DRAFT

AQUACULTURE PLAN FOR SHARK BAY

FISHERIES MANAGEMENT PAPER NO. 171

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Draft Aquaculture Plan
For Shark Bay

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AN INVITATION TO COMMENT

The Department of Fisheries invites people to make a submission on the issues discussed in this report - *Draft Aquaculture Plan for Shark Bay.* This plan has been prepared by *ecologia* Environmental Consultants and Makaira Pty Ltd and the Department of Fisheries.

Why Write a Submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action, including alternative approaches.

The Department of Fisheries will collate and summarise all public submissions received. Analysis of the submissions will be undertaken and recommended changes identified and documented.

Public submissions will be treated as public documents unless specifically marked confidential, and may be quoted in full or in part in any further reports on Shark Bay.

Developing a Submission

In your submission you may agree, disagree or comment on general issues or specific strategies listed. It may help to reduce the workload on individuals and increase the pool of ideas and information if you join a group with similar interests and make a joint submission.

When making comment on a specific issue in the report:

- Refer each of your comments to the appropriate section or chapter heading in the report;
- Clearly state your point of view;
- Indicate your reasoning or source of information; and
- Suggest alternate strategies, safeguards or information.

Public Submissions Form

A public submission form is available for use if this approach is preferred. When using the form, your submission need not be limited to the space available on the form. Please remember to include your name, address, the date and whether you want your submission to be confidential.

Closing Date

The closing date for submissions is 15 July 2004.

Contacts

Submissions should be addressed to:

Marine Planner
Fish & Fish Habitat Protection Program
Department of Fisheries
Locked Bag No. 39, Cloisters Square Post Office
PERTH WA 6850

If you wish to discuss the content of the document or require further information, please contact Ms Eve Bunbury on (08) 9482 7397.

PUBLIC SUBMISSION FORM

DRAFT AQUACULTURE PLAN FOR SHARK BAY

Marine Planner
Fish & Fish Habitat Protection Program
Department of Fisheries
Locked Bag No. 39, Cloisters Square Post Office
PERTH WA 6850

Name: _____

Organisation
(if applicable): _____

Address: _____

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I would like to make the following comments on the draft aquaculture plan for Shark Bay.

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EXECUTIVE SUMMARY

The Department of Fisheries has prepared this draft aquaculture plan for Shark Bay to provide an agreed framework for future management of aquaculture. The final plan will assist prospective aquaculturists in preparing proposals and will guide the Department of Fisheries in the decision making process for aquaculture licence and lease applications. The plan identifies constraints to aquaculture development and areas where aquaculture may occur. It also identifies species that may be used for aquaculture development. Implementation of this plan will ensure that aquaculture can occur in a sustainable manner, while retaining the unique features of Shark Bay.

Shark Bay's conservation values have been recognised at an international level. The area was inscribed on the World Heritage list in 1991 in recognition of the area's outstanding natural values and parts are included in the Shark Bay Marine Park and Hamelin Pool Marine Nature Reserve. The area is regarded as one of the most important marine environments in Western Australia.

In view of the high conservation values of Shark Bay, the objective of this draft aquaculture plan is to:

Provide guidance to aquaculture proponents, the community and government agencies on the future development of aquaculture activities in Shark Bay, while at the same time conserving the World Heritage values of Shark Bay for present and future generations, and minimising conflict with existing and future users of Shark Bay.

This objective is consistent with the intent of the Shark Bay World Heritage Property agreement signed by the Commonwealth and Western Australian Governments. The agreement requires that approval processes consider World Heritage values and development is undertaken in the context of key management plans produced by the Department of Conservation and Land Management and the Department of Fisheries.

This draft aquaculture plan builds upon the Gascoyne Aquaculture Development Plan and public consultation undertaken by the Department of Fisheries in 1997. Further public consultation, including a public meeting in Denham and face to face meetings with other interested groups, took place in late 1998 and the results were used to assist preparation of this draft plan.

The draft plan reviews the physical, biological and social environmental characteristics of the region and examines the existing management framework and its application to aquaculture in Shark Bay. Environmental impacts from aquaculture are highly dependent on a number of interrelated factors, namely location, production system, species grown and integration with other human activities.

Constraints to aquaculture in Shark Bay include the potential for conflicting use of resources, lack of infrastructure particularly beyond existing settlements, climate, and environmental constraints ranging from a lack of baseline information about water circulation to existing marine and national parks. Constraints, which are clearly defined geographically, are used to identify where aquaculture may and may not occur (see Table 1).

The draft plan identifies candidate species for aquaculture in Shark Bay using five criteria, namely:

- Marketing prospects;
- Culture technology viability;
- Level of production efficiency;
- Commercial viability; and
- Compatibility with production systems suitable for Shark Bay.

A number of species of marine finfish, aquarium fish and marine shellfish are listed as candidates for aquaculture, all of which, with the exception of Artemia, are native to the Shark Bay region. The potential for current and candidate species for Shark Bay is listed in Table 2.

Both onshore and offshore production systems may be suitable for Shark Bay. Onshore production systems using tanks and raceways with flow through water, farming high value fish in intensive, small-scale systems appears most viable. Onshore aquaculture production would most likely be vertically integrated (e.g. include hatcheries or other aspects of production) and horizontally integrated (e.g. be undertaken with other ventures such as tourism). Offshore production systems would most likely include longlines, seacages or floating tanks. Cages or floating tanks would be small to medium scale semi-intensive systems, farming high value fish, with production vertically integrated and in some instances horizontally integrated.

Onshore production systems or offshore floating tank systems provide the greatest opportunity for sound environmental management and environmentally acceptable operations.

Table 1 Site selection criteria for aquaculture in Shark Bay

Sites which may not be used for aquaculture
The following areas which have statutory protection are identified as areas where aquaculture may not occur: • Terrestrial Nature Reserves, including island nature reserves; • National Parks and Conservation Parks; • Marine Nature Reserves (Hamelin Pool) • The following Marine Park Management Zones: – Sanctuary Zones; – Recreation Zones; and – the Blue Lagoon, Boorabuggatta, Cape Peron and Gladstone Special Purpose Zones. • Gazetted navigation channels; and • Shipwrecks.
Sites where approval of aquaculture is unlikely
Sites where aquaculture is unlikely to be approved include areas of high conservation value and locations already extensively utilised by other interests. These include navigation areas, locations extensively used by commercial fishers, tourist operators or private visitors. High conservation areas include: • Mangroves, significant seagrass meadows, coral reefs and algal mat communities; • Major habitats of significant fauna, such as sea birds and marine mammals such as dugongs; and • Any other areas that might later be set aside for the protection of flora and fauna or habitats. In addition, sites that are in areas adjacent to, or otherwise able to affect, areas of high conservation value are unlikely to be approved for aquaculture operations (for example, waters adjacent to important sea-bird nesting areas). Sites with significant social importance or high visual amenity values are similarly unlikely to be approved.
Sites which may be considered favourably for aquaculture
All other areas may be considered favourably for aquaculture, but a detailed habitat description is required as part of an aquaculture proposal. The applicant will also be required to provide information on uses of the potential aquaculture site by other people, such as recreational fishers, tourism operators, and private users.

