Nations Food and Agriculture Organization species identification guide for fishery purposes. The living marine resources of the Western Central Pacific*, vol. 1, *Seaweeds, corals, bivalves and gastropods*, FAO, Rome.

Kinch, J, Purcell, S, Uthicke, S & Friedman, K 2008, 'Population status, fisheries and trade of sea cucumbers in the Western Central Pacific', in V Toral-Granda, A Lovatelli & M Vasconcellos (eds), *Sea cucumbers. A global review of fisheries and trade*, FAO Fisheries and Aquaculture technical paper no. 516, FAO, Rome, pp. 7–55.

Long, BG, Poiner, IR & Harris, ANM 1993, 'Method of estimating the standing stock of *Trochus niloticus* incorporating Landsat satellite data, with application to the trochus resources of the Bourke Isles, Torres Strait, Australia', *Marine Biology*, vol. 115, pp. 587–93.

——Skewes, TD, Dennis, DM, Poiner, IR, Pitcher, CR, Toranto, TJ, Manson, F, Polon, P, Karre, B, Evans, C & Milton, D 1996, *Distribution and abundance of beche-de-mer on Torres Strait reefs*, CSIRO Division of Fisheries final report, Queensland.

Murphy, NE, McLeod, I, Skewes, TD, Burridge, C & Rochester, W 2009, *Torres Strait hand collectables, 2009 survey: trochus*, CSIRO Marine and Atmospheric Research, Cleveland, Queensland.

Raudzens, EE 2007, *Torres Strait Trochus and Beche-de-mere Fishery Data Summary 2005 and 2006, Logbook Program*, AFMA, Canberra.

Skewes, T, Burridge, CM & Hill, BJ 1998, *Survey of Holothuria scabra (sandfish) on Warrior Reef, Torres Strait*, report to the Queensland Fisheries Management Authority, CSIRO Division of Marine Research, Queensland.

——Dennis, DM & Burridge, CM 2000, *Survey of Holothuria scabra (sandfish) on Warrior Reef, Torres Strait*, final report to the Queensland Fisheries Management Authority, CSIRO Division of Marine Research, Queensland.

——, ——Koutsoukos, A, Haywood, M, Wassenberg, T & Austin, M 2004, *Stock survey and sustainable harvest strategies for Torres Strait bêche-de-mer*, AFMA project no. R01/1345, CSIRO Division of Marine and Atmospheric Research, Cleveland, Queensland.

——Murphy, N. E, McLeod, I, Dovers, E, Burridge, C & Rochester, W. 2010. *Torres Strait hand collectables, 2009 survey: sea cucumber*, CSIRO, Cleveland.

——Taylor, S, Dennis, D, Haywood, M & Donovan, A 2006, *Sustainability assessment of the Torres Strait sea cucumber fishery*, CRC TS project task no. T1.4, final report, CSIRO Division of Marine and Atmospheric Research, Cleveland, Queensland.

SPC (Secretariat of the Pacific Community) 2008, 'Trochus and other marine mollusks', *Trochus Information Bulletin*, issue 14, July 2008.

Stutterd, E & Williams, G 2003, *The future of bêche-de-mer and trochus fisheries and aquaculture in Australia*, Bureau of Rural Sciences, DAFF, Canberra.

Uthicke, S, Welch, D & Benzie, JAH 2003, 'Slow growth and lack of recovery in overfished holothurians on the Great Barrier Reef: evidence from DNA fingerprints and repeated large-scale surveys', *Conservation Biology*, vol. 18, pp. 1395–404.

19 Western Deepwater Trawl Fishery

M Rodgers, A Sampaklis and T Pham

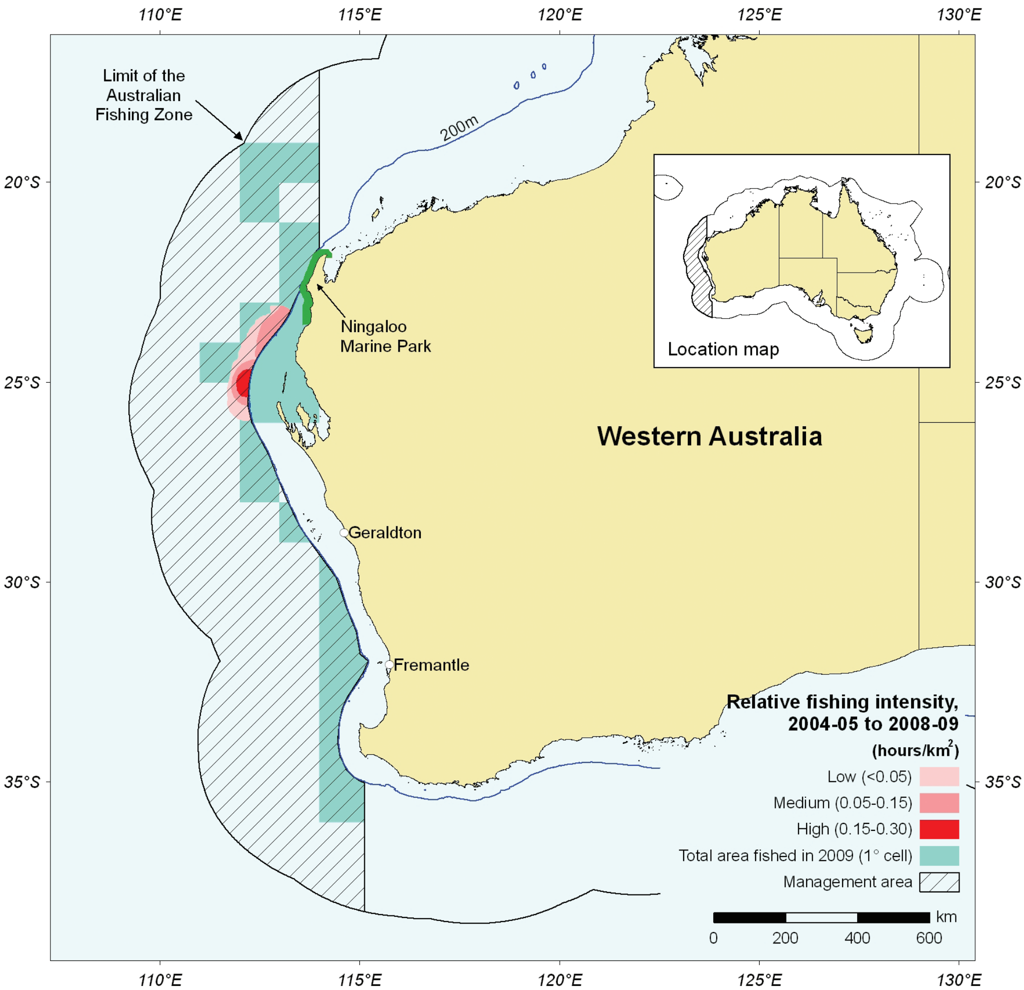


FIGURE 19.1 Relative fishing intensity in the Western Deepwater Trawl Fishery, 2004–05 to 2008–09

TABLE 19.1 Status of the Western Deepwater Trawl Fishery

Fishery status	2008		2009		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Deepwater bugs (*Ibacus* spp.)	Not overfished / not subject to overfishing	Uncertain	Not overfished / not subject to overfishing	Uncertain	Very low levels of fishing effort. No estimates of biomass.
Orange roughy (*Hoplostethus atlanticus*)	Not overfished / not subject to overfishing	Uncertain	Not overfished / not subject to overfishing	Uncertain	No targeting of orange roughy (zero catch). No estimates of biomass.
Ruby snapper (*Etelis carbunculus*)	Not overfished / not subject to overfishing	Uncertain	Not overfished / not subject to overfishing	Uncertain	Low levels of fishing effort. No estimates of biomass.
Economic status Fishery level	Estimates of net economic returns not available				Economic status uncertain. Total net economic returns likely to be low given high level of latency, low catches and effort.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING OVERFISHED / OVERFISHING UNCERTAIN NOT ASSESSED

TABLE 19.2 Main features and statistics of the Western Deepwater Trawl Fishery

Feature	Description
Key target and byproduct species	Deepwater bugs (*Ibacus* spp.) Orange roughy (*Hoplostethus atlanticus*) Ruby snapper (*Etelis carbunculus*)
Other byproduct species	Bar rockcod (*Epinephelus* spp.) Boarfish (Pentacerotidae) Deepwater flathead (*Neoplatycephalus conatus*) Mirror dory (*Zenopsis nebulosus*) Tang's snapper (*Lipocheilus carnolabrum*) Other minor byproduct species are included in Table 19.4.
Fishing methods	Demersal trawl
Primary landing ports	Fremantle, Geraldton
Management methods	Input controls: limited entry (11 permits) since 1998
Management plan	*Western Trawl Fisheries statement of management arrangements* (AFMA 2004)
Harvest strategy	*Western Trawl Fisheries Harvest Strategy—North West Slope Trawl Fishery (NWSTF) and Western Deepwater Trawl Fishery (WDTF)* (AFMA 2007)
Consultative forums	The Western Trawl Fisheries Management Advisory Committee was disbanded on 1 July 2009 and replaced by a small consultative panel tasked with focusing on key strategic issues in the WDTF and North West Slope Trawl Fishery.
Main markets	Domestic: Perth, Sydney, Brisbane—frozen/chilled International: United States, Spain, China, Japan—frozen
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	 Current accreditation dated 28 September 2005 Current accreditation (Wildlife Trade Operation) expires 15 November 2010
Ecological risk assessment	Level 1: Scale Intensity Consequence Analysis (SICA) completed on 254 species (Wayte et al. 2007) Level 2: Productivity Susceptibility Analysis (PSA) completed on 129 species (Wayte et al. 2007) Level 3: Draft Sustainability Assessment for Fishing Effects (SAFE) completed on 103 species (Zhou et al. 2009)

Table 19.2 continues over the page

TABLE 19.2 Main features and statistics of the Western Deepwater Trawl Fishery CONTINUED

Feature	Description			
Bycatch workplans	*Western Deepwater Trawl Fishery Bycatch and Discarding Work Plan*, 1 November 2008–31 October 2010 (AFMA 2008b)			
Fishery statistics[a]	**2007–2008 fishing season**		**2008–2009 fishing season**	
Fishing season	1 July 2007–30 June 2008		1 July 2008–30 June 2009	
TAC and catch by species:	TAC	Catch (tonnes)	TAC	Catch (tonnes)
—Deepwater bugs	None	8.6	None	< 1
—Orange roughy	None	0	None	0
—Ruby snapper	None	8.5	None	28.0
Effort	762 hours of trawling		482 hours of trawling	
Fishing permits	11		11	
Active vessels	3		1	
Observer coverage	Zero		Zero	
Real gross value of production (2008–09 dollars)	Confidential (<5 vessels)		Confidential (<5 vessels)	
Allocated management costs	$0.1 million		$0.1 million	

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; TAC = total allowable catch; TAE = total allowable effort; WDTF = Western Deepwater Trawl Fishery

a Fishery statistics are provided by fishing season unless otherwise indicated.

19.1 BACKGROUND

The Western Deepwater Trawl Fishery (WDTF) operates in Western Australia between the western boundary of the Great Australian Bight Trawl Sector in the south (115°08´E) and the western boundary of the North West Slope Trawl Fishery (NWSTF) in the north (114°E) (Fig. 19.1). The WDTF is predominantly an off-season diversification for Northern Prawn Fishery vessels. The fishery targets more than 50 species in waters exceeding 200 m depth, in habitats ranging from temperate–subtropical in the south to tropical in the north (Table 19.2).

The *Western Trawl Fisheries statement of management arrangements* (2004) aligns fishing seasons with financial years, and specifies a maximum of 11 fishing permits, each valid for five years (AFMA 2004). Different vessels may fish on the same permit, provided only one vessel is fishing at any time.

Catches in the WDTF were historically dominated by six main commercial finfish species or species groups: orange roughy (*Hoplostethus atlanticus*), oreos (Oreosomatidae), boarfish (Pentacerotidae), eteline snapper (Lutjanidae: Etelinae), apsiline snapper (Lutjanidae: Apsilinae) and sea bream (Lethrinidae). Between 2000 and 2005, deepwater bugs (*Ibacus* spp.) emerged as the most important target species, although there has been a large reduction in effort (and consequently catch) over the past three years. Orange roughy has not been targeted over the past six years. Most WDTF target species are thought to be long lived and slow to mature. These characteristics warrant a precautionary approach to management. The level of fishing and the extent of research activities are insufficient to provide estimates of sustainable yields.

TABLE 19.3 History of the Western Deepwater Trawl Fishery

Year	Description
1979	Exploratory fishing returned promising catches of big-spined boarfish.
Mid-1980s	Exploratory fishing for scampi and prawns began.
1987–88	102 vessels received endorsement to fish.
1990–91	Endorsements reduced to 10 vessels.
1994–95	Orange roughy catch peaked at 300 t.
1997–98	Effort shifted to target shelf-break finfish resources, and ruby snapper emerged as dominant target finfish stock.
1998	Limited entry of 11 fishing permits introduced.
2001	Stock assessment of ruby snapper undertaken; model results inconclusive because data were limited.
2002–03	Catch of deepwater bugs peaked at 160 t.
2004	AFMA statement of management arrangements, in lieu of a management plan, came into effect.
2005	CSIRO-managed research vessel undertook a mapping survey of benthic habitats on the continental shelf and slope of south-west Australia.
2006	An exploratory survey failed to detect target species in commercial quantities.
2006–07	A joint AFMA–CSIRO ecological risk assessment undertaken.
2008	Harvest strategy adopted by AFMA (January).
2009	WestMAC disbanded and replaced by a consultative panel for Western Trawl Fisheries.

AFMA = Australian Fisheries Management Authority; CSIRO = Commonwealth Scientific and Industrial Research Organisation; WestMAC = Western Trawl Fisheries Management Advisory Committee

19.2 HARVEST STRATEGY

The Western Trawl Fisheries harvest strategy (HS) (AFMA 2007), which applies to the NWSTF and the WDTF, reflects the mixed-species composition and opportunistic nature of the two fisheries. The HS acknowledges that there are no target reference points in terms of maximum economic yield (MEY). It aims to strike a balance between precautionary management arrangements and allowing industry to capitalise on fishing opportunities, while emphasising the need to collect biological data.

The HS prescribes species-specific threshold levels for 14 key commercial stocks (Table 19.4). Three catch trigger rules initiate management actions that progressively increase data and analysis requirements on the fisheries (Levels 1 and 2) and establish a limit reference point (Level 3). Separate triggers and control rules apply to vulnerable species identified through the ecological risk assessment (ERA) process (the ERA results have not yet been published by the Australian Fisheries Management Authority—AFMA).

There are no reference points because of the opportunistic nature and variable catch composition of the Western Trawl Fisheries. In the absence of other information or assessments, the triggers for target species are based on the highest historical catch. Level 1 is half the highest historical catch, Level 2 is the highest historical catch, and Level 3 is double the highest historical catch. Trigger levels and decision rules are applied independently within two latitudinal zones of the WDTF (north and south of 30°S).

The Level 1 trigger initiates an investigation to reveal why the trigger has been reached. This is undertaken through analysis of logbooks and examination of standardised data on catch per unit effort. It may also result in expert consultation and a possible revision of limit reference points. The Level 2 trigger results in stock assessments, using

biological parameters such as size-specific fishing mortality, natural mortality, growth and reproduction. A revision of trigger values is also undertaken. Exceeding the Level 3 trigger results in a cessation of fishing effort, pending a stock assessment and expert consultation.

The measures include a 50-animal move-on provision for high-risk chondrichthyans; for the WDTF, these include a number of deepwater sharks. The HS also specifies control rules for species identified as high risk under the ERA framework. High-risk teleosts and crustaceans have two trigger levels: an intermediate 2 t trigger (in effect initiating the same management responses as for the Level 1 trigger for target species) and a 4 t catch limit (Level 2).

TABLE 19.4 Catch and trigger levels for key commercial species in the WDTF

Species	Catch (tonnes)[a]	HS Level 1 trigger (tonnes)	HS Level 2 trigger (tonnes)	HS Level 3 trigger (tonnes)
Alfonsino (*Beryx splendens*)	0	20	30[bc]	150
Bar rockcod (*Epinephelus ergastularius*, *E. septemfasciatus*)	2	10	20	50
Boarfish (Pentacerotidae)	1	250[b]	500[b]	1000
Deepwater bugs (*Ibacus* spp.)	60	100	200	400
Deepwater flathead (*Neoplatycephalus conatus*)	28	200	500	1000
Deepwater prawns (multiple species)	0	100	200	400
Flame snapper (*Etelis coruscans*)	5	50	100	200
Gemfish (*Rexea solandri*)	<1	5	10	20
Mirror dory (*Zenopsis nebulosus*)	<1	10	25	50
Orange roughy (*Hoplostethus atlanticus*)	6	75	150	300
Ruby snapper (*Etelis carbunculus*)	14	25	50	100
Scampi (*Metanephrops australiensis*, *M. boschmai*, *M. velutinus*)	<1	100	200	400
Smooth oreodory (*Pseudocyttus maculatus*)	<1	2	4	8
Tang's snapper (*Lipocheilus carnolabrum*)	2	5	15	20

HS = harvest strategy

a Catch data from 2004–05 to 2007–08 pooled to maintain confidentiality

b In each of three consecutive years

c In each of five years from a 10-year period

19.3 THE 2009 FISHERY (2008–09 FISHING SEASON)

Key target and byproduct species

In the 2008–09 fishing season, a small number of operators were active in the WDTF, and effort was variable across the fishery. The catch was also small and diverse relative to the large fishing area. Effort in the WDTF from 2005–06 to 2006–07 was low (<300 trawl hours) relative to historical levels, but there was a noticeable increase in 2007–08, with correspondingly greater catches. However, in 2008–09 effort decreased to 482 hours of trawling (Table 19.2). The catch composition included an array of finfish species. The majority of the catch was comprised of ruby snapper (28 t), and there was a decrease in the catch of deepwater bugs (<1 t) from the previous fishing season (8.6 t).

Value data for the fishery prior to 2000–01 are confidential because of the small number of operators in the fishery (less than five). From 2002–03 to 2004–05, both volume and gross value of production (GVP) for the fishery (Figs. 19.2 and 19.3) fell considerably. Until recently deepwater bugs have been the fishery's most important catch. The substantial reduction in catch also caused GVP to fall to less than $1.0 million in real terms in 2004–05. The GVP of the fishery from 2005–06 to 2008–09 are not reported for confidentiality reasons. Catches improved throughout 2007–08 and 2008–09 but were still far below 2004–05 levels.

Western Alliance PHOTO: LOCKY MARSHALL

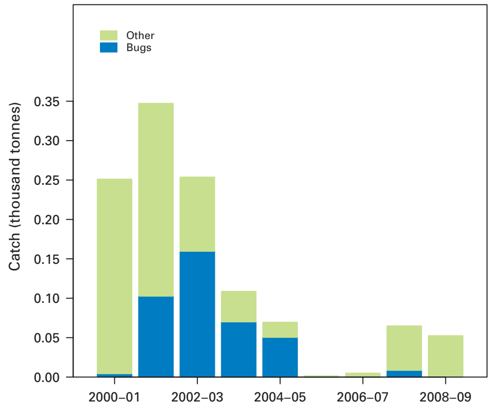


FIGURE 19.2 Catch by financial year, 2000–01 to 2008–09

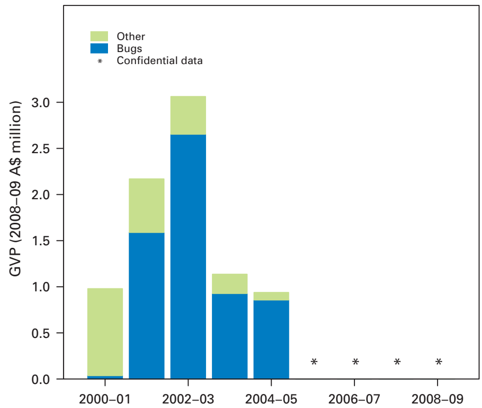


FIGURE 19.3 Real GVP by financial year, 2000–01 to 2008–09

Minor byproduct species

Byproduct species taken in the WDTF include bar rockcod (*Epinephelus* spp.), boarfish (Pentacerotidae), deepwater flathead (*Neoplatycephalus conatus*), mirror dory (*Zenopsis nebulosus*), Tang's snapper (*Lipocheilus carnolabrum*) and snapper (*Etelis* spp.) (Table 19.5). Given the opportunistic nature of the WDTF, the list of species in Table 19.5 is not exhaustive. As targeting practices change, it is likely that other species may be taken as byproduct. Catches of Tang's snapper should be monitored, as this is considered a high-risk species under AFMA's ERA process (AFMA 2008).

TABLE 19.5 Minor byproduct stocks—TACs/triggers, catches/landings and discards in the WDTF

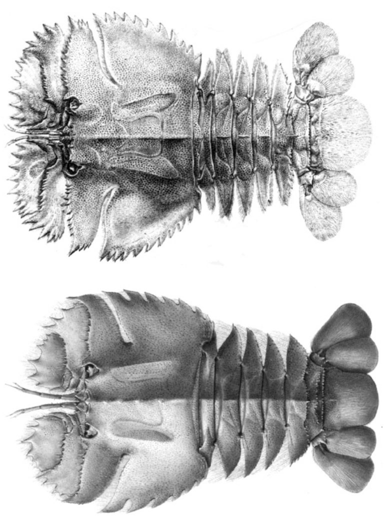
Species	TAC/ trigger	2004–05 to 2008–09 catch (tonnes)	2004–05 to 2008–09 discards (tonnes)
Deepwater flathead (*Neoplatycephalus conatus*)	HS triggers	32	0
Tang's snapper (*Lipocheilus carnolabrum*)	HS triggers	8	0
Flame snapper (*Etelis coruscans*)	HS triggers	5	0
Snapper, other (*Etelis* spp.)	None	5	0
Bar rockcod (*Epinephelus ergastularius, E. septemfasciatus*)	HS triggers	4	0
Amberjack (*Seriola dumerili*)	None	3	0
Latchet (*Pterygotrigla polyommata*)	None	3	0
Gould's squid (*Nototodarus gouldi*)	None	2	0
Mirror dory (*Zenopsis nebulosus*)	HS triggers	2	0.4
Cuttlefish (Sepiidae)	None	2	0
Northern pearl perch (*Glaucosoma buergeri*)	None	2	0
Boarfish (Pentacerotidae)	HS triggers	2	0.3
Barracouta (*Thyrsites atun*)	None	2	0

HS = harvest strategy; TAC = total allowable catch; WDTF = Western Deepwater Trawl Fishery

19.4 BIOLOGICAL STATUS

DEEPWATER BUGS

(*Ibacus* spp.)



LINE DRAWINGS: FAO

TABLE 19.6 Biology of deepwater bugs

Parameter	Description
General	Deepwater bugs inhabit shallow, inshore waters of the continental shelf and extend to the outer shelf and upper slope. They form spawning aggregations, exhibit low fecundity and are long lived, making them susceptible to overfishing.
Range	**Species:** In Australia, *Ibacus* spp. are predominantly found in subtropical to tropical regions, whereas *Thenus* spp. are found in temperate waters. **Stock:** The stock structure in the WDTF is unclear. It is assumed to be a basket stock for assessment purposes.
Depth	30–400 m
Longevity	>10 years
Maturity (50%)	**Age:** females 1.7–2 years post-settlement **Size:** ~5–5.5 cm CL
Spawning season	June–December
Size	**Maximum:** females 7 cm CL; males 7 cm CL **Recruitment into the fishery:** not determined

CL = carapace length; WDTF = Western Deepwater Trawl Fishery

SOURCES: White & Sumpton (2002), Haddy et al. (2005).

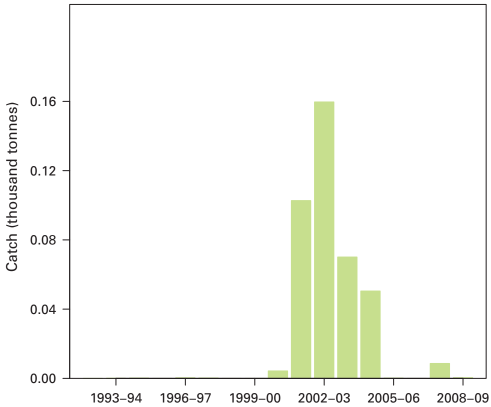


FIGURE 19.4 Deepwater bug catch history by financial year, 1992–93 to 2008–09

Stock status determination

No stock assessment exists for deepwater bugs. A weight-of-evidence approach, using catch and landing data since 1998–99 were used to determine stock status. Fishing effort and catches have been low over the past four years (Fig. 19.4). Given the low volume of catch in 2009, deepwater bugs are assessed as **not subject to overfishing** (Table 19.1). However, as catches have been much higher in the past and there are no estimates of biomass, it is **uncertain** if the stock is overfished.

Reliability of the assessment/s

There is limited information with which to assess stock status. Confidence that overfishing is not occurring is high, given low catch and effort levels in 2008–09.

Previous assessment/s

No previous stock assessments have been undertaken.

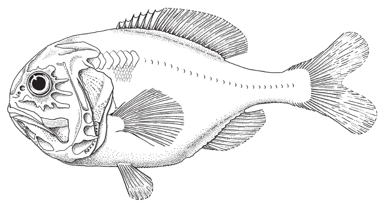
Trawl catch PHOTO: DAVID GUILLOT, AFMA

Future assessment needs

The low effort, low volumes of catch and sporadic targeting of key commercial species make it difficult to specify research and assessment requirements in the WDTF. Nonetheless, investigation of spatial patterns of catch and effort for key commercial species is required. Collection of basic biological information and spatial catch and effort information for deepwater bugs will be required for future assessments, particularly if catches increase and/or fishing practices change.

ORANGE ROUGHY

(*Hoplostethus atlanticus*)



LINE DRAWING: ROSALIND POOLE

TABLE 19.7 Biology of orange roughy

Parameter	Description
General	The stock structure of orange roughy in the WDTF is unclear.
Range	**Species:** Occurs in all temperate oceans except the north Pacific; in Australia, it occurs across the south coast from Sydney to Perth and is found in continental slope and seamount areas. **Stock:** The stock structure in the WDTF is unclear. It is assumed to be a single stock within the area of the fishery for assessment purposes.
Depth	180–1800 m, but usually found at 400–1000 m
Longevity	90–150 years
Maturity (50%)	**Age:** 20–30 years **Size:** ~25–30 cm SL
Spawning season	July–August
Size	**Maximum:** 50–60 cm SL **Recruitment into the fishery:** 24–42 years (size not available)

SL = standard length; WDTF = Western Deepwater Trawl Fishery

SOURCE: Gomon et al. (2008).

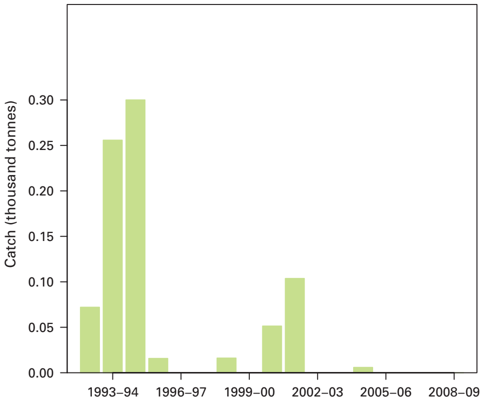


FIGURE 19.5 Orange roughy catch history by financial year, 1992–93 to 2008–09

Stock status determination

No model-based stock assessment exists for orange roughy caught in the WDTF. A weight-of-evidence approach, using catch and landing data since the 1998–99 fishing season were used to determine stock status. There has been no targeting of orange roughy since 2005–06 (Fig. 19.5). As a result, the WDTF orange roughy stock is assessed as **not subject to overfishing** (Table 19.1). Its overfished status is **uncertain** as there are no current estimates of biomass, and high levels of exploitation in the past create substantial uncertainty regarding biomass.

Reliability of the assessment/s

There is limited information with which to assess stock status. Confidence that overfishing is not occurring is very high, given the zero catch in 2008–09.

Previous assessment/s

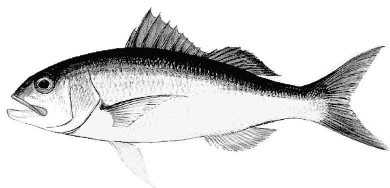
No assessment has been made of orange roughy stocks in the WDTF. An exploratory fishing survey in 2006 searched suitable habitats but failed to detect orange roughy. Consequently, there is some concern about the biomass of orange roughy in the WDTF.

Future assessment needs

Collection of basic biological information and spatial catch and effort data would be required to enable an assessment of the orange roughy stock in the WDTF. As orange roughy is not currently being targeted this is unlikely to occur in the immediate future. Monitoring of its status is required should fishing resume.

RUBY SNAPPER

(*Etelis carbunculus*)



LINE DRAWING: FAO

TABLE 19.8 Biology of ruby snapper

Parameter	Description
General	Ruby snapper is found over rocky bottoms; however, little is known about the biology of Australian stocks.
Range	**Species:** 21°15’S, 113°43’E – 26°24’S, 112°38’E; tropical waters from the Indo- and Central Pacific; in Australia, from north-western Western Australia to north-eastern Queensland **Stock:** The stock structure in the WDTF is unclear. It is assumed to be a shared stock with Western Australian state fisheries for assessment purposes.
Depth	90–400 m, limited to the shelf break and extreme upper slope.
Longevity	25 years
Maturity (50%)	**Age:** ~3 years **Size:** ~30 cm FL
Spawning season	3-month reproductive cycle over summer
Size	**Maximum:** in excess of 80 cm TL **Recruitment into the fishery:** not determined; optimal size for harvesting is 63 cm TL

FL = fork length; TL = total length; WDTF = Western Deepwater Trawl Fishery

SOURCES: Grimes (1987); Hunter (2001); Martinez-Andrade (2003).

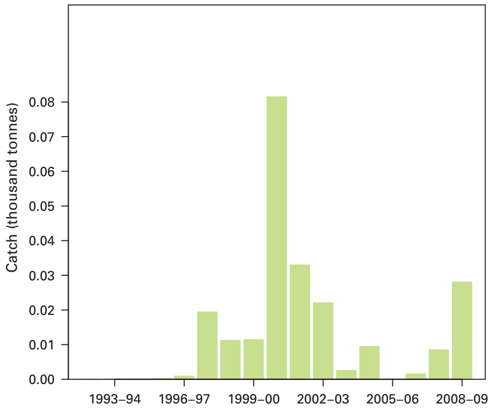


FIGURE 19.6 Ruby snapper catch history by financial year, 1992–93 to 2008–09

Stock status determination

No model-based stock assessment took place in 2009. Catch and landing data since the 1998–99 fishing season were used to determine stock status (Fig. 19.6). Effort has remained low, and the level of catch in recent years has also been low, although in 2008–09 catches increased slightly to a level similar to those in 2001–02 and 2002–03; consequently, ruby snapper is assessed as **not subject to overfishing** (Table 19.1). It is **uncertain** if the stock is overfished given previous levels of exploitation and the lack of a reliable biomass estimate.

Trawl catch PHOTO: MIKE GERNER, AFMA

Reliability of the assessment/s

There is limited information with which to assess stock status. Confidence that overfishing is not occurring is high, given low catch and effort levels in 2008–09.

Previous assessment/s

A stock assessment of ruby snapper was undertaken in 2001; however, model results were inconclusive because of data quality and quantity.

Future assessment needs

For ruby snapper, there is a need to collect biological data and improve sample sizes of fisheries data for future assessments, particularly if catches increase and/or fishing practices change.

19.5 ECONOMIC STATUS

There have not been any economic surveys of the fishery. Effort and catches in the fishery have been low over the past years. Given the low level of fishing effort and catch in 2007–08 and 2008–09, and the estimated high level of latency of permits, it is unlikely that profits in the fishery are significantly positive. The low level of fishing effort in 2007–08 and 2008–09 has been attributed to high fuel and operational costs (WestMAC 2008).

19.6 ENVIRONMENTAL STATUS

The HS proposes the identification of spatial closures to protect species and habitats identified as high risk under AFMA's ERA. An existing area closure includes the Ningaloo Marine Park (Commonwealth waters), which extends as a narrow band from Point Murat to south of Monck Head (Fig. 19.1). The majority of the marine park is in state waters, except for a small part in the north that encompasses the WDTF. The main objective of the WDTF Bycatch and Discarding Work

Plan (AFMA 2008b) is to minimise overall bycatch in the fishery over the long term.

Ecological risk assessment

AFMA's ERAs provided a list of high-risk species, based on their productivity (life history) and susceptibility to fishing effects. The ERAs considered target, byproduct and bycatch, including threatened, endangered or protected (TEP) species. Based on the ERA process, no interactions with TEP species were detected. Twenty-two high-risk species were identified; three of these are considered target species (gemfish, mirror dory and Tang's snapper), and 19 are byproduct species (Wayte et al. 2007; AFMA 2008a). Following the residual risk assessment, all high-risk species remained in the high-risk category and have been incorporated into the HS for the fishery (AFMA 2008a).

Habitats

Operators in the WDTF target catch using demersal trawl gear. The impact of trawling on benthic habitats has not been specifically investigated in the WDTF. However, trawling is potentially destructive to seabed habitats. Demersal trawling can have a significant impact on the sea floor by reducing structural complexity of the environment, and crushing, burying or exposing marine organisms (Watling & Norse 1998). The recovery potential of benthic assemblages is dependent on the growth potential of structure-forming organisms and the period of time between disturbances (Watling & Norse 1998). The areas most susceptible tend to be those that do not experience disturbance, such as shelf and slope habitats and those that rely on slow-growing organisms for habitat complexity (e.g. coral reefs) (Watling & Norse 1998).

Sharks

The strategic assessment of the WDTF recommended improved monitoring of catches of deepwater shark species, which are considered vulnerable to fishing because of their life-history characteristics. Three species of gulper shark—Harrisson's dogfish (*Centrophorus harrissoni*), southern dogfish (*C. zeehaani*, formerly *C. uyato*) and endeavour dogfish (*C. moluccensis*)—have since been nominated for threatened species status under the *Environment Protection and Biodiversity Conservation Act 1999,* and a decision is expected by 30 September 2010. Taxonomic studies have since determined that west Australian stocks of gulper sharks do not include Harrisson's dogfish, but rather a new species, *C. westraliensis* (White et al. 2008). The catch limit of 100 kg per day for dogfish that previously applied in the WDTF has been replaced by a 50-animal move-on provision under the new Western Trawl Fisheries Harvest Strategy, although no minimum distance is specified.

Marine turtles and seabirds

No interactions with marine turtles or seabirds have been reported in the WDTF.

19.7 HARVEST STRATEGY PERFORMANCE

The WDTF is a mixed finfish and crustacean fishery. Most fishing effort has targeted deepwater bugs and ruby snapper, with sporadic targeting of deepwater flathead. Although the HS has been implemented, catch levels of the 14 key commercial finfish and crustacean species have not exceeded the first trigger level, and so the control rules have not been enacted.

In some instances, the trigger levels are inconsistent with the prescribed approach in the HS. Level 2 triggers do not reflect high historical catches for alfonsino, bar rockcod, boarfish, deepwater flathead, flame snapper, mirror dory, scampi and ruby snapper. Additional information (such as ERA results) was also used in setting triggers, but this has not been applied consistently across all species. Boarfish is a prime example—the highest historical catch of boarfish in the WDTF was less than 5 t, but the Level 1 trigger for this species is 250 t;

as well, it is considered medium or high risk (depending on the species of boarfish) under the ERA process (AFMA 2008a).

Target species that were ranked as high risk under the ERA process are not subject to the prescribed intermediate and limit triggers detailed in the HS. In some cases, the triggers for these species are inconsistent with the historical high catch and do not appear to be precautionary. For example, both Tang's snapper and mirror dory were rated as high-risk species (AFMA 2008a), but neither is subject to the prescribed intermediate or limit triggers. Also, the Level 2 triggers are greater than the highest historical catches.

There is no evidence that stocks are below the default biomass proxy limit reference point, although there is also no evidence that the HS will ensure that stocks stay above the limit biomass level at least 90% of the time. A wide range of other species that are taken in the WDTF in small, yet consistent, quantities are not included in the HS.

It is too early to know whether the HS will be effective in maintaining a sustainable fishery, as this will depend on the level of future fishing effort. The WDTF also targets stocks that were exploited considerably more in the early period of the fishery, and it is possible that the HS may not adequately protect stocks that are subject to sustained fishing at low levels. Of concern is the reliability of Level 1 triggers, given that the HS may allow ongoing stock depletion (below the Level 1 trigger) without enacting a management response.

Bug PHOTO: ABARE–BRS

A review of the HS is planned for 2010, using the Sustainability Assessment for Fishing Effects (SAFE) methodology. It is recommended that the review considers the consistency of trigger levels with high historical catch across all species, as well as the reference period used to determine trigger values.

19.8 LITERATURE CITED

AFMA (Australian Fisheries Management Authority) 2004, *Western Trawl Fisheries statement of management arrangement*s, AFMA, Canberra.

——2007, *Western Trawl Fisheries Harvest Strategy—North West Slope Trawl Fishery (NWSTF) and Western Deepwater Trawl Fishery (WDTF)*, AFMA, Canberra.

——2008a Ecological risk management report for the Western Deepwater Trawl Fishery, August 2008, AFMA, Canberra.

——2008b, *Western Deepwater Trawl Fishery Bycatch and Discarding Work Plan 1 November 2008 – 31 October 2010*, AFMA, Canberra.

Gomon, M, Bray, D & Kuiter, R 2008, *Fishes of Australia's south coast*, New Holland Publishers, Sydney.

Grimes, CB 1987, 'Reproductive biology of the Lutjanidae: a review' in JJ Polovina & S Ralston (eds), *Tropical snappers and groupers: biology and fisheries management*, Westview Press, Colorado, pp. 239–94.

Haddy, JA, Courtney, AJ & Roy, DP 2005, 'Aspects of the reproductive biology and growth of Balmain Bugs (*Ibacus* spp.) (Scyllaridae)', *Journal of Crustacean Biology*, vol. 25, pp. 263–73.

Hunter, C 2001, ‘Stock assessment of ruby snapper (*Etelis carbunculus*)’, Honours thesis, University of Queensland.

Martinez-Andrade, F 2003, *‘A comparison of life histories and ecological aspects among snappers (Pisces: Lutjanidae)’*, PhD thesis, Louisiana State University.

Watling, L & Norse, EA 1998, ‘Disturbance of seabed by mobile fishing gear: a comparison to forest clearcutting’, *Conservation Biology*, vol. 12, no. 6, pp. 1180–97.

Wayte, S, Dowdney, J, Williams, A, Fuller, M, Bulman, C, Sporcic, M, Smith, A, 2007, *Ecological risk assessment for the effects of fishing: Report for the Western Deepwater Trawl Fishery*, report for the AFMA, Canberra.

WestMAC (Western Trawl Fisheries Management Advisory Committee) 2008, Draft minutes from WestMAC 16, Freemantle, 14August 2008, <www.afma.gov.au/fisheries/northern_trawl/deepwater/mac/default.htm>.

White, E & Sumpton, W 2002, *Assessment of the deep water line fishery in Queensland*, Agency for Food and Fibre Sciences project no. Q102081, final report to the Queensland Government, Department of Primary Industries, Brisbane.

White, WT, Ebert, DA & Compagno, LJV 2008, ‘Description of two new species of gulper sharks, genus *Centrophorus* (Chondrichthyes: Squaliformes: Centrophoridae) from Australia’, in PR Last, WT White & JJ Pogonoski (eds), *Descriptions of new Australian chondrichthyans*, CSIRO Marine and Atmospheric Research paper no. 22, pp. 1–21.

Zhou, S, Fuller, M & Smith, T 2009, *Rapid quantitative risk assessment for fish species in additional seven Commonwealth fisheries*, report to the AFMA, Canberra.

Trawl catch PHOTO DAVID GUILLOT, AFMA

Trawl catch PHOTO DAVID GUILLOT, AFMA

Trawl catch PHOTO DAVID GUILLOT, AFMA

20 South Tasman Rise Trawl Fishery

H Patterson and K Mazur

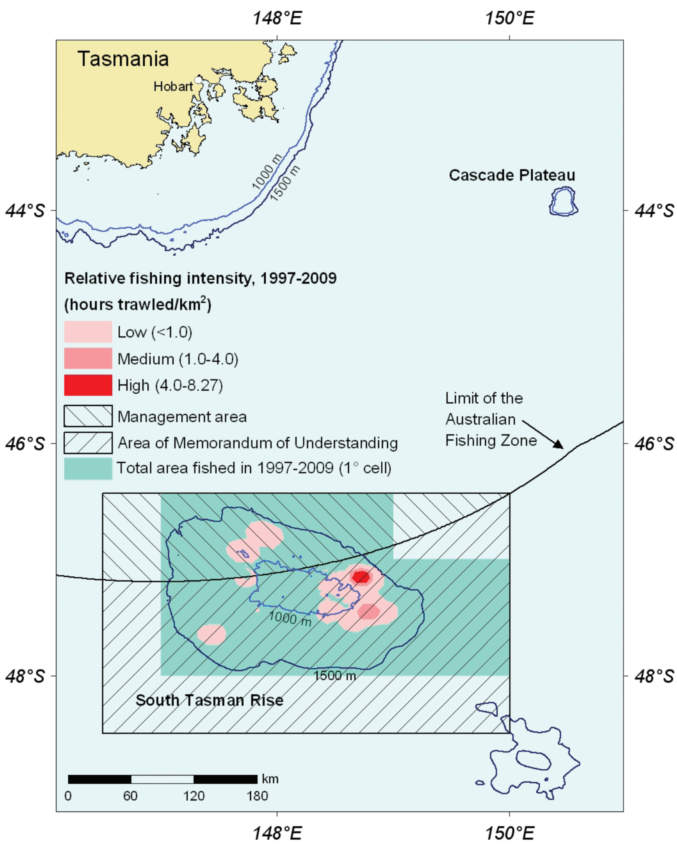


FIGURE 20.1 Relative fishing intensity in the South Tasman Rise Trawl Fishery, 1997–2009

TABLE 20.1 Status of the South Tasman Rise Trawl Fishery

Fishery status	2008		2009		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Orange roughy (*Hoplostethus atlanticus*)	Not overfished / not subject to overfishing (green)	Overfished / overfishing (red)	Not overfished / not subject to overfishing (green)	Overfished / overfishing (red)	Fishery closed since 2007 due to stock depletion
Economic status Fishery level	No net economic returns were generated as fishery was closed to commercial fishing				

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING — OVERFISHED / OVERFISHING — UNCERTAIN — NOT ASSESSED

TABLE 20.2 Main features and statistics of the South Tasman Rise Trawl Fishery

Feature	Description	
Key target and byproduct species	Orange roughy (*Hoplostethus atlanticus*)	
Other byproduct species	Smooth oreodory (*Pseudocyttus maculatus*) Spikey oreodory (*Neocyttus rhomboidalis*)	
Fishing methods	Demersal trawl	
Primary landing ports	Hobart	
Management methods	Fishery currently closed (since 2007). Previously, limited-entry 'international' fishery managed with New Zealand under a memorandum of understanding with a competitive TAC.[a]	
Management plan	No formal plan of management	
Harvest strategy	None—harvest strategy expired; no formal reference points	
Consultative forums	None	
Main markets	International: previously United States of America—frozen	
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Not applicable (high-seas fishery) Current accreditation (Exempt) expires 19 September 2010 Note: South Tasman Rise included with other high-seas fisheries	
Ecological risk assessment	None	
Bycatch workplans	None	
Fishery statistics[b]	**2008 fishing season**	**2009 fishing season**
Fishing season	None—Fishery closed	None—Fishery closed
TAC	Zero	Zero
Catch	Zero	Zero
Effort	Zero	Zero
Fishing permits	Zero	Zero
Active vessels	Zero	Zero
Observer coverage	Zero	Zero
Real gross value of production (2007–08 dollars)	$0	$0
Allocated management costs	2007–08: $0.05 million	2008–09: $0.03 million

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; TAC = total allowable catch

a The STRTF straddles the boundary of the Australian Fishing Zone (AFZ); the portion inside the AFZ technically falls into the southern remote zone of the Southern and Eastern Scalefish and Shark Fishery (SESSF), but the STRTF is managed separately from the SESSF

b Fishery statistics are provided by fishing season unless otherwise indicated.

20.1 BACKGROUND

The South Tasman Rise (STR) is an undersea ridge that extends south of Tasmania and into the Southern Ocean, stretching beyond the Australian Fishing Zone and into the high seas (Fig. 20.1). Australia was granted coastal state rights to manage the STR orange roughy resource as a straddling stock under the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea Relating to the *Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks* (UN 1995). Under this agreement, other countries are still entitled to access

the high-seas portion of the stock, provided that a cooperative management regime with consistent measures for both portions of the stock is established (see Chapter 21 for more information on straddling stocks). Australia and New Zealand established a memorandum of understanding for cooperative management of the stock in 1998; however, New Zealand vessels have not fished the STR since the end of the 2000–01 fishing season (Table 20.3). In the later years of the South Tasman Rise Trawl Fishery (STRTF), very little orange roughy was caught, with catch mostly comprising byproduct of smooth and spikey oreodory (Table 20.2).

Orange roughy PHOTO: AFMA

TABLE 20.3 History of the South Tasman Rise Trawl Fishery

Year	Description
1997	Orange roughy stock discovered, fishing effort increased.
1998	MOU between Australia and New Zealand established to control catches.
1998–99	Catches peaked at 3270 t (real GVP $11.7 million); declined sharply thereafter.
1999	Removals by illegal foreign fishing trawlers exacerbated stock depletion.
2000–01	MOU with New Zealand formalised.
2002	Formal limited-entry policy adopted.
2003	Harvest strategy established by Australia and New Zealand for a 4-year period (2003 to 2007).
2003–04	Fishing effort reduced to <100 shots.
2004–05	Catches fell to 73 t; real GVP fell to $247 000.
2007	Harvest strategy expired, not renewed.
2007–09	Fishery closed pending further agreement with New Zealand (no permits).

GVP = gross value of production; MOU = memorandum of understanding

20.2 HARVEST STRATEGY

The harvest strategy (HS) that was implemented in 2003 expired in 2007. This strategy had no formal target or limit reference points. Instead, the HS consisted of catch triggers that were used to set the total allowable catch (TAC) for the following year.

20.3 THE 2009 FISHERY

Key target and byproduct species

Australia and New Zealand agreed that there would be no fishing in 2007–08 and indefinitely thereafter, a decision that was upheld for the 2008–09 fishing season. Thus,

no permits were issued for this fishery in 2008–09. Resumption of fishing will require agreement between Australia and New Zealand on issues such as an appropriate TAC and a new HS. Historical gross value of production (GVP) is shown in Fig. 20.2.

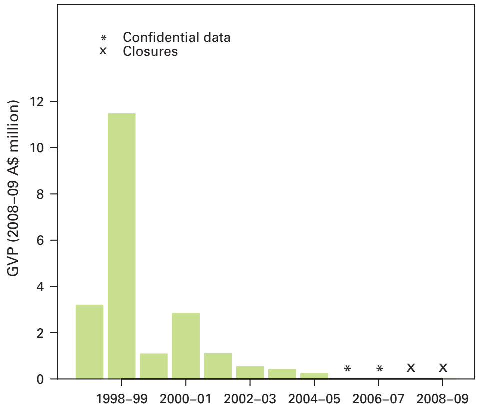


FIGURE 20.2 Real GVP of the STRTF by financial year, 1997–98 to 2008–09

Minor byproduct species

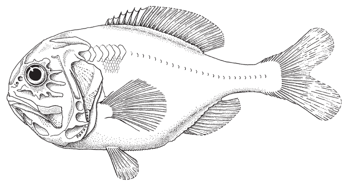
Smooth and spikey oreodories

Although smooth and spikey oreodories were previously considered important byproduct species, no formal stock assessment of these species in the STRTF was conducted in 2009. They were assessed in 2007 as not subject to overfishing and uncertain for overfished, before being dropped from the stock status determination process. If fishing does resume, it should be at a low level, and data on byproduct species will need to be collected so that robust assessments of their status can be undertaken. Catches of oreodories have historically been substantial (>1000 t in 1997–98, although catches declined dramatically thereafter), and catch limits on oreodories may need to be incorporated into a new HS or management arrangements.

20.4 BIOLOGICAL STATUS

ORANGE ROUGHY

(*Hoplostethus atlanticus*)



LINE DRAWING: ROSALIND POOLE

TABLE 20.4 Biology of orange roughy

Parameter	Description
General	Undergo little movement between the Australian Fishing Zone and the high seas, but are thought to aggregate at seamounts for spawning. Little is known about the early life-history traits of orange roughy, although larvae and juveniles are thought to be confined to the deep ocean.
Range	**Species:** Occurs in all temperate oceans except the north Pacific. In Australia, distributed along the southern coast from Sydney to Perth and on continental slope and seamount areas. **Stock:** Orange roughy on the South Tasman Rise are considered a discrete stock.
Depth	Range 180–1800 m; usually found at 400–1000 m
Longevity	90–150 years
Maturity (50%)	**Age:** 20–30 years **Size:** ~25–30 cm SL
Spawning season	July–August
Size	**Maximum:** 50–60 cm SL; weight: ~3–4 kg **Recruitment into the fishery:** 24–42 years; size: ~30 cm SL

SOURCE: Gomon et al. (2008).

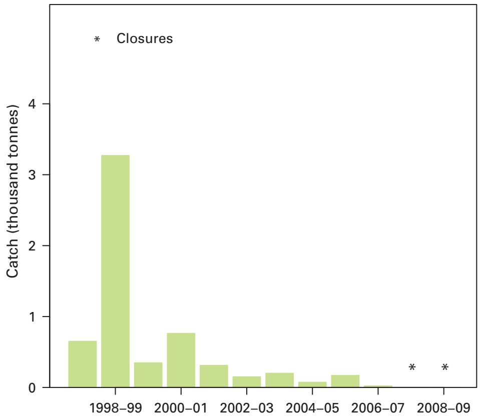


FIGURE 20.3 Orange roughy catch history by financial year, 1997–98 to 2008–09

Stock status determination

No model-based stock assessment of orange roughy was conducted in 2009, and no new data were available as fishing has not occurred since 2006. Given that the stock has been assessed as overfished since 2002–03, the fact that less than 10% of the TAC was landed from 2001 to 2006 (when fishing was occurring; Fig. 20.3), and the lack of any information to indicate a recovery or rebuilding of the stock, orange roughy remains assessed as **overfished**. Since the fishery is closed, the stock is **not subject to overfishing** (Table 20.1).

Reliability of the assessment/s

The previous assessment is not a model-based quantitative assessment, but instead is similar to a Tier 4 assessment under the Southern and Eastern Scalefish and Shark Fishery (SESSF) HS. Therefore, reliability is low. However, given the biology of the species and its low resilience to fishing pressure, as well as the state of other orange roughy stocks in the SESSF, the conclusion of the assessment that the stock has substantially declined (and thus is overfished) is considered accurate.

Previous assessment/s

The previous and only assessment of orange roughy stocks within the STRTF was carried out in 2003 using catches, catch rate and acoustic survey data collected during the winter spawning seasons of 1998 to 2002. The assessment indicated that the initial orange roughy biomass was not large and had been dramatically reduced. Catch and effort have declined dramatically in recent years (Fig. 20.3).

Future assessment needs

Because of the lack of data with which to assess the STR orange roughy stock, any future proposed fishing activity should be conducted at a low level and include a commitment to data collection, with appropriate observer coverage. Fishing should not recommence until there is a sufficiently reliable assessment that can provide an indication of current biomass and sustainable catch levels.

20.5 ECONOMIC STATUS

Economic performance

There have not been any economic surveys of the fishery. The only readily available indicator of economic performance is the level of latent effort. Over the four-year period in which the HS was in effect, the level of catch required for the TAC to remain unchanged in the following season was not met. This suggests that fishers were free to expand their effort but chose not to. New Zealand vessels also chose not to compete for the fishery's TAC over this period. Hence, it is unlikely that profits in the fishery were significantly positive in those years.

Overall economic status

Following its rapid development in the late 1990s, the STRTF suffered a sharp decline in catch rates and diminishing stocks. This was most likely the result of overfishing, caused by excessive effort from Australian and New Zealand vessels during the fishery's development phase, as well as unregulated fishing activity by foreign vessels in 1999. High latent effort in the years preceding the fishery's closure strongly suggests that economic returns were likely

to be low at that time, possibly even negative given that the TAC was competitive.

Future considerations

Unlike other Commonwealth-managed fisheries, the STRTF faces additional problems due to the straddling nature of the orange roughy stock. A coordinated management approach by Australia and New Zealand will continue to be important in rebuilding the stock to sustainable levels.

20.6 ENVIRONMENTAL STATUS

Orange roughy is listed as conservation dependent under the *Environment Protection and Biodiversity Conservation Act 1999*. The Australian Fisheries Management Authority is currently undertaking an Orange Roughy Conservation Programme (see Chapter 9).

In the first year of the fishery, there was a significant bycatch of corals, comprised of a large number of species. However, coral bycatch dropped considerably in later years (from 1750 t per year in 1997–98 to 100 t in 2000–01; Anderson & Clark 2003).

Threatened, endangered and protected species

Sharks, marine turtles and seabirds

Due to the limited effort in the fishery, interactions with sharks and seabirds are not considered a problem. However, if fishing recommences in the fishery, bycatch issues will need to be reconsidered.

Habitats

Although trawling is generally done over soft, sandy bottoms, seamounts typically have rough and hard bottoms, requiring heavy-duty trawl gear. As noted above, observer data indicate that early trawls contained substantial bycatch of corals.

20.7 HARVEST STRATEGY PERFORMANCE

No HS is currently in place for the fishery. A new HS will need to be developed if commercial fishing recommences in the fishery.

20.8 LITERATURE CITED

Anderson, OF & Clark, MR 2003, 'Analysis of bycatch in the fishery for orange roughy, *Hoplostethus atlanticus*, on the South Tasman Rise', *Marine and Freshwater Research*, vol. 54, pp. 643–52.

Gomon, M, Bray, D & Kuiter, R 2008, *Fishes of Australia's south coast*, New Holland Publishers, Sydney.

UN (United Nations) 1995, *Agreement for the implementation of the provisions of the United Nations convention on the Law of the Sea of 10 December 1982 relating to the conservation and management of straddling fish stocks and highly migratory fish stocks*, United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks, sixth session, New York, 24 July to 4 August 1995.

21 International fishery management arrangements

D Wilson, H Patterson, A Sands and I Stobutzki

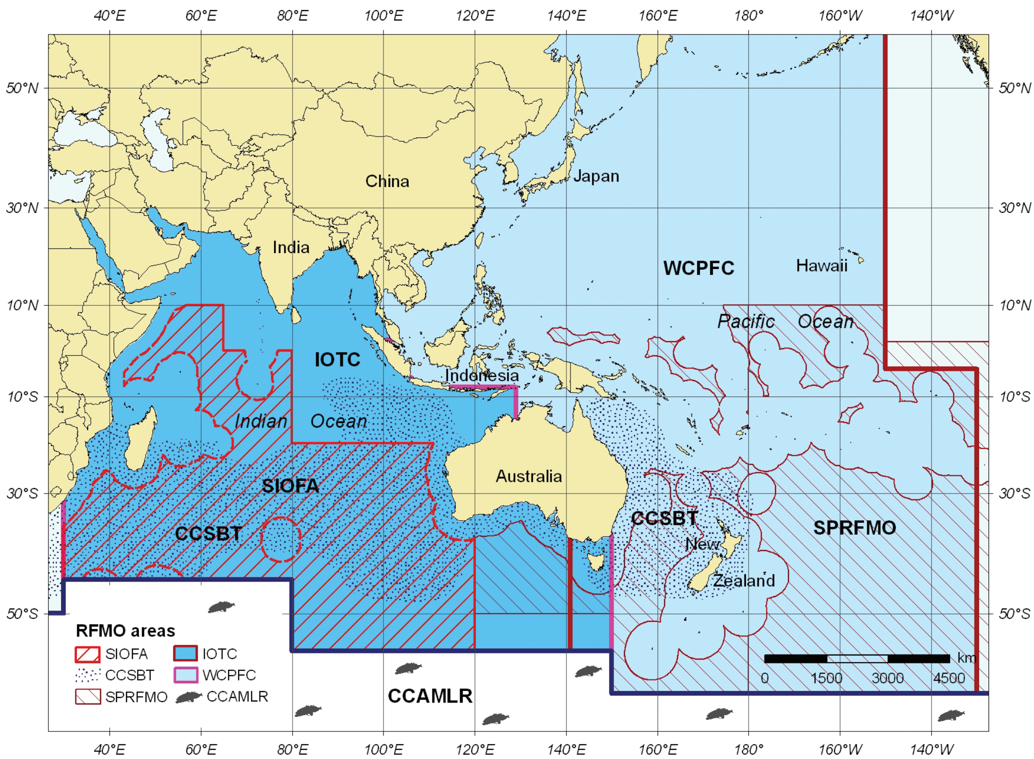


FIGURE 21.1 Areas of competence for regional fisheries management organisations and bodies to which Australia is a party

CCAMLR = Commission for the Conservation of Antarctic Marine Living Resources; CCSBT = Commission for the Conservation of Southern Bluefin Tuna; IOTC = Indian Ocean Tuna Commission; RFMO = regional fisheries management organisation; SIOFA = Southern Indian Ocean Fisheries Agreement; SPRFMO = South Pacific Regional Fisheries Management Organisation; WCPFC = Western and Central Pacific Fisheries Commission

21.1 INTRODUCTION

Several fishery resources of commercial importance to Australia have ranges extending outside the Australian Fishing Zone (AFZ) into the high-seas and the Exclusive Economic Zones (EEZ) of other countries. These stocks are important for Australian fishing industries in terms of food and economic security, and can only be managed effectively through cooperative regional action. In this situation, management responsibility is shared by multiple governments through international instruments (conventions and agreements), implemented through a regional fisheries management organisation (RFMO) or body (Fig. 21.1). As a party to these international instruments, Australia is obliged to implement measures agreed by the relevant RFMO in managing its domestic fishery; in a number of cases, Australia's domestic standards exceed those agreed by RFMOs. This chapter provides an overview of the international management arrangements to which Australia is a party. Detailed status reports of the domestic fisheries involved are provided in Chapters 22–28. Although the fisheries of the Torres Strait are also managed under an international agreement, they differ substantially from the fisheries described here and are therefore addressed separately in Chapters 14–18.

Through participation in RFMOs and other international fisheries-related forums, Australia aims to implement its commitments and obligations under overarching international instruments, including the:

- 1982 United Nations Convention on the Law of the Sea (UNCLOS)
- 1995 Agreement for the Implementation of the Provisions of the UNCLOS relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UN Fish Stocks Agreement)
- 1995 FAO Code of Conduct for Responsible Fisheries
- 1995 FAO Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas
- 2006 United Nations General Assembly (UNGA) Resolution on Sustainable Fisheries (UNGA61/105)
- 2009 FAO Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing.

The *Commonwealth Fisheries Harvest Strategy Policy* (DAFF 2007) requires that harvest strategies be developed for Commonwealth fisheries, with the exception of those that are managed under the joint authority of the Australian Government and another Australian jurisdiction or an international management body or arrangement. However, the policy notes that the Australian Government will advocate the principles of the policy within all jointly managed fisheries.

Globally, the species targeted on the high seas vary by area and fleet. Some of the most extensive high-seas fisheries are pelagic fisheries targeting highly migratory tunas and billfishes (defined under UNCLOS Annex 1). Currently, five RFMOs manage these highly migratory species. The management arrangements for the highly migratory tunas and billfish that are targeted by Australian fisheries are developed under three international agreements:

- Convention for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean
- Convention for the Conservation of Southern Bluefin Tuna
- Agreement for the Establishment of the Indian Ocean Tuna Commission.

Arrangements for demersal species in Antarctic waters and the AFZ of Australia's sub-Antarctic islands are implemented through the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR).

Australia is also participating in the development of new agreements to fill gaps in the international management of other migratory stocks that are targeted on the high seas. In 2006 Australia signed the Southern Indian Ocean Fisheries Agreement (SIOFA),

a new agreement covering the majority of the Indian Ocean, which has yet to enter into force.

Since 2006 Australia has participated in negotiations for the development of the South Pacific Regional Fisheries Management Organisation (SPRFMO). The discussions focus on the southern Pacific Ocean, north of the CCAMLR's jurisdiction, and on species that are not covered by the Western and Central Pacific Fisheries Commission (WCPFC). The convention text establishing the SPRFMO was adopted in November 2009.

Australia's continued engagement in RFMO negotiations and processes is critical to supporting access for the Australian fishing industry and promoting responsible management to ensure sustainability of the fisheries and the ecosystems that support them. Australia is also party to a range of international conservation commitments that apply generally to regional fisheries management. Relevant United Nations agreements include:

- International Plan of Actions for the Conservation and Management of Sharks, and Reducing Incidental Catch of Seabirds in Longline Fisheries (FAO 1999)
- Convention on the Conservation of Migratory Species of Wild Animals (CMS 2003), including the Agreement on the Conservation of Albatrosses and Petrels (ACAP 2006)
- Convention on Biological Diversity (CBD 1992)
- Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES 1973).

These agreements have implications for Commonwealth fisheries through the listing process under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). For example, in January 2010, mako and porbeagle sharks were listed as migratory species under the EPBC Act, which was a requirement when they were included in Appendix II of the Convention on Migratory Species. However, despite considering a substantial number of marine species for listing, the March 2010 meeting of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) closed without agreement on any new trade measures to protect marine species. Four proposals to include sharks in CITES Appendix II were rejected. The scalloped hammerhead, oceanic whitetip, porbeagle and spiny dogfish, were not added to CITES and can therefore continue to be traded without CITES permits. Australia is committed to improving the management of these species through the various RFMOs.

Internationally, emphasis is increasing on the need for effective implementation of ecosystem-based approaches to fisheries management. This is explicit in the UN Fish Stocks Agreement and some of the regional fisheries management instruments. Since the CCAMLR has the explicit objective of ecosystem conservation, the management of fishing activities in CCAMLR waters incorporates bycatch and ecosystem concerns. The CCAMLR management approach is an exception, as RFMO management typically remains centred on target stocks.

In 2006 the UNGA Resolution on Sustainable Fisheries called for countries to develop and apply best-practice guidelines for regional fisheries. Subsequently, the tuna RFMOs agreed, at their first joint meeting in 2007, to undergo performance reviews. To date, these have been completed for the CCAMLR (CCAMLR 2008), the Commission for the Conservation of Southern Bluefin Tuna (CCSBT 2008) and the Indian Ocean Tuna Commission (Anon 2009). The reviews highlight critical areas where management, research and processes need to be significantly strengthened.

The following sections outline the various regional fisheries management conventions and agreements to which Australia is a party.

21.2 WESTERN AND CENTRAL PACIFIC FISHERIES COMMISSION

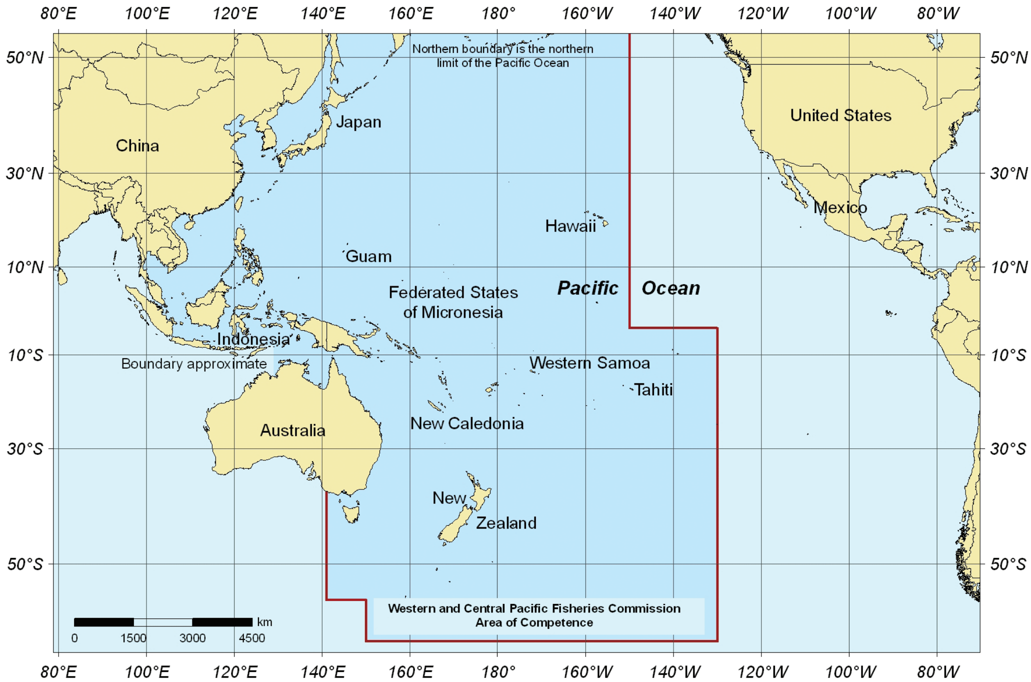


FIGURE 21.2 Area of competence of the Western and Central Pacific Fisheries Commission

Indonesian fishing vessels PHOTO: DAVID WILSON, ABARE–BRS

TABLE 21.1 Main features and statistics of the Convention for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean—implemented by the Western and Central Pacific Fisheries Commission

Feature	Description
Commencement date	19 June 2004
Objective	To ensure, through effective management, the long-term conservation and sustainable use of highly migratory fish stocks in the western and central Pacific Ocean in accordance with the 1982 United Nations Convention on the Law of the Sea and the 1995 UN Fish Stocks Agreement
Membership	Members: 25 Cooperating non-members: 7 Other: 7 participating territories
Species covered under the management mandate	All species of highly migratory fish stocks (defined as all fish stocks of the species listed in Annex I of the 1982 UNLCOS occurring in the WCPFC convention area), except sauries, and any other species of fish as the Commission may determine. Annex I. Highly migratory species (UNCLOS 1982) **Tuna:** albacore tuna (*Thunnus alalunga*)[a], bigeye tuna (*Thunnus obesus*)[a], blackfin tuna (*Thunnus atlanticus*), kawakawa (*Buthynnus affinis*), little tuna (*Buthynnus alletteratus*), northern bluefin tuna (*Thunnus thynnus*), skipjack tuna (*Katsuwonus pelamis*), southern bluefin tuna (*Thunnus maccoyii*)[a], yellowfin tuna (*Thunnus albacares*)[a], frigate tuna/mackerel (*Auxis thazard*), bullet tuna/mackerel (*Auxis rochei*) **Marlins/spearfish:** shortbill spearfish (*Tetrapturus anqustirostris*), Mediterranean spearfish (*Tetrapturus belone*), longbill spearfish (*Tetrapturus pfluegeri*), Atlantic white marlin (*Tetrapturus albidus*), striped marlin (*Tetrapturus audax*)[a], roundscale spearfish (*Tetrapturus georgei*), Indo-Pacific blue marlin (*Makaira mazara*), black marlin (*Makaira indica*), Atlantic blue marlin (*Makaria nigricans*) **Sailfish:** Indo-Pacific sailfish (*Istiophorus platypterus*)[a], Atlantic sailfish (*Istiophorus albicans*) **Swordfish:** broadbill swordfish (*Xiphias gladius*) **Pomfrets:** Family Bramidae **Oceanic sharks:** basking shark (*Cetorhinus maximus*), hammerhead sharks (Family Sphyrnidae), mackerel sharks (Family Isurida), requiem sharks (Family Carcharhinidae), sixgill shark (*Hexanchus griseus*), thresher sharks (Family Alopiidae), whale shark (*Rhinodon typus*)
Fishing methods	Purse seine (with or without fish aggregating devices) Pelagic longline Pole-and-line Minor line (handline, rod and reel, troll)
Primary landing ports	Industrial: Japan, Taiwan, American Samoa (USA), Philippines Artisanal: numerous
Management methods	Input controls: capacity limits, area closures Output controls: interim catch limits for flag states fishing for broadbill swordfish
Harvest strategy	None agreed at this time. The Commission applies the precautionary approach as defined by the convention.
Consultative forums	Commission, Scientific Committee, Technical and Compliance Committee, Northern Committee.
Main markets	Japan, Chinese Taipei—fresh, frozen
Commonwealth fisheries involved	Eastern Tuna and Billfish Fishery (see Chapter 22) Eastern Skipjack Fishery (see Chapter 23)

Table 21.1 continues over the page

TABLE 21.1 Main features and statistics of the Convention for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean—implemented by the Western and Central Pacific Fisheries Commission CONTINUED

Feature	Description	
Fishery statistics[b]	**2007 calendar year**	**2008 calendar year[c]**
Estimated total catch	2 488 829 t	2 495 344 t
Authorised vessels	Industrial: 9177 vessels from 27 flag states Artisanal[d]: many thousands	Industrial: n.a. Artisanal[d]: many thousands
Active vessels	11 006 vessels from 37 flag states	10 709 vessels from 39 flag states
Value of production	~US$4 billion	US$4.9 billion

UNCLOS = United Nations Convention on the Law of the Sea; WCPFC = Western and Central Pacific Fisheries Commission; n.a. = not available

a Species considered as important targets or byproduct for Australian Commonwealth fisheries. Southern bluefin tuna are managed by the Commission for the Conservation of Southern Bluefin Tuna

b Fishery statistics provided by calendar year unless otherwise indicated

c Data for 2009 are not available from the secretariat until late in 2010

d Artisanal vessels are those of length less than 24 m that fish within the EEZ of a coastal state.

