Aquaculture development in Australia
A review of key economic issues

Report to client
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A review of key economic issues

Anthony Cox, Luke Davies, Susan Hardcastle and Matthew Stubbs

ABARE report for the Fisheries Resources Research Fund

May 2001
AQUACULTURE DEVELOPMENT

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1. Introduction

The Australian aquaculture industry has grown significantly to the stage where it is estimated to have been worth over $680 million in 1999-2000 (ABARE 2001). While this represents significant growth of around 11 per cent a year since 1990-91, it is readily apparent that the growth has not been consistent across sectors of the industry. While over 40 species are being produced commercially, five main species — pearl oysters, edible oysters, salmon, prawns and tuna — accounted for over 80 per cent of the value of aquaculture production in 1999-2000 (figure A).

Despite the high expectations of the potential for aquaculture in the early to mid-1990s, growth has proved to be patchy, particularly in the latter half of the 1990s. While the value of production of species such as tuna and salmon has continued to grow, the value of production of some species, such as trout, edible oyster and eels, has declined. For other species, such as pearl oysters, mussels and crayfish, the value of production has remained fairly static in recent years.

The Commonwealth government’s Aquaculture Beyond 2000 initiative recognises a need for greater coordination and leadership if the aquaculture industry is to realise its full potential. The presence of a large number of producers across a diverse range of species who are selling into a myriad of markets presents a particular challenge in this regard. As part of the initiative, the Commonwealth government is currently developing, in conjunction with industry and the states, a national action plan for the Australian aquaculture

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**Gross value of aquaculture production, by species**

<table>
<thead>
<tr>
<th>Year</th>
<th>Pearl oysters</th>
<th>Atlantic salmon</th>
<th>Trout</th>
<th>Edible oysters</th>
<th>Prawns</th>
<th>Other species</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990-91</td>
<td>56%</td>
<td>14%</td>
<td>4%</td>
<td>17%</td>
<td>4%</td>
<td>5%</td>
</tr>
<tr>
<td>1999-2000</td>
<td>28%</td>
<td>13%</td>
<td>2%</td>
<td>8%</td>
<td>8%</td>
<td>12%</td>
</tr>
</tbody>
</table>

---

1
industry. The aim of the Aquaculture Action Agenda is to ensure that the industry’s potential is fully realised. It is envisaged that the Action Agenda will provide the means by which industry can coordinate activity, work with governments to determine how governments can best facilitate and support growth, and raise the profile of the industry.

One of the key factors in the debate over industry leadership and coordination is the decentralised nature of government involvement in the industry. The management and regulation of aquaculture in Australia is primarily a state government responsibility. Aquaculture operations fall within state government jurisdiction, as there is no aquaculture activity in Commonwealth waters. Commonwealth government policies and programs do, however, shape the environment in which the industry operates and therefore influence competitive capabilities (see box 1 for a brief history of Commonwealth involvement in aquaculture policy development). As a result, the Commonwealth government does have a role in aquaculture development, predominantly in the coordination of government policy over national issues. Such issues include:

- quarantine and the protection of Australia’s low disease status;
- disease outbreak controls;
- product quality, labeling and the provision of food safety assurances;
- application of national standards for food, environmental protection and preservation of biodiversity;
- facilitation of overseas trade; and
- taxation.

The Commonwealth government also provides funding for research into aquaculture, as well as for education through the higher education system.

A major issue for the aquaculture industry is that the industry often requires access rights to publicly owned resources, excluding activities that do or can occur under existing arrangements — for example, public access to coastal waters. Resource access may be usefully considered in terms of ‘property rights’. Property rights is the economic term given to the various rights and obligations that a sector or individual exercises over resources. Defining, allocating and enforcing such exclusive property rights is justified if the benefits exceed the costs, including environmental and management costs. While highly developed institutions for using and trading in resources exist for many land resources, the institutional arrangements for many water and coastal based resources are less well developed.
Box 1: A brief history of Commonwealth aquaculture policy development

Aquaculture expanded significantly in the 1980s with the range of species farmed, the number of locations involved and the value of the industry all increasing. In 1988, aquaculture’s growing importance and potential was highlighted in the Australian Science and Technology Council’s report Casting the Net. This report recommended that a review be undertaken of the current national status and future potential of aquaculture.

Consequently, the Standing Committee on Fisheries and Aquaculture (SCFA) directed the Working Group on Aquaculture (comprising representatives of all states and the Commonwealth government) to prepare, along with industry, a National Strategy on Aquaculture.

The National Strategy on Aquaculture in Australia was developed in 1993 with the aim of providing a context for management and a framework within which government and industry can cooperate to foster growth (SCFA 1994). The strategy identified key issues and goals central to the future growth and development of the industry. Issues covering industry structure and organisation, environmental management, marketing and product development, quarantine, and research and development were addressed in the strategy.

Since the strategy was implemented, significant progress has been made in many areas, including the development of state and territory land and water management plans, research into new species, improvements in food technology, increases in education and training, and the formation of the Australian Aquaculture Forum. The forum is the peak industry body representing the aquaculture industry at a national level and aims to assist the development of aquaculture in a sustainable manner.

In 1997 the Aquaculture Committee of the Standing Committee on Fisheries and Aquaculture completed a review of the progress of the National Strategy on Aquaculture in Australia (SCFA 1997). The review was based on the responses to a survey sent to farmers, Commonwealth, state and territory governments, research agencies, industry associations and other relevant stakeholders.

The review found that the strategy had been successful in that the aquaculture industry has grown significantly. Existing sectors (pearls, oysters, salmon, prawns and tuna) have expanded and emerging sectors (for example, abalone and native fish) have attracted considerable investor interest.

However, the review noted that there still remained areas that need to be addressed further. Priorities for future action suggested by the review included the development of a national environmental framework/guidelines for aquaculture, including industry codes of practice.

Another priority highlighted in the review that required further action was the need for designated aquacultural zones in coastal areas in all states and territories where aquaculture potential is high as well as areas with future potential. Achieving secure long term tenure sites and operations, and recognition of aquaculture as a legitimate user of natural resources are also important issues to be addressed by the strategy.

On research and development, the review recommended that the strategy work toward improving communication between industry and research providers so the industry can better identify needs and priorities, coordinate research objectives and communicate...
research outcomes. Also identified was a need to concentrate on integrating research and technology developments in other countries and encourage joint research activities to achieve the most productive outcomes from research and development.

Another priority identified in the review was marketing and product development. Three aspects were suggested for inclusion in the strategy: encouraging more market driven production, more effective support and resources for marketing skills and identifying new markets as well as opportunities for expansion of current markets.

The review concluded that progress in the areas of resource access, environmental framework and market access will be particularly significant in aiding the future development of aquaculture.

Following the review of the National Strategy on Aquaculture the Commonwealth government became more actively involved to ensure that aquaculture developed into an internationally competitive and sustainable industry. In 1997-98, the government moved toward a national approach to fish health by allocating an additional $7.4 million for fish health infrastructure.

In 1998 a code of conduct initiated by the Australian Aquaculture Forum and developed with the assistance from the Fisheries Research and Development Corporation and Environment Australia’s Coastal and Clean Seas Program was released (Australian Aquaculture Forum 1998). The code states that industry will work in conjunction with government and other stakeholders to ensure that aquaculture development is managed in a sustainable way.

This was to be accomplished through five guiding principles for environmental best practice. The five principles are:

• comply with regulations,
• respect the rights and safety of others,
• protect the environment,
• treat aquatic animals humanely and
• promote the safety of seafood and other aquatic foods for human consumption.

In addition, the Commonwealth government’s Aquaculture Beyond 2000 initiative recognises the importance and potential of aquaculture. As part of this initiative the government intends, in conjunction with industry and the state governments, to develop an agreed national action plan for the Australian aquaculture industry to ensure its potential is fully realised.

As an early step in the process to develop a national action plan a workshop was held in Canberra in August 1999. At this workshop a new peak aquaculture industry body, the National Aquaculture Council was formed to replace the Australian Aquaculture Forum. The National Aquaculture Council aims to be industry driven and open to industry organisations, businesses and individuals involved in aquaculture.
Furthermore, if there are externalities (that is, impacts on others) associated with defining these exclusive rights, the rights need to be adjusted to make the user bear the cost of the impact by ‘internalising these costs’ where it is cost effective to do so. That is, the benefits of internalising these costs have to be greater than the transaction costs for this to be achieved. If the property rights governing the resources used by aquaculture are clearly defined, the actions of aquaculturists should not affect other users, either positively or negatively. The role of government is to ensure that the private costs reflect the public costs as fully as possible.

As part of the Aquaculture Beyond 2000 initiative, ABARE has been asked to prepare a report on the key economic policy issues that affect the development of the aquaculture industry in Australia. The objective in the report is to review the key economic issues affecting the industry, to identify areas of market failure and/or regulatory failure in each of these issues and to suggest areas for improvement in government policy.

In identifying the key issues to be addressed, the major criterion has been selecting the economic areas in which changes in government policy are likely to have the biggest impact on development of the industry. These issues are resource allocation (including environmental management), research and development expenditure and regional development.
2. Government intervention and assistance

An issue common to the whole aquaculture industry is the efficiency with which markets and government institutions allocate the resources that the industry requires to expand. However, sometimes this allocation is distorted by market failure, which results in the net benefit to Australia from using these resources being reduced. Evidence of market failure can provide a rationale for government intervention to correct that failure. However, this is not a sufficient condition for intervention, as it needs to be demonstrated that the benefits that arise as a result of intervention outweigh the costs of that intervention. There is also the possibility of regulatory failure, where regulatory intervention fails to achieve its stated objective or where it results in unintended outcomes.

The economic policy issues addressed in this report are, therefore, assessed in terms of market and regulatory failure and the extent and nature of any government intervention that may be warranted. The literature on these issues is immense and it is not intended to provide a comprehensive review in this report. Rather, the key concepts will be outlined as they relate to the aquaculture industry.

Market failure

Market failure is defined as the situation in which private market decisions result in an inefficient allocation of community resources. From society’s perspective, resources should be allocated so that the net benefits available from the use of those resources is maximised over time. When this occurs the resource is used at an economically efficient level. Efficient resource use implies that resources are used in their highest value combinations of end uses, both currently and in the future. Value in this context includes not only commercial value, but also unpriced values. Unpriced values are those that, for any reason, are not subject to market transactions — for example, the value (termed existence value) that individuals place on the knowledge that certain species continue to exist.

Market outcomes are likely to be efficient when the value that society places on the various uses of resources can be expressed through market prices that arise through the process of trade. However, under certain circumstances, markets left to themselves may fail to provide such an efficient outcome. These include the existence of poorly defined property rights, imperfect competition,
natural monopolies, certain kinds of uncertainty and the need for public goods provision (Hartwick 1989; Weimer and Vining 1992).

The most obvious form of market failure in the aquaculture industry arises from the allocation of sites between aquaculture and other uses of the marine and freshwater environment. A number of uses of marine and freshwater resources are not readily traded in the market yet they are deemed to be important to the community (such as conservation). Allocation decisions that do not take into account the full range of commercial uses, noncommercial uses and nonuse values of resources may result in an inefficient allocation. This set of issues is addressed further in chapters 3 and 4.

There is also broad consensus that there is a role for government to intervene in research. The most commonly used argument for intervention is that much of the information produced from research can be categorised as a public good (Curran and Podbury 1994). This means that, among other things, it is difficult to exclude individuals from using the information even though they have not contributed to the cost of producing it. This free rider problem is particularly widespread in basic research, although it may also be an issue in diverse industries such as aquaculture. Issues of government intervention in research are discussed in chapter 5, along with other Commonwealth government involvement in issues with wider industry coverage such as food safety and international trade issues.

**Regulatory failure**

While the existence of a market failure may provide a rationale for government involvement there is no guarantee that government intervention that is aimed at solving a particular market failing will necessarily improve efficiency in the use of the resources overall. Government intervention may even have adverse effects on the efficiency with which other resources are used. Indeed, the failure of markets to allocate resources efficiently may be caused partly by the institutional arrangements introduced by governments rather than any inherent ability of markets to allocate resources.

Where there is a case for intervention, the most cost effective way of intervening needs to be selected. There is a spectrum of possible approaches, ranging from market based mechanisms to regulation. Where a lack of basic information is a problem, the most cost effective intervention may be one of providing the information. This may be one of the problems associated with the apparent lack of capital in the aquaculture industry. In other cases, the solution may involve the creation of property rights and other incentives required to establish a competitive market. At the other extreme, the government may
be required to own and manage the resource (for example, national parks) or to ban or restrict certain practices. Between these extremes, combinations of market based and regulatory policies can be applied (Weimer and Vining 1992).

Market failure is not the only justification for government involvement in the aquaculture industry. Involvement may be justified for social objectives such as developing industries in regional Australia. However, the effectiveness of any form of government intervention needs to be carefully assessed to ensure that the benefits outweigh the costs. Issues associated with regional development initiatives for aquaculture are addressed in chapter 6.
3. Resource allocation and property rights

As an expanding industry, aquaculture is faced with two forms of resource issues. First, the availability of certain natural resources, such as water sites, will affect the development of the aquaculture sector. As these resources are not limitless and may also be useful in other sectors, there is a need for a mechanism to allocate scarce resources efficiently both between aquaculture and other users, and between individual aquaculturists.

Second, while aquaculture depends on the quality of resources and on the health of aquatic stock, it can also affect its surrounding environment. There is therefore a need for policies to ensure the environmental sustainability of aquaculture and to address any external costs generated by aquaculture.

Resource access and environmental sustainability issues may be usefully considered in terms of ‘property rights’ (see chapter 1). The need to develop aquaculture policies that determine access to resources or that aim to minimise external costs arises because the property rights governing some resources in aquaculture are poorly defined (Tietenberg 1988).

For land based uses of resources, institutions (markets) have developed over time to govern resource access. Providing the property rights to the site are well defined, it becomes clear which individuals own the land and the resources that flow through it. The question of which user should have access to the site can then be solved over time through trade. Sites ultimately go to those who value them most, with the result that sites are eventually allocated efficiently. These practices are widely accepted as an appropriate means to settle questions about the use of resources.

However, while highly developed institutions for using and trading in resources exist for many land resources (and therefore for most land aquaculture), the institutional arrangements for many coastal sites are frequently less well developed. This absence of efficient markets for many coastal resources occurs for a variety of reasons (ABARE 1993). For instance, the public nature of water rights means that there is no way that an individual user can buy rights to part of a waterway from current users to conduct private activities. The effect is that an efficient sharing of aquatic resources is not always achievable. There is therefore a need for a more efficient allocation structure for many coastal resources.
Property rights and external costs

The definition of property rights over natural resources will affect any potential external impacts from aquaculture. If the property rights governing the natural resources used by aquaculture are clearly defined, the actions of aquaculturists should not affect other users, either positively or negatively. In practice, however, some resources used in aquaculture have poorly defined use rights, as it may not be possible for aquaculture operators to protect their rights. For instance, there may be nothing to prevent other fishers from harvesting the mature fish that aquaculture operators seeded in an open fishery earlier. In this case, the external effects of aquaculture on other fishers are positive, but occur to the detriment of the commercial aquaculture operation.

In enclosed aquaculture activities, on the other hand, operators may be unable to prevent culture fish from escaping, with the effect that commercial fishing could be affected. In this case, the absence of well defined property rights may adversely affect the other users of the area. Policies may then be required to ensure that they are minimised. For example, recent debate on salmon farming in Canada has focused on the risks of disease that escaped farmed salmon may introduce to native stocks, so affecting wild harvest operations.

In practice, the varying nature of aquaculture activities means that the potential for external impacts will also vary. Aquaculture activities range from ‘closed’ systems, where good control can be exerted over the movement of water and organisms (for example, aquariums), to open systems, where there is little or no control of either the movement of aquatic organisms or the water flow. An example of the latter might be salmon ranching. With open or semi-open systems, such as where net cages are used to hold fish, it is often difficult to prevent the occurrence of external costs because of problems in preventing feed or waste entering the aquatic environment. By comparison, external impacts may be easier to prevent using closed or semiclosed systems because fish and water inputs are more controlled. As a result, there may be a greater risk of resource use issues emerging with open systems than with closed.

External effects may thus arise because of the absence of well defined property rights over the use of natural resources. These external effects may result in tension between aquaculture and other sectors where aquaculture operators seek to protect their rights or where other users seek to protect theirs.

Resolving resource use issues in aquaculture

In the past, the various instruments used by governments to manage resource use have been categorised in different ways — see Jaffe, Peterson, Portney...
AQUACULTURE DEVELOPMENT


Regulatory instruments

Regulatory or prescriptive instruments to manage resource use are approaches where controls are implemented, compliance is monitored and noncompliance is penalised (ABARE 1993). Direct regulations stipulate for resource users how much of a resource is used and in what way it is used. For instance, the government might impose specific limits on the level of emissions that operators pump into water courses, or it may insist that aquaculture may only occur in identified regions.

Regulatory instruments work by directly altering the legal rights that individuals have over their access and use of resources. As a result, they can be used to reduce resource issues by explicitly forcing operators to change their production methods to reduce external impacts, or to allocate resources among competing users. However, by binding users to particular methods of production, regulatory instruments may restrict users’ ability to respond to changes in market conditions. For example, restrictions to set methods of aquaculture production reduce the incentive for operators to develop cheaper and possibly more competitive methods of production. In addition, unless precisely targeted, regulations seldom remove the fundamental incentives that users face when exploiting resources in the first place. That is, the resources are generally exploited in the way they are because they offer financial advantages to the user; while they continue to do so, resource conflicts may continue. As a result, the use of regulatory instruments to allocate resources may not resolve resource conflicts in the long term.

As noted in ABARE (1993), the use of regulations has generally resulted in inefficient resource allocations. However, a potential advantage of these instruments is that often they can provide the government with a high level of control over the behavior of those using the resources.

Economic instruments

Economic instruments to manage and allocate resources across uses are designed to influence the behavior of resource users to ensure that resources are used more efficiently — that is, to ensure that conflicts are reduced and the welfare associated with resource use is increased. They work by redefining the use rights to resources so that producers and consumers of natural
resources bear all (or as much as feasible) of the costs that their choices impose on others (Industry Commission 1997, citing Department of Finance 1994). In economic terms, these instruments attempt to ‘internalise the external costs’ of resource use.

As a result, economic instruments provide a management option to redress some of the conflicts arising from any external costs associated with aquaculture, such as losses in landscape value. They may also be used as a mechanism to allocate resource use directly, where competition exists. For instance, tradable permits for aquaculture sites are currently used to share out sites in some countries (chapter 4).

Economic instruments include a range of measures that alter the attractiveness of different options available to resource users. The main examples are charges and taxes on resource use, subsidies and tax concessions for the use of alternative resources, performance bonds and tradable permit schemes (Industry Commission 1997).