Table 2 Summary of the merits of current and candidate aquaculture species for Shark Bay

Species	Status	Comments
Blacklip pearl oyster *(Pinctada margaritifera)* **Wing oyster** *(Pteria penguin)*	Currently cultured in Shark Bay. Market factors are positive, culture technology is known, production efficiency and commercial viability are good.	Considered highly compatible with - and suited to - aquaculture in Shark Bay.
Shark Bay pearl oyster (*Pinctada albina)*	Have been cultured in Shark Bay. Probably less viable than blacklip oysters due to a lower market value for the product and less-well-known technology.	Suited to culture in Shark Bay, but possibly will be restricted due to availability of suitable sites.
Pink snapper (*Pagrus auratus*)	A hatchery has been established in Shark Bay. There are some uncertainties in respect of market demand, prices and hence commercial viability.	The species is well suited to production in Shark Bay, where hatchery-reared fish have been used to supplement depleted wild stocks. Maintenance of the three genetically diverse stocks will need to be a consideration.
Southern bluefin tuna (Thunnus maccoyii) **Yellowfin tuna** (Thunnus albacares)	Market prospects are very good. Production technologies are available for on-growing wild fish and developing hatchery production. Commercial viability will probably be very good.	Well suited to culture in offshore cages in areas with oceanic-quality water and remote from seagrasses. Possibly the most viable marine finfish candidates due to high value.
Mahimahi (Coryphaena hippurus) **Yellowtail kingfish** (Seriola lalandi) **Trevally** (Caranx spp., Pseudocaranx spp.)	Good market prospects for mahimahi and yellowtail kingfish, but market value for trevally is low. Culture technology, production efficiency and commercial viability are relatively well known for the first two species, but poorly known or unknown for trevally.	Possibly suited to production in onshore systems employing water treatment or recirculating systems. Suitable offshore sites are very limited.
Barramundi cod (*Cromileptes altivelis)* **Coral trout** *(Plectropomus spp.)* **Emperors** (*Lethrinus spp.)* **Sea perches** (*Lutjanus spp.)* **Estuary cod** (*Epinephelus coioi-des)*	Market demand and values are high, particularly for live fish. Culture technologies are poorly known but being developed. Production efficiency and commercial viability will probably be good.	Possibly suited to production in onshore systems employing water treatment or recirculating systems. Suitable offshore sites are very limited.
Westralian dhufish *(Glaucosoma hebraicum*) **Whitings** *(Sillago spp.)*	Domestic markets for dhufish are excellent, but production technology has not been developed. Whiting are less valuable. Production efficiencies and commercial viability are unknown.	Possibly suited to onshore systems with treatment or recirculating systems. Offshore sites are very limited and likely to be used for higher-value species.
Marine aquarium species (various species)	High-value markets but poorly-known culture technologies and unknown viability.	Ideally suited to onshore systems due to limited water requirements.
Artemia (*Artemia spp., Parartemia spp.)*	World-wide high-value markets, well-known culture technology and production efficiencies in certain systems. Commercially viable.	Non-native to Shark Bay. Well suited to integration with salt mining operations and evaporative salt lakes on pastoral leases.
Western rock oyster *(Saccostrea commercialis*)	Uncertain but possibly good demand and prices. Well-known technology and other production and viability factors.	Although native to Shark Bay, may not be viable due to site limitations.
Roe's abalone *(Haliotis roei)*	Good market prospects. Technology may be available soon and production efficiency and commercial viability are likely to be good at suitable sites.	Unlikely to be suitable, since appropriate sites are remote and better, alternate sites are available beyond Shark Bay.
Western rock lobster *(Panuliris cygnus)*	Very good market prospects Culture technology, production efficiency and commercial viability are all poorly known or unknown.	May be well suited to culture in Shark Bay using onshore grow-out with water treatment or recycling systems. Offshore culture is less likely, due to site limitations.
Saucer scallops *(Amusium balloti)*	Currently fished in Shark Bay in a wild stock fishery with highly variable recruitment.	A high growth rate and capacity to tolerate densities of around $1/m^2$ suggest suitability for bottom-culture ocean ranching.

SUMMARY OF RECOMMENDATIONS

Recommendation 1

Ensure that aquaculture development does not diminish the World Heritage Values of Shark Bay and occurs in accordance with the administrative arrangements detailed in the State/Commonwealth Shark Bay World Heritage Property Agreement. *(DEH/DOF/CALM)*

Recommendation 2

Consider the species listed in Table 2 as suitable candidates for aquaculture in Shark Bay. In the event that a proponent lodges an aquaculture application for Shark Bay involving species not included in the list, consider these other species according to their merits on an individual-case basis.

(DOF/proponents)

Recommendation 3

Protect the biodiversity of the World Heritage Area by using only species native to, or already established in, Shark Bay. *(DOF/proponents)*

Recommendation 4

Ensure that licensed aquaculturalists utilise local broodstock and provide a legislative mechanism to ensure access on a sustainable basis. Any translocation of broodstock must be subject to the translocation guidelines. *(DOF)*

Recommendation 5

Consider applications for wild stock reseeding and enhancement on a case-by-case basis.