The Western and Central Pacific Fisheries Commission (WCPFC) is responsible for the world's largest and most valuable tuna fishery. In 2008 the total tuna catch in the Convention Area was worth approximately US$4.9 billion (Williams & Terawasi 2009), up from approximately US$4 billion in 2007 (Lawson 2008) (Table 21.1). Tuna caught in the Convention Area contributed approximately 56% of the global tuna catch in 2008 (OFP & SPC 2009). The WCPFC area of competence (Fig. 21.2) includes the EEZ of many small island developing states, for whom tuna fishing is a primary source of income.

Before the 1980s pole-and-line was the major gear; since then, the catch of the purse-seine fleets has increased substantially and they are now responsible for most of the catch. The purse seiners target skipjack tuna (*Katsuwonus pelamis*) and also catch substantial amounts of bigeye tuna (*Thunnus obesus*) and yellowfin tuna (*T. albacares*), whereas the longliners target albacore tuna (*T. alalunga*), bigeye tuna and yellowfin tuna (Fig. 21.3). Australia's component of the fishery is primarily in the longline sector (Eastern Tuna and Billfish Fishery—ETBF, see Chapter 22) and, to a much lesser extent, the purse-seine sector (Eastern Skipjack Fishery, see Chapter 23).

The 2008 total tuna catch was the highest ever recorded, with purse seiners catching 74% of the total (longliners: 10%, pole-and-line: 7%; Williams & Terawasi 2009). Skipjack tuna contributed 67% of the 2008 total tuna catch, and yellowfin tuna 22%. Most of the catch (nearly 70%) was reported by the Philippines, Japan, Indonesia, the Republic of Korea and Fishing Entity of Taiwan. The total catch of Australia's ETBF longline fleet (6685 t) in 2008 was less than 0.3% of the total WCPFC catch, with yellowfin tuna, swordfish (*Xiphias gladius*) and albacore tuna making up the majority of Australia's catch.

The WCPFC Scientific Committee uses the reference points of B_{MSY} and F_{MSY} in providing its advice on stock status; species with biomass estimates $<B_{MSY}$ are considered overfished, and fishing mortality $>F_{MSY}$ is considered overfishing. There are currently no agreed harvest strategies, explicit limit reference points or decision rules that are followed when reference points are reached.

The WCPFC has agreed to binding measures to address the impact of fishing on marine turtles, seabirds and sharks, although the current lack of data will make monitoring the efficacy of these measures difficult, particularly as there is no observer program covering all the fleets. However, such a program is in the advanced stages of development.

Conservation and management measures

At each annual session of the WCPFC, the Commission takes decisions concerning the conservation and management of species under its mandate (Table 21.1). These decisions are binding on all members and cooperating non-members of the Commission. In 2009 the WCPFC adopted eight new conservation and management measures (CMMs), the details of which can be found on the WCPFC website (www.wcpfc.int). CMMs most relevant to the biological status of target, byproduct and bycatch stocks were:

- CMM 2009–02—on the application of high seas FAD (fish-aggregating device) closures and catch retention. To ensure consistent and robust application of FAD closures and catch retention in the high seas between 20°S and 20°N through the specification of minimum standards, and to apply high standards to the application of the FAD closure and catch retention in order to remove any possibility for the targeting of aggregated fish, or the discard of small fish.
- CMM 2009–03—on swordfish. To replace CMM 2008–05, and ensure swordfish catch and effort is limited to that reported for any one year in the period 2000 to 2006.
- CMM 2009–04—on sharks. To replace CMM 2008–06, on the utilisation and landing of sharks and shark products.
- CMM 2009–07—on Pacific bluefin tuna. To ensure that the current level of fishing mortality rate is not increased in the convention area.
- CMM 2009–10—on the monitoring of landings of purse-seine vessels at ports so as to ensure reliable catch data by species. To establish in 2010 an arrangement with a non-CCM to enable collection of species and size composition data from canneries in the non-CCM regarding purse-seine catch in the convention area. The progress shall be reported to the Commission.

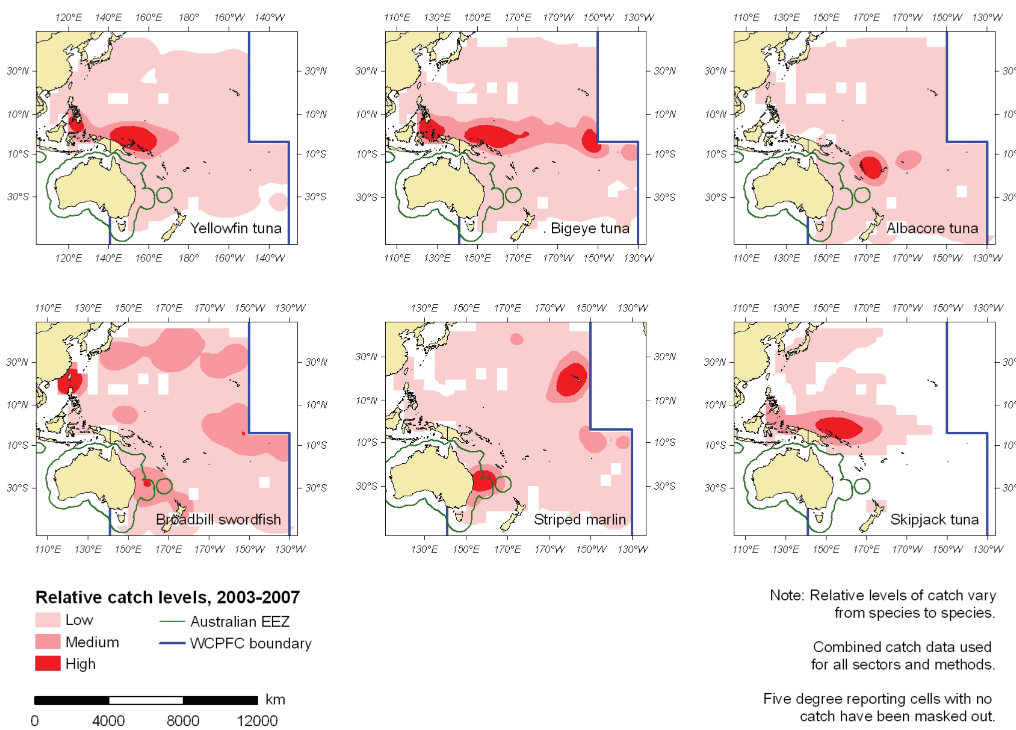


FIGURE 21.3 Relative catch levels of key target species in the WCPFC, 2003–2007

NOTE: Data for 2008 and 2009 not available at time of printing

21.3 COMMISSION FOR THE CONSERVATION OF SOUTHERN BLUEFIN TUNA

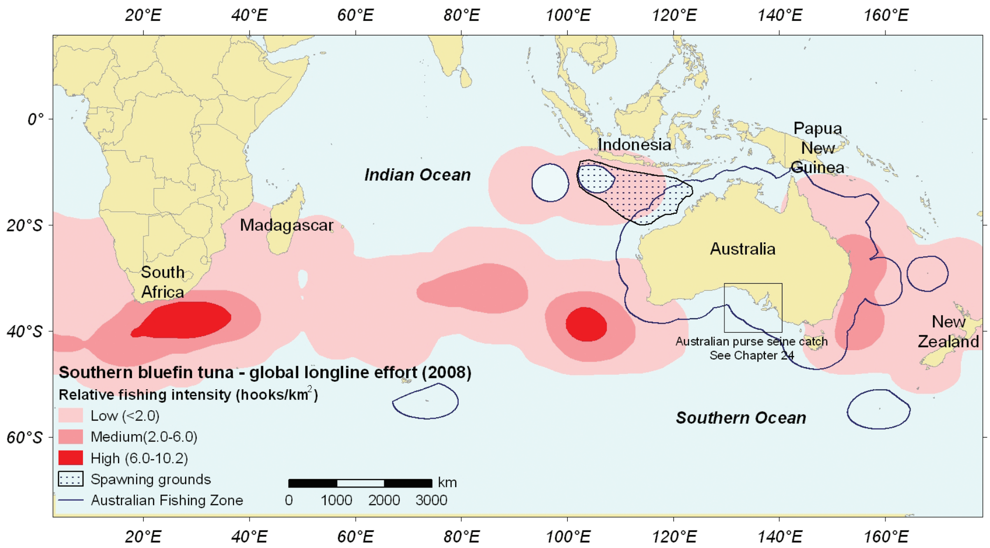


FIGURE 21.4 Relative fishing intensity for southern bluefin tuna in the area of competence of the Commission for the Conservation of Southern Bluefin Tuna, 2008

TABLE 21.2 Main features and statistics of the Convention for the Conservation of Southern Bluefin Tuna—implemented by the Commission for the Conservation of Southern Bluefin Tuna

Feature	Description
Commencement date	20 May 1994
Objective	To ensure, through appropriate management, the conservation and optimum utilisation of the global Southern Bluefin Tuna Fishery
Membership	Members: 6 Cooperating non-members: 3 Other: Fishing Entity of Taiwan is a member of the Extended Commission
Species covered under the management mandate	Southern bluefin tuna (*Thunnus maccoyii*)
Fishing methods	Purse seine Pelagic longline Minor line (handline, rod and reel, troll and poling)
Primary landing ports	Yaizu, Misaki—Japan; Port Lincoln—Australia
Management methods	Output controls: global total allowable catch for members and cooperating non-members of 11 810 t
Harvest strategy	No formal harvest strategy
Consultative forums	Commission, Compliance Committee, Scientific Committee, Stock Assessment Group
Main markets	Japan—fresh, frozen
Commonwealth fisheries involved	Southern Bluefin Tuna Fishery (see Chapter 24)

Table 21.2 continues over the page

TABLE 21.2 Main features and statistics of the Convention for the Conservation of Southern Bluefin Tuna—implemented by the Commission for the Conservation of Southern Bluefin Tuna CONTINUED

Feature	Description	
Fishery statistics[a]	**2008 calendar year**	**2009 calendar year**
TAC	11 810 t	11 810 t
Estimated total catch	11 369 t	n.a.
Authorised vessels	1743 fishing vessels from nine flag states 62 carrier vessels	1904 fishing vessels from 10 flag states 107 carrier vessels
Active vessels	n.a.	n.a.
Authorised farms	38 farms, 18 companies	38 farms, 18 companies
Value of production	n.a.	n.a.

n.a. = not available; TAC = total allowable catch

a Fishery statistics provided by calendar year unless otherwise indicated.

The Convention for the Conservation of Southern Bluefin Tuna, which established the Commission for the Conservation of Southern Bluefin Tuna (CCSBT), originated from discussions between Australia, Japan and New Zealand in the mid-1980s, following an observed decline in stock biomass. The convention applies when parties are fishing for southern bluefin tuna (SBT), rather than applying to fishing within a specified geographic area. Therefore, it covers areas of the Indian, Atlantic and Pacific Oceans, overlapping with the areas of competence of the CCAMLR, the WCPFC and the Indian Ocean Tuna Commission (IOTC) (Fig. 21.4). The CCSBT's primary management tool is a global, multiyear total allowable catch (TAC), which is allocated to the flag states as national allocations. Australia, Japan, the Republic of Korea and Fishing Entity of Taiwan held the majority (89%) of the global TAC in 2009 (Table 21.3).

Most fishing vessels are large-scale, industrial vessels, which use pelagic longlines to target surface schools. However, the Australian fishery uses purse seines to catch juveniles, which are then grown out in aquaculture cages. Globally, just over half the TAC is taken by the longline fleets, mostly in the Indian Ocean. The Australian purse seine catch is nearly half the global TAC and is taken primarily in the waters off South Australia (see Chapter 24), with only a minor amount caught by longline vessels in the ETBF. Japan's longline fleet takes most of its allocation from the south-west and south-east Indian Ocean, while Korea mainly fishes in the south-west Indian Ocean. The Indonesian SBT catch is principally taken as a byproduct of longlining for tropical tunas on the SBT spawning ground, near Java (Fig. 21.5). Fishing Entity of Taiwan takes the majority of its allocation from the waters off south-western Australia (Fig. 21.4).

The CCSBT approved vessel list can change on a daily basis. On average, over the 2009 calendar year, approximately 1904 fishing vessels from 10 flag states and 107 carrier vessels were authorised to fish for SBT (last updated 11 January 2010). The CCSBT has also established a list of authorised fish farms. In 2009 a total of 38 farms were authorised, all of which were located at Port Lincoln, South Australia. Members and cooperating non-members will not validate trade documents

Tuna at Tsukiji Market, Tokyo
PHOTO: HEATHER PATTERSON, ABARE–BRS

for farms not on the list and will not accept imports of SBT product from such farms.

In 2000 the CCSBT agreed to develop a management procedure, analogous to a harvest strategy, which would include agreed rules for determining how the TAC would be set. Work towards this started in 2002, but stalled in 2005 when substantial unreported catches over an extended period were revealed. In 2009 work recommenced towards the development of a management procedure, focused initially on reconditioning the stock assessment operating model and testing candidate management procedures. The Commission agreed in 2009 that the management procedure would be implemented in 2011 and would form the basis for setting the TAC for 2012 and beyond (CCSBT 2009).

At its 16th annual meeting, the CCSBT agreed that the status of the SBT stock was at a critical stage and that a meaningful reduction in the TAC was necessary to recover the stock and work towards an interim rebuilding target reference point of 20% of the original spawning stock (CCSBT 2009). Consequently, the CCSBT reduced the global TAC for 2010 and 2011 to 9449 t each year, as detailed in Table 21.3.

Tuna auction at Tsukiji Market, Tokyo
PHOTO: HEATHER PATTERSON, ABARE–BRS

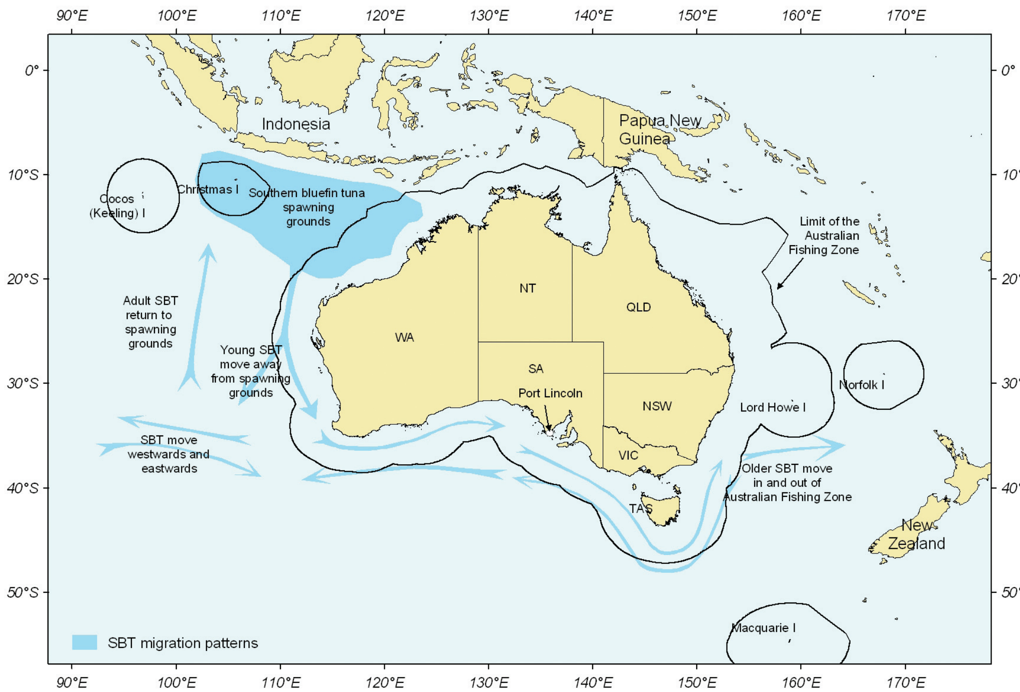


FIGURE 21.5 Southern bluefin tuna migration paths around Australia

TABLE 21.3 Allocated catch of southern bluefin tuna

Flag state	Allocated catch, 2009 (tonnes)	Annual allocated catch, 2010 and 2011 (tonnes)	Effective catch limit, 2010 and 2011 (tonnes)[a]
Members			
Australia	5 265	4 270	4 015
Japan	3 000	2 261	2 261
Republic of Korea	1 140	859	859
Fishing Entity of Taiwan	1 140	859	859
Indonesia	750	651	651
New Zealand	420	754	709
Cooperating non-members and observers			
Philippines	45	45	45
South Africa	40	40	40
European Community	10	10	10
Total catch allocation	11 810	9 749	9 449

a To contribute to the rebuilding of the southern bluefin tuna stock, Australia and New Zealand agreed to make additional annual voluntary reductions of 255 t and 45 t, respectively, for 2010 and 2011.

The CCSBT Ecologically Related Species Working Group discusses bycatch and ecosystem issues. This working group was initially established because of concerns regarding the incidental catch of seabirds. Aside from the CCAMLR, the CCSBT is the RFMO with the greatest overlap with the known distribution of albatross and petrels (Small 2005). Working group discussions have been hampered by a lack of available data on interactions with bycatch. In 2008 the CCSBT agreed to a non-binding resolution under which vessels would implement the bycatch mitigation measures of the WCPFC and the IOTC when fishing in these areas. Vessels fishing in CCAMLR waters must abide by the CCAMLR's management measures.

The performance and independent reviews of the CCSBT (Bolton 2008; CCSBT 2008) focused on a range of issues and noted that the CCSBT has significant challenges to face in fulfilling its mandate. In terms of the scientific base for management, the reviews noted with concern overfishing and under-reporting of global catches. The need to establish a reliable and accurate historical catch and catch per unit effort series for the fishery and the importance of accurate reporting and validation of future catch and effort were highlighted. Recommendations of the reviews included agreement on management objectives and a rebuilding strategy. The reviews also recommended more balance, in terms of scientific effort and management focus, between SBT and ecologically related species.

Conservation and management measures

At each annual session of the CCSBT, the Commission makes resolutions concerning the conservation and management of SBT. These resolutions are binding on all members and cooperating non-members of the extended Commission. In 2009 the CCSBT adopted two new resolutions (the details of which can be found on the CCSBT website—www.ccsbt.org):

- Resolution on the TAC and future management of southern bluefin tuna. The CCSBT agreed that the status of the SBT stock was at a critical stage and that

a meaningful reduction in the TAC was necessary in order to recover the stock and work toward reaching an interim rebuilding target reference point of 20% of the original spawning stock by a date yet to be determined. Consequently, the CCSBT reduced the SBT global TAC for 2010 and 2011 by 20% of the previously allocated global TAC of 11 810 t to 9449 t.

- Resolution on action plans to ensure compliance with conservation and management measures. To help ensure compliance with the TAC for 2010 and 2011, each member or cooperating non-member shall submit to the secretariat, by 1 April 2010, an action plan to ensure its compliance with the Commission's conservation and management measures—in particular, its allocation under the global quota for SBT. The action plan shall include a scheme to systematically verify catch data of SBT and ecologically related species reported by fishers.

Juvenile tuna, South-east Asia market
PHOTO: KATHRYN READ, DEWHA

21.4 INDIAN OCEAN TUNA COMMISSION

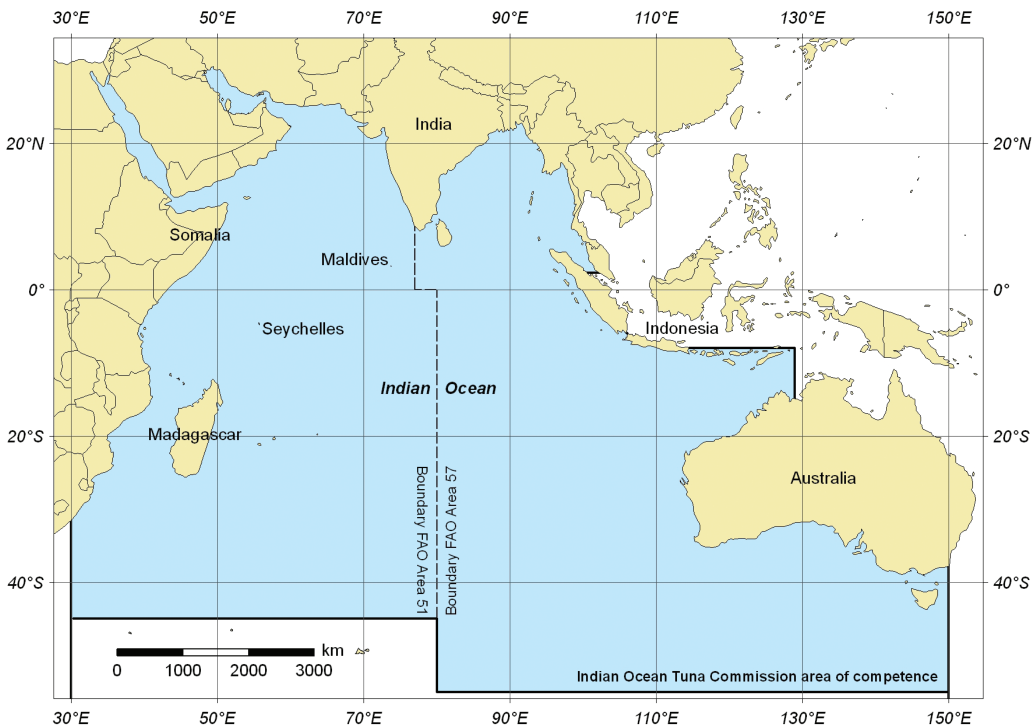


FIGURE 21.6 Indian Ocean Tuna Commission area of competence

TABLE 21.4 Main features and statistics of the Agreement for the Establishment of the Indian Ocean Tuna Commission—implemented by the Indian Ocean Tuna Commission

Feature	Description	
Commencement date	27 March 1996	
Objective	To promote cooperation among its members with a view to ensuring, through appropriate management, the conservation and optimum utilisation of stocks covered by the agreement and encouraging sustainable development of fisheries based on such stocks	
Membership	Members: 28 Cooperating non-contracting parties: 3	
Species covered under the management mandate	**Tuna:** albacore tuna (*Thunnus alalunga*)[a] , bigeye tuna (*Thunnus obesus*)[a], bullet tuna (*Auxis rochei*), frigate tuna (*Auxis thazard*), kawakawa (*Euthynnus affinis*), longtail tuna (*Thunnus tonggol*)[a], skipjack tuna (*Katsuwonus pelamis*)[a], southern bluefin tuna (*Thunnus maccoyii*)[a], yellowfin tuna (*Thunnus albacares*)[a] **Mackerel:** Indo-Pacific king macherel (*Scomberomorus guttatus*), narrow-barred Spanish mackerel (*Scomberomorus commersoni*) **Marlin:** black marlin (*Makaira indica*), Indo-Pacific blue marlin (*Makaira mazara*), striped marlin (*Tetrapturus audax*)[a] **Sailfish:** Indo-Pacific sailfish (*Istiophorus platypterus*) **Swordfish:** broadbill swordfish (*Xiphias gladius*)[a]	
Fishing methods	Purse seine Pelagic longline Minor line (handline, rod and reel, troll and poling) Gillnets	
Primary landing ports	Industrial: Seychelles, Thailand, Mauritius Artisanal: numerous	
Management methods	Input controls: fishing capacity	
Harvest strategy	None	
Consultative forums	Commission; Scientific Committee; working parties on tropical tunas, fishing capacity, billfish, data collection and statistics, neritic tunas, temperate tunas, ecosystems and bycatch	
Main markets	Japan—fresh, frozen	
Commonwealth fisheries involved	Western Tuna and Billfish Fishery (see Chapter 25) Western Skipjack Fishery (see Chapter 23)	
Fishery statistics[b]	**2007 calendar year**	**2008 calendar year**
Estimated total catch	1 433 947 t	1 387 421 t
Authorised vessels	Industrial: 3675 fishing and/or carrier vessels (2471 greater than 24 m)	Industrial: 3575 fishing and/or carrier vessels (2289 greater than 24 m)
Active vessels[c]	Industrial: 3907 fishing and/or carrier vessels (1737 greater than 24 m, 794 unknown length) Artisanal[d]: tens of thousands	Industrial: 4036 fishing and/or carrier vessels (1670 greater than 24 m, 793 unknown length) Artisanal: tens of thousands
Value of production	>US$3 billion	>US$3 billion

a Species considered as important targets or byproduct for Commonwealth fisheries. Southern bluefin tuna managed by CCSBT

b Fishery statistics provided by calendar year unless otherwise indicated; data for 2009 are not available from the secretariat until late in 2010

c The number of active vessels is higher than the number authorised to fish because vessels from Chinese Taipei cannot be authorised due to regulations of the Food and Agriculture Organization of the United Nations

d Artisanal vessels are those of length less than 24 m that fish within the EEZ of an Indian Ocean coastal state.

SOURCE: Gillett & Herrera (2010).

The IOTC is an intergovernmental organisation established under Article XIV of the constitution of the United Nations (UN) Food and Agriculture Organization. It is mandated to manage tuna and tuna-like species in the Indian Ocean and adjacent seas (Table 21.4). The IOTC area of competence (Fig. 21.6) covers a large number of countries and both artisanal and industrial fishing vessels. Membership of the IOTC is open to any Indian Ocean coastal country, and countries or regional economic integration organisations that are members of the UN or one of its specialised agencies that actively fish for tunas in the Indian Ocean.

The IOTC is responsible for the world's second largest tuna fishery, by both volume and value (Table 21.4). In 2008 the total tuna catch of the fishery was worth in excess of US$3 billion and contributed 24% of the global tuna catch. The Indian Ocean differs from the other oceans in that artisanal fisheries take almost as much as industrial fisheries. In catches of coastal countries (except for the Maldives, Sri Lanka and Indonesia), neritic species predominate, while the distant water fishing nations target tropical and temperate oceanic tunas and, to a lesser extent, swordfish. Since 1992 the total IOTC catch of tuna and tuna-like species has been more than 1 million t, peaking at 1.66 million t in 2006. Skipjack (31% of the 2008 catch) and yellowfin tuna (22%) make up more than half the catch. In 2008 gillnets accounted for 36% of the catch, purse seine 30% and longline 15%. Most catch (60–70%) comes from the western Indian Ocean (Fig. 21.7). The Australian catch in both the Western Tuna and Billfish Fishery and the Western Skipjack Fishery is very small relative to the entire IOTC catch (see Chapters 23 and 25).

The IOTC Scientific Committee uses the reference points of B_{MSY} and F_{MSY} in providing its advice on stock status; species with biomass estimates $<B_{MSY}$ are considered overfished, and fishing mortality $>F_{MSY}$ is considered overfishing. There are currently no agreed harvest strategies, explicit limit reference points or decision rules that are followed when reference points are reached.

The performance review of the IOTC (Anon 2009) included a review of the IOTC agreement and noted that a major weakness was that it did not explicitly include concepts such as the precautionary approach and ecosystem-based approach to fisheries management. In terms of management performance, the review noted that the limited quantitative data provided for many stocks was contributing to the high levels of uncertainty in the assessments of stock status. This is suggested to be due to lack of compliance with IOTC resolutions and also the limited information available for artisanal fisheries, which take a large part

Fish market, dried products
PHOTO: DAVID WILSON, ABARE–BRS

Juvenile tuna, South-east Asia market
PHOTO: KATHRYN READ, DEWHA

of the catch. In 2009 the Commission took steps towards rectifying these deficiencies by adopting a resolution that would strengthen the effectiveness of the IOTC.

Conservation and management measures

At each annual session of the IOTC, the Commission makes resolutions concerning the conservation and management of tuna and tuna-like species under its mandate (Table 21.4). These resolutions are binding on all members of the Commission. In 2009 the IOTC adopted six new resolutions (the details of which can be found on the IOTC website—www.iotc.org):

- Resolution 09/01—on the performance review follow-up. The Commission adopted a resolution that takes the first steps to progress the recommendations in the *Report of the IOTC Performance Review Panel: January 2009* (Anon 2009a), with the aim of strengthening the effectiveness of the IOTC.
- Resolution 09/02—on the implementation of a limitation of fishing capacity of contracting parties and cooperating non-contracting parties. The Commission strengthened its measures for the management of fishing capacity for tropical tuna, swordfish and albacore tuna stocks.
- Resolution 09/03—on establishing a list of vessels presumed to have carried out illegal, unregulated and unreported fishing in the IOTC area. In an attempt to eliminate illegal, unregulated and unreported (IUU) fishing, the Commission adopted a resolution that enables vessels flagged to members to be included on the List of IUU Vessels.
- Resolution 09/04—on a regional observer scheme. The Commission put in place a program comprising national observer schemes to collect verified catch data and other scientific data related to the fisheries for tuna and tuna-like species in the IOTC convention area. The resolution requires at least 5% coverage of the number of operations/sets for each gear type by fleet of 24 m and over, and under 24 m if fishing outside a member's EEZ. The commencement of the resolution was delayed until 1 July 2010, to allow member states to develop national programs. For vessels under 24 m fishing outside their EEZ, the required coverage should be achieved progressively by January 2013.
- Resolution 09/05—to prohibit the use of large-scale driftnets on the high seas in the IOTC area. The Commission prohibited the use of large-scale driftnets (>2.5 km in length) on the high seas of the IOTC convention area. The resolution also prohibited vessels configured to fish using large-scale driftnets. The resolution does not extend to the EEZ of member states.
- Resolution 09/06—on marine turtles. In recognition of the threatened status of the populations of the six marine turtle species found in the Indian Ocean, and the adverse impacts that fishing operations have on turtles, the Commission adopted measures to improve the data on marine turtle interactions, and ensure the use of best handling practices to improve the levels of survival of turtles returned to the sea after capture.

In addition, the Commission adopted an arrangement between the IOTC and the Secretariat for the Agreement for Albatrosses and Petrels to promote cooperation between the two organisations to enhance the conservation of albatrosses and petrels in the IOTC area. The objective of this cooperation is to support efforts to minimise the incidental bycatch of albatrosses and petrels within the IOTC convention area.

Yellowfin tuna PHOTO: DAVID WILSON, ABARE–BRS

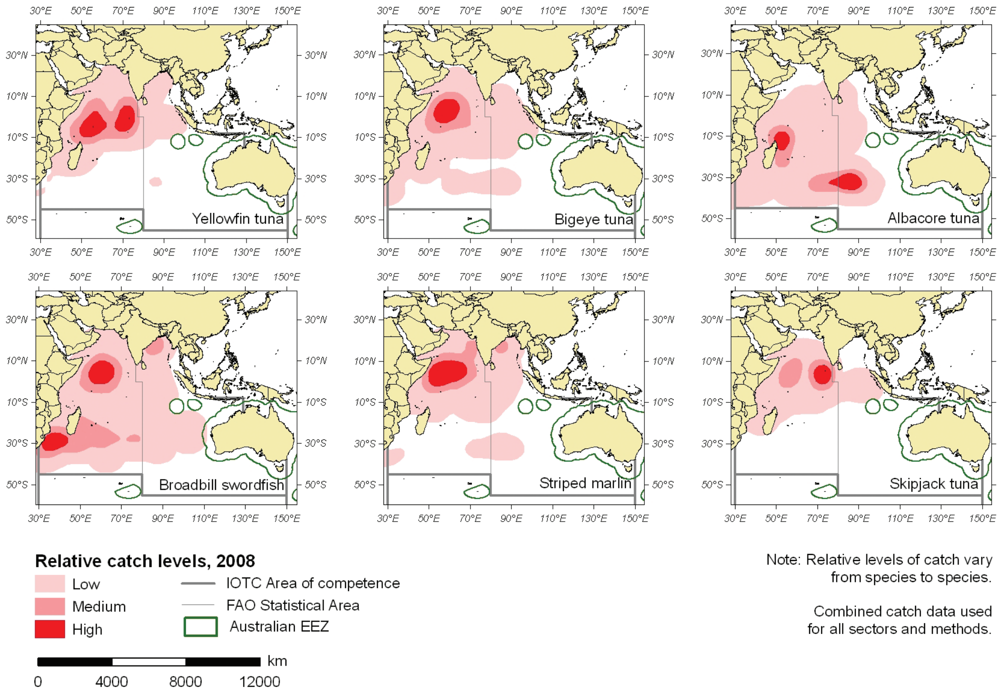


FIGURE 21.7 Relative catch levels of key target species reported in the IOTC, 2008

EEZ = Exclusive Economic Zone; FAO = Food and Agriculture Organization of the United Nations; IOTC = Indian Ocean Tuna Commission

Yellowfin tuna processing, Indonesia

PHOTO: DAVID WILSON, ABARE–BRS

Yellowfin tuna processing, Indonesia

PHOTO: DAVID WILSON, ABARE–BRS

21.5 COMMISSION FOR THE CONSERVATION OF ANTARCTIC MARINE LIVING RESOURCES

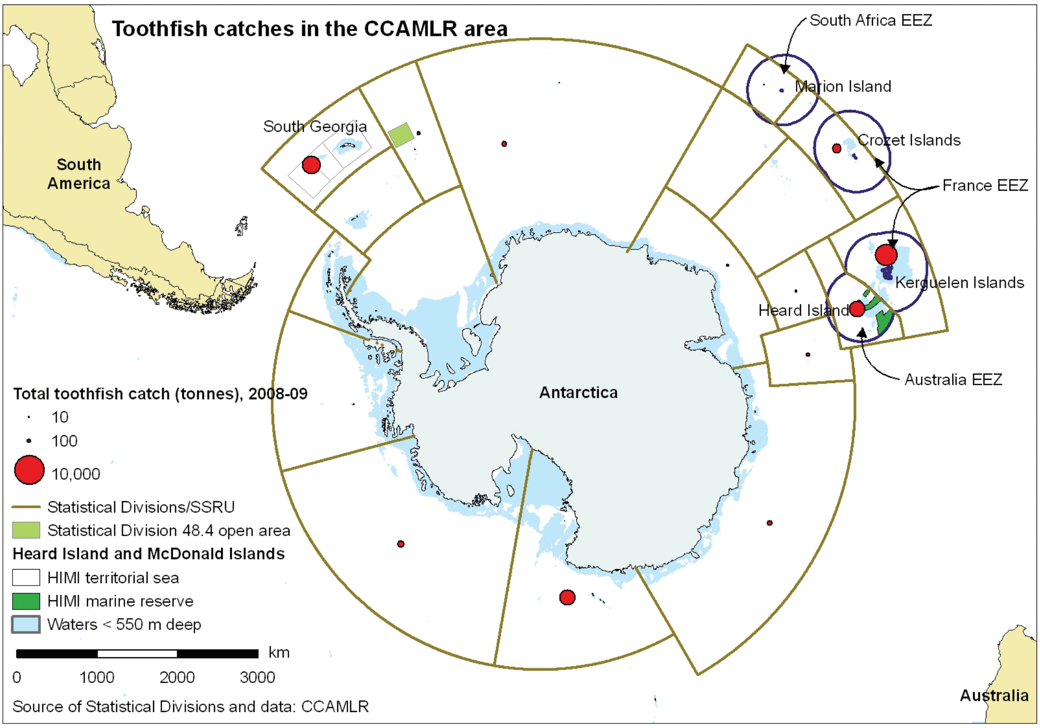


FIGURE 21.8 Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) area of competence and reported toothfish catches, 2008–09

EEZ = Exclusive Economic Zone; SSRU = small scale research unit

Hauling in toothfish catch PHOTO: AFMA

Austral leader PHOTO: JAY HENDER, ABARE–BRS

TABLE 21.5 Main features and statistics of the Convention for the Conservation of Antarctic Marine Living Resources

Feature	Description	
Commencement date	July 1982	
Membership	Members: 25 Non-member contracting parties: 9	
Species covered under the management mandate	All living marine resources, with the exception of seals and whales. Key species for Australia: Patagonian toothfish (*Dissostichus eleginoides*)[a] Antarctic toothfish (*Dissostichus mawsoni*)[a] Mackerel icefish (*Champsocephalus gunnari*)[a]	
Fishing methods	Trawl Demersal longline Pots	
Primary landing ports	Port Louis (Mauritius), Albany (Australia), Nelson (New Zealand), Capetown (South Africa), Port Stanley (Falkland Islands), Montevideo (Uruguay), Vigo (Spain)	
Management methods	Output controls: fishery-dependent TACs	
Harvest strategy	Fishery specific	
Consultative forums	Commission; Scientific Committee; Working Group on Incidental Mortality Associated with Fishing; Working Group on Fish Stock Assessment; Working Group on Ecosystem Monitoring and Management; Working Group on Statistics, Assessments and Modelling	
Main markets	United States, Japan—toothfish Eastern Europe—icefish United States, Europe—krill	
Commonwealth fisheries involved	Antarctic Waters Fishery (see Chapter 26) Heard Island and McDonald Islands Fishery (see Chapter 27) Macquarie Island Toothfish Fishery (see Chapter 28)	
Fishery statistics[b]	**2007–08 financial year**	**2008–09 financial year**
Estimated total catch	174 803 t	138 909 t
Authorised vessels	44 vessels (61 licences) from 15 flag states	37 vessels (55 licences) from 12 flag states
Active vessels	Not available	Not available
Value of production	Not available	Not available

a Species considered as important targets or byproduct for Commonwealth fisheries

b Fishery statistics provided by financial year

The CCAMLR was established to conserve and manage the Southern Ocean Antarctic ecosystem, mainly in high-seas areas. It originally stemmed from concern over fishing for krill (*Euphausia superba*) and the effects on the broader Antarctic ecosystem. The convention's objective is the conservation and rational use of Antarctic marine living resources. In managing fisheries within its area of competence (Fig. 21.8), the CCAMLR uses harvest strategies that specifically incorporate ecological links in setting TACs. Such an approach views the entire Southern Ocean as a suite of interlinked ecological systems; this approach distinguishes the CCAMLR from the multilateral fisheries conventions. The strategies result in conservative TACs that aim to reduce the potential impact of fishing on other species, such as predators of the target species. There is also a focus on mitigating impacts on the benthic environment and bycatch, particularly of seabirds. Fisheries in the CCAMLR region are required to have high levels of observer coverage and data collection and reporting, and there are specific requirements for new or exploratory fisheries.

The largest fisheries in terms of catch in CCAMLR waters are for krill (156 521 t in 2007–08) and Patagonian toothfish (*Dissostichus eleginoides*; 12 004 t). Of the Australian fisheries, the Antarctic Waters Fishery (see Chapter 26) and the Heard Island and McDonald Islands Fishery (see Chapter 27) fall within the CCAMLR's jurisdiction. These two Commonwealth fisheries target toothfish and mackerel icefish (*Champsocephalus gunnari*). IUU fishing within the CCAMLR region has been a significant problem during the past decade. The CCAMLR and countries including Australia have implemented a range of methods to reduce IUU fishing, including significant investment in monitoring, surveillance and enforcement. The stock assessments for target species also incorporate estimates of IUU catch.

IUU fishing poses a threat of extinction for several seabird populations in the region. The CCAMLR estimated that 8212 seabirds were killed in the 2006–07 fishing season as a consequence of IUU fishing in the convention area. Similar numbers were estimated to be killed in the preceding three years. The number of seabird mortalities resulting from IUU fishing could not be estimated for 2009 because most IUU effort observed was conducted by gillnet vessels, which have only recently begun fishing in the convention area. The CCAMLR is not yet able to estimate catch rates from gillnets or, consequently, seabird mortality resulting from IUU gillnet fishing.

The CCAMLR cooperates with three other agreements concerned with environmental conservation and resource management in the Antarctic: Annex II (Conservation of Antarctic fauna and flora) to the Protocol on Environmental Protection to the Antarctic Treaty, the Convention on the Conservation of Antarctic Seals, and the International Convention for the Regulation of Whaling (which is not part of the Antarctic Treaty System and is not restricted to the Southern Ocean) (www.npolar.no/cep/cephome.htm). As many marine animals (including seabirds) cross the northern boundary of the convention area, the CCAMLR Commission cooperates with other organisations and national institutions responsible for the management and conservation of areas adjacent to the CCAMLR boundaries.

The CCAMLR also developed and implemented a system to identify and mitigate impacts on vulnerable marine ecosystems (VMEs). Encounters with VMEs are reported to, and recorded by, the secretariat. This has resulted in the secretariat's VME Register, which will be used in further reducing impacts on VMEs. The CCAMLR was one of the few management organisations to meet the deadline set by United Nations General Assembly Resolution 61/105 to close areas of the high seas where VMEs are known or are likely to occur.

Conservation and management measures

At each annual session of the CCAMLR, the Commission reviews, amends and implements conservation measures that relate to conservation and management issues (Table 21.5). These measures can be general and apply to all areas; or are applicable to only one statistical division, for which they detail the TAC for a season, the members that can fish in that season and statistical division and other details. These decisions are binding on all members and cooperating non-members. Details of the conservation measures can be found on the CCAMLR website (www.ccamlr.org).

Fish pots and toothfish PHOTO: JAY HENDER, ABARE–BRS

21.6 SOUTHERN INDIAN OCEAN FISHERIES AGREEMENT

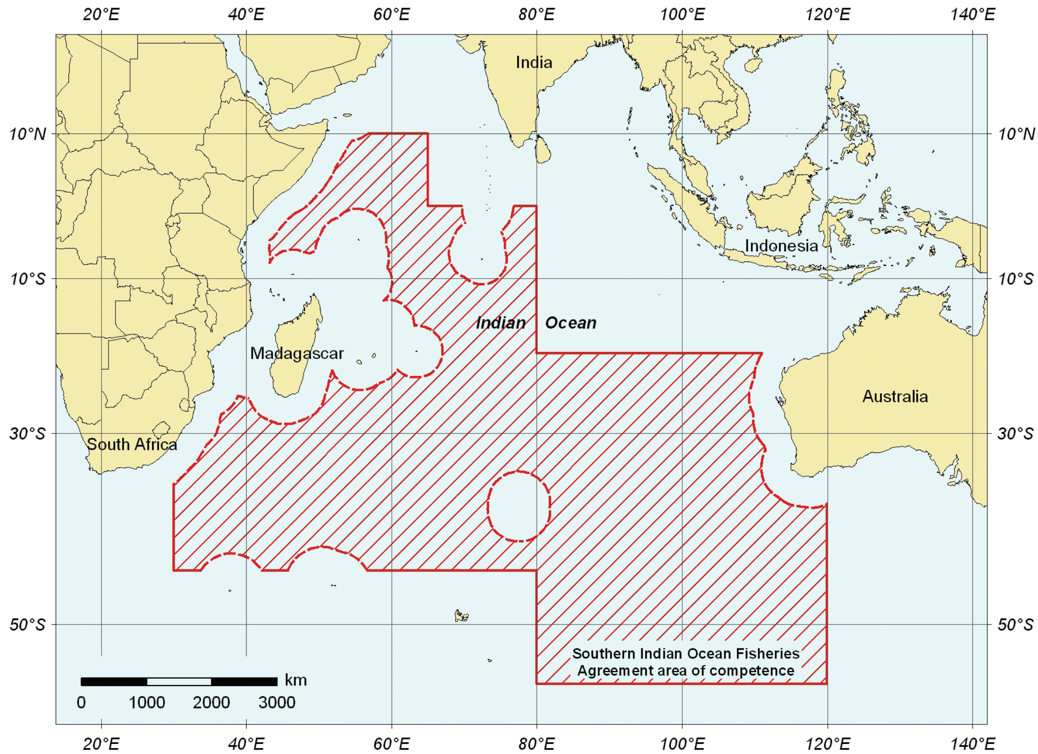


FIGURE 21.9 Southern Indian Ocean Fisheries Agreement area of competence

TABLE 21.6 Main features and statistics of the Southern Indian Ocean Fisheries Agreement

Feature	Description
Commencement date	Adopted 7 July 2006, not yet entered into force
Membership	Participants: 11
Species covered under the management mandate	Fish, molluscs, crustaceans and other sedentary species within the area, but excluding sedentary species subject to the fishery jurisdiction of coastal states and highly migratory species
Fishing methods	Currently trawl
Consultative forums	Pending commencement: Commission, Scientific Committee, Compliance Committee
Main markets	Not applicable
Commonwealth fisheries involved	High-seas permits

In 2006 Australia signed the SIOFA, which will enter into force once four states (two of which must be coastal states of the Indian Ocean) have ratified the agreement. Currently, 10 participants have signed the agreement, but only the Seychelles has ratified it to date.

The objectives of the agreement are:

- to ensure the long-term conservation and sustainable use of the fishery resources in the convention area through cooperation among the contracting parties
- to promote the sustainable development of fisheries in the area, taking into account the needs of developing states bordering the area that are contracting parties to the agreement—in particular, the small island developing states.

Conservation and management measures

Under the agreement, Australia is required to ensure that it has effective mechanisms to monitor fishing in the area and report on fishing operations and catch. Australian vessels fishing in the SIOFA region (Fig. 21.9) require high-seas permits. Previously, these were granted on an open-access basis, with few restrictions on the area to be fished or gear used. Since 2006 the Australian Fisheries Management Authority (AFMA) has begun implementing the actions agreed in the UNGA Resolution on Sustainable Fisheries. This has included requiring more detailed permit applications (in terms of gear, proposed area of operation, species targeted), mandatory observer coverage (100% on trawling permits), limiting fishing effort to areas previously fished and provisions to protect VMEs (FAO 2008).

Benoa Harbour, Indonesia PHOTO: DAVID WILSON, ABARE–BRS

21.7 SOUTH PACIFIC REGIONAL FISHERIES MANAGEMENT ORGANISATION

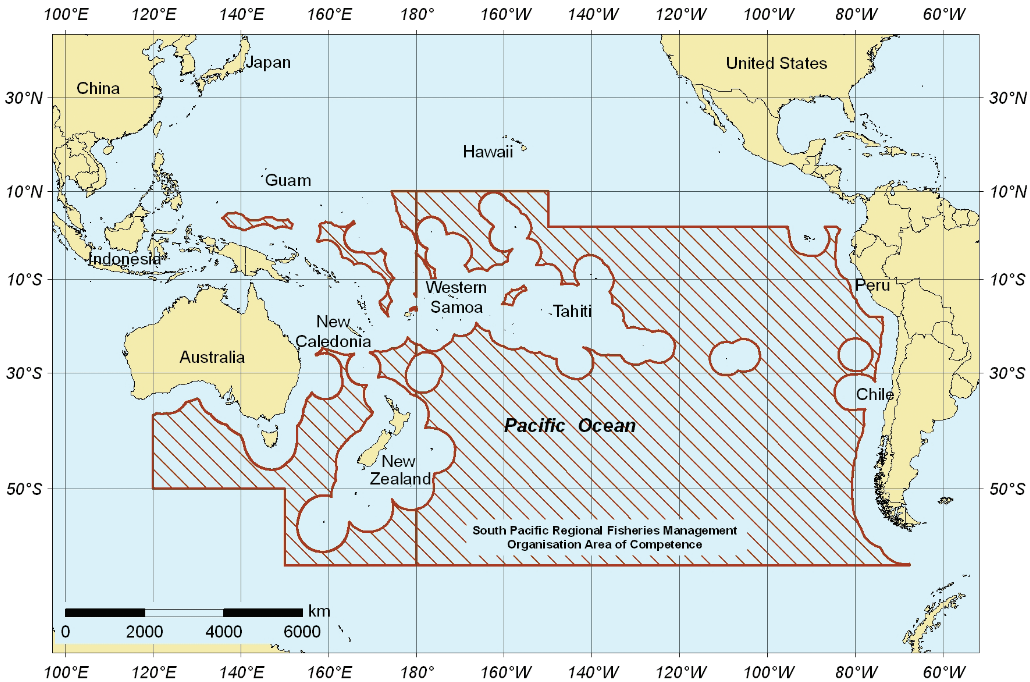


FIGURE 21.10 South Pacific Regional Fisheries Management Organisation area of competence

TABLE 21.7 Main features and statistics of the Convention for the Conservation and Management of the High Seas Fishery Resources of the South Pacific Ocean—to be managed under the South Pacific Regional Fisheries Management Organisation

Feature	Description
Commencement date	Adopted 14 November 2009; not yet in force
Membership	Participants in the negotiations to date: 24
Species covered under the management mandate	All 'fisheries resources' within the convention area, including molluscs, crustaceans and other living marine resources as may be decided by the Commission, but excluding: (i) sedentary species in so far as they are subject to the national jurisdiction of coastal states pursuant to Article 77 paragraph 4 of the 1982 Convention (ii) highly migratory species listed in Annex I of the 1982 UNCLOS (iii) anadromous and catadromous species (iv) marine mammals, marine reptiles and sea birds. The main target species of the pelagic fisheries is Peruvian jack mackerel (also known as Chilean jack mackerel). The demersal finfish fisheries target a range of species, with the dominant species being orange roughy, oreodories (Oreosomatidae), alfonsino (*Beryx splendens*) and blue-eye trevalla (*Hyperoglyphe antarctica*).
Fishing methods	Pelagic: purse seine, pelagic longline and midwater trawling Demersal: trawling, demersal longline, pots

Table 21.7 continues over the page

TABLE 21.7 Main features and statistics of the Convention for the Conservation and Management of the High Seas Fishery Resources of the South Pacific Ocean—to be managed under the South Pacific Regional Fisheries Management Organisation CONTINUED

Feature	Description
Primary landing ports	San Vicente, Caldera, Iquique, Mejillones—(Chile), Peru
Management methods	Voluntary interim measures covering both pelagic and demersal fisheries (including limits on effort and catch)
Harvest strategy	None
Consultative forums	Science Working Group (SWG), Data and Information Working Group (DIWG), Scientific Committee (SC), Compliance and Technical Committee (CTC) (once commenced)
Main markets	Not applicable
Commonwealth fisheries involved	High-seas permits

The Convention on the Conservation and Management of the High Seas Fishery Resources of the South Pacific Ocean was adopted on 14 November 2009 after three years of formal negotiations. New Zealand and the Cook Islands signed the convention in February 2010, and it will enter into force after it has been ratified by eight parties, including at least three coastal states and three non-coastal states that have vessels that fish or fished in the area. The convention will be implemented by the Commission of the SPRFMO.

The convention covers all ‘fisheries resources’ in the South Pacific, except the highly migratory species (managed by the WCPFC) and other species as noted in Table 21.7. The area has been fished by vessels from numerous countries using both pelagic and demersal gear (Fig. 21.10, Table 21.7). The largest fisheries are focused on pelagic species in upwelling areas of higher productivity off the west coast of South America. Other fisheries target demersal species found on seamounts and ridges in the central and western areas of the southern Pacific Ocean (www.southpacificRFMO.org).

The seamounts and ridges are recognised as likely to have VMEs (FAO 2008). These ecosystems are characterised by a range of criteria, including supporting species that are slow growing or spatially restricted, and species and communities that are susceptible to impacts from demersal fishing, particularly trawling. The *2006 UNGA Resolution on Sustainable Fisheries* recognised the need to conserve and protect VMEs from the impacts of fishing.

Conservation and management measures

While negotiations for the development of the convention were in progress, participants agreed to voluntary interim measures (the details of which can be found on the website—www.southpacificrfmo.org):

- Interim measures adopted by participants in negotiations to establish the South Pacific Regional Fisheries Management Organisation (adopted 2006 and effective September 2007). This includes measures for both pelagic and demersal fisheries to limit effort and catch to existing levels and fished areas. It also includes measures to assist in the identification and mapping of VMEs and assess the impact of demersal fisheries on these ecosystems.
- Revised interim measures for pelagic fisheries (adopted November 2009 and effective January 2010). The interim measures for pelagic fisheries targeting mackerels (*Trachurus* spp.) were revised in response to concern over the status of the Peruvian jack mackerel stocks (Anon 2009b). The measures focus on attempting to limit fishing effort and catch.
- Interim measure for deepwater gillnets in the convention area (adopted

November 2009 and effective February 2010). The participants agreed to ban the use of deepwater gillnets within the convention area.

Australian fishing in the convention area occurs under high-seas permits generally issued for demersal species. However, there has been relatively little fishing effort in recent years. AFMA has begun implementing the requirements under the interim measures as permit conditions.

21.8 LITERATURE CITED

ACAP 2006, *Agreement on the conservation of albatrosses and petrels*, amended, Second Meeting of the Parties, Christchurch, New Zealand, 13–17 November 2006.

Anon. 2009a, *Report of the IOTC Performance Review Panel, January 2009*, Indian Ocean Tuna Commission.

——2009b, *Report of the Science Working Group for the eighth meeting of the International Consultations on the establishment of the South Pacific RFMO*, Auckland, New Zealand, 2–6 November.

Bolton D, 2008, *Report of the independent expert*, Commission for the Conservation of Southern Bluefin Tuna, Canberra.

CBD (Convention on Biological Diversity) 1992, *Convention on biological diversity*, Rio de Janerio, June 1992.

CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources) 2008, *CCAMLR performance review report 1 September 2008,* CCAMLR, Hobart.

CCSBT (Commission for the Conservation of Southern Bluefin Tuna) 2008, *Report of the Performance Review Working Group*, CCSBT, Canberra.

——2009, *Report of the sixteenth annual meeting of the commission,* CCSBT, Canberra.

CITES (Convention on International Trade in Endangered Species) 1973, *Convention on International Trade in Endangered Species of Wild Fauna and Flora*, Washington DC, USA, amended June 1979.

CMS (Convention on Migratory Species) 2003, *Convention on the Conservation of Migratory Species of Wild Animals*, October 2003, CMS, Bonn.

Yellowfin tuna offload PHOTO: DAVID WILSON, ABARE–BRS

Yellowfin tuna offload PHOTO: DAVID WILSON, ABARE–BRS

DAFF (Australian Government Department of Agriculture, Fisheries and Forestry) 2007, *Commonwealth Fisheries Harvest Strategy: policy and guidelines*, DAFF, Canberra.

FAO (Food and Agriculture Organization of the United Nations) 1999, *International plan of action for reducing incidental catch of seabirds in longline fisheries. International plan of action for the conservation and management of sharks. International plan of action for the management of fishing capacity*, FAO, Rome, 1999.

——2008, *International guidelines for the management of deep-sea fisheries in the high seas. Annex F of the Report of the Technical Consultation on International Guidelines for the Management of Deepsea Fisheries in the High Seas*, Rome, 4–8 February and 25–29 August, FAO, Rome.

Gillett, R & Herrera, M 2010, *Estimating the fishing capacity of the tuna fleets in the Indian Ocean*, IOTC-2010-S14-04[E], Indian Ocean Tuna Commission.

Lawson, TA 2008, *Tuna fishery yearbook 2007*, Western and Central Pacific Fisheries Commission, Pohnpei, Federated States of Micronesia.

OFP (Oceanic Fisheries Programme) & SPC (Secretariat of the Pacific Community) 2009, 'Estimates of annual catches in the WCPFC statistical area', information paper WCPFC-SC5-2009/ST IP-1, scientific committee fifth regular session Vanuatu, 10–21 August.

Small, CJ 2005, *Regional fisheries management organisations: their duties and performance in reducing bycatch of albatrosses and other species*, BirdLife International, Cambridge, UK.

Williams, P & Terawasi, P 2009, 'Overview of tuna fisheries in the western and central Pacific Ocean, including economic conditions—2008', working paper WCPFC-SC5-2009/GN WP-1, scientific committee fifth regular session Vanuatu, 10–21 August.

Indonesian longline vessel PHOTO: DAVID WILSON, ABARE–BRS

22 Eastern Tuna and Billfish Fishery

D Wilson, A Sands, A Leatherbarrow and S Vieira

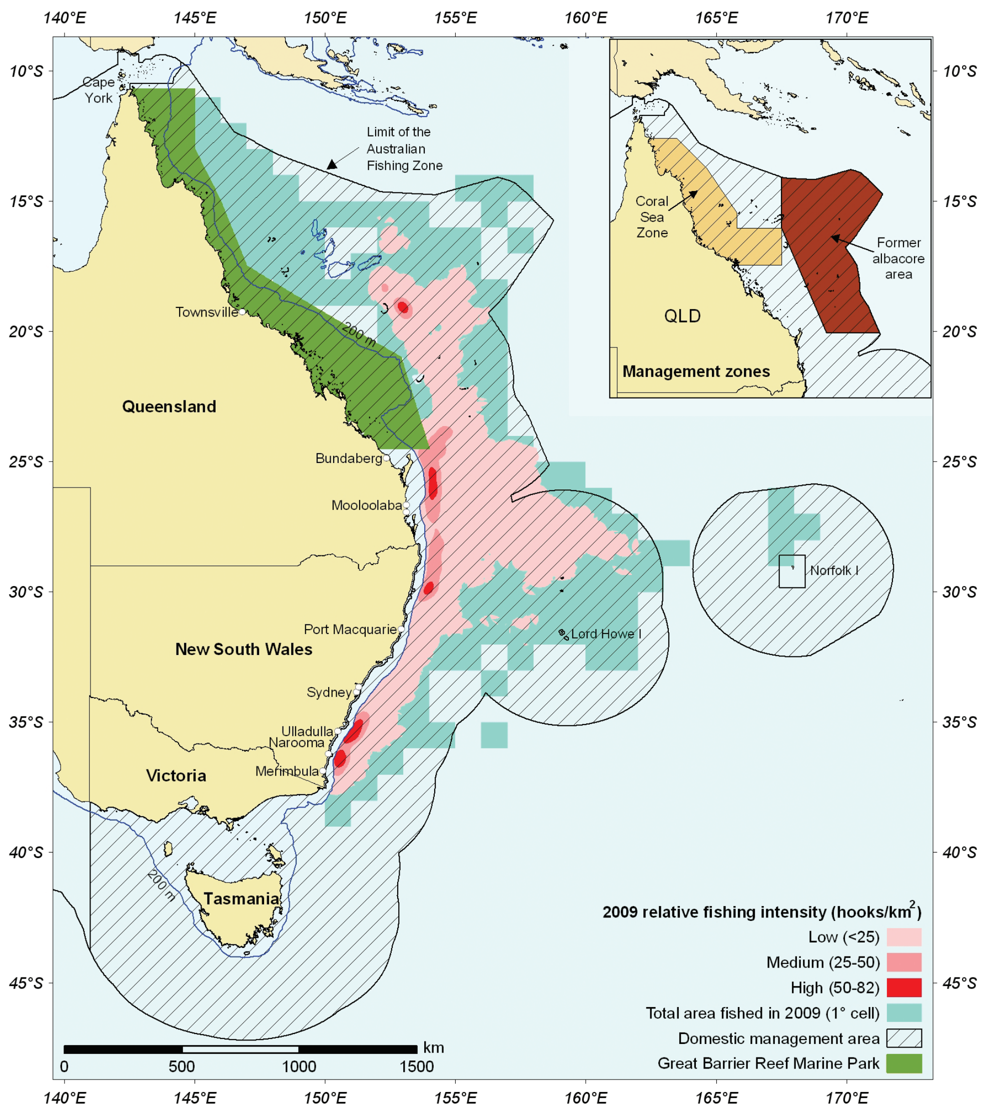


FIGURE 22.1 Relative fishing intensity in the Eastern Tuna and Billfish Fishery, 2009

TABLE 22.1 Status of the Eastern Tuna and Billfish Fishery

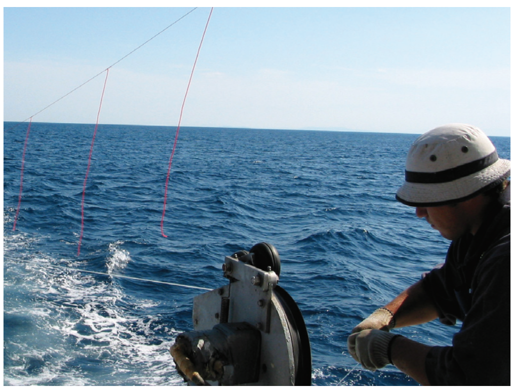
Fishery status	**2008**		**2009**		**Comments**[a]
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Marlin, striped (*Tetrapturus audax*)	Uncertain	Uncertain	Uncertain	Uncertain	Preliminary assessment; wide range of plausible conclusions on stock status (highly variable).
Swordfish (*Xiphias gladius*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Range of plausible conclusions on stock status, with most indicating not overfished and not subject to overfishing.
Tuna, albacore (*Thunnus alalunga*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Assessment indicates biomass is well above that required for maximum sustainable yield. Fishery targets a narrow band of older age classes.
Tuna, bigeye (*Thunnus obesus*)	Overfishing	Not overfished	Overfishing	Overfished	Current levels of fishing, combined with historical average levels of recruitment, moved the stock to an overfished state in 2009. Spawning stock biomass ~9–12% of SSB_0.
Tuna, yellowfin (*Thunnus albacares*)	Overfishing	Not overfished	Not subject to overfishing	Not overfished	2009 assessment indicates that the stock is in a slightly improved state compared with the previous 2007 assessment.
Economic status Fishery level	Net economic returns were -$1.1 million in 2007–08 (preliminary estimate).		Estimates of net economic returns not available, but likely to be moving in a positive direction.		Economic status uncertain but probably improving. Increased value contributions from bigeye and yellowfin tuna, combined with recent restructuring, have increased net economic returns. Status of bigeye tuna is a concern for future economic status. The move to more effective management arrangements will have a positive impact on future economic status.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING | OVERFISHED / OVERFISHING | UNCERTAIN | NOT ASSESSED

SSB = spawning stock biomass

a Ocean-wide assessments of species through the Western and Central Pacific Fishery Commission were used as the basis for stock status determination. The relevance of these regional assessments to the Australian Fishing Zone is unclear because mixing and interactions between stock components in the Western and Central Pacific Ocean and Australian Fishing Zone are not well understood, with the exception of striped marlin, which is largely impacted by the Eastern Tuna and Billfish Fishery fleet.

Longliner, Eden PHOTO: HEATHER PATTERSON, ABARE–BRS



Tori lines, Eastern Tuna and Billfish Fishery PHOTO: DAVE CRANSTON, AFMA

TABLE 22.2 Main features and statistics of the Eastern Tuna and Billfish Fishery

Feature	Description
Key target and byproduct species	Marlin, striped (*Tetrapturus audax*) Swordfish (*Xiphius gladius*) Tuna, albacore (*Thunnus alalunga*) Tuna, bigeye (*Thunnus obesus*) Tuna, yellowfin (*Thunnus albacares*)
Other byproduct species	Escolar (black oilfish) (*Lepidocybium flavobrunnneum*) Mahi mahi (*Coryphaena hippurus*) Moonfish (*Lampris guttatus*) Ray's bream (*Brama brama*) Rudderfish (*Centrolophus niger*) Shortbill spearfish (*Tetrapturus angustirostris*) Shortfin mako (*Isurus oxyrinchus*) Tuna, skipjack (*Katsuwonus pelamis*) Wahoo (*Acanthocybium solandri*) See Table 22.4 for a more detailed list.
Fishing methods	Pelagic longline Minor line (trolling, rod and reel, handline)
Primary landing ports	Bermagui, Cairns, Coffs Harbour, Mackay, Mooloolaba, Southport, Sydney, Ulladulla
Management methods	Input controls: gear restrictions (number of hooks that can be deployed) and spatial management. There are three zones: the Coral Sea, the area of the Australian Fishing Zone outside of the Coral Sea, and the high seas. Output controls: catch limits (swordfish only), byproduct and bycatch limits; black and blue marlin are not to be taken. As of 1 November 2009, the ETBF moved to interim effort restrictions (total allowable effort). In August 2009, annual fishing permits were replaced by vessel permits, Coral Sea zone fishing permits and longline and minor-line SFRs granted under the management plan. AFMA is currently working towards the introduction of quota-based management in March 2011.
Management plan	*Eastern Tuna and Billfish Fishery Management Plan 2005* (DAFF 2005) (amended 18 September 2007)
Harvest strategy	*Eastern Tuna and Billfish Fishery Harvest Strategy Framework 2007* (AFMA 2007)
Consultative forums	Eastern Tuna and Billfish Fishery Management Advisory Committee (ETBFMAC)—as of 1 July 2009, will be known as the Tropical Tuna MAC, which is the advisory body for the eastern and western tuna and billfish fisheries and skipjack fisheries; Eastern Tuna and Billfish Fishery Resource Assessment Group (ETBFRAG)—as of 1 July 2010, will be amalgamated with Western Tuna and Billfish Fishery Resource Assessment Group to form the Tropical Tuna RAG; Western and Central Pacific Ocean Fisheries Commission
Main markets	Domestic: fresh International: Japan, United States—mainly fresh; Europe—frozen; American Samoa, Thailand and Indonesia—albacore, mainly for canning
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Current accreditation dated 2 February 2010 Current accreditation (Wildlife Trade Operation) expires 20 January 2011
Ecological risk assessment	Level 1: Scale Intensity Consequence Analysis (SICA) completed on 390 species (Webb et al. 2007) Level 2: Productivity Susceptibility Analysis (PSA) completed on 390 species (Webb et al. 2007) Level 3: Sustainability Assessment for Fishing Effects (SAFE) completed on 207 species (AFMA 2009b)
Bycatch workplans	*Australian Tuna and Billfish Longline Fisheries Bycatch and Discarding Workplan, 1 November 2008 – 31 October 2010* (AFMA 2008)

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; ETBF = Eastern Tuna and Billfish Fishery

Table 22.2 continues over the page

TABLE 22.2 Main features and statistics of the Eastern Tuna and Billfish Fishery CONTINUED

Feature	Description					
Fishery statistics[a]	**2008 calendar year**			**2009 calendar year**		
Fishing season	1 July 2007–30 June 2008			1 July 2008–30 October 2009[b]		
TAC, catch and estimated value by species:	TAC (tonnes)	Catch (tonnes) 2008	Real value ($2007–08)	TAC (tonnes)	Catch (tonnes) 2009	Real value ($2008–09)
—marlin, striped	None	425	2.5 million	None	361	2.7 million
—swordfish	1400 (2007–08)	1483	6.8 million	1400 (2008–09)	1315	7.3 million
—tuna, albacore	None	1277	2.9 million	None	1523	4.6 million
—tuna, bigeye	None	1026	11.2 million	None	726	8.1 million
—tuna, yellowfin	None	1650	7.8 million	None	1387	14.3 million
Effort	Longline: 8.06 million hooks Minor lines: 310 lines			Longline: 8.82 million hooks Minor lines: 164 lines		
Fishing permits	Longline: 109 + 11 Coral Sea zone Minor line: 32			Vessel permits: 110 + 10 Coral Sea zone Longline effort SFRs: 1 000 041 Minor-line effort SFRs: 154		
Active vessels	Longline: 54 Minor line: 15			Longline: 55 Minor line: 11		
Observer coverage	Longline: 834 698 hooks (10.38%) Minor line: zero			Longline: 564 408 hooks (6.4%) Minor line: zero		
Real gross value of production (2008–09 dollars)	2007–08: $33 million			2008–09: $38.9 million		
Allocated management costs	2007–08: $3.0 million			2008–09: $2.9 million		

AFMA = Australian Fisheries Management Authority; EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; ETBF = Eastern Tuna and Billfish Fishery; SFR = statutory fishing right; TAC = total allowable catch

a Although fishing permits were renewed on a financial-year basis, the fishery statistics are provided by calendar year to align with international reporting requirements

b Fishers were granted a two-year permit in 2008 due to the uncertainties with moving to SFRs. These were revoked in November 2009 and replaced with vessel permits, Coral Sea zone fishing permits and longline and minor-line statutory fishing rights, which accounts for the unusual fishing season.