Compared with regulatory instruments where users are constrained in their behavior, the use of economic instruments has the advantage that resource users are able to determine the response to a situation that best suits them. In some cases, economic instruments alone may be adequate to redress resource conflict issues. For instance, a deposit–refund scheme could be used to ensure that the environmental condition of a region is restored after it has been used. In other cases, however, economic instruments alone may be inadequate to ensure efficient resource use. For example, while a tradable rights system may reduce conflicts between users, it may not achieve the biological conservation of the stock. To achieve this, it may be necessary to combine a tradable rights system with other regulatory instruments governing where, when and how many fish may be caught (ABARE 1993).

Site allocation between aquaculture and other uses
A range of approaches can be taken to the management of site allocation for aquaculture. In assessing these from an economic perspective, it is necessary to consider the ability of instruments to maximise the benefits to the community of resource use. In the remainder of this chapter, the Australian experience with managing resource access for aquaculture is discussed. This involves looking at both the variety of instruments used in the allocation process, and the nature of the property rights allocated.

Coastal and other resources are allocated between aquaculture and other uses, as well as between competing aquaculturists. In the early stages of industry
development, these two processes are often rolled together in case by case management. This is the case for seacage aquaculture in New South Wales and the Northern Territory, for example. In contrast, regulatory processes tend to be much more formal in states such as Tasmania, where there is significant competition between aquaculture and other users, as well as between aquaculturists.

Some allocation instruments explicitly incorporate consideration of the tradeoffs between competing uses. Zoning systems are an example of such considerations in practice in the allocation of sites between aquaculture and other uses, as are preference criteria in the allocation of sites between aquaculturists. Other instruments such as tradable permit schemes bypass the need for government to consider tradeoffs by passing the responsibility for decisions to traders.

The mechanisms to allocate sites between aquaculture and other uses tend to be regulatory rather than economic. This is the case in both Australia and overseas (Holland and Brown 1999). An approach that is gaining favor in Australia is to undertake large scale site allocations using explicit planning or zoning strategies. An alternative approach is for government to consider industry requests for sites as they are made. The status of the planning regimes, as they relate to aquaculture, that are in place in Australian states is summarised in table 1. A fuller description is provided in appendix A.

Each of the states and the Northern Territory has some semblance of a zoning or planning system, though they have varying degrees of detail, coverage and specific attention to aquaculture. No Australian state or territory has yet been through the process of formally mapping the entire coast and allocating specific zones to aquaculture. The most effective processes have been selective — either by location or species. Tasmania has probably the most developed processes, with selected regions mapped in fine detail and sites allocated for aquaculture use.

Planning regimes in Australian states are either aquaculture specific or more broadly based coastal planning and are generally the joint responsibility of state and local government. Most of these planning systems explicitly acknowledge changes in values of competing uses over time by recommending or requiring that plans be reviewed every five to ten years.

Advantages of zoning or planning schemes
Zoning or planning based systems provide a clearcut means of allocating resources across competing uses. By restricting activities to specific areas,
## Status of marine aquaculture planning regimes

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Coverage</th>
<th>Status</th>
<th>Area</th>
<th>Time horizon</th>
</tr>
</thead>
<tbody>
<tr>
<td>New South Wales</td>
<td>Case by case assessment by interagency focus group including planning authorities</td>
<td>Aquaculture only, emphasis on environmental impact – nonestuarine</td>
<td>Implemented</td>
<td>Entire coast</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>For the life of the aquaculture lease</td>
</tr>
<tr>
<td>Victoria</td>
<td>Coastal Action Plans</td>
<td>Overall coastal management</td>
<td>Implemented</td>
<td>Selected regions</td>
</tr>
<tr>
<td>Queensland</td>
<td>Local Government Planning Scheme</td>
<td>Zoning of land use including aquaculture activities</td>
<td>Implemented</td>
<td>Entire coast</td>
</tr>
<tr>
<td>Western Australia</td>
<td>Development Plans</td>
<td>Aquaculture only</td>
<td>Partly implemented</td>
<td>Selected regions</td>
</tr>
<tr>
<td>South Australia</td>
<td>Aquaculture Management Plans</td>
<td>Aquaculture only</td>
<td>Implemented, under review</td>
<td>Selected regions</td>
</tr>
<tr>
<td>Tasmania</td>
<td>Marine Farming Development Plans</td>
<td>Part of an integral coastal management strategy</td>
<td>Implemented, under review</td>
<td>Selected regions</td>
</tr>
<tr>
<td>Northern Territory</td>
<td>Control Plans</td>
<td>Zoning of land use activities including aquaculture</td>
<td>Implemented</td>
<td>Selected regions</td>
</tr>
</tbody>
</table>
these systems can be used to achieve a broad allocation of the rights to use resources in an area between various user groups or combinations of user groups (Geen and Lal 1991).

The use of broad planning schemes to define use rights to sites and to minimise conflict between competing users is intuitively appealing (although such schemes have their limitations, as discussed in the next section). Resource capability plans, like those of Tasmania or South Australia, are useful for determining whether aquaculture on a site will ‘fit’ with existing resource uses, and they are relatively straightforward and easy to comprehend. The Tasmanian approach — outlined in box 2 — is a well developed example of site allocation in practice in Australia. Zoning and planning approaches that are similar in principle are applied at a national scale in overseas countries such as Norway and Canada (Holland and Brown 1999).

Box 2: Site allocation in Tasmania

Introduction
The Marine Farming Planning Act 1995 was introduced with the aim of promoting the economic and environmentally sustainable development of marine aquaculture. The act was used to establish a well defined planning framework to achieve this aim.

The act was part of the Tasmanian government’s response to community concern about the impact of marine aquaculture on coastal areas. The act deals with community concerns by requiring that draft plans include a detailed environmental impact statement. It also requires that these draft plans be publicly exhibited for comment. Tasmanian authorities were also dissatisfied with the then ad hoc nature of coastal resource allocation (DPIWE 1996a). This resource allocation problem was addressed by adopting a planning approach to coastal resource allocation for marine aquaculture through Marine Farming Development Plans — for examples of such plans see DPIWE (1996a,b, 1997, 1998a,b,c,d, 1999) and HMT Planning Pty Ltd (1998). Currently, there are nine MFDPs in operation and one draft plan on public exhibit.

Framework of the Tasmanian site allocation process
Under the framework provided by the Marine Farming Planning Act 1995 there are two distinct processes involved in coastal resource allocation for marine aquaculture. The first is where plans are used to allocate coastal resources between different user groups (for example, recreational fishing, tourism, marine aquaculture, etc.) in a geographic area such as a bay or a channel. These plans are divided into zones according to different geographic or environmental characteristics. Zones are further divided into a number of marine aquaculture sites or farms. The second process is to allocate farms between marine aquaculture operators.

The legislative framework for coastal resource allocation is described in the Tasmanian State Coastal Policy 1996 (DPIWE 1996c). In principle, planning decisions should promote the sustainable development of coastal resources, be equitable and should involve the different spheres of government, the community and industry.
Marine Farm Development Plans

Marine Farm Development Plans (MFDPs) are prepared to establish the zones where marine aquaculture is permitted. Each plan has management controls that regulate marine aquaculture in that area.

The process of preparing an MFDP is as follows:

1. The Minister for Primary Industries, Water and the Environment specifies an area of state water to be covered by the MFDP.
2. The planners preparing the MFDP submit a draft MFDP to the Marine Farming Review Panel. The panel is a statutory body established by the act and its main function is to review draft MFDPs.
3. If the panel decides a draft MFDP is ready for public exhibition it is then displayed publicly. To be ready for public display, the draft MFDP should contain the following information:
   • objectives that are consistent with the principles and objectives of sustainable resource management (such as those stated in the Tasmanian State Coastal Policy 1996);
   • the proposed marine farming zones of a plan area;
   • the proposed maximum leasable area for marine aquaculture;
   • an environmental impact statement; and
   • draft management controls.

   The panel then considers any concerns arising as a result of public exhibition and incorporates any appropriate modifications into the draft.
4. The panel submits its recommendation to the Minister to grant or refuse approval of the draft MFDP.
5. The Minister grants or refuses final approval to make the MFDP a legally binding document.

Environmental impact statements are incorporated in MFDPs to determine the ecological sustainability of marine farming zones and to assist future environmental impact monitoring. Baseline environmental data (such as water quality before marine aquaculture) is collected during the preparation of these statements. However, because some marine farms existed prior to the introduction of the act, the baseline environmental data required to evaluate environmental impacts may not be available. This lack of data may undermine the assessment of pre-act sites as ecologically sustainable and, therefore, compromise attempts by planners to minimise the environmental impact of marine aquaculture.

Some zones of a MFDP have stricter management controls than other zones in the same plan area. This highlights the flexibility of the Tasmanian planning approach, as some zones are more sensitive than others to marine farming in an environmental or visual sense.
Zones in environmentally sensitive areas require more stringent management controls in order to allow marine aquaculture activities to proceed. However, in practice, MFDP management controls differ little from each other. Only a few zones have special management controls, reflecting some zone specific environmental or geographic characteristics (DPIWE 1996a,b, 1997, 1998a, 1999).

MFDPs are used as a means to limit the scope for potential conflict between marine aquaculture operators and other users. This is achieved by first establishing whether a previous pattern of use exists at a current or potential site, such as the use of part of a bay or channel for navigation purposes, before the establishment of marine farms. If previous use(s) exists, a ‘grandfathering’ approach is adopted such that the previous users’ rights prevail. Thus if a previous use exists before the marine farm was established, the conflict is usually resolved by relocating or varying the farm lease area, removing the obstruction to other users’ access.

In the case of the visual impact of marine farms, the grandfathering approach to allocating resource rights among different user groups is not applied as strongly. Planners seek to limit the visual impact of marine farming by using management controls in MFDPs rather than a grandfathering approach. These visual controls are prescriptive, for example, requiring structures, buoys, cages and netting to be grey or black in color (DPIWE 1996a).

Once an MFDP has been approved there is no explicit conflict resolution system if the initial allocation of marine aquaculture sites is found to be unsatisfactory to coastal users. Amendments to MFDPs cannot be made unless the plan has been in operation for two years. However, after this two-year period is over an aggrieved individual may request the Marine Farming Review Panel to amend the MFDP. The panel may then choose to instruct the Department of Primary Industries, Water and the Environment (DPIWE) to modify the MFDP in question. Following this, the panel may then advise the Minister to accept the DPIWE’s modification to the MFDP. Final approval of the modified MFDP rests with the Minister. The act also contains provisions for concerned individuals to appeal against amendments.

Under the act, a review of an MFDP must be made at least once every ten years. The review is made by the DPIWE to assess whether if the MFDP is effective in achieving the objectives of sustainable coastal resource management. If it is subsequently found that the MFDP no longer achieves the objectives, then the DPIWE is to request permission from the panel to modify the MFDP. Unlike MFDP preparation and proposed amendments, the Minister is not required to grant final approval of a modification arising because of a review.

Site allocation

The process of allocating marine farming leases is established in the Marine Farming Planning Act 1995. After individual farming leases have been made available the sites may be allocated by any conceivable allocation instrument including tender, auction or ballot.

The Board of Advice and Reference, like the panel, is a statutory body established by the act. The board is the Minister’s main source of advice on how a marine farming lease is
Box 2: Site allocation in Tasmania continued

to be allocated. It also advises the Minister on what allocation instrument can be used and who is eligible to participate in the allocation process. The Minister determines how a site is to be allocated.

Before the allocation process proceeds, the board determines the pool of eligible participants. Several factors are considered when advising the Minister on the eligibility of participants for the allocation process. These factors include previous marine aquaculture experience or knowledge, business experience, scientific contribution to aquaculture research and environmental record. After the board has determined the pool of eligible participants then the actual allocation process can commence.

In practice, the allocation process of marine farming leases is conducted by means of competitive tender. The board selects the successful applicant on the basis of not only the highest bid amount for the lease but also:

• financial viability;
• knowledge of marine aquaculture;
• business plan;
• potential environmental impact;
• potential economic benefits to the state; and
• potential employment generation.

The board then makes a recommendation to the Minister on who should be the leaseholder. The Minister will then accept or reject the recommendation of the board. On the occasions that the Minister has rejected the recommendation of the board, the lease had not been offered to remaining applicants, as the standard of the tenders did not meet the required criteria (R. Hall, DPIWE, personal communication, October 1999). Successful applicants have the choice of either paying the bid amount immediately or over ten years at the prevailing interest rate.

The terms of marine farming leases are contained in the act. Possession of a marine farming lease confers exclusive possession of a lease area for a period of up to thirty years. The act contains provisions that permit transfer of leases.

Zoning and planning are forms of regulation that act in advance of industry requests for sites. In doing so, the groundwork is set for quite sophisticated systems for allocating sites between aquaculturists — such as bidding systems within competitive tenders. This can operate to maximise the benefits that can flow from a site.

Zoning sites in advance of industry demand may be helpful under several circumstances. The first is when potential resource competitors may ‘lay claim’ (through use) to resources and object when aquaculturists make requests for sites. By recording an interest in resources, aquaculture can be
factored into plans that manage the extent and location of other activities, in attempts to maximise total community benefit.

The use of zoning or planning, rather than case by case assessment may be important if case by case regulation can be expected to produce a less efficient layout of sites than planning. This may occur if the costs and benefits of sites depend significantly on the location of other sites. For example, if there is some advantage to having sites in close proximity to each other (perhaps because of economies of scale in infrastructure provision), then the positioning of the first site in an area may encourage the location of others nearby, even though there may be a better place for the final group of operations.

Zoning or planning, rather than case by case assessment, may also be justified on the basis of administrative efficiency if there is a lower unit cost of assessing sites in bulk. There may also be benefits that flow from the formal consultative processes that tend to surround planning processes. In the processes that have a strong element of public consultation, such as in Tasmania, reduction of community conflict has been a major priority. The extent to which this conflict has been actually reduced has not been quantified to date. However, Ackerfors and Rosenthal (1995) note that the zoning system used to allocate sites to salmon farming in Canada in recent years appears to reduce conflicts at the sites where competition and conflict previously existed.

In addition, such zoning schemes require the involvement of several tiers of government and industry in order to become effective. As a result, they provide a potentially constructive forum through which federal and regional agencies come together to facilitate coastal zone management. This is likely to be particularly significant in Australia. Through the Oceans Policy process and increased involvement of Environment Australia in the management of resource use, the coordination of Commonwealth/state policies is likely to become increasingly important. A process likely to maintain and foster such links is the ‘one stop shop’ approach to processing site applications, whereby applicants deal with a single agency that interacts with each of the consenting bodies.

**Limitations to zoning systems**

There are some limitations to the effectiveness of zoning systems as a mechanism for resolving conflicts over sites. Zoning is a form of regulation that acts in advance of demand for sites. When demand for sites is irregular or of unknown nature or scale, it may not be feasible (or cost effective) to plan successfully. There are situations in which constructing a feasible use of a site is an innovation that cannot be planned for — and so must be managed on a
case by case basis. An example may be the proposed barramundi farm near the Tiwi Islands. The operation is a joint venture between the indigenous users of the site, a feed company and government (ABC National Rural News, 3 December 1999). To overcome the costs that result from a shortage of existing infrastructure, the operation is of a very large scale. A zoning exercise undertaken in advance would be unlikely to have anticipated such a combination of factors allowing the development to go ahead.

There are further limitations of zoning systems as a process for maximising resource use value. For a start, zoning and planning systems are little different in principle from bans on aquaculture. That is, they are used to ban aquaculture activities from specified areas. As a result, in zones where aquaculture is not permitted, the same rigidities apply to resource use, and potential benefits may be lost to the community from the prevention of aquaculture.

In particular, once designated, zones may become fixed and it may be difficult for new activities to gain access to areas. At their inception, many planning systems necessarily accommodate only existing uses of sites or uses thought likely by planners. Sites zoned for aquaculture may contain bundles of resources less suitable for future than current uses. This means that emerging forms of aquaculture may become ‘locked out’ of potentially useful sites, while established uses become locked in.

A simple approach to this issue may be to have ongoing or repeated planning processes. This may involve reassessing established zones or plans against new technologies, market conditions and competing values. For example, the requirements of pearl culture was not given particular consideration in the last zoning exercise in Queensland. With the prospect of developing a pearl culture sector, Queensland is likely to consider pearl requirements in the next review of zones (P. Hayles, Queensland Department of Primary Industries, personal communication, April 2000). Reviews of planning and zoning policies are undertaken every five years in Victoria, South Australia and the Northern Territory. Reviews are at least every six years in Queensland, and every ten years in Tasmania. There is no specific review period in Western Australia, while in New South Wales, allocations are for the life of the lease.

However, problems may arise if it is found that established aquaculture sites are poorly allocated. To some extent this is an unavoidable consequence of the uncertainty surrounding planning decisions. However, in some cases it may make economic sense to reverse previous misallocation. For example a new activity, X, may be highly profitable but require transport access blocked by activity Y, which may be less profitable. It would only be efficient to terminate activity Y to allow the establishment of activity X if the net benefits over

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time outweighed the economic cost of adjustment, including any required cleanup of the old site and investment at the new site.

It is important that any such reallocations are not coercive, as such policies would discourage investment. In sectors of the economy with clear property rights and established markets, such reallocations take place readily through market transactions, when viable. Outcomes similar to those of such market transactions may be possible if government places the onus on businesses to demonstrate that the objectives of zoning or planning are met by any adjustment. The business proposing the new activity, X, could negotiate compensation with the existing business, Y, and finally present a proposal to the regulator. However, such an approach may more closely resemble case by case management than zoning or planning.

New South Wales uses a system of relinquishing one site for another for the oyster industry. Many estuaries have been judged to be at an appropriate scale for oyster production. This assessment may be targeted toward a combination of optimal use of nutrient resources available to oyster production, and space allocation to other uses such as recreation. Leases on new sites within such an estuary are available only when an existing site is relinquished. Changing sites may be motivated by environmental factors influencing oyster growth or economic factors such as transport cost time or access to land facilities.

A problem with many examples of site allocation systems is the lack of an economic dimension to the assessment of locations. Most of the zoning systems in Australia lack an explicit economic dimension. For instance, in Western Australia the zoning processes are not specifically designed to identify appropriate locations but to map constraints such as navigation zones and marine parks. Other states have gone further. In South Australia, for example, carrying capacity concepts have been employed as well as an assessment of use competition to determine zones and maximum scales of production for different species within those zones.

Overlaying zoning or planning systems with an economic layer may involve using information on the profitability of various aquaculture sectors as well as the influence that location and quality of resources has on this profitability. For example, a bay in a remote location may have the physical capacity to accommodate significant aquaculture production, though the water temperature may support only low value species, or the transport costs may reduce profitability of an otherwise valuable species.

Effectively gathering resource quality information may involve allowing experimental trials of locations. This may be particularly useful for mussel and
seacage operations, for example, which are quite mobile, but require very particular conditions relating to water flow and composition. In New South Wales, temporary site allocation has been used to test the commercial viability of operations on particular sites and to produce information useful for environmental impact statements, necessary prior to long term site allocation.

An economic dimension to planning may also be important if the government wishes to reserve areas for other uses. These uses may not have the same economic requirements, such as access to an international airport, or particular water characteristics, for instance. It may therefore be possible to use an economic overlay to minimise the cost of other uses to aquaculture opportunities.