(DOF)

Recommendation 6

Maintain the genetic diversity of species endemic to Shark Bay and undertake appropriate risk assessments of translocation of animals where different genetic populations of species are known to exist. *(DOF/proponents)*

Recommendation 7

Refer any aquaculture proposals, which are likely to discharge into or have a significant impact on Shark Bay to the Environmental Protection Authority (EPA) under section 38 of the *Environmental Protection Act 1986*. *(DOF/EPA)*

Recommendation 8

Use the criteria listed in Section 6.7 and Figure 11 in determining where potential aquaculture lease or licence sites may be located within Shark Bay. *(Proponents/DOF)*

Recommendation 9

Ensure proponents provide the following information in their applications:

- A map of the major benthic habitats (e.g. seagrass meadows, coral or limestone reef, bare sand, mud) in and around the lease sites.
- A qualitative description of water movement, or a map of general water circulation in and around the lease, especially where sensitive marine communities are located within or close to lease sites.
- A map of the important biological resources (e.g. bird rookeries, seal or turtle nesting/haul-out beaches) in the proposed lease and surrounding area.
- A description of the potential environmental impacts from the proposal and details of how those impacts are to be minimised.
- A detailed description of site works (including water-based construction) and other processes likely to impact on the environment.
- Details of monitoring that will be carried out, including baseline monitoring, prior to project commencement so that environmental impacts can be adequately quantified.
- Details of contingency plans, if the World Heritage values of Shark Bay are compromised.

(Proponents/DOF/DOE/EPA)

Recommendation 10

Ensure that lease and/or license conditions for aquaculture include:

- A commitment to monitoring for the life of the project to enable environmental impacts to be adequately quantified;
- Conditions relating to the removal of infrastructure and reinstatement of the area disturbed by any environmental impact; and
- Performance criteria to measure whether the lease and/or license is being used in the manner for which it was intended. *(DOF/DEP/EPA)*

Recommendation 11

Review the success and appropriateness of management strategies contained in the Plan in five years. *(DOF/DEH)*

Recommendation 12

Support further research and monitoring in Shark Bay, particularly for water circulation studies around Denham and offshore, and for distribution mapping of biological resources.

(DEH/CALM/DOF)

SECTION 1 INTRODUCTION

1.1 Significant Features of Shark Bay

Shark Bay is a large embayment situated in the southern end of the Gascoyne Region, over 800km north of Perth, on the westernmost point of the coast of Western Australia (see Figure 1).

It comprises a series of broad gulfs, narrow inlets and shallow basins and includes Bernier, Dorre and Dirk Hartog Islands. Shark Bay was inscribed on the World Heritage list in 1991 in recognition of the area's outstanding natural values. The Shark Bay Marine Park and Hamelin Pool Marine Nature Reserve encompass a large portion of the bay.

Shark Bay is also one of the foremost areas for commercial and recreational fishing in Western Australia and supports a tourism industry focused around the dolphins at Monkey Mia and the region's natural values. A large area of salt production ponds and salt export facilities are operational at Useless Loop. Grazing livestock is the primary activity of pastoral stations in the region. The largest settlement in the area is the townsite of Denham.

The natural values of Shark Bay include:

- Outstanding examples representing the major stages of the Earth's evolutionary history;
- Outstanding examples representing significant ongoing geological process, biological evolution and man’s interaction with his natural environment;
- Formations and features of exceptional natural beauty, and exceptional combinations of natural and cultural elements; and
- Important and significant natural habitats where threatened species of animals or plants of outstanding universal value still survive.

1.2 Purpose of the Draft plan

The Department of Fisheries has prepared this draft aquaculture plan for Shark Bay to provide the public with its views on the future management of aquaculture in the area. The final plan will guide prospective aquaculturists in preparing proposals, and the Department of Fisheries in decision-making processes for aquaculture licence and lease applications.

This draft is the basis for further consultation with stakeholders and interested groups and will assist in the development of the final aquaculture plan for Shark Bay.

1.3 Area covered by the Draft plan

The area covered by this draft aquaculture plan is the area within the outer boundary of the World Heritage listed area (Figure 1). The area is roughly bounded by the town of Carnarvon to the north, and extends westwards to include the outer chain of Bernier, Dorre and Dirk Hartog islands, then over 200km southwards joining up with Edel Land and extending southwards to Zuytdorp Nature Reserve.

The western boundary is three nautical miles off the coast. The eastern boundary is adjacent to the coast

south from Carnarvon to Hamelin Pool, then continuing southwards approximately 30-70km inland from the west coast. The township of Denham and the areas around Useless Loop and Useless Inlet, although within the main boundary, are specifically excluded from the World Heritage property but are included in the area of this draft aquaculture plan. The boundary co-ordinates are listed in the Shark Bay Marine Reserves Management Plan 1996-2006.

1.4 Approach and Method

1.4.1 Approach

The Department of Fisheries is preparing aquaculture plans for a number of regions with aquaculture potential in Western Australia. In November 1996 the Department of Fisheries, in conjunction with the Gascoyne Development Commission, released the Gascoyne Aquaculture Development Plan. That plan gave broad guidance to aquaculture development in the Gascoyne Region, which extends from Zuytdorp Cliffs to North West Cape and inland 300 km to Mount Augustus, and includes the Shark Bay area.

The Department of Fisheries began more detailed planning for marine-based aquaculture in Shark Bay in 1997. The agency contracted *ecologia* Environmental Consultants and Makaira Pty Ltd to prepare a draft aquaculture plan for Shark Bay. Integral to this was a public consultation process (see Figure 2) to determine community views on aquaculture in Shark Bay, including consideration of areas of Shark Bay that could be used without infringing upon existing values.

Consultation with the public took place in February 1997 and again in late 1998. Consultation was achieved by a combination of direct mailing, a meeting in Denham, face-to-face meetings with individuals or representatives of groups, and follow-up phone calls to all people who neither attended a meeting with the consultants nor responded in writing. Twelve people attended a meeting held in Denham on 2 November 1998. Seven face-to-face meetings were held in Perth.

The initial direct mail-out list was based on stakeholders such as professional and recreational fishers, current and likely aquaculture operators, tourist operators, State government agencies with interests in the area, and peak conservation groups. Additional stakeholders were identified through the consultation process and these were all subsequently contacted in writing and by phone. A complete list of stakeholders consulted to date appears in Appendix A. Appendix B lists the main issues raised through preliminary consultation.

The information collected from this public consultation study has been entered into a Geographical Information System and utilised in this draft aquaculture plan.

1.4.2 Method

In order to prepare this draft aquaculture plan, the following tasks were undertaken by the consultants:

1. An extensive review of literature covering matters as diverse as:

- Existing administrative procedures which apply to aquaculture in Shark Bay;
- The existing physical, biological and social environment of Shark Bay;
- Environmental requirements of potential aquaculture species;
- Current aquaculture production systems; and

- Potential environmental impacts from and environmental management for aquaculture production systems.