22.1 BACKGROUND

The Eastern Tuna and Billfish Fishery (ETBF) extends from Cape York to the Victoria – South Australia border, including waters around Tasmania (Fig. 22.1). Domestic longline vessels are mostly 15–25 m long and use monofilament gear. The average number of days fished by vessels per year has increased over the past decade, and was around 115 days in 2009. Most trips are 2–15 days, but occasionally trips may extend up to 26 days. Almost no bigeye tuna or swordfish, and probably less than 5% of the yellowfin tuna catch, is taken by minor-line methods.

Swordfish catch rates have declined since the late 1990s, and the Western and Central Pacific Fisheries Commission (WCPFC) consequently put in place a conservation and management measure restricting catches south of 20°S. In reponse, the Australian Fisheries Management Authority (AFMA) set a total allowable catch (TAC) of 1400 t for swordfish on a financial-year basis (2008–09). In managing the TAC, trigger catch limits have been set for the catch of swordfish in each quarter of the year. Vessels are currently monitored through logbooks, verified landing records, vessel monitoring systems and observers. Some ETBF longliners target southern bluefin tuna (SBT) off New South

Wales during winter, after fishing for tropical tuna and billfish earlier in the year, while others take them incidentally when targeting other tunas. All SBT taken must be covered by quota and landed in accordance with the SBT management plan (AFMA 1995).

Gamefishing is popular in Australia. Many gamefishers tag and release their catch, especially marlins. Other recreational anglers target tuna and billfish in the area of the ETBF. There is also a well-developed fishery using charter vessels. Few data are available on recreational participation levels, catches and fishing effort directed at tuna and billfish, apart from data gathered through fishing tournaments, charter vessel logbooks and the National Recreational and Indigenous Fishing Survey (Henry & Lyle 2003).

On 1 November 2009 management of the ETBF changed to fall under the transitional arrangements of the management plan for the fishery (DAFF 2005). Under these arrangements, the ETBF will operate under a total allowable effort of 12 million hooks for an initial 16-month fishing season (1 November 2009 – 28 February 2011). The fishery will then move to output controls in the form of individual transferable quotas. Domestic management arrangements reflect Australia's obligations to the WCPFC (see Chapter 21).

TABLE 22.3 History of the Eastern Tuna and Billfish Fishery

Year	Description
1938	Formation of the Game Fishing Association of Australia.
1950s	Japanese and domestic longliners began fishing for tuna off Australia's east coast.
1970s	Catches increased with the introduction of purse-seining and the development of the skipjack tuna fishery (purse seine and pole-and-line). Development of gamefish industry for black marlin off Cairns (an important black marlin spawning ground).
1979	Declaration of the AFZ. Japanese longliners licensed under bilateral agreements. Australia progressively restricted access as domestic commercial and recreational fisheries for tuna and billfish grew.
1980s	Longlining increased markedly after successful air freighting of fresh-chilled tuna to Japan.
1986	A logbook for domestic longliners introduced. First meeting of the East Coast Tuna Management Advisory Committee.
1987	Nominal CPUE for domestic longlined yellowfin tuna peaked at around 27 fish per 1000 hooks (2 million hooks set).
1990s	Expansion into northern Queensland waters; high catch rates of yellowfin tuna and bigeye tuna. Recreational catches of striped marlin increased.
1992 to 1996	Catch rates varied between 12 and 18 yellowfin tuna per 1000 hooks.
Mid-1990s	Access to swordfish markets in the United States resulted in many fishers moving to southern Queensland ports (e.g. Mooloolaba) to target swordfish.
1995	AFMA began compulsory logbook return program as a condition of fishing permits, maintained a monthly audit and supported the program with regular field liaison.
Late 1990s	Longline catches and catch rates of striped marlin increased markedly. Locally based longline fleets increasingly targeted albacore tuna in the subtropical south Pacific Ocean for canning markets.
1997	Japan's longliners excluded from the AFZ. Nominal CPUE for swordfish and bigeye tuna peaked (approximately 4 fish per 1000 hooks with 6 million hooks set).
1998	Commercial retention of black marlin and blue marlin (dead or alive) by domestic longliners banned, with operators required to release them.
1999	Recreational anglers reported best striped marlin season on record.
Post-2000	AFMA placed specific operational area and quota-holding requirements on longliners to reduce the likelihood of southern bluefin tuna being captured without quota.
2001	Striped marlin catch peaked at 789 t.

Table 22.3 continues over the page

TABLE 22.3 History of the Eastern Tuna and Billfish Fishery CONTINUED

Year	Description
2003	AFMA implemented an at-sea observer program in the longline sector. Longline fishing effort peaked at 12.4 million hooks. Purse-seine fishery entitlements for skipjack tuna separated from the ETBF (see Chapter 23).
2004	The convention establishing the WCPFC entered into force on 19 June. Australia became a member of the Commission in November. Spanish longliners commenced fishing for swordfish in the international waters of the south-western Pacific Ocean.
2005	WCPFC agreed to adopt a range of measures directed towards the conservation and management of yellowfin and bigeye tuna, including consideration of temporary closures for the purse-seine fishery to reduce levels of fishing mortality on both species.
2006	Longliners began to use deep-setting techniques to target albacore tuna in response to reduced swordfish availability, high operating costs and market demand. The structural adjustment package resulted in the surrender of 99 of the 218 longline permits originally available to the fishery. AFMA introduced catch disposal records for the domestic fishery, which collect verified numbers and total weights of target species landed after each trip. AFMA placed an annual TAC of 35 t on the commercial catch of longtail tuna in the ETBF, plus a 10-fish trip limit in excess of 35 t—to commence in 2007. Threat abatement plan released (AAD 2006).
2007	AFMA closed the main fishing ground (the 'albacore area') to new entrants. AFMA introduced a TAC of 3200 t for albacore tuna within the albacore area for 2007. The availability of bigeye tuna and the strengthening of the Australian dollar saw targeting redirected from albacore tuna.
2008	Harvest strategy framework finalised; scheduled for implementation pending management strategy evaluation. In December, WCPFC adopted CMM2008-01, which seeks to reduce fishing mortality on bigeye tuna by 30% from the 2001–04 average level and limit yellowfin tuna fishing mortality to its 2001–04 level, in order to maintain stocks at levels capable of producing the maximum sustainable yield.
2009	Fishers operated under SFRs, with a total allowable effort for the ETBF of 12 million hooks for the 16-month season (1 November 2009 – 28 February 2011). WCPFC approved Australia's sea turtle mitigation plan. The Tropical Tuna Management Advisory Committee (Tropical Tuna MAC) commenced in July and is the advisory body for the ETBF, Western Tuna and Billfish Fishery, and Skipjack Tuna Fishery.

AFMA = Australian Fisheries Management Authority; AFZ = Australian Fishing Zone; CPUE = catch per unit effort; ETBF = Eastern Tuna and Billfish Fishery; SFR = statutory fishing right; TAC = total allowable catch; WCPFC = Western and Central Pacific Fisheries Commission

22.2 HARVEST STRATEGY

A harvest strategy (HS) framework, scheduled for full implementation in 2010, has been developed for the ETBF. In 2009 the HS was used to calculate the maximum effort (hooks) in the fishery during the period of interim management arrangements before quota will be introduced in 2011. Management strategy evaluation (MSE) is being used to test the likely performance of the HS for each of the five target species (albacore tuna, bigeye tuna, yellowfin tuna, striped marlin and swordfish). The framework consists of a target-driven catch per unit effort (CPUE) rule and a 'decision tree' that uses a range of fishery indicators and associated reference levels to make adjustments to the recommended biological catch (or level of fishing effort) for each target species. Empirical indicators of stock status are used because robust, region-specific assessments are not available for stocks within the ETBF. For each target species, the decision rule uses information on the relative values and trends in the standardised catch rates of three size classes of fish (small, prime, large) and the proportion of 'large' fish in the catch. The values of these indicators are compared with target reference levels. The target reference levels are based on the expected catch rates and size proportion when the level of mean spawners per recruit is at 48% of the pre-fished level (SPR_{48}). SPR_{48} was used as a proxy for the default target reference points required by the *Commonwealth Fisheries*

Harvest Strategy Policy (HSP) (DAFF 2007). The HS framework does not contain an explicit limit reference point; rather it has been designed to be target driven. MSEs are being used to tune the HS for each species so that it complies with the specifications of the policy. These evaluations will also take into account the multispecies nature of the fishery, so that the HS maintains the breeding potential of each species above an implicit limit reference point of SPR_{20}.

The intent of including the size-based indicators was to make the HS more robust to potential biases in longline catch rates as indices of stock abundance. The impact of uncertainty about the extent of linkages between the ETBF and wider Pacific Ocean stocks was investigated as part of the evaluations conducted during 2009. The HS is cost-effective in using data from existing programs that monitor commercial fishing activities. This will necessitate rigorous data verification and the collection of auxiliary data—for example, independent estimates of trends in fishing mortality and the level of discarding.

Yellowfin tuna, Sydney Fish Market
PHOTO: FIONA SALMON, DAFF

22.3 THE 2009 FISHERY

Total longline catches decreased from 6685 t in 2008 to 6086 t in 2009 (both target and byproduct species combined). However, annual longline effort in the ETBF increased from 8.06 million hooks in 2008 to 8.82 million hooks in 2009 (Table 22.2, Fig. 22.2). Effort has fallen from a peak of 12.40 million hooks in 2003, as a result of decreases in catch rates, the strength of the Australian dollar, increased operating costs, implementation of a TAC for swordfish and, possibly, the surrender of permits under the 2006 restructure package. A total of 55 vessels reported longlining during 2009.

Total minor-line catches increased from 25.6 t in 2008 to 131.5 t in 2009. There were 11 active minor-line vessels during 2009. The number of vessels that reported using minor line has steadily decreased from a peak of 52 vessels in 2001 (Table 22.2). Annual minor-line effort decreased from 310 lines in 2008 to 164 lines in 2009. This is a decrease from a peak of 975 lines in 2007. Effort in the minor-line sector does not follow the same declining trend as the number of active vessels; the peak effort in 2007 was during a year with only 21 vessels active.

The heavy-tackle recreational gamefish fishery for large black marlin (*Makaira indica*) off the Great Barrier Reef between Cairns and Lizard Island (October–November 2009) was reportedly substantially better than in the previous two years. Most charter vessels reported successful tagging and release of good numbers of large to very large marlin, with fish being present throughout the season, along the outer reef. Favourable currents were deemed to be a major contributing factor, in contrast to the previous poor seasons during which colder currents from the south persisted.

Juvenile black marlin did not appear in any numbers off Townsville in August–September 2009, resulting in a lack of this year-class in southern Queensland and New South Wales waters the following summer. However, larger black marlin ranging from 50 to 100 kg appeared in good numbers off the Sunshine Coast, extending to Port Stephens.

Striped marlin continued to dominate the recreational billfish catch in New South Wales, while blue marlin (*Makaird nigricans*) were largely absent from the wider grounds for the first time in many years. Large dolphinfish (15 to 25 kg) were a feature of the gamefish fishery in New South Wales, while yellowfin tuna were largely absent.

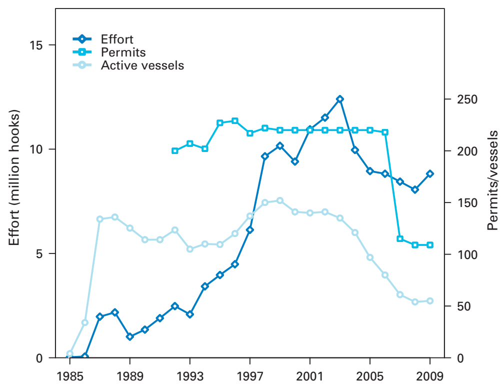


FIGURE 22.2 Longline effort in the ETBF, 1985 to 2009

Total gross value of production (GVP) for the ETBF increased by 18% in 2008–09, from $33 million in 2007–08 to $38.9 million in 2008–09 (2008–09 dollars). Although this is a substantial increase, GVP still remains well below the peak recorded in 2001–02 of $96.6 million (Fig. 22.3).

Historically, yellowfin tuna has typically been the dominant species in the fishery in gross value terms, with the exception of 2007–08, when bigeye tuna was the dominant species following a historical high catch in that year. In 2008–09 a 40% increase in yellowfin tuna prices, combined with a 31% increase in yellowfin tuna catch, resulted in this species once again becoming the dominant species in value terms. It accounted for $14.3 million or 37% of GVP. Price increases also occurred for all other key species in the fishery, with the exception of striped marlin. Bigeye tuna value declined by 28% from $11.2 million in 2007–08 to $8.1 million in 2008–09. Another key change in 2008–09 was a 60% increase in the value of albacore catch, to $4.6 million, the second highest value recorded for this species. The value of broadbill swordfish and striped marlin tonnage both increased by 8% in 2008–09, to $7.3 million and $2.7 million, respectively. The trend in the value of striped marlin (increase in value) differs from the trend of striped marlin catches (decrease in catch) reported earlier due to differences in reporting catches for financial year (1 July–30 June) versus calendar year.

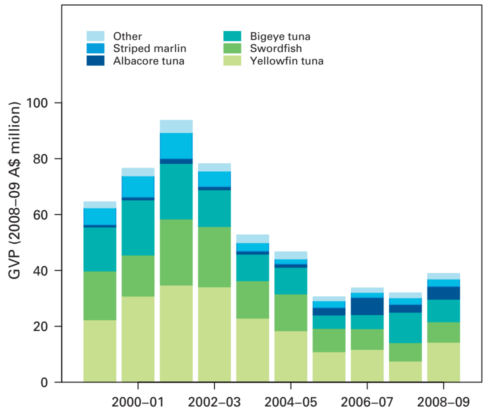


FIGURE 22.3 GVP in the ETBF by financial year, 1999–2000 to 2008–09

Estimates of the value and volume of the fishery's exports can be drawn from tuna export data after SBT exports have been removed. However, these data also include exports from the much smaller Western Tuna and Billfish Fishery (WTBF). Total tuna exports (excluding SBT) were valued at $19 million in 2008–09. The principal destination for Australian tuna is Japan, which received $12.5 million or 66% of total tuna exports (excluding SBT) in value terms in 2008–09. The United States, Spain, American Samoa and New Zealand were also important markets in 2008–09, receiving 8%, 6%, 6% and 5%, respectively, of Australian exports in value terms.

Australia exports a range of tuna-based products, many of which have been derived from the ETBF. Of species caught in the fishery, bigeye tuna was the fishery's most important export commodity in 2008–09, with Australian exports of this species valued at $5.9 million. This was closely

followed by yellowfin tuna, valued at $5.6 million in 2008–09. Albacore exports were valued at $4.5 million, and exports of swordfish were valued at $3.6 million.

Minor byproduct species

Commercial markets have developed in Australia and overseas for several other byproduct species, including mahi mahi (*Coryphaena hippurus*) and wahoo (*Acanthocybium solandri*). The ETBF has catch limits in place for longtail tuna (35 t) and sharks (20 sharks per vessel per fishing trip). ETBF fishers are able to take unlimited amounts of moonfish, rudderfish and escolar (AFMA 2009b). Table 22.4 lists byproduct species taken in recent years.

TABLE 22.4 Minor byproduct species—TACs/triggers, catches/landings and discards in the ETBF

Species	TAC/ trigger	2008 catch (tonnes)	2008 discards (number of individuals)	2009 catch (tonnes)	2009 discards (number of individuals)
Blacktip sharks (*Carcharhinus* spp.)	Trip limits	5	0	5	0
Blue shark (*Prionace glauca*)	Trip limits	5	1807	23	2769
Bronze whaler shark (*Carcharhinus brachyurus*)	Trip limits	5	266	16	407
Dusky shark (*Carcharhinus obscurus*)	Trip limits	1	296	4	716
Hammerhead sharks (*Sphyrna* spp.)	Trip limits	3	0	4	0
Indo-Pacific sailfish (*Istiophorus platypterus*)	None	1	0	1	0
Mahi mahi (*Coryphaena hippurus*)	None	170	71	145	114
Moonfish (*Lampris guttatus, L. immaculatus*)	None	63	0	76	0
Northern bluefin tuna (*Thunnus thynnus*)	None	3	0	2	0
Oceanic whitetip shark (*Carcharhinus longimanus*)	Trip limits	3	101	4	147
Oilfish (*Ruvettus pretiosus*)	None	148	121	96	117
Ray's bream (*Brama brama*)	None	45	0	41	0
Rudderfish (*Centrolophus niger*)	None	234	151	206	315
Sharks, other	Trip limits	0	173	1	326
Shortbilled spearfish (*Tetrapturus angustirostris*)	None	16	0	18	0
Shortfin mako shark (*Isurus oxyrinchus*)	Trip limits	54	150	69	468
Silky shark (*Carcharhinus falciformis*)	Trip limits	2	0	0	0
Skipjack tuna (*Katsuwonus pelamis*)	None	25	18	15	215
Southern bluefin tuna (*Thunnus maccoyii*)[a]	Quota	22	0	205	0
Tiger shark (*Galeocerdo cuvier*)	Trip limits	3	94	4	169
Wahoo (*Acanthocybium solandri*)	None	44	0	41	0

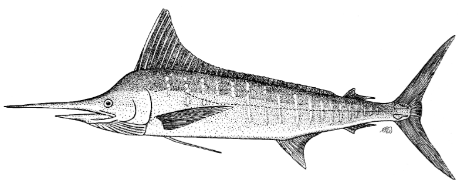
a Managed under quota in the Southern Bluefin Tuna Fishery (see Chapter 24)

On 29 January 2010, porbeagle, shortfin mako and longfin mako sharks were listed as migratory species under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The listing of the species is a legislated requirement following their listing in Appendix II of the International Convention on Migratory Species. Under the EPBC Act, it is an offence to take, trade, keep or move a member of a listed migratory species. However, actions taken under accredited fisheries management plans or arrangements are exempt from these offence provisions. The WTBF is an accredited fishery. The Australian Government Department of the Environment, Water, Heritage and the Arts has advised that this exemption allows commercial fishers to retain and trade the three shark species if they are brought up already dead, but requires that live caught sharks must be returned to the sea unharmed. All catches of these sharks, whether retained or released, must be reported in the daily fishing logbooks.

22.4 BIOLOGICAL STATUS

STRIPED MARLIN

(*Tetrapturus audax*)



LINE DRAWING: FAO

Striped marlin PHOTO: JULIAN PEPPERELL

TABLE 22.5 Biology of striped marlin

Parameter	Description
Range	**Species:** 46°N–47°S, 19°E–69°W; highly migratory pelagic species; distributed throughout tropical and subtropical waters of the Pacific Ocean. The south-western Pacific Ocean (SWPO) stock is regarded as a semidiscrete stock. Tagging studies suggest little mixing of adults across the SWPO. Mixing of juveniles is unknown. **Stock:** The boundaries for SWPO stock assessment purposes include the area from the equator to 40°S and from 140°E to 130°W. Historically, Japan, Fishing Entity of Taiwan, Korea, Australia, New Zealand, China and Pacific Island countries have contributed the major catches within this stock assessment region.
Depth	0–200 m, usually occurring in the upper mixed layer (<40 m)
Longevity	~11 years
Maturity (50%)	**Age:** females ~1.9 years; males ~1.4 years **Size:** females ~203 cm; males ~189 cm
Spawning season	October through January in the southern hemisphere. Concentrated spawning activity takes place during November–December; sparsely aggregated spawning grounds.
Size	**Maximum:** 265 cm lower jaw fork length (LJFL); 244 kg whole weight. Males and females grow to a similar size. **Recruitment into the fishery:** 86 cm LJFL; 4.2 kg (the average weight of striped marlin caught by Australian longliners is ~90 kg whole weight)

SOURCES: Bromhead & Pepperell (2004); Langley et al. (2006); Kopf & Davie (2009).

ETBF: Catches of striped marlin decreased in 2009 to 361 t, from 425 t landed in 2008 (Fig. 22.4). Longliners fishing for tuna and swordfish take substantial catches of striped marlin in the Pacific Ocean. Most catches are thought to be caught indirectly while longline gears are hauled or shot through the mixed layer of the water column (Kopf & Davie 2009). Higher catches of striped marlin have predominantly occurred in high-abundance spawning and feeding aggregations during recognised periods of the year. Other longline fleets, including Japan, Korea, Fishing Entity of Taiwan, New Caledonia and Fiji, also report catches of striped marlin as a byproduct during fishing for tunas and swordfish. In addition, both Australia and

New Zealand have large recreational fishing sectors for striped marlin (Langley et al. 2006). No striped marlin were caught by the ETBF minor-line sector in 2008 or 2009.

WCPFC convention area: The 2008 catch (1721 t) of striped marlin south of the equator was less than in 2007 (1995 t) and 2006 (2156 t) (Fig. 22.5).

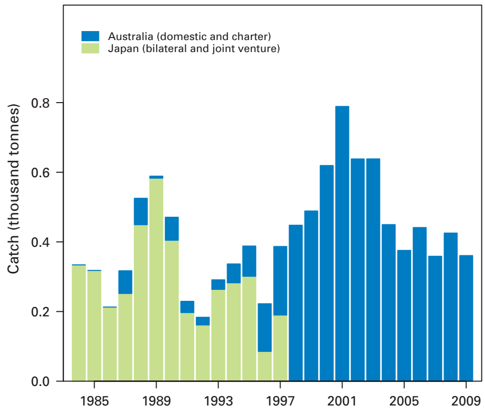


FIGURE 22.4 Striped marlin catch history (ETBF), 1984 to 2009

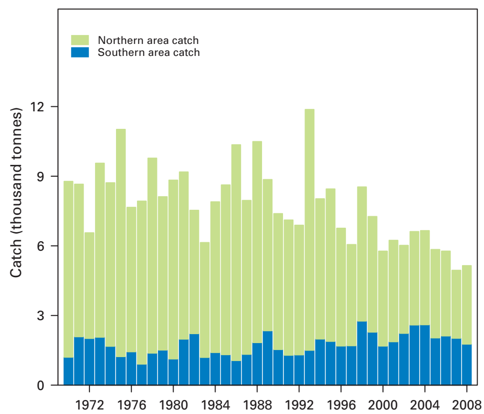


FIGURE 22.5 Striped marlin catch history (WCPFC convention area), 1970 to 2008

NOTE: 2009 data are currently unavailable from the WCPFC.

Stock status determination

No stock assessment was conducted for south-western Pacific Ocean (SWPO) striped marlin in 2009. The only assessment of striped marlin in the SWPO was undertaken in 2006 by the ABARE–BRS and the Secretariat of the Pacific Community (SPC) (Langley et al. 2006). This assessment was considered to be preliminary as there was a great deal of uncertainty regarding key parameters, particularly natural mortality and growth. The assessment highlighted significant declines in abundance, particularly in the 1950s and early 1960s, when Japanese longliners targeted the species in the Coral Sea. However, several of the plausible scenarios indicated that current fishing mortality equalled or exceeded F_{MSY}, and current spawning biomass levels equalled or were below the level that would support maximum sustainable yield (MSY). The WCPFC Scientific Committee (SC) subsequently recommended that, as a precautionary measure, there be no increase in striped marlin fishing mortality in the south-western Pacific, particularly in the area encompassing the Coral and Tasman Seas, as these fisheries account for the majority of the striped marlin catch in this area. The stock status description and the management recommendations from the 2006 assessment and the WCPFC SC remain current.

Catches over the past two decades within the SWPO have been relatively stable (Fig. 22.5), and recent biological work (see Kopf & Davie 2009) suggests a more optimistic outlook for the stock (higher productivity). However, it is premature to speculate how stock status would change with changes in some of the key productivity parameters to the stock assessment model for the SWPO. Therefore, both the overfished and overfishing status for striped marlin remain **uncertain** (Table 22.1) and are likely to remain so until the formal stock assessment is updated.

Reliability of the assessment/s

There is considerable uncertainty surrounding some of the key inputs to the model—in particular, natural mortality and growth. However, from a management perspective, current catch levels for the area are comparable with the range of MSY estimates calculated.

Previous assessment/s

None.

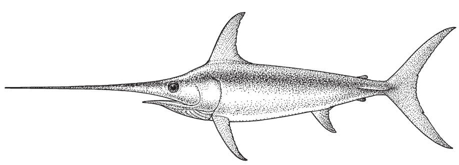
Future assessment needs

A recent study, completed in 2009, provided the first reliable estimates of important biological parameters pertaining to age, growth and reproduction dynamics for the SWPO stock (see Kopf & Davie 2009). This is now believed to be the most current and reliable biological information available and will be pivotal to future stock assessments for striped marlin in the SWPO.

Additional work to benefit future assessment includes tagging research to determine movement patterns and dispersal rates from spawning grounds, and the duration and frequency of spawning events (Table 22.5) in the Coral Sea; a more comprehensive analysis of catch and effort data, particularly variations in targeting and fishing power of the Japanese longline fleet; more accurate estimates of catches, retention and discard rates by the New Zealand commercial longline fleet; and incorporation of historical size data from the commercial catch.

SWORDFISH

(*Xiphius gladius*)



LINE DRAWING: GAVIN RYAN

Swordfish on longline PHOTO: JAY HENDER, ABARE–BRS

TABLE 22.6 Biology of swordfish

Parameter	Description
Range	**Species:** 60°N–50°S with a worldwide distribution, including the Mediterranean. Highly migratory pelagic species; large, solitary adults are most abundant at 15–35° north and south of the equator. Distribution varies with sex—large females more common at higher latitudes, and males in tropical and subtropical waters. **Stock:** Genetic studies suggest several semi-independent stocks (a northern stock, a south-western stock and two or three eastern Pacific Ocean stocks). The boundary for SWPO stock assessment purposes is the southern region of the WCPFC convention area, defined as 0–50°S and 140°E–130°W.
Depth	During the day, in deeper waters (down to 700 m, may dive to 1000 m). At night, move to surface waters to feed.
Longevity	30+ years
Maturity (50%)	**Age:** females 6–7 years; males 1–3 years **Size:** females ~150 cm orbital fork length (OFL); males ~90 cm OFL
Spawning season	The extent and duration of spawning are linked with sea-surface temperature, with spawning activity greatest at sea-surface temperatures above 24 °C. Off eastern Australia, spawning lasts from September to March, with the main activity between December and February.
Size	**Maximum:** ~455 cm TL; 536.15 kg whole weight. Sexual dimorphism in size, growth rates, and size and age at maturity—females reach larger sizes, grow faster and mature later than males. Most swordfish larger than 200 kg are female. **Recruitment into the fishery:** Swordfish start being caught in the ETBF at ~6.5 kg; the average weight of broadbill swordfish caught by Australian longliners is ~62 kg whole weight.

SOURCES: Nakamura (1985); Young et al. (2003); Campbell (2008); Kolody et al. (2008); Pepperell (2009).

ETBF: Catches of swordfish decreased in 2009 to 1315 t, from 1483 t in 2008 (Fig. 22.6). The TAC is set on a financial-year basis; catches in the 2007–08 and 2008–09 financial years were below the 2009 TAC of 1400 t. No swordfish were caught by the ETBF minor-line sector in 2008 and 2009.

WCPFC convention area: The total catch for swordfish for 2008 was 26 190 t,

slightly lower than the record set in 2007 (26 522 t) (Fig. 22.7). Of this catch, 12 983 t was caught in the SWPO area, south of 20°S.

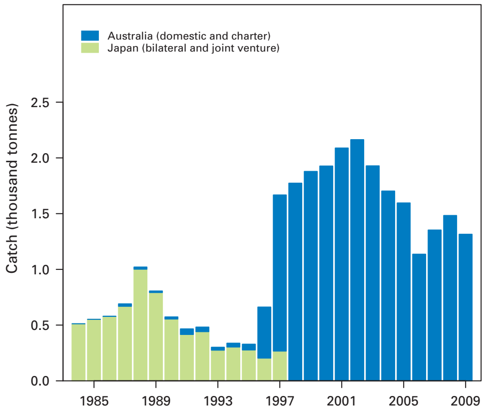


FIGURE 22.6 Swordfish catch history (ETBF), 1984 to 2009

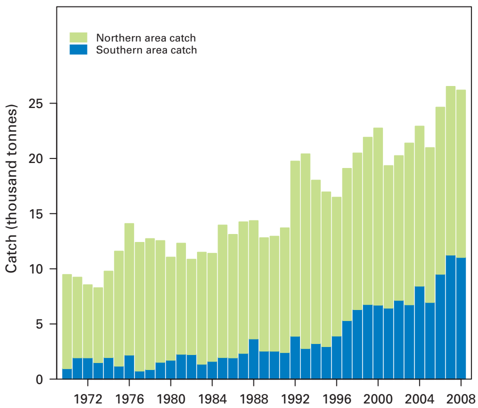


FIGURE 22.7 Swordfish catch history (WCPFC convention area), 1970 to 2008

NOTE: 2009 data are currently unavailable from the WCPFC.

Stock status determination

No new assessment for swordfish was undertaken by the WCPFC in 2009. Thus, the 2008 assessment (Kolody et al. 2008) and updated catch and effort data were used to determine stock status. MULTIFAN-CL software was used to conduct the 2008 assessment (Kolody et al. 2008). The important changes from the previous assessment included a refined spatial structure, two to three years of new catch and effort data, revised estimates of migration from tagging data, and recognition of increased uncertainty in growth rates and age at maturity. Recent increases in CPUE by the Australian and New Zealand fleets, combined with substantially decreased nominal catch and effort, improved the signal in the data available for the assessment and suggested that the stock may be rebuilding. Total adult biomass was estimated to have declined by approximately 42% in 2007 from unfished levels (B_{2007}/B_0 = 0.58, range 0.45–0.79), while spawning stock biomass had declined by approximately 57% (SSB_{2007}/SSB_0 = 0.43, range 0.31–0.63) (Kolody et al. 2008).

In terms of the MSY-based reference points used by the WCPFC, fishing mortality in relation to MSY (F_{2007}/F_{MSY}) was estimated at approximately 0.44 (range 0.18–0.67). Since the estimate of current spawning biomass is close to the HSP default target of 0.48 (B_{MEY}), and recent catches are well below the estimate for MSY, swordfish in the south-west Pacific is assessed as **not overfished** and **not subject to overfishing** (Table 22.1).

Reliability of the assessment/s

There is still some uncertainty surrounding stock structure of swordfish in the southern Pacific Ocean, which affects the interpretation of the stock assessment results. The apparent fidelity of swordfish to particular areas (i.e. seamounts) is a matter for concern, as this can lead to localised depletion. Localised depletion has been used as a factor in determining an overfishing status for swordfish in the Indian Ocean (see Chapter 25). Some trends in catch rates may be misleading (with respect to biomass/abundance trends) due to operational factors that could influence catchability. There is uncertainty about the growth of swordfish, in part due to different methods used for estimating ages. Hence, the current assessment includes models that span this uncertainty in growth and size at maturity. Other uncertainties include the following:

- The stock–recruitment relationship could not be reliably estimated, and there is some evidence for shifting recruitment regimes in both the south-western and the south-central Pacific Ocean.

- Commercial catch rates are used as relative abundance indices, and the effectiveness of the standardisation methods is unknown.
- There are recent conflicting trends between the Australia/New Zealand and the Japanese CPUE series.
- The migratory link between the SWPO, south-central Pacific Ocean and broader Pacific (and possibly Indian Ocean) populations remain poorly quantified.
- Growth rates, maturity schedules and natural mortality for this species remain poorly quantified (Kolody et al. 2008).

Previous assessment/s

There is no specific swordfish assessment for the ETBF. The stock in the SWPO is assumed to be independent of the broader Pacific Ocean stocks. In 2006 the first stock assessment of swordfish in the SWPO was undertaken by Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO), in collaboration with New Zealand. Two assessment packages were used, MULTIFAN-CL and CASAL. As the MULTIFAN-CL assessment included an extensive exploration of model uncertainty, its results formed the basis for the stock summary. The assessment explored a variety of plausible scenarios and assumptions, but no definitive conclusions were made on stock status. Nevertheless, the assessment showed consistent declines in stock abundance in recent years, and most model projections predicted further declines at current levels of fishing mortality. The WCPFC SC concluded that any further increases in fishing mortality would probably move swordfish in the SWPO to an overfished state.

Future assessment needs

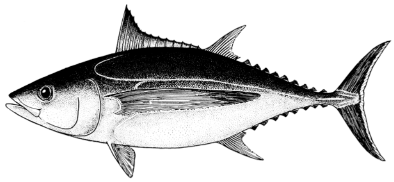
Assessments would be improved by comparing methods for estimating age and maturity of swordfish, direct validation of ageing methods, and collection of additional gear deployment (targeting) data to improve understanding of commercial catch rate. Ideally, this might include some portion of the commercial fleet setting standardised gear with consistent survey methodology; research into the relationship between fish distributions and movement in relation to oceanographic variability; collection and exchange of better catch composition data for all fleets (length, mass and sex); and direct age estimation from otoliths. Existing data (e.g. Spanish fleet catch size composition data for 2005 to 2008) should be included, as well as electronic, conventional and genetic tagging programs to help quantify migration characteristics within the south-western to south-central Pacific and adjacent waters.

The complex migration patterns of swordfish and sexual differences in growth rates (Table 22.6) mean that size-composition monitoring should also record catch location and swordfish sex. This would require monitoring at sea because swordfish are landed gilled and gutted.

Swordfish being offloaded PHOTO: JOHN KALISH, ABARE–BRS

ALBACORE TUNA

(*Thunnus alalunga*)



LINE DRAWING: FAO

TABLE 22.7 Biology of albacore tuna

Parameter	Description
Range	**Species:** Highly migratory pelagic species. Widely distributed throughout the world's oceans from 59°N to 46°S and from 180°W to 180°E. **Stock:** A discrete stock in the south Pacific. The boundaries for stock assessment purposes include the area of the Pacific Ocean south of the equator and 140°E to 110°W.
Depth	0–600 m; mostly caught in waters less than 300 m
Longevity	>14 years
Maturity (50%)	**Age:** 5–6 years **Size:** females ~85 cm FL; males ~60 cm FL
Spawning season	November–March; spawn in subtropical and tropical waters (~10°S–25°S)
Size	**Maximum**: ~127 cm FL; 40 kg whole weight **Recruitment into the fishery:** ~45–50 cm FL. The average weight of albacore caught by Australian longliners is ~15 kg.

SOURCES: Collette & Nauen (1983); Shomura et al. (1993); Campbell (2008); Hoyle & Davies (2009); Pepperell (2009).

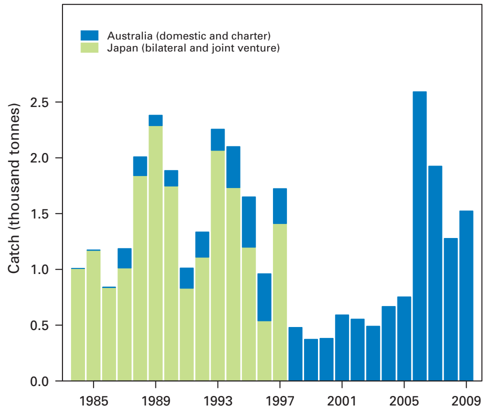


FIGURE 22.8 Albacore tuna catch history (ETBF), 1984 to 2009

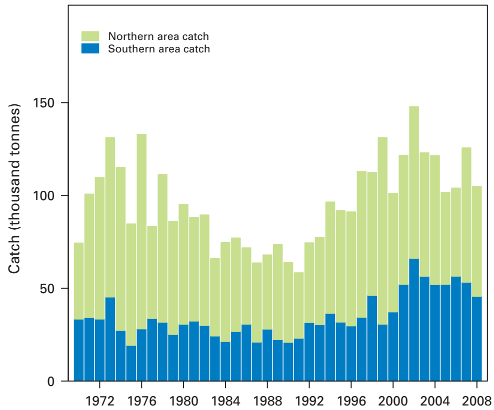


FIGURE 22.9 Albacore tuna catch history (WCPFC convention area), 1970 to 2008

NOTE: 2009 data are currently unavailable from the WCPFC.

ETBF: Catches of albacore tuna by the longline fleet increased in 2009 to 1523 t, up from 1277 t landed in 2008 (Fig. 22.8). No albacore tuna was caught by the ETBF minor-line sector in 2009; 0.84 t was caught in 2008.

WCPFC convention area: The 2008 south Pacific albacore catch (51 672 t) was lower than in 2007 (59 495 t) (Williams & Terawasi 2009) and the record catch of 69 273 t taken in 2006 (Fig. 22.9); however, it was still within the higher range of catches achieved since 2001 (51 000–66 000 t). Longline has accounted for the majority (>75%) of south Pacific albacore catch, except in 1989, when driftnets accounted for the majority.

Stock status determination

A full stock assessment on south Pacific albacore tuna was conducted by the SPC (using MULTIFAN-CL) in 2008, and a comparative assessment was conducted in 2009 (Hoyle & Davies 2009). In the 2009 assessment, many of the model's underlying structural assumptions were reviewed, with a focus on providing reliable estimates of population dynamics. Major changes to model data inputs and structure in the base case included an update of catch, effort and size data to mid-2008; revised CPUE from a General Linear Model for distant-water fishing nation longline fisheries; time-dependent variance in CPUE; changes to

growth modeling; monthly data aggregation for troll fisheries; model timing changed to mid-year; time splits in longline selectivity and first age bias in troll selectivity; use of 0.75 rather than 0.9 for stock–recruitment steepness; and catchability decline estimated for the initial stages of the fishery (Hoyle & Davies 2009).

The estimate of current spawning biomass relative to the spawning biomass in the absence of fishing ($SB_{2007}/SB_{2007, F=0}$) was estimated at 0.64, indicating that the fishery is not in an overfished state. Recent catches of south Pacific albacore (59 495 t and 51 672 t in 2007 and 2008, respectively) have been below the MSY estimate of 81 580 t (Hoyle & Davies 2009). Since the estimate of current spawning biomass is well above the HSP default target of 0.48 (B_{MEY}), and recent catches are well below the estimate for MSY ($F_{current}/F_{MSY} = 0.29$), the south Pacific albacore tuna stock is assessed as **not overfished** and **not subject to overfishing** (Table 22.1).

Reliability of the assessment/s

The latest stock assessment produced stock size and MSY based on a credible model, with many sources of potential bias removed from the previous assessment in 2008. However, there remains considerable uncertainty about the early trend in biomass, which impacts on the reliability of depletion-based reference points. The 2009 assessment results differ moderately from the results of the 2008 assessment due to the changes in relative abundance indices, splits in selectivity, assumed values of steepness and changes in growth modelling. These changes have resulted in a more realistic and credible model that fits the data better. The problems with bias in the CPUE series that result from switches in targeting, which were identified in 2008, appear to have been largely resolved. The conflict between information in the CPUE and the longline length-frequency data remains, but its effects have been reduced. The new growth estimates fit the troll fishery length-frequency data well and are close to estimates derived from otoliths.

Previous assessment/s

The 2008 South Pacific albacore assessment by the SPC (conducted using MULTIFAN-CL) differed considerably from the 2006 assessment (Hoyle et al. 2008). This was due to changes in relative abundance indices (specifically, the inclusion of standardised CPUE data as relative abundance indices for the Japanese, Korean and the Fishing Entity of Taiwan longline fisheries, and the New Zealand troll fishery), selectivity, and biological parameters for natural mortality and reproductive potential. These represent changes to the data inputs of the assessment and model structure, as well as refinements to the model specification; the resulting estimates indicated that spawning biomass was lower and fishing mortality higher than indicated by earlier assessments.

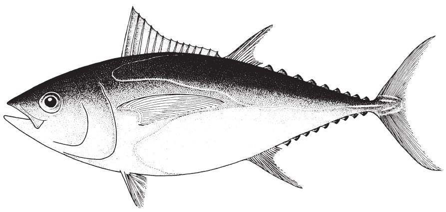
The WCPFC SC noted that, despite improvements to model-fit in 2008 and the removal of some biases, significant fitting problems remained, with contradictory trends in size and CPUE. In particular, recent fishing mortality estimates were uncertain, and $F_{current}/F_{MSY}$ was strongly affected by the structural model uncertainty. Some of the structural uncertainty was related to the failure to model the increasing length of fish selected by the fishery through time. Additional uncertainty is associated with the recent large decline in standardised CPUE of the Fishing Entity of Taiwan fleet and whether this accurately reflected a decline in biomass.

Future assessment needs

Reducing parameter uncertainties for south Pacific albacore, including selectivity, and understanding recent declines in CPUE trends for the Fishing Entity of Taiwan fleet are considered a high priority.

BIGEYE TUNA

(*Thunnus obesus*)



LINE DRAWING: FAO

TABLE 22.8 Biology of bigeye tuna

Parameter	Description
Range	**Species:** 40°N–40°S, 180°W–180°E; highly migratory pelagic species; inhabit tropical and subtropical waters worldwide in temperatures of 13–29 °C, except for the Mediterranean Sea. **Stock:** Genetic studies indicate a single stock across the Pacific Ocean. The boundary for stock assessment purposes is the area of the western and central Pacific Ocean, defined as 40°N–35°S and 120°E–150°W.
Depth	0–250 m
Longevity	~16 years
Maturity (50%)	**Age:** ~3 years **Size:** ~36 kg
Spawning season	Spawn in equatorial waters throughout the year (15°N–15°S)
Size	**Maximum:** 197 kg whole weight **Recruitment into the fishery:** Bigeye tuna start being caught in the ETBF at ~11 kg. The average weight of bigeye caught by Australian longliners is ~37 kg.

SOURCES: Collette & Nauen (1983); Shomura et al. (1993); Campbell (2008); Harley et al. (2009); Pepperell (2009).

ETBF: Catches of bigeye tuna by the longline fleet decreased to 726 t in 2009, from 1026 t in 2008 (Fig. 22.10). Catches by the ETBF minor-line sector increased from 4.7 t in 2008 to 109.3 t in 2009.

WCPFC convention area: The total bigeye catch for 2008 (157 054 t) was the second highest on record (Fig. 22.11; after 2004—157 173 t), mainly due to the relatively high estimated catch from the purse-seine fishery (Williams & Terawasi 2009). The provisional purse-seine catch estimate for bigeye tuna for 2008 (46 811 t) was the highest on record. However, this may be revised after all the observer data for 2008 have been received and processed. Provisional bigeye longline catch (87 504 t) was the third highest on record.

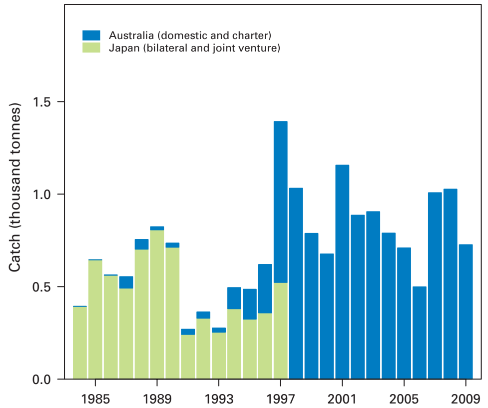


FIGURE 22.10 Bigeye tuna catch history (ETBF), 1984 to 2009

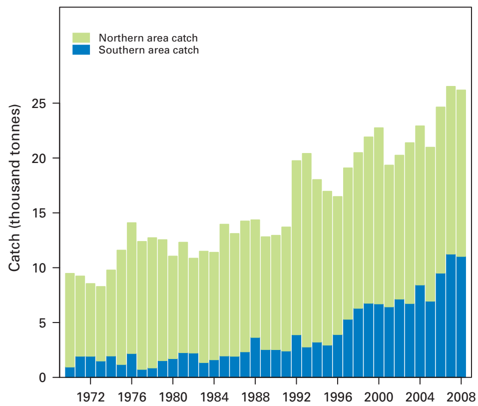


FIGURE 22.11 Bigeye tuna catch history (WCPFC convention area), 1970 to 2008

NOTE: 2009 data are currently unavailable from the WCPFC.

Stock status determination

The bigeye tuna assessment in 2009 (Harley et al. 2009) is comparable to the 2008 assessment (Langley et al. 2008), with the following modifications: updating of catch, effort, and size data for 2007, and incorporation of some limited data for the 2008 fishing year; revisions to recent historical data for some fisheries (e.g. since 2000); an extended purse-seine catch

history that partially corrected for logsheet reporting bias; new standardised CPUE series for the main longline fisheries based on an improved methodology; and exclusion of some historical size data from the Philippines, which previously contained samples from the Indian Ocean (Harley et al. 2009).

In the 2009 assessment, the impacts of changes in data, weighting of different data sources, key parameter values, and other structural model assumptions were examined. Although a range of values for the stock–recruitment parameter of steepness were used in model runs (0.55 to 0.98; WCPFC 2010), we consider that the value of 0.75 is the most plausible, based on the biology of similar species. Harley et al. (2009) also indicate that the level of depletion can be estimated when the non-equilibrium nature of recent recruitment is taken into account.

Spawning biomass (averaged over the period 2004–2007) is estimated at 12% of the level predicted to exist in the absence of fishing ($SB_{2004–2007}/SB_{2004–2007,\ F=0} = 0.12$); for 2008 spawning biomass levels, the value is 9% ($SB_{2008}/SB_{2008,\ F=0} = 0.09$). The bigeye tuna stock is therefore assessed as **overfished** (Table 22.1).

In terms of the MSY-based reference points used by the WCPFC, fishing mortality in relation to MSY ($F_{2004–2007}/F_{MSY}$) is 2.55. A 61% reduction in fishing mortality from the 2004–07 level would be required to reduce fishing mortality to sustainable levels. Harley et al. (2009) also used a range of other steepness values, but all model runs conclude that the stock is **subject to overfishing**.

Under the WCPFC conservation and management measure for bigeye and yellowfin tuna (CMM-2008-01; WCPFC 2008), bigeye tuna fishing mortality is to be reduced by 30% from the annual average for 2001–04 (~130 000 t; ~91 000 t after the 30% reduction) or 2004 catches (~157 000 t; ~141 000 t after the 30% reduction), over a three-year period, commencing in 2009. Bigeye catches have since averaged ~146 000 t (for 2005–2008), with 2008 seeing near-record catches (157 054 t). These current catch levels are higher than those under a 30% cut required from 2009 onwards. Recent catches are almost triple the most plausible estimate of MSY of 52 120 t (Harley et al. 2009).

The 2009 stock assessment indicates a continued decline of the spawning stock biomass of the western and central Pacific Ocean (WCPO) bigeye stock, as noted in previous assessments. The combination of increased fishing mortality on bigeye tuna to levels well above F_{MSY}, as documented in the 2009 assessment, and the inadequacy of the conservation and management measure adopted by the WCPFC to reduce fishing mortality by 30% implies that spawning stock biomass will continue to decline if effective action is delayed. Identifying and implementing effective management measures to address the inadequacy of the conservation and management measure is the most urgent issue facing the Commission with regard to maintaining the sustainability of target tuna stocks.

Reliability of the assessment/s

The bigeye tuna assessment is considered comprehensive, although data from 2008 were not complete for some fisheries—most notably the distant water longline fisheries—at the time of the assessment. There are indications that the high recruitment estimated in this and previous bigeye tuna assessments may be an artefact of structural assumptions of the model rather than actual recruitment.

Previous assessment/s

There is no specific bigeye tuna assessment for the ETBF. It is unlikely that bigeye tuna occurring in the area of the ETBF comprise a separate stock, though some separation from the broader WCPO stock is feasible (Table 22.8). A similar modelling approach (MULTIFAN-CL) was used in the 2008 assessment (Langley et al. 2008). The 2008 assessment included additional fisheries and changes in fishery configurations from the 2006 assessment (Hampton et al. 2006); however, these represented refinements to the model rather than substantive changes to structure. For several years, age and spatially structured assessment models have consistently

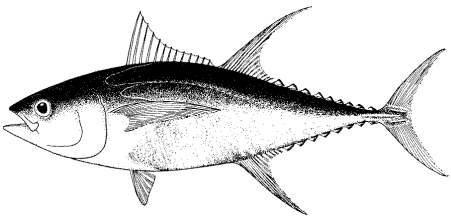
indicated that overfishing of bigeye tuna is occurring in both the WCPO and the eastern Pacific Ocean. Previous assessments estimated that fishing mortality was at least 25% above the level that would produce MSY. For bigeye tuna, the greatest impact from fishing is in equatorial waters; bigeye tuna at higher latitudes, such as in the ETBF, was estimated to be moderately exploited.

Future assessment needs

Future assessment needs include the refinement of bigeye tuna parameters (including age, growth and reproductive biology), refined estimates of historical bigeye tuna catch by purse seiners, and the continuation of the Indonesia and Philippines Data Collection Project.

YELLOWFIN TUNA

(*Thunnus albacares*)



LINE DRAWING: FAO

Yellowfin tuna, Sydney Fish Market
PHOTO: FIONA SALMON, DAFF

TABLE 22.9 Biology of yellowfin tuna

Parameter	Description
Range	**Species:** 40°N–40°S, 180°W–180°E; highly migratory pelagic species; inhabit tropical and subtropical waters worldwide except for the Mediterranean Sea. **Stock:** Considered to consist of a single stock in the WCPO. The boundary for stock assessment purposes is the area of the WCPO, defined as 40°N–40°S and 120°E–150°W.
Depth	1–250 m; usually occur in the mixed layer (<100 m)
Longevity	~9 years
Maturity (50%)	Age: ~2 years Size: ~28 kg
Spawning season	Spawn mainly during summer where sea-surface temperatures are at least 26 °C. In equatorial waters, mature females are capable of releasing millions of eggs at a time, and can spawn every 1 or 2 days during the spawning season.
Size	**Maximum:** 176 kg whole weight; 180 cm FL **Recruitment into the fishery:** Yellowfin tuna start being caught in the ETBF at ~9.1 kg. The average weight of yellowfin caught by Australian longliners is ~34 kg whole weight.

SOURCES: Collette & Nauen (1983); Shomura et al. (1993); Lehodey & Leroy (1999); Campbell (2008); Langley et al. (2009); Pepperell (2009).

ETBF: Catches of yellowfin tuna by the longline fleet decreased in 2009 to 1387 t, from 1650 t in 2008 (Fig. 22.12). This is below the record catch of 3148 t in 2003. Catches of yellowfin tuna by the ETBF minor-line sector increased from 3.2 t in 2008 to 19.5 t in 2009.

WCPFC convention area: The total yellowfin tuna catch in 2008 (539 481 t) was the highest on record, nearly 77 000 t (17%) higher than the previous record set in 1998 (462 786 t) (Fig. 22.13; Williams & Terawasi 2009). This new record was primarily due to the record catch in the purse-seine fishery (325 904 t—60% of the yellowfin tuna catch), which increased by approximately 88 000 t from 2007 catches (237 573 t—50% of the catch). The provisional 2008 longline catch for yellowfin tuna (69 516 t) is the lowest since 1999.

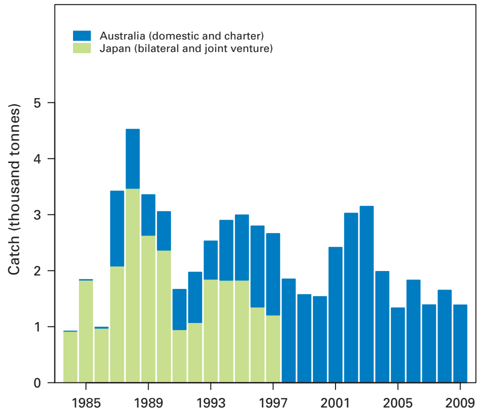


FIGURE 22.12 Yellowfin tuna catch history (ETBF), 1984 to 2009

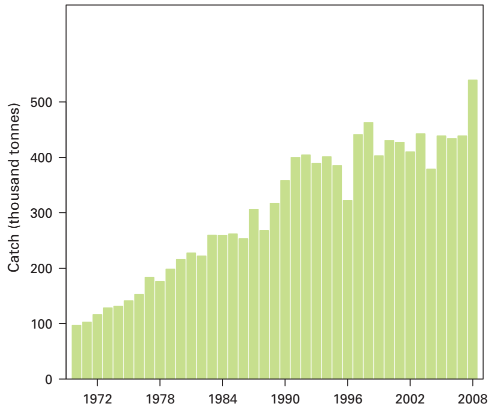


FIGURE 22.13 Yellowfin tuna catch history (WCPFC convention area), 1970 to 2008

NOTE: 2009 data are currently unavailable from the WCPFC.

Stock status determination

Results from the 2009 yellowfin tuna stock assessment (Langley et al. 2009) indicate an improvement in the status of the WCPO yellowfin stock since the previous assessment carried out in 2007 (Langley et al. 2007). The 2009 assessment model is age and spatially structured, and the catch, effort, size composition and tagging data used are classified by fisheries and quarterly time periods from 1952 through 2008. Other differences between the 2007 and 2009 assessments are a result of the input data and structural assumptions used in the 2009 base case assessment, specifically:

- fixing of the steepness parameter of the stock–recruitment relationship (SRR) at a specified level, rather than estimating steepness within the model
- a down-weighting of the effective sample size of the length- and weight-frequency data for all fisheries from 0.1 to 0.2 times the actual sample size
- a revision of the age-specific natural mortality and maturity schedules (mortality-at-age and spawning fraction) (Hoyle et al. 2009)
- a revision of the catch history of the purse-seine fishery that includes a substantially higher level of catch (Lawson 2009)
- a revision of the principal longline CPUE indices (Hoyle 2009)
- a reduction in the penalty on the effort deviations for the principal longline fisheries (from an assumed coefficient of variation of 0.1 to 0.2 with temporal variation in the coefficient of variation of individual observations) and a further reduction in the penalty on the effort deviations via iterative reweighting
- modification of the standardised effort series of the principal longline fisheries to account for the increase in the catchability (fishing efficiency or effort creep) of the longline fleet.

Assuming a moderate value for steepness of the spawner–recruit relationship (0.75), results from the assessment indicate that depletion of the yellowfin tuna stock in the WCPO has increased steadily over time, reaching a level of approximately 59% of unexploited biomass ($B_{current}/B_{current,\,F=0}$ = 0.59), indicating that the stock is not in an overfished state. Although estimates of $SB_{current}/SB_{current,\,F=0}$ were not provided in the stock assessment report by Langley et al. (2009), estimates of $SB_{2004–2007}/SB_0$ (0.53), also indicate that the stock is **not overfished** (Table 22.1).

The 2009 base-case model provided an estimate of the $F_{current}/F_{MSY}$ ratio of 0.58, which was substantially lower than the base-case estimate (0.95) in the 2007 assessment (Langley et al. 2007). This change is largely due to the addition of fisheries data,

assumptions on the steepness parameter, and the period for computing the reference points being advanced two years (from 2002–05 to 2004–07). Estimates of $F_{current}/F_{MSY}$ indicate that the yellowfin tuna stock in the entire WCPO is **not subject to overfishing**, and the entire stock appears to be capable of producing MSY. However, the levels of fishing mortality, exploitation rates and depletion differ between regions. Exploitation rates are highest in the western equatorial region, which accounts for approximately 95% of the total yellowfin tuna catch, and the adult and spawning biomass in this region is estimated to have declined to about 35% and 30%, respectively, of the unexploited level (Langley et al. 2009). No increase in fishing mortality should be permitted in the western equatorial region.

If overfishing criteria were applied at the level of sub-areas within the WCPO, the western equatorial region may be considered subject to overfishing, but not yet overfished, while the remaining sub-areas would be neither overfished nor subject to overfishing. Impacts are considered low off the east coast of Australia, where the ETBF operates.

Under the WCPFC conservation and management measure for bigeye and yellowfin tuna (CMM-2008-01; WCPFC 2008), yellowfin tuna fishing mortality is to remain at the annual average of 2001–04 (~415 000 t) or 2004 catches (~379 000 t), over a three-year period commencing in 2009. Yellowfin tuna catches have since averaged ~463 000 t (for 2005–2008), with 2008 seeing record catches (539 481 t). These current catch levels are substantially higher than those mandated by the conservation management measure. However, catches are lower than the 2009 base case estimate of MSY of 636 800 t (Langley et al. 2009).

Reliability of the assessment/s

Sensitivity analyses were conducted by Langley et al. (2009) to investigate the influence of a range of key model inputs, principally those relating to steepness of the SRR, the levels of catch from the Indonesian/ Philippines and purse-seine fisheries, mortality-at-age, and the western equatorial region CPUE index. The interaction between each of these factors and the other key model assumptions (relative weighting of longline CPUE and size-frequency data and increase in longline catchability) was also examined. Both analyses revealed that most of the uncertainty in estimates of $F_{current}$ and $B_{current}$ relative to MSY-based reference points was attributable to the value of steepness for the SRR. Model options with low values of steepness approached the MSY-based reference points; however, none of the range of model options yielded estimates of fishing mortality exceeding F_{MSY} or levels of current spawning biomass below (or close to) SB_{MSY}. The probability distributions derived from the likelihood profiles were consistent with these observations. Based on the biology of yellowfin tuna and other tuna species, we consider the most plausible value of steepness to be 0.75.

Previous assessment/s

There is no specific yellowfin assessment for the ETBF. The amount of mixing between WCPO and ETBF stocks is uncertain (Table 22.9) ; however, tagging studies are currently in progress to obtain information on movement. The SPC Oceanic Fisheries Program (SPC–OFP) developed an integrated, spatial and age-structured model (MULTIFAN-CL) that estimates population parameters at regional and subregional levels. The 2007 assessment of yellowfin tuna stock status was consistent with the 2005 and 2006 assessments; however, the $F_{current}/F_{MSY}$ ratio for 2007 was slightly lower (0.95, compared with 1.11 in the 2006 assessment) (Langley et al. 2007). This difference was largely due to the new configuration of the fisheries, their updated size data and improvements to the model, and the variations are not considered to be significant. Levels of catch before 2007 and fishing effort were not considered sustainable, with a relatively high probability (47%) that the stock was subject to overfishing.

Future assessment needs

Langley et al. (2009) identified a range of assumptions in the model that should be

investigated through directed research. Further studies are required to refine estimates of growth, natural mortality and reproductive potential, incorporating consideration of spatio-temporal variation and sexual dimorphism; examine in detail the time series of size-frequency data from the fisheries, which may lead to refinement in the structure of the fisheries included in the model; consider size-based selectivity processes in the assessment model; collect age-frequency data from the commercial catch to improve current estimates of the population age structure; improve the accuracy of the catch estimates from a number of key fisheries, particularly those catching large quantities of small yellowfin; refine the methodology and data sets used to derive CPUE abundance indices from the longline fishery; and refine approaches to integrate the recent tag release–recapture data into the assessment model.

22.5 ECONOMIC STATUS

Information available

Since the mid-1990s, the Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences (ABARE–BRS) has regularly surveyed commercial operators in the ETBF and used the collected data to estimate both vessel-level financial performance and fishery-level net economic returns (NER). The most recent survey results are for the 2005–06 and 2006–07 financial years (Vieira et al. 2008). Preliminary non-survey–based estimates of NER are available for the fishery for 2007–08 (Vieira et al. 2010). Collected survey data have also been used to calculate productivity indices and profit decompositions (Kompas et al. 2009) and output to input ratios (Vieira et al. 2010). Estimates of the latent permits in the fishery are also available. There is currently no bioeconomic model for the fishery.

Little information exists about the economic status of the recreational sector of the ETBF. Galeano et al. (2004) assessed the economic values associated with recreational and charter fishing in the ETBF for the 2001–02 financial year. Their findings showed that NER at the time were relatively low in both components of the sector. Since more recent information is not available for the sector, its economic status is not discussed.

Level of latent effort

The ETBF was still being managed under a permit-based system in 2008–09, and many vessels operated under more than one permit. This means that it is difficult to determine how many permits were fished against, even though information about the number of active vessels is obtainable. As recently as 2002–03, 12.7 million hooks were set under the 220 issued permits. Table 22.10 shows that, by 2005–06, only 9.3 million hooks were set under a similar number of permits (218). Under this scenario, the ability of operators to vary the level of fishing effort applied to the fishery meant that effort could fluctuate depending on the NER of the fishery. Positive NER could therefore be dissipated quickly with the activation of latent effort.

Following the buyback of permits through the concession buyback component of the *Securing our Fishing Future* structural adjustment package, permit numbers were halved to 109 in 2006–07, while the number of hooks set remained relatively stable at 8.9 million. This indicates a large reduction in latent effort. Permit numbers remained at 109 in 2008–09, while active vessel numbers declined to 56. Hook numbers also declined slightly from 2006–07 levels, to 8.4 million.

Pole and line fishing, research PHOTO: JAY HENDER, ABARE–BRS

TABLE 22.10 Vessels, permits, hooks and shots in the ETBF

Year	Active vessels	Total permits (per calendar year)[a]	Hooks (millions)	Shots
2004–05	113	220	9.4	9869
2005–06	92	218	9.3	8976
2006–07	71	109	8.9	7314
2007–08	57	109	8.2	6543
2008–09	56	109	8.4	6460

a For example, 2004–05 represents the 2005 calendar year.

SOURCES: AFMA records and logbook data; Evans (2007).

Net economic returns

Between 2003–04 and 2006–07, substantial net economic losses occurred in the fishery. Preliminary estimates of NER suggest a likely improvement in 2007–08 (Fig. 22.14), given reductions in active vessel numbers (and costs) following the *Securing our Fishing Future* package and increased catches of high-value bigeye tuna (Vieira et al. 2010).

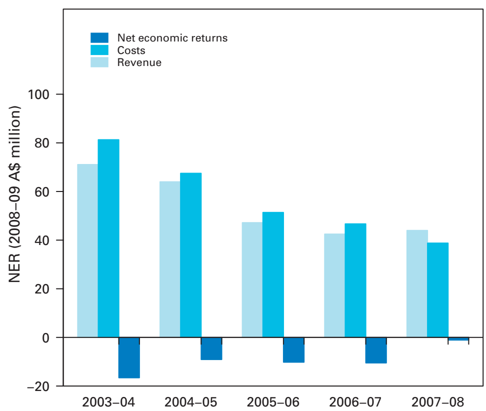


FIGURE 22.14 Real revenue, costs and NER (including management costs) for the ETBF by financial year (2008-09 dollars), 2003–04 to 2007–08

SOURCE: Vieira et al. (2010).

NOTE: Estimates for 2007–08 are non-survey based preliminary estimates.

Estimates of NER are not yet available for 2008–09. However, a few key factors can be identified that were likely to have driven changes to NER in 2008–09, including:

- a 19% increase in real GVP in 2008–09
- reasonably constant vessel numbers
- a 17% decrease in the real average off-road price of diesel, from 102 cents per litre in 2007–08 to 85 cents per litre in 2008–09
- relatively constant effort levels, with a 2.4% increase in hook numbers and a 1.3% decline in shot numbers between 2007–08 and 2008–09.

Together, these factors suggest a positive increase in NER. The increase in GVP in 2008–09 has been generated with similar vessel numbers and effort levels to 2007–08, suggesting that a higher dollar return is being earned for a similar investment of resources in the fishery. The large fall in the diesel fuel price in 2008–09 would also have had a positive impact on NER by putting downward pressure on total costs. Fuel has accounted for around 18% of total vessel-level costs in recent years.

Output-to-input ratio

A fishery level output-to-input ratio can indicate how effectively key fishing inputs have been used to harvest catch over time, but also reflects changes in stock abundance. The ratio presented here takes the form of an index that combines time-series indexes of fishery output (fish catch) and key input use (labour, capital, fuel and repairs) (Vieira et al. 2010).

Aggregate input use in the ETBF has been declining since 2003–04 (Fig. 22.15). The rate of annual decline gradually slowed in every year between 2003–04 and 2006–07 (a 12% decline occurred in 2006–07). However, in 2007–08, the rate of decline increased to 24%. This was a result of the reduction in vessel numbers caused by the *Securing our Fishing Future* package. Estimates of input use are not yet available for 2008–09.

Aggregated output follows a similar trend to input use before 2006–07 (Fig. 22.15). In 2006–07; however, despite a continued fall in input use, aggregated output is estimated

to have increased by 20%. Key drivers were increased catches of albacore, yellowfin and bigeye tuna. In 2007–08 aggregate output declined by only 2%, with falls in yellowfin and albacore catches being offset by a doubling of bigeye tuna catch. The aggregate output index declined by 5% in 2008–09.

Since 2005–06, the output to input ratio has increased relatively rapidly as a result of these changes (Fig. 22.15). In 2006–07 the 20% increase in the aggregated output index and continued falls in input use resulted in a 38% increase in the output-to-input ratio. The increasing trend continued in 2007–08, with a 27% increase in the output-to-input ratio. These changes indicate that outputs are being produced relatively more effectively per unit of input for key inputs in the fishery. For this trend to continue in 2008–09, input use would need to continue to decline, given relatively constant output.

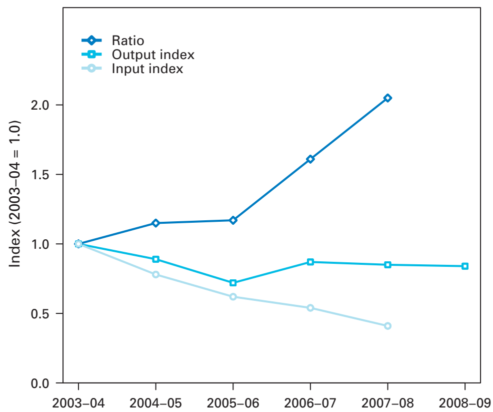


FIGURE 22.15 Indexes of input use, output and output-to-input ratio for the ETBF, 2003–04 to 2008–09

NOTE: Estimates for 2007–08 are non-survey based preliminary estimates. Base year for indexes is 2003–04.

Vessel-level performance

Real GVP per vessel has followed an increasing trend since 2005–06 (Fig. 22.16). In 2008–09 a 19% increase in average prices and a 3% increase in catch per vessel resulted in a 22% increase in GVP per vessel to $695 000. Price increases occurred for all key species groups in that year. A decline in catches of highly valued bigeye tuna in 2008–09 resulted in a 28% decline in its relative share of GVP, while a large increase in yellowfin tuna catch per vessel resulted in its share of GVP per vessel increasing by 89%.

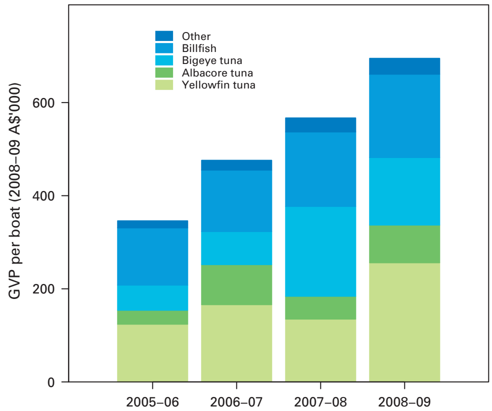


FIGURE 22.16 Real GVP by species per vessel in the ETBF, 2005–06 to 2008–09 (2008–09 dollars)

NOTE: Estimates for 2007-08 are non-survey based preliminary estimates.