An approach to planning of resource allocation that may provide the economic overlay discussed, as well as incorporating expected future aquaculture resource use, is to allow industry participants to propose site allocation plans or zones. Such a system has been used in Storm Bay, Tasmania. In such plans, industry participants are likely to give consideration to resource quality factors that have economic consequences.

There is increasing experience with the use of economic information in assessing benefits and costs of alternative resource allocations for comparable industries. Some significant examples are: the Regional Forest Agreement process (Dann et al. 1997); the assessment into resource use in Shoalwater Bay, which included military, fisheries and recreational use (ABARE, AGSO and BRS 1993); and the assessment of resource use in the Lake Eyre basin, which is used for mining, agriculture and as a water source (ABARE 1996). These experiences are likely to become increasingly useful with the implementation of Australia’s Oceans Policy, which requires the incorporation of economic considerations into marine planning processes:

‘Ocean resources should be allocated to the mix of uses within a planning area that offers the greatest long term community benefits (taking economic, environmental, social and cultural values into account) compatible with maintaining ecosystem health.’ (Commonwealth of Australia 1998, p. 37).

Site allocation between aquaculture producers

A variety of instruments can be used in the allocation between aquaculturists, each with different implications for the efficiency of resource use. However, the nature of the rights allocated can also affect the benefits that flow from aquaculture. In many cases, the property rights allocated to aquaculturists in Australia are inadequate when considered in the context of economic efficiency.
The nature of property rights

A number of characteristics of property rights over aquaculture sites are desirable in order to ensure the efficient use of resources. Many of these are legislatively available in the lease and licence systems of Australian states, though in many cases the rights that have generally been allocated to date fall short of these conditions in practice. For example, while in South Australia there is the facility for government to allocate 40 year aquaculture leases, most aquaculture takes place under a development permit and an aquaculture licence, which must be renewed every year. Similarly, in New South Wales, marine aquaculture leases can legally be granted for fifteen years, but in practice it has recently been difficult for aquaculturists to gain approval for such leases. Before applying for leases, a number of aquaculturists in New South Wales have sought permission to operate trial projects to allow information to be collected on the environmental impacts of operations.

A summary of the property rights systems legislatively available in Australian states is given in table 2, with a fuller description in appendix A. It should be noted that because of impediments to the granting of full rights, in some states, these full rights have rarely been granted. In some cases this may be seen as a teething period for new legislation. In Western Australia for example, the use of leases for aquaculture rather than licences only is expected to become effective soon.

Perhaps the most important characteristics of property rights for aquaculture are exclusivity and duration of rights. A property right is exclusive if the owner of the right receives all of the benefits and bears all of the costs of using the resource. The incentives to take into account the full benefits and costs of

<table>
<thead>
<tr>
<th></th>
<th>Lease duration</th>
<th>Transferable</th>
<th>Divisible</th>
<th>Exclusive access</th>
</tr>
</thead>
<tbody>
<tr>
<td>New South Wales</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Victoria</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– reserved Crown land</td>
<td>21</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>– unreserved Crown land</td>
<td>21</td>
<td>No</td>
<td>Subletting only</td>
<td>Yes</td>
</tr>
<tr>
<td>Queensland – licence only</td>
<td>15</td>
<td>Yes</td>
<td>na</td>
<td>No</td>
</tr>
<tr>
<td>Western Australia</td>
<td>21</td>
<td>Yes (for pearling)</td>
<td>no</td>
<td>Yes</td>
</tr>
<tr>
<td>South Australia</td>
<td>40</td>
<td>Yes</td>
<td>yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Tasmania</td>
<td>30</td>
<td>Yes</td>
<td>negotiable</td>
<td>Yes</td>
</tr>
<tr>
<td>Northern Territory</td>
<td>4 or perpetuity</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
resource use are greater the more exclusive is the property right. As a simple example, the investment of a finfish farmer is likely to be significantly discouraged if recreational (or commercial) fishers have rights to harvest fish from the farm. However, exclusive access to the location of the site is often not necessary, as long as the aquaculture activities are not interfered with. Exclusive access in some cases may be an impediment to the allocation of sites, as other users of the space may object. For example, in the Northern Territory it is thought by many to be unhelpful to prevent line fishing over pearling leases.

A significant duration of rights is important so that long term income can provide a return for appropriate investment. Like nonexclusive rights, short term property rights can inhibit investment, because much of the benefit of potential investment may flow after current rights have ceased. Where duration of rights is implied (through expectation of renewed permits, for example) rather than existing as entitlement, it may be difficult for finance to be attracted, as the strength of the implication may be difficult for industry outsiders to assess. This may be the case in Victoria, where marine aquaculture currently operates under a one year licence system. Government must show cause for nonrenewal of licences under the current system. However, a lease of significant duration, even if contingent on the existence of a licence, may act as a signal to outsiders (such as providers of finance) of the economic value of the expectation of licence renewal.

Another important feature of property rights, fundamental to site trading systems, is the transferability of rights. Transferability allows resources to flow to users that value them most. Trading systems are discussed more fully in a later section. It may also be important for rights to be divisible, allowing transfer of a portion of the property rights. This would be valuable if an aquaculture site could more profitably accommodate a number of specialist producers than a single operator.

Method of allocation

In this section, a variety of instruments for allocating sites between aquaculturists are discussed. Instruments can be used to allocate these rights in a ‘static’ sense — that is, where lease allocations are largely fixed for the duration of the lease or permit. Alternatively, they can be used to determine initial allocations of rights that can be subsequently transferred (sold or sublet) between users within the duration of the lease. A summary of the methods used to allocate sites between aquaculturists in Australian states and the Northern Territory is provided in table 3. In some cases, these principles could be extended to allocate sites across sectors.
A fairly traditional and transparent approach to site allocation is to use ‘first come, first served’ principles. While no Australian state currently uses this process alone, it is a useful benchmark that may represent the simplest mechanism for determining initial site allocations. It may also be difficult to use other systems in the absence of an effective zoning system. The less formal allocation processes of New South Wales, the Northern Territory and Western Australia can roughly be characterised as ‘first come, first served’. However, the case by case management in these jurisdictions clearly also involves examination of applicant credentials as well as the prospects of use proposals. The ‘first come, first served’ method is used for providing access to aquaculture resources in New Zealand (see Holland and Brown 1999, p. 37).

‘First come, first served’ systems for allocating sites overseas have not always been accompanied by efforts to manage the cumulative effects of multiple operations. Excessive levels of activity on a site may result in excessive impacts on tourism, the residential sector, or other users of the environment. As a result, ‘first come, first served’ bases for allocating site permits have not always been retained in countries overseas (Holland and Brown 1999, p.37).

However, ‘first come, first served’ approaches to site allocation need not be accompanied by poor environmental management. There are a number of environmental performance management mechanisms that can be implemented independently of the process of choosing between businesses. Such instruments are discussed further in the next chapter.

The allocation of sites between businesses on an almost arbitrary basis, however, is likely to fail to be efficient if that allocation is fixed and not transferable. The businesses allocated sites may lack the necessary expertise or financial resources, or may be in the business of producing a species of relatively low profit. Alternatively, they may produce a species that is not as well suited to the site as are some other species.

### Allocation of sites between aquaculturists

<table>
<thead>
<tr>
<th>Allocation method</th>
<th>South</th>
<th>New South Wales</th>
<th>Victoria</th>
<th>Queensland</th>
<th>Western Australia</th>
<th>South Australia</th>
<th>Tasmania</th>
<th>Northern Territory</th>
</tr>
</thead>
<tbody>
<tr>
<td>First come, first served</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Preference criteria</td>
<td>X^1</td>
<td>X^1</td>
<td>X^1</td>
<td>X^1</td>
<td>X</td>
<td>X^1</td>
<td>X^1</td>
<td></td>
</tr>
<tr>
<td>Bidding system/tender</td>
<td>P</td>
<td>X^1</td>
<td>X^1</td>
<td>P^1,2</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

X Primary method(s). P Legislatively empowered to use.
1 See appendix A for further details. 2 Includes negotiation.
The characteristics of a process that may be deficiencies when dealing with a large number of operators may be appropriate when dealing with a small number of operators. In areas with little aquaculture, it may be individual business innovation that invents a profitable use for a site. It may stifle such innovation to put the new site to tender.

Further, if property rights covering sites are well defined and are fully transferable (as discussed above) then the efficiency of the initial allocation should have little impact on the efficiency of the final allocation. Trading systems for aquaculture sites are discussed more fully later in this chapter, in the section on dynamic allocation of sites.

**Bidding systems**
Under a bidding system, rights to use a site go to the highest bidder (providing that the bidder can demonstrate an ability to meet certain environmental constraints). This approach means that, in principle, rights would flow to the most efficient user groups.

Bid options can be used in a number of Australian states to allocate aquaculture sites, most prominently in Tasmania as part of the competitive tendering process. New South Wales, Victoria, Tasmania and the Northern Territory have this facility, though it is not currently standard practice in any of these cases. In New South Wales, for instance, aquaculture leases may be allocated by auction, public tender or ballot. Alternatively, a potential aquaculturist may simply apply for a lease in a selected area. Because of the small number of leases (other than oyster leases) granted in New South Wales, this has been the process used to date. The use of bidding systems may become increasingly useful as aquaculture expands in many Australian states. In Tasmania there is also flexibility, although a competitive tender process is generally used, which involves a bid for the lease, as well as claims against a number of other selection criteria. These criteria are discussed further below.

Bidding systems have also been used overseas. In the 1970s, for example, they were used in Japan to determine the allocation of farming grounds for laver culture through an annual lottery. At the same time, a limit was applied to the number of nets used per family in order to ensure that the available grounds were distributed equally among all families (Hirasawa 1980). Today, public offerings are occasionally held in British Columbia which allow competitors for a site to submit sealed bids to the relevant government agency for use rights, though further criteria must also be met (British Columbia Ministry of Agriculture, Fisheries and Food 1997).
A feature of bidding systems is that there is a transfer of a proportion of the expected commercial benefits of the venture (or resource rent) to government. This has primarily distributional consequences, rather than efficiency consequences (provided transaction costs are low). However, where there is not such a transfer there is the potential for aquaculturists to expend an inefficiently large portion of the commercial gains from aquaculture attempting to acquire leases. Substantial bids may also act as a useful signal to government that there are in fact significant benefits from a sector — in the view of industry. Opposing this is the concern with the possibility that the ‘up front’ cost of acquiring sites through auction may inhibit certain forms of worthy investment because of capital market imperfections.

The use of bidding systems to allocate aquaculture sites could in principle be extended to allocate sites between competing sectors, rather than simply between individual businesses. Operators from a sector offering the highest bid for a site could gain access to the space. However, depending on the use to which sites are put, bidding systems on their own may not be sufficient to ensure the most efficient use of sites in the long term. This may be where access to a site does not constrain individual exploitation, resulting in excessive environmental degradation or overcrowding in a region.

Similarly, when rights are obtained through a ‘one off’ allocation, the efficiency of resource allocations is unlikely to be maintained over time. Changes in the value of resources to different sectors may mean that an original allocation achieved through a bidding system is no longer that which best satisfies the desires of the community. As a result, it would be necessary to combine a bidding system with trading systems, or with regulatory and monitoring mechanisms to control waste, access to broodstock or to mitigate visual impacts.

**Preference criteria**

The allocation of aquaculture sites between businesses in Australian states tends to involve consideration by the government of a number of criteria, often in addition to any bidding system. These criteria may reside within the approval processes of a number of discrete government agencies, which must give consent for development to go ahead. This is the case in Queensland. Alternatively, a ‘one stop shop’ approach can be taken. In Tasmania, for example, there is an explicit list of criteria against which a coordinated assessment of applications for sites is made. The criteria examined in Tasmania are:

- financial viability;
- knowledge of marine aquaculture;
- business plan;
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- potential environmental impact;
- potential economic benefits to the state; and
- potential employment generation.

A notable feature of this list is that a number of the criteria do not target economic efficiency. For example, the employment generation criterion is designed to influence the distribution of income rather than the efficiency of resource use. It is conceivable that a potential operator using capital intensive technology may be refused an allocation in favor of an operator employing a greater number of staff, even though the former plan may generate greater net benefits. This is particularly significant if the future of Australian aquaculture is capital intensive rather than labor intensive.

Allocation on the basis of criteria other than efficiency has also occurred in other countries. In New Brunswick, Canada, large scale job losses occurred in the local commercial fishing industry during the 1980s and 1990s when the North Atlantic groundfish fishery collapsed. In response, the provincial government sought to redistribute rights and wealth in the region by focusing on the needs of ex-commercial fishing operators. As a result, the allocation of new marine sites for finfish aquaculture purposes currently involves the use of an explicit order of preference, so that commercial fishers have first refusal on the use of the sites.

This means that if aquaculture operators compete with wild harvesters to use a coastal site for, say, salmon farming, commercial fishers still have preference on site access, even if their enterprise is less valuable to the region. If two or more wild harvest applicants are eligible to be approved for the same site, access is granted to the applicant who lives closest to the site.

In the late 1970s, a similar criteria based process was applied in Japan to settle competition for resource access between aquaculture operators and wild harvest fishers for the use of coastal zones. At that time the allocation of sites was determined according to eligibility, where all applicants for a site had to have prior fishing experience, and order of priority (Hirasawa 1980).

Criteria for allocating sites among users in Australia tend to reflect a variety of objectives other than the needs of special interest groups (such as ex-commercial fishing operators). For instance, criteria are often largely focused on ensuring that sites go to the operators who are likely to operate the most successful business. This could lead toward the most efficient allocation of sites across uses in the short term and, if permits were tradable, the efficiency of resource allocation could be sustained in the long term.
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However, selection criteria for aquaculture site allocation in Australia are sometimes combined with a bidding system in a tendering process. This is regularly the case in Tasmania. The need for both the bidding system and criteria designed to assess likely business profitability is questionable. This is particularly so if the administrative costs of assessing tenders is high.

The question naturally arises of what ‘appropriate’ selection criteria for allocating sites (and other) resources might be. This will depend in part on what it is that governments wish to achieve. The conventional objective of economists in resource allocation has been the generation of social efficiency — in effect, the maximisation of wealth and welfare in the community (see Tietenberg 1988 for an introduction to efficiency). However, other objectives may also exist. Governments may seek to achieve a more equitable distribution of wealth by concentrating resources on particular social groups, or on industries with an impact on particular groups. This may be the basis for the Tasmanian government’s preference for businesses with high labor requirements, over those with the potential for maximum wealth generation alone.

Governments often seek to achieve an allocation of resources where both efficiency and equity objectives are included. In some cases, multiple goals for resource management can be complementary. For instance, a successful tradable quota system can be used to meet environmental goals while optimising resource use efficiency in the same set of instruments. On the other hand, some multiple goals for resource management may conflict, requiring policy makers to make tradeoffs between conflicting goals. The ability to achieve goals other than wealth may then affect the wealth creating potential of the resource. For example, a preference for operations that produce high levels of employment would inevitably mean forgoing some level of potential value from site use in favor of increasing employment.

It is therefore important that any criteria for allocating space (or other) resources should be accompanied by an explicit recognition of the tradeoffs made that allow one user or activity to have access to resources rather than another. Any criteria should be accompanied by recognition of the costs of each decision. This is particularly so if the initial allocation of sites is fixed — that is, where more profitable users of the sites can not acquire access to the sites from the initial users. Trading systems are discussed in the next section.

Trading systems
Dynamic instruments for allocating rights to sites across uses allow rights to be transferred across users, usually within the same sector, although they may also have the potential to facilitate intersectoral transfers as well. Transferable rights systems are characterised by trading systems and/or subleasing systems,
whereby lease holders are able to transfer the rights to use a site to another holder.

Australian rights systems accommodate transfers quite well — whether it is by means of business sale, or lease transfer. An unprofitable snapper farmer may, for example, sell the business (or sublease the site) to a kingfish farmer. This may be a transfer of the productive resources of the site to a higher value use (in the particular location).

Trading systems involve the allocation of rights to use a site that are tradable across users. The initial allocation of rights can be determined on a variety of bases, such as those discussed above — that is, ‘first come, first served’ criteria based allocation methods or bidding systems. The advantage of the trading system is that, in theory at least, rights tend to flow to operators who are prepared to pay the most (and value them the highest).

New South Wales, Victoria and Tasmania have the facility to use rights systems for aquaculture that include transferability (table 3). While it has been noted that the property rights that tend to be granted in practice often fall short of those in table 3, in most cases transfer of sites can take place through the sale of aquaculture businesses. Some form of transferability is fundamental to site trading systems. In principle, this approach allows flexibility in the allocation of space across competing users. Between competing aquaculture operators, permits for access to use a site can be traded between operators to ensure that sites are ultimately allocated to the most efficient aquaculturists. Furthermore, in principle, leases could be traded across sectors so that sites are transferred to the most efficient users.
4. Managing environmental issues

The impacts of aquaculture on the environment range from positive through relatively benign, to negative. Aquaculture may offer, for example, an important means of mitigating the costs of addressing the major environmental issue of inland salinity. In contrast, the cumulative effect of many farms in an enclosed estuary or river may warrant efforts to limit nutrient runoff.

The introduction of aquaculture to an area may also introduce new issues for the environmental management of current uses and plans. For example, the introduction of the culture of filter feeders (such as oysters or mussels) places additional pressure on managers of ‘upstream’ users of water resources to minimise the risk of releasing toxic materials. The additional costs of risk mitigation that may have to borne by others outside the aquaculture industry may or may not be justified by the benefits of the new aquaculture use.

The potentially large benefits of some forms of aquaculture may justify a rethink of overall environmental planning in certain regions. For instance, environmental planners may consider that existing activities such as agriculture, sewage treatment and residential land release an acceptable quantity of nutrient, but that additional release by aquaculture should be avoided. However, existing activities may be able to limit nutrient release at costs that are low compared with the benefit of permitting aquaculture. If this is so, it may be that environmental regulators should ‘make room’ for aquaculture in their plans for regional nutrient release levels over time.

There are a number of mechanisms that can be used to manage the interactions between aquaculture and the environment. These range from relatively blunt instruments (such as bans on some activities in some locations, and approval of others) through to instruments that offer economic incentives to minimise negative environmental impact and maximise positive impact. Institutionally sophisticated instruments such as tradable pollution permits as well as pollution taxes and cleanup payments may be limited by the feasibility of effectively measuring impact levels, which may require continuous flow monitoring or complex modeling of location specific impacts. In other cases, problems lie in the difficulty of defining the impacts to be measured. Visual impact is a key example here.

While sophisticated environmental management instruments can offer significant benefits, these may be outweighed (particularly in the early stages of industry development) by the cost of implementing such schemes.
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Nevertheless, improvements may often be made, over very blunt environmental management instruments, by innovative approaches designed to establish the right incentive structures.

Information gathering

A hurdle for the formation of appropriate environmental management policies for sectors of industries as well as individual operators is the lack of complete certainty about the impacts of a proposed or ongoing operation. While it may be reasonable to expect a resource user to be responsible for the costs of complying with environmental management and any associated risks of environmental damage, this may be assigned to the user in defining the property rights for resource access and use. However, since the risks of external costs associated with resource use can rarely be eliminated and in many cases are quite uncertain, the question arises of how much risk governments are willing to accept in exchange for aquaculture production. Given the substantial cost of gathering information to reduce uncertainty, the question also arises of how much information should be provided by government. Governments need to trade off the likely benefits that aquaculture production may generate to the community against the risks that external costs may arise.