2. Public consultation that built on consultation undertaken in 1997, which involved a meeting in Denham and face-to-face discussions with key stakeholders.
3. Identification of potential aquaculture species by utilising a set of selection criteria appropriate to Shark Bay.
4. Identification of production systems which would be suited to Shark Bay;
5. Consideration of potential environmental impacts and their management from aquaculture production systems likely in Shark Bay; and
6. A constraints mapping exercise identifying areas where aquaculture cannot occur; areas with significant known constraints; and areas with no known constraints but which may have constraints when site-specific investigations are undertaken.

The consultants prepared a preliminary draft aquaculture plan, which was then reviewed by Department of Fisheries staff and the Aquaculture Development Council (ADC) and revised to take into account the comments received. The document was then referred to several government agencies, including the Department of Conservation and Land Management (CALM), the Department of Environment (DOE), the Department of Environment and Heritage (DEH) and the World Heritage Unit, Environment Australia for consideration and again revised.

The Draft Aquaculture Plan for Shark Bay is now being made available to the public for a three-month comment period before finalisation.

SECTION 2 THE PHYSICAL, BIOLOGICAL AND SOCIAL FEATURES OF SHARK BAY

2.1 Physical features

2.1.1 Geomorphology

Shark Bay is a major, shallow embayment approximately 13,000 km^2 in area, formed by inundation of the coastal plain and protected by several offshore limestone islands. At its northern lower reaches, Shark Bay opens to the Indian Ocean.

Towards the upper, southern reaches of Shark Bay there is a succession of gulfs, narrow inlets (oriented north-south) and basins. The bay also includes many sand bars, the most significant of which is the Faure Sill, which bars the entrance to Hamelin Pool and delineates its northern margin. The eastern and western gulfs of Shark Bay are divided by Peron Peninsula.

Wide, intertidal flats dominate the shores of Shark Bay and the seabed comprises mainly calcareous sands. Extensive seagrass meadows dominate shallow banks throughout the bay. The hydrology of Shark Bay is governed by numerous shallow banks and sills, which control the direction and extent of water movements. This results in the increase in salinity towards the upper reaches of the bay and the presence of the three dominant water types, *viz*.: oceanic, metahaline and hypersaline (see section 2.1.3).

The formation of the Faure Sill has led to the partial separation of Hamelin Pool from the remainder of Shark Bay. The resulting hypersaline conditions are one of the many geological and biological features of Hamelin Pool that have significant conservation values.

Shark Bay also contains the Wooramel Seagrass Bank, which is purportedly the largest seagrass bank in the world and has strong conservation values.

Two major, seasonal rivers enter and form deltas at the eastern shore of Shark Bay: the Gascoyne and Wooramel rivers.

2.1.2 Climate

Shark Bay lies across two climatic zones. The eastern portion lies within the arid, warm temperate climatic zone, while the western portion is at the northern extreme of the temperate climatic zone (Bureau of Meteorology, 1995). Generally, the area experiences variable to moderate rainfall with a winter maximum or non-seasonal distribution.

The summers are usually hot and dry and the winters cool to mild. The mean annual rainfall at Carnarvon, located at the northeastern part of Shark Bay, is 226 mm, with maximum falls occurring between May and July. The mean maximum and minimum daily temperatures recorded at the same station are respectively 32.5°C in February and 11.1°C in July.

The Shark Bay area experiences southerly winds for most of the year. Strongest during the summer, when they can persist for several days, the winds commonly blow at speeds of over 25 km/h. They are lighter and more variable over winter. In summer, the area can experience tropical cyclones that develop each year over the warm waters to the north and north-west of Western Australia.

2.1.3 Oceanography and Water Quality

The water at the open end of Shark Bay may be considered oceanic. There is a marked transition southwards, towards the upper reaches of the eastern and western gulfs as the salinity increases to metahaline and, in the upper reaches of the Eastern Gulf, hypersaline conditions.

Wave energy is low to moderate within Shark Bay and low within the more protected inlets. Tides are the major cause of water movement within the bay, where the maximum tidal range is about 1.2 metres.

Coastal areas off the west coast of Western Australia are influenced by the Leeuwin Current, which is a southerly flow of warm, low-salinity, tropical water that varies seasonally in strength, peaking during the winter and autumn. The Leeuwin Current is responsible for the occurrence of tropical species at Shark Bay and higher latitudes, which are outside the normal distribution range of these species. The region tends to delimit the northerly distribution of temperate species, possibly due to increasing water temperatures and the suitability of the substrate for demersal species.

Therefore, Shark Bay is in an important biogeographical overlap zone that contains both tropical and temperate marine species. The Leeuwin Current mainly influences open coastal areas and waters within Shark Bay are not significantly affected by it, as only occasional intrusions of warm water penetrate north and south of Bernier Island and Dorre Island.

Oceanic water enters Shark Bay through the northern Geographe Channel between Carnarvon and Bernier Island, the Naturaliste Channel between Dorre Island and Dirk Hartog Island, and the South Passage between Dirk Hartog Island and Steep Point.

A major feature of Shark Bay is the significant salinity gradients (or salinoclines), which have a major impact on the local biota. The aquatic flora and fauna of the hypersaline inlets, particularly Hamelin Pool, are relatively devoid of marine life. Towards the lower reaches of the bay, as the salinity decreases and approaches that of the open ocean, the diversity and abundance of species increases.

The major recognised salinoclines in Shark Bay are: the Faure salinocline; the Cape Peron salinocline; and the Freycinet salinocline. These salinoclines are areas where maximum exchange between lower-salinity waters to the north and higher-salinity waters to the south takes place. The salinity of water in Shark Bay increases from 35-38,000 parts per million (‰) in the northern embayment to 46-53 ‰ in the Freycinet Basin (in the upper reaches of the western gulf) to the more extreme values of 60-65 ‰ in Hamelin Pool (in the upper reaches of the eastern gulf).

The water column is isohaline; that is, the salinity does not appear to vary with water depth. This feature suggests strong turbulence and mixing of surface with bottom waters, and is supported by the high dissolved oxygen concentrations in bottom water and rapid temperature fluctuations of bottom waters in response to diurnal atmospheric temperature changes.

The waters in Shark Bay are generally high in quality and contain a low level of pollutants, due in part to the isolation of the area, its lack of urban or industrial development and the low rainfall. Seawater temperatures in the bay are more variable than in the adjacent ocean.

Due to the shallow water, the sea-surface temperatures in Shark Bay fluctuate in response to changes in atmospheric temperature. In winter, water temperatures in the upper reaches may fall to 17-18°C and, in summer, they can reach 24-26°C. The winter and summer water temperatures in the adjacent oceanic zone are 19-22°C and 22-24°C respectively. In the lower reaches of northern Shark Bay, where water depths are greater, the temperature of oceanic waters has a greater influence on sea-surface temperatures.