All key cost items increased between 2005–06 and 2007–08 (Fig. 22.17). Per vessel labour costs are estimated to have increased by 51% to $192 000 (2008–09 dollars), in line with increases in revenue per vessel (vessel operators generally pay crew a share of revenue). Fuel costs per vessel increased by 27%, due to relatively high fuel prices in 2007–08. Total costs per vessel increased by 25%, from $631 000 to $790 000. These increases are less than observed increases in GVP per vessel.

Although cost estimates are not yet available for 2008–09, a 4.2% increase in average effort per vessel (from 144 000 to 150 000 hooks per vessel), combined with an 18% decline in the off-road price for diesel, suggests that costs per vessel are likely to have remained constant. Given increases in GVP per vessel, this suggests that vessel-level economic performance improved in 2008–09.

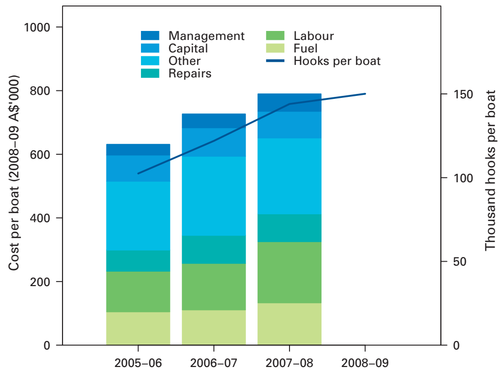


FIGURE 22.17 Real costs per vessel by cost category and effort per vessel for the ETBF, 2005–06 to 2008–09

NOTE: Cost estimates for 2007–08 are non-survey-based preliminary estimates. Estimates for 2008–09 are not yet available.

Overall economic performance

Evidence suggests that the ETBF has typically had some of the economic characteristics of an unmanaged, open-access fishery, despite being a controlled fishery. ABARE–BRS's estimates of NER for years before 2008–09 suggest that the fishery earned only very small or negative NER. Low profits led to a large proportion of the fishery's permits not being fished against.

The buyout that took place as a part of the *Securing our Fishing Future* package had its intended impact of leaving fewer vessels sharing a similar amount of catch and GVP. NER are estimated to have recovered substantially in 2007–08 as a result, although were still negative. It is difficult to estimate NER in 2008–09 without survey data. However, GVP increases, combined with relatively constant effort levels, suggest a positive movement in NER in 2008–09.

The biological status of stocks targeted in the fishery provides some context to the fishery's recent economic performance. Bigeye tuna in 2009 has become overfished following recent high levels of overfishing. Catches of this species accounted for 34% of GVP in 2007–08 and were the main driver of profit improvements in 2007–08. In 2008–09 the species' contribution to GVP declined to 21%, but it was still relatively important in value terms. Therefore, the overfished status of bigeye tuna is a risk for the future economic status of the fishery. Furthermore, recent improvements in profitability may have occurred at the expense of future NER in the fishery.

Future considerations relevant to economic performance

The fishery is introducing management arrangements based on individual transferable quotas (ITQs) in March 2011. This will introduce transferable rights to the fishery (other than just trade in permits), allowing catches to be constrained more easily than under a fishing permit–based system. It also avoids problems associated with effort creep and the inability to control catch and catch composition. Localised depletions have been an issue in the fishery's history for swordfish.

The true test of the new management system will be whether TACs are set at levels that actually restrict catch. If they are, the fishery would move away from an open-access point—where NER are close to zero (as has been the case in recent years)—and closer to a point where economic yields are maximised. If not, economic efficiency and NER are unlikely to improve significantly.

In addition to these arguments for the appropriate setting of TACs, the *Securing our Fishing Future* buyback package resulted in a large amount of public funds being spent on compensating operators to exit the fishery. Appropriate management arrangements are imperative to securing the potential long-term benefits of the buyback. Such arrangements must restrict catch and effort to levels that allow the fishery's recent profit improvements to at least be maintained, if not improved. This also applies at the international level, where such restrictions will allow internationally shared stocks such as bigeye tuna to rebuild and be caught at lower cost in the longer term.

22.6 ENVIRONMENTAL STATUS

More than 100 marine species have been recorded from the ETBF longline sector, including tuna and tuna-like fish, billfish, sharks, rays, various other fish, seabirds, sea turtles and marine mammals. The WCPFC has agreed to a series of conservation and management measures to address the bycatch of marine turtles, seabirds and sharks. Similarly, AFMA developed the Australian Tuna and Billfish Longline Fisheries—Bycatch and Discarding Workplan (AFMA 2008) in response to concerns about bycatch. The focus of the workplan is developing management responses to high ecological risks and developing measures to avoid fishery interactions with species listed under the EPBC Act. The workplan covers from 1 November 2008 to 31 October 2010 (AFMA 2008).

Ecological risk assessment

AFMA, in conjunction with the CSIRO, has undertaken three levels of ecological risk assessment (ERA) for the ETBF (Table 22.2). Three hundred and ninety species were initially assessed in the ERA process (Webb et al. 2007). Of these, eight species were considered to be at high risk to the effects of pelagic longline fishing in the ETBF: four chondrichthyans (longfin mako, crocodile shark, pelagic thresher and dusky shark), two teleost species (two species of ocean sunfish), two cetacean species (short-finned pilot whale and false killer whale) and one turtle species (leatherback turtle) (AFMA 2009b). These species will be addressed through environmental risk management strategies, which include making the carriage of line cutters and de-hookers compulsory in 2010.

Threatened, endangered and protected species

In 2009 a single humpback whale was reported as an interaction in the ETBF. The whale was struck by a longline vessel while setting line. Although injured, its likely survival was not determinable.

Sharks

Of the 166 species of sharks found in Australian waters, fewer than 12 are commonly caught by pelagic longliners (AFMA 2009b). In 2001 a BRS report highlighted high levels of shark bycatch and the widespread practice of 'shark finning' in Australia's longline tuna fisheries (Rose & McLoughlin 2001). Since 2000 AFMA has enforced a landing limit of 20 sharks per vessel per fishing trip and banned the practice of finning sharks at sea. In 2005 AFMA also banned the use of wire leaders or 'traces' on longline branchlines in the ETBF. The measure is intended to reduce shark mortality: sharks are more likely to bite through synthetic fibre leaders and escape. A BRS study confirmed that banning wire leaders reduced shark catches and may increase catch rates of target species, such as bigeye tuna (Ward et al. 2008). However, the study also highlighted the possibility of unseen or 'cryptic' mortality among the many animals that are able to escape by biting through the leader. In 2009 there were no reported interactions with threatened or endangered shark species in the ETBF.

Marine turtles

Of the seven species of marine turtle, six are found in Australian waters: the loggerhead turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricata*), olive ridley sea turtle (*Lepidochelys olivacea*), flatback sea turtle (*Natator depressus*) and leatherback sea turtle (*Dermochelys coriacea*). Public concern over incidental catches of marine turtles resulted in fishery closures for United States longliners in the north Pacific Ocean. A new conservation and management measure (CMM2008-03), effective from 1 January 2010, was adopted at the WCPFC annual meeting in December 2008. The measure requires vessels fishing for swordfish in shallow sets to implement one of three bycatch mitigation techniques: the use of large circle hooks and whole fish bait, a mitigation plan or any other approved measure. Australia's turtle mitigation plan was accepted by the WCPFC at the Commission meeting in December 2009 (AFMA 2009a).

The main objective of Australia's turtle mitigation plan is to reduce the number of turtle interactions in the broadbill swordfish fishery. The plan lists a series of observed trigger interaction rates for individual species, as well as the ETBF as a whole. If they are exceeded, a series of management actions are invoked, such as the formation of a Sea Turtle Mitigation Working Group and the compulsory use of whole finfish baits and large circle hooks. Circle hooks have been documented to reduce catch rates of marine turtles and can improve catch rates of most target species compared with tuna hooks (Ward et al. 2008), although increased catch of some bycatch species, including sharks, may also result. In 2009, 25 marine turtle interactions were reported (logbook records) in the ETBF; a single mortality was reported (Table 22.11).

Seabirds

Seabirds, such as albatrosses and shearwaters, are attracted to longline baits when vessels are setting their gear, and birds can become hooked and drown. In 2009 a total of six seabird interactions were reported in the ETBF; four of these were mortalities. Pelagic longline fishing was identified as a key threatening process for seabirds under the EPBC Act. As a result, a threat abatement plan was created (AAD 2006). Under the plan and other measures introduced by AFMA to reduce seabird bycatch, all ETBF operators fishing south of 25°S are required to carry and deploy an approved bird-scaring 'tori' line, and to use a line weighting system and thawed baits. There is a ban on offal discharge while setting, and discharge during hauling must be avoided. A recent report by the BRS (Lawrence et al. 2009) highlighted the complexities of estimating seabird bycatch rates in the ETBF. Model-based estimation methods were recommended over simple observed seabird bycatch rates, as the effect of spatial and temporal bias in observer coverage can be considered in the modelling process. Both the observer data and the model-based results show that, although seabird bycatch rates have generally decreased over time, seabird bycatch may occasionally exceed the performance measure specified in the threat abatement plan of 0.05 birds per 1000 hooks in some areas and seasons.

TABLE 22.11 Threatened, endangered and protected species caught and discarded in the ETBF

	Number (and mortalities)	
Bycatch	**2008**	**2009**
Leatherback turtles	5 (1)	11 (0)
Loggerhead turtles	4 (0)	7 (1)
Green turtles	1 (0)	1(0)
Olive Ridley turtles	2 (1)	0 (0)
Unidentified turtles	1 (1)	3 (0)
Seabirds	12 (8)	6 (4)
TEP shark species	0 (0)	0 (0)

TEP = threatened, endangered or protected

Pelagic habitats

No habitats or ecological communities were identified as being at high risk from the effects of pelagic longline fishing in the ERA process (AFMA 2009b).

22.7 HARVEST STRATEGY PERFORMANCE

The HS framework for the ETBF was scheduled for implementation in 2008; however, CSIRO is still performing management strategy evaluation to determine the potential performance of the HS. This includes 'tuning' to meet biological, management and industry objectives.

Although ITQs have been identified as the preferred method of control, the limited data available from the fishery and the regional extent of the key stocks present problems for the estimation of scientifically robust TACs. In this context, management of the fishery should be adaptive, and allow for upward or downward adjustment of TACs when new information becomes available. For this reason, development of a management strategy with biological reference points and decision rules must continue to be a major consideration in the implementation of the HS for the fishery.

22.8 LITERATURE CITED

AAD (Australian Antarctic Division) 2006, *Threat abatement plan, for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations,* AAD, Kingston, Tasmania.

AFMA (Australian Fisheries Management Authority) 1995, *Southern Bluefin Tuna Fishery Management Plan 1995*, DAFF, Canberra, Federal Register of Legislative Instruments F2008C00099.

——2007, *Eastern Tuna and Billfish Fishery harvest strategy framework 2007*, AFMA, Canberra.

——2008, *Australia's Tuna and Billfish Longline Fisheries, Bycatch and Discarding Workplan, November 1, 2008 to October 31, 2010*, AFMA, Canberra.

——2009a, 'Australia—Revised draft Eastern Tuna and Billfish Fishery sea turtle mitigation plan', information paper WCPFC6-2009/IP16, sixth regular session, Tahiti, 7–11 December.

——2009b, *Ecological risk management*: *report for the Eastern Tuna and Billfish Fishery*, AFMA, Canberra.

Bromhead, D, Pepperell, J, Wise, B & Findlay, J 2004, *Striped marlin: biology and fisheries*, final report to the AFMA & the Fisheries Resources Research Fund, BRS, Canberra.

Campbell, R 2008, 'Summary of catch and effort information pertaining to Australian longline fishing operations in the Eastern Tuna and Billfish Fishery', information paper presented to the ETBF Resource Assessment Group meeting, Mooloolaba, Queensland, 27–28 March.

Collette, BB & Nauen, CE 1983, *FAO species catalogue*, vol 2, *Scombrids of the world: an annotated and illustrated catalogue tunas, mackerels, bonitos and related species known to date*, FAO Fisheries Synopsis no. 125, FAO, Rome.

DAFF (Australian Government Department of Agriculture, Fisheries and Forestry) 2005, *Eastern Tuna and Billfish Fishery Management Plan 2005*, DAFF, Canberra, Federal Register of Legislative Instruments F2007C00758.

——2007, *Commonwealth Fisheries Harvest Strategy: policy and guidelines*, DAFF, Canberra.

Striped marlin research PHOTO: JULIAN PEPPERELL

Evans, SK 2007, 'Eastern Tuna and Billfish Fishery data summary 2005–2006', Data Group, AFMA, Canberra.

Galeano, D, Langenkamp, D, Levantis, C, Shafron, W & Redmond, I 2004, *Economic value of charter and recreational fishing in Australia's Eastern Tuna and Billfish Fishery*, ABARE eReport 04.10 prepared for the Fisheries Resources Research Fund, Canberra.

Hampton, J, Langley, A & Kleiber, P 2006, 'Stock assessment of bigeye tuna in the western and central Pacific Ocean, including an analysis of management options', WCPFC-SC2 SA WP-2, Manila, Philippines, 7–18 August.

Harley, S, Hoyle, S, Langely, A, Hampton, J & Kleiber, P 2009, 'Stock assessment of bigeye tuna in the western and central Pacific Ocean', working paper WCPFC-SC5-2009/SA-WP-4, scientific committee fifth regular session, Vanuatu, 10–21 August.

Henry, GW & Lyle, JM 2003, *The National Recreational and Indigenous Fishing Survey*, DAFF, Canberra.

Byproduct offloading PHOTO: JOHN KALISH, ABARE–BRS

Hoyle, SD, Langley, AD & Hampton, WJ 2008, *Stock assessment of Albacore tuna in the south Pacific Ocean*. Secretariat of the Pacific Community No. WCPFC-SC4-2008/ SA-WP-8.

——& Davies, N 2009, 'Stock assessment of albacore tuna in the south Pacific Ocean', working paper WCPFC-SC5-2009/SA-WP-6, scientific committee fifth regular session, Vanuatu, 10–21 August.

Kolody, D, Campbell, R & Davies, N 2008, 'A MULTIFAN-CL assessment of south-west Pacific swordfish', working paper WCPFC-SC4-2008/SA-WP-6, scientific committee fourth regular session, Papua New Guinea, 11–22 August.

Kompas, T, Che, N & Gooday, P 2009, *Analysis of productivity and the impacts of swordfish depletion in the eastern tuna and billfish fishery*, ABARE research report 09.4, Canberra.

Kopf, KR & Davie, P 2009, *Population biology and habitat preferences of striped marlin, Kajikia audax in the southwest Pacific Ocean*, report for NSW Fisheries & the AFMA, Canberra.

Langley, A, Hampton, J, Kleiber, P & Hoyle, S 2007, 'Stock assessment of yellowfin tuna in the western and central Pacific Ocean, including an analysis of management options', working paper WCPFC SC3-SA SWG/WP-01, scientific committee third regular session, Honolulu, Hawaii, 13–24 August 2006.

——Hampton, J, Kleiber, P & Hoyle, S 2008, 'Stock assessment of bigeye tuna in the western and central Pacific Ocean, including an analysis of management options', working paper WCPFC-SC4-2008/SA-WP-1 rev.1, scientific committee fourth regular session, Papua New Guinea, 11–22 August.

——Harley, S, Davies, N, Hampton, J & Kleiber, P 2009, 'Stock assessment of yellowfin tuna in the western and central Pacific Ocean', working paper WCPFC SC5-SA-2009/SA-WP-03, scientific committee fifth regular session, Vanuatu, 10–21 August.

——Molony, B, Bromhead, D, Yokawa, K & Wise, B 2006, 'Stock assessment of striped marlin (*Tetrapturus audax*) in the south west Pacific Ocean', working paper WCPFC-SC2-2006/SA WP-6, scientific committee second regular session, Philippines, 7–18 August.

Lawrence, E, Giannini, F, Bensley, N & Crombie, J 2009, *Estimation of seabird bycatch rates in the Eastern Tuna and Billfish Fishery*, BRS, Canberra.

Lehodey, P, & Leroy, B 1999, 'Age and growth of yellowfin tuna (*Thunnus albacares*) from the western and central Pacific Ocean as indicated by daily growth increments and tagging data', WP YFT-2, SCTB 12, Papeete, French Polynesia, 16–23 June.

Nakamura, I 1985, *FAO species catalogue*, vol 5, *Billfishes of the world: an annotated and illustrated catalogue of marlins, sailfishes, spearfishes and swordfishes known to date*, FAO Fisheries Synopsis no. 125, FAO, Rome.

Pepperell, J 2009, *Fishes of the open ocean: a natural history and illustrated guide*, University of New South Wales Press, Sydney.

Rose, R 2002, *Efficiency of individual transferable quotas in fisheries management*, ABARE report prepared for the Fisheries Resources Research Fund, Canberra.

——& McLoughlin, K 2001, *Review of shark finning in Australian fisheries*, BRS, Canberra.

Shomura, RS, Majkowski, J & Langi, S (eds.) 1993, *Interactions of Pacific tuna fisheries*, vol. 2, Papers on biology and fisheries, proceedings of the first FAO Expert Consultation on Interactions of Pacific Tuna Fisheries, Noumea, New Caledonia, 3–11 December 1991, FAO Fisheries Technical Paper, no. 336, FAO, Rome.

Vieira, S, Perks, C, Mazur, K, Curtotti, R & Li, M 2010, *Impact of the structural adjustment package on the profitability of Commonwealth fisheries*, ABARE research report 10.01, Canberra.

——Wood, R & Causer, T 2008, *Australian fisheries surveys report 2008, results for selected fisheries 2005–06 and 2006–07*, ABARE report prepared for the Fisheries Resources Research Fund, Canberra.

Ward, P, Epe, S, Kreutz, D, Lawrence, E, Robins, C & Sands, A 2008, *Implementation of bycatch mitigation measures in Australia's pelagic longline fisheries: the effects of circle hooks on target and non-target catches*, final report to the Natural Heritage Trust, BRS Canberra.

——Lawrence, E, Darbyshire, R & Hindmarsh, S 2008, 'Large-scale experiment shows that nylon leaders reduce shark bycatch and benefit pelagic longline fishers', *Fisheries Research*, vol. 90, pp. 100–08.

WCPFC (Western and Central Pacific Ocean Fisheries Commission) 2008, 'Conservation and management measure for bigeye and yellowfin tuna in the western and central Pacific Ocean', Conservation and Management Measure 2008–01, fifth regular session, Republic of Korea, 8–12 December.

Webb, H, Hobday, A, Dowdney, J, Bulman, C, Sporcic, M, Smith, T, Stobustzki, I, Fuller, M & Furlani D 2007, *Ecological risk assessment for the effects of fishing: Eastern Tuna & Billfish Fishery: longline sub-fishery*, report for the AFMA, Canberra.

Williams, P & Terawasi, P 2009, 'Overview of tuna fisheries in the western and central Pacific Ocean, including economic conditions—2008', working paper WCPFC-SC5-2009/GN WP-1, scientific committee fifth regular session, Vanuatu, 10–21 August,

Young, J, Drake, A, Brickhill, M, Farley, J & Carter, T 2003, 'Reproductive dynamics of broadbill swordfish, *Xiphias gladius*, in the domestic longline fishery off eastern Australia', *Marine and Freshwater Research*, vol. 54, pp. 315–32.

23 Skipjack Tuna Fisheries

A Sands, D Wilson, R Summerson and C Perks

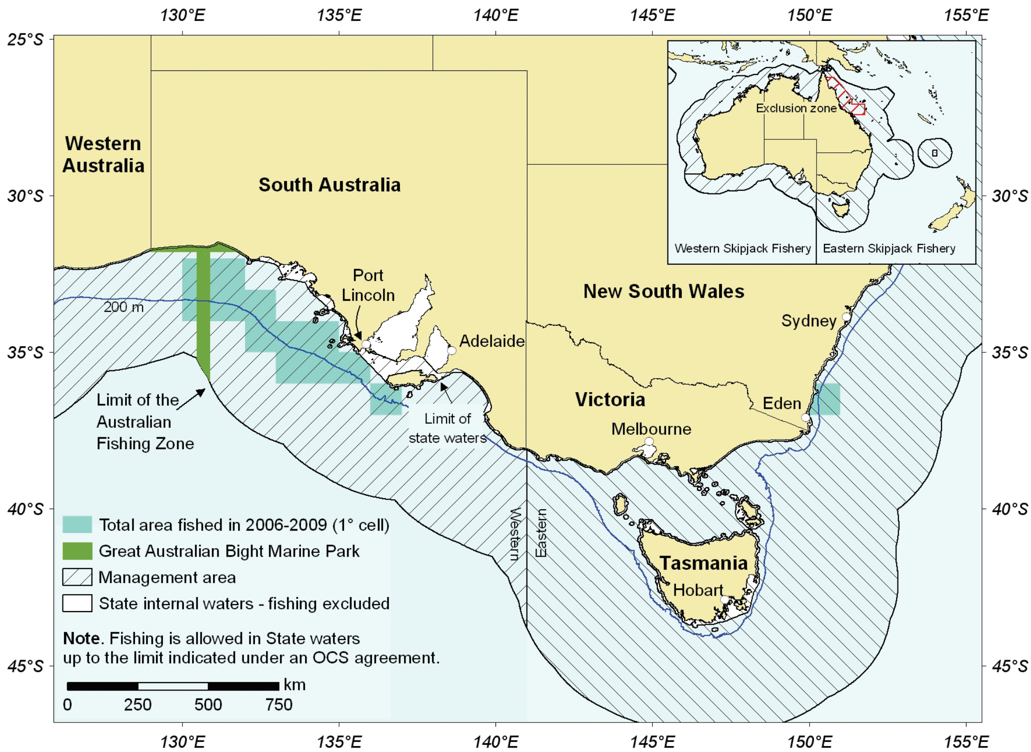


FIGURE 23.1 Area fished in the Skipjack Tuna Fisheries, 2006–2009

TABLE 23.1 Status of the Skipjack Tuna Fisheries

Fishery status	2008		2009		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Indian Ocean skipjack tuna[a] (*Katsuwonus pelamis*)	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Indicators do not give cause for concern, except for the exploitation rate by foreign fleets which increased substantially until 2006.
Western and central Pacific Ocean skipjack tuna[a] (*Katsuwonus pelamis*)	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Stock assessment does not give cause for concern, except for the constantly increasing exploitation rate by foreign fleets.
Economic status Fishery level	Estimates of net economic returns not available				Economic status uncertain. Total net economic returns likely to be low with few domestic vessels fishing in either area in recent years.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING — OVERFISHED / OVERFISHING — UNCERTAIN — NOT ASSESSED

a Domestic assessments are unreliable because interactions with broader regional stocks are uncertain. Ocean-wide assessments of species through the Western and Central Pacific Fisheries Commission and the Indian Ocean Tuna Commission were used as the basis for stock status determination.

TABLE 23.2 Main features and statistics of the Skipjack Tuna Fisheries

Feature	Description
Key target and byproduct species	Skipjack tuna (*Katsuwonus pelamis*)
Other byproduct species	Bigeye tuna (*Thunnus obesus*) Yellowfin tuna (*Thunnus albacares*) Mahi mahi (*Coryphaena hippurus*)
Fishing methods	Purse seine (approximately 98% of catch), pole-and-line methods (managed as a minor-line component of the ETBF—Chapter 22 and WTBF—Chapter 25 when poling is used on its own)
Primary landing ports	Port Lincoln
Management methods	Input controls: limited entry, gear (net size), area controls Output controls: bycatch limits
Management plan	Skipjack Tuna Fishery management arrangements 2009 (AFMA 2009)
Harvest strategy	*Skipjack Tuna Harvest Strategy* (AFMA 2008a)
Consultative forums	Tropical Tuna Management Advisory Committee (domestic) ESF: Western and Central Pacific Fisheries Commission (international) WSF: Indian Ocean Tuna Commission (international)
Main markets	Domestic: cannery product Foreign fleets: Thailand and American Samoa (canneries)
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Current accreditation dated 30 November 2005 Current accreditation (Wildlife Trade Operation) expires 30 November 2011

Table 23.3 continues over the page

TABLE 23.2 Main features and statistics of the Skipjack Tuna Fisheries CONTINUED

Feature	Description	
Ecological risk assessment	Level 1: Scale Intensity Consequence Analysis (SICA) completed on 328 species (Daley et al. 2007) Level 2: Productivity Susceptibility Analysis (PSA) completed on 320 species (Daley et al. 2007) Level 3: Sustainability Assessment for Fishing Effects (SAFE) completed on 144 species (Zhou et al. 2009)	
Bycatch workplans	*Australia's Tuna Purse Seine Fisheries Bycatch Action Plan* (AFMA 2005)	
Fishery statistics[a]	**2007–2008 fishing season**	**2008–2009 fishing season**
Fishing season	1 July 2007 – 30 June 2008	1 July 2008 – 30 June 2009
TAC or TAE	None	None
Catch	847 t	885 t
Effort	670 search hours	406 search hours
Fishing permits	ESF: 19 WSF: 13	ESF: 19 WSF: 13
Active vessels	ESF: 1 WSF: 2	ESF: 0 WSF: 2
Observer coverage	ESF purse seine: 100% WSF purse seine: zero	ESF purse seine: zero WSF purse seine: zero
Real gross value of production (2008–09 dollars)	Confidential (<5 vessels)	Confidential (<5 vessels)
Allocated management costs	$0.09 million	$0.1 million

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; ESF = Eastern Skipjack Fishery; ETBF = Eastern Tuna and Billfish Fishery; TAC = total allowable catch; TAE = total allowable effort; WSF = Western Skipjack Fishery; WTBF = Western Tuna and Billfish Fishery

a Fishery statistics provided by fishing season unless otherwise indicated.

23.1 BACKGROUND

The Eastern Skipjack Fishery (ESF) and Western Skipjack Fishery (WSF) extend throughout the same areas as the Western Tuna and Billfish Fishery (see Chapter 25) and the Eastern Tuna and Billfish Fishery (see Chapter 22) (Fig. 23.1), with the exception of an area off north Queensland (Coral Sea Zone, Cairns–Townsville Restricted Area). Together, the ESF and WSF comprise the Skipjack Tuna Fisheries (STF). Under Offshore Constitutional Settlement (OCS) arrangements, the Commonwealth manages skipjack tuna (as well as other tuna and tuna-like species) between the shoreline and three nautical miles (with the exception of New South Wales) (Table 23.3). Although skipjack tuna are widely distributed throughout the Australian Fishing Zone (AFZ), the main Australian fishing grounds have been historically located off south-eastern Australia and in the Great Australian Bight. In the ESF, skipjack are fished from southern New South Wales to north-eastern Tasmania. During the year, some of the southern bluefin tuna (*Thunnus maccoyii*) purse-seine fleet occasionally fishes for skipjack in the Great Australian Bight.

Although the fisheries extend into the high-seas areas of the Indian and Pacific Oceans, the Australian fisheries are considered to have little impact on Pacific and Indian Ocean stocks because they are located at the edge of the species' range. Catches in the south-eastern AFZ are highly variable and depend on recruitment from lower latitudes. Catches

in the south-western AFZ are opportunistic and highly variable, with several years of zero or near-zero catches over the past five years. Skipjack are not always present in the AFZ as they are believed to be heavily influenced by interannual variability in environmental conditions. The variability in the availability of skipjack in the AFZ, variable participation levels and low profit margins will influence the sustainable management of the resource. All operators are required to keep logbooks, and only authorised vessels are permitted to tranship at sea (Table 23.2).

Skipjack tuna PHOTO: KEVIN MCLOUGHLIN, ABARE–BRS

TABLE 23.3 History of the Skipjack Tuna Fisheries

Year	Description
1950s	Fishing began—offshoot from the Southern Bluefin Tuna Fishery off southern New South Wales.
1970s	Introduction of skipjack purse-seining in the ETBF.
1980s	Skipjack replaced southern bluefin tuna as main species for canning after collapse of Southern Bluefin Tuna Fishery and redirection of most South Australian southern bluefin tuna to the Japanese sashimi market. Skipjack catches in the western and central Pacific Ocean nearly doubled.
1988 to 1990	Australian catches increased from 61 t to 1617 t.
1990	AFMA introduced limited entry to the fishery, placed a moratorium on purse-seine net size and limited the take of yellowfin and bigeye tuna as byproduct to 50% per set and 2% of each vessel's total catch per season.
1991–92	Australian skipjack catches peaked at 7000 t.
1996	New logbook and transhipment forms introduced. The Agreement for the Establishment of the Indian Ocean Tuna Commission entered into force on 27 March 1996. Australia became a member of the Commission on 13 November 1996.
1997	Program to collect length-frequency data introduced.
1999	Heinz–Greenseas cannery at Eden closed.
2002	AFMA established the Skipjack Consultative Committee to advise the AFMA Board on skipjack tuna management.
2003	Purse-seine fishery entitlements for skipjack separated from the ETBF and WTBF, resulting in creation of the ESF and WSF.
2004	The Convention for the Western and Central Pacific Fisheries Commission entered into force on 19 June 2004. Australia became a member of the Commission in November 2004.
2006	Skipjack Consultative Committee disbanded. AFMA started dealing directly with permit holders.
2007	WCPFC recognised Australia's skipjack development plan.
2008	Skipjack harvest strategy adopted by AFMA; yet to be triggered due to low levels of fishing. WCPFC agreed to limits on purse-seine effort and to progress work on developing reference points.
2009	Formal management arrangements for the STF developed. The Tropical Tuna Management Advisory Committee (Tropical Tuna MAC) commenced in July and became the advisory body for the ETBF, WTBF and STF.

AFMA = Australian Fisheries Management Authority; ESF = Eastern Skipjack Fishery; ETBF = Eastern Tuna and Billfish Fishery; STF = Skipjack Tuna Fisheries; WCPFC = Western and Central Pacific Fisheries Commission; WSF = Western Skipjack Fishery; WTBF = Western Tuna and Billfish Fishery

23.2 HARVEST STRATEGY

The harvest strategy (HS) consists of a series of catch level triggers that invoke decision rules. The control rules initiate closer monitoring of the fisheries, semi-quantitative assessments and revision of trigger levels. Separate sets of triggers apply for the eastern and western fisheries, based on historical catch levels of skipjack in the domestic fisheries and regional assessments of stock status. Management action is initiated only when there is clear evidence of significant expansion in catches. The HS accommodates the developing nature of the fisheries, in which there is considerable variation in skipjack availability, uncertainty about future catch levels and no current concern regarding stock status. Target and limit reference points are not currently defined.

23.3 THE 2009 FISHERY (2008–09 FISHING SEASON)

Key target and byproduct species

In the 2008–09 fishing season, there were no active vessels in the ESF and two active vessels in the WSF. Value data for the STF have been confidential since 2005–06 due to the small number of active vessels in the fishery, and the real gross value of production has been highly variable in recent years because of fluctuating catch levels. Both of these factors are believed to be a result of high variability of skipjack tuna in the south-eastern AFZ (which is dependent on recruitment from lower latitudes), rather than declining stock levels.

Minor byproduct species

Southern bluefin tuna can only be retained by operators who hold quota for that species. Regulations limit the yellowfin and bigeye tuna take to less than 50% of the total catch in any trip and less than 2% of each vessel's annual catch. In addition, any blue or black marlin caught must be returned to the sea. Catches of other byproduct species, such as mahi mahi (*Coryphaena hippurus*) and frigate mackerel (*Auxis thazard*), are allowed under OCS agreements with Queensland, Western Australia and the Northern Territory.

There is a trip limit of 20 sharks, excluding school shark, gummy shark, saw shark and elephant fish of the families Callorhinchidae, Chimaeridae and Rhinochimaeridae (which must be retained with fins intact). Catches of byproduct species cannot be reported for confidentiality reasons.

Skipjack is also caught as byproduct in other tuna fisheries (see Chapter 22—Eastern Tuna and Billfish Fishery, and Chapter 25—Western Tuna and Billfish Fishery).

Indian Ocean

Skipjack has become the most important tuna species in the Indian Ocean, in terms of catch. The development of fishing methods using fish-aggregating devices (FADs) has increased skipjack catches by purse seiners in recent years—89% of current (2008) purse-seine skipjack catch is taken under natural FADs (log schools). The proportion of catch taken by industrial purse seiners (~34%) has decreased since 2006 (~42%), while the proportion of catch taken by gillnets in the artisanal fisheries has increased (~30% to ~34%).

Preliminary data for the Indian Ocean suggest that the 2008 catch of skipjack (405 198 t) may be the lowest reported since 1998 (Fig. 23.2). In contrast, the 2006 catch (605 980 t) was the highest on record. Catch rates in 2008 continued to decline from 2006 in both the industrial purse-seine fishery and the Maldives artisanal fishery. Vessels have been avoiding traditional skipjack fishing grounds known for high catch rates because of piracy off the coast of Somalia (IOTC 2010). The decline in catch rates in the Maldives fishery may be due to higher than average sea-surface temperatures and the marked increase in fuel prices (IOTC 2010).

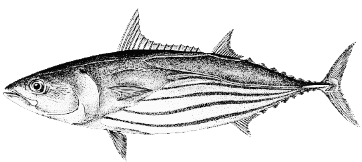
Western and central Pacific Ocean

Global catches of skipjack tuna have been increasing steadily since 1950 (Fig. 23.3). In the past decade, skipjack has been the most commonly caught species in the western and central Pacific Ocean (WCPO). Catches of skipjack in the WCPO were an estimated 1.63 million t in 2008 (the second highest on record and 67% of the total tuna catch) and 1.71 million t in 2007 (the highest on record). Purse seine is the most common fishing method used, but a substantial percentage of skipjack is also caught using pole-and-line and other methods.

23.4 BIOLOGICAL STATUS

SKIPJACK TUNA

(*Katsuwonus pelamis*)



LINE DRAWING: FAO

TABLE 23.4 Biology of skipjack tuna

Parameter	Description
General	Highly fecund. Pacific Ocean and Indian Ocean stocks of skipjack are assumed to be discrete.
Range	**Species:** Highly migratory. Found in nearly all tropical and subtropical waters except the eastern Mediterranean and the Black Sea; typically inhabits waters with temperatures of 15–30 °C. **Stock (WCPFC):** The boundaries for stock assessment purposes include the area of the western and central Pacific Ocean from 45°N to 20°S and from oceanic waters adjacent to the east Asian coast to 150°W. **Stock (IOTC):** The boundaries for the assessment are the IOTC Convention Area (see Chapter 21).
Depth	0–260 m
Longevity	<12 years
Maturity (50%)	**Age:** 1–2 years **Size:** 41–43 cm FL
Spawning season	Spawns opportunistically throughout the year when conditions are favourable
Size	**Maximum:** ~110 cm FL; 35 kg whole weight **Recruitment into the fishery:** 40–65 cm FL

IOTC = Indian Ocean Tuna Commission; WCPFC = Western And Central Pacific Fisheries Commission

SOURCES: Collette & Nauen (1983); Shomura et al. (1994); Langley et al. (2008); Pepperell (2009); IOTC (2010).

Skipjack tuna at Vietnamese food market
PHOTO: ANNETTE SANDS, ABARE–BRS

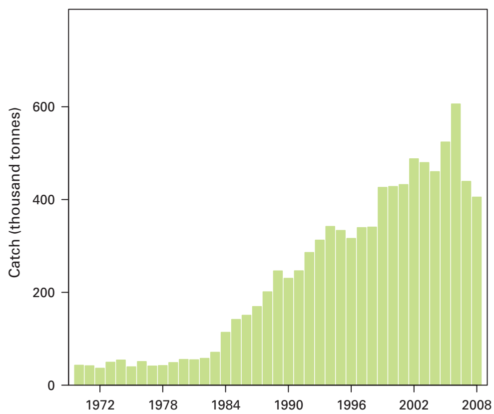


FIGURE 23.2 Skipjack tuna catch history in the IOTC Statistical Area, 1970 to 2008

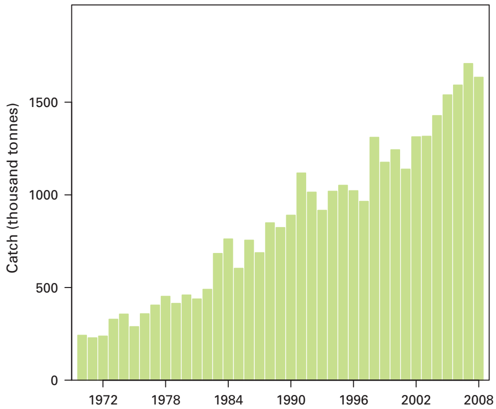


FIGURE 23.3 Skipjack tuna catch history in the WCPFC Statistical Area, 1970 to 2008

Indian Ocean skipjack tuna

Stock status determination

No quantitative stock assessment for skipjack tuna in the Indian Ocean is currently available, and the maximum sustainable yield (MSY) has not been estimated.

Fishery indicators (trends in catches and catch per unit effort—CPUE, average fish weights, spatial extension of the fishery) and exploitation rates from analyses of tagging data were updated and assessed in 2009. There was a large and continuous increase in skipjack catches from the mid-1980s until 2006 (Fig. 23.2), which has been credited to the expansion of the FAD-associated fishery in the western Indian Ocean (IOTC 2010). The standardised (by search time) CPUE series, although preliminary, fluctuated without trend (IOTC 2010). However, when the standardisation included fishing efficiency, an overall decline in CPUE from 1984 to 2008 was observed. The average weights of skipjack tuna taken by the various gears have remained relatively stable since 1991 (IOTC 2010). The estimated numbers of skipjack recruits in the western Indian Ocean are larger than the numbers for both bigeye and yellowfin tuna (IOTC 2010). This confirmed that substantially larger numbers of skipjack tuna are present in the Indian Ocean than either yellowfin or bigeye tuna. Exploitation rates of skipjack are estimated to be relatively low, not exceeding even 20% for the most selected age range of the stock (IOTC 2010).

In 2009 the Indian Ocean Tuna Commission (IOTC) Scientific Committee (SC) noted that the life-history characteristics and high productivity of skipjack tuna (Table 23.4) suggest that this stock is resilient and not prone to overfishing (IOTC 2010). Furthermore, the stock status indicators suggest that there is no immediate concern about the status of skipjack in the Indian Ocean. However, the SC also noted that catches cannot be increased at the current rate indefinitely and that the potential interaction between fisheries could be a source of concern. As a result, it recommended that the skipjack tuna catch needs to be monitored regularly. The IOTC has scheduled a quantitative stock assessment in 2010. The skipjack tuna stock in the Indian Ocean is assessed as **not overfished** and **not subject to overfishing** (Table 23.1).

Reliability of the assessment/s

Standardised CPUE analyses are still provisional and would be improved by including detailed information reflecting changes in the fishing power and efficiency of purse seiners over time.

Previous assessment/s

In 2007 the IOTC Working Party on Tropical Tunas (WPTT) analysed a range of stock status indicators, including trends in catches, nominal CPUE, average weight of the catch and number of one-degree squares visited or fished to gain a general understanding of the state of the stock. The results indicated that, although catches should not be increased at the current rate indefinitely, there is no need for immediate concern about the status of skipjack tuna in the Indian Ocean.

Future assessment needs

Catches of skipjack tuna have continued to increase as fishing effort has increased. However, catches declined in 2007 and 2008, and this trend has appeared to continue in 2009 (based on preliminary 2009 purse-seine data). The causes of this decline

need to be examined, given the decline in the CPUE trend standardised for fishing efficiency. The IOTC SC identified the stock assessment for skipjack as a priority for the 2010 WPTT meeting (IOTC 2010).

Western and central Pacific Ocean skipjack tuna

Stock status determination

The previous quantitative stock assessment for skipjack tuna was carried out in 2008 (Langley & Hampton 2008), using updated catch, size and tagging data. Results indicated that there had been little change in stock status since the previous assessment in 2005 (WCPFC 2010). The stock assessment model was conducted at two spatial scales: the entire WCPO stratified into six regions, and a model restricted to the two regions encompassing the equatorial region (the vast majority of catch from the WCPO skipjack fishery occurs in the equatorial region). As the equatorial model is a more robust assessment and not sensitive to the assumptions applied to the northern regions of the model, the key conclusions from the stock assessment are limited to the equatorial model. The model estimated the fishery's reference points as $B_{2008}/B_{MSY} = 2.99$ and $F_{2008}/F_{MSY} = 0.26$, indicating that skipjack tuna is neither overfished nor subject to overfishing.

Current high catches are believed to be sustainable, provided that recruitment does not continuously fall below the long-term average. No new information on the stock status of this species was presented to the Western and Central Pacific Fisheries Commission (WCPFC) in 2009, other than total catches (1.63 million t in 2008; Fig. 23.3), which have been well below the estimates of MSY (base case) (2 264 000 t) (Langley & Hampton 2008). The stock status assessment of **not overfished** and **not subject to overfishing** therefore remains valid (Table 23.1).

Reliability of the assessment/s

There are concerns about potential contractions in stock distribution and biomass, which may be first indicated by changes in the presence or abundance of fish at the edges of the distribution. These effects may not have been fully accounted for in the stock assessment for WCPO skipjack, which focused on the centre of the stock's distribution in tropical waters (WCPFC 2010). Specifically, the broader WCPO assessment model only applies to waters north of 20°S, as there are relatively minor catches (in terms of the whole fishery) south of this point. Care must be taken when interpreting the results for skipjack in Australian waters. Since Australian waters are at the edge of the skipjack distribution, there is the potential for localised depletion. However, this is not considered a matter of immediate concern. The distribution of recruitment among model regions is a critical assumption in the broader WCPO assessment. The data are insufficient to estimate this reliably within the broader assessment model, and many of the key model outputs are strongly influenced by the values assumed.

Previous assessment/s

There is no specific stock assessment for skipjack in the ESF. However, stock assessments of the WCPO skipjack tuna stock have been undertaken by the Secretariat of the Pacific Community using MULTIFAN-CL since 2000. Data used in the 2005 assessment included catch, effort and length-frequency data for the fisheries defined in the analysis, and tag–recapture data. Recruitment variability, influenced by environmental variability, was identified as the primary influence on stock size and fishery performance. The base-case model predicted that $B_{current}/B_{MSY} = 3.59$; as this value is above 1.0, it suggests that the current biomass is well above the size needed to achieve MSY. The model predicted a fishing mortality rate of $F_{current}/F_{MSY} = 0.12$, which is well below the level that produces MSY. Based on these results, the recommendation in 2005 was that skipjack tuna is exploited at a moderate level relative to its biological potential, and it was classified as not overfished and not subject to overfishing in the WCPO.

Future assessment needs

The current assessment results may not be sensitive to early events, which typically occur at the edges of stock distribution. Temperate waters such, as those off Japan and at the southern edge of the distribution in south Pacific waters, represent the edges of the WCPO skipjack tuna stock. Careful and continuous monitoring of these indicators, and comparisons with indicators for the central distribution of the stock in tropical waters will be important for future research. Continued monitoring and improvement in fisheries statistics, and incorporation of tag–release and recovery data into the stock assessment will also be important.

23.5 ECONOMIC STATUS

Economic performance

Given the low level of activity in the domestic fishery, no economic surveys have been conducted in the STF. Latent effort provides an indication of economic performance. Currently, 19 permits are issued in the ESF and 13 in the WSF. These are held by 18 operators, seven of whom hold permits for both fisheries. Only two vessels were active in the fishery in the 2008–09 fishing season (Table 23.5).

TABLE 23.5 Number of active purse-seine vessels in the STF

	Eastern Skipjack Fishery	Western Skipjack Fishery
Number of permits 2008–09	19	13
Year	**Active vessels**	
2003–04	3	1
2004–05	0	0
2005–06	2	3
2006–07	0	0
2007–08	1	2
2008–09	0	2

Overall economic status

Few vessels have fished in either fishery in recent years, indicating the low profitability of the fishery in Australian waters. Neither the Indian Ocean nor the WCPO skipjack tuna stocks are considered overfished; however, stock availability varies from year to year. Operators capitalise on this, fishing opportunistically in years of relatively abundant stocks and not using their permits in years of relatively scarce stocks. As a result, effort in the fishery is more dependent on availability than on prices, although lower prices in recent years have also contributed to lower effort levels.

Future consideration

The low value of production in this fishery does not justify additional economic surveys. Given current information and the size and value of the fishery, there is no pressing need for additional economic information.

23.6 ENVIRONMENTAL STATUS

In 2005 the Australian Fisheries Management Authority released the first bycatch action plan for tuna purse-seine fisheries, covering both the skipjack and southern bluefin tuna fisheries (AFMA 2005). The aim of the plan is to gain an understanding of the range of significant bycatch issues and, if required, develop and implement mitigation measures. Independent data collection by observers will assist in achieving the aims of the plan. There has been very little observer coverage aboard domestic vessels targeting skipjack because of the low level of effort in recent years.

Ecological risk assessment

AFMA, in conjunction with the Commonwealth Scientific and Industrial Research Organisation (CSIRO), have undertaken three levels of ecological risk assessment (ERA) for the STF (Table 23.2). A

total of 328 species were initially assessed in the ERA process (Daley et al. 2007). Of these, 124 species were considered to be at high risk to the effects of fishing in the STF, including: 5 chondrichthyans, 9 reptiles, 85 seabirds and 25 marine mammals. A total of 25 species, mostly threatened, endangered and protected species, remained high risk after applying the residual risk guidelines (AFMA 2010).

Threatened, endangered and protected species

Sharks, marine turtles and seabirds

Fishers report few interactions with non-target species, such as sharks, marine mammals, turtles and seabirds, but there is an absence of verified data on bycatch in Australia's skipjack fisheries. To date, no interactions of skipjack purse-seine nets with marine mammals, turtles or sharks have been recorded. Although seabirds are commonly present during tuna purse-seine operations, there have been few recorded interactions (AFMA 2008b).

Pelagic habitats

During purse-seining, no contact is made between the net and the substrate; therefore, minimal habitat impacts occur. Habitats were eliminated at the end of the Level 1 ecological risk assessment for this reason (Daley et al. 2007).

23.7 HARVEST STRATEGY PERFORMANCE

The decision rules have yet to be implemented in either skipjack tuna fishery, as catches have not exceeded trigger levels. There is no direct obligation to develop a HS for the STF under the *Commonwealth Fisheries Harvest Strategy Policy* (HSP), as skipjack tuna is managed under the WCPFC and IOTC. The decision rules for the domestic fisheries were developed taking into account the highly variable and international nature of the fisheries, their low value, the current

Unloading skipjack tuna PHOTO: KEVIN MCLOUGHLIN, ABARE–BRS

low levels of catch in the AFZ and the potential for development of the fisheries.

In keeping with the intent of the HSP, the decision rules are sufficient to detect expansion in the fisheries. However, they are not adequate to restrict effort because the decision rules simply call for monitoring and revision of trigger levels. The suggested analyses, especially in the international context, would add a substantial time lag to the process.

23.8 LITERATURE CITED

AFMA (Australian Fisheries Management Authority) 2005, *Australia's tuna purse–seine fisheries Bycatch Action Plan 2005*, AFMA, Canberra.

——2008a, *Skipjack tuna harvest strategy*, AFMA, Canberra.

——2008b, *Skipjack Tuna Fishery annual status report*, AFMA, Canberra.

——2009, *Skipjack tuna fishery management arrangements 2009*, AFMA, Canberra.

——2010, *Ecological risk management report for the Skipjack Tuna Fishery*, March 2010, AFMA, Canberra.

Collette, BB, & Nauen, CE 1983, *Scombrids of the World: An Annotated and Illustrated Catalogue of Tunas, Mackerels, Bonitos, and Related Species Known to Date*, FAO species catalogue, v. 2. Rome: United Nations Development Programme.

Daley, R, Dowdney, J, Bulman, C, Sporcic, M, Fuller, M, Ling, S & Hobday, A 2007, *Ecological Risk Assessment (ERA) for the Effects of Fishing: Skipjack Tuna Fishery,* report for the Australian Fisheries Management Authority, Canberra.

IOTC (Indian Ocean Tuna Commission) 2010, *Report of the twelfth session of the scientific committee of the IOTC*, Victoria, Seychelles, 30 November–4 December 2009, IOTC-2009-SC-R[E].

Langley, A, & Hampton, J 2008, 'Stock assessment of skipjack tuna in the western and central Pacific Ocean', working paper WCPFC-SC4-2008/SA-WP-4, presented at the fourth meeting of the scientific committee of the Western and Central Pacific Fisheries Commission, Papua New Guinea, 11–22 August 2008.

Langley, A & Hampton, J 2008, *Stock assessment of skipjack tuna in the western and central Pacific Ocean*, working paper WCPFC-SC4-2008/SA-WP-4, presented at the fourth meeting of the Scientific Committee of the Western and Central Pacific Fisheries Commission, 11–22 August 2008, Papua New Guinea.

Shomura, RS, Majkowski, J and Langi, S (eds.) 1994, *Proceedings of the First FAO Expert Consultation on Interactions of Pacific Tuna Fisheries, 3-11 December 1991*, Noumea, New Caledonia. Vol. 2–Papers on biology and fisheries. FAO Fisheries Technical Paper 336(2):439

WCPFC (Western and Central Pacific Fisheries Commission) 2010, *Report of the Scientific Committee Fifth Reguler Session, Port Villa, Vanuatu, 10–21 August, 2009*, WCPFC, Federated States of Morconesia.

Zhou, S, Fuller, M & Smith, T 2009, *Rapid quantitative risk assessment for fish species in seven Commonwealth fisheries*, CSIRO, Cleveland.

24 Southern Bluefin Tuna Fishery

H Patterson, G Begg, R Curtotti and S Vieira

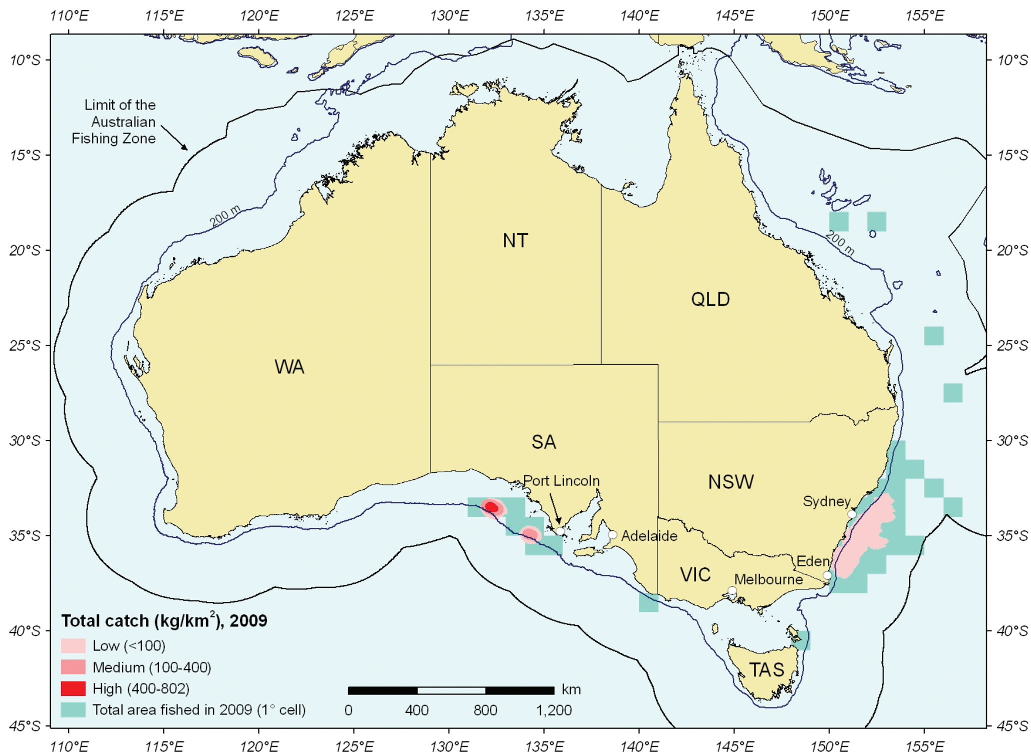


FIGURE 24.1 Catch distribution in the Southern Bluefin Tuna Fishery, 2009

TABLE 24.1 Status of the Southern Bluefin Tuna Fishery

Fishery status	2008		2009		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Southern bluefin tuna (*Thunnus maccoyii*)	Overfishing (red)	Overfished (red)	Overfishing (red)	Overfished (red)	Spawning stock biomass ~5% of SSB_0.
Economic status Fishery level	Estimates of net economic returns not available but likely to be positive, although falling. Biological status of stocks indicates that current returns may not be sustainable over the long term.				Although net economic returns are positive, the stock's overfished status is a concern.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING   OVERFISHED / OVERFISHING   UNCERTAIN   NOT ASSESSED

TABLE 24.2 Main features and statistics of the Southern Bluefin Tuna Fishery

Feature	Description	
Key target and byproduct species	Southern bluefin tuna (*Thunnus maccoyii*)	
Other byproduct species	None	
Fishing methods	Purse seine; pelagic longline: monofilament mainline gear (southern bluefin tuna a byproduct in longline fishery); minor line (troll and poling)	
Primary landing ports	Port Lincoln	
Management methods	Output controls: individual transferable quotas, area restrictions to control incidental catches in the longline fishery.	
Management plan	*Southern Bluefin Tuna Fishery Management Plan 1995* (AFMA 1995) (amended 2008)	
Harvest strategy	No formal harvest strategy	
Consultative forums	Southern Bluefin Tuna Management Advisory Committee (SBTMAC) Commission for the Conservation of Southern Bluefin Tuna (CCSBT)	
Main markets	International: Japan—frozen, fresh	
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Current accreditation dated 21 February 2008 Current accreditation (short-term exemption) expires 21 October 2010	
Ecological risk assessment	Level 1: Scale Intensity Consequence Analysis (SICA) completed on 207 species (Hobday et al. 2007) Level 2: Productivity Susceptibility Analysis (PSA) completed on 193 species (Hobday et al. 2007) Level 3: Sustainability Assessment for Fishing Effects (SAFE) completed on 83 species (Zhou et al. 2009)	
Bycatch workplans	*Australia's Tuna Purse Seine Fisheries Bycatch Action Plan 2005* (AFMA 2005); *Australia's Tuna and Billfish Longline Fisheries, Bycatch and Discarding Workplan, November 1, 2008 to October 31, 2010* (AFMA 2008)	
Fishery statistics[a]	**2008 fising season**	**2009 fishing season**
Fishing season	1 December 2007–30 November 2008	1 December 2008–30 November 2009
Total allowable catch	5265 t	5265 t
Catch	Purse seine: 5211 t Pelagic longline: 23 t	Purse seine: 5015 t Pelagic longline: 227 t

Table 24.2 continues over the page

TABLE 24.2 Main features and statistics of the Southern Bluefin Tuna Fishery CONTINUED

Feature	Description	
Fishery statistics[a]	**2008 fising season**	**2009 fishing season**
Effort	Purse seine: 1217 search hours; 134 shots	Purse seine: 1180 search hours; 139 shots
Fishing permits	98 SFR owners initially allocated quota at start of fishing season	96 SFR owners initially allocated quota at start of fishing season
Active vessels	Purse seine: 7 Longline: 17	Purse seine: 8 Longline: 24
Observer coverage	Purse seine: 7 shots (11.8%) Longline: 8.8% in ETBF, 12.7% in WTBF	Purse seine: 11 shots (7.9%) Longline: 6.4% in ETBF, 8.5% in WTBF
Real gross value of production (2008–09 dollars)	Commonwealth fishery (all methods): $45.9 million South Australia aquaculture: $186.7 million (includes Commonwealth input)	Commonwealth fishery (all methods): $45.3 million South Australia aquaculture: $141.4 million (includes Commonwealth input)
Allocated management costs	2007–08: $2.11 million	2008–09: $1.90 million

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; ETBF = Eastern Tuna and Billfish Fishery; SFR = statutory fishing right; WTBF = Western Tuna and Billfish Fishery

a Fishery statistics provided by fishing season unless otherwise indicated.

24.1 BACKGROUND

Southern bluefin tuna (SBT) constitutes a single, highly migratory stock that spawns in the north-east Indian Ocean and migrates throughout the temperate, southern oceans. SBT is one of the most highly valued fish species for sashimi, especially in Japan. It is therefore targeted by fishing fleets from a number of nations, both on the high seas and within the Exclusive Economic Zones of Australia, New Zealand, Indonesia and South Africa (Table 24.2). Young fish (aged one to four years) move from the spawning ground into the Australian Fishing Zone and southwards along the Western Australian coast. Surface-schooling juveniles are found seasonally in the continental-shelf region of southern Australia, but the proportion of the juvenile stock that migrates into this area is not known. Juvenile SBT are targeted in the Great Australian Bight by Australian purse seiners (Fig. 24.1), which predominantly take two- to three-year-old fish and small numbers of one- and four-year-old fish. Throughout the rest of its range, SBT is targeted by pelagic longliners, including domestic longliners operating along Australia's east coast (Fig. 24.1). Longliners harvest all ages, from juveniles about three years old (~100 cm fork length; 20 kg whole weight) through to adults (10+ years old).

Vessel departing Port Lincoln
PHOTO: KATRINA PHILLIPS, DAFF

TABLE 24.3 History of the Southern Bluefin Tuna Fishery

Year	Description
1930s	Commercial fishing for SBT began off south-east Australia.
1950s	Pole and live-bait fishing began for surface-schooling SBT (New South Wales and South Australia).
Early 1960s	Global catch of SBT peaked at 81 605 t.
Pre-1979	Japanese vessels operated unregulated in what became the AFZ.
1979 to 1997	Japanese longliners operated in AFZ under licence (Australia–Japan joint venture).
Early 1980s	Clear signs that the SBT stock was overfished became evident.
1982	Australia's catch of SBT peaked at 21 500 t. Most of the catch processed for canning.
1983	TAC of 21 000 t introduced for Australian catch.
1984	Introduction of individual transferable quotas led to reduction in latent effort in New South Wales and Western Australia, and concentration of quota holdings in South Australia.
1989	Australia, Japan and New Zealand began trilateral discussions to set non-binding international management measures, including national allocations of 5265 t (Australia), 6065 t (Japan) and 420 t (New Zealand).
1990	First trials of ranching SBT in South Australia.
1993	Australia, Japan and New Zealand developed informal, collaborative management arrangements and signed an international convention (to come into force in 1994).
1994	CCSBT established—responsible for global management of the SBT stock.
Late 1990s	Around a third of the global catch not controlled by CCSBT. A lack of MCS mechanisms allowed large amounts of IUU fishing to remain unchecked.
1997	Japanese fishers excluded from the AFZ following failure to agree on global TAC.
1998 to 2002	Failure to agree on global TAC or national allocations. Australia maintained TAC of 5265 t.
1998	Japan unilaterally embarked on its EFP, increasing its reported catch by 1464 t to 7500 t.
1999	Japan again unilaterally conducted its EFP, reporting a catch of 7554 t. Non-CCSBT catch, including 1464 t from Japanese EFP, estimated to exceed 7400 t. Australia and New Zealand sought and obtained the prescription of interim measures by the ITLOS to halt the Japanese EFP. Australia did not pursue CITES nomination of SBT.
2000	International arbitral tribunal determined ITLOS did not have jurisdiction over EFP.
2001	Republic of Korea became a member of CCSBT.
2002	Fishing Entity of Taiwan became a member of the extended Commission.
2004	Philippines formally accepted as a cooperating non-member of CCSBT.
2005	A nomination to list SBT as a threatened species under the EPBC Act rejected by the then Minister for the Environment and Heritage.
2006	CCSBT revealed large, unreported catches of SBT from 1985 to 2005. Some estimates exceeded 178 000 t (Polacheck & Davies 2008). Severe loss of confidence in the primary catch series used in stock assessment, and abandonment of the adoption of a management procedure (incorporating a rebuilding strategy) by CCSBT. CCSBT reduced the global TAC from 2007 to 2009 inclusive (11 810 t per year), including a reduced national allocation to Japan (3000 t) for 2007 to 2011, to be reviewed in 2011. South Africa and European Community formally accepted as cooperating non-members of CCSBT.
2008	Indonesia became a member of CCSBT. CCSBT adopted MCS measures to eliminate IUU fishing (to be implemented in 2010). CCSBT estimated SBT spawning stock biomass to be less than 10% of pre-exploitation biomass (CCSBT 2008a). CCSBT concluded there were no signs the stock had begun to rebuild; instead, historically low recruitment from 1999 to 2002 would lead to further declines in spawning stock biomass in the near future.
2009	CCSBT reduced the global TAC by 20% for 2010 and 2011 because of the poor status of the SBT stock, which was estimated to be ~5% SSB_0. Australia's TAC was reduced to 4015 t per year for the next two years. CCSBT agreed to implement a management procedure in 2011 to be used in TAC setting from 2012 and beyond. An interim rebuilding target of 20% of unfished spawning stock biomass was agreed. A new nomination to list SBT as a threatened species under the EPBC Act is currently being assessed.

AFZ = Australian Fishing Zone; CCSBT = Commission for the Conservation of Southern Bluefin Tuna; CITES = *Convention on International Trade in Endangered Species of Wild Fauna and Flora*; EFP = experimental fishing program; EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; ITLOS = International Tribunal for the Law of the Sea; IUU = illegal, unregulated and unreported; MCS = monitoring, control and surveillance; SBT = southern bluefin tuna; TAC = total allowable catch

24.2 HARVEST STRATEGY

The *Commonwealth Fisheries Harvest Strategy Policy* is not prescribed for fisheries, such as the Southern Bluefin Tuna Fishery (SBTF), that are managed by international management bodies. The CCSBT, however, is developing a management procedure (similar to a harvest strategy) to be implemented by 2011 (Table 24.3). Once in place, this will form the basis of setting the total allowable catch (TAC). The CCSBT has also agreed to an interim rebuilding target of 20% of unfished spawning stock biomass.

24.3 THE 2009 FISHERY

Key target and byproduct species

National annual catch allocations for 2009 were Australia—5265 t, Japan—3000 t, New Zealand—420 t, Republic of Korea—1140 t, and Fishing Entity of Taiwan—1140 t. Interim catch allocations for cooperating non-members and observers for 2009 were Indonesia—750 t, Philippines—45 t, South Africa—40 t, and European Community—10 t. Korea and Chinese Taipei pledged to limit their respective actual catches to less than 1000 t until at least 2009, so the effective annual TAC for 2007 to 2009 will be below 11 530 t.

Australia's total catch for the 2009 fishing season was 5242 t, with almost all harvested fish (5015 t, representing 96% of the total catch) being fish captured in the purse-seine fishery (Fig. 24.5) and transferred to grow-out pontoons in Port Lincoln. Approximately 227 t were caught by longline in the Eastern Tuna and Billfish Fishery (ETBF), and less than 1 t by longline in the Western Tuna and Billfish Fishery (WTBF). There were insufficient data from which to estimate the total Australian recreational catch during 2009.

In 2009, 8 purse-seine and 24 longline vessels contributed to the total catch. The observer program of the Australian Fisheries Management Authority (AFMA) aims to monitor 10% of SBT fishing activities and employs international observers in compliance with CCSBT observer standards. In 2008–09 the purse-seine coverage was 7.9% of sets. A coverage level of 32.9% was achieved in the longline ETBF south of 30°S from May to September (the months in which SBT are usually caught), and 8.5% in the longline WTBF.

In 2008–09 the value of the fishery's commercial production was $45.3 million (Fig. 24.2). This is about half the 2002–03 value of $90 million and also significantly lower than in earlier years. Recent exchange rate movements and competition from northern bluefin tuna ranched in the Mediterranean have reduced the price of SBT on the Japanese market. The method for estimating the gross value of production (GVP) of the SBTF is explained in Box 1 (page 41 of Chapter 1).

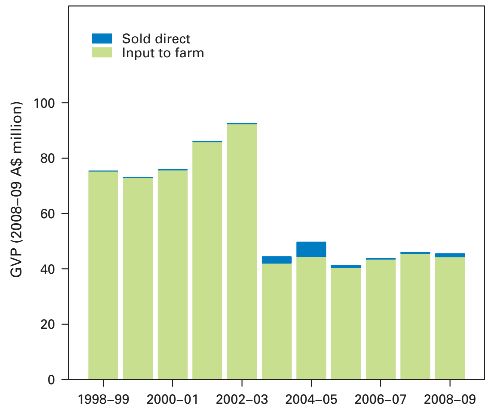


FIGURE 24.2 Real value of SBT production by financial year, 1998–99 to 2008–09

Trade

Between 2002–03 and 2008–09, Australian exports of SBT declined in value by 50% (in real terms) to $158 million (Fig. 24.3). As noted above, this reflects reduced prices on the main Japanese market caused by increased competition from the Mediterranean, as well as the relatively high value of the Australian dollar, which reduced the competitiveness of Australian exports. Unit

export values of frozen and fresh or chilled SBT declined by 59% and 47%, respectively, from 2002–03 to 2008–09 (Fig. 24.4).

In the purse-seine sector, there is a lag between the capture of SBT and the sale of the final product from ranches. Schools of SBT are usually captured in the Great Australian Bight between January and March, whereas exports peak in July–September after fish have been fattened in ranch pontoons. Therefore, care is required when comparing trends in the gross value of the capture fishery and the value of exports. For example, the large drop in the GVP of the capture fishery between 2002–03 and 2003–04 appears as a fall in export value in the following year (2003–04 to 2004–05).

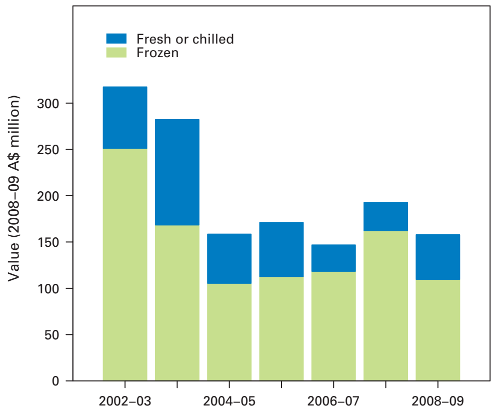


FIGURE 24.3 Real value of SBT exports, by processing method, financial years 2002–03 to 2008–09

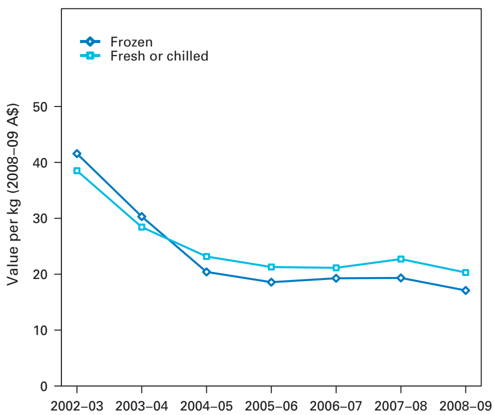


FIGURE 24.4 Real unit value of SBT exports, by processing method, financial years 2002–03 to 2008–09

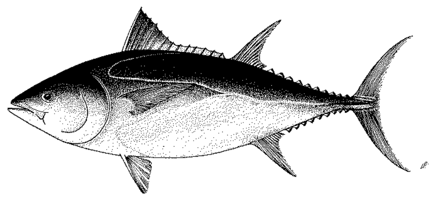
Minor byproduct species

Australian logbook and observer data suggest that there is minimal incidental catch during purse-seine fishing for SBT. Longlining bycatch consists mainly of large, pelagic fish, including substantial numbers of sharks. Longline byproduct is reported in the ETBF and WTBF chapters (Chapters 22 and 25).