Many of the impacts of aquaculture may be quite location specific. For instance, any additional risk of algal blooms that nutrient release by aquaculture may produce may depend on a large number of factors including water temperature and rainfall patterns, as well as levels of nutrient in the water from other sources.

To some extent, science can be used to reduce uncertainty about the effects of aquaculture on other users, although it can rarely eliminate it. Rather, it can be used to more narrowly define the boundaries of risk. As a result, scientific investigation and monitoring has a valuable role to play in avoiding resource use conflicts. Prior to the establishment of operations, an important tool for reducing uncertainty is an environmental impact assessment, which is a systematic, integrated assessment of both the positive and negative impacts of new developments. The purpose in an assessment is to identify and predict environmental impacts and their consequences, to interpret and communicate information about the impacts and to provide information to the decision making and planning processes (European Commission 1995). In the longer term, ongoing monitoring may also be important.

Environmental costs

Aquaculture, like most industries, has the potential to produce levels of environmental impact that are not socially desirable if interactions are not well
managed. These may include spreading fish diseases, fish escape, modifying
habitats, and releasing nutrient pollution. It is of key importance for the devel-
opment of the aquaculture industry, however, that environmental management
is done in ways that do not unnecessarily raise costs or inhibit expansion.

Waste

Aquaculture production systems usually involve the introduction of materials
(particularly feed) and may involve modification of the site to accommodate
production. As a result, wastes are usually produced, such as uneaten food,
faecal and urinary products but also chemicals (for example, vaccines) that
may find their way into the environment. Filter feeders such as mussels are an
important exception. Rather than releasing wastes, mussels actually remove
nutrients from the water.

The release of waste products from aquaculture sites can have both localised
impacts, such as changes in the marine life below the sea cages and, if waste
levels are high, broader impacts from increased nutrient levels in surrounding
waters. These impacts have been discussed in a number of studies interna-
tionally. For example, Tsutsumi, Kikuchi, Higashi, Imasaka and Miyazaki
(1990) noted that some fish farming activities in Japan in the past resulted in
significant organic pollution of the water and bottom sediment in the vicinity
of cages, resulting in the temporary disappearance of benthic animals. Where
wastes are inadequately managed, the potential effects can be significant —
see, for example, Gowen, Rosenthal, Mäkinen and Ezzi (1990) and Munford

The waste impacts of aquaculture can potentially be managed in a number of
ways. Mechanisms for waste management can broadly be categorised as either
regulatory or economic and include the use of simple siting guidelines through
to tradable pollution permits. The most appropriate system may depend on
factors including the feasibility and cost of monitoring pollution. For exam-
ple, high monitoring costs may outweigh any efficiency gains from using a
tradable pollution system rather than siting guidelines, particularly if the indus-
try is small or in its early stages.

Bans are perhaps the most rigid regulatory mechanisms for controlling waste
impacts, though their simplicity and transparency can be of value. Bans work
by effectively removing altogether any rights to a particular resource use (input
or practice) that leads to the waste impact. The use of bans on particular inputs
or methods of production provides a rapid means of reducing the potential for
waste damage and environmental degradation in an area. It also provides
explicit guidance for operators to be certain about what is or is not an accept-
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able practice. For example, the use of a particular chemical may be banned in any quantity because of the waste impacts.

However, as a means of reducing resource use conflicts and of ensuring resource use efficiency, bans can be limiting, particularly in the long term. For a start, the use of a ban does not allow any recognition of the tradeoffs of the potential benefits from aquaculture against waste emissions. Also a ban on the use of a particular input or practice does not remove the fundamental incentive facing operators to choose it in the first place. That is, operators adopt such behavior because it makes business sense. Unless equivalent bans are then put on alternative damaging substitute practices, resource conflicts may continue to arise.

At the same time, with developments in technology or changes in the value of aquaculture products, the socially desirable level of particular activities or inputs in an area may change. As a result, the efficiency of resource use over time under a ban may be diminished.

Bans are of most use when the negative impacts far outweigh the benefits from the practice or input use at any level. However, many of the waste impacts of aquaculture result from the release of excrement and uneaten food, which is unavoidable at some level if aquaculture (of many species) is to take place, and may cause minimal disruption to the environment if kept at reasonable levels.

Standards, while still somewhat rigid, are a regulatory instrument that focuses to a greater extent on the environmental outcome. As a result, the aquaculturist has the freedom to meet the standard in the lowest cost way, depending on site and market conditions. Standards are designed to provide minimum or maximum limits on defined outcomes. For instance, in waste management, they may work by removing the right to reduce water quality below a certain level or to release waste beyond a maximum level. The incentive to innovate in waste minimisation is clearly created by the benefits of producing greater quantities of output within the standard.

Siting guidelines and site allocation processes for many forms of aquaculture are an important aspect of environmental management, and are likely to continue to be so. As discussed in the previous chapter, while often making little use of market mechanisms, if economic considerations are taken into account, site allocation processes can incorporate efforts to maximise the net commercial benefits of aquaculture while minimising resource use conflicts and negative environmental impacts.
The inclusion of site allocation processes in environmental management allows for the management of the cumulative effects of aquaculture and other activities through limits on the number of farms (with a particular average waste output) in an area. It also allows management to be tailored to the particular local environment, its sensitivity to aquaculture, and its value for other uses. However, for management to take account of location specific characteristics of the environment may require substantial information, which is discussed in the section on information gathering.

The use of site allocation processes in the absence of other mechanisms has a number of drawbacks as a waste management tool. If waste output is the limiting factor in the allocation of sites in an area, it may be that net benefits can be created by efforts in each farm to create technical efficiencies in waste reduction. Incentives to become more efficient may be created by regulators defining aquaculture rights to include specific waste limits (or rights), while accommodating proposals for expanded production within those waste limits.

Individual farm limits on waste output may also be combined with provision for the transfer or trade of rights to release certain forms of waste in order to produce further efficiencies. These may result from the transfer of rights from inefficient producers to efficient producers, or transfer of rights from those that can reduce waste at low cost. Such a system may also be useful for transfers between sectors of the aquaculture industry or between industries. For a further discussion of the principles of emissions trading, see Hinchy, Thorpe and Fisher (1993), Young, Gomboso, Collins and Howes (1994) and Hinchy, Hanslow, Fisher and Graham (1998).

Despite substantial potential benefits in the right circumstances from more sophisticated mechanisms such as waste emissions trading systems, there are a number of considerations that may favor simpler systems in many cases. One is the difficulty and cost of monitoring waste release. It may be that occasional planned checks by authorities of water quality offers a poor guide to the quantity of waste released over a period of time. This may be because of natural fluctuations and the potential for producers to manipulate water quality on the day of monitoring by, for example, feeding less on that day. If it is costly to overcome such difficulties where they exist, waste output based systems (such as waste taxes, tradable waste rights, and waste caps) may offer little benefit beyond the simplest of systems such as siting guidelines. Any gains may be completely outweighed by monitoring costs.

Second, waste may not be a tradable commodity as it may be spatially differentiated. The damage caused by waste in one area may not be the same as damage caused by the same volume of waste (however measured) being
released in another location. Therefore, because of such variability, the markets may become too thin to allow an efficient price determination process to be developed.

The economic implications (for the efficiency of management systems) of measurement errors and the potential to cheat depend not only on the system, but also on the extent and uniformity of the inaccuracy. If for all operators, at all times, measured pollution is 20 per cent lower than actual pollution, it is a simple scaling exercise to understand actual waste output. If individual or global caps are set accordingly there would be little impact on the outcome of a waste quota market or any other system.

However, if the ability (or willingness) to cheat varies between operators, a waste quota market system would produce not a tendency for transfer of pollution rights to the points of greatest benefit, but rather a transfer of wealth to those with the greatest ability to cheat, from other producers. Similarly, under a system of individual caps, some producers would face real waste restrictions, while others would not, creating an inefficient production cost differential and the incentive to invest in technologies that make avoidance of restrictions easier.

Such inefficient outcomes may also exist between industries. Binding restrictions may be placed on waste from aquaculture (or sites may be limited), while other industries that produce similar waste in larger quantities may not be so restricted. For example, it may be that certain forms of agriculture that release nutrients into waterways have low net benefit, while aquaculture may produce large benefits if it were permitted to produce similar levels of waste. It could be argued that a proportion of waste emission rights should be transferred from the agriculture activity to aquaculture. If this cannot be done within a market system, there may be potential for such a transfer by way of tightening regulatory restrictions on the agricultural activity, while allowing aquaculture to expand.

**Impact on amenity values**

Many of the environmental impacts of aquaculture are related not to influence on ecosystems, but rather to visual impacts and interference with recreational uses of sites. Resolution of conflict with other users is discussed in earlier chapters, though it may be helpful to comment here on issues relating to ‘visual pollution’, which is the cause of many objections to aquaculture development. Mussel farms, for example, may face objections due to the visibility of buoys used to support longlines. Oyster farming also faces criticism due to the visibility of oyster racks in estuaries at low tide, as well the space taken up close
to shorelines in these estuaries. Seacages, and onshore production facilities may also be considered by some to mar coastline valued for its visual appeal.

Often these impacts are difficult to reduce by any means other than restricting the extent of the aquaculture activity. When this is the case, governments must weigh the net commercial benefits of the proposed aquaculture venture against the value the community places in an unaltered appearance of the potential aquaculture site. However, it may be that negative visual impacts can be minimised through restrictions on the extent of visibility, rather than extent of the aquaculture activity. Unfortunately, the difficulty of defining, or quantifying the impact, of these public externalities can produce a tendency for often costly case by case management that imposes regulatory solutions. For example, there may be regulation of the color of buoys for mussel longlines. Other solutions to visibility problems may include submersible seacages, restrictions on lighting, times of work and exact location of sites.

When measures such as these are imposed, regulators should be mindful of the cost of the improved appearance in terms of reduction in net value of the aquaculture operation. Some improvements may be low cost, while others can threaten the viability of the aquaculture operation.

**Abandoned sites**

In industries that make use of public spaces, environmental rehabilitation work may be required after an activity or project is completed or abandoned. This may be worthy of consideration for some aquaculture sectors. The problem presents because there may be few natural incentives for users to carry out rehabilitation of their own accord. The work required can range from removal of equipment through to restoration of natural vegetation and land features. Where there are major earth works that, for example, interfere with water flows that are considered important, or if there is equipment used that is likely to have a lower scrap value than the cost of removal (such as oyster sticks), it may be useful to implement a policy that influences the incentives faced by aquaculturists.

A mechanism that can be used to alter the incentives faced by aquaculturists is a performance bond, returned to the operator if rehabilitation is carried out to standards clearly identified as a condition of the lease. In the event that the operator goes out of business and/or fails to meet the conditions of operation and environmental standards required, the bond would instead be used to clean up the area. The bonds can also be used as an adjunct to any system of fines associated with poor environmental performance during the life of the lease. To ensure that an operator is not economically disadvantaged, if they do follow
lease guidelines, the bond should earn interest over the period. For a discussion of the nature, operation and impact of performance bonds, see ABARE (1993).

An example of an environmental performance bond being used for aquaculture is in the oyster industry in New South Wales. In response to substantial rehabilitation costs for abandoned sites in recent years, industry participants will, from 2001, be required to pay a bond, or contribute to a trust fund that will be used to rehabilitate abandoned sites (R. Bow, Aquaculture Administration, New South Wales Fisheries, personal communication, June 2000). Perhaps the fundamental problem for cleanup of oyster sites is the negligible salvage value of oyster racks, compared with the cost of removal.

Despite the potential benefits of deposit–refund schemes, environmental rehabilitation costs for many forms of aquaculture are far less significant than those for other activities such as mining, which may have cleanup costs running into millions of dollars. When rehabilitation costs are low, it may be that the costs of administering a deposit–refund scheme outweigh any benefits.

**Escaped fish, parasites, diseases and secondary organisms**

Farm fish may escape into the wild for a number of reasons, including human error, storm damage to net cages, inadvertent release during transport and predator damage to net cages. Diseases and other organisms may also be introduced into the environment because of aquaculture, in the process of transporting feed, fingerlings or brood stock.

The release of organisms into the wild environment may represent a negative externality on other users by adversely affecting wild fish stocks and their environment. Nonindigenous diseases may, for example, have a large impact on populations that have not evolved resistance. There was speculation, for instance, that disease carried in pilchards imported as feed for farmed tuna was responsible for substantial pilchard deaths in southern Australia.

Escaped fish (either the fish intended for transport, or an accidentally transported species) can cross breed with wild fish, which may have effects on the genetic integrity and survival of wild stocks. Alternatively, feral populations of transported species may be established. Through predation and competition for food, feral populations can alter the environment, potentially affecting commercial and recreational fishing as well as other activities that use aquatic resources.
While there are natural economic incentives for farmers to keep stock in their net cages, and to avoid importing disease, many of the benefits of reduced risk are not private. Consequently, aquaculturists may, from society’s perspective, insufficiently ward against such risks.

Clearly, a zero risk approach is both impossible and an inappropriate target. For instance, even if it had been found that the pilchard deaths were related to tuna farming, it may still be that the very large benefits of tuna farming outweigh the costs associated with reduced pilchard numbers. It would therefore be appropriate that risks and the costs associated with such risks be somehow incorporated into the property rights granted to aquaculturists in establishing their operations.

The policy response to the risks associated with the translocation of living and nonliving materials for aquaculture (as well as the culture of previously transported organisms) tends to be regulatory rather than market based, because of the difficulty that would usually exist in establishing property rights over ecosystems, or the pricing of risk to those ecosystems.

The National Policy for the Translocation of Live Aquatic Organisms (Commonwealth of Australia 1999) sets out federal policy relating to translocation of live aquatic organisms into and within the country, while quarantine policies deal with transport into the country of dead aquatic organisms, such as frozen or fresh fish. The intention of the translocation policy is to set out a consistent national framework for assessing the risk associated with moving organisms between locations.

From an economic perspective, it is necessary to consider not only the risks associated with translocation, but also the tradeoffs. What would be the costs resulting from a negative event occurring through translocation? And second, what does the community forgo by choosing not to allow translocation? Very often, it will not be feasible to explicitly quantify these values. However, qualitative economic analysis can often add a useful layer to the information on which judgments on translocation can be made.

The costs associated with preventing translocation may indeed be substantial for certain sectors of the aquaculture industry. Translocation offers the potential to match living resources (including broodstock, collected or cultured fingerlings and location specific species characteristics) with physical resources such as land and water characteristics as well as infrastructure. For instance, a species considered for culture in a particular location may not exist in the adjacent natural environment or, alternatively, the genetic stock in the adjacent environment may be inferior (from an aquaculture perspective) to
stock in another location. Consequently, prevention of translocation may prevent the use of a site for aquaculture, or may lower the productivity of that site.

Alternatively, the tradeoffs may be in terms of higher costs of inputs. Fingerlings, for example, may be available to growout operators at much lower cost in one part of the country (due, for example, to economies of scale in hatchery production) than in another. Not only can this reduce the net benefits to growout operators, but it can also reduce incentives faced by hatcheries to expand to an efficient scale. Furthermore, hatcheries may be able to exploit monopoly powers over growout operators (by raising prices) if they do not face competition from hatcheries in other locations.

Markets may also be affected by limits on translocation. For instance, the trade in live fish for restaurants can depend on transport over significant distances. Oysters and mussels are also often sold live, as are crabs and freshwater crayfish. Limiting transport of these (or any transport of dead product) potentially reduces the benefits that can be gained by both aquaculturists and potential consumers of aquaculture products.

Environmental benefits

There are a number of positive environmental impacts that aquaculture has the potential to offer. These should be given consideration in both planning and regulatory approaches to aquaculture and the environment.

Filtration

It has been discussed that certain forms of aquaculture have waste impacts that may be of concern to government at some level. In contrast a number of other species that can be cultured can have the effect of improving water quality. These may include seaweeds and filter feeders such as mussels. Aquaculture of seaweed or mussels may, for instance, reduce levels of nutrient in the water. This could be used to offset pollution from nutrient releasing aquaculture such as finfish farming, or other sources of nutrient pollution such as agriculture or residential areas.

Policies to encourage the production of ‘environmental goods’ such as filtration may be, broadly speaking, economic or regulatory. Economic measures may include subsidies to production and the use of these goods as ‘sinks’ in any existing quota market for pollution. That is, if there is a quota market for nutrient pollution (discussed in the section on waste impacts), for example, filterers would be granted a right to pollute that could then be sold to an aquaculturist that must release nutrient in order to produce.
More regulatory approaches may include such measures as concessionary treatment of applications for sites by producers that will, as a byproduct, produce an environmental good. For example, greater visual impacts could be tolerated for a mussel grower on the basis that they will counter some pollution from another sector.

Cost mitigation of environmental cleanup

Increasing attention has been given lately to the potential of aquaculture to play a part in integrated approaches to environmental management. These may include measures to deal with problematic inland salinity, as well as the treatment of sewage. The basic idea is that if there is an environmental good to be produced (such as reduced levels of salt in ground water), the net costs of producing that environmental good may be reduced by secondary activities that produce revenues in excess of additional costs.

For instance, it may be considered technically feasible to reduce ground water salinity in an area by pumping ground water through a series of evaporation ponds. However, the cost of constructing ponds, dedicating land, and pumping may be high, or even prohibitive in that it exceeds the benefits of reduced ground water salinity. If aquaculture could make use of these ponds, it may be able to create a second stream of benefits (net of additional costs), that together with the benefit of reduced salinity exceed the costs.

It is important that to be of benefit, the additional cost of labor, equipment, facilities and so on must be less than benefits from sale of fish. That is, the aquaculture activity must be viable on the basis that it can make some positive payment for the ponds and the water.

The use of integrated aquaculture (and perhaps agriculture) to mitigate the costs of environmental services presupposes some policy tool to provide incentives for the provision of the environmental service (assuming there is some market failure driving the environmental problem). This may be a payment for desalination services, or direct collective investment in provision of the service.

Stock enhancement and security

Aquaculture offers the opportunity to actively enhance stock and to ensure against extinction in the wild. Economies of scale in hatchery production mean that the cost for a hatchery to produce additional fingerlings to add to wild populations may be quite low. Release of fingerlings into the wild, particularly
when stocks are depleted, may produce benefits for commercial or recreational wild capture fisheries that exceed the cost of additional fingerling production.

Furthermore, the existence of a secondary stock within the aquaculture industry can offer a safeguard against extinction or dramatic depletion through management failure or environmental mishap. This may be a significant benefit if wild stocks are particularly vulnerable, if, for instance, they exist largely in a single river system. In the case that the wild resource becomes severely depleted, the wild ecosystems may be reseeded from the stock within the aquaculture industry. However, a biologically astute approach must be taken to ensure that the safeguards apparently offered are indeed genuine. To be useful, the aquaculture industry must offer sufficient genetic diversity to form a viable population in the wild.