2.2 The Biological Environment

2.2.1 Terrestrial

2.2.1.1 Flora and Vegetation Communities

Eleven distinct vegetation communities are found in the Shark Bay area, and the area is noteworthy in that it includes a zone of transition between the South West Botanical Province and the Eremaean Botanical Province. This occurrence is unusual in Australia and is of considerable scientific interest relating to patterns of distribution and abundance.

The Shark Bay World Heritage Property contains 823 known species and includes 15 more plant species declared rare flora species under the *Wildlife Conservation Act 1950 (CALM, 1998).* The main vegetation groups are as follows:

- Acacia shrub lands on calcareous loams;
- Mallee over spinifex;
- Saltbush Bluebush and Saline Flats;
- Tree heath;
- Acacia shrub lands with birridas;
- Limestone heath;
- Acacia shrub lands on sand plain;
- Mixed shrub lands on sand;
- Acacia, native pine and eucalypt shrub lands;
- Acacia over spinifex; and
- Mud flats, drift sand and other bare areas.

2.2.1.2 Fauna

Shark Bay is an extremely important site for the conservation of several species of native animals, whose distribution has been severely diminished since European settlement. The Shark Bay region forms a refuge for many species that were once widespread across mainland Australia - a product of the isolation of habitats upon islands and peninsulas in the area.

This geographical remoteness has slowed the spread of introduced predators and competitors. As such, Shark Bay meets the World Heritage criteria for "the most significant habitats, where threatened species of animals and plants of outstanding universal value from the point of view of science conservation, still survive."

The region includes a network of reserves that aim to conserve the endangered and threatened terrestrial species of the area. Most species that are considered threatened or are specially protected under the Western Australian *Wildlife Conservation Act 1950* are represented in the reserve system.

Populations of threatened species in the area are being enhanced by the implementation of recovery plans, with the aim to reduce the risk of extinction for species by ensuring their environment remains as intact as possible. These plans also aim to increase the numbers of individuals or populations of threatened species by reducing the impact of predators and competitors. Work is currently underway on Peron Peninsula to control the feral animal populations so that the area can support some of the species that were found there prior to European settlement.

A list of species and populations, considered threatened and their occurrence on terrestrial reserves, is shown in Table 3 below.

Table 3 Representation of threatened species in reserves

Threatened species		Representation in Reserve
Common name	**Scientific name**	
Banded hare-wallaby or muning	*Lagostrophus fasciatus*	Bernier and Dorre Islands Nature Reserve
Western barred bandicoot	*Perameles bougainville*	Bernier and Dorre Islands Nature Reserve
Rufous hare-wallaby or mala	*Largorchestes hirsutus*	Bernier and Dorre Islands Nature Reserve
Boodie or burrowing bettong	*Bettongia lesueur*	Berringer and Dorre Islands Nature Reserve
Shark Bay mouse	*Pseudomys fieldi*	Bernier Island Nature Reserve
Greater stick-nest rat	*Leporillus conditor*	Salutation Island Nature Reserve
Baudin Island spiny-tailed skink	*Egernia stokesii aethiops*	Baudin Island Nature Reserve
Thick-billed grass-wren	*Amytornis textilis*	Francois Peron National Park
Mallee fowl	*Leipoa ocellata*	Francois Peron National Park and Zuytdorp Nature Reserve
Dirk Hartog black and white fairy wren	*Malurus leucopterus leucopterus*	Not common in terrestrial reserves

2.2.1.3 Mammals

The mammalian fauna of Shark Bay contains endemic and relic species and sub-species, as well as many species at their geographical limits. However, of the 37 indigenous mammal species recorded, more than half are now locally extinct. For example, five of the nine indigenous mammals found upon Bernier and Dorre Islands are considered threatened, with four of these five species having naturally occurring populations persisting only at these sites.

2.2.1.4 Birds

The Japan-Australia Migratory Bird Agreement (JAMBA), and China-Australia Migratory Bird Agreement (CAMBA) cover more than 35 species of birds that occur in the area. The reserve islands provide the roosting sites for many of these species. Francois Peron National Park is home to over 100 species of bird and represents the range limit for three of these species. Two threatened species, the mallee fowl and the thick-billed grass-wren, are present within the park, of which the latter is now restricted to Shark Bay.

2.2.1.5 Reptiles and Amphibians

The reptilian fauna of the area is diverse, with more than 70 species of reptile and 10 species of amphibians occurring in the area.

Twenty-nine species of reptile are believed to occur in the Francois Peron National Park. Bernier Island and Dorre Island also support a diverse reptile fauna, with more than 30 species being present. Eight species are at their range extension limits. Skinks, geckos, and legless lizards are all represented, as well as several snake species including the highly venomous mulga or king brown snake.

The threatened western spiny-tailed skink (*Egernia stokesii badia)*, and the woma or Ramsay's python (*Aspidities ramsayi)* are reptiles occurring in the region that are listed as specially protected under the *Wildlife Conservation Act 1950.* The declared threatened loggerhead turtle *(Caretta caretta)* and the green turtle (*Chelonia mydas*) are also known to use the area as a breeding ground throughout the summer months.

2.2.2 Marine

2.2.2.1 Seagrass

Approximately 4,000 km^2 of the Shark Bay marine environment consists of seagrass meadows, which is the largest reported area of this kind in the world. Seagrass is an important component in maintaining the structure and productivity of this unique area.

Amphibolis antartica is the dominant species in an assemblage of 12 different seagrass species. The meadows are an essential link in the food web of Shark Bay, providing a high productivity biomass, as well as being a source of nutrients and a habitat and nursery for both fish and invertebrates. Figure 3 shows the approximate distribution of seagrass meadows in Shark Bay.

2.2.2.2 Mangroves

Mangroves occur as isolated trees in the south to thickets in the north (Wooramel coast) and form an integral part of this environment. Mangroves provide feeding and nursery habitats for a variety of marine fauna and birds. The mangroves have an important role in the coastal ecology, helping stabilise the coast against the actions of wind and waves by means of their extensive root systems.