24.4 BIOLOGICAL STATUS

SOUTHERN BLUEFIN TUNA

(*Thunnus maccoyii*)



LINE DRAWING: FAO

TABLE 24.4 Biology of southern bluefin tuna

Parameter	Description
Range	**Species:** Mostly distributed between 30°S and 60°S in southern temperate oceans, excluding the eastern Pacific Ocean. **Stock:** Southern bluefin tuna constitutes a single, highly migratory pelagic stock.
Depth	0–500 m
Longevity	40+ years
Maturity (50%)	**Age:** ~10–12 years **Size:** 120–130 cm FL
Spawning season	September–April. A single-known spawning ground is located in the north-east Indian Ocean (10–20°S, 105–120°E).
Size	**Maximum:** 225 cm FL; ~200 kg whole weight **Recruitment into the fishery:** ~55 cm FL; 3.5 kg whole weight (9–12 months of age)

SOURCE: Gomon et al. (2008).

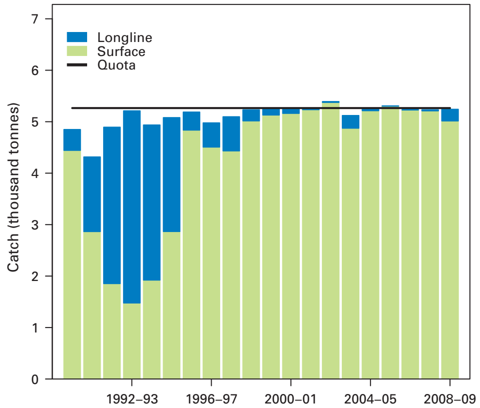


FIGURE 24.5 Southern bluefin tuna catch history (Australia) by financial year, 1989–1990 to 2008–09

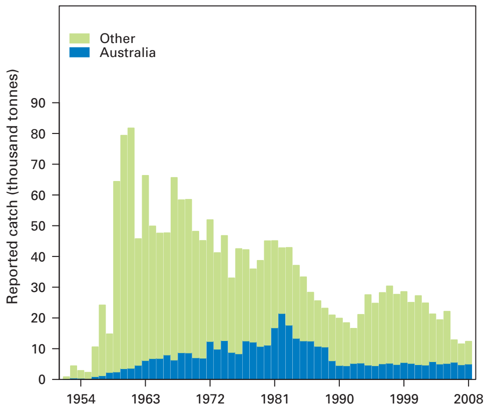


FIGURE 24.6 Southern bluefin tuna catch history (reported global), 1952 to 2008

NOTE: Total global catches exceeded reported global catches over 1985–2005; some scientists estimate unreported catches to have surpassed 178 000 t over this period (Polacheck & Davies 2008).

Stock status determination

In 2009 a revised operating model was used to run various scenarios using different annual catches to determine the impact on the stock. All the scenarios indicated results consistent with those from previous assessments in recent years; the stock remains at a very low level (~5% of unfished spawning stock biomass) and well below the level that could produce maximum sustainable yield (MSY) (CCSBT 2009). Recruitment during the past 20 years is estimated to be below that seen from 1950 to 1980. Recent trends in recruitment (since 2005) have yet to become apparent, although poor recruitment from 2000 to 2002 is evident as weak year-classes, which will have a negative impact on the spawning stock. Median projections under the 2009 TAC of 11 810 t (global catch) for the base case indicate a decline in the biomass until 2013 (CCSBT 2009). In order to rebuild the stock, and to buffer against further poor recruitment, a 20% TAC reduction was implemented for the 2010 fishing season. SBT is considered to be **overfished** and **subject to overfishing** (Table 24.1).

Reliability of the assessment

The CCSBT operating model is sophisticated and well accepted by the international scientific community. Furthermore, intensive data collection and research have taken place over many years into both the biology of SBT and associated fisheries. However, the recognition in 2006 that the true global catch of SBT has been much greater than previously reported means that much of the previous assessment work is now invalid. Most important is the lack of information on how reported effort levels relate to the estimated levels of unreported catch.

Previous assessment/s

In 2006 as a result of uncertainty in historical catch (Fig. 24.6) and catch per unit effort (CPUE) arising from two decades of unreported catch and effort, a series of scenarios encompassing a wide range of possible circumstances were evaluated in lieu of a stock assessment. Outcomes of these scenarios were consistent with each other and suggested the SBT spawning stock to be at a low fraction of its original biomass and well below the level that could produce MSY. All scenarios indicated that any future catches over 14 925 t posed very serious threats to the stock, and that catches must be reduced below this level if the spawning stock biomass is to rebuild (CCSBT 2006).

Results from a limited range of scenarios in 2008 were generally consistent with those from 2006, if not indicative of further decline. Scenarios indicated that the spawning

stock biomass was still very low (generally below 10% of pre-exploitation spawning stock biomass, a level at which recruitment may be at risk of further decline), and well below the level that could produce MSY. In 2008 a relative index of abundance obtained from aerial surveys of surface-schooling juveniles in the Great Australian Bight (a fisheries-independent indicator of recruitment) was incorporated into the operating model. Analysis of independent indicators suggested historically low recruitment from 1999 to 2002 (CCSBT 2008a).

Future assessment needs

The next stock assessment will occur in 2011. The management procedure should also be implemented in 2011, and this will govern the TAC setting process for 2012 and beyond. In the short term, the immediate need of the CCSBT is to ensure accurate catch and effort reporting to enable accurate biomass predictions possible in the light of uncertainties and historical unreported catches (CCSBT 2008b).

24.5 ECONOMIC STATUS

The Australian Bureau of Agricultural and Resource Economics–Bureau of Rural Sciences did not survey the SBTF, so estimates of net economic returns (NER) are not available. The vertically integrated characteristics of the wild catch sector and farming sector make assessment of economic performance in the wild catch sector difficult. However, indicators of fishery economic performance available include latent effort, value of quota, export prices, effort and catch rates. The discussion that follows focuses on performance in the period ending 2008–09. This period is prior to recent TAC changes for SBT.

Latency

AFMA sets the TAC for the SBTF to coincide with the national allocation from the CCSBT. Under the informal trilateral discussions, Australia's allocation remained constant at 5265 t over the period 1989 to 2009. The quota has generally been filled every year since 2000, although small overcatches in 2003 and 2006 led to corresponding allocation reductions in 2004, 2007 and 2008 (Table 24.5). These consistently low levels of quota latency in the fishery indicate that NER have been positive.

TABLE 24.5 Latent effort in the SBTF

Season	Catch (tonnes)	TAC (tonnes)	% of TAC caught	Latency (%)
2005	5244	5265	99.6	0.4
2006	5635	5265	107	–7.0
2007	4813	5265	91.4	8.6
2008	5051	5265	95.9	4.1
2009	5242	5265	99.6	4.1

TAC = total allowable catch

Value of quota

Generally, the value a holder places on a unit of quota is related to the holder's perception about the current and future profits of the fishery, meaning that quota values can provide an indication of fishery profitability. Anecdotal evidence suggests that this may not be the case in the SBTF given limited trade, quota aggregation among a small number of operators and seasonal leasing to cover requirements to fish in other Commonwealth fisheries (e.g. Eastern Tuna and Billfish Fishery).

Despite these factors, movements in quota lease prices from season to season may still give a broad indication of relative profitability between fishing seasons. Anecdotal evidence suggests that SBT lease quota prices declined in 2008–09, reflecting the negative effect of the global financial crisis on international tuna demand. This has also been reflected by a significant build-up of cold store inventories in key export markets with tuna wholesalers attempting to hold off selling product until demand and prices improve.

Export prices

Figure 24.4 showed that SBT export prices declined from 2002–03 to 2008–09. In 2008–09 the average SBT export price in real terms dropped by 9% from $19.80 per kilogram in 2007–08 to $17.96 per kilogram (2008–09 dollars). The latter price is 39% lower than the $29.52 recorded in 2002–03. Furthermore, comparing the 2008–09 price to the average export price for the incomplete 2009–10 financial year (July 2009 to April 2010) reveals a further 25% drop to $13.45 per kg. These price declines further indicate that NER are likely to have declined in 2008–09.

Overall economic performance

The SBTF is a high value, high-profit fishery. However, given the biological status of the SBT stock, it is likely that some proportion of profits over the past few decades have been generated by fishing down the stock rather than harvesting at sustainable levels, at least at the global scale. Consequently, the current level of profits may not be sustainable over the longer term.

The economic indicators discusssed provide some guidance as to which way NER in the wild catch sector have moved relative to previous years. Prices are at historically low levels, indicating that the gross returns on catch are low relative to previous years. A stable catch rate indicates that the cost of fishing remains relatively stable, although lower fuel prices in 2008–09 could imply a slight decrease in aggregated costs. Together with anecdotal evidence of declines in quota lease prices, these indicators suggest that NER in the fishery have declined.

It it likely that long term NER from the SBTF could be maximised through a reduction in global catches to allow stocks to recover to more abundant levels so that the costs of fishing are lower and the risk to overall stock sustainability is reduced.

24.6 ENVIRONMENTAL STATUS

The CCSBT has several measures in place to mitigate the environmental impact of fishing. This includes reducing seabird interactions through the mandatory use (by all Members and Cooperating Non-Members) of tori lines on SBT longline vessels below 30°S. The CCSBT Scientific Observer Program has a target coverage level of 10% for catch and effort in all fisheries. The CCSBT also publishes education pamphlets and guides on seabirds and sharks for SBT fishers. The Working Group on Ecologically Related Species (WG-ERS) has recommended that all Members and Cooperating Non-Members implement international guidelines on sharks, seabirds and turtles (e.g. the FAO Guidelines to reduce sea turtle mortality in fishing operations); comply with all measures to protect ecologically related species (ERS) implemented by the Indian Ocean Tuna Commission (IOTC) and the Western Central Pacific Fisheries Commission (WCPFC); and collect and report data on ERS to the CCSBT, for sharing with the IOTC and the WCPFC. The WG-ERS has also recommended that a risk assessment be undertaken for ERS in the SBTF.

Ecological risk assessment

An ecological risk assessment based on the methodology developed by AFMA and the Commonwealth Scientific and Industrial Research Organisation was undertaken for SBT. The Level 2 assessment indicated that only two species, of the 193 assessed, were considered to be at high risk: SBT and white shark (Hobday et al. 2007). A Level 3 assessment was also conducted on 83 non-target species (6 chondrichthyans and 77 teleosts) to determine the impact of SBT fishing on the sustainability of these species (AFMA 2009). It was determined that the risk to the sustainability of these non-target species was low (Zhou et al. 2009).

Threatened, endangered and protected species

Seabirds

In waters south of 30°S, albatross and other seabirds are occasionally hooked on longline gear when diving on baits during line setting. In August 1998, the then Australian Government Minister for the Environment and Heritage approved a threat abatement plan to reduce the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations; this was updated in 2006 (DEWR 2006; see Chapter 22 for further details).

Sharks

Interactions between sharks and purse seines are rare. For example, observer data from 2003 to 2008 showed interactions with only a single hammerhead shark and a single mako shark during that period; both sharks were released alive. However, it is likely that observers miss some interactions. The observer program monitors 10% of both purse seine and longline catch. From these data, the purse seine method appears to have very infrequent interactions with shark species. Interactions with sharks using longline gear are noted in the ETBF and WTBF chapters (Chapters 22 and 25).

Unloading Southern bluefin tuna
PHOTO: DOUG HAZELL, AFMA

Pelagic habitats

There is minimal negative interaction with pelagic habitats.

24.7 HARVEST STRATEGY PERFORMANCE

Australia's national allocation of 5265 t remained unchanged from 1989 to 2009, despite serious declines in spawning stock biomass and poor recruitment. The CCSBT is in the process of developing a harvest strategy (or management procedure) by 2011, which will include interim and long-term rebuilding targets and management objectives for the stock. In the interim, Australia has accepted a 24% reduction in its allocation over the 2010 and 2011 fishing seasons to 8030 t.

24.8 LITERATURE CITED

AFMA (Australian Fisheries Management Authority) 1995, *Southern Bluefin Tuna Fishery Management Plan 1995*, DAFF, Canberra, Federal Register of Legislative Instruments F2008C00099.

——2005, *Australia's Tuna Purse Seine Fisheries Bycatch Action Plan 2005*, AFMA, Canberra.

——2008, *Australia's Tuna and Billfish Longline Fisheries, Bycatch and Discarding Workplan, November 1, 2008 to October 31, 2010*, AFMA, Canberra.

——2009, *Ecological risk management report for the Southern Bluefin Tuna Fishery*, December 2009, AFMA, Canberra.

Campbell, D, Brown, D & Battaglene, T 2000, 'Individual transferable catch quotas: Australian experience in the southern bluefin tuna fishery', *Marine Policy*, vol. 24, pp. 109–17.

CCSBT (Commission for the Conservation of Southern Bluefin Tuna) 2006, *Report of the seventh meeting of the stock assessment group*, Tokyo, 4–11 September 2006, CCSBT.

——2008a, *Report of the thirteenth meeting of the scientific committee*, Rotorua, 5–12 September 2008, CCSBT.

——2008b, *Report of the performance review working group*, part two, *Report of the independent expert*, CCSBT.

——2009, *Report of the fourteenth meeting of the scientific committee*, Busan, 5–11 September 2009, CCSBT.

DEWR (Department of the Environment and Water Resources) 2006, *Threat abatement plan for the incidental catch (or bycatch) of seabirds during longline fishing operations*, DEWR, Canberra, <www.aad.gov.au/MediaLibrary/asset/MediaItems/ml_399394109837963_FINAL%20ThreatAbatement2007-4-combined6c.pdf>.

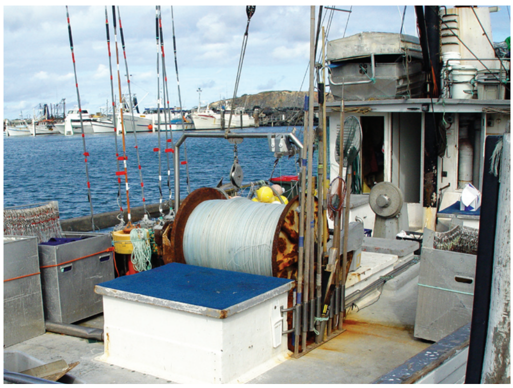
Gomon, M, Bray, D & Kuiter, R 2008, *Fishes of Australia's south coast*, New Holland Publishers, Sydney.

Hobday, AJ, Dowdney, J, Bulman, C, Sporcic, M, Fuller, M & Ling, S 2007, *Ecological risk assessment for the effects of fishing: Southern Bluefin Tuna Purse Seine Fishery*, report for AFMA, Canberra.

Polacheck, T & Davies, C 2008, *Considerations of implications of large unreported catches of southern bluefin tuna for assessments of tropical tunas, and the need for independent verification of catch and effort statistics*, CSIRO Marine and Atmospheric Research paper 023, CSIRO, Hobart.

Zhou, S, Fuller, M & Smith, T 2009, *Rapid quantitative risk assessment for fish species in seven Commonwealth fisheries*, report for AFMA, Canberra.

Southern bluefin tuna pontoon PHOTO: AFMA



Radio buoys and longline gear, Coffs Harbour PHOTO: AFMA

25 Western Tuna and Billfish Fishery

D Wilson, P Sahlqvist, H Patterson and S Vieira

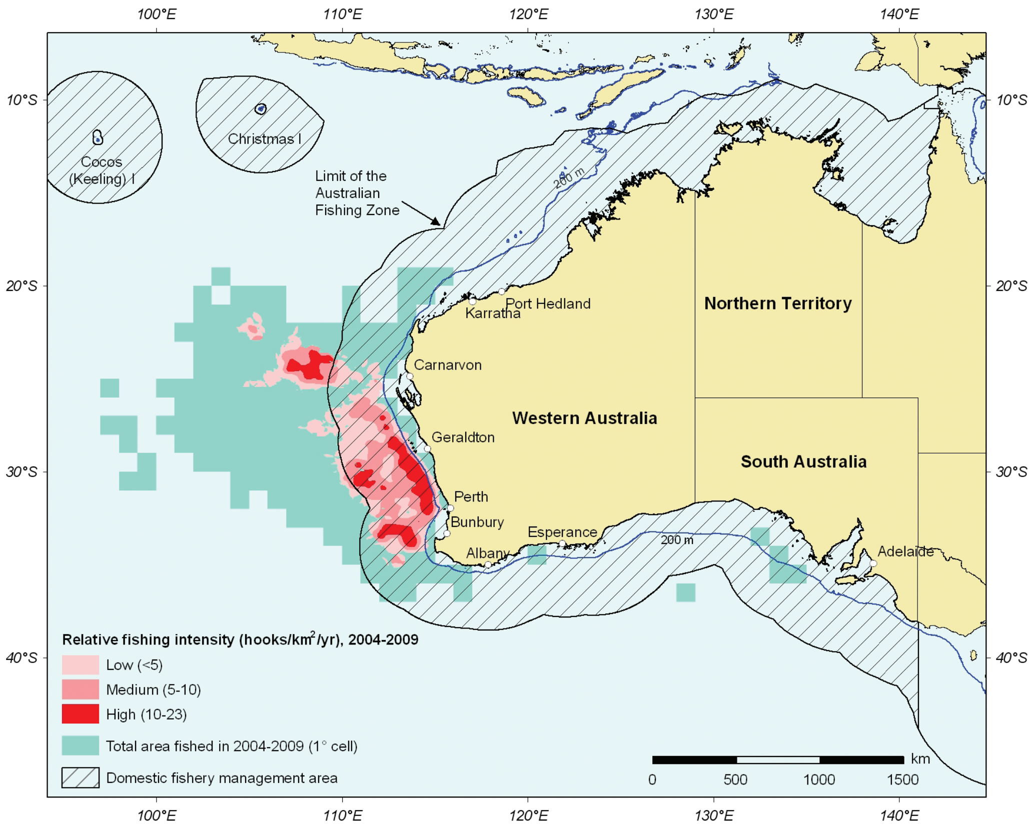


FIGURE 25.1 Relative fishing intensity in the Western Tuna and Billfish Fishery, 2004–2009

TABLE 25.1 Status of the Western Tuna and Billfish Fishery

Fishery status	2008		2009		Comments[a]
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Marlin, striped (*Tetrapturus audax*)	Uncertain	Uncertain	Uncertain	Uncertain	No current assessment. CPUE trends declining. Aspects of biology, productivity and fisheries, combined with the lack of data, are a cause for concern.
Swordfish (*Xiphius gladius*)	Overfishing	Uncertain	Overfishing	Uncertain	Localised depletion evident in the south-west and north-west Indian Ocean, overrides ocean-wide assessments.
Tuna, albacore (*Thunnus alalunga*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Catches have continued to decline since 2000 due to a reduction in targeted effort.
Tuna, bigeye (*Thunnus obesus*)	Uncertain	Not overfished	Not subject to overfishing	Not overfished	Current fishing patterns are considered sustainable.
Tuna, longtail (*Thunnus tonggol*)	Not assessed	Not assessed	Uncertain	Uncertain	No current assessment. Agreed as a priority for assessment by the IOTC.
Tuna, yellowfin (*Thunnus albacares*)	Overfishing	Not overfished	Overfishing	Not overfished	Current levels of overfishing and historical average levels of recruitment have moved the stock close to an overfished state.
Economic status Fishery level	Estimates of net economic returns not available but likely to be low				Economic status uncertain. Latent effort remained high in 2009, suggesting low total net economic returns.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING (green) — OVERFISHED / OVERFISHING (red) — UNCERTAIN (yellow) — NOT ASSESSED (grey)

CPUE = catch per unit effort; IOTC = Indian Ocean Tuna Commission

a Domestic assessments are unreliable because interactions with broader regional stocks are uncertain. Ocean-wide assessments of species through the Indian Ocean Tuna Commission were used as the basis for stock status determination.

TABLE 25.2 Main features and statistics of the Western Tuna and Billfish Fishery

Feature	Description
Key target and byproduct species	Marlin, striped (*Tetrapturus audax*) Swordfish (*Xiphius gladius*) Tuna, albacore (*Thunnus alalunga*) Tuna, bigeye (*Thunnus obesus*) Tuna, longtail (*Thunnus tonggol*) Tuna, yellowfin (*Thunnus albacares*)
Other byproduct species	Blue shark (*Prionace glauca*) Mahi mahi (*Coryphaena hippurus*) Rudderfish (*Lepidocybium flavobrunneum*) Tuna, skipjack (*Katsuwonus pelamis*) Tuna, southern bluefin (*Thunnus maccoyii*) A complete list of minor byproduct species is provided in Table 25.4.
Fishing methods	Pelagic longline (monofilament mainline) Minor line (handline, rod and reel, troll and poling)
Primary landing ports	Fremantle, Geraldton

Table 25.2 continues over the page

TABLE 25.2 Main features and statistics of the Western Tuna and Billfish Fishery CONTINUED

Feature	Description
Management methods	Input controls: limited entry, gear and area restrictions Output controls: bycatch restrictions Individual transferable quotas to be implemented under the management plan once SFRs are finalised in 2010.
Management plan	*Western Tuna and Billfish Management Plan 2005* (DAFF 2005) (amended 2006) SFRs to be issued in 2010
Harvest strategy	*Development and preliminary testing of the harvest strategy framework for the Western Tuna and Billfish Fishery* (Davies et al. 2008)—not implemented Reference points and triggers: not defined
Consultative forums	WTBF Management Advisory Committee (WTBFMAC), WTBF Resource Assessment Group (WTBFRAG)—moved to the Tropical Tuna MAC (TTMAC) and Tropical Tuna Resource Assessment Group (TTRAG) in 2010
Main markets	International: Japan, United States—fresh, frozen Domestic: fresh, frozen
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Current accreditation dated 2 February 2010 Current accreditation (Exempt) expires 01 December 2014
Ecological risk assessment	Level 1: Scale Intensity Consequence Analysis (SICA) completed on 348 species (Webb et al. 2007) Level 2: Productivity Susceptibility Analysis (PSA) completed on 348 species (Webb et al. 2007) Level 3: Sustainability Assessment for Fishing Effects (SAFE) completed on 187 species (Zhou et al. 2007)
Bycatch workplans	*Australian Tuna and Billfish Longline Fisheries Bycatch and Discarding Workplan, 1 November 2008–31 October 2010* (AFMA 2008)

Fishery statistics[a]	2008 fishing season		2009 fishing season	
Fishing season	1 January–31 December		1 January–31 December	
TAC and catch by species:	TAC (tonnes)	Catch (tonnes)	TAC (tonnes)	Catch (tonnes)
—marlin, striped	None	< 1	None	< 1
—swordfish	None	142	None	349
—tuna, albacore	None	10	None	20
—tuna, bigeye	None	26	None	62
—tuna, longtail	35	7	35	11
—tuna, yellowfin	None	< 1	None	12
Effort	Pelagic longline: 226 061 hooks set Minor lines: unknown number of hooks set		Pelagic longline: 528 038 hooks set Minor lines: unknown number of hooks set	
Fishing permits	93, plus 3 carrier vessels		93, plus 3 carrier vessels	
Active vessels	Pelagic longline: 1 Minor line: 1		Pelagic longline: 3 Minor line: 1	
Observer coverage	28 750 hooks (12.72%)		44 790 hooks (8.5%)	
Real gross value of production (2008–09 dollars)	Confidential (<5 vessels)		Confidential (<5 vessels)	
Allocated management costs	2007–08: $0.52 million		2008–09: $0.42 million	

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; TAC = total allowable catch; WTBF = Western Tuna and Billfish Fishery; SFR = statutory fishing right

a Fishery statistics provided by fishing season unless otherwise indicated.

25.1 BACKGROUND

Domestic management arrangements for the Western Tuna and Billfish Fishery (WTBF) (Fig. 25.1) reflect Australia's obligations to the Indian Ocean Tuna Commission (IOTC) (see Chapter 21). Although the management plan for the fishery commenced in 2005, the fishery continues to be managed under transitional provisions while the process of allocating statutory fishing rights (SFRs) is completed (Table 25.2). The Australian Fisheries Management Authority (AFMA) is currently in the process of granting SFRs. Under the plan, total allowable catches (TACs) are proposed for five species (bigeye tuna, longtail tuna, yellowfin tuna, striped marlin and swordfish). The proposed TACs are considerably higher than historical catches, but under the plan they apply to the high seas as well as the Australian Fishing Zone (AFZ), and are intended to provide for an expansion of the fishery into the Indian Ocean. Other species, both target (albacore tuna) and non-target, may need to be considered for future quota management. A 12-month fishing season commenced under the management plan, starting 1 July 2010.

Western Australia has an active recreational gamefish fishery, targeting sailfish (*Istiophorus platypterus*), black marlin (*Makaira indica*), blue marlin (*M. nigricans*), striped marlin and yellowfin tuna. Under the management plan for the fishery, AFMA will be able to direct fishers not to fish in certain areas. For example, summer and winter closures could be used to exclude commercial fishers from areas selected to benefit recreational fishers targeting sportfish species (such as marlins).

TABLE 25.3 History of the Western Tuna and Billfish Fishery

Year	Description
1950s	Japan began pelagic longlining off Australia, targeting bigeye tuna in the south-west and striped marlin in the north-west of the fishery.
1979	From November, Japan operated in the AFZ under bilateral agreements.
1980 to 1997	Australia progressively restricted areas of access for Japan's longliners. Concerns over targeting of marlin by joint-venture vessels led to a 50 nm exclusion zone.
1985	Freeze on the issue of new Commonwealth fishing vessel licences (July).
1986	Domestic pelagic longliners first operated in the waters of the WTBF.
1994	Western Australia legislated to prevent the landing for commercial sale of all billfish of the Istiophoridae family (not enforced until December 1999, over-ridden by Commonwealth legislation in 2005).
1994 to 1996	OCS agreements place tuna and tuna-like species under the jurisdiction of the Commonwealth.
1995	Longlining declared a key threatening process for seabirds.
1996	The agreement for the establishment of the Indian Ocean Tuna Commission entered into force on 27 March. Australia became a member of the Commission on 13 November.
1997	Japan's longliners, operating under a joint venture with the Commonwealth and the Tuna Boat Owners Association, were excluded from the AFZ in November (due largely to consideration of recreational fishing interests).
1997 to 1998	Domestic longline fishery began to develop. Interest in the WTBF increased substantially, with an increase in investment and prices paid for the transfer of fishing permits. Most activity over the continental slope (Perth–Shark Bay and Exmouth–Karratha areas).
1998	*Fisheries Management Act 1991* amended to require all commercial fishers to return black and blue marlin to sea irrespective of life status. Threat abatement plan released for the incidental catch of seabirds during longline fishing operations (superseded by AFMA 2008).
1999	Western Australian Department of Fisheries announced it would enforce legislation prohibiting the landing of striped marlin, spearfish and sailfish (December).

Table 25.3 continues over the page

TABLE 25.3 History of the Western Tuna and Billfish Fishery CONTINUED

Year	Description
2000	Vessel numbers peaked, and replacement of small (15–20 m) longliners by larger vessels began. The fleet's capacity to operate on distant grounds increased, leading to considerable activity outside the AFZ. The Australian Government introduced a ban on shark finning in tuna fisheries, which prohibits the possession or landing of fins separated from carcasses. All shark byproduct in the WTBF must be landed with fins attached (either naturally or by other means) to the carcass.
2001	Peak catches taken in the fishery (longline and minor line combined: ~3370 t). Use of wire traces banned (September). Australian Tuna and Billfish Fisheries Bycatch Action Plan launched (superseded by AFMA 2008).
2002	Catch levels and fishing effort began to decline due to low prices and higher operating costs. Concerns over the possible localised depletion of swordfish off the Western Australian coast.
2004	Second Bycatch Action Plan released (superseded by AFMA 2008).
2005	Management plan commenced (21 October). Fishery continues to be managed under transitional provisions while the process of allocating SFRs is completed. IOTC adopted a resolution that the weight of fins held aboard a vessel should not exceed 5% of the weight of sharks on the vessel.
2006	AFMA placed annual TAC of 35 t on the commercial catch of longtail tuna, plus a 10-fish trip limit in excess of 35 t—to commence in 2007. *Securing our Fishing Future*–initiated buyback of Commonwealth fishing concessions reduced the number of WTBF permits to 111. Second threat abatement plan released (AAD 2006).
2007	Commencement of the process for granting SFRs under the WTBF management plan. Provisional grant of SFRs made in April. Review of provisional grant by the SFR Allocation Review Panel in December. Final grant of SFRs delayed due to legal challenges.
2008	Harvest strategy framework for quota species adopted by AFMA. IOTC Scientific Committee recommended that the resolution on fin:body weight ratio be replaced with one that requires shark fins to be landed attached to the body, either naturally or by other means. Despite attempts by Australia, the French Territories and the European Union to have the IOTC adopt such a resolution, the measure was not agreed upon at the Commission level.
2009	Insufficient effort in the WTBF to begin to implement the harvest strategy framework (expected to be implemented once effort increases to a point where sufficient data become available for use in the framework).

AFMA = Australian Fisheries Management Authority; AFZ = Australian Fishing Zone; IOTC = Indian Ocean Tuna Commission; OCS = Offshore Constitutional Settlement; SFR = statutory fishing right; TAC = total allowable catch; WTBF = Western Tuna and Billfish Fishery

25.2 HARVEST STRATEGY

A harvest strategy (HS) has been developed for the WTBF (Davies et al. 2008) and is scheduled for implementation once effort increases in the fishery to a point where sufficient data become available for use in the strategy (the number of active vessels in 2008 and 2009 was less than five, Table 25.2). The framework includes a 'decision tree' that defines rules and subsequent adjustments to the recommended biological catch (or level of fishing mortality). Empirical indicators of stock status are used because robust, region-specific assessments are not available for stocks within the WTBF.

For each target species, standardised catch rates for three size classes of fish (small, prime and large) will form the main performance indicators. The values of the indicators will be compared with target and limit reference points. By considering size data, the HS should be more robust to potential biases associated with using only longline catch rates as indices of abundance. Research is in progress to examine the impact of uncertainty in the linkages between the WTBF and the wider Indian Ocean stocks on the implementation of the strategy. The outcomes of the management strategy evaluation process for the Eastern Tuna and Billfish

Fishery will shape any future development and implementation of a HS for the WTBF.

The IOTC uses reference points based on maximum sustainable yield (MSY) for status determination; a biomass below B_{MSY} is considered overfished. However, as there is no formal HS in place for IOTC stocks, the limit reference point proxies in the *Commonwealth Fisheries Harvest Strategy Policy* apply. Data usually show a lag of at least one full calendar year. Thus, in most cases, stock assessments run in 2009 use complete data up until the end of 2007, and preliminary data to the end of 2008.

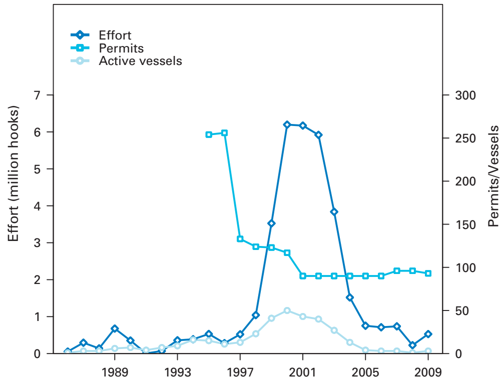


FIGURE 25.2 Longline effort in the WTBF, 1986 to 2009

25.3 THE 2009 FISHERY

Key target and byproduct species

The total catch in 2009 was 462 t, compared with 197 t in 2008. Gross value of production (GVP) since 2005 is confidential as fewer than five vessels have fished each year (Figs. 25.2, 25.3). During 2004 to 2009, a total of 4 476 492 hooks were set in the fishery, with a total reported catch of 2663 t (longline 2589 t; minor line 74 t). Despite the peak catches of approximately 3370 t (longline and minor line combined) in 2001 (Fig. 25.4), the WTBF accounted for less than 0.5% of the total tuna and billfish catch in the Indian Ocean (Dowling et al. 2005). The value of the WTBF fell from $41.2 million in 2000–01 to $4.1 million in 2004–05 (2008–09 dollars) (Fig. 25.5). The value of the fishery since 2004–05 cannot be reported for confidentiality reasons, as fewer than five vessels have been active in the longline fishery during that time.

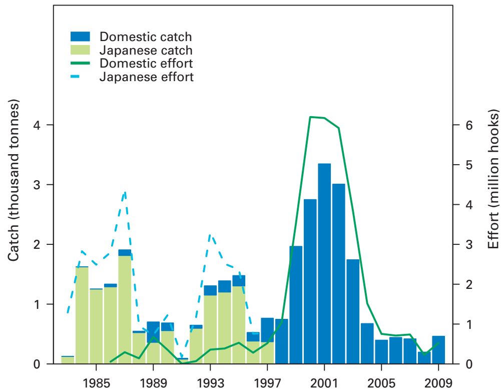


FIGURE 25.3 Longline catch and effort in the WTBF, 1983 to 2009

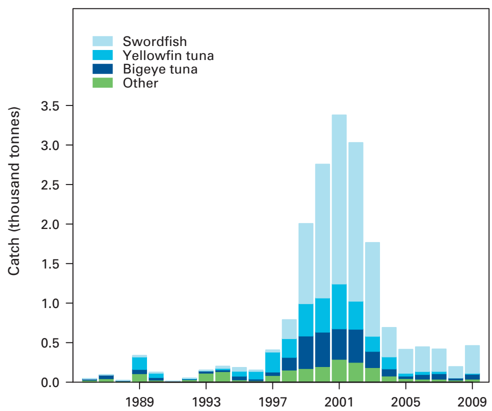


FIGURE 25.4 Total annual catch by species in the WTBF, 1986 to 2009

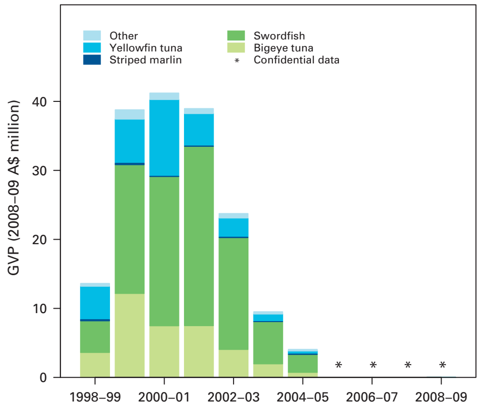


FIGURE 25.5 Real GVP for the WTBF by financial year, 1998–99 to 2008–09

NOTES: Estimates for 2005–06 to 2008–09 are confidential as less than five vessels operated. Albacore values are included in the 'other' category.

Minor byproduct species

Offshore Constitutional Settlement arrangements currently give the Western Australian Government jurisdiction over sharks. WTBF operators are permitted to land a maximum of 20 sharks per vessel per fishing trip within the AFZ and, upon application, up to 100 pelagic sharks per trip during single-jurisdiction high-seas trips beyond the AFZ. These 100 sharks must comprise a maximum of 80 blue whaler sharks (*Prionace glauca*) and a maximum of 20 sharks or rays from of the following eight oceanic species:

- crocodile shark (*Pseudocarcharias kamoharai*)
- silky shark (*Carcharhinus falciformis*)
- oceanic whitetip shark (*Carcharhinus longimanus*)
- smooth hammerhead (*Sphyrna zygaena*)
- pelagic stingray (*Dasyatis violacea*)
- shortfin mako (*Isurus oxyrinchus*)
- porbeagle (*Lamna nasus*)
- thresher shark (*Alopias vulpinus*).

One permit carried this condition in 2009. Zero retention applies to all other shark and ray species of subclass Elasmobranchii.

On 29 January 2010, porbeagles, shortfin makos and longfin makos were listed as migratory species under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The listing of the species is a legislated requirement following their listing in Appendix II of the International Convention on Migratory Species. Under the EPBC Act, it is an offence to take, trade, keep or move a member of a listed migratory species. However, actions taken under accredited fisheries management plans or arrangements are exempt from these offence provisions. The WTBF is an accredited fishery. The Australian Government Department of the Environment, Water, Heritage and the Arts (DEWHA) has advised that this exemption allows commercial fishers to retain and trade the three shark species if they are brought up already dead, but requires that live caught sharks must be returned to the sea unharmed. All catches of these sharks, whether retained or released, must be reported in the daily fishing logbooks.

A breakdown of the minor byproduct species landed and discarded from 2004 to 2009 is shown in Table 25.4, with blue shark, skipjack tuna, rudderfish and oilfish dominating catches.

Unloading swordfish PHOTO: JACQUI COOK, CSIRO

TABLE 25.4 Minor byproduct species—TACs/triggers, catches/landings and discards from the longline sector of the WTBF from 2004 to 2009

Species	TAC/ trigger	2004 to 2009 catch (tonnes)	2004 to 2009 discards (individuals)
Blacktip sharks (*Carcharhinus* spp.)	Trip limit	0.3	0
Blue shark (*Prionace glauca*)	Trip limit	49	34 359
Bronze whaler (*Carcharhinus brachyurus*)	Trip limit	0.3	109
Crocodile shark (*Pseudocarcharias kamoharai*)	None	0.1	20 017
Mahi mahi (*Coryphaena hippurus*)	None	11	0
Moonfish (*Lampris guttatus, L. immaculatus*)	None	1.8	0
Northern bluefin tuna (*Thunnus thynnus*)	None	0.4	0
Oceanic whitetip shark (*Carcharhinus longimanus*)	Trip limit	1.5	635
Oilfish (*Ruvettus pretiosus*)	None	19.6	234
Porbeagle (*Lamna nasus*)	Trip limit	0.1	0
Ray's bream (*Brama brama*)	None	0.5	0
Rudderfish (*Centrolophus niger*)	None	23	103
Scalloped hammerhead (*Sphyrna lewini*)	Trip limit	0.4	211
Shortbilled spearfish (*Tetrapturus angustirostris*)	None	0.6	0
Shortfin mako (*Isurus oxyrinchus*)	Trip limit	1.7	1 450
Skipjack tuna (*Katsuwonus pelamis*)	None	30	0
Southern bluefin tuna (*Thunnus maccoyii*)[a]	Quota	2.8	225
Thresher shark (*Alopias vulpinus*)	Trip limit	<0.1	0
Wahoo (*Acanthocybium solandri*)	None	0.9	0
Yellowtail scad (*Trachurus novaezelandiae*)	None	0.6	384

a Managed under quota in the Southern Bluefin Tuna Fishery (see Chapter 24)

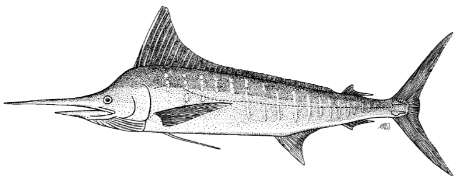
Swordfish PHOTO: JACQUI COOK, CSIRO

Line setting with chute PHOTO: AFMA

25.4 BIOLOGICAL STATUS

STRIPED MARLIN

(*Tetrapturus audax*)



LINE DRAWING: FAO

TABLE 25.5 Biology of striped marlin

Parameter	Description
Range	**Species:** Occurs in both the Indian and Pacific Oceans; rarely found in the Atlantic Ocean. Prefers temperate (cooler) waters and tends to be less migratory than other marlins. In the Indian Ocean, seasonal concentrations of striped marlin occur off the east African coast (0–10ºS), in the south and western Arabian Sea, in the Bay of Bengal and in north-western Australian waters. **Stock:** Throughout the Indian Ocean Tuna Commission convention area (see Chapter 21).
Depth	Mainly inhabits the surface layer to depths of around 200 m
Longevity	~10 years
Maturity (50%)	**Age:** 2–3 years **Size:** not determined
Spawning season	November–December. Early Japanese surveys provided evidence for separate spawning grounds in the eastern and western Indian Ocean, but stock structure is not known. Spawns once per season.
Size	**Maximum:** 300+ cm FL; 400+ kg whole weight. Males and females grow to a similar size. **Recruitment into the fishery:** varies by fishing method; not determined

SOURCES: Bromhead et al. (2004); Froese & Pauly (2009); IOTC (2010).

WTBF: Approximately 11 t of striped marlin was taken by Australian operators from 2004 to 2009, at an average of less than 2 t per year. Peak catches of approximately 28 t and 23 t were taken in 1989 and 1999, respectively (Fig. 25.6). Logbook records indicate that large numbers of striped marlin are not retained by commercial fishers, but rather released alive. Information on recreational catches has not yet been collated and analysed. The IOTC is actively seeking this information for ocean-wide assessment purposes.

IOTC statistical area: Longliners account for most of the catch. Recorded catches of striped marlin averaged 5833 t from 1993 to 1999 (peak of 7872 t in 1993) (Fig. 25.7). Since then, catches have declined substantially, to an average of 3231 t from 2000 to 2008, with 2760 t and 2605 t taken in 2007 and 2008, respectively. Catches are relatively evenly divided between the eastern and western Indian Ocean, and vessels from Taiwan—and to a lesser extent Indonesia—take most of the catch (IOTC 2010). Purse-seine fleets also take striped marlin as byproduct, although those catches are poorly recorded. The IOTC has limited data to determine whether current catch levels are too high; however, there is general agreement that historical levels of take have resulted in depletion of the stock (IOTC 2010).

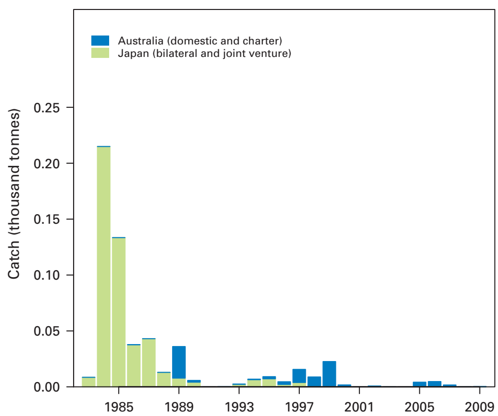


FIGURE 25.6 Striped marlin catch history (WTBF), 1983 to 2009

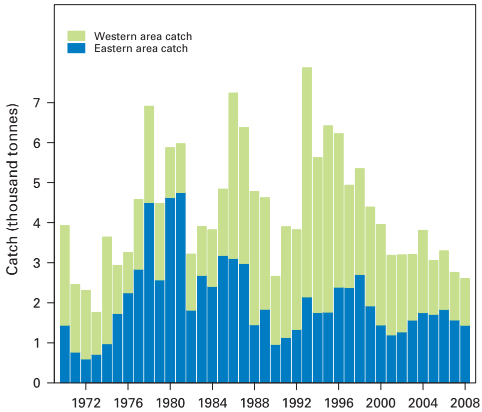


FIGURE 25.7 Striped marlin catch history (IOTC convention area), 1970 to 2008

NOTE: 2009 data are currently unavailable from the IOTC.

Stock status determination

No quantitative stock assessment is currently available for striped marlin, and there is limited reliable information on the catches throughout the IOTC convention area. In addition, there is no information on the structure of the stock or growth and mortality. Thus, due to the lack of fishery data for several gears, only preliminary stock indicators were used to determine stock status. The longline catch and effort datasets from Japan and the Fishing Entity of Taiwan, which represent the best available information, were examined.

The nominal catch per unit effort (CPUE) exhibited dramatic declines since the beginning of the fishery in two major fishing grounds (west equatorial and north-west Australia), and the catches in the initial core areas also decreased substantially (IOTC 2010). The continual decline shown by this indicator over time signals that the stock is being depleted and may be both overfished and subject to overfishing.

The IOTC Working Party on Billfish determined that striped marlin is primarily taken by longliners at sea-surface temperatures above 25 °C (93.5% of the total catches from 1952 to 2007), and that these catches are from equatorial areas of the Indian Ocean and along the east African coast (IOTC WPB 2009). The annual nominal CPUE calculated for the Japanese longline fleet fishing in these water temperatures shows a major decline, falling to 6% of its initial level (late 1950s) (IOTC-WPB 2009), again suggesting an overfished status. However, given the poor quality of the data available for this stock, the 2009 status remains **uncertain** for both the overfished and overfishing categories (Table 25.1).

Reliability of the assessment/s

Considerable uncertainty surrounds the degree to which the stock indicators used in 2009 represent abundance, since factors such as changes in targeting and discarding practices, fishing grounds and management practices are likely to interact with the trends.

Aspects of the species' biology (single spawning period, two spawning sites), productivity (Table 25.5) and fisheries (large increases in the catch of unidentified billfish by gillnet fleets operating mainly in the waters of Sri Lanka, India and Pakistan in recent years) (IOTC 2010), combined with the lack of data on which to base a more formal assessment, are causes for concern.

Previous stock assessment/s

A preliminary estimation of stock indicators was attempted by the IOTC in 2008, with similar conclusions as those outlined above for 2009 (IOTC 2009).

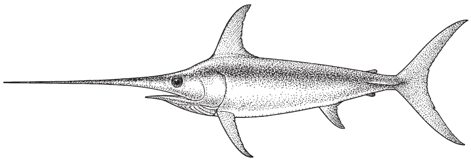
Future assessment needs

Additional stock indicators for this species are required; in the absence of a quantitative stock assessment, such indicators are the only means to monitor the status of the stock and assess the impacts of fishing.

Marlin research PHOTO: JULIAN PEPPERELL

SWORDFISH

(*Xiphius gladius*)



LINE DRAWING: GAVIN RYAN

TABLE 25.6 Biology of swordfish

Parameter	Description
Range	**Species:** Northern coastal state waters to 50°S. Likely substocks. Juvenile swordfish are commonly found in tropical and subtropical waters and migrate to higher latitudes as they mature. Large, solitary adult swordfish are most abundant at 15–35°S. Males are more common in tropical and subtropical waters. **Stock:** Throughout the Indian Ocean Tuna Commission convention area (see Chapter 21). One pan-ocean stock has been assumed. However, spatial heterogeneity in stock indicators (catch per unit effort trends) indicates the potential for localised depletion of swordfish in the Indian Ocean.
Depth	Extensive diel vertical migrations, from surface waters during the night to depths of 1000 m during the day
Longevity	30+ years
Maturity (50%)	**Age:** females 6–7 years; males 1–3 years **Size:** females ~170 cm lower-jaw FL; males ~120 cm lower-jaw FL
Spawning season	Highly fecund batch spawner. May spawn as frequently as once every 3 days over a period of several months in spring. Spawning occurs from October to April in the vicinity of Reunion Island.
Size	**Maximum**: 455 cm lower-jaw FL; 550+ kg total weight in the Indian Ocean. Sexual dimorphism in size, growth rates and size and age at maturity—females reach larger sizes, grow faster and mature later than males. Most swordfish larger than 200 kg are female. **Recruitment into the fishery:** varies by fishing method; ~60 cm lower-jaw FL for artisanal fleets and methods. Swordfish taken by WTBF longliners are 20–100 kg (average 50 kg total weight). By one year of age, a swordfish may reach 90 cm lower-jaw FL (~15 kg).

SOURCES: Froese & Pauly (2009); Poisson & Fauvel (2009); IOTC (2010).

WTBF: Swordfish is the primary target species in the WTBF, and approximately 68% of the total reported landings from 2000 to 2009 were swordfish (Fig. 25.3). In 2009 76% of the total reported landings in the WTBF were swordfish (349 t). A total of 1754 t of swordfish was taken by Australian operators from 2004 to 2009, at an average of 292 t per year. Peak catches of 2136 t were taken in 2001 (Fig. 25.8).

IOTC statistical area: In the 1990s, exploitation of swordfish increased markedly, from 7215 t taken in 1990 to 35 480 t in 1998 (Fig. 25.9). Catches then stabilised around 32 000 t from 1999 to 2002, before increasing to 36 190 t in 2003 and 36 267 t in 2004. The highest catches are taken in the south-west Indian Ocean; however, in recent years, the fishery has been extending eastward. Since the peak catches of 2004, catches have steadily declined to 23 235 t in 2008 (Fig. 25.9). The IOTC has determined the MSY to be 33 000 t annually (IOTC 2010).

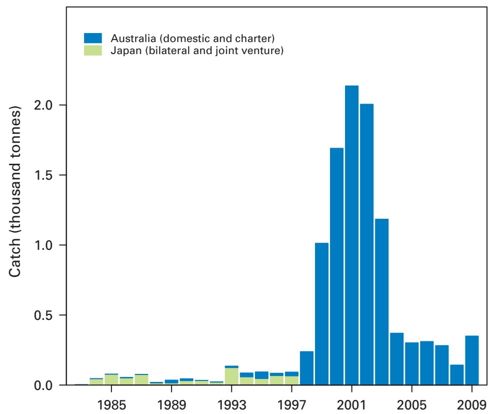


FIGURE 25.8 Swordfish catch history (WTBF), 1983 to 2009

Swordfish unloading

PHOTO: JOHN KALISH, ABARE–BRS

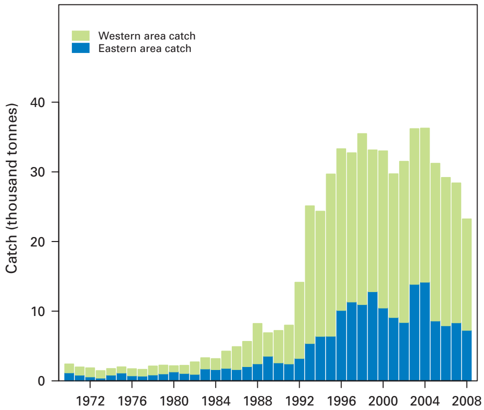


FIGURE 25.9 Swordfish catch history (IOTC convention area), 1970 to 2008

NOTE: 2009 data are currently unavailable from the IOTC.

Stock status determination

A range of ocean-wide stock assessment models were used in 2009 by the IOTC to determine the status of the Indian Ocean swordfish stock. The stock-status reference points from the range of models varied considerably, but a number of general consistencies were evident. Given the limitations identified for each model, and the uncertainties associated with the data inputs, restricting the stock status advice to a single model would likely understate the uncertainty. Here we attempt a qualitative summary across the models and data-based indicators described in the reports of the IOTC Working Party on Billfish (IOTC 2009) and the IOTC Scientific Committee (IOTC 2010).

The IOTC Scientific Committeee (SC) agreed that, based on the ocean-wide assessment models run in 2009, MSY could reasonably be assumed to be approximately 33 000 t (~32 000–34 000 t) (IOTC 2010). The ocean-wide estimates of depletion ranged from $B_{2007}/B_0 = 0.19$ to 0.87 (median = 0.48), suggesting that the Indian Ocean–wide stock is not overfished.

Comparison across models suggests that current catches are probably near the level of MSY ($F_{2007}/F_{MSY} = 0.79$), but could be somewhat higher or lower depending on the model used, suggesting the ocean-wide stock is not subject to overfishing. However, the fidelity of swordfish to particular areas is a matter for concern as this can lead to localised depletion that would undermine the findings of ocean-wide assessments (IOTC 2010). Localised depletion has occurred in other parts of the world where swordfish have been heavily targeted.

In previous years, localised depletion was inferred on the basis of decreasing CPUE, following fine-scale analyses of the catch and effort data. In 2009 four sub-areas of the IOTC convention area were again examined. The CPUE of the Japanese fleet in the south-west Indian Ocean demonstrated the greatest decline of the four areas examined; the La Reunion (French territories) CPUE series also showed a declining trend in the same area over the past 11 years. Therefore, the possibility that localised depletion is still occurring in some areas cannot be ruled out. Given the general declining trend in all the CPUE series, the IOTC expects that abundance will likely decline further at current effort levels, especially considering that increases in efficiency have not been fully addressed in the current CPUE standardisation (IOTC 2010).

The reported CPUE declines are a cause for concern, and we consider these to outweigh the non-spatially separated (ocean-wide) assessments carried out in 2009. In addition, in 2009 an exploratory assessment using Stock Synthesis 3 software was undertaken by Kolody et al. (2009). The model disaggregated the stock by age, sex and four subregions. Although preliminary, the results support the conclusion that localised depletion is occurring in the south-west, and to a lesser extent the north-west, of the Indian Ocean due to overfishing. It is therefore highly likely that the stock is **subject to overfishing** in the south-west Indian Ocean, and possibly other areas (e.g. north-west). At this point, there is insufficient information to determine if these sub-areas have been depleted to below the HSP biomass limit reference point of B_{20}, and therefore the overfished status is assessed as **uncertain** (Table 25.1) based on subregional depletion rather than the ocean-wide assessment results discussed above.

Reliability of the assessment/s

The 2009 stock status estimates varied considerably between assessment models, indicating a high degree of uncertainty. MSY estimates of ~28 000–34 000 t are at the lower end of the range for some models and the upper end of the range for others. All approaches suggest that depletion could reliably be considered in the range of 0.4–0.5 (B_{2007}/B_0), although this may also be an upper or lower end of the plausible range, depending on the model (IOTC 2010).

The longline Japanese and Taiwanese CPUE series show conflicting trends: the Japanese (byproduct) fleet data suggest substantial decline in abundance before around 2000, and the Taiwanese (targeted) fleet data suggest stable abundance over this period (IOTC 2010).

Given the general recent declining trend in all the CPUE series, and the fully exploited status of the stock, abundance will decline further at current effort levels, especially considering that the issue of increases in efficiency has not been fully addressed in the current standardisation (IOTC 2010). With the uncertainty in the assessments, there is a high probability that limit reference points have been, or will be, exceeded in the near future; and this will become more likely if effort remains at current levels or increases further. Precautionary measures, such as capacity control or catch limits, will reduce the risk of creating an overcapacity problem or exceeding the biomass limit reference point (B_{20}).

Previous assessment/s

In 2004 the IOTC reviewed trends in standardised catch rates for the longline fleets of Japan and Taiwan. There was a constant pattern of decline in all areas exploited, with more pronounced declines for the Japanese longliners. Large uncertainties existed about stock structure and the effects of variations in targeting. The mean weights of swordfish taken by various fleets showed no clear trend during the 1990s. It was concluded that the rapid increase in swordfish catches throughout the Indian Ocean in the late 1990s was unlikely to be sustainable in the long term. An assessment in 2006 indicated that the stock was probably not overfished, but that levels of fishing were too high ($F_{current} > F_{MSY}$), particularly in localised areas in the south-west Indian Ocean. MSY estimates ranged between 23 540 t and 27 000 t, whereas the 2006 catch was 29 185 t.

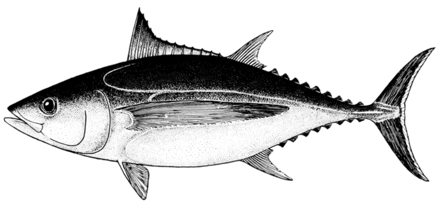
The results of the IOTC's 2008 stock assessment (using 2006 data) were more optimistic than those from 2006, when overfishing was considered to have occurred. Based on the point estimates and confidence limits, the assessment model results indicated that overfishing of the swordfish stock in the Indian Ocean was not occurring, and the stock appeared not to be in an overfished state. However, more recent catch levels (averaging 32 658 t per year between 2002 and 2006) were slightly above the estimate of MSY (31 500 t; 80% confidence limits 24 500 t to 34 400 t) (IOTC 2008). In addition, the CPUE of the Japanese fleet in the south-west Indian Ocean exhibited the strongest decline of the four main fishing grounds examined in 2008. Furthermore, the La Reunion CPUE series showed a declining trend in the area over the past 10 years. Based on the declining CPUE trends and likely localised depletion in 2008, it was considered highly likely that overfishing was occurring in the south-west Indian Ocean, although the biomass of the stock was uncertain.

Future assessment needs

The 2009 assessments do not yet show clear signals of declines in the size-based indices, but these indices should be carefully monitored. Since females mature at a larger size than males, a reduction in the biomass of large animals could potentially have a strong effect on the spawning biomass. The exploratory assessment carried out by Kolody et al. (2009) that disaggregated the stock by age, sex and four subregions should be further refined to take into account spatial heterogeneity in stock structure.

ALBACORE TUNA

(*Thunnus alalunga*)



LINE DRAWING: FAO

TABLE 25.7 Biology of albacore tuna

Parameter	Description
Range	**Species:** Temperate tuna species living mainly in mid-oceanic gyres of the Pacific, Indian and Atlantic oceans. Distributed from 5°N to 40°S in the Indian Ocean; some mixing with the Atlantic Ocean likely. Highly migratory. Pre-adults (2–5 years old) appear to be more migratory than adults. **Stock:** Throughout the Indian Ocean Tuna Commission convention area (see Chapter 21). In the Indian Ocean, there is probably only one southern stock because there is no northern gyre.
Depth	0–600 m
Longevity	~8 years (Indian Ocean). However, this may be an underestimate as albacore have been reported to live to at least 10 years in the Pacific Ocean.
Maturity (50%)	**Age:** 5–6 years **Size:** ~90 cm FL
Spawning season	Main spawning grounds appear to be east of Madagascar between 15°S and 25°S. Spawn in warm waters (sea-surface temperature >25 °C) during the 4th and 1st quarters of each year.
Size	**Maximum:** reported to 140 cm FL; ~60 kg whole weight **Recruitment into the fishery**: 45–50 cm FL; 2–2.5 kg whole weight

SOURCES: Froese & Pauly (2009); IOTC (2010).

WTBF: A total of 85 t of albacore tuna was taken by Australian operators in the area of the WTBF from 2004 to 2009, at an average of 14 t per year. Peak catches of almost 94 t were taken in 2001 (Fig. 25.10).

IOTC statistical area: In the Indian Ocean, most (98%) of the albacore catch is taken by longliners from Taiwan and Japan operating between 20°S and 40°S, with remaining catches taken by purse seine and other gear. Large catches of juvenile albacore were taken by drifting gillnets in the southern Indian Ocean (30–40°S) between 1985 and 1992, with peak gillnet catches in excess of 25 000 t taken in 1990 (IOTC 2010). Annual catches declined following the cessation of drift gillnetting, and increased again from 1998 to 2001 (ranging from 37 674 t to 43 725 t). In contrast, the average annual catch for 2003 to 2006 was 24 805 t (Fig. 25.11). In 2007 and 2008, catches returned to pre-2003 levels, with 33 228 t and 33 056 t landed, respectively (Fig. 25.11). Since 2003 catches have been distributed almost equally between the western and eastern Indian Ocean (slightly more in the west). The IOTC has determined the MSY for this stock to be within the range 28 260–34 415 t annually (IOTC 2010).

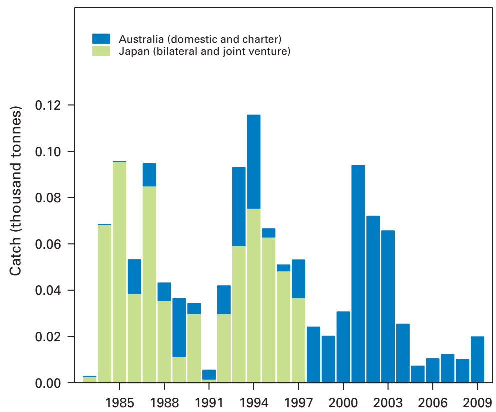


FIGURE 25.10 Albacore tuna catch history (WTBF), 1983 to 2009

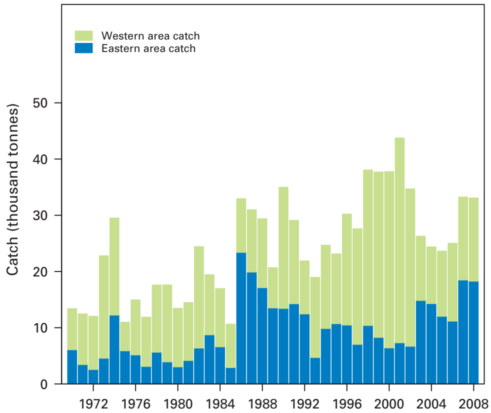


FIGURE 25.11 Albacore tuna catch history (IOTC convention area), 1970 to 2008

NOTE: 2009 data are currently unavailable from the IOTC.

Stock status determination

Stock status was determined for 2009 using the most recent catch and effort data (2008), in conjunction with the IOTC's 2008 stock assessment. In the absence of a specified biomass limit reference point, the HSP defaults (see DAFF 2007) were used to determine status. In 2008 the IOTC completed an assessment of the Indian Ocean fishery using an age-structured production model to examine the effect on stock status of the interaction between age at selection by the fishery and age at maturity (IOTC 2009). The analysis used total catch biomass (1950 to 2007) and Taiwanese longline data on CPUE (1980 to 2006) to estimate model parameters. Other fishery-dependent indicators show considerable stability over long periods. The IOTC assessment found no indications that the stock is overfished ($B_{2007}/B_{MSY} > 1$; $B_{2007}/B_0 > 0.2$), and overfishing is currently unlikely to be occurring ($F_{2007}/F_{MSY} = 0.48–0.91$) (IOTC 2010). Estimates of MSY from the assessment ranged from 28 260 t to 34 415 t, and the total catch in 2008 was 33 056 t.

Despite catches returning to pre-2003 levels in 2007 and 2008 (Fig. 25.11), they are still considered to be within sustainable levels. Thus, based on the preliminary analyses undertaken in 2008 and the most recent catches, there are no indications that the albacore stock is overfished, and overfishing is not likely to be occurring for the scenarios envisaged. Thus, the Indian Ocean albacore tuna stock is assessed as **not overfished** and **not subject to overfishing** (Table 25.1).

Reliability of the assessment/s

The nominal catch statistics for albacore tuna recorded in the IOTC databases are thought to be complete until the mid-1980s (IOTC 2010). Catch and effort data are fully or almost fully available up to the early 1990s, but only partially available since then, due to the almost complete lack of catch and effort records from the Indonesian longline fleet. The effort statistics are thought to be of good quality for most of the fleets for which longline catches series are available, with the exception of the Republic of Korea and the Philippines (IOTC 2010). Data for these countries are not used in the assessment.

There were considerable differences in the estimates of some stock parameters (the current levels of exploitation, and current levels relative to MSY levels) in the assessments by the IOTC in 2008. Accuracy of the assessment is considered acceptable, despite the 2008 stock assessment being carried out on preliminary catch data from 2007 (interim figure of 31 226 t used). The final landing figure of 34 174 t is at the upper end of the MSY range (IOTC 2009).

Previous assessment/s

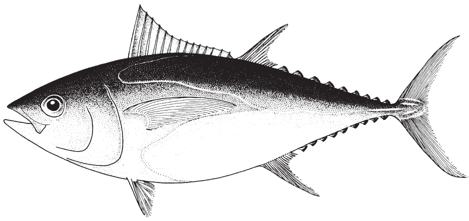
An assessment of the status of albacore tuna in the Indian Ocean was attempted in 2004, but results were inconclusive (stock status uncertain). Indicators such as average fish size and catch rates showed no signs of decline.

Future assessment needs

The dynamics of Indian Ocean albacore tuna appear to have a well-defined spatial nature, with relatively few juvenile and immature fish available to the fishery. Additional information is needed on the spawning condition of fish by location, growth and maturity. Improvements to the current indices of abundance and interpretation of catch data are also needed.

BIGEYE TUNA

(*Thunnus obesus*)



LINE DRAWING: FAO

TABLE 25.8 Biology of bigeye tuna

Parameter	Description
Range	**Species:** Inhabit the tropical and subtropical waters of the Pacific, Atlantic and Indian Oceans. **Stock:** Throughout the Indian Ocean Tuna Commission convention area (see Chapter 21). Large movements of bigeye tuna identified through tagging research support the assumption of a single stock for the Indian Ocean.
Depth	Adult bigeye tuna are normally found below 150 m, to a maximum depth of 300 m during the day and in warmer surface waters at night. Juveniles frequently school at the surface underneath floating objects.
Longevity	15+ years (Indian Ocean)
Maturity (50%)	**Age:** ~3 years **Size:** ~100 cm FL
Spawning season	Spawn in equatorial waters throughout the year.
Size	**Maximum:** 200 cm FL (250 cm TL); 210 kg whole weight (~180 kg when 8 years) **Recruitment into the fishery:** ~30 cm FL (purse seine), ~60 cm FL (longline)

SOURCES: Froese & Pauly (2009); IOTC (2010).

WTBF: A total of 338 t of bigeye tuna was taken by Australian operators from 2004 to 2009, at an average of approximately 56 t per year. Peak catches of 436 t were taken in 2000 (Fig. 25.12).

IOTC statistical area: Total annual catches of bigeye tuna from the Indian Ocean have increased steadily since the start of the fishery, reaching 100 000 t in 1993 and peaking at 151 135 t in 1999 (Fig. 25.13). Since 2000 catches have remained relatively stable, averaging 128 575 t for 2000–06, with 125 029 t taken in 2007. In 2008 total catch decreased to 110 288 t. Approximately three-quarters of the catch is taken from the western Indian Ocean. The IOTC has determined the maximum sustainable yield for this stock to be approximately 110 000 t annually (IOTC 2010).

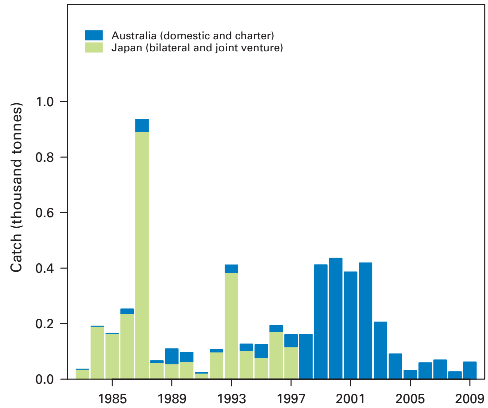


FIGURE 25.12 Bigeye tuna catch history (WTBF), 1983 to 2009

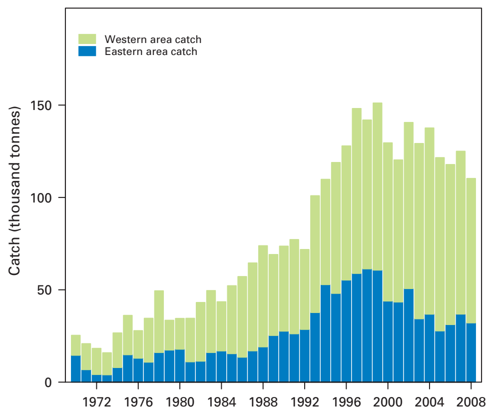


FIGURE 25.13 Bigeye tuna catch history (IOTC convention area), 1970 to 2008

NOTE: 2009 data are currently unavailable from the IOTC.

Stock status determination

In 2009 the IOTC applied four stock assessment models to the Indian Ocean bigeye tuna stock, with the age-structured production model (ASPM) model being selected as the most reliable (IOTC 2010). It was considered that the other assessment approaches needed further exploration and development.

In the absence of a specified biomass limit reference point, the HSP defaults (see DAFF 2007) are used to determine stock status. The 2009 assessment indicated that the current (2008) spawning stock biomass is above the default biomass limit reference points ($SB_{2008}/SB_0 = 0.34$; $SB_{2008}/SB_{MSY} = 1.17$). Therefore, the stock is assessed as **not overfished** (Table 25.1). The total catch of bigeye tuna in 2008 (110 288 t) is at the current estimate of MSY (110 000 t). The ASPM assessment, using partial 2008 catch data, estimated that the 2008 catch is close to the MSY ($F_{2008}/F_{MSY} = 0.90$). Thus, the Indian Ocean bigeye tuna stock is assessed as **not subject to overfishing**. However, biomass trajectories indicate that the spawning stock biomass has been declining since the late 1970s and is now just below the HSP default biomass target. Combined with fishing mortality rates that have been increasing steadily since the 1980s (IOTC 2010), this indicates that the stock will move towards an overfished state in coming years unless measures are taken to reduce fishing mortality.

Reliability of the assessment/s

Uncertainty in the assessment arises from unquantified improvements in fishing efficiency, inadequate size data from recent longline catches and poor estimates of bigeye tuna growth and mortality rates. In the western Indian Ocean, there has been a rapid increase in the number of juvenile bigeye tuna caught by purse-seine fishing around drifting fish-aggregating devices. In addition, although the various models used by the IOTC in 2009 to estimate MSY broadly agreed, they produced quite different estimates of absolute levels of virgin and current biomass (IOTC 2010). This was probably due to how the variations in CPUE were interpreted by each model. The indices of abundance from two longline fleets (Japanese and Taiwanese) for this stock present divergent trends over the past few years, and the differences observed in targeting are not fully explained.