Policies to make use of the potential stock enhancement and security benefits of certain sectors of the aquaculture industry may include:

• establishment of government hatcheries;
• direct purchase of fingerlings from commercial hatcheries;
• payment for the maintenance of an aquaculture stock; and
• concessionary treatment in site allocation and other interactions between government and industry.

Interactions with other policy issues

Government policies, which often focus on a particular industry, may have unintended impacts on other industries. While these may be ironed out over time, industries like aquaculture that expand quickly on a number of fronts may raise new issues that require alteration of current government policies. Two of these issues relating to aquaculture are the suitability of wild fishery management policies to deal with collection of broodstock and seed for aquaculture use, and the need of aquaculture for clean safe waters.

Interaction with wild harvest management

Sectors of the aquaculture industry often depend on the ability to collect broodstock or juveniles from the wild for growout. As a result, aquaculture may be adversely affected by policies that are designed to manage wild harvest fisheries, but which may in some cases be mismatched to collection for aquaculture purposes.

The extent and duration of the dependence of industry sectors on wild stock varies between species. Some require only enough time for the first cohort to
become mature, while others require technological improvement in order to close the life cycle. In some cases, economic factors favor continued use of wild resources. For instance, even with the technical capacity to spawn southern bluefin tuna, it may be that the cost of collection of juveniles from the wild for growout is lower than the cost of spawning and raising the tuna to a similar size.

The stocks targeted by aquaculturists for use as broodstock and as seed for growout are often managed as wild harvest fisheries using such mechanisms as quotas, limited licences, effort limits and seasonal closures. Alternatively, they may be stocks not otherwise managed. However, such stocks may require some restriction on collection if aquaculture is expected to have a substantial impact.

Some management tools cope quite well with the incorporation of aquaculture while others lack the necessary flexibility to accommodate the unforeseen use of the resource. The least flexible mechanisms are bans, including area bans and seasonal bans. For example, while seasonal closures may be seen as a pragmatic tool for the management of certain wild prawn fisheries, they may inadvertently prevent the collection of small numbers of individuals for breeding, even though such collection may have substantial commercial benefit and negligible impact on the wild fishery (W. Izzard, Cairns Live Prawns, personal communication, May 1999).

Management systems that are inherently rigid, such as bans, can be adapted by special measures to deal with aquaculture. These may be permits for limited collection of broodstock perhaps including requirements to release fingerlings into the wild in order to minimise the impact of aquaculture on wild stocks, or even produce a positive effect.

Other naturally flexible mechanisms such as individual transferable quota systems generally accommodate aquaculture quite well. Aquaculturists may purchase quota within the market, as has occurred in the southern bluefin tuna industry. At times, however, it may be useful to expand the flexibility of individual transferable quota systems to provide credits for fish returned to the water.

Need for clean, safe water

Because most aquaculture products are used for food, at times eaten raw, it is important for the industry to meet consumer demands for product that is consistently clean and safe. It is clearly in each producer’s interests to be seen as a safe supplier. However, because of the large number of sources of seafood,
and the difficulty (cost) for consumers to become familiar with these sources (even with branding), a food safety scare caused by producers in one location can have an impact on demand for product from other locations. As a result, if the issue is left to the market alone, each producer may insufficiently (from the perspective of the industry and society) protect against the risk of producing unsafe foods. It is a tradeoff between providing sufficient inspection services and allocating the costs of providing these services. No one individual producer faces the full cost of noncompliance.

There may be a role for government to ensure that the risk of aquaculture (or any other activity) producing unsafe food is low. This clearly involves transport and handling procedures, but particularly in the case of aquaculture, also the management of the environment in which the seafood is grown. This involves both care to locate sites away from sources of pollution risk and efforts to manage pollution sources that may have an impact on aquaculture. Which of these should be emphasised depends (other factors being equal) on a comparison of the benefit of aquaculture in a particular location and the cost of reducing the risk of dangerous pollution.

Given the purity of many Australian waters in comparison with overseas sources of seafood, it may be that an emphasis on food safety in Australian aquaculture also offers the potential for a premium to be earned in export markets.
5. Research and other Commonwealth intervention

Overview of research expenditure on aquaculture

Public sector aquaculture research in Australia is carried out or commissioned by state and Commonwealth government departments and agencies, as well as by universities. Private sector research, while difficult to measure, generally comprises on-farm experimentation within companies, and contribution to and cooperation with public sector agencies and funding sources.

At the Commonwealth level, the Fisheries Research and Development Corporation (FRDC) administers a research fund financed primarily by the Commonwealth government, but with a degree of industry contribution. The FRDC does not undertake research itself, but provides financial resources for research agencies and private industry to meet research requirements identified by the FRDC and its advisory bodies.

Funding for the FRDC is provided by:

- the Commonwealth government providing unmatched funds equivalent to 0.5 per cent of the average gross value of fisheries production for the three preceding years;
- state, territory and Commonwealth fishers and aquaculture operators providing contributions of at least 0.25 per cent of the gross value of production, with all payments above 0.25 per cent being voluntary; and
- the Commonwealth government matching contributions by state, territory and Commonwealth fishers and aquaculture operators up to a maximum of 0.25 per cent of the gross value of production.

The funding of the FRDC differs from that employed for most other rural research and development corporations. For most bodies they are generally funded on the basis of the government matching, dollar for dollar, industry research and development levies up to a maximum of 0.5 per cent of the industry’s gross value of production.

The Commonwealth government contribution of 0.5 per cent of the gross value of production without any matching industry funding is made on the grounds that it is the Commonwealth’s role to manage fisheries resources on behalf of the community beyond the state maritime boundaries. The seafood industry contribution of at least 0.25 per cent of the gross value of production recog-
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nises the need for research and development that will be commercially oriented and will deliver results that will improve industry performance and profitability. The Commonwealth government’s matching of the industry levy contribution (up to 0.25 per cent of the gross value of production) is in line with policy principles that: beneficiaries from research should pay roughly in proportion to the benefits received; and the greater the spillover benefits, the greater the proportion that the Commonwealth government should contribute (FRDC 1999).

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) carries out research as its core activity, undertaking research considered likely to be of benefit to the nation. It receives direct funding from the Commonwealth government, but also bids for additional funds available to carry out particular projects of work. The Cooperative Research Centre for Aquaculture (CRC) has become increasingly significant since its establishment in 1994. Funding for the CRC is provided by the Commonwealth Department of Industry, Science and Resources, with additional resources contributed by CRC participants — universities, research agencies and private industry. The Department of Agriculture, Fisheries and Forestry has two research agencies (ABARE and the Bureau of Rural Sciences) that undertake research projects on aquaculture.

State governments, which together undertake more aquaculture research and development than does the Commonwealth, also have research centres responsible for aquaculture. These centres or agencies are attached, in each case, to the relevant state department responsible for aquaculture. For instance, the Victorian research agency responsible for aquaculture — Marine and Freshwater Resources Institute (MAFRI) — is attached to the Department of Natural Resources and Environment. The comparable agency in South Australia, the South Australian Research and Development Institute (SARDI), is a group of the Department of Primary Industries and Resources. Queensland, New South Wales, Tasmania, Western Australia and the Northern Territory all have similar centres or agencies that undertake aquaculture research.

Total public sector spending on aquaculture related research is high relative to public research expenditure in other primary industries. In 1996-97, total Commonwealth and state government expenditure on aquaculture research was $22.9 million (ABS, unpublished data). This was 5.2 per cent of the gross value of production for the same year (figure B). By way of comparison, in the same period, public research expenditure on forestry and commercial fishing was 4.6 per cent and 2.5 per cent respectively of the gross value of production (ABARE 1998a,b). At the other end of the scale, government research and development on minerals and energy resources was 0.6 per cent of gross value of production in the same year.
Since 1992-93, Commonwealth spending on aquaculture research as a proportion of gross value of production has grown at the expense, to some extent, of research into wild fisheries (figure C). State spending has continued to exceed Commonwealth spending on research and development for both aquaculture and wild fisheries (figure D).

Queensland had the largest expenditure of all the states on aquaculture research and development in 1996-97, with 24 per cent of total government and university expenditure. Tasmania was the next largest (12 per cent), followed by New South Wales (9 per cent). Western Australia, with by far the greatest aquaculture value of production, performs only 2 per cent of public sector research and development. This may be because the pearl industry, making up the bulk of the value of Western Australian aquaculture, is a well established and organised industry with little requirement for government research.
It was not possible to gather aquaculture research and development spending data by species for all government institutions. However, data on FRDC and CRC spending by species are available. Although FRDC and CRC together fund only about 20 per cent of total government and university aquaculture research in Australia, this may offer a reasonable indication of total spending because of the FRDC and CRC practices of levering resources from institutions for individual projects. In figure E, the annual average expenditure by the FRDC and CRC on broad species groups is plotted against the gross value of production of each group. It is relevant that the species that receive the greatest research spending are not those with the highest production value. As discussed later, this pattern is not inconsistent with an ‘optimal investment’ approach to government research spending, whereby effort is directed to areas of greatest expected benefit over time. However, it is also important to take into account relative changes over time in the research expenditure and gross values.
The role of government in aquaculture research and development

The broad rationale for government intervention in research and development is that, if left solely to private investors, some research of benefit to society as a whole would not be done. The specific reasons why this might occur differ among research projects although there are some common elements. Research projects can be classified in various ways to reflect those common elements.

The appropriate categorisation to use depends on the particular purpose. For policy development, research can usefully be placed into two broad categories. The first is research leading to the development of new technology that might be adopted by private firms or government business enterprises. This category includes both applied research and the basic research that provides the building blocks for the development of technology. It might usefully be described as ‘industry’ research. The second category is research that is the special responsibility of government and might usefully be described as ‘public interest’ research.

Industry research

The rationale frequently used to justify intervention in industry research is that the results of some research are a ‘public’ good. Such goods have two key characteristics. First, the use of a public good by one person generally does not alter the ability of others to use it. This is described as being nonrival or perfectly expansible. Second, it is not possible to prevent or exclude others from using it. This is described as a lack of appropriability.

The nonrival characteristic of research is a key difficulty in formulating appropriate research and development policies. If it were simply that research results were not appropriable, a policy solution of providing or strengthening property rights where possible generally would be appropriate. Such a policy would enable private researchers to restrict the use of the research results and recoup the cost of their research in the same way they would recoup the costs of any other investment. However, with research results being nonrival, social benefits from the research would be higher if research results were made available to all at the cost of dissemination of the results.

Dissemination costs would usually be small relative to the cost of the research and researchers would be unable to capture sufficient benefits to recoup the costs of the research. Hence, there is a policy tension in a ‘market’ or property right policy solution. Providing sufficiently strong property rights to give
incentives for private enterprise to undertake research is inconsistent with maximising the social benefits from the research once the results are produced. This conflict between providing incentives to undertake research and obtaining maximum benefits from the results of research is one of the ongoing policy issues in developing patent legislation and in providing other forms of intellectual property rights. The conflict is not just in determining clearly definable principles for setting property rights. It also extends to consideration of competition in associated product markets. For example, establishing intellectual property rights might not be a socially desirable policy if it permits private firms to gain a technological advantage and use that to establish or strengthen a monopoly position. Nor would it necessarily be desirable if it led to ‘patent races’ as described by Dasgupta (1988). Conversely, patents can be seen as a means of permitting dissemination of research results in circumstances where they might otherwise have been kept secret.

The policy issue is whether there are alternative mechanisms that would generate greater social benefits. One possibility is to subsidise industry research. This might add to social welfare if used when firms cannot establish effective property rights. However, there is a substantial risk that subsidising research when private investors do have effective property rights would result in a net social cost. Linking access to subsidies to the provision of public benefits by the researchers may overcome the problem. For example, it might be possible to link subsidies to wider dissemination of results. Another suggestion is that there might be a case for governments to fully fund research and make the results publicly available rather than to provide intellectual property rights (Lindner 1993).

Not all research results are public goods. Private investors in research can appropriate some of the benefits by means such as keeping the results secret or, as incumbent firms, taking advantage of the results of their research in the short term. In these circumstances, the results of the research can be described as ‘joint’ goods in that they are produced as part of the products in which they are incorporated. The results of other research might be ‘tacit’ in that undertaking the research itself is necessary to obtain the experience to apply those results. Hence, those undertaking the research can obtain a major part of the benefit by selling their services.

More generally, research results comprise some part that is public, some part that is jointly produced and other parts that are tacit. Reflecting this mix of characteristics, some combination of policies is likely to provide the best outcome. Possible policies include providing property rights, subsidising private research and funding research for the benefit of society as a whole.
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The policy challenge is to find an optimal mix of these policies. This mix is likely to vary among industries depending on their structure, the effectiveness of patents and other intellectual property rights and the extent to which broader public benefits arise from the research.

Public interest research

Governments have a special responsibility to ensure that research is undertaken where it is required for the management of resources under government control, for the efficient provision of services, such as education and defence, and for policy formation. Pure public interest research would not be undertaken by private enterprise without government funding or a willingness by government to pay for the results. Hence, unlike industry research, government involvement in public interest research is required whether or not the results of the research are a public good.

In fact, if public interest research generates results that are a private good, additional intervention might be required. In some circumstances, private researchers undertaking such research might be able to establish property rights over the results. If that were to occur, the results might be monopolised and either be unavailable to the broader community or be available only at high cost.

Government involvement in public interest research is also likely to differ in nature from its involvement in industry research. For example, there usually would be no economic advantage from governments establishing property rights to the results of public interest research unless private investors might do so in the absence of government action.

There are further key differences between public interest and industry research in establishing the objectives for research, setting up the institutional arrangements necessary for meeting those objectives, and in ensuring the research results are adopted. The government role in industry research is to facilitate research of benefit to society as a whole that would not be undertaken if left solely to private investors. Such research must be adopted by industry for it to be of benefit and this would be fostered by direct industry involvement. Further, industry is likely to have particular informational advantages in selecting research projects and in directing the research, although there might be a conflict of interest in directing funding to research that would have been undertaken in the absence of government intervention. By contrast, it is the responsibility of government to choose the research required to meet its own requirements and to ensure that the research is done. It might seek expert
advice from industry and other sources and contract out particular activities, but the responsibility for decisions remains with the government.

It is difficult to draw a clear and meaningful distinction between public interest research and private good research due to the considerable overlap between the research that would benefit industry and that which would be required by government for its own purposes. For example, some part of the university research funded by government, notionally for the purpose of education and training, is of direct interest to industry. Similarly, some part of industry funded research would be of benefit to government in meeting its public interest research commitment.

This overlap of interests raises an important policy question. Should the government fund all the research it requires and make the results freely available to industry, should it share the cost of the research through a subsidy or other arrangement or should it only fund the research which would not otherwise be done by private investors?

As with industry research, there is no simple solution to this question. Pragmatically, funding research that private investors would otherwise undertake would not add to social welfare. However, it is not clear that there are procedures available that would enable governments to distinguish projects that would be funded from those that would not. There would also be difficulties in establishing appropriate cost sharing arrangements. Nevertheless, maintaining the distinction between the funding provided to assist industry and that provided for research for government purposes is important for transparency in policy development and administration.

**Forms of intervention**

Government involvement in aquaculture research and development can take a number of forms. Perhaps the simplest form of government intervention in research and development is direct action such as the establishment of research and development agencies (for example, CSIRO). Such an approach allows government to undertake research that may not otherwise be carried out because of market failure, while maintaining a free flow of the information that results from research and development activities. However, such bureaucratic structures can fail to provide decision makers with sufficient signals about the relative net benefits of different research paths. This is particularly important for applied research and efforts to develop industry specific technologies.
A less direct form of intervention is that of subsidies through the tax system. This allows the market and production knowledge held by industry to inform research decisions. However, this system may suffer from other inefficiencies. Tax subsidies can be thought of as providing a payment to businesses that undertake research and development for the benefits that flow to others in the industry and the community. It is unlikely that such benefits would be a uniform proportion of research costs. While most of the benefits of research aimed at creating a patentable technology would flow to the business carrying out the research, this would not be the case for more basic research. Uniform tax subsidies for all research and development activities may fail to encourage the activities for which the market failure is most acute — those with the greatest public benefit.

An alternative to direct government action and blanket tax-subsidies is the provision of grants to industry and specialist research agencies to provide research and development services (such as through a semi-independent agency such as the FRDC). This system has some advantages. Grants can be directed to projects judged to be of greatest expected net benefit, and the size of grants as a proportion of total project cost can be varied to reflect the extent to which the project is perceived to be a public rather than a private good. There may also be cost advantages over direct government action, resulting from competition between researchers, though there may be additional costs resulting from reduced objectivity, rent seeking behavior and market concentration resulting from economies of scale and a limited market. Systems of grants for research and development also potentially suffer from many of the information problems that hinder attempts at direct government action. As it is costly to determine public demand, institutional mechanisms rather than price signals must be relied on to indicate the value of projects and as a result there is a tendency for research priorities to be driven by research providers.

A combination of the approaches discussed above is quite common. Core funding may be provided to government research and development bodies, which may also receive project specific grants. Government grants may also contribute to the industry’s development activities, such as experimental farming. Alternatively, partnerships between industry and government can be formed. An example of this is the salmon hatchery that was established as a joint venture between the Tasmanian government and private companies to encourage the development of the commercial industry.

**Determining research priorities**

An emerging issue in the aquaculture industry is the way in which overall research priorities are determined. At the recent Aquaculture Beyond 2000 workshop, participants expressed the view that more emphasis needed to be
placed on the development and extension aspects of research and development in setting spending priorities (ACIL 1999, p. 12). At the same time, it was recognised that strategic and longer term research objectives should not be overlooked in seeking solutions to short term problems. Underlying these concerns is the fact that the aquaculture industry covers a diverse range of species and, with a limited pool of resources, it is possible that research spending may be spread too thinly across the industry.

In recent years, a considerable amount of effort has gone into developing techniques for evaluating research projects and selecting a research portfolio for the fisheries sector that produces the greatest benefits (see, for example, Lal, Holland and Collins 1994; Stephens, Tran, Battaglene, Curtotti and Bull 1995). Progress toward funding agency objectives is likely to be progressed by processes aimed at identifying the research proposals with the highest expected payoffs. A pragmatic framework for comparison and evaluation of projects is for funding agencies to assess both the maximum possible magnitude of benefits likely relative to the costs (the ‘attractiveness’ of the research) and the likelihood of realising and maintaining those benefits (the research ‘feasibility’). There will inevitably be some degree of subjectivity because of the lack of complete information though standard benefit–cost analysis under uncertainty (and a number of variants) can be used to develop a systematic and consistent comparison between research proposals.

Because of the different levels of uncertainty and different expected benefits associated with projects, a funding agency is likely to choose some combination of research projects with a variety of levels of attractiveness and feasibility. An agency may trade off the attractiveness of some proposals against the feasibility of others. In addition, a risk averse agency will be likely to trade off expected benefits against risks.

Beyond the technical evaluation of research proposals, however, there is considerable scope for research funding agencies to determine broad areas of research priority. For example, an agency might consider that proposals aimed at minimising ecosystem interactions should receive a higher priority in a given year than proposals aimed at reducing feed costs. In determining these broad areas of priority, it might be expected that agencies will take into account the expected benefits likely to be realised from further research in each area. However, there may be institutional constraints on the ability of the agency to undertake such a task.