2.2.2.3 Fish

The area encompassed by Shark Bay is predominantly inhabited by tropical fish species (83 per cent) and is considered to be the southern-most mainland Australia site supporting such a large number of species with tropical affinities. Of a total of 323 fish species recorded in the region, the non-tropical species contribute the remaining 17 per cent, consisting of warm temperate origin species (11 per cent) and cool temperate species (6 per cent). This area has a greater range of species than other comparable locations (even those of considerably greater size such as the Houtman Abrolhos Islands, west of Geraldton).

Finfish species caught in Shark Bay by commercial fishers are diverse, but pink snapper, mullet, whiting, and bream are the most popular. Also targeted commercially are reef species, such as coral trout, cod, and tuskfish, whilst mackerel and mulloway form the bulk of pelagic species preferred by (commercial) fishers.

Research indicates there are three separate stocks of pink snapper in the Shark Bay area. The majority of commercially-caught snapper are taken from the oceanic stocks outside the bay, whereas most of the recreational catch is taken from inside the bay. The two inshore stocks appear to be more susceptible to overfishing.

Shark Bay also has a proliferation of sharks of varying sizes - from the smaller school sharks to the larger species of tigers, whalers and hammerheads. The sharks fill an important niche in the ecosystem as large predators and help maintain the unique ecological balance of the region.

2.2.2.4 Corals

Marsh (1990) recorded 80 species of hermatypic (reef building) corals in the region with several species being at their range limit. This included one endemic species at the northern-most extension of its range, whilst 14 per cent of species were at their southern limits in range.

Salinity was found to play an important role in the distribution of coral, with few species growing in the metasaline sections of the bay and no species inhabiting the hypersaline regions. The high flow of water about the Bernier, Dirk Hartog and Dorre Islands, with the resulting near-constant temperature and salinity regimes, provide the most favourable conditions for coral growth.

The inshore corals are much more patchy in growth and are typically of smaller size. These communities tend to be on the northern leeward side of outcrops and grade into coral rubble in the more exposed positions.

2.2.2.5 Invertebrates

The invertebrates comprise the overwhelming bulk of marine creatures, and the Shark Bay region is of no exception to this rule. Life forms consisting of crustaceans, molluscs, cnidarians, bryozoans, echinoderms and a host of other groups, ranging from benthic to free-swimming organisms, are all found in Shark Bay waters.

The distribution of these groups is influenced by the salinity profiles in Shark Bay, as well as species-specific food and shelter requirements. The areas of seagrass, coupled with high organic productivity and the carbonate sand flats, have resulted in a remarkable diversity and abundance of benthic fauna. In turn, this has resulted in an area of significant zoogeographical importance.

2.2.2.6 Mammals

The dugong, which was declared a specially protected species under the *Wildlife Conservation Act 1950*, occurs in Shark Bay in greater numbers than recorded elsewhere. The dugong population is estimated at around 10,000 individuals, making Shark Bay an internationally-significant site.

Large numbers of dugong adults and calves inhabit the seagrass meadows between Faure and Gladstone Islands during summer, as the animals take advantage of optimum water temperatures and available food sources.

The distribution of dugong is seasonally influenced and, as such, they occupy an extensive habitat range within Shark Bay.

Preliminary reports suggests that the well-documented and widely-publicised group of bottlenose dolphins that frequent Monkey Mia contribute to a larger population of approximately 2,700 of these cetaceans in the Shark Bay area. Bottlenose dolphins at Peron Peninsula have been observed herding fish into the shallows.

Humpback whales have been reported to be returning to the region in ever-increasing numbers after a hunting-induced hiatus in the early 1900s (Bannister, 1994). Orca are also visitors to the area and are thought to prey upon the dugong during the winter months. A less frequent visitor to Shark Bay is the Australian sealion. Sometimes found in South Passage, this phenomenon is considered an exception and not recognised as a range extension for the species.

2.2.2.7 Reptiles (Turtles and seasnakes)

Two species of turtles are known to inhabit the region. The green turtle *(Chelonia mydas)*, abundant along the north-western coast of Western Australia, is common throughout Shark Bay. Its breeding areas are thought to be restricted to Turtle Bay on Dirk Hartog Island and to a lesser extent on Peron Peninsula. Turtle Bay is one of only two sites where the declared threatened loggerhead turtle *(Caretta caretta)* is known to nest. Two other turtle species have been recorded in the waters of Shark Bay. The hawksbill and leatherback turtle have been sighted, but are not common to the region.

Shark Bay is home to six of Western Australia's 22 species of sea snake, including the locally endemic *Aipysurus pooleorum*.

2.2.2.8 Birds

Seabirds are an important component of the Shark Bay ecosystem and numerous nesting sites are found within the World Heritage property. Fourteen species use the area for nesting, whilst a further 50 species visit the locality.

Most of the islands in Shark Bay are used as bird breeding sites at some point during the year and the region has the largest population of pied cormorants in the State. Pelicans are known to nest at only 9 or ten breeding sites in Western Australia - Pelican Island in Shark Bay is an important winter breeding ground for these birds.

2.3. Social features

2.3.1 Historical Shipwrecks

There are 14 wrecks within in the World Heritage Area. The most significant of these are the *Zuytdorp*, which sunk off the Zuytdorp Cliffs in the southern extremity of the World Heritage Area (south of the area shown in Figure 1); the *Gudrun*, which sits on the sandy flats north of Cape Peron; and the *Perserverant*, which sits off the north-east of Dirk Hartog Island (Figure 1). The remaining wrecks are ships not officially recognised by the Western Australian Maritime Museum as historic shipwrecks.

2.3.2 Other Historical Sites

Important Aboriginal sites occur throughout the area, especially on Peron Peninsula and Dirk Hartog Island, evidencing 22,000 years of Aboriginal occupation of Shark Bay.

The area is also significant for its maritime history. Shark Bay is the site of the first recorded European landing – by Dirk Hartog in 1616. William Dampier, who named Shark Bay, followed in 1699. The site at Cape Inscription where Hartog and others landed has been marked by various plaques and memorials over the years. A copy of the original Hartog pewter plaque now sits at the Shark Bay Shire Office.

Quarantine hospitals were set up for Aborigines with leprosy and venereal disease on Bernier Island and Dorre Island in 1904, but were abandoned in 1911. After World War Two, a whaling station was established at Carnarvon. Between 1950 and 1962, up to 7,852 humpback whales were harvested. The station collapsed in 1963 due to a lack of whales (CALM, 2003).

2.4 Conservation importance of Shark Bay

Shark Bay's conservation significance is exemplified by its status as a World Heritage Area: the existence of Shark Bay Marine Park and Hamelin Pool Nature Reserve; the Francois Peron National Park; and the vesting of Bernier, Dorre and Koks islands as Nature Reserves.