Previous assessment/s

The origin of bigeye tuna recruits to the western AFZ is not known, and there is no specific bigeye tuna assessment for the WTBF. However, the IOTC's Working Party on Tropical Tunas used age-structured models in 2004 and 2006 to assess the status of bigeye tuna in the Indian Ocean. The models indicated that the bigeye tuna biomass was above the size needed to support MSY, suggesting that the stock was not overfished. Catches for several years before 2005 were above MSY, implying that overfishing was occurring. A more optimistic assessment in 2006 and reduced catches in 2005 suggested that the reported catch was around MSY and that fishing mortality was below the level that produces MSY (F_{MSY}). The assessment results were treated with caution because there was concern that the reduced catches of bigeye tuna were linked to high catches of yellowfin tuna, and that fishing effort was returning to the pattern that produced higher catches in previous years.

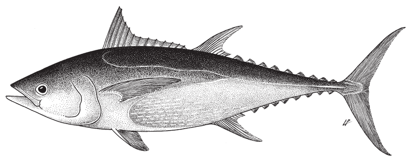
In 2008 the IOTC applied a surplus production model to Japanese longline CPUE and total catch biomass data. This was considered to be a preliminary analysis; however, the results indicated that the probability (86%) of B_{2007} being greater than B_{MSY} was high (IOTC 2009).

Future assessment needs

Uncertainties in the assessments need to be reduced by improving available indices of abundance, size information for the catches of longline fisheries, catch-at-size and catch-at-age data, information on rates of natural mortality at various life stages (Table 25.8) and information on changes in fishing power.

LONGTAIL TUNA

(*Thunnus tonggol*)



LINE DRAWING: FAO

TABLE 25.9 Biology of longtail tuna

Parameter	Description
Range	**Species:** Tropical and subtropical neritic (coastal) waters globally, between 47ºN and 33ºS. Limited data available on stock structure throughout its worldwide distribution. **Stock:** Throughout the Indian Ocean Tuna Commission Convention Area (see Chapter 21). Very little is known of the movements of fish in the WTBF, or whether fish move from the AFZ into the waters of neighbouring countries such as Indonesia. In the absence of reliable evidence relating to stock structure, a precautionary approach was undertaken by assuming longtail tuna exist as a single stock in the wider IOTC area.
Depth	Juveniles mainly limited to surface waters, while larger fish are found in surface and subsurface waters (10 m to an unknown maximum).
Longevity	~19 years
Maturity (50%)	**Age:** 1 year **Size:** ~40–46 cm FL; 4–5 kg
Spawning season	The spawning season varies according to location. Off the west coast of Thailand, there are two distinct spawning seasons: January–April and August–September. Probably spawns more than once a year throughout its range, similar to other species of tuna.
Size	**Maximum:** ~145 cm FL; ~36 kg whole weight; most common size in the Indian Ocean is 40–70 cm **Recruitment into the fishery:** 2–3 years in the WTBF

SOURCES: Froese & Pauly (2009); Griffiths et al. (2010); IOTC (2010); Griffiths (in press).

WTBF: A total of 55 t of longtail tuna was taken by Australian commercial operators from 2006 to 2009. Peak catches of 32 t were taken in 1998 by minor-line methods (Fig. 25.14). The recreational take has not been determined.

IOTC statistical area: Longtail tuna catches in 2008 (103 082 t) were higher than the average catch taken from 2003 to 2007 (92 920 t) (Fig. 25.15). Longtail tuna is caught mainly by gillnet and to a lesser extent by artisanal purse seiners. The majority of the catch is taken from the western Indian Ocean area (IOTC 2010). In recent years, the countries with the highest catches of longtail tuna are Indonesia, Iran, Oman, Yemen and Pakistan. The IOTC has limited data to determine whether current catch levels are too high and has made this stock a priority for assessment (IOTC 2010).

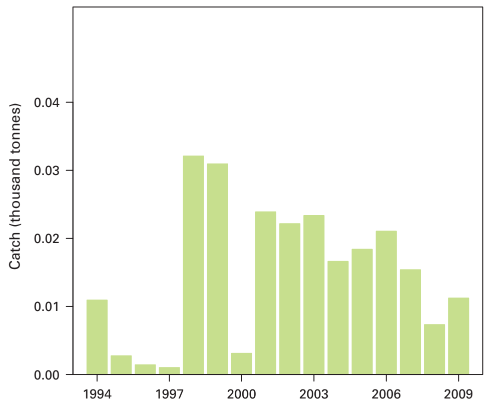


FIGURE 25.14 Longtail tuna catch history (WTBF), 1994 to 2009

Longline hooks PHOTO: AFMA

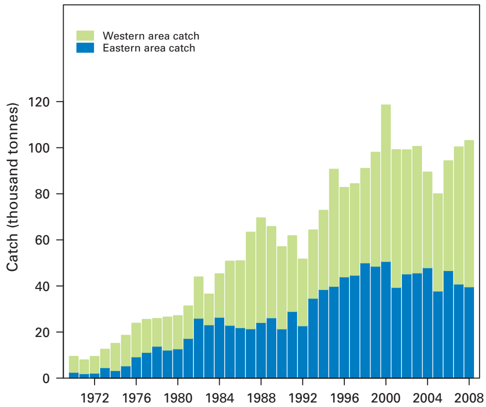


FIGURE 25.15 Longtail tuna catch history (IOTC Convention Area), 1970 to 2008

NOTE: 2009 data are currently unavailable from the IOTC.

Stock status determination

Longtail tuna has been included in this year's report for the first time. The criteria for stock inclusion in the *Fishery status reports* are outlined in Chapter 1. In the case of longtail tuna, they are currently considered an important byproduct stock in the WTBF, but more importantly, the IOTC consider this species to be of high ecological and economical importance thoughout the IOTC Convention Area. The IOTC has identified this stock as a key target species for many coastal states and identified it as a high priority for formal stock assessment by the Working Party on Neritic Tunas as early as possible (IOTC 2010). In the WTBF, recent commercial catch levels have exceeded those of other quota species assessed for biological status (albacore tuna and yellowfin tuna). A catch limit of 35 t applies to longtail tuna in the WTBF.

No quantitative stock assessment or analysis of CPUE trends is currently available for longtail tuna throughout the IOTC Convention Area. However, an assessment recently completed by Griffiths et al. (2010) for longtail tuna off the east and the northern Australian coast, found that the stock is currently not subject to overfishing, noting that the assessed stock had limited overlap with the IOTC Convention Area.

In the area of the WTBF, historical catches by commercial fishers are unlikely to have resulted in substantial localised depletion of the stock; however, recreational catches are unquantified. Given the restricted coastal distribution of lontail tuna and their slow growth rates, they may be particularly vulnerable to overexploitation by sport fishers in the AFZ and artisanal fishers within the IOTC convention area. It remains uncertain whether catch rates in and near the AFZ are affected by broader Indian Ocean catches, such as those from Indonesia. Due to these uncertainties, the overfished and overfishing status for longtail tuna is **uncertain** (Table 25.1).

Reliability of the assessment/s

Not applicable.

Previous assessment/s

None.

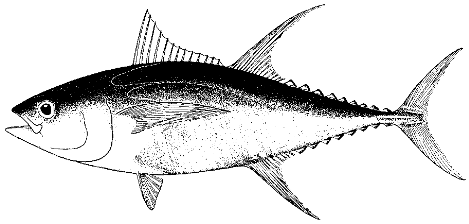
Future assessment needs

The IOTC SC noted in 2009 that catches of longtail tuna are continuing to increase (IOTC 2010). Management decisions are complicated by uncertainties about the degree of stock mixing between the WTBF and broader regions, and research to determine the level of mixing is required. Quantification of the total recreational and artisanal take is urgently needed.

Longliner crew about to haul line
PHOTO: DAVE CRANSTON, AFMA

YELLOWFIN TUNA

(*Thunnus albacares*)



LINE DRAWING: FAO

TABLE 25.10 Biology of yellowfin tuna

Parameter	Description
Range	**Species:** Tropical and subtropical waters globally. **Stock:** Throughout the Indian Ocean Tuna Commission convention area (see Chapter 21). Large movements of yellowfin tuna identified through tagging research, support the assumption of a single stock for the Indian Ocean.
Depth	Juveniles mainly limited to surface waters, while larger fish are found in surface and subsurface waters. Archival tagging has shown that they dive to depths of more than 1000 m, probably to feed on mesopelagic prey.
Longevity	9 years
Maturity (50%)	**Age:** ~2 years (~25 kg) **Size:** ~100 cm FL
Spawning season	Mainly December–March in the equatorial area (0–10°S), with the main spawning grounds west of 75°E. Secondary spawning grounds exist off Sri Lanka and the Mozambique Channel and in the eastern Indian Ocean off Australia. Spawn where sea-surface temperatures are at least 26 °C. May spawn every one or two days over several months.
Size	**Maximum:** ~180 cm FL (estimates from the Pacific are much larger); 200 kg whole weight **Recruitment into the fishery:** ~30 cm FL; varies by fishing method

SOURCES: Froese & Pauly (2009); IOTC (2010).

WTBF: A total of 265 t of yellowfin tuna was taken by Australian longline operators from 2004 to 2009, at an average of 44 t per year. The minor-line fleet reported 2 t landed over the same period. Peak catches of 557 t and 10 t were taken in 2001 by the longline and minor-line fleets, respectively (Fig. 25.16).

IOTC statistical area: Yellowfin catches in 2008 (322 272 t) were slightly lower than the average catch taken from 1998 to 2002 (331 771 t); in the 2003–06 period, the average annual catch was 461 250 t (Fig. 25.17). The artisanal fishery component in the Indian Ocean (mainly using pole and line, driftnet and handline) is substantial, taking an estimated 35% of the total yellowfin tuna catches during 2000–2008 (IOTC 2010). The majority of the catch is taken from the north-western Indian Ocean (north of 12°S) and in the Mozambique Channel (north of 25°S). The IOTC has determined the annual MSY for this stock to be approximately 300 000 t (IOTC 2010).

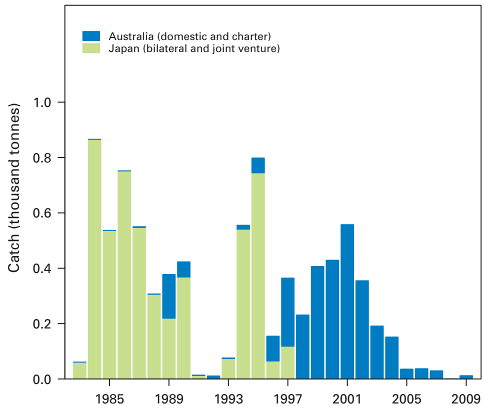


FIGURE 25.16 Yellowfin tuna catch history (WTBF), 1983 to 2009

Stock status determination

Multiple runs of the Multifan-CL assessment model were carried out in 2009 and included important information from the IOTC tagging program (i.e. growth, natural mortality, movement patterns). The 2009 assessment indicates that recent levels of fishing mortality are at historically high levels and that the stock experienced a period of overfishing from 2003 to 2006.

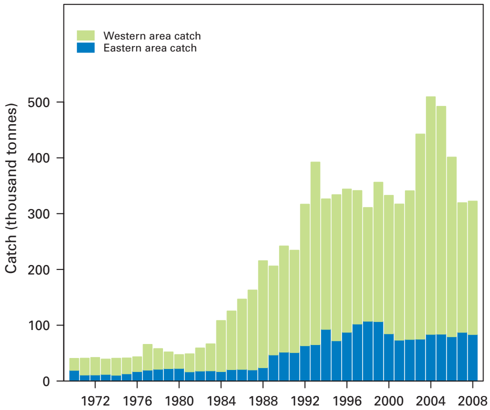


FIGURE 25.17 Yellowfin tuna catch history (IOTC convention area), 1970 to 2008

NOTE: 2009 data are currently unavailable from the IOTC.

Estimates of total and spawning stock biomass (SSB) continue to decline; this decline was probably accelerated by the high catches of 2003 to 2006 (IOTC 2010), despite recent catches returning to pre-2003 levels. Current catches (322 272 t in 2008) are higher than the estimated MSY of 300 000 t, and annual catches over 2003–2006 (averaging 461 250 t) were substantially higher than all estimated values of MSY.

The 2009 stock assessment indicated that the SSB for 2008 was close to the limit reference point of SSB_{20}, and fishing mortality levels were well in excess of MSY. This would indicate that the stock is close to an overfished state and subject to overfishing. However, given the preliminary nature of the catch, effort and size data for 2008, and the known difficulties of the model in estimating population levels for this stock in the final year of the series (which may lead to an exaggerated estimate of the decline of adult biomass and a pessimistic diagnosis of the status of the stock), the IOTC SC considered that management advice should be based on the status of the stock to 2007 (data until the end of 2007). The IOTC noted that the stock assessment model, run using data up to the end of 2008, indicates that the stock is likely to have moved into an overfished state.

Using catch and effort data up to the end of 2007, the assessment carried out in 2009 by the IOTC (IOTC 2010) indicates that the estimate of spawning biomass is above the default limit reference point ($SB_{2007}/SB_0 = 0.34$), and therefore yellowfin tuna is assessed as **not overfished** (Table 25.1). Current fishing mortality levels ($F_{2007}/F_{MSY} = 1.16$) indicate that the stock remains assessed as **subject to overfishing**. The SC agreed that the stock will move to an overfished state in the near future unless fishing mortality is reduced. The IOTC SC recommended that catches should not exceed 300 000 t in 2010.

Reliability of the assessment/s

The reliability of estimates of the total catch has continued to improve over the past few years, and the IOTC has conducted several reviews of the nominal catch databases. This has led to marked increases in estimated catches of yellowfin tuna since the early 1970s. In 2009 new stock assessment areas were defined within the IOTC Convention Area, in order to obtain more homogeneously fished areas (IOTC 2010). New standardised CPUE series were calculated for both the Japanese (1960 to 2008) and Taiwanese longline (1989 to 2008) fleets in each area. However, the two CPUE histories showed divergent trends; the Japanese CPUE series showed a marked steady decline, whereas the Taiwanese CPUE series has been stable over the past 30 years in most areas. Both CPUE series show a decline in most areas since 2006 (IOTC 2010).

The apparent disagreement between the estimated value of MSY (around 300 000 t) and the long-term average yearly catches obtained from this stock from 1992 to 2002 (337 398 t) might also indicate that further refinements are needed in the application of the model to this stock. However, as the model appears to indicate, it is also possible that current estimates of MSY are lower than expected due to recent high catches having affected the recruitment capacity of the stock (IOTC 2010).

The current diagnosis of stock status is considered more realistic than previous assessments. However, uncertainties remain. For instance, detailed results (on recruitment, spatial distribution, movement patterns and

fishing mortalities) obtained for some of the individually modelled areas within the Indian Ocean do not realistically account for the known spatial dynamics of this stock (IOTC 2010).

Previous assessment/s

In 2003 the IOTC found that there had been a steady increase in fishing mortality on yellowfin tuna since 1980, accompanied by a substantial decline in biomass in the mid-1980s. Catchability in the purse-seine fishery had increased, possibly as a result of the use of drifting fish-aggregating devices. The updated assessment in 2005 concluded that catch levels between 1992 and 2002 had been near the level that would produce the MSY and that fishing mortality should not be allowed to increase. It was noted that continued purse-seining on fish-aggregating devices would likely increase the mortality of juvenile yellowfin tuna and further reduce the stock biomass. Catches from 2003 to 2006 were well above those levels, and it was considered that such harvest rates would not be sustainable unless supported by very high recruitment.

A further assessment was undertaken in 2007, based on several modelling approaches (IOTC 2008). Despite differences in the modelling, it was concluded that fishing levels had continued to exceed MSY levels. Model estimates of MSY ranged from 271 000 t to 360 000 t. High catches from 2003 to 2006 (average 461 250 t) constitute overfishing.

In 2008 the IOTC assessment of the yellowfin tuna stock in the Indian Ocean indicated that estimates of total and spawning stock biomass were above or just below their respective MSY-based reference points; B_{2007}/B_{MSY} ranged from 1.13 to 0.93 and SB_{2007}/SB_{MSY} ranged from 1.18 to 0.61, indicating that the stock was close to an overfished state. Fishing mortality estimates for 2007 were above their respective MSY-based reference points for all but one of the assessments examined; F_{2007}/F_{MSY} ratios ranged from 0.9 to 1.60, indicating that overfishing was occurring. The degree of overfishing was somewhat lower than that estimated to have occurred during 2003 to 2006; the $F_{2003–2006}/F_{MSY}$ ratio ranged from 1.22 to 1.75 (IOTC 2008). The 2008 stock assessments indicated that recruitment has declined in recent years. Reliable estimates of MSY ranged between 250 000 t and 300 000 t. The IOTC suggested that the 2007 catch of 319 434 t may have been above the MSY, and annual catches from 2003 to 2006 were substantially higher.

Future assessment needs

It remains uncertain whether longline catch rates in and near the AFZ are affected by broader Indian Ocean longlining, by intensive western Indian Ocean purse-seining, or by artisanal fisheries operating throughout the Indian Ocean. Because management decisions are complicated by uncertainties in the degree of stock mixing between the WTBF and broader regions (Table 25.10), research is required to determine the level of mixing.

Unloading catch, Fremantle PHOTO: JACQUI COOK, CSIRO

The results from the IOTC assessment in 2009 again demonstrated the value of tagging information for assessment purposes (IOTC 2010). The value of this source of information is likely to increase over time as more tags are returned from a wider area and for older fish.

25.5 ECONOMIC STATUS

Economic performance

In 2003 the Australian Bureau of Agricultural and Resource Economics (ABARE) conducted an economic survey of the WTBF (Galeano et al. 2004). Estimates of financial and economic performance were compiled for the 2001–02 financial year and can be used with other indicators to evaluate the likely economic performance of the fishery in 2008–09. Estimates of latent effort in the fishery are also available for recent years.

Latency

In 2009, 96 permits (93 fishing and 3 carrier vessel permits) were issued for the WTBF. In 2004, 13 longline vessels fished in the WTBF and, in every financial year since then, fewer than five vessels have operated (Fig. 25.2). This substantial degree of latent effort indicates that net economic returns (NER) from fishing are low in absolute terms.

Net economic returns

Real NER in 2001–02 were $1.9 million (in 2008–09 dollars). This is very low, given that 43 and 40 vessels operated in the fishery in 2001 and 2002, respectively. Low NER were partly caused by a significant increase in fishing power as the fishery grew in the late 1990s and many new, large vessels entered the fishery. Since latent effort in the fishery remained high and the previous estimates of the fishery's NER for 2001–02 were low, it is expected that NER were also low in 2008–09.

Overall economic status

Although ABARE estimates show that a small, positive NER was earned in 2000–01, declines in catches, fish prices and, consequently, fishing receipts between 2001–02 and 2004 were likely to have had negative impacts on NER. The large declines in vessel participation since 2004 also indicate that the returns from the fishery have been low in recent years. In 2009, latent effort remained high, suggesting that NER were likely to have been substantially lower in 2009 than in 2001–02.

Future considerations

The introduction of quota management is likely to make it easier for fishers to rationalise their fishing operations. Fishers will only be able to trade entire permits rather than smaller shares of the fishery's catch. However, the degree to which SFR holders have an incentive to trade quota SFRs (permanently or temporarily) will be influenced by the individual species TACs set under the new management arrangements. The proposed TACs are substantially higher than historical catches and so will provide minimal incentive for trade. Additionally, if economic conditions in the fishery were to suddenly improve, a rapid increase in effort could eventuate, putting positive returns and stock sustainability at risk. The proposed TACs have been set at high levels to allow for a potential increase in fishing in the high seas; however, setting spatial TACs so that catches in the high seas can be managed separately from catches in domestic waters may be a more effective approach.

25.6 ENVIRONMENTAL STATUS

Fishery management in the WTBF has historically been complicated by fishers operating in different biogeographical regions and catching a different suite of byproduct and bycatch species. Future assessment of environmental impacts of the fishery will

require detailed information from each biogeographical region. The overall impact of fishing on byproduct and bycatch species across the Indian Ocean is poorly known. As a result, both Australia and the IOTC consider that improving the understanding of the status of byproduct and bycatch species is a high priority. In response to bycatch concerns, AFMA formulated the Australian Tuna and Billfish Longline Fisheries Bycatch and Discarding Workplan, which commenced in 2008 and covers from 1 November 2008 to 31 October 2010 (AFMA 2008). The objective of the plan is to develop a longer term strategy for overall minimisation of bycatch. The workplan focuses on developing management responses to high ecological risks and measures to avoid fishery interactions with species listed under the EPBC Act.

Ecological risk assessment

AFMA, in conjunction with the Commonwealth Scientific and Industrial Research Organisation (CSIRO) has undertaken three levels of ecological risk assessment (ERA) for the WTBF (Table 25.2). By assessing the impacts of fishing on all parts of the marine environment, the ERAs take an ecosystem-based assessment approach. The aim of the ERA process is to help prioritise research, data collection, monitoring needs, and management actions for fisheries, and ensure that they are managed both sustainably and efficiently. In a report to DEWHA in relation to the export approval of the WTBF under the EPBC Act, AFMA (2009b) indicated that it had commissioned the CSIRO to conduct a comprehensive, rapid, quantitative assessment of the risk from fishing to the sustainability of all chondrichthyan and teleost species. The project extended the methodology of the previous Level 2 Productivity Susceptibility Analysis (Webb et al. 2007) to provide quantitative estimates of risk for a large number of fish species. Classifications of risk were divided into low, medium, high and extreme high; each category had a corresponding precautionary criterion to take into account uncertainty.

The project examined 187 fish species in the WTBF (38 chondrichthyans and 149 teleosts). No species were classified as at risk of potential overfishing (AFMA 2009b). The results of the Level 3 assessment (Zhou et al. 2009) will be combined with the results of the residual risk assessment (AFMA 2009a) and addressed through environmental risk management strategies. These strategies include a chondrichthyan working group and the Australian Tuna and Billfish Longline Fisheries Bycatch and Discarding Workplan. AFMA has indicated that these will be implemented and reviewed over the coming years. Given the connectivity of stocks beyond the AFZ, the final strategy will need to take into account broader Indian Ocean issues.

Habitats

No habitats or communities were identified by the ERA process as being at high risk from the effects of pelagic longline fishing (AFMA 2009).

Threatened, endangered and protected species

In 2009 a single humpback whale was reported as being entangled by longline gear (mainline). The mainline was removed from the tail and the whale released in good condition.

Sharks

In 2009 there were no interactions with threatened, endangered or protected sharks reported in logbooks.

Marine turtles

Catches of turtles have been recorded in WTBF logbooks, although interaction rates are low. In 2009 a total of 10 marine turtle interactions (six leatherback turtles, two loggerhead turtles and two hawksbill turtles) were reported in logbooks in the WTBF. All were released alive.

Seabirds

The non-target group at highest risk from the fishery is seabirds. This risk is being addressed through a combination of the threat abatement plan (TAP) (AAD 2006), AFMA requirements and, when fishers operate in the IOTC area, Resolution 10/06 of the IOTC. The collective requirements are for all longline operators fishing south of 25ºS to use an approved 'tori' line, to set their longlines only at night, not to discharge offal during line setting and hauling, and use of line weighting and thawed baits. There is a total ban on offal discharge throughout the fishery. A pilot observer program indicated that seabird bycatch rates in the WTBF were below the TAP target of 0.05 birds per 1000 hooks. The WTBF has not exceeded the agreed seabird bycatch limit since 2006, when the revised TAP was implemented (AFMA 2008). In 2009 a single seabird interaction was reported in logbooks in the WTBF (yellownosed albatross–dead).

25.7 HARVEST STRATEGY PERFORMANCE

The HS framework developed for the WTBF has not yet been implemented, due to the limited effort in the fishery in recent years. AFMA has indicated that the framework will be used to develop a complete HS, to be implemented once effort increases in the fishery. Before the HS is implemented, appropriate control rules and target and limit reference points will need to be determined.

Although individual transferable quotas have been identified as the preferred method of control, the limited data available from the fishery and the regional extent of the key stocks present problems for the estimation of scientifically robust TACs. Management of the fishery should be adaptive, allowing for upward or downward adjustment of TACs when new information becomes available. For this reason, development of biological reference points and control rules must continue to be a major consideration in the development of the HS for the fishery.

Yellow-nosed albatross PHOTO: MIKE GERNER, AFMA

25.8 LITERATURE CITED

AAD (Australian Antarctic Division) 2006, *Threat abatement plan, for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations*, AAD, Kingston.

AFMA (Australian Fisheries Management Authority) 2008, *Australia's Tuna and Billfish Longline Fisheries, Bycatch and Discarding Workplan, November 1, 2008 to October 31*, 2010, AFMA, Canberra.

——2009a Residual risk assessment of the level 2 ecological risk assessment species results report for the Western Tuna and Billfish Fishery, November 2009, AFMA, Canberra.

——2009b, *Western Tuna and Billfish Fishery, August 2009*, report to DEWHA & AFMA, Canberra, <www.environment.gov.au/coasts/fisheries/commonwealth/southern-western-tuna-billfish/pubs/report-sep09.pdf>.

Bromhead, D, Pepperell, J, Wise, B & Findlay, J 2004, *Striped marlin: biology and fisheries*, BRS, Canberra.

DAFF (Department of Agriculture, Fisheries and Forestry) 2005, *Western Tuna and Billfish Management Plan 2005*, DAFF, Canberra, Federal Register of Legislative Instruments F2006C00722.

——2007, *Commonwealth Fisheries Harvest Strategy: policy and guidelines*, DAFF, Canberra.

Davies, C, Campbell, R, Prince, J, Dowling, N, Kolody, D, Basson, M, McLoughlin, K, Ward, P, Freeman, I & Bodsworth, A 2008, *Development and preliminary testing of the harvest strategy framework for the Western Tuna and Billfish Fishery*, CSIRO, Hobart.

Dowling, N, Peel, S & Basson, M 2005, *Data summary for the Southern and Western Tuna and Billfish Fishery*, CSIRO Marine Research, Hobart.

Froese, R, & Pauly, DE 2009. *FishBase,* version 02/2009, FishBase Consortium, <www.fishbase.org>.

Galeano, D, Langenkamp, D, Shafron, W & Levantis, C 2004, *Australian fisheries surveys report 2003*, ABARE, Canberra.

Griffiths, SP, in press, 'Stock assessment and efficacy of size limits on longtail tuna (*Thunnus tonggol*) caught in Australian waters', *Fisheries Research*, <doi:10.1016/j.fishres.2009.12.004>.

——Fry, GC, Manson, FJ & Lou, D 2010, 'Age and growth of longtail tuna (*Thunnus tonggol*) in tropical and temperate water of the central Indo-Pacific', *ICES Journal of Marine Science*, vol. 67, pp. 125–34.

IOTC (Indian Ocean Tuna Commission) 2008, *Report of the tenth session of the scientific committee*, Seychelles, 5–9 November 2007, IOTC-2007-SC-R[E].

——2009, *Report of the eleventh session of the scientific committee*, Seychelles, 1–5 December 2008, IOTC-2008-SC-R[E].

——2010, *Report of the twelfth session of the scientific committee*, Seychelles, 30 November–4 December 2009, IOTC-2009-SC-R[E].

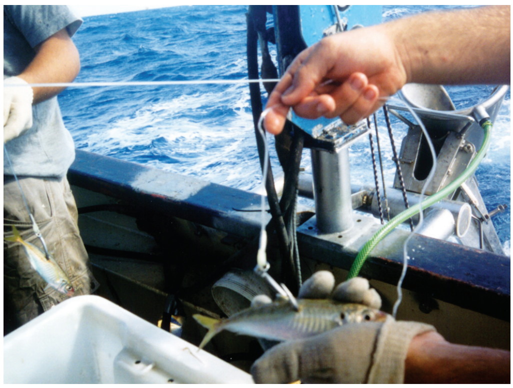
——WPB 2009, *Report of the seventh session of the IOTC working party on billfish*, Seychelles, 6–10 July 2009, IOTC-2009-WPB-R[E].

Kolody D 2009, *An exploratory "stock synthesis' assessment of the Indian Ocean swordfish fishery 1950–2007*, Seychelles, 6–10 July 2009, IOTC-2009-WPB-10.

Poisson, F & Fauvel, C 2009, 'Reproductive dynamics of swordfish (*Xiphias gladius*) in the southwestern Indian Ocean (Reunion Island), part 1, Oocyte development, sexual maturity and spawning', *Aquatic Living Resources*, vol. 22, pp. 45–58.

Webb, H, Bulman, C, Sporcic, M, Dowdney, J, Fuller, M, Smith, T & Hobday, A 2007, Ecological risk assessment for the effects of fishing: report for the Western Tuna and Billfish sub-Fishery, AFMA, Canberra.

Zhou, S, Fuller, M & Smith, T 2009, Rapid quantitative assessment for fish species in seven Commonwealth fisheries, CSIRO Marine Research, Hobart.



Live bait on hooks PHOTO: AFMA

26 Antarctic Waters Fishery

H Patterson, D Wilson and K Mazur

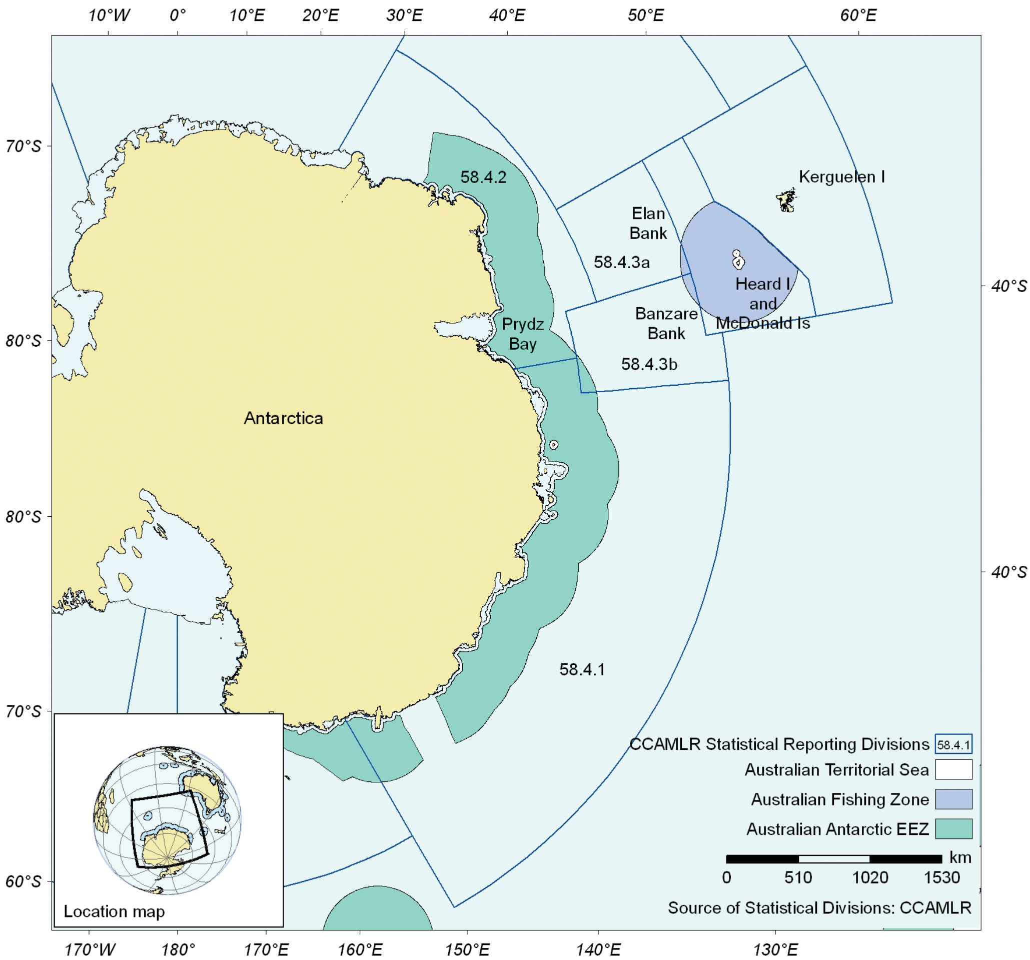


FIGURE 26.1 Area of the Antarctic Waters Fishery

TABLE 26.1 Status of the Antarctic Waters Fishery

Fishery status	2008		2009		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Toothfish (*Dissostichus eleginoides*, *D. mawsoni*)	Uncertain	Uncertain	Overfishing	Overfished	Statistical Division 58.4.3b very likely depleted below 20% B_0; high levels of illegal, unregulated and unreported fishing in several statistical divisions.
Economic status Fishery level	Estimates of net economic return estimates not available				Latency high, suggesting net economic returns are low. Australia did not participate in the fishery in 2008–09.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING · OVERFISHED / OVERFISHING · UNCERTAIN · NOT ASSESSED

TABLE 26.2 Main features and statistics of the Antarctic Waters Fishery

Feature	Description	
Key target and byproduct species	Antarctic toothfish (*Dissostichus mawsoni*) Patagonian toothfish (*D. eleginoides*)	
Other byproduct species	Grenadiers (*Macrourus* spp.) Skates (*Bathyraja* spp., *Amblyraja* spp.)	
Fishing methods	Demersal longline; gillnets used by IUU fishers	
Primary landing ports	Port Louis (Mauritius), Albany	
Management methods	Input controls: limited entry Output controls: open TAC for approved CCAMLR members Temporal and spatial closures	
Management plan	No formal management plan	
Harvest strategy	CCAMLR default harvest strategy for toothfish not yet implemented (Constable et al. 2000)	
Consultative forums	Sub-Antarctic Fisheries Management Advisory Committee (SouthMAC), Sub-Antarctic Resource Assessment Group (SARAG)	
Main markets	International: United States, Japan—frozen	
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Current accreditation dated 28 November 2005 Current accreditation (Wildlife Trade Operation) expires 25 November 2011	
Ecological risk assessment	Not initiated	
Bycatch workplans	*Antarctic Fisheries Bycatch Action Plan 2003* (AFMA 2003)	
Fishery statistics (domestic)	**2008 fishing season**	**2009 fishing season**
Fishing season	Statistical Divisions 58.4.1 and 58.4.2: 1 December 2008 – 30 November 2009 Statistical Divisions 58.4.3a and 58.4.3b: 1 May 2009 – 31 August 2009	
Total allowable catch	Various open precautionary catch limits in different statistical divisions; see Table 26.3	
Catch	Australian catch: 2.9 t Total catch: see Table 26.3	Australian catch: 0 t Total catch: see Table 26.3
Fishing permits	1	0
Active vessels	1 Australian vessel	0 Australian vessels

Table 26.2 continues over the page

TABLE 26.2 Main features and statistics of the Antarctic Waters Fishery CONTINUED

Feature	Description	
Observer coverage	100% vessel coverage	Not applicable
Real gross value of production (2008–09 dollars)	Confidential (<5 vessels)	Not applicable
Allocated management costs	2007–08: $0.1 million	2008–09: $0.1 million

CCAMLR = Commission for the Conservation of Antarctic Marine Living Resources; EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*, TAC = total allowable catch

a Fishery statistics provided by fishing season unless otherwise indicated.

TABLE 26.3 Precautionary catch limits, reported catches and estimated illegal, unregulated and unreported catches in Antarctic waters

	2008				2009			
Statistical Division	Precautionary catch limit (tonnes)	Reported catch (tonnes)	Estimated IUU catch (tonnes)	Total catch (tonnes)	Precautionary catch limit (tonnes)	Reported catch (tonnes)	Estimated IUU catch (tonnes)	Total catch (tonnes)
58.4.1	600	411	94	505	210	222	152	374
58.4.2	780	216	0	216	70	66	176	242
58.4.3a	250	9	0	9	86	31	0	31
58.4.3b	150	143	246	389	120	104	610	714

IUU = illegal, unregulated and unreported

26.1 BACKGROUND

In recent years, an Australian-flagged vessel has obtained approval from the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) to engage in new and exploratory fisheries for toothfish in Statistical Divisions 58.4.1, 58.4.2, 58.4.3a and 58.4.3b. Statistical Divisions 58.4.1 and 58.4.2 are adjacent to Australia's Antarctic Territory and overlap with Australia's Antarctic Exclusive Economic Zone (EEZ), and Statistical Divisions 58.4.3a and 58.4.3b are high-seas fisheries (areas of national jurisdiction within these statistical divisions are closed to fishing) (Fig. 26.1). The 200-nautical mile (nm) EEZ extending from Australia's Antarctic Territory is not defined as part of the Australian Fishing Zone for the purposes of the Commonwealth *Fisheries Management Act 1991*. However, under the Fisheries Management Regulations, the Act extends to Australian citizens and bodies corporate, Australian vessels and Australian persons on Australian vessels in this area. The Act also allows for the formation of regulations to apply to areas defined by the regulations as outside the EEZ.

Recent finfish-fishing activity in the Antarctic has focused on continental-slope and submarine banks (550–2000 m depth), which are accessible to bottom longline and trawl. Both Antarctic toothfish and Patagonian toothfish are taken (Table 26.2), but species-specific management arrangements are not in place. Waters adjacent to continental Antarctica (within Statistical Divisions 58.4.1 and 58.4.2) are a difficult fishing environment, and there has been less fishing there than in many other Antarctic areas. Fishing in this area (the high Antarctic) is restricted to late summer, when the sea ice is at its minimum. Outside of the high-latitude regions of the Antarctic (e.g. in Statistical Divisions 58.4.3a–b), the season is considerably longer.

The CCAMLR's 'new and exploratory fisheries' are managed through a range of binding conservation measures. Provisions within these conservation measures include tagging for both target and byproduct species, the carriage of at least one CCAMLR-designated scientific observer, catch limits and move-on rules for byproduct species, prohibition of fishing in waters shallower than 550 m to protect benthic ecosystems and seabird bycatch mitigation measures. Total allowable catches (TACs) are available to all CCAMLR members approved to conduct new and exploratory fisheries in an area; fishing by all members ceases once these competitive catch limits are reached. All members engaged in new and exploratory fisheries must participate in a five-day catch and effort reporting scheme. The CCAMLR Secretariat circulates aggregate catches and an estimate of when the TAC will be reached at the end of each five-day reporting period.

New and exploratory fisheries are classified as such until the CCAMLR Scientific Committee is able to estimate abundance and potential yield, advise appropriate catch and effort levels and review the fishery's impact on dependent and related species. In the interim, precautionary catch limits are based on information from comparable assessed CCAMLR fisheries, and tag returns and catch rates to date. Illegal, unregulated and unreported (IUU) removals remain a significant obstacle to sustainable management in the CCAMLR area (see Chapter 21). These catches, which were previously taken by longline but are now taken by gillnet, are estimated and taken into account when setting precautionary TACs.

TABLE 26.4 History of the Antarctic Waters Fishery

Year	Description
1999 to 2000	Australia conducted experimental trawling in Statistical Divisions 58.4.1 and 58.4.2. Large bycatch of benthic invertebrates led to interim protection for all waters shallower than 550 m on the continental shelf.
2002	IUU fishing estimated to begin in Statistical Division 58.4.2. CCAMLR closed Statistical Division 58.4.4 due to overfishing by IUU vessels.
2002–03	Australia conducted exploratory longline fishing in Statistical Division 58.4.2.
2003	IUU fishing estimated to begin in Statistical Divisions 58.4.3a–b.
2003–04	Australia conducted exploratory longline fishing in Statistical Divisions 58.4.2 and 58.4.3b.
2004–05	Australia conducted exploratory longline fishing (10 research shots) in Statistical Division 58.4.3a.
2005	IUU fishing estimated to begin in Statistical Division 58.4.1.
2006–07	20 IUU vessels sighted in Statistical Division 58.4.3b. Australia obtained evidence of significant depletion of the toothfish stock in this statistical division.
2008	Australia conducted research survey on BANZARE Bank, Statistical Division 58.4.3b. Based on evidence of depletion, SSRU B in 58.4.3b was closed to fishing. CCAMLR lowered catch limits in Statistical Divisions 58.4.1, 58.4.2 and 58.4.3a–b for the 2008–09 fishing season.
2009	No Australian activity. High levels of IUU fishing occurring.

CCAMLR = Commission for the Conservation of Antarctic Marine Living Resources; IUU = illegal, unregulated and unreported; SSRU = small-scale research unit

26.2 HARVEST STRATEGY

The CCAMLR has adopted the following reference points and control rules for Patagonian and Antarctic toothfish:

- Reference point 1: median escapement of the spawning biomass at the end of a 35-year projection period is 50% of the median pre-exploitation level (S_{50}).
- Reference point 2: ensure that the probability of the spawning biomass dropping below 20% of its pre-exploitation median level (S_{20}) is less than 10% over the projection.
- Control rule: choose the lower of the two catch levels estimated to satisfy reference points 1 and 2, respectively.

This harvest strategy has not yet been formally implemented for CCAMLR Statistical Area 58.4 because insufficient data are available.

26.3 THE 2009 FISHERY

There was no activity by an Australian vessel in this fishery in 2009. In May 2008, an Australian-flagged longliner conducted a randomised survey over BANZARE Bank (Statistical Division 58.4.3b), which consisted of 15 standardised sets over two strata covering areas of commercial fishing activity (Table 26.4). The purpose of the survey was to obtain information for a scientific basis for setting catch limits in the area. Both Patagonian toothfish (520 kg) and Antarctic toothfish (2545 kg) were caught, but catch rates were low (0–225 kg per 1000 hooks), indicating that toothfish were depleted to low densities across the majority of the surveyed area (Welsford et al. 2008). Antarctic toothfish were distributed across the entire survey area. The predominance of large, reproductively active Antarctic toothfish indicates that BANZARE Bank is an important spawning area, with probable links to nearby areas in east Antarctica where juveniles and maturing fish are found. Patagonian toothfish were largely immature and captured on the western part of BANZARE Bank. Given these contrasting population characteristics, species-specific management arrangements may be needed for the sustainable use of toothfish resources in Statistical Division 58.4.3b and adjacent areas.

Legal and IUU catches for all the statistical divisions are shown in Table 26.3 (CCAMLR 2010). Three vessels from two members (Republic of Korea and Uruguay) fished in 58.4.1, while two vessels, one each from Japan and the Republic of Korea fished in 58.4.2. A single vessel from Japan fished 58.4.3a, while two vessels, one each from Japan and Uruguay fished the BANZARE Bank (58.4.3b). Notifications of intentions to fish in the next season were given for all Divisions.

Minor byproduct species

Byproduct species in the Antarctic Waters Fishery are generally limited to grenadiers and skates (Table 26.5). High TACs in 2008 for grenadiers in Statistical Divisions 58.4.1 and 58.4.2 were reduced significantly in 2009, and catches fell accordingly. Skate catches are very low. Under CCAMLR regulations, discharge of offal is prohibited south of 60ºS, but items that would not attract birds are allowed to be discarded north of 60ºS.

Iceberg PHOTO: RHYS ARANGIO, AUSTRAL FISHERIES

TABLE 26.5 Minor byproduct stocks—TACs and catches/landings[a]

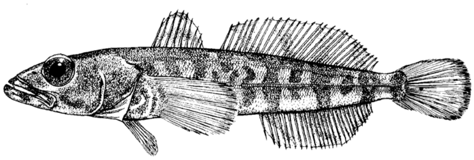
Species	Statistical Division	TAC, 2008 (tonnes)	Catch, 2008 (tonnes)	TAC, 2009 (tonnes)	Catch, 2009 (tonnes)
Grenadiers (*Macrourus* spp.)	58.4.1	96	36	33	8
	58.4.2	124	12	20	1
	58.4.3a	26	0	26	2
	58.4.3b	80	7	80	4
Skates (*Bathyraja* spp., *Amblyraja* spp.)	58.4.1	50	0	50	0
	58.4.2	50	0	50	0
	58.4.3a	50	2	50	2
	58.4.3b	50	1	50	1

a Discarding is not permitted.

26.4 BIOLOGICAL STATUS

TOOTHFISH

Patagonian toothfish (*Dissostichus eleginoides*)
Antarctic toothfish (*D. mawsoni*)



LINE DRAWING: FAO

Patagonian toothfish PHOTO: AUSTRAL FISHERIES

TABLE 26.6 Biology of toothfish

Parameter	Description
Patagonian toothfish	See Chapter 27 (Heard Island and McDonald Islands Fishery)
Antarctic toothfish	Similar to Patagonian toothfish, but thought to be faster growing
Range	**Species:** Circumpolar, 60–78°S **Stock:** Stock structure of the area unknown, although Antarctic toothfish are likely a single stock across the areas; each statistical division receives its own TAC for both toothfish species combined.
Depth	0–1600 m
Longevity	30+ years
Maturity (50%)	**Age:** uncertain (8–10 years for Patagonian toothfish) **Size:** females ~120 cm TL (BANZARE Bank); males ~90 cm TL
Spawning season	May–June (BANZARE Bank)
Size	**Maximum:** ~180 cm TL; weight ~75 kg **Recruitment into the fishery:** 10+ years of age (may be older on BANZARE Bank)

SOURCES: Lack (2001); Welsford et al. (2008).

Stock status determination

The following sections describe the result of the 2008 stock assessment—which was the first for Statistical Divisions 58.4.1, 58.4.2, 58.4.3a and 58.4.3b—and an update for 58.4.3b carried out in 2009 (Welsford et al. 2009).

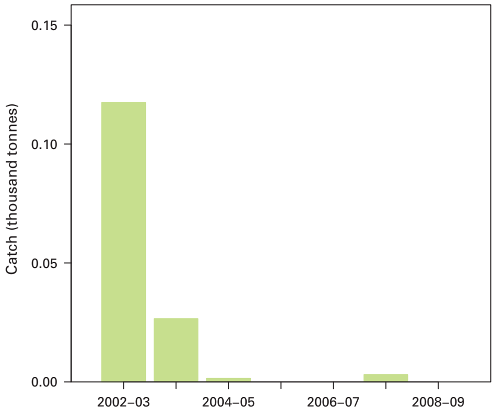


FIGURE 26.2 Australian toothfish catch history by financial year, 2002–03 to 2008–09

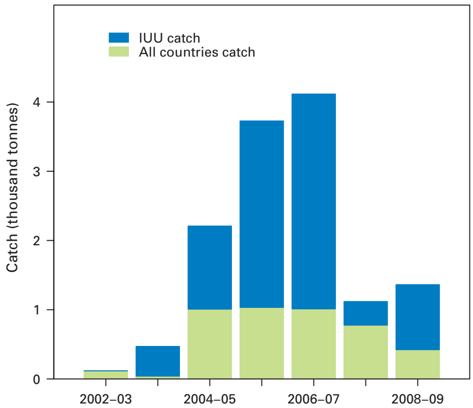


FIGURE 26.3 Toothfish catch history by financial year, all fleets, 2002–03 to 2008–09

Statistical Divisions 58.4.1 and 58.4.2

Four assessment methods based on catch per unit effort (CPUE) trends, local depletion, a constant recruitment model and mark–recapture data were compared for toothfish stocks in Statistical Divisions 58.4.1 and 58.4.2; however, a very low rate of tag returns prevented a reliable stock assessment (Agnew et al. 2008). Analyses have confirmed variable toothfish distribution and densities throughout these areas. Juveniles appear in higher proportions in the west, but overall densities increase to the east, particularly in an area east of Prydz Bay (Fig. 26.1). Preliminary calculations of sustainable yield suggest that precautionary catch limits should be significantly lower than those set in 2008 (Agnew et al. 2008). These limits were lowered in 2009; however, IUU catches are still a problem in these Divisions. Given the lack of a reliable assessment for these areas, they are assessed as uncertain for both the overfished and overfishing status.

Statistical Division 58.4.3a

Few analyses are available for Statistical Division 58.4.3a. Hillary (2008) assessed this stock based on tag returns, and this led to a decrease in the TAC in 2008. However, there is still a great deal of uncertainty about the stock status, and no updated assessment has been made. The stock is therefore considered uncertain for both overfished and overfishing status in this Division.

Statistical Division 58.4.3b

An assessment in 2008 using a Leslie depletion analyses of stratified catch and effort data provided evidence of recent depletion of toothfish on individual fishing grounds (e.g. up to 83% of initial biomass captured in a single season on Ground B; McKinlay et al. 2008). Evidence of a reduction in mean fish weights in Ground A over three seasons (2004–05 to 2006–07) was also noted. Welsford et al. (2009) updated this assessment and used estimated time series of historical catches to derive estimates of B_0. Their analyses also indicated that the stock was depleted in all the grounds and patches examined and would be unlikely to sustain fishing at the optimal level for at least seven years. In addition, there is evidence of poor recruitment and large IUU removals in recent years (e.g. six times the catch limit in Division 58.4.3b in 2009).

A random stratified survey by an Australian vessel in 2008 also provided evidence of substantial depletion and indicated that there are few fish outside the preferred fishing grounds (Welsford et al. 2008). In addition, the survey indicated that most Antarctic toothfish, which dominate the fishery, are large spawning adults; BANZARE Bank is the only area in east Antarctica where spawning Antarctic toothfish have been found.

Based on such information, the southern area of the BANZARE Bank (small-scale research unit B) was closed to fishing, because the preferred fishing grounds in this area were determined to be depleted. The stock is therefore assessed as **overfished** and **subject to overfishing** in this Statistical Division.

Summary

Given the strong evidence for significant depletion in 58.4.3b, the fact that this Statistical Division appears to be a spawning area for Antarctic toothfish and evidence of poor recent recruitment, the overall stock is assessed as **overfished** (Table 26.1). As high levels of catch (both legal and IUU) continue, particularly in 58.4.3b, the stock is also assessed as **subject to overfishing**.

Reliability of the assessment/s

The assessments for Statistical Division 58.4.3b are generally robust as they use commercial catch and effort data on a fine spatial scale to determine the level of depletion. Conservative estimates of IUU fishing in the Statistical Division were also considered. The depletion evidence for Division 58.4.3b was sufficient for the CCAMLR to close small-scale research unit B to fishing, and the updated information from 2009 may prompt further closures. The assessments for 58.4.1 and 58.4.2 were hindered by a low number of tag returns and therefore are generally uncertain.

Previous assessment/s

No assessments before 2008 are available for these areas.

Future assessment needs

Stock assessment of Antarctic and Patagonian toothfish resources in Statistical Divisions 58.4.1, 58.4.2 and 58.4.3 requires better information on the distribution, abundance, population characteristics and movement of different stocks in the area, as well as improved estimation of length classes and total amounts taken by IUU fishers.

26.5 ECONOMIC STATUS

In recent years, Australia has not been active in the fishery, apart from a 2008 research survey over BANZARE Bank (Statistical Division 58.4.3b). Overall, the competitive TACs in Statistical Division 58.4, which apply to all CCAMLR members approved to conduct new and exploratory fisheries in a given statistical division, have not been met by approved operators, particularly in Statistical Divisions 58.4.2 and 58.4.3. High amounts of unfilled quota suggest that net economic returns from the fishery are currently low.

26.6 ENVIRONMENTAL STATUS

CCAMLR members approved to conduct new and exploratory fisheries must adopt mitigation measures to lessen the environmental impacts of fishing. These measures include temporal and spatial closures, total seabird catch limits per vessel, mandatory streamer (tori) lines and line weighting, precautionary TACs and move-on rules for non-target species.

Plastic packaging bands must not be used on bait boxes, and plastic waste must not be discarded at sea. The loss of fishing gear and other non-biodegradable items must be reported. Bycatch, offal and other waste products from fish processing must be retained on board to avoid attracting seabirds and mammals. Discharge of poultry products is prohibited because of disease risks to seabirds. On-board lighting must be kept at a minimum to avoid seabird collisions, and any death or serious injury to a marine mammal or seabird must be reported. Each vessel must carry a CCAMLR-designated observer, and use of vessel monitoring systems is mandatory.

Since around 2002, some toothfish stocks targeted by new and exploratory fisheries (Statistical Divisions 58.4.3b and 58.4.4) have been observed to undergo rapid and unsustainable depletion, largely as a result of IUU fishing. The CCAMLR has adopted a range of binding conservation

measures aimed at eliminating IUU fishing from the CCAMLR area.

Patagonian toothfish was nominated for listing as a threatened species under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in 2008. In May 2009, the Minister for the Environment, Heritage and the Arts, on advice from the Threatened Species Scientific Committee, determined that toothfish was not eligible for listing.

Ecological risk assessment

No ecological risk assessment has been carried out for this fishery.

Threatened, endangered and protected species

Seabirds

No seabird mortalities associated with the toothfish fishery were reported for Divisions 58.4.1, 58.4.2 or 58.4.3. IUU fishing is likely to be responsible for large numbers of seabird mortalities (estimated to be 8212 in 2006–07) in the CCAMLR area (CCAMLR 2007). The number of seabird mortalities resulting from IUU fishing could not be estimated for 2009 because of a lack of information on the interaction rate with gillnets. The CCAMLR is not yet able to estimate catch rates from gillnets or, consequently, seabird mortality resulting from IUU gillnet fishing. Incidental mortality rates arising from IUU fishing may be unsustainable for some seabird populations if unmitigated in the future.

Marine mammals

No marine mammal mortalities associated with the toothfish fishery were reported for Statistical Divisions 58.4.1, 58.4.2 or 58.4.3 in 2009. The number of marine mammal mortalities resulting from IUU fishing could not be estimated because of a lack of information on the interaction rate with gillnets.

Benthic habitats

To avoid substantial adverse impacts on benthic habitats, CCAMLR members have adopted interim conservation measures prohibiting bottom trawling and deep-sea gillnetting in high-seas areas within the CCAMLR area. As well, areas identified as vulnerable marine ecosystems are closed until they can be reviewed by the CCAMLR Scientific Committee.

26.7 HARVEST STRATEGY PERFORMANCE

Not applicable.

Baiting longline hooks PHOTO: AFMA

Observer with toothfish PHOTO: AFMA

26.8 LITERATURE CITED

AFMA (Australian Fisheries Management Authority) 2003, *Antarctic Fisheries Bycatch Action Plan 2003*, AFMA, Canberra.

Agnew, DJ, Edwards, C, Hillary, R, Mitchell, R & L—pez Abellán, LJ 2008, *Revised assessment of toothfish stocks in Divisions 58.4.1, 58.4.2, WG-FSA-08/43*, CCAMLR Working Group on Fish Stock Assessment, Hobart.

CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources) 2007, *Report of the ad hoc Working Group on Incidental Mortality Associated with Fishing,* 8–12 October, CCAMLR, Hobart, <www.ccamlr.org/pu/e/e_pubs/sr/07/toc.htm>.

——2010, *Statistical Bulletin*, vol. 22 (2000–2009), CCAMLR, Hobart.

Constable, AJ, de la Mare, WK, Agnew, DJ, Everson, I & Miller, D 2000, 'Managing fisheries to conserve the Antarctic marine ecosystem: practical implementation of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR)', *ICES Journal of Marine Science*, vol. 57, pp. 778–91.

Hillary, RM 2008, *Exploratory assessment methods for exploratory fisheries: an example case using catch, IUU catch and tagging data for division 58.4.3a, WG-SAM-08/5*, report to the CCAMLR Working Group on Statistics, Assessments and Modelling, Hobart.

Lack, M 2001, *Antarctic toothfish: an analysis of management, catch and trade*, report for TRAFFIC Oceania.

McKinlay, JP, Welsford, DC, Constable, AJ & Nowara, GB 2008, 'An assessment of the exploratory fishery for *Dissostichus* spp. on BANZARE Bank (CCAMLR Division 58.4.3b) based on fine-scale catch and effort data', *CCAMLR Science*, vol. 15, pp. 55–78.

Welsford, DC, Constable, AJ & McKinlay, JP 2009, 'Development of recovery plans for depleted toothfish stocks in the Indian Ocean sector of the Southern Ocean', WG-FSA-09/44', report to the CCAMLR working Group on Fish Stock Assessment, Hobart.

——Robertson, T & Nowara, G 2008, 'Report on a longline survey conducted by the FV *Janas* in May 2008 on BANZARE Bank, and an assessment of the status of *Dissostichus* spp. in Division 58.4.3b, WG-FSA-08/57', report to the CCAMLR Working Group on Fish Stock Assessment, Hobart.

Toothfish aboard Eldfisk PHOTO: AFMA

27 Heard Island and McDonald Islands Fishery

H Patterson, D Wilson and K Mazur

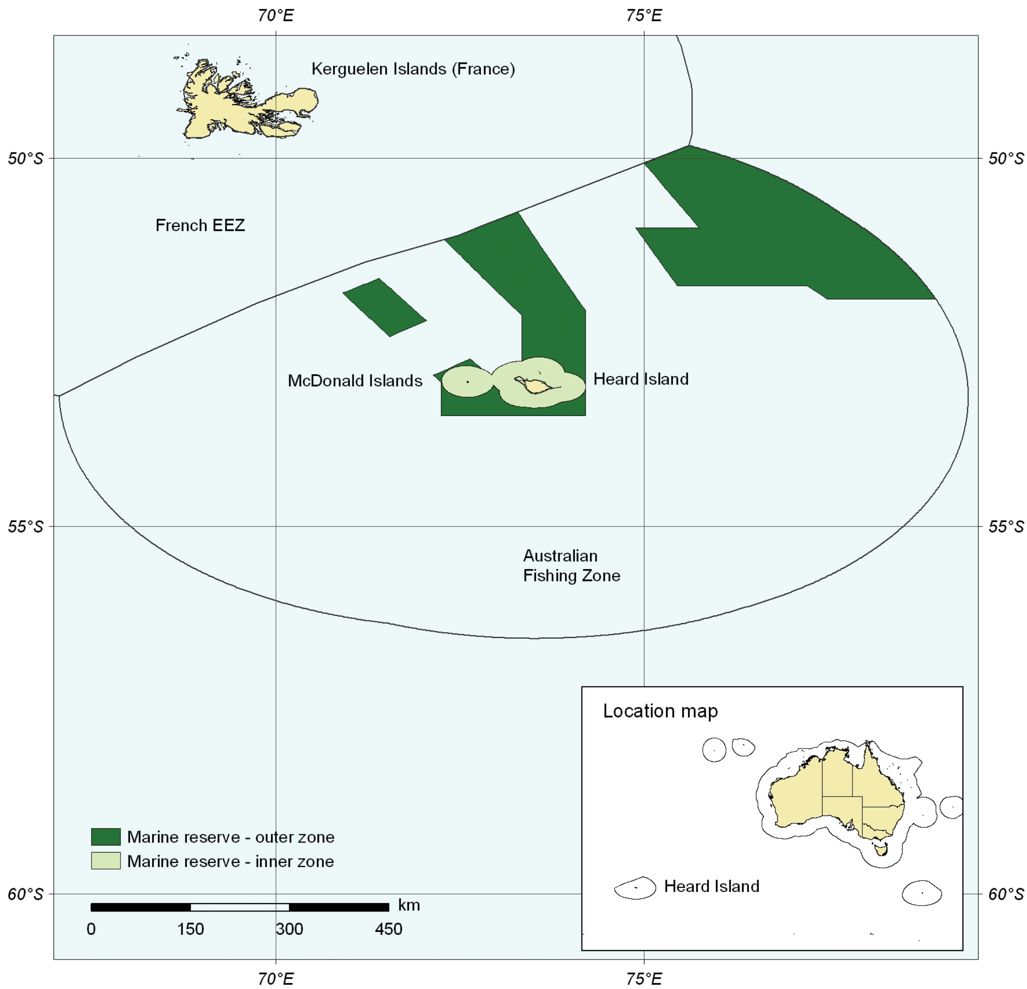


FIGURE 27.1 Area of the Heard Island and McDonald Islands Fishery

TABLE 27.1 Status of the Heard Island and McDonald Islands Fishery

Fishery status	2007		2008		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Mackerel icefish (*Champsocephalus gunnari*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Total allowable catches set in accordance with a precautionary harvest strategy.
Patagonian toothfish (*Dissostichus eleginoides*)	Not subject to overfishing	Not overfished	Not subject to overfishing	Not overfished	Total allowable catches set in accordance with a precautionary harvest strategy.
Economic status Fishery level	Estimates of net economic return estimates not available				Latent effort remained low in 2009, suggesting positive net economic returns.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING — OVERFISHED / OVERFISHING — UNCERTAIN — NOT ASSESSED

TABLE 27.2 Main features and statistics of the Heard Island and McDonald Islands Fishery

Feature	Description
Key target and byproduct species	Mackerel icefish (*Champsocephalus gunnari*) Patagonian toothfish (*Dissostichus eleginoides*)
Other byproduct species	Grenadiers (*Macrourus* spp.) Grey rockcod (*Lepidonotothen squamifrons*) Skates (*Bathyraja* spp.) Unicorn icefish (*Channichthys rhinoceratus*)
Fishing methods	Demersal longline, demersal trawl, midwater trawl, pot
Primary landing ports	Port Louis (Mauritius), Albany
Management methods	Input controls: limited entry, gear restrictions Output controls: TAC Temporal and spatial closures, move-on provisions if bycatch thresholds reached
Management plan	*Heard Island and McDonald Islands Fishery Management Plan*, 2002 (AFMA 2002)
Harvest strategy	CCAMLR default harvest strategies for toothfish and mackerel icefish (Constable et al. 2000; Candy & Welsford 2009)
Consultative forums	Sub-Antarctic Fisheries Management Advisory Committee (SouthMAC), Sub-Antarctic Resource Assessment Group (SARAG), Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)
Main markets	International: United States, Japan, eastern Europe—frozen
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Current accreditation dated 2 February 2010 Current accreditation (Exempt) expires 9 May 2012

Table 27.2 continues over the page

Feature	Description			
Ecological risk assessment: —Demersal trawl	Level 1: Scale Intensity Consequence Analysis (SICA) completed on 169 species (Daley et al. 2007) Level 2: Productivity Susceptibility Analysis (PSA) completed on 87 species (Daley et al. 2007) Level 3: Sustainability Assessment of Fishing Effects (SAFE) completed on 61 species (Zhou et al. 2009)			
—Demersal longline	Level 1: SICA completed on 103 species (Bulman 2008) Level 2: PSA completed on 19 species (Bulman 2008) Level 3: SAFE completed on 14 species (Zhou et al. 2009)			
—Midwater trawl	Level 1: SICA completed on 106 species (Bulman 2007) Level 2: PSA completed on 106 species (Bulman 2007) Level 3: SAFE completed on 22 species (Zhou et al. 2009)			
Bycatch workplans	*Antarctic Fisheries Bycatch Action Plan 2003* (AFMA 2003)			
Fishery statistics[a]	**2008 fishing season**		**2009 fishing season**	
Fishing season	1 Dec 2007 – 30 Nov 2008 (trawl) 1 May–14 Sep 2008, with extensions of 15–30 Apr and 15 Sept–31 Oct 2008 (longline)		1 Dec 2008 – 30 Nov 2009 1 May–14 Sep 2009 with extensions of 15–30 Apr and 15 Sept–31 Oct 2009 (longline)	
TAC and catch by species:	TAC (tonnes)	Catch (tonnes)	TAC (tonnes)	Catch (tonnes)
—mackerel icefish	220	199	102	83
—Patagonian toothfish	2500	2280	2500	2464
—byproduct species	See Table 27.4	See Table 27.4	See Table 27.4	See Table 27.4
Effort	143 trawl days 2 870 000 hooks 0 pot hauls		96 trawl days 3 666 000 hooks 4822 pot hauls	
Fishing permits	4 quota SFR holders		4 quota SFR holders	
Active vessels	3		3	
Observer coverage	100% vessel coverage		100% vessel coverage	
Real gross value of production (2008–09 dollars)	Confidential (<5 vessels)		Confidential (<5 vessels)	
Allocated management costs	2007–08: $1.4 million		2008–09: $1.1 million	

CCAMLR = Commission for the Conservation of Antarctic Marine Living Resources; EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; SFR = statutory fishing right; TAC = total allowable catch

a Fishery statistics provided by fishing season unless otherwise indicated.

27.1 BACKGROUND

The Australian external Territory of Heard Island and McDonald Islands (HIMI) is located in the southern Indian Ocean about 4000 km south-west of Perth (Fig. 27.1), within the area under the jurisdiction of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR; see Chapter 21). It has been described as the only example of an unmodified sub-Antarctic island ecosystem, and is included on the register of the national estate and the World Heritage List because of its biological, geological and scientific values. The islands and their surrounding territorial waters (out to 12 nautical miles [nm]) are regulated under the *Environment Protection and Management Ordinance 1987*, administered by the Australian Antarctic Division (AAD) of the Department of the Environment, Water, Heritage and the Arts. Waters between 12 nm and 200 nm form part of the Australian Fishing Zone (AFZ). The Heard Island and McDonald Islands Marine Reserve Management Plan 2005, made

pursuant to the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), provides a comprehensive management regime for the HIMI Marine Reserve. The marine reserve includes the islands, their surrounding territorial waters and parts of the HIMI Exclusive Economic Zone (Fig. 27.1), extending in parts to the outer boundary of the HIMI AFZ. The plan prohibits commercial fishing within the marine reserve.

Illegal, unregulated and unreported (IUU) fishing within the HIMI AFZ, almost exclusively targeting Patagonian toothfish, was a significant problem from the mid-1990s, but has declined sharply in recent years. Although difficult to estimate, IUU catches are likely to have been well in excess of the total allowable catch (TAC) in certain years and seriously undermined efforts to apply agreed precautionary stock assessment methods. Estimated IUU catches for the HIMI area peaked at around 7000 t in the 1996–97 fishing season. As a result of Australian surveillance and enforcement activities in the area (in cooperation with adjoining nations in the CCAMLR region, notably France), there has been no identified IUU activity in the HIMI AFZ for the past several years. CCAMLR measures to counter IUU fishing include the mandatory use of vessel monitoring systems, a catch documentation scheme for Patagonian toothfish and a list of IUU vessels.

Management of the Heard Island and McDonald Islands Fishery (HIMIF) is based on the precautionary approach adopted by the CCAMLR. The Australian Antarctic Division (AAD), in collaboration with industry, regularly conducts fisheries-independent, random-stratified trawl surveys for both Patagonian toothfish and mackerel icefish to collect data on abundance, sex-specific length frequencies, otoliths, genetic samples and bycatch. The HIMIF operates on the basis of a 10-day catch and effort reporting system, and a monthly fine-scale (haul-by-haul) catch and effort reporting system. Fine-scale biological data are recorded in accordance with the CCAMLR Scheme of International Scientific Observation.

TABLE 27.3 History of the Heard Island and McDonald Islands Fishery

Year	Description
1970s	Unregulated Soviet and Polish fishing around HIMI removed tens of thousands of tonnes of mackerel icefish.
1979	Australia declared a 200 nm Exclusive Economic Zone around HIMI. Commercial fishing ceased.
1982	CCAMLR established—HIMI resources to be managed within CCAMLR's jurisdiction.
1987	Joint Soviet–Australian exploratory fishing.
1990 to 1993	Australia conducted research cruises to assess abundance and distribution of fish stocks in HIMI sector of the Australian Fishing Zone.
1995	CCAMLR set initial TACs for toothfish (297 t), icefish (311 t) and other bycatch species (50 t per species).
1996	Heard Island Wilderness Reserve declared, protecting islands and territorial waters out to 12 nm.
1997	AFMA implemented an interim management policy restricting fishing to a maximum of three vessels, using demersal and pelagic trawl only. Conditions of the policy included carriage of two observers on every trip, provision of data, and development of a fishing plan with a research component.
1997	Fishing under AFMA's interim management policy began in May.
2002	Commencement of the *Heard Island and McDonald Islands Fishery Management Plan* 2002, and declaration of the HIMI Marine Reserve.
2002 to 2006	Demersal longline trials to target toothfish commenced in the 2002–03 fishing season and were repeated annually until 2005–06, with scientific permits granted under the HIMIF management plan.
2005	Demersal longlining became an approved fishing method for toothfish in November.
2005 to 2006	Pots (fish traps) to target toothfish trialled during two exploratory fishing trips.
2009	Catch limit for Dissostichus eleginoides revised to 2550 t. This will be carried over to the 2010–11 season.