The question of determining broad research priorities is seen as being particularly relevant for aquaculture at the moment.
To enable the benefits of research to be maximised the probability of commercial success of potential projects needs to be considered in the selection process. A number of questions on the likely marketability, production costs, and the current state of knowledge about the species in question will be relevant in eliminating clearly nonviable research paths and in isolating areas of uncertainty.

Regarding the marketability of species, relevant questions would include:
- does an established market exist?
- what is the indicative price and how variable is it?
- how is price likely to change as total supply changes?

Questions on production costs would include:
- what kind of land and water resources would be required?
- how costly/abundant are they?
- is conflict with other users likely to be a problem?
- how costly are other inputs likely to be?

On the research side the following questions should be considered:
- how extensive is existing knowledge?
- what are the gaps?
- how feasible and costly is commercialisation likely to be?

As discussed previously, one of the concerns expressed about the nature of aquaculture research and development is that funds are spread too thinly across a large number of species. (There are currently over 70 aquaculture species being researched in Australia — the FRDC is funding research projects for 35 of these.) It is not clear that a systematic consideration of the potential commercial success of projects would lead to a pattern of research spending that is relevant to the farming of fewer species than is currently the case. However, such an approach would increase the chance of the expected benefits of research and development expenditure being maximised.

In order to foster processes that select projects of genuine value to current and future industry, it may be useful to consider the notion of duplication from an economic perspective. It may be recognised that it can be a poor use of resources to undertake two separate research efforts into the same species. However, it may also be a misallocation of resources to undertake research
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into different species that, if commercialised, will make use of similar resources and receive comparable prices at market. For example, from an economic perspective, there may be considerable duplication if research is undertaken into two species that would require similar seacage sites, and compete as relatively close substitutes at market. In spite of this, it may be appropriate to allow such duplication if the risks are significant, for each species, of failure to successfully develop culture techniques.

Basic and applied research

Consideration should be given to the proportion of available funds allocated to acquiring the basic scientific knowledge necessary for growing and breeding a species, compared with the amount spent on more applied work, such as the development of technologies such as tanks, pens, feed systems and disease prevention.

It can be argued that there is likely to be a greater degree of market failure in the provision of basic research relative to applied research. This is because it is more likely that the benefits from research undertaken closer to the commercialisation stage can be more readily appropriated by the organisation undertaking the research. The same cannot necessarily be said for basic research where the benefits may be more widely applicable, easily diffused and may not fully accrue to the researcher.

As a result, a minor commitment only of government funds may be necessary to develop applications for quite advanced research, because the applications begin to resemble private rather than public goods. Subtle judgment, within an institutional structure that possesses appropriate incentive, may be necessary to both budget for a gradual withdrawal of government involvement and to ensure that the appropriate withdrawal does take place as research becomes more applied.

Sectoral composition of research funding

The allocation of public research and development resources between sectors should be significantly influenced by the extent to which the research and development for that sector is a public rather than private good. In the attempt to maximise the benefit of spending to society, there is little reason to fund projects that would otherwise be completed by the private sector. This is particularly so if the benefits flow wholly to a single producer or an organised group of producers and do not extend to other potential users of the information.
In many cases, research and development relevant to large and established sectors is more likely to resemble a private good than is research relevant to small and new sectors. Consequently, industry from large and established sectors is more likely to fund its own research and development in the absence of government funding. Funding for research that industry would undertake of its own accord could perhaps be better spent on projects that industry would not itself undertake, provided the expected benefits exceed costs. A possible exception to this principle is when similar research is performed by a number of private operators. There may be a role for government to coordinate effort in order to reduce potential duplication.

Large and established industry sectors are not without market failure in research and development. There are areas of research, relevant to such sectors, for which benefits flow to a number of current and potential producers. Because producers acting individually would not sufficiently provide such research, some allocation of government funds to these sectors is appropriate. Moreover, if government can produce research benefits (net of those that would be provided privately), the payoff can be great, in the case of high value sectors. For instance, a 1 per cent cost reduction in a very large industry may be a greater benefit than a 10 per cent cost reduction in a small industry. The more organised is a sector, though, and the more static is the group of industry participants, the greater is the potential for sufficient research in the absence of government funds.

Research and development for small industry sectors with significant growth potential, and particularly for yet to be established sectors, is more likely to possess public good characteristics. Many of the benefits of research are likely to flow to other than the current participants of such sectors, so there is diminished incentive for current participants to undertake the research. Additionally, research for small and new sectors is often relatively basic, involving ground level investigation, needing a higher proportion of government funding than more applied research.

It is possible that research and development for small (and new) industry sectors will produce benefits that can be captured by a small number of individuals or firms. In these cases it would be appropriate for research and development to be funded by those capturing the benefits. As with the case for large firms, there may be a role for government in coordinating effort.

Localised and broadly spread benefits

Some research and development activities produce a flow of benefits to a clearly identifiable group — either a geographic region, or producers of partic-
ular species. Other activities produce benefits that are more broadly spread (for example, research on ecosystem impacts of aquaculture). While intervention can be justified for both types of research, on the basis of market failure, the public good nature of research with broadly spread benefits is least likely to be overcome by industry cooperation. Research with broadly spread benefits, then, has a particular need for government intervention — assuming there are such areas of research for which benefits can be expected to exceed costs. If, ignoring this, government funds are allocated only to research paths with localised benefits, it is likely that in the interest of maximising the net benefit of government spending on research and development, a reallocation of resources toward broadly spread benefits would be appropriate.

Allocation of resources to research that produces benefits to identifiable geographic areas may be helpfully informed by consideration of the available resources in region. Plentiful relevant land and sea resources combined with transport and other infrastructure can result in low costs and significant growth. The potential benefits resulting from research relevant to such areas are often greater than are potential benefits from research relevant to other areas. The effects of aquaculture on regional economies are examined in chapter 6.

Evaluating research outcomes

It can also be difficult to assess the benefits of past research and development activities. A fair assessment of these benefits is an important tool for determining the appropriateness of decision mechanisms, as well as for informing expectations of the benefits of future work. Formal benefit–cost studies are one method of assessing benefits. Done well, however, they can be costly. Consequently, many institutions combine formal benefit–cost analysis of a sample of all activities, with a less formal overview of other activities. It may also be useful to commission regular external reviews of operations to assess performance against objectives and to identify opportunities for improvement of processes. Without such reviews, it may go unrecognised that current institutional mechanisms are not faithfully addressing objectives. Improvement may be quite possible even when benefit–cost scores are favorable. Of course, in all cases, the cost of such reviews should be compared with the likely benefits.

Other Commonwealth government involvement in aquaculture

There are a number of other areas where there is Commonwealth government involvement in the aquaculture industry, although such involvement is not
Food safety

Food safety is the assurance that food will not cause harm to the consumer when it is prepared and eaten according to its intended use. The argument for government regulation of food safety is that market forces will not lead to acceptable safety standards and that consumers lack information about food safety.

An independent body, the Australia New Zealand Food Authority (ANZFA), has been established by the Commonwealth, state, territory and New Zealand governments, and is responsible for developing, varying and reviewing standards for food available in Australia and New Zealand. Once ANZFA determines a food standard, it must then be automatically adopted by the states and territories. These standards deal with the description of the product, its composition and other requirements such as maximum permitted levels of metals and contaminants and maximum residue levels for agricultural and veterinary chemicals.

At a wider level, Australia and New Zealand are members of the World Trade Organisation (WTO). The WTO recognises the Codex Alimentarius Commission as the international body responsible for standards and guidelines that protect public health, ensure fair trading in food and promote harmonisation of standards between countries. ANZFA takes account of Codex principles in the Food Standards Code, and ensures that the integrity of the Australian and New Zealand food standards are maintained. On a similar level, the standards applicable to foods imported into Australia are the same standards applying to foods manufactured in Australia.

Quarantine

The local industry is also protected through quarantine measures administered through the Australian Quarantine and Inspection Service (AQIS). Through these quarantine measures, Australia aims to control the chances of exotic pests and diseases entering Australia, by strictly controlling the entry of animals and goods, including biological and genetic material. Food is an area of particular concern. Fresh and partially processed foods brought into Australia have the potential to introduce exotic pests and diseases. Quarantine control is achieved by the total prohibition of some products, or products from some countries. Additionally for other products, Australia has strictly controlled import conditions that require various treatments — for example,
fumigation, storage temperature controls etc that must be supported by import permits and attestations on export certificate from authorities in the country of origin (AQIS 2000).

Genetically modified organisms

Advances in gene technology issues have the potential to provide significant benefits to the Australian aquaculture industry directly through higher productivity and indirectly from lower feed costs flowing through from increased crop production because of higher crop yields. (Genetically modified soybeans have widespread use in the production of feeds for fish and prawns.) Nevertheless, the very characteristics of gene technology that produce many of the benefits (such as the ability to introduce genes from one species into a different species) are also those that cause concern in the community. These concerns are related to the potential unintended effects on the health of people or the environment.

For example, in North America, fears have been expressed about the commercial release of Atlantic salmon that have been modified to carry a growth hormone from the pacific chinook salmon that is hooked to a powerful promoter sequence. This boosts the fish’s growth rate so that they reach market size quicker (Reichhart 2000). As there is some risk that caged salmon may escape into the wild, environmentalists and others have raised concerns about the impact of these fish on wild populations. Being more vigorous feeders, there are concerns that the introduced fish would disturb the ecology of salmon streams by competing with native fish for resources. There is the possibility that the genetically modified fish will breed with their wild counterparts with unpredictable consequences.

Alternatively, users of genetically modified organisms could be taxed to the extent that they cause harm to others, or subsidised to the extent that they contribute benefits. However, the necessary scientific data and information about which group loses and which group gains are not known with enough certainty to make these sorts of arrangements viable (Hinchy and Fisher 1991).

The shortcomings of property rights arrangements and tax and subsidy arrangements have meant that the regulatory arrangements governing the environmental release of genetically modified organisms have been based on simply prohibiting release of those that are assessed to have unacceptable risks. The risk assessment is largely scientific based. There would be advantages in extending the assessments to include economic consideration, but there are difficulties in quantifying the costs and benefits (Hinchy and Fisher 1991).
Aspects of a property rights solution already exist in the sense that those who release genetically modified organisms into the environment are legally responsible for any damage that this release causes to other parties. These legal liabilities (or threat of them) mean that the costs are internalised in many cases. However, a practical difficulty is that litigation is risky and expensive. Further, it is not always easy to link the release of a genetically modified organism to a particular problem (Foster 1999).

The federal government, through various regulatory agencies, monitors the use of gene technology. Biotechnology Australia was established in the 1999-2000 Commonwealth budget. It is a multidisciplinary government agency (consisting of the Departments of Industry, Science and Resources, Health and Aged Care, Agriculture, Fisheries and Forestry, Education, Training and Youth Affairs, and Environment and Heritage). It is responsible for coordinating non-regulatory biotechnology issues for the Commonwealth government, and seeks to provide balanced and factual information on biotechnology to the Australian community.

A Commonwealth Gene Technology Bill is currently under development, and is expected to be introduced into federal parliament during 2001. The aim of the bill is to provide a nationally consistent scheme for regulation and application of gene technology. The main regulators of matters dealing with gene technology issues are:

- **Genetic Manipulation Advisory Committee** (GMAC), established in 1987, and currently administered by the Department of Health and Aged Care, is responsible for issuing guidelines for contained research and the release of genetically modified organisms into the environment.

- **Interim Office of the Gene Technology Regulator** (IOGTR) works closely with GMAC to manage any potential risks associated with gene technology, and to ensure coordinated regulation and any safeguards set in place are comprehensive.

- **Australia New Zealand Food Authority** (ANZFA), maintain laws and systems that ensure the safety, and regulate the labeling, of food, in Australia and New Zealand.

- **Australian Quarantine and Inspection Service** (AQIS) develops policies and procedures relating to incoming passengers, mail, animals and plants, that have quarantine significance. This includes genetically manipulated products imported into Australia that may pose a pest and disease risk.
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Export control measures

Under the Constitution, the Commonwealth government has responsibility for all trade matters. Import and quarantine matters have been discussed above. To date most marine species caught and exported from Australia have been exempted from regulation under the Wildlife Protection (Regulation of Exports and Imports) Act 1982. Amendments passed in June 1999 to schedule 4 of the act will remove this general exemption and require that any marine species that is exported, and the fishing operations involved in their capture, be assessed to determine whether they are demonstrably ecologically sustainable (Kay and Hughes 2000).

Assessments are to be conducted over the next two years and, until then, current export arrangements for marine species will remain in place. Such measures are unlikely to have a direct impact on aquaculture production with the possible exception of tuna and some prawn species where juvenile stock are caught and subsequently farmed until they reach a more commercially accepted size. However, potentially as a result of such assessments, the harvesting of some wild catch species could be reduced and so lead to increased demand for species produced under aquaculture conditions.

Export assistance measures

Aquaculture exporters are also able to tap into the services provided by Austrade (or the Australian Trade Commission) — the Commonwealth government’s export and investment facilitation agency. Austrade provides advice to companies on which overseas markets hold the highest sales potential for their product, how they can build a presence in these markets, and what sort of practical and financial help is available. Market information tailored to the specific requirements of each business can be made available and can include detailed market intelligence such as the competition, the prospects, cultural considerations, distribution systems and government regulations. Many of Austrade’s services are free or partially subsidised by the government. When the preparatory work is done, Austrade’s overseas offices can assist with arranging market visits.

Assistance under such programs is based on the premise that small and medium sized enterprises tend to have inferior access to information than larger firms. As a result there is market failure as firms may be ignorant of the benefits of, or the knowhow to export. Similarly smaller companies are not as well networked as larger companies and are likely to be less well known than their counterparts overseas (Harcourt 2000).
Further financial assistance is available under Austrade’s Export Market Development Grants scheme that seeks to encourage small and medium sized exporters to seek out and develop overseas markets. Under the scheme, eligible businesses are reimbursed for part of the export marketing costs they incur, such as overseas representation, marketing visits, communications, trade fairs costs, literature and advertising and short term consultants. A business may receive eight grants of up to $200,000 a year. After receiving eight grants, three more grants may be available for promotion to each new export market developed. The scheme’s funding is limited to a total budget allocation of $150 million a year (Austrade Board 2000).

Traditional economic arguments of such support are based on the notion of market failure because of the existence of externalities. There can also be ‘reputational’ externalities that refer to a situation where one firm’s markets may build up product reputation and market presence for other Australian competitors. Sometimes these positive ‘spillovers’ can be internalised by joint marketing programs such as the Supermarket to Asia program for food. On the other hand, there may be the possibility of negative reputational externalities from firms (Productivity Commission 2000).

Another rationale for such export promotion schemes is that exporting provides benefits to Australia by encouraging Australian firms to compete with overseas firms, providing increased knowledge and skills to Australia that would not otherwise be available. Exporters tend to be more innovative and committed to training and education, helping to increase Australia’s access to knowledge capital (Harcourt 2000).

Capital market

In many aquaculture sectors, the potential for growth relies on the ability of small businesses to grow into medium or large businesses. This business growth and the establishment of new businesses and sectors depend on the ability of enterprises to raise funds to purchase equipment and training and to cover running costs when flows of revenue are low. In this regard, aquaculture is not unlike other new, diverse industries with potential for rapid growth. However, there has been some concern that availability of funds has hampered growth in the aquaculture industry.

The most common problem has been in small to medium sized enterprises obtaining finance, often because of information asymmetries between the information that businesses have available and the information that investors or financiers require to make their assessments of funding requests. This lack of information makes it hard for the investor or financier to gauge the quality of the project (Lattimore, Madge, Martin and Mills 1998).
Also, it has been found that many small and medium sized enterprises are missing out on equity finance because they are unaware of the key data available to attract such funds (Ernst and Young and the Centre for Innovation and Enterprise 1997). Firms were found not to have reporting systems in place to allow outside investors to appraise business performance, limited formal business growth plans or strategies in place, and a lack of awareness about the sources and nature of different types of equity providers. There may be some role for government in raising the awareness among small businesses of the factors and type of information they require when seeking finance whether through loans or equity from investors.
6. Regional development

In many regional and rural areas of Australia, aquaculture is regarded as an important component in the push for increased development. The development of an aquaculture industry would diversify a region’s economic base. The industry would offer employment, benefiting the populations of regional centres and surrounding areas. Other potential benefits include the establishment of educational and training opportunities and extension services, and opportunities for production of inputs to aquaculture. For example, crops such as lupins may be grown locally for the manufacture of aquaculture feed. Further benefits could arise from the establishment of wholesale and retail outlets to supply local markets for a larger regional population.

The focus on regional development initiatives has intensified in recent years. At the Commonwealth level, for example, one of the objectives of the Commonwealth Department of Transport and Regional Services is to provide policy advice to maximise the potential of Australia’s regions and to manage appropriate regional adjustment measures. Through its Regional Australia Strategy, the government is committed to understanding and addressing the needs of regional Australia. Within this strategy, the government has identified key priorities, including improving regional services, fostering employment and business initiatives, enhancing regional infrastructure, improving family and community lifestyles and achieving environmental sustainability.

Each of the state governments has also identified regional development as being a high policy priority. Through a variety of mechanisms the governments are pursuing similar objectives to the Commonwealth. However, their strategies tend to focus more on industry development rather than the delivery of services such as telecommunications. In this regard, it is likely that state governments will have a more significant role in the encouragement of the aquaculture industry.

The purpose in this chapter is to review the role of government in the promotion of aquaculture as part of regional development initiatives. A rationale that is often used to justify assistance to emerging industries such as aquaculture is the infant industry argument. In simple terms, the infant industry argument is that while a firm/enterprise is growing to its most efficient size, its average production costs are higher in the beginning and consequently the firm will not be competitive with already established firms (Craven 1984). As the aquaculture industry is based in regional areas, assistance to aquaculture may contribute to regional development. However, such assistance is not neces-
sarily without costs and evaluation of assistance programs is needed to ensure that they result in a net benefit to the community.

**Efficiency of government assistance**

It is clear that governments can play an important role in developing a positive environment for the establishment and development of industry by providing infrastructure such as roads, ports and education, as well as the provision of simple, stable institutional rules and providing macroeconomic stability. However, considerable government expenditure is also allocated to assist individual industries directly. The assistance that governments provide to these individual industries to enhance economic development can, in some cases, be inefficient. A report by the Industry Commission (1996) assessed state and local government assistance to industry and found that most state budgetary assistance was selective and discretionary and had little or no positive effect on the welfare of Australians.

The report found that most selective assistance arose from the states engaging in competitive bidding for major investments and events because they perceived a gain for their state through employment and income. However, rivalry between jurisdictions for development and jobs at best shuffled jobs between regions and at worst reduced overall activity.

From an economic perspective, the overall impact of a shift in resources resulting from selective industry assistance will be to reduce the real income of the community as a whole unless there is an industry specific market failure. As well as representing a transfer from either taxpayers or consumers to business, there is likely to be a net loss in efficiency of resource use as a result of this transfer. While some groups gain, this will be outweighed by the cost of groups that do not gain (Industry Commission 1996).