Table 4 provides examples of the world heritage values that make Shark Bay so important in terms of conservation.

Table 4 World Heritage Values of Shark Bay

World Heritage values	Examples
Outstanding examples representing the major stages of the earth's evolutionary history.	• Stromatolites and microbial mats of Hamelin Pool • Hamelin Pool and Lharidon Bight • Holocene deposits adjacent to Hamelin Pool and Lharidon Bight
Outstanding examples representing significant ongoing geological process, biological evolution and man's interaction with his natural environment.	*Marine Environment* • Unique hydrological structure, banks and silts, steep salinity gradients, three biotic zones • Faure sill • Hypersaline environment of Hamelin Pool • Microbial communities • High genetic biodiversity due to steep environmental gradients (e.g. snapper, venerid clams, bivalves) • Seagrass meadows, and their role in the evolution of the marine environment • Expanse of meadows and diversity of seagrass species • Wooramel seagrass bank • Carbonate deposits and sediments • Northern limit of transition region between temperate and tropical marine environments, resulting in high species diversity (e.g. 323 fish species, 2218 bivalve species, and 80 coral species) *Terrestrial Environment* • Botanical province transition zone. Most pronounced in the southern parts of Nanga and Tamala Stations • Range limits (145 plant species at northern limit. 39 species at southern limit, and 28 vascular plant species endemic) • Isolation of fauna habitats on islands and peninsulas - 5 threatened mammals on Bernier and Dorre islands • Range limits and fauna species richness (100 species of herptofauna - 9 endemics, 230 species of birds representing 35% of Australia's total species) • Species evolution illustrated in rufous hare-wallaby and banded hare-wallaby
Superlative natural phenomena, formation or features: for instance, outstanding examples of the most important ecosystems; areas of exceptional natural beauty; and areas of exceptional combinations of natural and cultural elements.	• Stromatolites • Hypersaline environment of Hamelin Pool • Faure Sill • Wooramel seagrass bank • Coastal scenery of Zuytdrop cliffs, Dirk Hartog Island, Peron Peninsula and Heirisson and Bellefin Prongs • Fragum beaches of Lharidon Bight • Inundated birridas and lagoons such as Big Lagoon • Strongly contrasting colours of the dunes/cliffs, beaches and adjacent sea of Peron Peninsula • Abundance of Marine Fauna (dugongs, dolphins , sharks, rays, turtles and fish) • Annual wildflower season display
The most important and significant natural habitats where threatened species of animals or plants of outstanding universal value still survive.	• 5 out of Australia's 26 endangered mammals (Shark Bay mouse, banded hare-wallaby, rufous hare-wallaby, western barred bandicoot, and burrowing bettong). • Bernier Island subspecies of ash-grey mouse • 12 threatened reptiles (e.g. Baudin Island skink and woma) • Endemic sandhill frog • 35 migratory bird species • Threatened thick billed grasswren • Endemic Dirk Hartog subspecies of the southern emu-wren • Dugong (approx. one eighth of the world's population) • Humpback whale • Loggerhead and green turtles • Some threatened flora species

SECTION 3 OTHER HUMAN USES OF SHARK BAY

A range of commercial and recreational activities currently occurs in Shark Bay and many of these are mapped in Figures 4 - 8. The compatibility, or otherwise, of aquaculture with existing uses of resources in Shark Bay is discussed in more detail in Section 4.4.2 of this report.

3.1 Commercial fisheries

Shark Bay is one of the foremost areas for commercial and recreational fishing in Western Australia. The State's major fisheries for prawns, scallops, snapper and western sand whiting are all located within this region and provide considerable employment opportunities for the community, either as crew aboard the boats or in onshore-based processing and vessel maintenance activities.

The main commercial fisheries operating in Shark Bay are two trawl fisheries - the Shark Bay Prawn Managed Fishery and the Shark Bay Scallop Managed Fishery (Figures 4a(i) and 4a (ii)) - plus the Shark Bay Beach Seine and Mesh Net Managed Fishery (Figure 4b) and the Shark Bay Snapper Managed Fishery (Figure 4c).

The Shark Bay Prawn Managed Fishery extends northwards to the Ningaloo Marine Park, southwards to near Zuytdorp Point and includes the waters of Shark Bay. It targets western king prawns (*Penaeus latisulcatus*), brown tiger prawns (*Penaeus esculentus*) and several smaller species, including coral prawns and endeavour prawns (*Metapenaeus spp.).* King prawns are the dominant species, comprising about 70 per cent of the catch. Tiger prawns make up most of the remaining.

The 27 boats in the fishery also catch between 20 per cent and 30 per cent of the annual scallop catch in Shark Bay. Management of the fishery is based on limited entry, crew limitations, gear controls, season and area openings and closures, moon phase closures and daily fishing time controls.

The Joint Trawl Management Advisory Committee (JTMAC) provides advice to the Minister for Fisheries on the management of the fishery. The total landings for the 2001 season were 1,696 tonnes, comprising 1,322 tonnes of king prawn, 371 tonnes of tiger prawns and 3 tonnes of endeavour prawns. There were also 165 tonnes of coral prawns landed. Plans are currently being developed for the fishery aimed at reducing the volume of by-catch caught in the trawl nets.

The Shark Bay Scallop Managed Fishery, the State’s most valuable scallop fishery, is based on the saucer scallop (*Amusium balloti*). Its boundaries include Indian Ocean and Shark Bay waters land-ward of the 200 m isobath between latitudes 23°34′ south and 26°30′ south, together with waters of Shark Bay south of latitude 26°30′ south. An area in the Naturaliste Channel, between Dirk Hartog and Dorre islands is closed to commercial scallop trawling and reserved for recreational use.

The fleet comprises vessels licensed only to take scallops (14 Class A licences) and vessels that also fish for prawns in the Shark Bay Trawl Managed Fishery. Cooperative management of the fishery is achieved through JTMAC and controls include a limit on the number of licences, fishing area restrictions and daily trawl restrictions. Management of the fishery is aimed at catching the scallops at the best size, thereby maximising economic return, while maintaining breeding stock levels. By-catch reduction devices were introduced in the fishery in 2002. The catch for the 1999 season was 1,700 tonnes (total weight) with an estimated value of $7.4 million.