AFMA = Australian Fisheries Management Authority; CCAMLR = Commission for the Conservation of Antarctic Marine Living Resources; HIMI = Heard Island and McDonald Islands; HIMIF = Heard Island and McDonald Islands Fishery; TAC = total allowable catch

27.2 HARVEST STRATEGY

The harvest strategies for the HIMIF are consistent with the principles of the CCAMLR and have been in operation since the fishery began in the mid-1990s. Where spawning biomass estimates are available (as in the HIMIF, where the annual trawl survey provides a key input into biomass estimates), the harvest strategies are implemented through the application of control rules.

Mackerel icefish

- Limit reference point: maintain the spawning stock biomass at 75% of the level that would occur in the absence of fishing at the end of a two-year model projection of the population. A reliable estimate of biomass and population structure (such as a recent survey) is necessary to establish the population status at the start of the model projection period.
- Control rule: choose a catch level that satisfies the reference point with 95% probability, based on the one-sided lower 95% confidence bound of the biomass estimate used as the starting point of a two-year projection (obtained from the survey).

Patagonian toothfish

- Reference point 1: median escapement of the spawning biomass at the end of a 35-year projection period is 50% of the median pre-exploitation level (S_{50}).
- Reference point 2: ensure that the probability of the spawning biomass dropping below 20% of its pre-exploitation median level (S_{20}) is less than 10% over the projection.
- Control rule: choose the lower of the two catch levels estimated to satisfy reference points 1 and 2, respectively.

Mackerel icefish haul PHOTO: JAY HENDER, ABARE–BRS

27.3 THE 2009 FISHERY

Key target and byproduct species

In the 2009 fishing season, two longline vessels and one trawl vessel landed 2547 t, comprising 83 t of mackerel icefish (TAC: 102 t) and 2464 t of Patagonian toothfish (TAC: 2500 t; catch: 1287 t trawl, 1167 t longline, 10 t pot), (Figs. 27.2, 27.3, respectively) (CCAMLR 2010). The longline vessels operated in deeper water, catching larger and older fish than the trawl fishery. However, poor weather conditions and several vessel breakdowns in 2009 made fishing difficult. The number and weight of toothfish that are damaged or suffer from jellymeat condition (a disease causing degeneration of protein) must be included in the total catch, but no fish were observed in this condition in the 2009 fishing season. Under restrictions on disposal of offal (which are designed to protect seabirds from interactions with fishing operations), there is no discarding of toothfish in jellymeat condition in this fishery.

There was no evidence of IUU fishing in the HIMIF in the 2009 fishing season. The gross value of production is confidential due to the limited number of active vessels.

Minor byproduct species

The catch limits of deep-sea skates, unicorn icefish and grey rockcod are based on assessments of long-term annual yield that were estimated using a generalised yield model (GYM) in 1997 (Constable et al. 1998). Data inputs included limited biological data and biomass estimates from surveys in the HIMI area, and parameters for similar species obtained from the literature. Catch limits were set in accordance with the reference point applied to mackerel icefish (see Table 27.3). However, although the catch limits are considered precautionary, the assessments have not been updated. The catch limit for grenadiers is based on parameters determined from commercial and research data obtained from the HIMIF and BANZARE Bank (Statistical Division

58.4.3b, on the Greater Kerguelen Plateau to the south of Statistical Division 58.5.2, see Chapter 26), which also require updating. In 2009, CCAMLR scientific observers focused on tagging and collecting data from rajids for assessment purposes. Australia has conducted a tagging program for rajids caught in the HIMIF since 2001, providing data on movement and growth rates (Nowara & Lamb 2008). Updated information was provided on length–weight relationships, length-at-maturity, and abundance and distribution estimates from survey data, as well as an update on the tagging program; however, the data were not used to update the assessments.

In the mackerel icefish trawl fishery, byproduct (mostly unicorn icefish) comprised approximately 7% of the catch weight of the target species (Table 27.4). In the Patagonian toothfish trawl fishery, byproduct comprised approximately 8% of the catch weight of the target species, and was dominated by unicorn icefish, grey rockcod and skates. In the toothfish longline fishery, byproduct comprised approximately 11% of the catch weight of target species, and was dominated by macrourids and smaller amounts of skates. Under CCAMLR regulations, discarding is not permitted, except for skates, sharks and invertebrates (that cannot be processed for fish meal) that are alive upon capture and deemed to have a high chance of survival if returned to the sea. The intention is that discards must avoid attracting seabirds and marine mammals which increases the risk of incidental mortality.

TABLE 27.4 Minor byproduct stocks—TACs and catches in the HIMIF

Species	TAC (tonnes)	2007–08 catch (tonnes)	2008–09 catch (tonnes)
Grenadiers	360	86	112
Grey rockcod	80	20	19
Skates and rays	120	24	35
Unicorn icefish	150	45	54

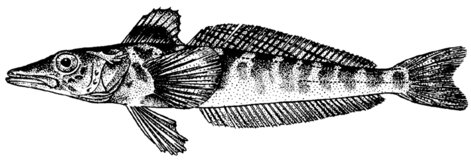
TAC = total allowable catch

SOURCE: CCAMLR (2009).

27.4 BIOLOGICAL STATUS

MACKEREL ICEFISH

(*Champsocephalus gunnari*)



LINE DRAWING: FAO

TABLE 27.5 Biology of mackerel icefish

Parameter	Description
Range	**Species:** Continental shelves of sub-Antarctic islands, 48–66°S. A separate population on Shell Bank (eastern edge of plateau) has a different breeding season and length distribution, but its commercial exploitation is prohibited. **Stock:** Area of the HIMIF.
Depth	Bentho-pelagic; shallow coastal waters, typically 100–350 m but as deep as 700 m
Longevity	6 years (Kerguelen Plateau); few fish survive beyond 4 years in the HIMIF
Maturity (50%)	**Age:** 3–4 years **Size:** 24–26 cm TL
Spawning season	April–September (Indian Ocean sector); highly variable recruitment
Size	**Maximum:** ~45 cm TL (Kerguelen Plateau) **Recruitment into the fishery:** ~24 cm TL; age: ~3 years

SOURCE: Williams et al. (2001).

Icefish packed PHOTO: JAY HENDER, ABARE–BRS

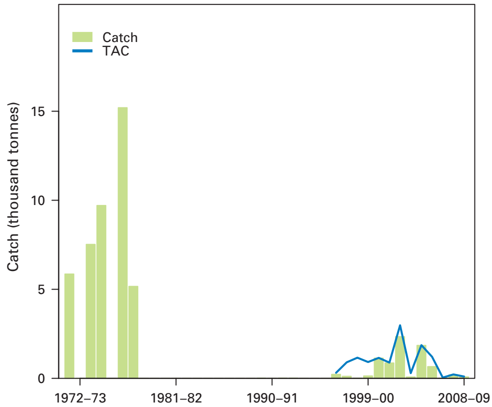


FIGURE 27.2 Mackerel icefish catch history by financial year, all fleets, 1971–72 to 2008–09

Stock status determination

The method for the 2009 assessment update was unchanged from the method used in previous years (e.g. Welsford 2007). The assessment was conducted after the random stratified trawl survey (RSTS) for mackerel icefish in July 2009, which indicated that the 3+ year-class dominates the stock, accounting for nearly 99% of the biomass (Welsford 2009). The assessment estimates that the current biomass is 5893 t, up substantially from the 2008 estimate of 660 t. The TAC for the 2010 fishing season (Fig. 27.2) was set in accordance with the harvest strategy. However, given the relatively high biomass of mackerel icefish, and the fact that few fish survive beyond four years, a fishing strategy similar to that used to the 2005–06 season was applied: the catch calculated for two years can be taken in a single year, with the expectation that there will be no exploitation of the stock the following year. The TAC for the 2009–10 season was therefore set at 1658 t. Taking into account the life history of this species, the next large cohort will likely not be available for fishing until after the 2010–11 season. Given the harvest rate relative to the stock biomass estimate, and the conservative TAC setting process followed by the CCAMLR, the stock is assessed as **not overfished** and **not subject to overfishing** (Table 27.1).

Reliability of the assessment/s

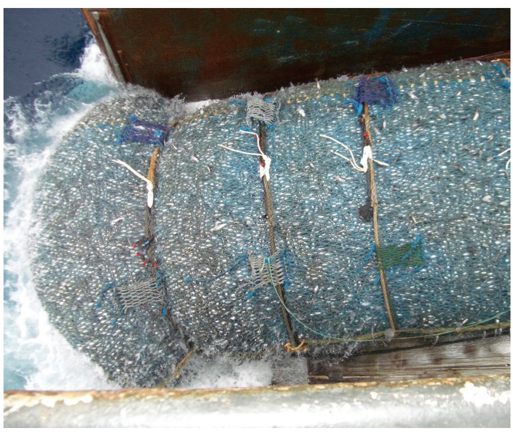
The assessment is considered reliable because it is based on fisheries-independent data, produces precautionary TACs that are expected to satisfy CCAMLR control rules, and is subject to stringent peer review through the Sub-Antarctic Resource Assessment Group (SARAG) and relevant CCAMLR working groups.

Previous assessment/s

Assessment of the HIMIF mackerel icefish stock is based on a short-term projection implemented in a GYM (Welsford 2009). Stock biomass is projected over a relatively short (two-year) period, to account for the species' lifespan and large annual differences in cohort abundance. The assessment for the 2007–08 season was based on the results of the random stratified trawl survey conducted in July 2008, which determined that the population was dominated by a 2+ year-class, with no other strong cohorts apparent in the fishery, and a low biomass (660 t). A catch level of only 102 t was assessed as satisfying the control rules for mackerel icefish. However, given the very high biomass estimated from the 2009 survey, it is likely that the 2008 assessment underestimated biomass, with escapement likely higher than the target of 75%.

Future assessment needs

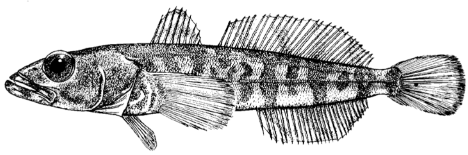
The development of a management procedure for mackerel icefish has been identified by the CCAMLR as a high priority.



Icefish haul PHOTO: JAY HENDER, ABARE–BRS

PATAGONIAN TOOTHFISH

(*Dissostichus eleginoides*)



LINE DRAWING: FAO

TABLE 27.6 Biology of Patagonian toothfish

Parameter	Description
General	Bentho-pelagic; slow growing, late maturing and with low reproductive capacity. Vulnerable to overfishing.
Range	**Species:** Marine plateaus and continental shelves of sub-Antarctic islands, 33–66°S **Stock:** Area of the HIMIF
Depth	Shelf and upper slope, 300–2000+ m
Longevity	30+ years
Maturity (50%)	**Age:** 8–10 years **Size:** 70–95 cm TL
Spawning season	June–September
Size	**Maximum:** ~200 cm TL (~100 kg) **Recruitment into the fishery:** 12–15 cm TL (size at which semipelagic juveniles become demersal), although toothfish <20 cm are rare in research or commercial catches.

SOURCES: Gon & Heemstra (1990); Everson & Murray (1999).

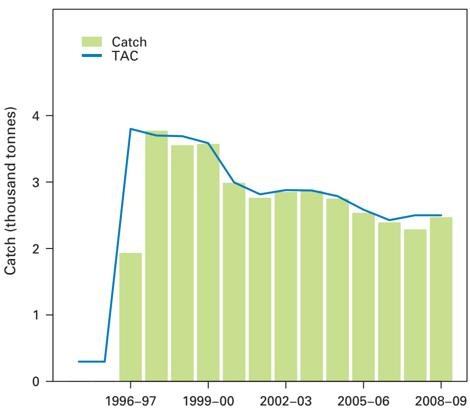


FIGURE 27.3 Patagonian toothfish catch history by financial year, all fleets, 1994–95 to 2008–09

Stock status determination

The catch level for the 2008–09 fishing season (Fig. 27.3) was determined using the CASAL stock assessment software (Candy & Welsford 2009) that used the same parameters as the 2008 assessment (Candy & Constable 2008). Inputs included abundance estimates (by length) obtained from multiyear random stratified trawl surveys (RSTS), catch-at-age proportions obtained from subfishery and year-specific length-frequency data, standardised catch per unit effort for the trawl grounds, and IUU estimates (Candy & Welsford 2009). Although the model used in CASAL was not spatially explicit, spatial complexity in the fishery was modelled using separate fishing selectivity functions for each fishing ground and longline/trawl combination. Identified uncertainties in the assessment include the number of ages fully selected by the RSTS, and the sensitivity of biomass estimates to different weightings of survey versus commercial data. The spawning stock biomass was estimated to be at 63% of B_0. Although this is a decline from the 2007 estimate of 73%, it is still well above the limit reference point and adheres to the CCAMLR HS control rules (Constable et al. 2000). The long-term yield that satisfies the decision rules is 2550 t. The stock is assessed as **not overfished** and **not subject to overfishing** (Table 27.1). Given the stability of the model, the CCAMLR has agreed that using yield estimates for two years is likely a low risk.

Reliability of the assessment/s

The assessment of Patagonian toothfish is considered to be reliable because many sources of uncertainty are explicitly taken into account in the projection model. Further, the assessment methods are subjected to thorough peer review through SARAG and relevant CCAMLR working groups. The resulting precautionary TACs are expected to satisfy CCAMLR control rules. However, the lack of information on historical removals by IUU fishers operating around HIMI until very recently remains a source of uncertainty in assessments.

Previous assessment/s

The 2008 assessment was very similar to the updated 2009 assessment, and a catch level of 2500 t was determined to satisfy the CCAMLR control rules. For the 2007 assessment, estimates of yield were obtained from both an integrated assessment model (CASAL) and GYM, the latter having been used in previous assessments. Results from CASAL were similar to those from GYM, but CASAL takes better account of differences in gear selectivities and provides a better method for incorporating parameters (e.g. catchability) from the research surveys.

Future assessment needs

A number of toothfish tagged in the HIMIF have been recaptured in adjacent French waters, indicating linkages between populations in the Australian and French Exclusive Economic Zones on the Kerguelen Plateau. Development of a plateau-wide assessment is a priority for understanding the toothfish stock targeted by the HIMIF, and is currently the focus of collaboration between Australian and French scientists. Australia and France held the first International Science Symposium on the Kerguelen Plateau in Concarneau, France, in April 2010 to further scientific cooperation. A refinement of the current assessment could also be undertaken by incorporating length-at-age data from 2008 and 2009, potentially developing a sex-specific model, and incorporating tagging data to estimate model parameters other than natural mortality (CCAMLR 2009).

27.5 ECONOMIC STATUS

Economic performance

The Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences does not conduct economic surveys of the HIMIF. The only economic indicator available is the level of latency of quota.

In 2007–08 (as in previous years), the Patagonian toothfish catch was close to its TAC with only 8.8% of the TAC remaining uncaught (Table 27.7). Latency then decreased to 1.4% in 2008–09 given an 8% increase in catch and a stable TAC. These low amounts of quota latency for Patagonian toothfish indicate positive net economic returns (NER) for this species.

In 2007–08 the TAC for mackerel icefish increased five-fold to 220 t, against which 199 t were caught, resulting in 9.5% of quota remaining unfilled. In 2008–09 the TAC for mackerel icefish was more than halved to 102 t, of which 83 t was caught, leaving 18.6% of the TAC unfilled.

Low latency in the Patagonian toothfish quota, which comprised around 92% of the fishery's 2008–09 TACs, suggests that NER for the fishery are positive. Overall, latency in the fishery decreased from 8.8% in 2007–08 to 2.1% in 2008–09, largely as a result of increased catches of Patagonian toothfish.

TABLE 27.7 Latent effort in the HIMIF

Species	Catch (tonnes)		TAC (tonnes)		Percentage of TAC unfilled	
	2007–08	2008–09	2007–08	2008–09	2007–08	2008–09
Mackerel icefish	199	83	220	102	9.5	18.6
Patagonian toothfish	2280	2464	2500	2500	8.8	1.4
Total	2479	2547	2720	2602	8.8	2.1

TAC = total allowable catch

Overall economic status

It is important to note that a precautionary harvest strategy that is consistent with the principles of the CCAMLR is in place for this fishery. As such, TACs are restrictive so stock biomass can be maintained at levels that are higher relative to most Commonwealth fisheries managed according to a MEY objective.

Accordingly, for Patagonian toothfish, most recent biomass estimates put the stock at 63% of B_0; substantially higher than the limit reference point for the fishery (50%) and also the B_{MEY} proxy normally used for other Commonwealth fisheries (48%). The TAC set for Patagonian toothfish is regularly filled. Both indicators suggest that profits are generally positive (although fishing in the sub-Antarctic probably makes them variable).

The fishery is an example of how ITQs can be used as a primary management control, in conjunction with input controls aimed at protecting the environment. The use of ITQs provides the best chance that profits will be maximised, subject to a precautionary harvest strategy and strict operational constraints placed on vessels.

27.6 ENVIRONMENTAL STATUS

The HIMI Marine Reserve, which was declared under the EPBC Act in October 2002, comprises the islands, territorial sea around the islands (to 12 nm) and additional marine areas, extending in places to the 200 nm Exclusive Economic Zone boundary. The HIMI Marine Reserve is zoned as highly protected (International Union for the Conservation of Nature [IUCN] Category 1a: fishing prohibited), representing one of the largest no-take marine protected areas in the world.

CCAMLR conservation measures outline mitigation measures required in the longline and trawl fisheries; these include closed seasons, mandatory streamer (tori) lines and line weighting. Precautionary TACs are set for a variety of non-target species or species groups in the HIMIF (see Table 27.3), and fishing must cease if any are exceeded. Additionally, if a single haul catches more than 1 t of a non-target species or more than 2 t of a non-target species group, the vessel must move at least 5 nm and not return to the location for at least five days. Move-on rules are also triggered when single hauls containing more than 100 kg of mackerel icefish include a specified proportion of fish smaller than the minimum legal total length (24 cm). Furthermore, participants in the fishery are required to satisfy strict conditions to lessen environmental impacts. For example, plastic packaging bands must not be used on bait boxes, plastic waste must not be discarded at sea, and the loss of fishing gear and other non-biodegradable items must be reported. Discharge of brassicas (the plant family that includes broccoli) is prohibited because of the possibility of establishing pests on the islands. Two observers are deployed on each voyage.

Patagonian toothfish was nominated for listing as a threatened species under the EPBC Act in 2008. In May 2009, the Minister for the Environment, Heritage and the Arts, on advice from the Threatened Species Scientific Committee, determined that toothfish was not eligible for listing. The HIMIF obtained certification of the mackerel icefish fishery from the Marine Stewardship Council in 2006. The fishery started the reassessment process for recertification on 7 April 2010; this process will be completed in early 2011.

Icy conditions PHOTO: RHYS ARANGIO, AUSTRAL FISHERIES

Ecological risk assessment

For the HIMIF, three ecological risk assessment (ERA) processes were undertaken by gear type (demersal trawl, midwater trawl and demersal longline) (Table 27.2). Under the Level 2 assessment for demersal trawl, 52 species or species groups were identified as being at high risk. After the application of the residual risk guidelines, three skate species (*Bathyraja irrasa*, *B. murrayi* and *B. eatonii*) remained at high risk. The Level 3 SAFE assessment identified the same three species as being at high risk. These species are widely distributed across the Kerguelen Plateau in both Australian and French territories. No depletion of these species in the HIMI fishing grounds is evident at this stage (Nowara et al. 2009).

Under the Level 2 assessment for midwater trawl, 17 species were identified as being at high risk. After the application of the residual risk guidelines, only one species, porbeagle, remained classified as being at high risk. However, the Level 3 SAFE assessment indicated that no species was at high risk.

For the ERA of demersal longline in the HIMIF, the Level 2 assessment indicated that 14 species were at high risk. After the application of the residual risk guidelines, only a single species remained at high risk, a skate (*B. irrasa*). However, the Level 3 SAFE assessment indicated that no species was at high risk.

The ecological risk management reports for the HIMIF (AFMA 2009a, b, c) will be reviewed in the next edition of the *Fishery status reports*.

Threatened, endangered and protected species

Seabirds

The threat abatement plan to reduce the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations (AAD 2006) applies to the HIMI longline fishery. Bycatch, offal and other waste products from fish processing must be retained on board to avoid attracting seabirds and mammals. Discharge of poultry products is prohibited because of disease risks to seabirds. On-board lighting must be kept at a minimum to avoid seabird collisions, and any death or serious injury to a marine mammal or seabird must be reported. In 2008–09 one white-chinned petrel was killed in the HIMI longline fishery. A single cape petrel was killed in the HIMI trawl fishery.

Marine mammals

Two elephant seal mortalities were reported in the HIMI longline fishery in 2009. A total of seven mortalities were reported in the entire convention area by all nations, as a result of interactions with longlines. No mortalities associated with trawling were reported for finfish fisheries.

Fishing vessel PHOTO: RHYS ARANGIO, AUSTRAL FISHERIES

Processing toothfish PHOTO: RHYS ARANGIO, AUSTRAL FISHERIES

Benthic habitats

Habitats in the HIMIF were not assessed as part of the ERA due to a lack of suitable data. However, the HIMI Marine Reserve, described above, affords a high level of protection. Furthermore, the CCAMLR has a system in place to identify and mitigate impacts on vulnerable marine ecosystems (see Chapter 21).

27.7 HARVEST STRATEGY PERFORMANCE

Harvest strategies developed for the target species in the HIMIF are consistent with the precautionary approach of the CCAMLR and have been used to set catch limits since the fishery began in the mid-1990s. The harvest strategies take into consideration the importance of the target species (especially mackerel icefish) as prey items in the sub-Antarctic, and catch limits must be sufficiently precautionary to ensure that target species abundance meets the ecological needs of dependent species (e.g. seabirds and marine mammals).

Target stocks are assessed on an annual basis (or biennial for Patagonian toothfish, as of 2007–08), and monitored each year by fisheries-independent RSTS. A management strategy evaluation framework is currently being developed for the HIMIF.

The catch history of target and non-target species, the overall economic performance of the HIMIF, and the mitigation of environmental interactions suggest that the harvest strategy has been effective in ensuring that this fishery is managed in a manner consistent with the principles of ecologically sustainable development. The harvest strategies developed for the HIMIF are more precautionary than the guidelines of the *Commonwealth Fisheries Harvest Strategy Policy* (DAFF 2007) as CCAMLR harvest strategies require projections and high levels of probability (see HS section for the HS control rules that apply to HIMIF).

27.8 LITERATURE CITED

AAD (Australian Antarctic Division) 2006, *Threat abatement plan, for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations*, AAD, Kingston, Tasmania.

AFMA (Australian Fisheries Management Authority) 2002, *Heard Island and McDonald Islands Fishery Management Plan 2002*, DAFF, Canberra, Federal Register of Legislative Instruments F2007C00693.

——2003, *Antarctic Fisheries Bycatch Action Plan 2003*, AFMA, Canberra.

——2009a, Ecological risk management report for the Heard Island and McDonald Islands Fishery - Demersal Longline sub-Fishery December 2009, AFMA, Canberra.

——2009b, Ecological risk management report for the Heard Island and McDonald Islands Fishery - Demersal Trawl sub-Fishery December 2009, AFMA, Canberra.

——2009c, Ecological risk management report for the Heard Island and McDonald Islands Fishery - Midwater Trawl sub-Fishery December 2009, AFMA, Canberra.

Bulman, C, Daley, R, Sporcic, M, Fuller, M, Stevenson, D & Hobday, A 2007, *Ecological risk assessment for the effects of fishing: Report for the midwater trawl sub-fishery of the Heard and McDonald Islands Fishery*, report to the AFMA, Canberra.

——Daley, R, Stevenson, D, Hobday, A, Sporcic, M, & Fuller, M 2008, *Ecological risk assessment for the effects of fishing: Report for the demersal longline sub-fishery of the Heard and McDonald Islands Fishery*, report to the AFMA, Canberra.

Candy, SG & Constable, AJ 2008, 'An integrated stock assessment for the Patagonian toothfish (*Dissostichus eleginoides*) for the Heard and McDonald Islands using CASAL', *CCAMLR Science*, vol. 15, pp. 1–34.

——& Welsford, DC 2009, *Update of the integrated assessment for the Patagonian toothfish (Dissostichus eleginoides) for the Heard and McDonald Islands (Division*

58.5.2), WG-FSA-09/20, report to the CCAMLR working Group on Fish Stock Assessment, Hobart.

CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources) 2009, *Report of the twenty-eighth meeting of the scientific committee for the Conservation of Antarctic Marine Living Resources*, 26 October – 6 November, CCAMLR, Hobart.

——2009a, Ecological risk management report for the Heard Island and McDonald Islands Fishery – Demersal Longline sub-Fishery December 2009, AFMA, Canberra.

——2009b, Ecological risk management report for the Heard Island and McDonald Islands Fishery – Demersal Trawl sub-Fishery December 2009, AFMA, Canberra.

——2009c, Ecological risk management report for the Heard Island and McDonald Islands Fishery – Midwater Trawl sub-Fishery December 2009, AFMA, Canberra.

——2010, *Statistical Bulletin*, vol. 22 (2000–2009), CCAMLR, Hobart.

Constable, AJ, de la Mare, WK, Agnew, DJ, Everson, I & Miller, D 2000, 'Managing fisheries to conserve the Antarctic marine ecosystem: practical implementation of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR)', *ICES Journal of Marine Science*, vol. 57, pp. 778–91.

——Williams, R & de la Mare, WK 1998, 'Assessment of by-catch in trawl fisheries at Heard and McDonald islands', *CCAMLR Science*, vol. 5, pp. 231–43.

DAFF (Australian Government Department of Agriculture, Fisheries and Forestry) 2007, *Commonwealth Fisheries Harvest Strategy: policy and guidelines*, DAFF, Canberra.

Daley, R, Bulman, C, Stevenson, D, Hobday, A, Sporcic, M & Fuller, M 2007, *Ecological risk assessment for the effects of fishing: Report for the demersal trawl sub-fishery for the Heard and McDonald Islands Fishery*, report to the AFMA, Canberra.

Everson, I & Murray, AW 1999, 'Size at sexual maturity of Patagonian toothfish (*Dissostichus eleginoides*)', *CCAMLR Science*, vol. 6, pp. 37–46.

Gon, O & Heemstra, PC (eds) 1990, *Fishes of the Southern Ocean*, JLB Smith Institute of Ichthyology, Grahamstown.

Nowara, GB & Lamb, T 2008, *The Australian skate tagging program at Heard Island and McDonald Islands, CCAMLR Division 58.5.2, WG-FSA-08/55*, report to the CCAMLR Working Group on Fish Stock Assessment, Hobart.

——Welsford, DC, Lamb, T, Gasco, N, Pruvost, P & Duhamel, G 2009, *Distribution and abundance of skates on the Kerguelen Plateau (CCAMLR Divisions 58.5.1 and 58.5.2), WG-FSA-09/43*, report to the CCAMLR Working Group on Fish Stock Assessment, Hobart.

Welsford, DC 2007, *Preliminary assessment of mackerel icefish (Champsocephalus gunnari) in the vicinity of Heard Island and McDonald Islands (Division 58.5.2), based on a survey in July 2007, using the generalised yield model, WG-FSA-07/47*, report to the CCAMLR Working Group on Fish Stock Assessment, Hobart.

——2009, *Preliminary assessment of mackerel icefish (Champsocephalus gunnari) in the vicinity of Heard Island and McDonald Islands (Division 58.5.2), based on a survey in April 2009, using the generalised yield model, WG-FSA-09/33*, report to the CCAMLR Working Group on Fish Stock Assessment, Hobart.

Williams, R, van Wijk E, Constable, A & Lamb, T 2001, *The fishery for Champsocephalus gunnari and its biology at Heard Island (Division 58.5.2), WAMI-01/4*, report to the CCAMLR Workshop on Assessment Methods for Icefish, Hobart.

Zhou, S, Smith, T & Fuller, M 2007, *Rapid quantitative risk assessment for fish species in major Commonwealth fisheries*, report to the AFMA, Canberra.

28 Macquarie Island Toothfish Fishery

H Patterson, D Wilson and K Mazur

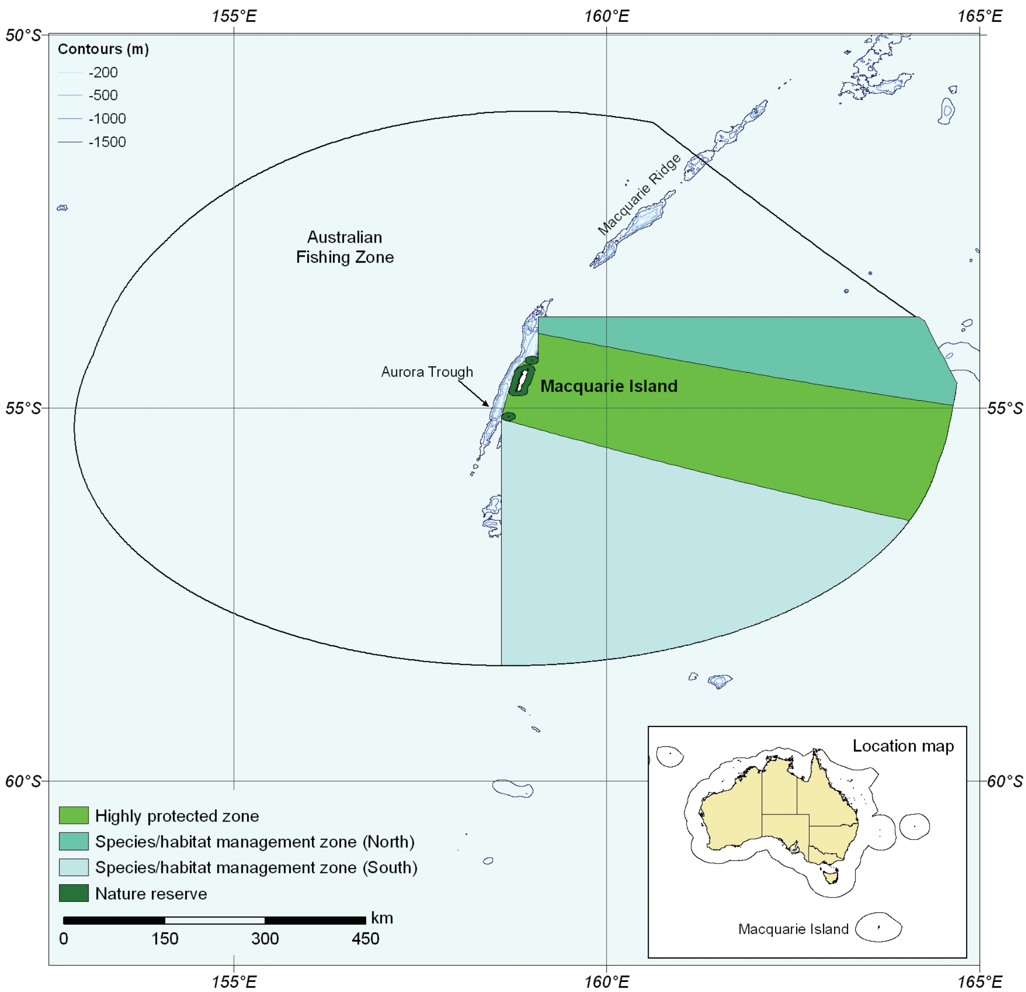


FIGURE 28.1 Area of the Macquarie Island Toothfish Fishery

TABLE 28.1 Status of the Macquarie Island Toothfish Fishery

Fishery status	2008		2009		Comments
Biological status	Overfishing	Overfished	Overfishing	Overfished	
Patagonian toothfish (*Dissostichus eleginoides*)	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Not overfished / not subject to overfishing	Level of available biomass estimated to be high. Total allowable catches set at conservative levels.
Economic status Fishery level	Estimates of net economic return estimates not available				Latent quota low in Aurora Trough, and very low in Macquarie Ridge. Net economic returns for fishery are likely to be positive.

NOT OVERFISHED / NOT SUBJECT TO OVERFISHING   OVERFISHED / OVERFISHING   UNCERTAIN   NOT ASSESSED

TABLE 28.2 Main features and statistics of the Macquarie Island Toothfish Fishery

Feature	Description			
Key target and byproduct species	Patagonian toothfish (*Dissostichus eleginoides*)			
Other byproduct species	Grenadier (*Macrourus carinatus*) Violet cod (*Antimora rostrata*)			
Fishing methods	Demersal trawl, trial demersal longline			
Primary landing ports	Port Louis (Mauritius); Albany			
Management methods	Input controls: limited entry, gear restrictions and closures Output controls: TAC			
Management plan	*Macquarie Island Toothfish Fishery Management Plan 2006* (AFMA 2006), amended 2009			
Harvest strategy	Aurora Trough—harvest strategy (Tuck & Lamb 2009) Limit reference point: 66.5% of the 1995 trawl available biomass			
Consultative forums	Sub-Antarctic Fisheries Management Advisory Committee (SouthMAC), Sub-Antarctic Resource Assessment Group (SARAG)			
Main markets	International: United States, Japan—frozen			
EPBC Act assessments: —listed species (Part 13) —international movement of wildlife specimens (Part 13A)	Current accreditation dated 2 February 2010 Current accreditation (Exempt) expires 28 November 2010			
Ecological risk assessment: —Demersal trawl —Longline	Level 1: Scale Intensity Consequence Analysis (SICA) completed on 168 species (Daley et al. 2007) Level 2:Productivity Susceptibility Analysis (PSA) completed on 168 species (Daley et al. 2007) Level 3: Sustainability Assessment of Fishing Effects (SAFE) completed on 56 species (Zhou et al. 2009) Ecological risk assessment not initiated			
Bycatch workplans	*Antarctic Fisheries Bycatch Action Plan 2003* (AFMA 2003)			
Fishery statistics[a]	**2007–2008 fishing season**		**2008–2009 fishing season**	
Fishing season	1 July 2007–30 June 2008		1 July 2008–30 June 2009	
TAC and catch by area: —Aurora Trough (toothfish) —Macquarie Ridge (toothfish)	TAC (tonnes) 390 (trawl) 86 (an increase to 228 possible for the trawl fishery)	Catch (tonnes) 223 (trawl) 5 (longline) <1 (trawl); 79 (longline)	TAC (tonnes) 390 (trawl); effective TAC 312[b] 150 (an increase to 198 possible for the trawl fishery)	Catch (tonnes) 307 (trawl) 150 (longline)

Table 28.2 continues over the page

TABLE 28.2 Main features and statistics of the Macquarie Island Toothfish Fishery CONTINUED

Feature	Description	
Byproduct	200 t TAC for all species combined; 50 t for any one species	200 t TAC for all species combined; 50 t for any one species
Effort	22 trawl days 171 750 hooks	22 trawl days 360 000 hooks
Fishing permits	2 quota SFR holders 1 scientific permit	2 quota SFR holders 1 scientific permit
Active vessels	2	2
Observer coverage	100% vessel coverage	100% vessel coverage
Real gross value of production (2008–09 dollars)	Confidential (<5 vessels)	Confidential (<5 vessels)
Allocated management costs	2007–08: $0.20 million	2008–09: $0.20 million

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; SFR = statutory fishing right; TAC = total allowable catch

a Fishery statistics provided by fishing season unless otherwise indicated

b The TAC was determined at 390 t before the assessment. After the assessment was completed, an 'effective TAC' of 312 t was agreed upon with industry on the basis of the outcome of the assessment.

Patagonian toothfish PHOTO: RHYS ARANGIO, AUSTRAL FISHERIES

28.1 BACKGROUND

Macquarie Island is a sub-Antarctic island about 1500 km south of Tasmania (Fig. 28.1). The island is a nature reserve in the Tasmanian reserve system and is included on the World Heritage List. The waters within three nautical miles (nm) of the island are under Tasmanian jurisdiction, while the Commonwealth manages waters between 3 nm and the 200 nm outer boundary of the Australian Fishing Zone. The south-eastern quadrant of the Macquarie Island region out to 200 nm is a marine park. All extractive industries, including fishing, are prohibited within a central segment of the quadrant. Although the Macquarie Island Toothfish Fishery (MITF) is outside the area of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), the ecosystem-based management model used by the CCAMLR has been adopted for the fishery.

TABLE 28.3 History of the Macquarie Island Toothfish Fishery

Year	Description
Pre–1994	Historical whaling and sealing activity.
1994–95	A single-vessel, exploratory demersal trawl fishery began in the Aurora Trough.
1995–96	A continuing tag–recapture study initiated, forming the basis of stock assessment.
1996–97	A developmental trawl fishery established in the Aurora Trough. Fishing grounds on Macquarie Ridge discovered, with large catches of toothfish initially taken from a large aggregation.
1999	South-eastern quadrant of Macquarie Island region declared a marine park under the *National Parks and Wildlife Conservation Act 1975*.
1999 to 2003	Aurora Trough effectively closed to commercial fishing; fishing limited to a single licensed trawler to maintain tag–release and recapture work and undertake experimental acoustic surveys.
2003–04	Commercial trawling in the Aurora Trough resumed.
2007	*Macquarie Island Toothfish Fishery Management Plan 2006* commenced in July, replacing the Macquarie Island Fishery Interim Management Plan. A 3-year longline trial commenced, primarily on the Macquarie Ridge grounds.
2009	Longline trial extended for one additional year by the AFMA Commission for the 2010–11 fishing season. Management plan amended to change the fishing year to the period beginning on 1 July 2009 and ending at the end of 14 April 2010; and each subsequent year beginning on 15 April.

AFMA = Australian Fisheries Management Authority

28.2 HARVEST STRATEGY

Aurora Trough

The following control rules apply to the Aurora Trough:

- Limit reference point: 66.5% of the 1995 trawl available biomass (assumed to represent B_0 for the trawl fishery).
- Control rules: If the estimate of available biomass is greater than the limit reference point, the annual total allowable catch (TAC) is 10% of the current estimate of available biomass.

These control rules are expected to allow at least 50% escapement of the spawning biomass, which is consistent with the principle established by the CCAMLR for toothfish and with the *Commonwealth Fisheries Harvest Strategy Policy.*

Macquarie Ridge

In the absence of tag-based stock assessments, the control rule applied to the Macquarie Ridge has been to assume no recruitment to the fishery, and then reduce the previous season's TAC by the catch and one year of natural mortality for the trawl fishery.

A precautionary catch limit of 150 t was determined to allow for the continuation of the longline trial on the Macquarie Ridge. This approach is consistent with that adopted for CCAMLR new and exploratory fisheries.

28.3 THE 2009 FISHERY (2008–09 FISHING SEASON)

Key target and byproduct species

In 2008–09 the total trawl catch in the Aurora Trough was 307 t, from an effective TAC of 312 t (Fig. 28.2), at an average catch rate of approximately 13 t/km^2; this was higher than the catch rate of the previous season (10 t/km^2). Average daily catch rates were around 38 t/km^2 for the first 10 days of fishing, but declined to an average of 11 t/km^2 for the final 12 fishing days. These catch rates were up from the 2007–08 average of 11 t/km^2. A single

trawl shot on the Macquarie Ridge captured 306 kg of toothfish at a catch rate of 0.54 t/km^2. This is consistent with previous years.

Observers tagged 661 toothfish in the Aurora Trough, and 273 tagged fish were recaptured, including one tagged in 1996–97. In 2008–09 there were 14 tag releases and one tag recapture on the Macquarie Ridge (Tuck & Lamb 2009).

In August 2007 a single vessel completed the first year of the three-year longline trial, catching 79 t from a catch limit of 86 t. The trial was research oriented, with the vessel fishing as widely as possible along the Macquarie Ridge and exploring new areas as opportunity permitted. Two observers tagged 216 toothfish, and 2 tagged fish were recaptured. The second year of the trial was completed in July 2008 (2008–09 season), catching approximately 148 t of a 150 t catch limit. Observers tagged 465 toothfish, and 18 tagged fish were recaptured. The third voyage was completed in August 2009 (2009–10 season) and caught approximately 212 t, combining a 150 t catch limit for the Macquarie Ridge with a 60 t TAC for the Aurora Trough. Observers tagged 759 toothfish, and 36 were recaptured.

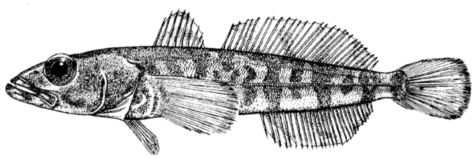
Minor byproduct species

Byproduct is generally low in the MITF and is regulated, with a 200 t TAC for all species combined and a 50 t limit for any one species. The byproduct catch has never exceeded the 50 t total in a season. Byproduct is comprised primarily of finfish (e.g. grenadier and violet cod).

28.4 BIOLOGICAL STATUS

PATAGONIAN TOOTHFISH

(*Dissostichus eleginoides*)



LINE DRAWING: FAO

Table 28.4 Biology of Patagonian toothfish

Parameter	Description
Range	**Species:** Marine plateaus and continental shelves of sub-Antarctic islands, 33–66°S. **Stock:** Aurora Trough and Macquarie Ridge likely comprise a single stock, but are currently assessed separately. The aim is to move to a single assessment for Macquarie Island toothfish.
Depth	Bentho-pelagic; shelf and upper slope, 300–2000+ m
Longevity	30+ years
Maturity (50%)	**Age:** 8–10 years **Size:** 70–95 cm TL
Spawning season	June–September
Size	**Maximum:** ~200 cm TL (~100 kg) **Recruitment into the fishery:** 12–15 cm TL (size at which semipelagic juveniles become demersal), although toothfish <20 cm are rare in research or commercial catches.

SOURCES: Gon & Heemstra (1990); Everson & Murray (1999).

Longlining for Patagonian toothfish
PHOTO: AUSTRAL FISHERIES

Longlining for Patagonian toothfish
PHOTO: RHYS ARANGIO, AUSTRAL FISHERIES

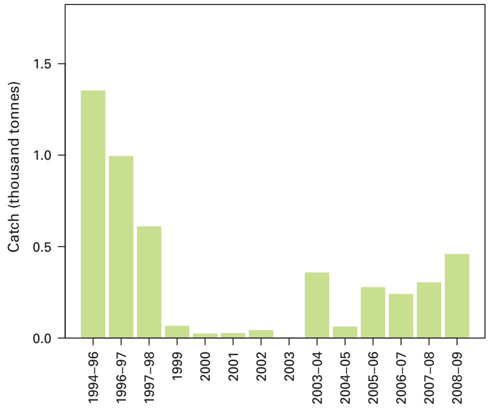


FIGURE 28.2 Patagonian toothfish catch history, 1994–96 to 2008–09

NOTE: different administrative periods throughout history of the fishery.

Stock status determination

The 2009 stock assessment for the Aurora Trough was updated using data up to February 2009 (Tuck & Lamb 2009). The assessment indicated that the available biomass was 2188 t, which was 65.8% of the initial biomass (1995 available biomass). Under the TAC setting process for the Aurora Trough, which requires that available biomass be above 66.5% of initial biomass in order to set a commercial TAC, the TAC for the 2009–10 season was reduced to a research TAC of 60 t. As there was only a single trawl shot on the Macquarie Ridge, there were not enough data to update the assessment for that area. The TAC for the 2009–10 season was set at 66 t for trawl (with a 175 t trigger for the trawl sector if trawl catch rates reached a threshold of an average of 10 t/km^2 over three consecutive fishing days), using the current decision rule of reducing the previous season's TAC by the catch and one year of natural mortality. Given the high biomass for the Aurora Trough, the conservative TAC setting process and the low level of fishing, the stock was assessed as **not overfished** and **not subject to overfishing** (Table 28.1)

Reliability of the assessment/s

The tag-based assessment does not explicitly take into consideration the length frequency of the catch or standardised catch rates. Furthermore, because separate assessments have been conducted for the Aurora Trough and the Macquarie Ridge, movement of the stock between the grounds has not been taken into account. Because of very limited trawl activity and a lack of tagging data, there is no recent reliable assessment for the Macquarie Ridge.

For the longline trial, a precautionary catch limit of 150 t was set for the Macquarie Ridge in 2008–09. This was consistent with the approach adopted for the CCAMLR's new and exploratory fisheries.

Previous assessment/s

The MITF stock assessment has been based on data from the tag–recapture experiment initiated in 1995–96 and repeated on an annual basis. The assessment uses a population model that includes the dynamics of tagged and non-tagged fish, daily tag releases, tag recaptures, total commercial catches (Fig. 28.2), an estimate of natural mortality and an estimate of the annual net change in available biomass between seasons. The assessment is limited to data from the trawl fishery, and separate assessments are conducted for the Aurora Trough and Macquarie Ridge.

The 2008 assessments indicated that a TAC of 312 t for the Aurora Trough and a TAC of 75 t for the Macquarie Ridge would satisfy the control rules (Tuck & Lamb 2008). However, the 2008 assessment was not completed before the start of the season. The 2007–08 TAC of 390 t was used, on the understanding that a revised lower TAC might be established for the 2008–09 season. The TAC of 312 t determined by the assessment was the agreed catch limit that applied in the Aurora Trough. A catch limit of 150 t was considered precautionary for the Macquarie Ridge, with an increase to 198 t for the trawl sector if trawl catch rates

reached a threshold average of 10 t/km^2 over three consecutive fishing days. Although the TACs were not set in accordance with the control rule of the existing harvest strategy for the Aurora Trough, the level of biomass was very high (94% of the 1995 available trawl biomass), and the stock was not considered overfished or subject to overfishing.

Future assessment needs

Recognising the limitations of the existing assessment method, a multigear, spatially explicit assessment, based on the Stock Synthesis 3 (SS3) model, is under development and will be used in the 2010–11 season. This assessment will incorporate both trawl and longline catch and tagging data, accounting for different selectivities by fishing gear and between the main fishing grounds.

28.5 ECONOMIC STATUS

The Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences does not conduct economic surveys of the fishery. The only available indicator of economic performance is the latency of quota. Between 2003–04 and 2006–07, the fishery's TAC for the Aurora Trough sector was close to filled. However, latency in quota for the Aurora Trough rose to 42.8% in 2007–08 (Table 28.5). The increase in quota latency in the fishery can be attributed to an increase in the TAC from 241 t in 2006–07 to 390 t in 2007–08, and a small decrease in catch, from 238 t to 223 t. In 2008–09 latency in the Aurora Trough sector fell sharply to 1.6%, on an effective TAC setting of 312 t, following a 25% reduction in the TAC set for 2007–08.

Before the longline trial in 2007–08, trawling was the only method allowed on the Macquarie Ridge, and limited trawl effort was applied in the sector. When longlining began in 2007–08, the TAC was close to filled, and in 2008–09 was filled.

Overall economic status

The harvest strategy for this fishery is highly conservative, implying restrictive catch limits that maintain stock biomass at levels that are higher relative to other Commonwealth managed fisheries. Therefore, quota latency is generally low, indicating positive NER.

There was a sharp decrease in latent quota in the MITF from 36.6% in 2007–08 to 1.6% in 2008–09. This decrease in quota latency coincided with a decline in the Aurora Trough TAC (312 t), and an increase of 74% in the catch limit for the Macquarie Ridge (to 150 t). The low quota latency for both the Macquarie Ridge (0%) and the Aurora Trough (1.6%) suggests that positive NER continued to be generated in this fishery in 2008–09.

TABLE 28.5 Quota latency in the MITF

Area	Catch (tonnes)		TAC (tonnes)		Percentage of quota unfilled	
	2007–08	2008–09	2007–08	2008–09	2007–08	2008–09
Aurora Trough	223	307	390	312	42.8	1.6
Macquarie Ridge	79	150	86	150	8.1	0.0
Total	**302**	**457**	**476**	**462**	**36.6**	**1.6**

TAC = total allowable catch

28.6 ENVIRONMENTAL STATUS

Two observers have been present on all vessels since the 1997–98 fishing season. A catch limit of 200 t applies to all non-target species combined, with a 50 t limit on any one species. In July 2008 (2008–09 fishing season), skates were caught, for the first time in the history of the fishery, in deep waters off the Macquarie Ridge outside the main fishing areas. Skates are a common byproduct of toothfish fisheries elsewhere, but were thought not to occur in the vicinity of Macquarie Island.

Patagonian toothfish was nominated for listing as a threatened species under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in 2008. In May 2009, the Minister for the Environment, Heritage and the Arts, on advice from the Threatened Species Scientific Committee, determined that toothfish was not eligible for listing.

Macquarie Island has not been subject to the level of illegal, unregulated and unreported fishing pressure experienced in the Heard Island and McDonald Islands or Antarctic waters regions, due largely to its remote location and the close proximity of the fishery to the inhabited island.

Ecological risk assessment

An ecological risk assessment (ERA) process was undertaken for the MITF using demersal trawl gear (Table 28.2). Under the Level 2 assessment, 48 species were identified as being at high risk. However, all of these species were removed from the high risk category after the application of the residual risk guidelines (AFMA 2009). A Level 3 SAFE assessment indicated that no species were at high risk (Zhou et al. 2009).

Threatened, endangered and protected species

Seabirds

No seabird interactions have been observed in the trawl sector since 2003. The Macquarie Island population of the grey-headed albatross (*Thalassarche chrysostoma*), which is currently threatened by habitat reduction caused by intense rabbit grazing on the island, has been nominated for listing as endangered under the EPBC Act. Although this and other albatross are vulnerable to capture in longline fisheries, the trial longline fishery operates in accordance with strict mitigation measures to minimise seabird bycatch. The MITF trial longline fishery operates under stricter mitigation measures than outlined by the threat abatement plan of the Department of the Environment, Water, Heritage and the Arts to reduce the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations. No seabird interactions have been observed during the longline trial.

Marine mammals

No marine mammal interactions have been observed in the trawl sector since 2003. There was one marine mammal interaction during the longline trial from 2007 to 2009. During the second year of the trial (July 2008, in the 2008–09 fishing season), a New Zealand fur seal was hooked through a flipper and later observed to swim away.

Benthic habitats

A survey of the benthic habitats around Macquarie Island indicated that the terrain was barren and rocky, often with steep features (Butler et al. 2000). The benthic fauna was found to be sparse. The fishery, therefore, may have little impact on the benthic fauna and, as noted above, no species was found to be at high risk during the ERA process. Habitats in the MITF were not assessed as part of the ERA due to a lack of suitable data.

28.7 HARVEST STRATEGY PERFORMANCE

The harvest strategy for the Aurora Ridge trawl grounds has been used since the mid-1990s, predating the *Commonwealth Fisheries Harvest Strategy Policy* (HSP). However, there is currently no formal harvest strategy for the Macquarie Ridge, which is likely to be an important fishing ground for the longline fishery in the future. In 2010, with the development and application of the new, spatially-explicit assessment method, a review of the existing harvest strategy needs to be undertaken. Specifically, a new harvest strategy encompassing both the Aurora Trough and Macquarie Ridge needs to be developed, and the principles of the HSP need to be explicitly considered and incorporated.

28.8 LITERATURE CITED

AFMA (Australian Fisheries Management Authority) 2003, *Antarctic Fisheries Bycatch Action Plan 2003*, AFMA, Canberra.

——2006, *Macquarie Island Toothfish Fishery Management Plan 2006*, DAFF, Canberra, Federal Register of Legislative Instruments F2006L00933.

——2009, Ecological risk management report for the Macquarie Island Toothfish Fishery – Demersal Trawl sub-Fishery, December 2009, AFMA, Canberra.

Butler, A, Williams, A, Koslow, T, Gowlett-Holmes, K, Barker, B, Lewis, M & Reid, R 2000, *A study of the conservation significance of the benthic fauna around Macquarie Island and the potential impact of the Patagonian Toothfish fishery*, final report to Environment Australia, CSIRO Marine Research.

Daley, R, Bulman, C, Stevenson, D, Hobday, A, Sporcic, M & Fuller, M 2007, *Ecological risk assessment for the effects of fishing: Report of the demersal trawl sub-fishery for the Macquarie Island Fishery*, report for the AFMA, Canberra.

Everson, I & Murray, AW 1999, 'Size at sexual maturity of Patagonian toothfish (*Dissostichus eleginoides*)', *CCAMLR Science*, vol. 6, pp. 37–46.

Gon, O & Heemstra PC (eds) 1990, *Fishes of the Southern Ocean*, JLB Smith Institute of Ichthyology, Grahamstown.

Tuck, GN & Lamb, T 2008, *Abundance estimation and TAC setting for Patagonian toothfish (Dissostichus eleginoides) at Macquarie Island: 2008*, report to the Sub-Antarctic Resources Assessment Group, Hobart, <www.afma.gov.au>.

——2009, *Abundance estimation and TAC setting for Patagonian toothfish (Dissostichus eleginoides) at Macquarie Island: 2009*, report to the Sub-Antarctic Resources Assessment Group, Hobart, <www.afma.gov.au>.

Zhou, S, Fuller, M & Smith, T 2009, *Rapid quantitative risk assessment for fish species in seven Commonwealth fisheries*, report for the AFMA, Canberra.

Toothfish in freezer PHOTO: JAY HENDER, ABARE–BRS

29 Joint authority fisheries

I Stobutzki and A Moore

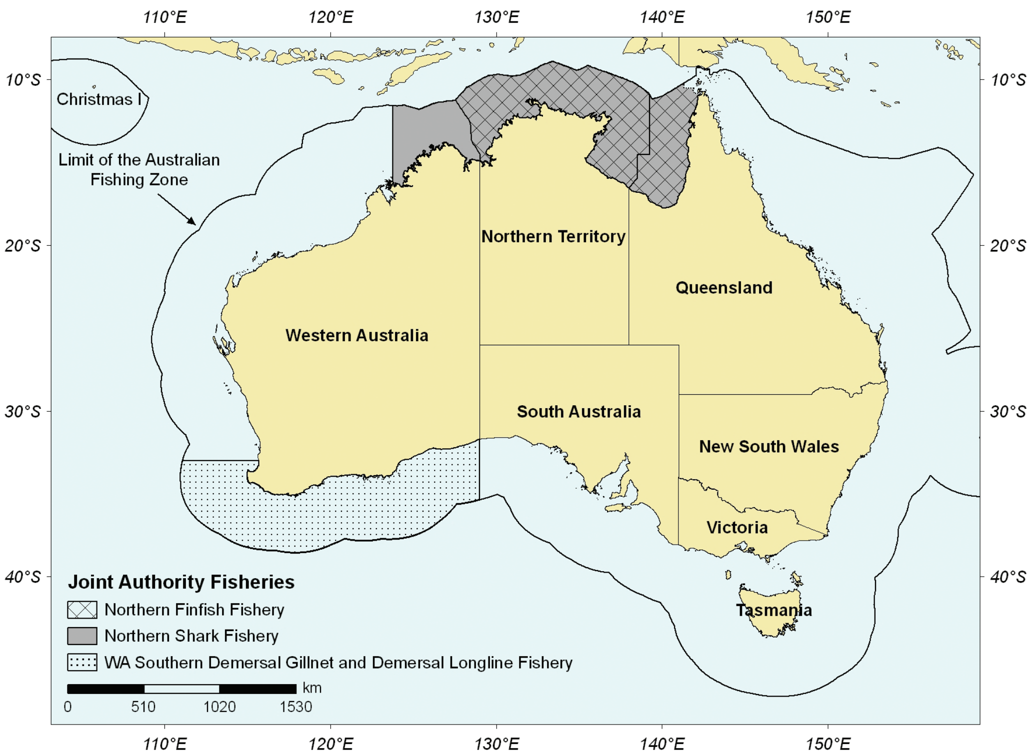


FIGURE 29.1 Geographic extent of the joint authority fisheries

29.1 INTRODUCTION

The Australian Government is responsible for several fisheries managed under joint authority arrangements with a state or territory government. The joint authority arrangements are species-based, as well as area-based, and recognise that stocks are likely to be shared with adjacent national and international jurisdictions. In northern Australian waters, there are several shark and finfish joint authorities that are collectively referred to as the Northern Shark Fishery and the Northern Finfish Fishery. This chapter reviews these northern fisheries and the Western Australian Joint Authority Southern Demersal Gillnet and Demersal Longline Fishery (JASDGDLF). In each case, the day-to-day

management of the fishery is undertaken by the state or territory under its legislation.

The Torres Strait fisheries, which are also managed under a joint authority, differ from the fisheries addressed here because the Australian Government is responsible for their day-to-day management. These fisheries are also covered by the *Torres Strait Treaty* with Papua New Guinea (see Chapter 14).

The Western Australia Fisheries Joint Authority (WAFJA) has managed the JASDGDLF since 1988. In 1995 under the Offshore Constitutional Settlement (OCS), jurisdiction of the finfish resources (with the exceptions of tuna and tuna-like species) in the waters off northern Western Australia was passed directly to the Western Australian Government, and so these resources are not addressed here. The shark resources in the north of Western Australia, east of 123°45'E, became the responsibility of the WAFJA.

Also in 1995, under the OCS, the Northern Territory Fisheries Joint Authority and the Queensland Fisheries Joint Authority were given jurisdiction to manage northern finfish (with the exceptions of tuna and tuna-like species) and sharks in waters adjacent to each jurisdiction out to the boundary of the Australian Fishing Zone (AFZ). The relevant jurisdictions assess and report on the management and status of these fisheries, which are not formally assessed here.

Dried fish, south-east Asia
PHOTO: KATHRYN READ, DEWHA

29.2 WESTERN AUSTRALIAN SOUTHERN DEMERSAL GILLNET AND DEMERSAL LONGLINE FISHERY

Background

Commercial fishing for sharks off the southern coast of Western Australia has occurred since the 1940s. Currently, two shark fisheries operate in this area. The JASDGDLF is managed cooperatively by the Western Australian and Australian Governments, with day-to-day management undertaken by Western Australia. The fishery extends south-east from Cape Bouvard, just north of Bunbury on the southern west coast, to the Western Australia – South Australia border (Fig. 29.1). Under a complementary management plan, Western Australia also manages a demersal gillnet–longline fishery that extends north from Cape Bouvard and catches many of the same species. The status of the major species of the two fisheries is assessed by the Department of Fisheries, Western Australia. Annual production from the fishery is valued at approximately $4 million.

The principal species targeted in the JASDGDLF are gummy shark (*Mustelus antarcticus*), whiskery shark (*Furgaleus macki*) and dusky shark (*Carcharhinus obscurus*). Another 25 species of shark and scalefish are also caught regularly, the most common being sandbar shark (*C. plumbeus*), hammerhead shark (Sphyrnidae) and wobbegong shark (Orectolobidae) (McAuley & Baudains 2007a). School shark (*Galeorhinus galeus*) was historically targeted in the south-eastern

region of the fishery but is currently a minor component of the fishery's byproduct.

Logbook data for the fishery in 2005–06 indicated a total shark catch of 909 t. Reported dusky shark catches are mostly *C. obscurus*, but there is likely to have been some misidentification with bronze whaler shark (*C. brachyurus*). Catches of scalefish, such as queen snapper (*Nemadactylus valenciennesi*), blue groper (*Achoerodus gouldii*) and dhufish (*Glaucosoma hebraicum*), have collectively totalled about 150 t per year in recent years.

In 2006 the Western Australian Government introduced a number of changes in all commercial fisheries to reduce mortality for shark species, especially dusky shark and sandbar shark. The changes, made explicitly to bring the fisheries back to 2001–02 effort levels, include the protection of all sharks and rays (other than the target species), a maximum size limit for dusky shark, additional controls on the use of longline, and the conversion of monthly gear units to daily gear units. Closures from 16 August to 15 October have also been introduced in continental-shelf waters west of 118°E to protect whiskery sharks during their pupping season.

In 2009 the fishery was granted approved Wildlife Trade Operation (WTO) status under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) until 2012.

Status of the stocks

The fishery is managed primarily through setting effort levels, which are intended to achieve target biomass levels of 40% of the initial level for the key target species. The timeframe for achieving the target level varies from species to species.

Gummy shark

The most recent assessment of Western Australian gummy shark (1998) was that its biomass, at 43% of the initial level, was slightly above the target. Gummy shark catches from the two southern gillnet and longline fisheries peaked at 500 t in 1991–92, but declined subsequently. Most of the catch is taken in the JASDGDLF, where the 2001–02 catch of gummy shark (343 t) was 40% higher than in the previous year. There have been further catch increases since then (456 t in 2003–04, 460 t in 2004–05 and 451 t in 2005–06). Development of an updated assessment model for the stock is a priority; until that happens, status is assessed through monitoring of catch and catch-rate data. Spawning biomass levels were classified as sustainable for gummy shark in 2009 (McAuley 2009).

Whiskery shark

Previous assessments indicated that the whiskery shark biomass declined until 2002–03, but that this decline had slowed since the late 1990s and biomass was around 35% of initial levels. A 2004 assessment indicated only about a 24% likelihood that whiskery shark would reach its target level by 2010. Activation of latent effort was seen to be limiting the possibility for this stock to rebuild, suggesting the need for additional management measures. Whiskery shark catch

Dried sharkfin, south-east Asia
PHOTO: KATHRYN READ, DEWHA

rates have increased substantially (29–94%). Subsequent management changes appear to have improved the situation: the best estimate of total biomass is that it reached 38% of its unfished level in 2005–06. Whiskery shark is considered to be recovering (McAuley 2009).

Dusky shark

Most dusky sharks taken by the fishery are juveniles. Demographic analyses estimated that fishing mortality on this component of the population was sustainable, but that the future viability of the fishery would be compromised by catches of older dusky shark elsewhere. Declining catch rates throughout south-western Australia suggest that the breeding population has been depleted and recruitment has declined. There has been concern that the incidental catch of dusky shark in the Commonwealth-managed Western Tuna and Billfish Fishery could deplete the population, although economic conditions have led to strong declines in fishing effort in that fishery in recent years.

A marked increase in the use of hooks by Western Australian shark fishers from the mid-1990s increased the catches of large dusky shark (and sandbar shark). A recent demographic study indicated that the species is less productive than previously thought, and that combined removals by fishing and natural mortality have depleted the breeding stock. The recent management changes, particularly in the northern shark fisheries (see Section 29.3), might take more than a decade to become evident in available data. Dusky shark is considered to be overfished (McAuley 2008a), and the status of this species was a major factor in recent management changes.

School shark

School shark is also taken in the JASDGDLF; hence, future management of school shark must take into account its overfished status in the Southern and Eastern Scalefish and Shark Fishery. Assessments of school shark in that fishery take into account catches from the JASDGDLF. The 2004–05 school shark catch in the JASDGDLF was 4 t.

Shark trade PHOTO: KATHRYN READ, DEWHA

29.3 NORTHERN SHARK FISHERY

Background

Australian gillnetters began fishing in northern Australian waters in about 1980, although there was significant fishing from foreign vessels before this. The Northern Shark Fishery was developed during the 1980s and 1990s and was transferred to the relevant joint authorities in 1995. The fishery covers waters off Australia's northern coast, encompassing the Gulf of Carpentaria, Timor and Arafura Seas, Joseph Bonaparte Gulf and the northern coast of Western Australia.

The main fishing methods are gillnetting and longlining, and most activity and catch occurs in waters off the Northern Territory. Historically, the main commercial species have been blacktip sharks—Australian blacktip (*Carcharhinus tilstoni*), common blacktip (*C. limbatus*) and spot-tail shark (*C. sorrah*)—and grey mackerel (*Scomberomorus semifasciatus*). The Australian and common blacktip are difficult to differentiate and so have been treated as a species complex, with the assumption that the majority are the Australian blacktip. Other tropical shark species, including hammerheads and tiger shark (*Galeocerdo cuvier*), are also caught. Over time, the species targeted have varied in the different jurisdictions with changes in gear and targeting practices. Sharks are also taken as bycatch and byproduct in other fisheries in the region.

Northern Territory Offshore Net and Line Fishery

Most of the fishing in the waters off the Northern Territory occurs inshore (<12 nm from the coast), targeting blacktip sharks and grey mackerel. The status of the fishery is reviewed in Buckworth & Beatty (2008). Pelagic gillnets (limited to 2000 m net length) are the main fishing gear, but longlines can be used. From the 1980s to early 1990s, fishing effort was variable but generally declining. Effort then increased to the historical peak in 2003 (1800 vessel days). In 2005 measures were introduced to contain effort, which declined to 729 vessel days in 2007 and 780 vessel days in 2008. There are currently 17 licences in the fishery, with 11 active in 2007.

The catch has been variable, generally mirroring effort changes. The highest catch was reported in 2003, at 1687 t, including 899 t of shark (of which 501 t was blacktip shark) and 766 t of grey mackerel. Total landings have decreased since 2003, to a total catch of 1193 t in 2007; this included 925 t of shark (of which 493 t was blacktip shark) and 240 t of grey mackerel. The total catch was valued at $3.39 million, and the catch of 'other sharks' ($1.51 million) was more valuable than the catch of blacktip ($0.76 million). The total catch per unit effort (CPUE) has been variable and was declining in the late 1990s, raising concerns that the stocks had not recovered from the heavy exploitation by the foreign fleet. Grey mackerel catches increased steadily to a peak in 2003 and declined in recent years (Northern Territory Government, 2009). The fishery is currently an approved WTO under the EPBC Act until 28 November 2010.

Queensland Gulf of Carpentaria Inshore Fin Fish Fishery

The Queensland Joint Authority manages sharks in the Gulf of Carpentaria waters off Queensland as part of the Gulf of Carpentaria Inshore Fin Fish Fishery. The status of the fishery is reviewed in Roelofs (2009). The fishery has two sectors: an offshore sector (7–25 nm) targeting tropical sharks and grey mackerel, and an inshore sector (0–7 nm) targeting barramundi and sharks. The main gear used is gillnets, with the offshore sector limited to a maximum of 1200 m net length. In 2007, there were five licences (four active) in the offshore sector and 87 (80 active) in the inshore sector.

The total shark catch from both sectors increased rapidly between 1993 (172 t) and 1995, when it peaked at 450 t. Catch then declined until 1997. Since 1997, catch has been variable but increasing until 2003

(474 t). In 2007 the total shark catch from this fishery dropped to 147 t, of which 45 t was reported as blacktip shark. Effort directed at sharks has declined by 70% since 2004.

The annual gross value of production (GVP) for the entire fishery has averaged $11 million since 2003, with a reported value of $12.45 million in 2008 (Roelofs 2009). Barramundi and grey mackerel make the greatest contribution to GVP, and the contribution from sharks has declined since 2003 (Roelofs 2009).

Queensland considers the target species in this fishery to be 'fully exploited' (Roelofs 2009). Some concern has been expressed about the sustainability of the shark species and grey mackerel at the current catch levels, due to a paucity of species-specific information (Roelofs 2009). The fishery is currently an approved WTO under the EPBC Act until 20 August 2010.

Western Australia Joint Authority Northern Shark Fishery

For reporting and assessment purposes, the Western Australia Joint Authority Northern Shark Fishery (WAJANSF) is combined with the adjacent Western Australia North Coast Shark Fishery (WANCSF), which is managed by the Western Australian Government. Western Australia assesses the status of these fisheries in McAuley (2008b). The WAJANSF operates from longitude 123°45'E to the border with the Northern Territory, and the WANCSF operates from longitude 114°06'E to 123°45'E. Since 2005 demersal gillnets and longlines have been permitted within both fisheries, with longlines being the main gear used. There are nine licences in the WANCSF and five in the WAJANSF; however, only two licences were active in both fisheries in 2007.

There was a rapid increase in effort in these fisheries between 1999–2000 (<100 000 hook days) and 2004–05 (1.2 million hook days). The total catch had a corresponding increase from around 100 t (1999–2000) to 1294 t (2004–05). Fishing practices also changed, with a shift from primarily gillnetting in the north-eastern region of the fishery to increased demersal longline effort in the south-western region (McAuley & Baudains 2007b). The changes reflected an increased targeting of sandbar sharks (*Carcharhinus plumbeus*) and other large species, including tiger shark, hammerhead shark, pigeye shark (*C. amboinensis*) and lemon shark (*Negaprion acutidens*). The changed practices also resulted in a reduction in the catch of blacktip sharks.