For example, assistance to one firm to encourage a new investment is often at the expense of the region’s existing businesses. Existing firms can suffer directly and/or indirectly. Local competitors can suffer through the preferment of the new firm. The fact that the new firm has been subsidised through, for example, the provision of grants, reduced setup costs or tax rebates may provide it with a competitive advantage over existing businesses. Also other businesses can be penalised indirectly through the higher taxes that they must pay to fund the selective assistance programs.

In addition, concentration on specific industry assistance measures and bidding for investment diverts government resources away from the governments’ other responsibilities. This may result in the government spending less
on the provision of public infrastructure and services, such as roads, education and health. Alternatively, if the government determined that the level of provision of public infrastructure and services was correct, the revenue used to provide the incentive package may otherwise have funded a cut in state taxes.

Despite the inefficiencies of governments providing selective assistance, governments continue to assist industry. The two key reasons why governments provide assistance include the correction of the adverse effects resulting from market failure. The second reason is providing assistance for promoting economic development.

As noted above, promotion of economic development especially in rural areas is currently a major objective of all governments in Australia. The provision of assistance to the aquaculture industry aims at helping to achieve this objective by potentially creating jobs and generating incomes. It is unclear whether there has been any rivalry or any bidding wars between the states to attract aquaculture investments. The extent of any rivalry between the states may be limited given that investment can be constrained by the suitability and availability of sites. For example, salmon aquaculture is only feasible around the southernmost part of the Australian coastline, with Tasmania being the most suitable area. For some other species, however, there could be potential for investment to be lured to particular states by government assistance. These are species that are not necessarily restrained by location of the site, such as freshwater species. Similarly, aquaculture of tropical species is feasible across a large part of northern Australia.

Australia’s well being can be enhanced by assistance that is provided to target market failures such as where the market fails to signal sufficiently the benefits of research and development. However, to avoid some of the potential inefficiencies caused by assistance, governments need to ensure that policy is essentially neutral between firms and industries to ensure that no firm or industry is disadvantaged over others (Industry Commission 1996).

Regional benefits of aquaculture

It is difficult to quantify the benefits derived from aquaculture without completing a full analysis of the regional economies where aquaculture enterprises are located. Such a study is beyond the scope of this report. The aim in this section is to highlight the regional employment and output effects of aquaculture using the more limited input–output analysis approach. This is done with reference to two studies that have assessed the flow-on effects of the aquaculture industry in two regions.
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The contribution of aquaculture to regional Australia will depend on the size of the aquaculture activities and the types of input required for the different species farmed.

Employment

There are a number of estimates of the level of employment in the Australian aquaculture industry. The Cooperative Research Centre for Aquaculture (1999) estimated that over 7000 people were employed (casually and full time) in aquaculture in 1997-98 (table 4), with around 6000 employed in seafood farming and the rest in pearl farming. On the other hand, the Australian Bureau of Statistics estimated that 3179 people were employed in the industry in September 1998 (ABARE 2000). The ABS number underestimates employment in aquaculture as it excludes owner-operator enterprises not employing labor and respondents who do not identify aquaculture as their primary business.

Aquaculture employment in Australia, by state, 1997-98

<table>
<thead>
<tr>
<th>Employment</th>
<th>New South Wales</th>
<th>Victoria</th>
<th>Queensland</th>
<th>Western Australia</th>
<th>South Australia</th>
<th>Tasmania</th>
<th>Northern Territory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>2 800</td>
<td>440</td>
<td>800</td>
<td>550</td>
<td>1 200</td>
<td>1 150</td>
<td>350</td>
</tr>
<tr>
<td>Indirect b</td>
<td>8 700</td>
<td>1 250</td>
<td>2 000</td>
<td>900</td>
<td>3 600</td>
<td>4 600</td>
<td>1 050</td>
</tr>
<tr>
<td>Total</td>
<td>11 500</td>
<td>1 690</td>
<td>2 800</td>
<td>1 450</td>
<td>4 800</td>
<td>5 750</td>
<td>1 400</td>
</tr>
</tbody>
</table>

a Employment includes both full time and casual. b For South Australia and the Northern Territory, indirect employment is based on an assumed multiplier factor of 3. For all other states, values are as provided by respective state aquaculture departments.

Sources: CRC for Aquaculture (1999); Tasmanian Department of State Development (1999); Kelly, J., Paspaley Pearls, personal communication, July 1999.

Output effects

As with any industry or set of enterprises, the presence of an aquaculture enterprise affects the local economy of which it is part. In order to support the enterprises’ activities, aquaculturists require spat, feedstuffs, other material inputs, labor, energy and services. Some of these inputs, especially labor, energy and services, may be provided by persons and companies based in the local region. Requirements for other inputs, such as feedstuffs, may be sourced more widely. For example, around half of the feed for prawn aquaculture is imported from Indonesia.

The impact of aquaculture activity can be measured by a range of economic indicators such as the value of output (business turnover), value added, employment and household income. In order to estimate the flow-on effects
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of aquaculture activity, multipliers can be used. Multipliers are a summary way of expressing some responses (direct and indirect) to an economic change (box 3).

Two recent studies have sought to assess the economic impact of aquaculture in specific regions. Both studies examined the direct and indirect benefits of aquaculture.

In a study conducted by Economic Research Associates (1997), the economic impacts of aquaculture in the Great Southern Region in Western Australia were calculated using species specific multipliers. Both type I and type II multipliers for mussels, yabbies and marron were estimated for the whole of Western Australia in the study (table 5). The type I multiplier includes the direct impacts and production induced impacts of aquaculture while the type II multiplier

Box 3: Multipliers

Multipliers are a summary way of expressing the responses to an economic change that are included in an input–output analysis. They can be used to approximate the total impact in an economy or region of changes in the demand for the output of any one of its industries. Multipliers can take a number of forms:

- **Output multipliers** relate changes in industry outputs to changes in final demands. More specifically, they measure the dollar sum of direct and indirect output requirements from all industries needed to deliver an additional dollar of final demand for the products of a particular industry.

- **Employment multipliers** measure the employment response to an increase in final demand, both directly in the industry concerned and indirectly in supplying industries.

- **Income multipliers** measure the amount of income that is generated by a change in final demand both in the industry directly and in other industries that service the industry (IAC 1989).

Multipliers describe average effects, not marginal effects, and reflect assumptions of: no economies of scale; unused capacity in all industries; unused labor; no other fixed resource constraints; and no technological change. Generally, average effects are expected to be higher than marginal effects within this framework of assumptions. In addition, multiplier analysis only takes account of some forms of interdependence, such as the sales and purchase links between industries and the composition of consumption from income. Other forms of interdependence, such as collective competition for fixed factors of production, changes in prices that induce producers and consumers to alter the mix of their purchases and other constraints that operate on the economy as a whole are not taken into account. The combination of the assumptions used means that input–output multipliers are generally higher than would realistically be the case. In other words, they tend to overstate the potential impact of a final demand stimulus (ABS 1995).
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5 Estimated multipliers for aquaculture in Western Australia

<table>
<thead>
<tr>
<th>Species</th>
<th>Employment multipliers</th>
<th>Output multipliers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type I</td>
<td>Type II</td>
</tr>
<tr>
<td>Mussels</td>
<td>1.14</td>
<td>1.66</td>
</tr>
<tr>
<td>Yabbies</td>
<td>1.13</td>
<td>1.52</td>
</tr>
<tr>
<td>Marron</td>
<td>1.55</td>
<td>1.99</td>
</tr>
</tbody>
</table>


includes the direct impacts, the production induced impacts as well as the induced consumption impacts of aquaculture.

In 1995-96, approximately 40 people were directly employed in aquaculture in the Great Southern region. Adjusting the multipliers in table 5 so that they can be applied to the Great Southern region, the study estimated that the aquaculture industry indirectly generated employment for 26 people in the region due to the flow-on effects (table 6). The study also found the industry generated an estimated direct output of $1.27 million, which increased to $2.57 million dollars when indirect effects were taken into account.

Some of the flow-on effects derived from aquaculture production in the Great Southern region can be determined by the amount of expenditure that takes place by the industry. In the study, expenditure by the aquaculture industry is estimated at $1.75 million. The study also estimated that the majority of expenditure occurred within the region. Exceptions were major capital expenditures on barges, some vehicle purchases and some specialist inputs.

In a study conducted by EconSearch for the PIESA Aquaculture Group, the total economic impact of tuna and oyster farming in the Eyre Peninsula region in South Australia was examined. The study also examined the impact of aquaculture on the major regional centre in the Eyre Peninsula region, Port Lincoln, as this is where the aquaculture industry is predominantly based.

The study found that aquaculture activity in the Eyre Peninsula region generated $88.2 million in 1996-97, which is approximately 55 per cent of total business income (table 7). This had flow-on effects for the South Australian economy, generating an estimated $72.3 million in other regional sectors (EconSearch Pty Ltd 1998).

6 Estimated aquaculture impacts in the Great Southern region, 1995-96

<table>
<thead>
<tr>
<th>Impact</th>
<th>Employment a no.</th>
<th>Output $m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct impact</td>
<td>40</td>
<td>1.27</td>
</tr>
<tr>
<td>Flow-on effect</td>
<td>25.7</td>
<td>1.30</td>
</tr>
<tr>
<td>Total impact</td>
<td>65.7</td>
<td>2.57</td>
</tr>
</tbody>
</table>

a Full time equivalent.

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Employment in aquaculture also was found to have significant flow-on effects, with every job in aquaculture generating 2.5 other jobs in the rest of the region. While employment in aquaculture in the Eyre Peninsula region is smaller than in the agriculture industries of sheep and grains, the ratio of jobs created in other sectors for each single industry job is greater in aquaculture than in the other industries. In addition income earned by the people employed in aquaculture is greater, on average, than income earned by employees in the sheep and grains industries located in the region.

With around 17 per cent of the workforce employed in aquaculture activities in Port Lincoln, employment in aquaculture is more significant than for the whole Eyre Peninsula region. Average household income is higher for people

<table>
<thead>
<tr>
<th>Sector</th>
<th>Employment income</th>
<th>Output</th>
<th>Value added</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>no.</td>
<td>%</td>
<td>$m</td>
</tr>
<tr>
<td><strong>Tuna</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuna farming (direct)</td>
<td>240</td>
<td>31</td>
<td>9.6</td>
</tr>
<tr>
<td>Fishing</td>
<td>205</td>
<td>26</td>
<td>9.2</td>
</tr>
<tr>
<td>Property and</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>business services</td>
<td>24</td>
<td>3</td>
<td>0.6</td>
</tr>
<tr>
<td>Processing</td>
<td>36</td>
<td>5</td>
<td>0.6</td>
</tr>
<tr>
<td>Trade</td>
<td>108</td>
<td>14</td>
<td>2.1</td>
</tr>
<tr>
<td>Other manufacturing</td>
<td>26</td>
<td>3</td>
<td>0.6</td>
</tr>
<tr>
<td>Transport</td>
<td>39</td>
<td>5</td>
<td>1.2</td>
</tr>
<tr>
<td>Other sectors</td>
<td>99</td>
<td>13</td>
<td>2.3</td>
</tr>
<tr>
<td>Total</td>
<td>777</td>
<td>100</td>
<td>26.3</td>
</tr>
<tr>
<td><strong>Oysters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oyster farming (direct)</td>
<td>162</td>
<td>74</td>
<td>3.4</td>
</tr>
<tr>
<td>Property and</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>business services</td>
<td>3</td>
<td>1</td>
<td>0.1</td>
</tr>
<tr>
<td>Trade</td>
<td>22</td>
<td>10</td>
<td>0.4</td>
</tr>
<tr>
<td>Other manufacturing</td>
<td>3</td>
<td>1</td>
<td>0.1</td>
</tr>
<tr>
<td>Transport</td>
<td>4</td>
<td>2</td>
<td>0.1</td>
</tr>
<tr>
<td>Other sectors</td>
<td>26</td>
<td>12</td>
<td>0.6</td>
</tr>
<tr>
<td>Total</td>
<td>220</td>
<td>100</td>
<td>4.7</td>
</tr>
<tr>
<td><strong>Total aquaculture</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquaculture (direct)</td>
<td>402</td>
<td>40</td>
<td>13.0</td>
</tr>
<tr>
<td>Fishing</td>
<td>205</td>
<td>21</td>
<td>9.2</td>
</tr>
<tr>
<td>Other sectors</td>
<td>390</td>
<td>39</td>
<td>8.8</td>
</tr>
<tr>
<td>Total</td>
<td>997</td>
<td>100</td>
<td>31.0</td>
</tr>
</tbody>
</table>

employed in aquaculture in Port Lincoln than for the region as a whole. In Port Lincoln the predominant activity is tuna farming where income and returns are substantially higher.

The study found around 240 people were directly employed on tuna farms in 1996-97, with a further 540 jobs generated as a result of flow-on business activity. These jobs are created in the fishing, trade, property and business services, processing, transport, and other manufacturing sectors.

In contrast to tuna, however, the study found that oyster farming does not generate as many flow-on effects for the rest of the region in terms of employment and household income. However, oyster farming is a labor intensive operation that directly employed around 160 people (full time equivalents) in 1996-97. Flow-on business activity was estimated to generate a further 60 jobs and an additional $1.3 million in wages in other local businesses. These flow-on effects are greatest in the trades and services sector (for example, electricians and metal workers).

Around 80 per cent of the total value of oyster production in South Australia is generated in the Eyre Peninsula region. Direct business income generated in the region was estimated in the study at around $4.8 million, with an additional $5.3 million earned by other sectors. The study also found that value added activities in the oyster farming sector generated over $6.0 million in the Eyre Peninsula region, and $3.2 million in other sectors of the economy.

The role of government in the regional development of aquaculture

If a government is committed to regional development that encompasses aquaculture, there are a number of instruments that the government can use to assist aquaculture development. These include: regional development plans; soft loans / tax breaks / grants; and government provision of infrastructure and services.

Regional development plans

Regional development plans and strategic plans can play an important role by providing a sound framework in which the aquaculture industry can develop. Regional development plans are currently the main instrument that state governments use to promote aquaculture development in Australia. All state and territory governments have, or are developing, strategic plans that take a whole-of-government approach to developing aquaculture within their respective states and territories.
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The common objective in these plans is for the government to act as a facilitator through strategic planning to promote and support aquaculture development and its long term growth. Governments can achieve this by identifying sites that are best suited for aquaculture production and by ensuring sustainable, profitable and equitable use of the region’s resources. Another function of regional development plans is that they can act as a signal to potential investors that the government is committed to aquaculture development, implying that policy will continue to accommodate the industry.

The Victorian and Western Australian governments have both devised regional development plans for aquaculture. The Victorian government is committed to promoting marine and inland aquaculture as a major avenue for investment growth in Victoria. Consequently, the Victorian government along with industry developed a Victorian Aquaculture Strategy (DNRE 1998) that aims to develop a profitable, diverse, ecologically sustainable and well managed aquaculture industry.

The Western Australian government has been financially supportive toward the development of aquaculture in Western Australia through commitment of government resources. For example in 1994, the state government allocated $4.5 million over three years, to expand and develop aquaculture in Western Australia. Key achievements included the establishment of the Aquaculture Development Council and the commissioning of the Broome Tropical Aquaculture Park.

The Western Australian government, through its fisheries department, develops policies, standards and guidelines. The Western Australian government has developed and implemented Aquaculture Development Plans for key areas such as the Gascoyne region, Albany Harbours and the Kimberley region. A Kimberley Aquaculture Development Group has been established to implement the Kimberley Aquaculture Development Plan. As a component of the Kimberley Aquaculture Development Plan the Western Australian government has proposed a development involving a commercial barramundi industry at Lake Argyle (Kimberley Development Commission 1999).

In New South Wales, the state government through New South Wales Fisheries, develops Aquaculture Strategic Plans for particular parts of the industry and particular issues facing aquaculturists. Strategic plans are developed and implemented with input from consultative industry based committees and provide a basis on which aquaculture development can be promoted. Strategic plans have been completed for the aquaculture of silver perch, oysters, prawns and for aquaculture using inland saline waters (New South Wales Council on the Cost of Government 1997).
In July 1997 a standing committee representing industry and government was established to develop a strategic plan to ensure the long term development of the northern New South Wales land based coastal aquaculture industry. Through the plan, the committee formed a vision along with goals, identified opportunities and made recommendations on how to overcome limitations to ensure the industry’s long term sustainability (Northern New South Wales Aquaculture Industry Steering Committee 1998).

However, most states have experienced common issues that are not addressed in the plans and are limiting the growth of the industry. The two main issues constraining the industry include the lack of coordination between government agencies and the difficulty of obtaining access to suitable sites for aquaculture. Other commonly identified issues include the need to improve the expertise and experience with aquaculture within government departments, reducing the complexity in obtaining development approval and making sure that the process incorporates transparency, certainty and consistency, and improving promotion and marketing strategies along with developing networks.

For example, a review of the Victorian Aquaculture Strategy undertaken by the Aquaculture Regulatory Task Force in 1999 highlighted some of the limitations of the strategy. Such limitations included the complexity of dealing with multiple consenting authorities, the lack of access to suitable sites, long term leases not being available to enable security of tenure, and complexity of current licensing arrangements and lack clarity on performance outcomes.

The review found that such regulatory and administrative limitations have imposed impediments to market access, raised business costs and consequently reduced the competitiveness of the Victorian aquaculture industry. The review made recommendations to remove such impediments to allow the growth of a more competitive aquaculture industry. It was recommended that an aquaculture ‘one stop shop’ or single point of contact between state government and aquaculturists be established. Another recommendation was the issuing of long term leases for aquaculture activities for 21 years. It was also recommended that criteria and guidelines for licence applications and performance based ‘best practice environment’ management guidelines be developed (Aquaculture Regulatory Review Task Force 1999).

In New South Wales, the lack of coordination between government agencies and the complexity of obtaining approval for development were found to be limitations that regional plans did not address and consequently hindered the growth of the aquaculture industry. To overcome these limitations an integrated development assessment process was implemented in July 1998.
The consent authority for aquaculture development approvals in New South Wales is the local council. The licensing authorities are New South Wales Fisheries and the Environment Protection Authority. Under the integrated development assessment process, all other associated licences, permits and approvals required by other agencies can be linked with the development consent issued by the local council. This process has enhanced the consistency and coordination of the requirements of key government agencies (Northern New South Wales Aquaculture Industry Steering Committee 1998).

As noted earlier in this report, Tasmania is the only state that has introduced a complete ‘one stop shop’ system for individuals or firms wanting to engage in aquaculture production. The Tasmanian Department of Primary Industries, Water and the Environment approves site allocations, licences and conducts environmental assessments. Other states have ‘one stop shops’ in place for each of the three individual processes: for example, Western Australia, New South Wales, Victoria and the Northern Territory have a ‘one stop shop’ system in place for site allocation for marine aquaculture; and New South Wales, Western Australia, Victoria, Northern Territory and South Australia have developed ‘one stop shops’ for aquaculturists to obtain licences.