Sandbar sharks were recognised as the target species for the fishery in 1997–98, and catch in the northern fisheries peaked at 762 t in 2004–05. This species was also taken in significant amounts in southern shark fisheries in Western Australia. The stock assessment for sandbar sharks, which considers all take of the species across Western Australian fisheries, suggested that cumulative levels of fishing mortality were increasingly unsustainable between 2000–01 and 2003–04 (McAuley et al. 2007). A 58% decline in breeding stock abundance has also been inferred from fishery-independent survey data from the north-coast region (McAuley & Baudains 2007b).

New management measures that were put in place in 2005 in the WANCSF to prevent targeting of sandbar sharks included closure of about 60% of the fishery to protect breeding stock and limits on the permitted number of fishing days (200 gillnet and 100 longline fishing days). At the same time, new management arrangements were agreed with industry for the WAJANSF, including a limit of 400 gillnet days and 200 longline days. These new measures resulted in an 89% drop in total effort between 2004–05 and 2005–06, down to 141 923 hook days (152 days out of the permitted 900 days). There was a corresponding 85% decrease in total reported catch, from 1294 t (2004–05) to 189 t (2005–06). Longlines accounted for 84% of the 2005–06 catch. The fisheries are now intended to target blacktips; the 2005–06 catch was dominated by blacktip sharks (76 t), pigeye sharks (43 t), hammerhead sharks (27 t) and tiger sharks (12 t), with negligible catch of sandbar sharks (<1 t). The estimated value was $490 000 for 2005–06.

Confidentiality requirements associated with the small number of operators in the

fisheries prevent the publication of 2006–07 catch and effort figures. McAuley (2008b) reports that both the total fishing effort and the catches of all species were significantly lower in 2006–07 than before 2005–06. It is expected that the catches will remain at these low levels or be further reduced in the future.

In 2008 the WAJANSF's WTO approval under the EPBC Act was revoked because a formal management plan had not been finalised. The WANCSF's approval expired in early 2009 and has not been renewed. Therefore, product from these fisheries cannot be exported.

Other catches, including illegal fishing

Sharks are caught as bycatch and byproduct in other state and territory fisheries and the Northern Prawn Fishery (NPF). In Western Australia, the 2006–07 catch by other state-managed fisheries was less than in previous years (31 t in 2005–06), due to a ban on retention in non-shark fisheries (McAuley 2008b; McAuley & Baudains 2007b). The Northern Territory estimates that other fisheries landed 39 t in 2007, with retention banned in some fisheries or limited by byproduct limits in others (Buckworth & Beatty 2008). The retention of any shark product has been banned in the NPF since 2001.

Australia allows access by traditional Indonesian fishers to a limited area of the AFZ off north-western Western Australia (MoU Box). The size and composition of shark catches taken by these traditional fishers are unknown.

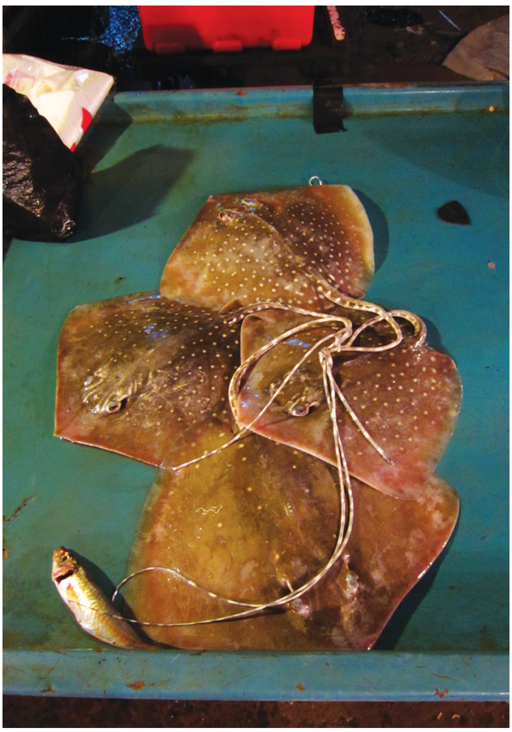
Illegal fishing activity by Indonesian vessels increased in northern Australian waters until 2004–05. Sharks were a primary target for these vessels, particularly for fins. The Australian Government responded with a major increase in the level of surveillance and policing, as well as collaborative programs

Dried fish products, south-east Asia PHOTO: KATHRYN READ, DEWHA

in Indonesia, which resulted in a substantial decrease in the level of illegal fishing. Coastwatch reported an 80% reduction in sightings from 2006 to 2007. In 2007–08, 156 Indonesian vessels were apprehended in northern Australian waters (compared with 216 in 2006–07 and 367 in 2005–06). There were also nine legislative forfeitures, in which vessels had catch and gear confiscated (compared with five in 2006–07 and 178 in 2004–05). The volume and species composition of the catches are not well understood, and the impact of illegal fishing on the shark stocks is currently unknown.

Status of the stocks

All joint authorities are limited-entry fisheries, and each has regulations controlling the gear permitted. In Western Australia and the Northern Territory, the number of fishing days is also constrained. The Northern Australian Fisheries Committee (NAFC)—which includes representatives from the Australian, Queensland, Northern Territory and Western Australian Governments—aims to facilitate complementary management and research across the jurisdictions for shared stocks. Support from the NAFC and recent Fisheries Research and Development Corporation projects have improved species identification of the catches and increased observer coverage in these fisheries.



Stingray trade, south-east Asia
PHOTO: KATHRYN READ, DEWHA

The NAFC established a cross-jurisdictional assessment group to examine the status of shared shark stocks. In May 2008, it updated the blacktip shark stock assessment, initially developed in the 1990s. The earlier assessment estimated that the sustainable yield for blacktip sharks should be at least 2000 t per year from the Northern Territory, Queensland and Western Australian fisheries combined. The 2008 assessment indicated that the fishery catch levels are below the estimated sustainable yield and that the current level of effort is sustainable. The estimates are uncertain due to a range of factors, including the accuracy of the data from the Taiwanese fishery, the unknown illegal fishing catch and species identification issues. However, the CPUE trend from the Northern Territory, where the majority of blacktip shark is caught, has been increasing in recent years, and current catch levels are substantially less than those taken by the foreign fleet historically.

Recent genetic studies (Ovenden et al. 2009) show little genetic differentiation across the north between the spot-tail and Australian blacktip shark, suggesting that it may be appropriate to manage these as single stocks across the region. However, the results for common blacktip shark suggest that there may be genetic subdivision within Australian waters.

Genetic studies also detected an apparent change in the relative proportion of the common and Australian blacktip sharks in the catch. In the 1980s, the Australian blacktip was the major component of the catch, with the common blacktip caught in much lower numbers (Australian: common, 300:1) (Stevens & Davenport 1991). Recent studies have

indicated a ratio closer to 1:1 (Ovenden et al. 2009). Biological information also suggests that the common blacktip is less productive than the Australian blacktip. Further genetic research is currently in progress to investigate the current species composition, but this issue is a key uncertainty in the assessment.

Whereas the Australian blacktip is restricted to Australia, the spot-tail and common blacktip also occur in Indonesian waters. Studies for the spot-tail shark suggest that the Australian populations are separate from populations in waters off central Indonesia. However, other shark species—the blue shark (*Prionace glauca*) and scalloped hammerhead (*Sphyrna lewini*)—showed no evidence of subdivision between Australia and Indonesia and so may require cooperative management. The high level of shark fishing in Indonesian waters and the lack of a full understanding of the connectivity between populations in Australian and eastern Indonesian waters suggest that the northern shark populations should be monitored closely.

In 2004 the Australian Government released its National Plan of Action for the Conservation and Management of Sharks. Recent research and improvements in data collection and monitoring from northern shark fisheries align with priorities identified by the national plan.

29.4 NORTHERN FINFISH FISHERY

Background

Foreign pair and stern trawlers (Japanese, Taiwanese, Thai and Chinese) fished waters off northern Australia from the 1930s. After the declaration of the AFZ, foreign trawlers were licensed to fish in the area until 1990. The main regions fished were the Timor and Arafura Seas and the north-west shelf off Western Australia. The foreign fleets' highest catches were 37 100 t in the north-west shelf (1973), 9100 t in the Timor Sea (1974) and 10 000 t in the Arafura Sea (1983). Australian trawlers started fishing in the area in 1985; a domestic trap-and-line fishery began on the north-west shelf in 1984, and droplining in the Timor Sea began in 1987.

In 1995 the finfish resources (except tuna and tuna-like species) off Western Australia became solely the jurisdiction of the Western Australian Government. In the waters off Queensland and the Northern Territory, they became the responsibility of joint authorities.

The main species targeted are large red snappers (saddle-tail snapper—*Lutjanus malabaricus* and crimson snapper—*L. erythropterus*) and gold-band snappers (primarily *Pristipomodies multidens*, but also *P. typus* and *P. filamentous*). The joint authorities include trawl, dropline and trap fisheries and have developed differently over time.

Northern Territory

The Northern Territory Joint Authority manages three fisheries targeting tropical snappers: the Timor Reef Fishery, the Demersal Fishery and the Finfish Trawl Fishery. The Timor Reef Fishery operates offshore north-west of Darwin in a specific area of the Timor Sea. The Demersal and Finfish Trawl Fisheries operate in the waters 15 nm offshore to the AFZ boundary, excluding the area of the Timor Reef Fishery. Although the areas of these two fisheries overlap, currently the Finfish Trawl Fishery does not operate in the areas targeted by the Demersal Fishery.

Vessels in the Demersal and Timor Reef Fisheries use vertical droplines and baited traps to target goldband snappers, but also catch red snappers, red emperor (*Lutjanus sebae*) and cods (*Epinephelus* spp.). There is a single licence in the Finfish Trawl Fishery, and that vessel uses a semipelagic, demersal trawl to target red snappers (75% of the catch), primarily saddle-tail snapper. The fisheries' status is reviewed in McKey & Errity (2008a, b, c).

In 2007, 11 licences were active in the Timor Reef Fishery, recording 1340 vessel days, and 8 licences were active in the

Demersal Fishery, recording 297 vessel days (slightly higher than in 2006). Most of the effort in the Demersal Fishery occurs in areas adjacent to the Timor Reef Fishery, with several operators holding licences in both fisheries. There was less fishing effort than in 2005 in the Timor Reef Fishery and more in the Demersal Fishery. The move to more activity in the Demersal Fishery in 2006 is suggested to be in response to fishers being less active in the Timor Reef Fishery due to oil and gas seismic surveys and fuel costs (McKey & Errity 2008a, 2008b).

The Timor Reef Fishery reported a total catch of 689 t in 2007 (slightly lower than in 2006—726 t), worth $4.53 million. The catch included 403 t of goldband snappers and 227 t of red snappers. The Demersal Fishery reported a total catch of 330 t in 2007, which is an increase from 223 t in 2006 and 79 t in 2005. The 2007 catch was worth $1.94 million, compared with $1.32 million in 2006. The Demersal Fishery catch included 153 t of goldband snappers and 155 t of red snappers. The catch composition of these fisheries varies with the gear used; droplines catch a higher proportion of goldband snappers, whereas traps catch nearly equal proportions of goldband snappers and red snappers. In 2007 there was greater use of traps in both fisheries. The Timor Reef Fishery has been granted an exemption from export restrictions under the EPBC Act for five years, until 2014.

Effort in the Finfish Trawl Fishery increased from 1995 (158 vessel days) to a peak in 2003 of 294 vessel days. Effort is currently lower than the peak, with the single operator reporting 257 vessel days in 2007, slightly more than in 2006 (235 vessel days). The total catch in 2007 was 843 t, slightly down from 2006 (866 t). Red snappers made up 72% of the catch (610 t), while goldband snappers contributed 4% (34 t). The value of the fishery is confidential since there is a single operator. CPUE has been stable in this fishery since the late 1990s. The Finfish Trawl Fishery has been granted an exemption from export restrictions under the EPBC Act for five years, until 2014.

Queensland

The Queensland Fisheries Joint Authority manages the Gulf of Carpentaria Developmental Finfish Trawl Fishery, which targets red snappers. The fishery, which commenced in 1998, operates beyond 25 nm from the coast to the AFZ boundary. In 2006 there were three licences in the fishery, with two actively fishing. The vessels use semipelagic, demersal trawls. The total catch has been increasing since 2001 (7 t) and reached 613 t in 2006. Of the total catch, 409 t were red snapper, predominantly crimson snapper (233 t), and 24 t were goldband snapper. Effort in 2006 was around 280 vessel days, an increase from 220 vessel days in 2005.

The fishery has a total allowable catch of 1250 t for quota species (red snappers, goldband snappers, red emperor and some sweetlip). This is based on a 1994 assessment that estimated an annual sustainable yield for the total Gulf of Carpentaria of 2900–9000 t. The fishery is currently an approved WTO under the EPBC Act until 29 November 2010.

The Queensland Gulf of Carpentaria Line Fishery, primarily a trolling fishery for Spanish mackerel (*Scomberomorus commersoni*), also catches some red snapper (17 t in 2007; Garland 2008).

Other catches, including illegal fishing

Queensland and the Northern Territory report catches of the species detailed above by recreational fishers and charter vessels. The Commonwealth-managed NPF also captures some red snappers as bycatch.

Substantial fishing for red snappers occurs in Indonesian waters, particularly trawling in the Arafura Sea, with some of this activity occurring close to the Australian border. Saddle-tail snapper is the dominant red snapper caught in this area. An Australian–Indonesian project, conducted in 1999–2000, supported by the Australian Centre for International Agricultural Research (ACIAR), focused on examining the connectivity between the Australian and Indonesian

stocks and collecting fishery information and biological parameters to facilitate assessments of the red snapper stocks.

Significant quantities of red snappers have been documented on Indonesian vessels apprehended fishing illegally in northern Australian waters. Illegal fishing has declined significantly, but the extent of catch and impact on Australian stocks have not been quantified.

Status of the stocks

Total landings in 2006 from the target fisheries across both jurisdictions are estimated at 1440 t of red snappers and 584 t of goldband snappers. The Northern Territory is responsible for 72% of the red snapper catch and 96% of the goldband snapper catch. All fisheries are limited entry and have constraints on gear. The Northern Territory has adopted triggers of a total catch of 2500 t for red snapper and 900 t for goldband snapper for a review of management arrangements.

The Northern Territory assesses the goldband snapper from the Timor Reef Fishery and the Demersal Fishery as a single stock. There are indications that there may be some productive areas currently not harvested within the Demersal Fishery due to their distance from shore. Current harvest levels by the Northern Territory fisheries are below the set management trigger limits (McKey & Errity 2008b). The goldband snapper stocks in the Timor Sea may be shared by Indonesia and Australia (Ovenden et al. 2002). Understanding of the Indonesian catch and its implications for the stock assessment is limited.

Research suggests that the Northern Territory and Queensland fisheries target a single red snapper stock, whereas the north-west shelf stocks (managed by Western Australia) are separate. Although there is some separation of the stocks in Indonesian and Australian waters, there are also areas across the AFZ where both countries fish the same stock, particularly in the Arafura Sea (Salini et al. 2006).

In 1997 the sustainable annual yield from the Arafura Sea was estimated between 1500 t and 2500 t. In 2004 the Australian–Indonesian ACIAR project undertook an assessment for the Arafura Sea region (Blaber et al. 2005). Although the Australian catches were comparatively low, the results suggest that the current combined catch from Indonesia and Australia was not likely to be sustainable, due to the high level of Indonesian fishing. The biomass was estimated to have been reduced to 11–31% of original levels. However, there are significant uncertainties in terms of the data from the Indonesian sector and the level and impact from illegal fishing.

The NAFC is currently overseeing the development of a cross-jurisdictional harvest strategy framework for red snapper. Given the potential connectivity with Indonesian stocks, close monitoring of the domestic fisheries and development of complementary management across the jurisdictions need to continue.

South-east Asia market
PHOTO: KATHRYN READ, DEWHA

29.5 LITERATURE CITED

Blaber, SJM, Dichmont, CM, Buckworth, RC, Badrudin, Sumiono, B, Nurhakim, S, Iskandar, B, Fegan, B, Ramm, DC & Salini, JP 2005, 'Shared stocks of snappers (Lutjanidae) in Australia and Indonesia: integrating biology, population dynamics and socio-economics to examine management scenarios', *Reviews in Fish Biology and Fisheries*, vol. 15, pp. 111–27.

Buckworth, R & Beatty, T 2008, 'Offshore Net and Line Fishery status report 2007', in *Fishery status reports 2007*, Northern Territory Department of Regional Development, Primary Industry, Fisheries and Resources, Fisheries Report no. 94, pp. 70–85.

Garland, A 2008, *Annual status report, Gulf of Carpentaria Line Fishery 2007*, Department of Primary Industries and Fisheries, Queensland.

McAuley, R 2008a, 'Demersal gillnet and longline fisheries status report', in, *State of the fisheries report 2007/08*, Department of Fisheries, Western Australia, pp. 237–43.

——2008b, 'Northern Shark fisheries status report', in WJ Fletcher & K Santoro (eds), *State of the fisheries report 2007/08*, Department of Fisheries, Western Australia, pp. 178–82.

——& Baudains, G 2007a, 'Demersal gillnet and longline fisheries status report', in WJ Fletcher & K Santoro (eds), *State of the fisheries report 2006/07*, Department of Fisheries, Western Australia, pp. 241–49.

——& Baudains, G 2007b, 'Northern shark fisheries status report', in WJ Fletcher & K Santoro (eds), *State of the fisheries report 2006/07*, Department of Fisheries, Western Australia, pp. 184–8.

——Simpfendorfer, CA & Hall, NG 2007, 'A method for evaluating the impacts of fishing mortality and stochastic influences on the demography of two long-lived shark stocks', *ICES Journal of Marine Science*, vol. 64, pp. 1710–22.

McAuley, R 2009, Northern shark fisheries status report. In *State of the Fisheries Report 2008/09*, (eds, Fletcher, WJ and Satoro, K), Department of Fisheries, Western Australia, pp 173-177.

McKey, D & Errity, C 2008a, 'Timor Reef Fishery status report 2007', in *Fishery status reports 2007*, Northern Territory Department of Regional Development, Primary Industry, Fisheries and Resources, Fisheries Report no. 94, pp 98–106.

——& Errity, C 2008b, 'Demersal Fishery status report 2007', in *Fishery status reports 2007*, Northern Territory Department of Regional Development, Primary Industry, Fisheries and Resources, Fisheries Report no. 94, pp. 40–8.

——& Errity, C 2008c, 'Finfish Trawl Fishery status report 2007', in *Fishery status reports 2007*, Northern Territory Department of Regional Development, Primary Industry, Fisheries and Resources, Fisheries Report no. 94, pp. 53–9.

Ovenden, JR, Kashiwagi, T, Broderick, D, Giles, J & Salini, J 2009, 'The extent of population genetic subdivision differs among four co-distributed shark species in the Indo-Australian archipelago', *BMC Evolutionary Biology*, vol. 9, p. 40, <www.biomedcentral.com/1471-2148/9/40>.

——Lloyd, J, Newman, SJ, Keenan, CP & Slatter, LS 2002, 'Spatial genetic subdivision between northern Australia and south-eastern Asian populations of *Pristipomoides multidens*: a tropical marine reef fish species', *Fisheries Research*, vol. 59, pp. 57–69.

Roelofs, A 2009, *Annual status report 2008, Gulf of Carpentaria Inshore Fin Fish Fishery*, Department of Primary Industries and Fisheries, Queensland.

Salini, JP, Ovenden, JR, Street, R, Pendrey, R, Haryanti & Ngurah 2006, 'Genetic population structure of red snappers (*Lutjanus malabricus* Bloch & Schneider, 1801 and *L. erythropterus* Bloch, 1790) in central and eastern Indonesia and northern Australia', *Journal of Fish Biology*, vol. 68, pp. 217–34.

Stevens, JD & Davenport, SR 1991, *Analysis of catch data from the Taiwanese Gill-Net Fishery off Northern Australia, 1979–1986*, CSIRO Marine Laboratory report 213, Hobart.

Acronyms and abbreviations

AAD	Australian Antarctic Division
ABARE	Australian Bureau of Agricultural and Resource Economics
ABARE–BRS	Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences
ABS	Australian Bureau of Statistics
ACIAR	Australian Centre for International Agricultural Research
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
APSM	age-structured production model
AOS	acoustic-optical system
BANZARE	British, Australian and New Zealand Antarctic Research Expeditions
BAP	bycatch action plan
BRD	bycatch reduction device
BRS	Bureau of Rural Sciences
BSCZSF	Bass Strait Central Zone Scallop Fishery
CBD	Convention on Biological Diversity
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CL	carapace length
CMM	conservation and management measure
CMS	Convention of the Conservation of Migratory Species
CPUE	catch per unit effort
CSF	Coral Sea Fishery
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTS	Commonwealth Trawl Sector (of the SESSF)
DeepRAG	Deepwater Resource Assessment Group
DEEDI	Department of Employment, Economic Development and Innovation (Queensland)
DEPM	daily egg production method
DEWHA	Department of the Environment, Water, Heritage and the Arts
ECDTS	East Coast Deepwater Trawl Sector (of the SESSF)

EEZ	Exclusive Economic Zone
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
ERA	ecological risk assessment
ERM	ecological risk management
ERS	ecologically related species
ESD	ecologically sustainable development
ESF	Eastern Skipjack Fishery
ETBF	Eastern Tuna and Billfish Fishery
FAD	fish-aggregating device
FAO	Food and Agriculture Organization of the United Nations
FL	fork length
FMA	*Fisheries Management Act 1991*
FRV	fisheries research vessel
GABRAG	Great Australian Bight Resource Assessment Group
GABTF	Great Australian Bight Trawl Fishery
GABTS	Great Australian Bight Trawl Sector (of the SESSF)
GHTS	Gillnet, Hook and Trap Sectors (of the SESSF)
GNEC	Great North East Channel
GVP	gross value of production
GYM	generalised yield model
HIMI	Heard Island and McDonald Islands
HIMIF	Heard Island and McDonald Islands Fishery
HS	harvest strategy
HSF	harvest strategy framework
HSP	*Commonwealth Fisheries Harvest Strategy Policy*
IOTC	Indian Ocean Tuna Commission
ISMP	Integrated Scientific Monitoring Program
ITQ	individual transferable quota
IUCN	International Union for the Conservation of Nature
IUU	illegal, unregulated and unreported (fishing)
JASDGDLF	Joint Authority Southern Demersal Gillnet and Demersal Longline Fishery
MAC	management advisory committee
MCY	maximum constant yield
MEY	maximum economic yield
MITF	Macquarie Island Toothfish Fishery
MSE	management strategy evaluation
MSY	maximum sustainable yield

NAFC	Northern Australian Fisheries Committee
NER	net economic returns
NIF	Norfolk Island Fishery
NIIF	Norfolk Island Inshore Fishery
NORMAC	Northern Prawn Fishery Management Advisory Committee
NPF	Northern Prawn Fishery
NPRAG	Northern Prawn Resource Assessment Group
NWSTF	North West Slope Trawl Fishery
OCS	Offshore Constitutional Settlement
OFL	orbital fork length
ORCP	Orange Roughy Conservation Programme
PNG	Papua New Guinea
PSA	Productivity Susceptibility Analysis
PZJA	Torres Strait Protected Zone Joint Authority
QDPI&F	Queensland Department of Primary Industries and Fisheries
RAG	resource assessment group
RBC	recommended biological catch
RFMO	regional fisheries management organisation
RRA	Residual Risk Assessment
RSTS	random stratified trawl survey
RUSS	Reducing Uncertainty in Stock Status (project)
SAFE	Sustainability Assessment of Fishing Effects
SARAG	Sub-Antarctic Resource Assessment Group
ScallopRAG	Bass Strait Central Zone Scallop Fishery Resource Assessment Group
SB	spawning biomass
SBT	southern bluefin tuna
SBTF	Southern Bluefin Tuna Fishery
SC	Scientific Committee
ScHS	Scalefish Hook Sector (of the SESSF)
SED	seal exclusion device
SEMAC	South East Management Advisory Committee
SESSF	Southern and Eastern Scalefish and Shark Fishery
SETFIA	South East Trawl Fishing Industry Association
SFR	Statutory Fishing Right
SharkRAG	Shark Resource Assessment Group
ShelfRAG	Shelf Resource Assessment Group
SHSGS	Shark Hook and Shark Gillnet Sector

SICA	Scale, Intensity, Consequence Analysis
SIOFA	Southern Indian Ocean Fisheries Agreement
SL	standard length
SlopeRAG	Slope Resource Assessment Group
SPC	Secretariat of the Pacific Community
SPF	Small Pelagic Fishery
SPFRAG	Small Pelagic Fishery Resource Assessment Group
SPRFMO	South Pacific Regional Fisheries Management Organisation
SquidMAC	Southern Squid Jig Fishery Management Advisory Committee
SquidRAG	Southern Squid Jig Fishery Resource Assessment Group
SRR	stock–recruitment relationship
SSB	spawning stock biomass
SSJF	Southern Squid Jig Fishery
SSRU	small scale research unit
STF	Skipjack Tuna Fisheries
STR	South Tasman Rise
STRTF	South Tasman Rise Trawl Fishery
SWPO	south-western Pacific Ocean
TAC	total allowable catch
TAE	total allowable effort
TAP	threat abatement plan
TED	turtle excluder device
TEP	threatened, endangered or protected (species)
TIB	Traditional Inhabitant Boat (sector)
TL	total length
TSFF	Torres Strait Finfish Fisheries
TSHCF	Torres Strait Hand Collection Fishery
TSPF	Torres Strait Prawn Fishery
TSPZ	Torres Strait Protected Zone
TSRA	Torres Strait Regional Authority
TSRLF	Torres Strait Reef Line Fishery
TSSMF	Torres Strait Spanish Mackerel Fishery
TSTRLF	Torres Strait Tropical Rock Lobster Fishery
TVH	Transferable Vessel Holder
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea

UNFSA	United Nations Fish Stock Agreement
UNGA	United Nations General Assembly
VME	vulnerable marine ecosystem
WAFJA	Western Australia Fisheries Joint Authority
WAJANSF	Western Australia Joint Authority Northern Shark Fishery
WANCSF	Western Australia North Coast Shark Fishery
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	western and central Pacific Ocean
WDTF	Western Deepwater Trawl Fishery
WestMAC	Western Trawl Fisheries Management Advisory Committee
WG-ERS	Working Group on Ecologically Related Species
WPTT	Working Party on Tropical Tunas
WSF	Western Skipjack Fishery
WTBF	Western Tuna and Billfish Fishery
WTO	Wildlife Trade Operation

Units

´	minutes of latitude or longitude (for example, 34° 20´ S)
°E, °N, °S, °W	degrees east, north, south, west of Greenwich
°C	degrees Celsius
cm	centimetre
kg	kilogram
km	kilometre
km^2	square kilometre
m	metre
mm	millimetre
nm	nautical mile
t	tonnes (metric ton, 1000 kg)

Year spans

The following conventions have been used to express year ranges:

1999–2000	financial year
1999 to 2000	calendar year

Glossary

A

Accounting profit. *See* Profit, accounting.

Acoustic survey. Systematic method of gathering information on the abundance of a species in a water body with the help of echo sounders and sonar, which use ultrasonic sound to detect the fish.

Aerial survey. Method of gathering information on movements and density of fish near the surface by visual observation and photography from low-flying aircraft.

Age–length composition (age–length key). Frequency of fish of each age in each length-group in a catch (or population) of fish. Tables of yearly age–length composition of catches provide the input for cohort analysis. See also Cohort analysis.

Age–length curve. Curve that shows the relation of length and age.

Age-structured assessment. Assessment of the status of a fish stock based on the relative abundances of fish of different ages in the stock.

Ageing technique. Method of determining the ages of fish, most often done by counting daily or seasonal rings laid down in hard parts of the fish body, such as otoliths, scales or vertebrae.

Aggregation. Group of fish that comes together, often to feed or spawn.

Allocated management costs. Costs of managing a fishery that are directly related to that fishery. Excludes overheads such as licensing, research, enforcement costs and surveillance. Allocated management costs have recoverable (industry funded) and non-recoverable (Australian Government funded) components.

Aquaculture. Commercial growing of marine or freshwater animals and aquatic plants. Often called 'fish farming'.

Archival tag. Implanted fish tag that detects and records ('archives') environmental variables (e.g. water temperature) and location over time.

Area closure. Closure of a given area/fishing ground for a defined period as a tool in the management of a fishery.

Area swept. Area of the sea floor over which a demersal trawl net is dragged during its operation, estimated by multiplying the width of the net mouth by the distance the net is dragged.

Artisanal fishing. Fishing for subsistence using traditional methods.

Australian Fishing Zone (AFZ). A zone 200 nautical miles wide around Australia's mainland and territorial coasts, within which Australia controls domestic and foreign access to fish resources.

Autonomous adjustment. An ongoing process in all fisheries. As technologies and prices change, the characteristics of the fishing fleet required to maximise the net value from the fishery will also change and, as a result, fishery fleet behaviour has a tendency to change in line with market signals. Autonomous adjustment can be accelerated by changes in the fishery management environment. For example, the primary role for government in structural adjustment is to establish a management regime that removes any incentives that lead to over-capacity, and that facilitates autonomous adjustment to occur in response to changing economic and biological conditions.

B

B (biomass). Total weight of a stock or a component of a stock.

Basket stock. Stock of undifferentiated species managed as a single group within a fishery.

Beach price. A price per unit of fish that excludes payments for freight, marketing and processing, as would be paid at the point of landing. Usually expressed as the weight of the fish when whole.

B_{LIM} (biomass limit reference point). The point beyond which the risk to the stock is regarded as unacceptably high.

B_{MEY} (biomass at maximum economic yield). Average biomass corresponding to maximum economic yield.

B_{MSY} (biomass at maximum sustainable yield). Average biomass corresponding to maximum sustainable yield.

B_{TARG} (target biomass). The desired biomass of the stock.

B_0 (mean equilibrium unfished biomass). Average biomass level if fishing had not occurred.

Benthic. Associated with the bottom of a water body.

Beverton–Holt. Mathematical function that describes the relationship between stock size and recruitment.

Biodiversity. Biological diversity; variety among living organisms, including genetic diversity, diversity within and between species, and diversity within ecosystems.

Biological reference point. Indicator providing a standard for comparison. Can be either a 'target reference point' or a minimum biologically acceptable limit ('limit reference point'). Often based on fishing mortality rates, biomass or on the maintenance of adequate recruitment to the stock.

Brood. Group of young produced by an animal at the same time.

Buyback. Purchase of fishing vessels and licences by the government.

Bycatch. A species that is: (a) incidentally taken in a fishery and returned to the sea; or (b) incidentally affected by interacting with fishing equipment in the fishery, but not taken.

Bycatch reduction device (BRD). A device that allows fish and other animals to escape immediately after being taken in/with fishing gear (e.g. a trawl net).

Byproduct. A species taken incidentally in a fishery while fishing for the target species that has some commercial value and is retained for sale.

C

Carapace. The exoskeleton covering the upper surface of the body of a crustacean.

Carapace length (CL). In prawns, the distance from the posterior margin of the orbit to the mid-caudodorsal margin of the carapace; in lobster, the distance from the tip of the rostrum to the mid-caudodorsal margin of the carapace.

Catch per unit effort (CPUE). The number or weight of fish caught by a unit of fishing effort. Often used as a measure of fish abundance.

Catch rate. *See* Catch per unit effort.

Catch-at-age data. Data on the number of fish of each age group in the catch, usually derived from representative samples of the catch.

Catch-at-length data. Data on the number of fish of each length group in the catch, usually obtained by measuring the lengths of fish in representative samples, but occasionally derived from individual weights of fish.

Catch-at-weight data. Data on the number of fish of each weight group in the catch, usually obtained by measuring the individual weights of fish in representative samples.

Catchability. The extent to which a stock is susceptible to fishing; quantitatively, the proportion of the stock removed by one unit of fishing effort.

Chondrichthyans. Fishes that have skeletons made of cartilage rather than bone. This group includes sharks and rays (elasmobranchs) and chimaeras (holocephalans).

Codend. The closed end of a trawl net.

Cohort. Those individuals of a stock born in the same spawning season.

Cohort analysis. Technique for estimating the magnitude of fishing mortality and the number of fish at each age in a stock by tracing the history of cohorts.

Conservation dependent species. The EPBC Act dictates that a native species is eligible to be included in the ***conservation dependent*** category at a particular time if, at that time: (a) the species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered; or (b) the following subparagraphs are satisfied: (i) the species is a species of fish; (ii) the species is the focus of a plan of management that provides for management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long term survival in nature are maximised; (iii) the plan of management is in force under a law of the Commonwealth or of a State or Territory; (iv) cessation of the plan of management would adversely affect the conservation status of the species.

Continental shelf. Seabed from the shore to the edge of the continental slope (usually 200 m depth).

Continental slope. Region of the outer edge of a continent between the generally shallow continental shelf and the ocean floor, usually distinguished from the shelf by the 200 m isobath.

Control rules. Agreed responses that management must make under pre-defined circumstances regarding stock status. Also called 'harvest control rules' and 'decision rules'.

Critically endangered ecological community. The EPBC Act dictates that an ecological community is eligible to be included in the ***critically endangered*** category at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.

Critically endangered species. The EPBC Act dictates that a native species is eligible to be included in the ***critically endangered*** category at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.

D

Daily egg production method (DEPM). A method of estimating the spawning biomass of a fish population from the abundance and distribution of eggs and larvae.

Danish seining. A trawling method used by relatively small vessels in shallow waters (up to about 200 m). Lengths of weighted ropes of up to 2800 m are laid out on the sea floor in a diamond pattern with the vessel at one end of the diamond and the net at the other. As the vessel moves forward the diamond becomes elongated allowing the fish to be herded into the path of the net (*c.f.* Purse-seining).

Delay-difference model. Type of population model that incorporates age structure.

Demersal. Found on or near the benthic habitat (*c.f.* Pelagic).

Demersal trawling. Trawl gear designed to work on or near the sea bed. Such gear is used to take demersal species of fish and prawns.

Depletion (stock depletion). Reduction in the biomass of a fish stock**.**

Developmental fishery. A fishery managed under developmental fishery permits. Developmental fishing involves fishing in an area of Australian jurisdiction as specified in the permit, involving activities including (a) assessing the commercial viability of a

fishery, and (b) assessing the commercial viability of kinds of fishing activities, vessels or equipment specified in the permit.

Discarding. Any part of the catch which is returned to the sea, whether dead or alive.

Domestic fishery. Fishery within the Australian Fishing Zone operated by Australian-flagged vessels.

Dressed weight. Weight of the carcass after processing (that is, with gills and viscera removed).

Driftnet. Gillnet suspended by floats so that it fishes the top few metres of the water column.

Dropline. Fishing line with one or more hooks, held vertically in the water column with weights, generally used on the continental shelf and slope. Several droplines may be operated by a vessel, manually or mechanically.

E

Ecologically sustainable development. Using, conserving and enhancing the community's resources so that ecological processes are maintained and the total quality of life, now and in the future, is improved.

Economic efficiency. A fishery is economically efficient when fishery-level efficiency and vessel-level efficiency are achieved, and management costs are as low as they can be while still providing the necessary level of management. Fishery-level and vessel-level efficiency mean that effort is restricted to the point where the difference between fishing revenue and cost is greatest, and fishers are applying that level of effort at least cost.

Economic profit. *See* Profit, economic.

Ecosystem. A complex of plant, animal and microorganism communities that, together with the non-living components, interact to maintain a functional unit.

Effort. A measure of the resources used to harvest a fishery's stocks. The measure of effort appropriate for a fishery depends on the methods used and the management arrangements. Common measures include the number of vessels, the number of hooks set and the number of fishing days or nights.

Effort creep. The tendency for fishing effort to increase beyond the levels intended by a targeted input control. It is caused by innovative fishers adapting their fishing techniques to legally circumvent controls, often by using an unregulated input in place of a regulated input. Effort creep compels managers to tighten controls regularly, leading to some gear being made redundant.

Effort restriction. Restriction of the permitted amount of fishing effort (for example, trawl hours) in a particular fishery; used as a management tool.

Egg survey. Systematic gathering of information on the occurrence and abundance of fish eggs and larvae by collecting them in nets and traps.

El Niño – Southern Oscillation. Large-scale, cyclical (3–7 years), warming and cooling episodes across the equatorial Pacific; warm water pools in the east during El Niño conditions and, conversely, in the west during La Niña conditions.

Endangered ecological community. The EPBC Act dictates that an ecological community is eligible to be included in the ***endangered*** category at a particular time if, at that time: (a) it is not critically endangered; and (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.

Endangered species. Species in danger of extinction because of its low numbers or degraded habitat, or likely to become so unless there is an improvement in the factors affecting its status. The EPBC Act dictates that a native species is eligible to be included in the ***endangered*** category at a particular time if, at that time: (a) it is not critically endangered; and (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.

Endemic species. Species that occur naturally and exclusively in a given place.

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). Australia's national environment law. The legislation focuses on protecting matters of national importance, such as World Heritage sites, national heritage places, wetlands of international importance (Ramsar wetlands), nationally threatened species and ecological communities, migratory species, Commonwealth marine areas and nuclear actions.

Escapement. The number, expressed as a percentage, of fish that survive through a particular event (e.g. predation, natural mortality, fishing mortality), often to spawn.

Exclusive Economic Zone (EEZ). A 200 nautical mile zone declared in August 1994 by Australia in line with the United Nations Convention on the Law of the Sea. Australia has the right to explore and exploit, and the responsibility to conserve and manage, the living and non-living resources within this area (*c.f.* Australian Fishing Zone).

Exploitation rate. The fraction of total animal deaths caused by fishing, usually expressed as an annual value. Can also be defined as the proportion of a population caught during a year.

Extinct in the wild. The EPBC Act dictates that a native species is eligible to be included in the ***extinct in the wild*** category at a particular time if, at that time: (a) it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or (b) it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.

Extinct species. The EPBC Act dictates that a native species is eligible to be included in the ***extinct*** category at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.

F

Farmgate price. *See* Beach price.

F (fishing mortality). The instantaneous rate of fish deaths due to fishing a designated component of the fish stock. F reference points may be applied to entire stocks or segments of the stocks and should match the scale of management unit. Instantaneous fishing mortality rates of 0.1, 0.2 and 0.5 are equivalent to 10%, 18% and 39% of deaths of a stock due to fishing. *See also* Mortality, M (natural mortality).

Fecundity. Number of eggs an animal produces each reproductive cycle; the potential reproductive capacity of an organism or population.

Fish-aggregating device (FAD). Buoys and platforms used to attract and 'hold' pelagic fishes to enhance fishing. Can be as simple as a floating log or bamboo raft, but tuna fishers setting purse seine nets around tuna schools now deploy sophisticated FADs that allow satellite tracking and interrogation of information, such as sea surface temperature.

Fish meal. Protein-rich animal feed made of fish or fish waste.

Fisheries Management Act 1991. One of two main pieces of legislation (along with the *Fisheries Administration Act 1991*) that details AFMA's responsibilities and powers.

Fishery-independent survey. Systematic survey carried out by research vessels or contracted commercial fishing vessels to gather information independently of normal commercial fishing operations.

Fishery-level efficiency. Occurs when total catch or effort is restricted to the level that maximises the net economic returns created by the fishery over time, accounting for the impact of current catches on future stocks, catches and fishing costs.

F_{LIM} (fishing mortality limit reference point). The point above which the removal rate from the stock is too high.

F_{MEY} (fishing mortality at maximum economic yield). The fishing mortality rate that corresponds to the maximum economic yield.

F_{MSY} (fishing mortality maximum sustainable yield). The fishing mortality rate that achieves the maximum sustainable yield.

F_{TARG} (fishing mortality target). The target fishing mortality rate.

Fishing capacity. Total fishing effort that can be expended by a fleet operating in a fishery.

Fishing down. Reduction in the average age and size of a stock that is being fished for the first time. Catches are highest at first, but the rate cannot be sustained once the abundance of older fish has been reduced.

Fishing effort. Amount of fishing taking place, usually described in terms of gear type and the frequency or period of operations; for example, 'hook sets', 'trawl hours', 'searching hours'.

Fishing power. Effectiveness of a vessel's fishing effort relative to the effectiveness of other vessels.

Fishing season. The period during which a fishery can be accessed by fishers. May equate to a calendar year or a portion of a calendar year. Sometimes referred to as a fishing year.

Fishing year. See Fishing season.

Flag of convenience. Registration of a ship to a country other than the country of ownership.

Footrope. Forms the lower lip of the net opening in trawl gear. Configuration depends on the expected bottom morphology; a more robust footrope is required on rough fishing ground.

Fork length (FL). Length of a fish measured as the distance between the tip of the snout and the point of the fork or 'V' of the tail. Commonly used to record the length of commercial fish because it is little affected by damage to the tail fin (*c.f.* Total length). Fork length is measured flat, from point to point, not by stretching a tape along the body surface, which would result in a longer measurement for full-bodied fish like tuna. *See also* Lower-jaw fork length.

Free diving. Diving under water without the assistance of breathing apparatus. Gear used may include a snorkel, facemask, flippers, weight belt and wetsuit.

Fully fished. Describes a fish stock for which current catches and fishing pressure are close to optimal (e.g. catches are close to the maximum sustainable yield). For a fully fished species, increases above the optimum may lead to overfishing. *See also* Overfished.

G

Gear restriction. Restriction on the amount and/or type of fishing gear that can be used by fishers in a particular fishery; used as a management tool.

Generation time. Average time taken for an individual animal to replace itself in a population.

Ghost fishing. The capture and killing of fish in gear that has been lost, usually nets or traps.

Gillnet. Type of passive fishing gear consisting of panels of net held vertically in the water column, either in contact with the seabed or suspended from the sea surface, such that fish attempting to swim through the net are entangled. The mesh size of the net determines the size range of fish caught, as smaller fish can swim through the meshes and larger fish are not enmeshed. *See also* Driftnet.

Global positioning system (GPS). A system that uses satellite signals to accurately determine a vessel's position and course.

Gross value of production (GVP). A value found by multiplying the volume of catch by the beach price per unit. In the case of a multispecies fishery, the fishery's GVP is the sum of the GVP of each species. GVP is not a good indicator of economic performance because it does not consider costs.

Grow-out pontoons. Pontoons supporting cages in which wild caught fish are fattened until they reach marketable size.

Growth model. Mathematical description or representation of the rate at which a species grows at different sizes or ages.

Growth overfishing. The harvesting of too many small fish; a restraint on catching them would result in an overall increase in the fishery's yield.

H

Handline. Hand-held lines of various types used to catch fish.

Harvest strategy. Strategy outlining how the catch in a fishery will be adjusted from year to year depending on the size of the stock, the economic or social conditions of the fishery, conditions of other interdependent stocks and uncertainty of biological knowledge. Well-managed fisheries have an unambiguous (explicit and quantitative) harvest strategy that is robust in the unpredictable biological fluctuations to which the stock may be subject.

Haul net. Fishing gear similar to a Danish seine, but operated from a small vessel in shallow water (less than 5 m) or from the shore. Unlike a Danish seine, it has short ropes and is hauled while the vessel is stationary.

Headrope (headline). In a trawl, the length of rope or wire to which the top wings and cover netting are attached.

High grading. A type of discarding motivated by an output control system. Depending on the costs of fishing and price differences between large and small fish of the same species, fishers may have an incentive to discard small, damaged or relatively low-value catch so that it does not count against their quota. They then hope to fill the quota with a higher value fish in the future.

High-seas. Waters outside national jurisdictions.

Hookah. Underwater breathing device consisting of an onboard air compressor and an air supply tube attached to a diver's mouthpiece or helmet.

Hopper. Seawater container used on a trawler to assist in sorting the catch. Hoppers can preserve product quality, increase the efficiency of sorting and increase the survival of released bycatch. Developed on prawn trawlers in northern Australia in the 1980s.

I

Index of abundance. Relative measure of the abundance of a stock; for example, catch per unit of effort.

Individual transferable effort (ITE). Shares of a total allowable effort that are allocated to individuals. They can be traded permanently or temporarily. Analogous to individual transferable quotas in a fishery managed with a total unit allowable catch. Usually issued at the start of a fishing season.

Individual transferable quota (ITQ). Management tool by which portions of the total available catch quota are allocated to fishers (individuals or companies). The fishers have long-term rights over the quota but can trade quota with others. *See also* Quota.

Input controls. Management measures that place restraints on who fishes (licence limitations), where they fish (closed areas), when they fish (closed seasons) or how they fish (gear restrictions).

Inshore waters. Waters of the shallower part of the continental shelf, usually less than 3 nm.

Intertidal. The part of the land that is submerged at high tide and exposed at low tide.

Isobath. Contour line linking points of the same depth.

Isotherm. Contour line linking points of the same temperature.

J

Jig. Vertical line with lures, which is moved up and down, or jigged, by hand or machine.

Joint authority. An Offshore Constitutional Settlement arrangement whereby a fishery

is managed jointly by the Australian Government and one or more states or territories under a single (Commonwealth, or State or Territory) jurisdiction.

Joint venture. Collaborative fishing operation, usually involving two companies from different countries.

K

Key commercial species. A species that is, or has been, specifically targeted and is, or has been, a significant component of a fishery.

Key threatening process. The EPBC Act dictates that a key threatening process is defined as a process that threatens the survival, abundance or evolutionary development of a native species or ecological community, requiring the formal development of a threat abatement plan. A threatening process is eligible to be treated as a key threatening process if: (a) it could cause a native species or an ecological community to become eligible for listing in any category, other than conservation dependent; or (b) it could cause a listed threatened species or a listed threatened ecological community to become eligible to be listed in another category representing a higher degree of endangerment; or (c) it adversely affects 2 or more listed threatened species (other than conservation dependent species) or 2 or more listed threatened ecological communities.

L

Latent effort. Fishing capacity that is authorised for use but not currently being used. Depending on how a fishery is managed, latent effort might appear as unused vessel SFRs, gear SFRs, quota SFRs, permits or nights fishing. It is an important and very low-cost indicator of fishers' views about the profitability of a fishery. High levels of latent effort suggest that low profits in the fishery do not justify fishing. It is likely that fisheries in which latent effort exists are close to the open-access equilibrium. Apart from being an indicator of efficiency, latent effort can also be detrimental to the fish stock and to any chances the fishery may have of being profitable in the future. For example, a significant increase in the market price of a fishery's product is likely to entice inactive effort into the fishery. If enough inactive effort is triggered, the fish stock could be jeopardised. At the very least, profits are likely to be dissipated as soon as they arise.

Length–frequency distribution; modal size. The number of individuals in a catch or catch sample in each group of lengths (length intervals). The modal size is the length group into which most individuals fall. Some distributions may show several modes, reflecting fish of different ages.

Limited entry fishery. Fishery in which the fishing effort is controlled by restricting the number of operators. Usually requires controlling the number and size of vessels, the transfer of fishing rights and the replacement of vessels (*c.f.* Open access fishery).

Line fishing. Fishing methods that use fishing lines in one form or another, including handlines, hand reels, powered reels, pole-and-line, droplines, longlines, trotlines and troll lines.

Logbook. Official record of catch and effort data made by fishers. In many fisheries, a licence condition makes the return of logbooks mandatory.

Log schools. *See* Fish-aggregating device (FAD).

Long-term potential yield. Estimate of the largest annual harvest that could be taken sustainably from a fish stock, allowing for variable environmental conditions. May be estimated in various ways, from taking an average of a time series of historical catches to using sophisticated mathematical models.

Longline. Fishing gear in which short lines (branchlines or droppers) carrying hooks are attached to a longer main line at regular intervals. Pelagic longlines are suspended horizontally at a predetermined depth with the help of surface floats. The

main lines can be as long as 100 km and have several thousand hooks. Droppers on demersal longlines (set at the seabed with weights) are usually more closely spaced.

Lower-jaw fork length. Length of a fish measured as the distance between the tip of the lower jaw and the point of the fork or 'V' of the tail. Commonly used to record the length of commercial fish with bills (e.g. swordfish) because it is little affected by damage to the tail fin (*c.f.* Total length) and bill. Fork length is measured flat, from point to point, not by stretching a tape along the body surface, which would result in a longer measurement for full-bodied fish like tuna.

M

M (natural mortality). Deaths of fish from all causes except fishing. Usually expressed as an instantaneous rate or as a percentage of fish dying in a year. *See also* F (fishing mortality), Mortality.

Mainline. Longline fishing gear consists of a mainline kept near the surface or at a particular depth by means of regularly spaced floats or weights. Branchlines with baited hooks are attached to the mainline at regular intervals.

Management strategy evaluation. Procedure whereby alternative management strategies are tested and compared using simulations of stock and fishery dynamics.

Maximum constant yield (MCY). Maximum constant catch sustainable for all probable future levels of stock biomass (*see also* Long-term potential yield). A larger long-term average catch might be achieved if the catch is adjusted each year to take account of stock increases and decreases because of environmental variability. A different approach from using maximum sustainable yield.

Maximum economic yield (MEY). The sustainable catch or effort level for a commercial fishery that allows net economic returns to be maximised. Note that for most practical discount rates and fishing costs, MEY will imply that the equilibrium stock of fish is larger than that associated with MSY. In this sense, MEY is more environmentally conservative than MSY and should, in principle, help protect the fishery from unfavourable environmental impacts that may diminish the fish population.

Maximum sustainable yield (MSY). The maximum average annual catch that can be removed from a stock over an indefinite period under prevailing environmental conditions. MSY defined in this way makes no allowance for environmental variability, and studies have demonstrated that fishing at the level of MSY is often not sustainable (*c.f.* Long-term potential yield).

Migration. Non-random movement of individuals of a stock from one place to another, often in groups.

Minimum size. Size below which a captured animal may not legally be retained. Usually specified by species. May be varied as a management tool.

Minor line. Term adopted by AFMA to refer to several line-fishing methods, including trolling or fishing using a rod and reel, handline, or pole-and-line.

Mode; modal size. *See* Length–frequency distribution.

Model (population). Hypothesis of how a population functions; often uses mathematical descriptions of growth, recruitment and mortality.

Morphology. Study of the form and shape of animals and plants; by extension, that form or shape.

Morphometrics. The form and shape of an animal. Differences in morphometrics are often used to distinguish different stocks of the same species.

Mortality. Deaths from all causes (usually expressed as a rate or as the proportion of the stock dying each year).

MULTIFAN–CL. A length-based, age-structured model for stock assessment of fisheries.

N

Nautical mile (nm). Unit of distance equivalent to one minute of the great circle of the earth (equivalent to 1.852 km).

Net economic returns (NER). A fishery's net economic return over a particular period is equal to fishing revenue less fishing costs. Fishing costs include the usual accounting costs of fuel, labour and repairs and maintenance, as well as various economic costs such as the opportunity costs of labour and capital. These measure how much these resources would have been compensated had they been operating in the next best alternative. The concept of net economic returns is very closely related to economic efficiency. Only in an economically efficient fishery will net economic returns be maximised.

Neritic. Designating, or of, the ecological zone (neritic zone) of the continental shelf extending from low tide to a depth of around 180 m.

Non-detriment finding. Relating to a CITES appendix listed species—a conclusion by a Scientific Authority that the export of specimens of a particular species will not impact negatively on the survival of that species in the wild. The non-detriment finding by a Scientific Authority is required before an export or import permit or a certificate for an introduction from the sea may be granted for a specimen of an Appendix-I species, and before an export permit or a certificate for an introduction from the sea may be granted for a specimen of an Appendix-II species.

Non-target species. Species that are unintentionally taken by a fishery or not routinely assessed for fisheries management. *See also* Bycatch and Byproduct.

Not overfished. *See* Overfished.

O

Oceanic. Open-ocean waters beyond the edge of the continental shelf.

Offshore Constitutional Settlement (OCS). The 1982 package of uniform national, state and territory laws. Basis on which Australian governments at those levels enter into agreements for specified fisheries to be managed by a particular government or group of governments. A fishery might be managed by the Australian Government, one or more state or territory governments, or any combination of the two acting through a joint authority. Fisheries for which OCS arrangements are not in place may be managed under joint control or continue under current management arrangements.

Offshore waters. Usually oceanic waters, but can refer to outer continental shelf waters (*c.f.* Onshore waters).

Onshore waters. Waters abutting the coastline.

Open access fishery. Fishery in which there is no limit on the number of operators or vessels (*c.f.* Limited entry fishery). Such a fishery is liable to suffer the 'tragedy of the commons'. Under open access, a fishery operates with a harvest and effort that result in total revenue equalling costs, with no economic profits being generated. The fishing effort employed at this point exceeds that which would achieve MEY. A open access equilibrium is a point where there is no limit on the number of operators or vessels allowed to operate in the fishery

Operating model. Simulation of stock dynamics (and the impact of fishing) used in management strategy evaluation.

Opportunity cost. The compensation a resource forgoes by being employed in its present use and not in the next best alternative. For example, the opportunity cost incurred by the skipper of a fishing vessel is the amount he or she would have received in some alternative occupation. The opportunity cost of owning a fishing vessel might be the interest that could be earned if the vessel was sold and the capital invested elsewhere. These costs are not usually reflected in a firm's financial accounts but are very important costs nonetheless.

Otoliths. Bone-like structures formed in the inner ear of fish. The rings or layers can be counted to determine age.

Otter trawl. Demersal trawl operated by a single vessel in which the net is held open horizontally by angle-towed otter boards (large rectangular 'boards' of timber or steel) and vertically by a combination of floats on the headrope and weights on the ground line. Attached between the head and ground ropes and the towing warps, the otter boards are spread apart by the hydrodynamic forces acting on them when the net is towed.

Output controls. Management measures that place restraints on what is caught, including total allowable catch, quota, size limits and species.

Overfished. A fish stock with a biomass below the biomass limit reference point. 'Not overfished' implies that the stock is not below the threshold, and is now used where status classifications of 'fully fished' or 'underfished' were used in earlier editions of *Fishery status reports*.

Overfishing, subject to. A stock is experiencing too much fishing and the removal rate from the stock is unsustainable. Also:

- Fishing mortality (F) exceeds the limit reference point (F_{LIM}). When stock levels are at or above B_{MSY}, F_{MSY} will be the default level for F_{LIM}.
- Fishing mortality in excess of F_{LIM} will not be defined as overfishing if a formal 'fish down' or similar strategy is in place for a stock and the stock remains above the target level (B_{TARG}).
- When the stock is less that B_{MSY} but greater than B_{LIM}, F_{LIM} will decrease in proportion to the level of biomass relative to B_{MSY}.
- At these stock levels, fishing mortality in excess of the target reference point (F_{TARG}) but less than F_{LIM} may also be defined as overfishing, depending on the harvest strategy in place and/or recent trends in biomass levels.
- Any fishing mortality will be defined as overfishing if the stock level is below B_{LIM}, unless fishing mortality is below the level that will allow the stock to recover within a period of ten years plus one mean generation time, or three times the mean generation time, whichever is less.
- Any directed (targeted) fishing of an overfished stock (stock level is below B_{LIM}) will amount to overfishing.

P

Pair trawling. Trawling by two vessels steaming in parallel with the net towed between them. Very large nets can be held open and towed in this way. The net is generally hauled alternately aboard the two vessels for processing of the catch.

Parameter. Characteristic feature or measure of some aspect of a stock, usually expressed as a numerical value (e.g. *see* M (natural mortality)).

Parental biomass. Weight of the adult (reproductively mature) population of a species. *See also* Spawning biomass.

Pelagic. Inhabiting surface waters rather than the sea floor. Usually applied to free-swimming species such as tunas and sharks (*c.f.* Demersal).

Pole-and-line fishing (poling). Fishing method in which fishers attract schools of fish to the vessel with live or dead bait, get them into a feeding frenzy with more bait and water sprayed onto the sea surface to simulate the behaviour of small baitfish, and then use poles with short, fixed lines and lures to 'pole' the fish aboard. Also called 'pole-and-live-bait fishing'.

Population structure. Composition of a population in terms of size, stock (genetic or regional), age class, sex, etc.

Potential yield. *See* Long-term potential yield.

Precautionary approach. Approach to resource management in which, where there are threats of serious irreversible environmental damage, lack of full scientific certainty is not used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and an assessment of the risk-weighted consequences of various options.

Productivity. An indication of the birth, growth and death rates of a stock. A highly productive stock is characterised by high birth, growth and mortality rates, and can sustain high harvesting rates.

Productivity indices. A productivity index shows whether more or less output is being produced over time with a unit of input. The index is calculated by combining changes in total output (fish) to changes in total inputs such as fuel, labour and capital.

Profit, accounting. The difference between total revenue and explicit costs. Explicit costs refers to costs such as wages, fuel, repairs, maintenance and depreciation of physical capital (e.g. vessels). Where costs exceed total revenue, it is an accounting loss. Unlike economic profit, it does not include opportunity cost. *See also* Profit, economic.

Profit, economic. The difference between total revenue and explicit and opportunity costs (*see* Opportunity cost). Explicit costs refer to costs such as wages, fuel, repairs and depreciation of physical capital (e.g. vessels). Economic profit differs from accounting profit in that opportunity cost is not considered in accounting profit. *See also* Profit, accounting.

Profit, decompositions. Profit decomposition studies are an extension of productivity index studies and provide more detailed information regarding inputs and outputs. A profit index decomposition approach enables decomposition of profit into its components: productivity, the prices of outputs and inputs, and vessel capital. This method offers important advantages over traditional measures of productivity in fisheries because it provides individual firm-level measures and quantifies the contribution of productivity, inputs, and outputs to relative profits.

Protected species. As per the meaning used in the *Environment Protection and Biodiversity Conservation Act 1999*.

Purse seining. Harvesting large quantities of surface-schooling pelagic fish by surrounding the school with a net. A line that passes through rings on the bottom of the net can be tightened to close the net so that the fish cannot escape (*c.f.* Danish seining).

Q

Quad gear. Four fishing nets towed simultaneously by a vessel, with the opening of each net being controlled by otter boards.

Quota. Amount of catch allocated to a fishery as a whole (total allowable catch) or to an individual fisher or company (individual transferable quota).

Quota species. Species for which catch quotas have been allocated.

R

Real terms/real prices. Real prices are historical or future prices adjusted to reflect changes to the purchasing power of money (most commonly measured by the consumer price index). Such prices may also be expressed as being in real terms. Commonly, a year is indicated alongside a real price. This indicates the reference year against which prices in other years are compared. Prices quoted in real terms allow for meaningful comparison over time.

Rebuilding plan. Management plan to rebuild a stock when the measure of its status (e.g. its biomass) is below the biomass limit reference point (i.e. it is assessed as overfished). Stock rebuilding plans should include elements that define rebuilding targets, rebuilding time horizons and control rules related to the rate of progress.

Recovery plan. Management process to rebuild a stock when a measure of its status (e.g. its biomass) is outside a defined limit (i.e. it is assessed as overfished). Recovery plans should include elements that define stock-specific management objectives, harvesting strategies specified by control rules and recovery periods.

Recruit. Usually, a fish that has just become susceptible to the fishery. Sometimes used in relation to population components; for example, a recruit to the spawning stock.

Recruitment overfishing. Excessive fishing effort or catch that reduces recruitment to the extent that the stock biomass falls below the predefined limit reference point.

Reference point. Indicator of the level of fishing (or stock size); used as a benchmark for assessment (*see also* Biological reference point).

Ricker Curve/Function. Mathematical function that describes the relationship between stock size and recruitment.

Risk analysis. Analysis that evaluates the possible outcomes of various harvesting strategies or management options.

S

Sashimi. Japanese dish of raw sliced fish.

SB_{MSY}. Spawning or 'adult' equilibrium biomass at MSY.

Seasonal closure. Closure of a fishing ground for a defined period; used as a management tool, often to protect a stock during a spawning season.

Seines. Seine nets are usually long, flat nets like a fence that are used to encircle a school of fish, with the vessel driving around the fish in a circle. Purse seine and Danish seine nets are used in a range of fisheries.

Settlement. Transition from a pelagic larval stage to a substrate-associated juvenile or adult existence.

Shelf break. Region where the continental shelf and continental slope meet, commonly around depths of 200 m; that is, where the seabed slopes steeply towards the ocean depths.

Shot-by-shot. Pertaining to each separate deployment of a fishing gear by a fishing vessel.

Size-at-age. Length or weight of fish at a particular age.

Size-at-first-maturity. Length or weight of fish when they reach reproductive maturity.

Size–frequency. *See* Length–frequency distribution.

Slope (mid-slope; upper slope). Continental slope—the more steeply dipping seafloor beyond the edge of the continental shelf.

Spawner-per-recruit. An index that gives the number of spawners of age X divided by the initial number of recruits.

Spawning biomass. The total weight of all adult (reproductively mature) fish in a population. Also called 'spawning stock biomass'.

Species group. Group of similar species, often difficult to differentiate without detailed examination.

SPR_{40}. Spawning potential ratio (or egg production) at 40% of unfished levels.

Standardised data. Data that have been adjusted to be directly comparable to a unit that is defined as the 'standard' one. For example, catch per unit effort data are often used as an indicator of fish abundance.

Standard length (SL). The length of a fish measured from the tip of the snout to the posterior end of the last vertebra or to the posterior end of the mid-lateral portion of the hypural plate.

Statutory fishing rights (SFRs). Rights to participate in a limited-entry fishery. An SFR can take many forms, including the right to access a particular fishery or area of a fishery, the right to take a particular quantity of a particular type of fish, or the right to use a particular type or quantity of fishing equipment.

Steepness. Steepness (h) is conventionally defined as the proportion of unfished recruitment (R_0) produced by 20% of unfished spawning biomass (S_0). Steepness is a key parameter of the Beverton–Holt spawner–recruit model. Steepness controls

the response of stock productivity to changes in spawning biomass, and as such, heavily influences estimates of management quantities such as MSY-based benchmarks (*see* Stock–recruitment relationship).

Stock. Functionally discrete population that is largely distinct from other populations of the same species and can be regarded as a separate entity for management or assessment purposes. Some species form a single stock (southern bluefin tuna), while others form several stocks (albacore tuna in the northern and southern Pacific Ocean).

Stock recruitment. *See* Recruit.

Stock–recruitment relationship. Relationship between the size of the parental biomass and the number of recruits it generates. Determination of this relationship is difficult, and involves studying the population's size–age composition, growth and mortality rates.

Stock-reduction analysis. Assessment method that estimates the biomass of a fish population from its catch history, information on the productivity of the species and a time series of abundance indices, such as CPUE.

Straddling stock. Migratory species that spend part of their life cycle in two or more jurisdictions, especially those that migrate between EEZs and the high-seas.

Sub-Antarctic waters. Waters adjacent to, but not within, the Antarctic Circle (about 66°30´S).

Sub-tropical waters. Waters adjacent to, but not within, the tropics; in the Australian region, the waters south of the Tropic of Capricorn (about 23°28´S).

Surface fishery. Fishing with pole and line, bait vessel, troll or purse seine to target surface-swimming species.

Surplus-production. Inherent productivity of a fish stock that can be harvested sustainably. Based on the theory that, at large stock size, rates of reproduction and stock increase are slowed by self-regulating mechanisms, and that the stock increases faster after removals as it attempts to rebuild. In theory, fishing can be moderated to take advantage of the more productive rates of stock increase, provided it does not exceed the stock's capacity to recover.

Surplus-production model. Mathematical representation of the way a stock of fish responds to the removal of individuals (e.g. by fishing).

Sustainable yield. Catch that can be removed over an indefinite period without reducing the biomass of the stock. This could be either a constant yield from year to year, or a yield that fluctuates in response to changes in abundance.

T

Tagging. Marking or attaching a tag to an animal so that it can be identified when recaptured; used to study fish growth, movement, migration, stock structure and size. *See also* Archival tag.

Target fishing (targeting). Fishing selectively for particular species or sizes of fish.

Target species. *See* Key commercial species.

Taxonomic group. An organism's location in the biological classification system; used to identify and group those with similar physical, chemical and/or structural composition.

Threat abatement plan. Plan formalised under endangered species legislation to counter the effects of a listed key threatening process.

Threatened species. As per the meaning used in the *Environment Protection and Biodiversity Conservation Act 1999*.

Tori line. Line with streamers, towed as a scaring device over the area behind a vessel where sinking baited hooks are within range of diving seabirds; attached to a tori pole (boom) at the vessel's stern.

Total allowable catch (TAC). For a fishery, a catch limit set as an output control on fishing (*see also* Output controls). Where resource sharing arrangements are in place between commercial and recreational fishers, the term total allowable commercial catch (TACC) will apply. The

term ’Global’ is applied to TACs that cover fishing mortality from all fleets, including Commonwealth, States and Territory’s.

TAC, agreed. The TAC for individual quota species as determined by the AFMA Commission.

TAC, actual. The actual TAC for a species is the agreed TAC (defined above) with amendments applied, such as carryover or debits from the previous year.

Total allowable commercial catch (TACC). *See* Total allowable catch (TAC).

Total allowable effort (TAE). An upper limit on the amount of effort that can be applied in the fishery.

Total length (TL). The length from the tip of the snout to the tip of the longer lobe of the caudal fin, usually measured with the lobes compressed along the midline. It is a straight-line measure, not measured over the curve of the body (*c.f.* Fork length).

Tragedy of the commons. A situation where users of a shared resource expand their use of the resource past the point that would be optimal if there was a sole owner because the cost of beyond-optimal use is distributed across all users.

Trap fishing. Fishing by means of traps, often designed to catch a particular species (e.g. rock lobster pots).

Trawl fishing. Fishing method in which a large, bag-like net is drawn along behind a vessel to target either demersal or pelagic fish species. There are many variations.

Trigger catch limit. When catches reach this limit, management actions are triggered to assess whether fishing should continue and at what level.

Trigger points. Pre-specified quantities (total catch, spawning biomass, etc.) that indicate the need for a review of fishery management.

Trolling. Fishing method in which lines with baits or lures are dragged by a vessel at 2–10 knots. Used widely to catch fish such as Spanish mackerel, yellowtail kingfish and several tuna species.

Trotline. Dropline with hooks that are held away from the mainline by rigid spacers.

Turtle excluder device. A device fitted to a net, and modification made to a net, that allows turtles to escape immediately after being captured in the net.

U

Uncertain. Status of a fish stock that might be overfished, not overfished, or subject to overfishing, but for which there is inadequate or inappropriate information to make a reliable assessment.

Underfished. Status of a fish stock that has potential to sustain catches higher than those currently taken. Not applied to stocks where catches have been limited to enable the stock to rebuild. *See also* Overfished.

V

Vessel-level efficiency. Vessel-level efficiency requires that revenues be maximised and catching costs be minimised for a given quantity of catch. The choice of management regime will have a substantial bearing on whether vessel-level efficiency is achieved, as it largely defines the incentive structure that fishers operate within.

Vessel monitoring system (VMS). Electronic device that transmits the identity and location of a vessel.

Virgin biomass. Biomass of a stock that has not been fished (also called the ‘unfished’ or ‘unexploited’ biomass).

Virtual population analysis. Mathematical modelling technique used in stock assessment, in which the number of fish in each cohort is estimated from numbers in the next oldest or next youngest age group, adjusted for the changes due to fishing and natural mortality. *See also* Cohort analysis.

Vulnerable ecological community. The EPBC Act dictates that an ecological community is eligible to be included in the *vulnerable* category at a particular time if, at that time: (a) it is not critically endangered nor endangered; and (b) it is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.

Vulnerable species. Species that will become endangered within 25 years unless mitigating action is taken. *See also* Endangered species. The EPBC Act dictates that a native species is eligible to be included in the ***vulnerable*** category at a particular time if, at that time: (a) it is not critically endangered or endangered; and (b) it is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.

W

Wire trace/leader. Relatively short length of steel wire placed between a swivel and the hook. Reduces chance of gear being bitten off and increases retention of some species, such as sharks and other large pelagic fish.

Y

Year-class. Individuals spawned in the same year (or spawning season, when that spans the end of one year and the beginning of the next).

Yield. Total weight of fish harvested from a fishery.

Yield-per-recruit analysis. Analysis of how growth and natural mortality interact to determine the best size of animals to harvest; for example, it may be more economically beneficial to catch fish when they are young and plentiful, or when they are older and larger but fewer.

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