Soft loans / tax breaks / grants

There are various mechanisms that governments can use to attract new industry such as aquaculture into an area to assist regional development. At the regional level, local governments can provide incentives, such as offering land at reduced rates and/or reducing council fees, to attract new industry into the area. At the federal and state levels, governments can assist with the development of the aquaculture industry by providing soft loans, tax breaks and grants.

Soft loans are loans provided usually by government on subcommercial terms — that is, lower than interest rates and/or fees than could be attained in commercial markets. Concessional loans are available from AusIndustry for product or process design; trial production runs; regulations and standards compliance; protection of intellectual property; and trial and demonstration activities.

State governments may also provide direct grants to the aquaculture industry. In Western Australia, for example, the state government established an Aquaculture Development Fund in 1994 to facilitate the development of the aquaculture industry. Funding is provided for Aquaculture Industry Development Projects (up to $50 000) and for Marketing, Industry Promotion and Study Tours (up to $20 000). To be eligible for funding, the project must demonstrate a positive production and profitability impact on the industry, a transference of technology and knowledge within and across industry sectors,
and that at least half of the total value of the project is derived from private funding. The Fund is administered by the Aquaculture Development Council (Fisheries Western Australia 1999).

**Government provision of infrastructure and services**

Governments can encourage regional development through aquaculture by providing infrastructure, government funded research, and information and extension services.

Governments can provide funds for infrastructure to assist in the development of an industry. A justification for governments’ providing such funding is market failure. It is difficult to exclude individuals from using public infrastructure. Therefore individuals are unwilling to pay for the production of infrastructure, such as roads, as each individual can choose to ‘free ride’ on the production of others. Consequently, the market tends to underproduce goods of this nature.

The Western Australia government recognised a lack of regional infrastructure for aquaculture in the state and consequently approved the establishment of a Tropical Aquaculture park in Broome to be managed by Fisheries Western Australia. The aim of the park is to facilitate the development of tropical aquaculture in Western Australia by establishing essential industry infrastructure. The park facilitates the development of financially independent operations in commercial aquaculture, research and development, and related areas such as education and training. The park provides the following infrastructure: sites available for lease, all weather vehicle access, access to saline ground water and raw seawater and bypass water disposal (Fisheries Western Australia 1998).

Governments can also encourage investment, expenditure and employment into the region where the industry is located by providing funding for research and development into an industry. Furthermore, the results from research and development may lead to the development of efficient production techniques designed for specific regions. This would lower the cost of producing a certain product and could therefore enhance the growth of that industry. By subsidising particular research and development, governments can target industries located in areas where regional development is desired.

In a number of the states’ regional development plans, governments provide funding for research and development centres. For example, in Western Australia, the state government provided funds through the Kimberley Aquaculture Plan for the development of the Broome Tropical Aquaculture

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**AQUACULTURE DEVELOPMENT**

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Governments can encourage regional development through aquaculture by providing infrastructure, government funded research, and information and extension services.

Governments can provide funds for infrastructure to assist in the development of an industry. A justification for governments’ providing such funding is market failure. It is difficult to exclude individuals from using public infrastructure. Therefore individuals are unwilling to pay for the production of infrastructure, such as roads, as each individual can choose to ‘free ride’ on the production of others. Consequently, the market tends to underproduce goods of this nature.

The Western Australia government recognised a lack of regional infrastructure for aquaculture in the state and consequently approved the establishment of a Tropical Aquaculture park in Broome to be managed by Fisheries Western Australia. The aim of the park is to facilitate the development of tropical aquaculture in Western Australia by establishing essential industry infrastructure. The park facilitates the development of financially independent operations in commercial aquaculture, research and development, and related areas such as education and training. The park provides the following infrastructure: sites available for lease, all weather vehicle access, access to saline ground water and raw seawater and bypass water disposal (Fisheries Western Australia 1998).

Governments can also encourage investment, expenditure and employment into the region where the industry is located by providing funding for research and development into an industry. Furthermore, the results from research and development may lead to the development of efficient production techniques designed for specific regions. This would lower the cost of producing a certain product and could therefore enhance the growth of that industry. By subsidising particular research and development, governments can target industries located in areas where regional development is desired.

In a number of the states’ regional development plans, governments provide funding for research and development centres. For example, in Western Australia, the state government provided funds through the Kimberley Aquaculture Plan for the development of the Broome Tropical Aquaculture
Park. In the Northern Territory, a Darwin Aquaculture Centre was developed and in Victoria, Snob Creek Fish Hatchery conducts research and development into aquaculture. In Queensland, the Department of Primary Industries has set up aquaculture research stations in Cairns, Walkamin and Bribie Island. The South Australian government’s research and development institute located at the Aquatic Sciences Centre at West Beach was developed to conduct research into aquaculture. Finally, in Tasmania, the Department of Primary Industries and Fisheries together with the University of Tasmania have developed the Tasmanian Aquaculture and Fishing Institute through which research into aquaculture is undertaken. In addition, in 1994-95 the Tasmanian state government provided $2.1 million for the development of the Taroona Marine Research Laboratories to conduct research into aquaculture including the development of new species.

Such research facilities benefit local economies by ensuring that technical developments are transferred to producers and through the flow on effects the research centres generate. For example, the Broome Tropical Aquaculture Park employs a number of administrators, scientists and technicians. It therefore introduces a range of skilled and semiskilled expertise and offers new employment prospects for the region. The park is also used as a training centre by Broome TAFE. The park also benefits the region through its expenditure on inputs and services.

The Broome Tropical Aquaculture Park therefore plays a role in providing a foundation for growth in the aquaculture industry and therefore encouraging regional development in Broome and the surrounding regions. The park has assisted with the growth of the industry by establishing industry infrastructure and by decreasing the reliance of the industry on wild stock. An impediment to the Kimberley aquaculture industry is the lack of seed or juvenile organisms for growout or stocking. A pearl hatchery has been established at the park and the park is promoting the use of barramundi eggs from the Darwin Aquaculture Park to produce juvenile fish suitable for stocking. The park also facilitates the development of financially independent operations through the provision of lease sites and research and development.

Finally, governments through information and extension services can provide potential developers and existing operators with information to enhance the industry’s potential growth and therefore contribute to regional development. Individuals obtaining information require a certain amount of resources to gather, compile, process and transfer data. Centralised information gathering and distribution could be more efficient in the sense that the same amount of information could be obtained using fewer resources (Bohm 1987).
New South Wales Fisheries assists the development of the aquaculture industry in New South Wales by assisting potential new entrants to the industry by supplying technical information and extension services. For example, they provide advice about site selection and project design.

In Western Australia, one of the aims of the Kimberley Aquaculture Development Plan is to provide extension services to operating Kimberley aquaculturists to improve the efficiency of operations from farm to market. In addition the plan aims to provide a comprehensive industry information package for prospective aquaculturists.
Appendix A: Summary of state and territory regulations governing aquaculture

New South Wales

Site allocation

- The *Fisheries Management Act 1994* is the legislation used to allocate aquaculture leases.

- Aquaculture leases may be allocated by auction, public tender or ballot. Alternatively, a potential aquaculture operator may apply for an aquaculture lease.

- Applications for marine aquaculture proposals on Crown land are assessed by an Interdepartmental Committee for Mariculture. The committee is made up of representatives from the Department of Urban Affairs and Planning, Waterways Authority, Environment Protection Authority, Department of Business and Regional Development, Department of Land and Water Conservation, New South Wales Fisheries and National Parks and Wildlife Service.

- Marine aquaculture applications are assessed by the committee under the *Environmental Planning and Assessment Act 1979* (EPAA).

- The application is also assessed against legislation administered by each representative’s department.

- Local government may become involved if authorised under the EPAA.

Environmental regulations

- An objective of New South Wales Fisheries’ marine aquaculture policy is to ensure ecological sustainability.

- At the assessment stage of applications for proposed marine aquaculture projects, the application is assessed by the Interdepartmental Committee for Mariculture to ensure marine aquaculture projects are consistent with the aims of the EPAA.

- The aims of the EPAA are to promote social and economic welfare through the use of natural resources whilst improving environmental conditions. Another aim of the EPAA is to minimise conflict over natural resource use.
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- The individual representatives of the Interdepartmental Committee for Mariculture also have responsibility for regulating specific aspects of marine aquaculture as determined by their legislative requirements.
- For example, the Environment Protection Authority regulates effluent discharge of marine aquaculture operations whereas the Department of Land and Water Conservation regulates marine aquaculture in estuaries.

Terms of leases
- Aquaculture leases may be issued for up to fifteen years, are transferable and may be subdivided. However, an aquaculture lease does not confer exclusive possession.

Victoria

Site allocation
- There is no single piece of legislation used to allocate Crown land for aquaculture sites in Victoria. There are three pieces of legislation used to allocate Crown land: the Land Act 1958, Crown Land (Reserves) Act 1978 and Coastal Management Act 1995. These acts are administered by the Department of Natural Resources and Environment (DNRE).
- Unreserved Crown land is leased under the Land Act 1958. Allocation is by auction, tender or negotiation.
- Crown land which is reserved for a specific purpose is leased under the Crown Land (Reserves) Act 1978 by application.
- The Coastal Management Act 1995 is used to allocate coastal Crown land with the use of planning instruments.
- Initially, the Victorian Coastal Strategy establishes the long term objectives of coastal management.
- Coastal Action Plans may need to be prepared for specific coastal regions.

Environmental regulations
- The Fisheries Act 1995 is used to minimise the environmental impact of aquaculture through the stipulation of conditions on aquaculture licences. This act is administered by the DNRE.
The Coastal Management Act 1995 is used to ensure sustainable use of resources.

The Environmental Protection Authority, Rural Water Authorities and local government regulate land based aquaculture sites.

The Victorian government may acquire land for the purpose of coastal preservation as permitted under the Crown Land (Reserves) Act 1978.

Terms of leases

• Leases issued under the Lands Act 1958 may be issued for 99 years with the lease allowed to be subdivided, transferable and conferring exclusive access to the lease area.

• The term of leases allocated for reserved Crown land may be up to 21 years, with leases able to be sublet but not subdivided, are not transferable but do confer exclusive access.

Queensland

Site allocation

• The majority of Queensland aquaculture sites are on private freehold and leasehold land.

• In principle, aquaculture operators may be able to obtain a special lease from the Department of Natural Resources (DNR) but this has yet to occur.

• Operators of aquaculture ventures that are not based on private land may obtain an aquaculture licence to operate on Crown land. Licences are for either marine or freshwater aquaculture.

• The Queensland Department of Primary Industries (QDPI) handles the application of aquaculture licences under the Fisheries Act 1994. To acquire an aquaculture licence, the following approvals must also be obtained by the applicant:
  
  – land use approval for proposed aquaculture operations on private land can be obtained from local government under the Integrated Planning Act 1997; if the proposed site is on Crown land, such approval is obtainable from the DNR.

  – an environmental licence may need to be obtained from the Department of Environment and Heritage (DEH) under the Environmental Protection Act 1994.
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• For proposed marine aquaculture projects other approvals may need to be obtained for:
  – construction works on tidal lands from DEH;
  – permit to remove, destroy or damage marine plants and/or perform works or related activity in a fish habitat area from the QDPI;
  – special approvals for a proposal that involves aquaculture activities in Commonwealth Marine Park or State Marine Park waters from the DNR; and
  – permission may be required from the Beach Protection Authority on unoccupied state land.

• Proposed freshwater aquaculture projects may need to obtain additional approvals for water supply from natural waterways or a licence for the construction of very large dams from the DNR.

• Both marine and freshwater proposed aquaculture projects that intend to collect wild broodstock require a general fisheries permit for culture stock collection. This permit is issued by the QDPI on behalf of the Queensland Fisheries Management Authority (QFMA).

Environmental regulations

• Aquaculture ventures that have a total area of the ponds and enclosures greater than 5 hectares are required to obtain an environmental licence.

• Environmental licences determine the manner and the technology of waste water disposal by a proposed aquaculture venture on an individual basis.

• The preference of the DEH (that issues these licences) is to have all waste water recycled.

• However, if effluent discharge is allowed, the condition attached to the licences may state the maximum rate of discharge, implementation of a site based management plan, and require the purchase of pollution control equipment among other possible conditions.

• The other approvals discussed in the site allocation deal with specific aspects of the environmental impact of a proposed aquaculture project.

Terms of licences

• Generally, licences are issued for a fifteen year period and are transferable.
Western Australia

Site allocation
• Aquaculture licences and leases, and pearl oyster farm licences and leases in coastal waters of Western Australia are obtained by application to Fisheries Western Australia as required under the Fisheries Resource Management Act 1994 (FRMA) and the Pearling Act 1990 respectively.

• The majority of inland aquaculture is carried out on private land, so site allocation issues are more relevant for marine aquaculture. Large scale land based aquaculture projects such as prawn or abalone farming are often conducted on Crown land. Consultation and approval from a number of other government agencies is required prior to the granting of any licence.

• Applications for aquaculture licences and leases, and pearl oyster farm licences and leases in coastal waters of Western Australia are assessed and approved by Fisheries Western Australia following the approval of other relevant decision making authorities such as the Department of Environmental Protection, Department of Conservation and Land Management and local government.

• Consultation with other interested state government agencies and peak community and industry groups also form part of the assessment and approval process. Applications are also advertised for a 60 day public comment period.

• The principles that are used to approve applications include:
  – having regard to the FRMA or Pearling Act 1990 (whichever is applicable),
  – other relevant legislation (for example, the Land Administration Act 1997),
  – Ministerial guidelines,
  – submissions and comments arising from consultations and
  – the potential effects of the proposal on other resource users.

• Fisheries Western Australia has developed a number of aquaculture plans for key areas in Western Australia. The plans are designed to provide guidance to prospective aquaculturists and decision makers by identifying constraints to aquaculture development and areas where aquaculture can occur.
Environmental regulations

• The application process for marine leases and licences conducted by Fisheries Western Australia is consistent with the environmental conservation objectives of the FRMA. In addition, applications are assessed by the Department of Environmental Protection through the Environmental Protection Authority for potential environmental impacts under the Environmental Protection Act 1982.

• Local government authorities have the responsibility of assessing applications in relation to their respective town planning legislation.

• Approval from the Waters and River Commission is required in circumstances where the project involves the diversion of a natural watercourse, a bore is drilled or the project is located in a drinking water catchment area.

• The Department of Conservation and Land Management is responsible for the protection of flora and fauna as stated under the Conservation and Land Management Act 1950. The approval of the Department of Conservation and Land Management and the Minister for the Environment is required for projects situated in marine parks or reserves.

Terms of leases

• Aquaculture and pearl farming leases may be granted for periods up to 21 years. The granting of a lease or licence does not confer exclusive occupation of the lease area and does not generally preclude access to, or rights of passage through, a farm site by other legitimate users.

South Australia

Site allocation

• Marine aquaculture sites are allocated on the basis of Aquaculture Management Plans (AMPs) that define where marine aquaculture activities may be allowed. AMPs are prepared by Primary Industries South Australia (PISA).

• Applications for development approval are submitted to the Development Assessment Commission (DAC) as authorised under the Development Act 1993.

• Applications for marine aquaculture sites are made to the Director of Fisheries. The applications are assessed against the policy requirements of the relevant AMPs.
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- Environmental factors are a key factor in assessing applications.
- Sites are allocated under the Harbors and Navigation Act 1993.
- If the application for a marine aquaculture site is approved, a site is allocated to the applicant on a first come, first served basis.
- Inland aquaculture activities are generally carried out on private land so there exists no inland aquaculture specific site allocation process.

Environmental regulations

- The planning system established by the Development Act 1993 and the use of AMPs are the key policy instruments used to regulate and manage marine aquaculture development.
- The statutory body that conducts development assessments, DAC, is required to consult with the Environmental Protection Authority and the Coastal Protection Board.
- AMPs contain management policies that are issued to regulate and manage marine aquaculture within the defined area.
- Inland aquaculture proposals are also required to undergo development assessments as stated under the Development Act 1993. Local government conducts the assessment against council development plans.
- If a proposed inland aquaculture proposal intends to discharge waste water or draw surface or ground water, a licence must be issued by the Environmental Protection Authority or a permit by the Department for Environment, Heritage and Aboriginal Affairs respectively.

Terms of leases

- Marine aquaculture leases issued under the Harbors and Navigation Act 1993 may have a life of up to forty years and a right to exclusive occupation of the lease area.

Tasmania

Site allocation

- The Marine Farming Planning Act 1995 is the legislation used to allocate marine farming leases.
Marine farming development plans (MFDPs) are used to plan and manage the marine aquaculture industry. MFDPs outline the areas where marine aquaculture farms are allowed and how large each site is.

An environmental impact statement (EIS) must be included in an MFDP to be approved. An EIS contains information on the present environmental condition of the plan area.

Community consultation is a part of MFDP preparation. Modifications arising because of community consultation will be incorporated if considered appropriate.

A ‘grandfathering’ approach is used to allocate coastal resources between different user groups within a MFDP. ‘Grandfathering’ in this context is where the user group with the oldest established pattern of use of a particular coastal resource is granted priority in access.

MFDPs can be prepared by both the private and public sector. However, in practice, government has prepared the majority of MFDPs.

The *Marine Farming Planning Act 1995* contains information on the process that marine farming leases are allocated. First, a pool of eligible participants is selected. Then the sites are allocated by any means deemed appropriate.

**Environmental regulations**

The *Marine Farming Planning Act 1995* contains provisions that allow planners to adopt environmental regulations that best meets the needs of the plan area.

In practice, environmental regulations are very similar. Some variation occurs because of plan specific environmental or geographic features.

Data obtained from the EIS is used to monitor the environmental impact of marine aquaculture farms.

Regulations are of a prescriptive nature. For example, the maximum stocking density for salmonid is 25 kilograms a cubic metre. Regulations like this are to limit the impact of marine farming on the local environment.

Visual impacts of marine aquaculture are also managed in a more stringent fashion. For example, structures, buoys, cages and netting have to be black or grey in color.
Terms of leases

- Marine farming leases have a duration of up to thirty years and may be transferred; lease areas may be modified by planning authorities or by the operator. Exclusive possession is conferred to the leaseholder.

Northern Territory

Site allocation

- Site allocation of Crown land for the purpose of aquaculture is permitted under the *Fisheries Act*. This act enables the Minister of the Department of Land, Planning and Environment (DLPE) to make the allocation decision.

- The allocation of the lease can be done by auction, tender or as a result of advertising that a lease is available.

- Aquaculture activities must be approved by the Aboriginal Areas Protection Authority to ensure that the site is not an Aboriginal sacred site.

- Heritage areas cannot be developed under the *Heritage Conservation Act*.

Environmental regulations

- The maintenance of environmental values is enforceable by the DLPE under the *Environmental Assessment Act*. An environmental assessment may be required in the form of a public environmental report or an environmental impact statement.

- Extraction of water and the application of effluent standards are administered by the DLPE under the *Water Act*.

- The *Waste Management and Pollution Act* regulates the disposal of effluent.

Terms of leases

- Crown land leases for aquaculture may be issued for up to four years or in perpetuity.
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