The Shark Bay Beach Seine and Mesh Net Managed Fishery (Figure 4b) operates in the waters of Shark Bay and currently takes a mixture of whiting (Sillaginidae), sea mullet (*Mugil cephalus*), tailor (*Pomatomus saltatrix*) and yellow-fin bream (*Acanthopagrus latus*). Entry to the fishery is limited,

with restricted, family-only transfers and gear/effort limitations. A unit in the fishery comprises one primary vessel, a maximum of three netting dinghies and a maximum team size of three fishers.

Most of the catch is marketed through the (local) fish processing factory in Denham. Effort is primarily driven by market needs as opposed to fish availability, with catches conforming to commercially acceptable limits, which are frequently above the legal minimum size for the species concerned. During the 1999 season, the respective catches of all species and whiting were 263 and 115 tonnes, with estimated values of $830,000 and $442,000.

The Shark Bay Snapper Managed Fishery (Figure 4c), in operation since the late 1980s, has been managed until recently using a mixture of input and output controls. In 2001, new management arrangements were introduced under the provisions of the *Shark Bay Snapper Fishery Management Plan Amendment 2000* to bring the total fishery under quota management. Units are transferable, although a number of governing policies and principles exist, including the requirement to hold a minimum of 100 units.

The annual (1 September to 31 August) total allowable catch of pink snapper (*Pagrus auratus*) is currently set at 563,750kg. There are 5,125 units in the fishery and the current value of each unit is 110kg. The fishery is located in waters between latitudes 23°34′ south and 26°30′ south and in Shark Bay north of Cape Inscription. The main fishing method is by mechanised handline. During the 1999 season, the respective catches of pink snapper and other species were 450 and 146 tonnes, with estimated values of $2.06 million and $0.6 million.

3.2 Aquaculture

There are currently seven licences for non-*P. maxima* pearl oyster culture within the World Heritage Area. The majority of these operations are based upon the leeward sides of Dirk Hartog Island and Peron Peninsula (see Figure 5). Of these, only two licences are currently producing commercial quantities of black-lipped oyster *(Pinctada margitifera*), Shark Bay pearl oyster *(Pinctada albina*) and Wing oyster *(Pteria penguin*).

In addition, there is a land-based finfish hatchery that is trialing the production of pink snapper. There are also three licences endorsed for sea-cage aquaculture of finfish. Prior to production, the Department of Environment requires all operators to be licensed. Currently no licensees have this endorsement.

The waters of Shark Bay are considered to contain extremely low levels of pollutants due to the relatively small urban and industrial development in the area. This situation, coupled with the relatively sheltered nature of the site, provides an ideal locality for aquaculture.

3.3 Recreational Fishing

Recreational fishing is a major activity within Shark Bay and this past-time is carried out in most parts of the area in some form.

Recreational fishing comprises both shore-based and boat-based activities. Shore-based fishing and netting occurs throughout Shark Bay where the coast is accessible to the public, similarly for dinghy-based fishing (Figures 6 and 7). Key areas are around Denham, Monkey Mia, Freycinet and Grey Point.

Boat-based recreational fishing is undertaken from larger boats and charter boats around outlying islands such as Dorre and Bernier, along the western shore of Dirk Hartog Island down to Zuytdorp

Point and in open water areas. A number of charter boats specialising in recreational fishing operate in Shark Bay.

Following consultation with the community and fishing industry representatives, the Department of Fisheries recently introduced new management arrangements for recreational fishing in the Gascoyne bioregion, which includes Shark Bay. In particular, specific management arrangements are in place to protect vulnerable inner gulf stocks of pink snapper. Information on key recreational fishing areas, including usage and capture rates, are contained in the Department of Fisheries' Fisheries Research Report No. 139. (Sumner, N. R.; Williamson, P. C. and B.E. Malseed, 2002).

3.4 Tourism

Tourism is an industry of increasing importance in the Shark Bay region. The marine environment is the primary site of tourist activities, such as the viewing the stromatolites at Hamelin Pool or the dolphins at Monkey Mia, sailing, windsurfing, recreational fishing, snorkeling and diving.

The historical aspects of Shark Bay's development also attract tourists. Examples of historically-based attractions include the Freshwater Camp, and the shell-block buildings such as the Old Pearler Restaurant and St Andrew's Church.

3.5 Mining, Petroleum and Minerals

Salt is extracted at Lake McLeod (Carnarvon) and Useless Loop (Shark Bay) and provides a relatively stable source of income for the area, generating approximately $45 million per annum. The Shark Bay mining tenement is completely excluded from the World Heritage property. The mining of gypsum is ephemeral in nature, as the deposits are typically small and restricted in occurrence.

Coquina shell is mined in a quarry at Lharidon Bight and is used locally as a building, landscaping and road material. It is also an important resource as shell grit on poultry farms. Existing petroleum and mining tenements are indicated on Figure 8.

Petroleum exploration is minimal, with no active tenements for more than a decade and field exploration has not taken place for more than 20 years. No oil wells have ever been sunk in the area. The Western Australian Government has stated that drilling or production would not be allowed in any marine nature reserves, sanctuary zones and recreation zones of marine parks, or special purpose zones of marine parks where such activities are incompatible with the purpose of the zone.

3.6 Potential future uses

Pressure is being placed on the Shark Bay area to accommodate growth in a number of established industries. This includes growth in the tourism industry, expansion of aquaculture within the bay and adjacent land, and expansion of the solar salt extraction at Useless Loop.

SECTION 4 CONSTRAINTS ON AQUACULTURE OPERATIONS IN SHARK BAY

4.1 Conservation Significance of Shark Bay

A major constraint on the development of aquaculture in Shark Bay is the high conservation value of the site and the need to ensure that aquaculture is managed to minimise environmental impacts. The Shark Bay World Heritage Area is of international significance and Australia has an obligation to identify and conserve the values of the area.

The values of the Shark Bay World Heritage Area are listed in the various management plans discussed in this Section and are summarised in Table 4.

4.2 Environmental Constraints

The environmental constraints that apply to aquaculture in Shark Bay depend upon location and the proposed operation. Many environmental constraints are well-known and clearly identifiable, such as the location of the Shark Bay Marine Park, the Hamelin Bay Marine Nature Reserve, and a proposed Fish Habitat Protection Area (Figure 9). Other environmental constraints, such as the need to protect dolphins or dugongs, are difficult to quantify, as insufficient baseline information is available to determine precisely where these constraints apply.

An assessment of constraints to aquaculture is given in Table 5, which lists environmental constraints, their status, applicability across aquaculture types, and effect on aquaculture development.

Table 5 Environmental constraints on aquaculture development

Environmental constraint	**Status**	**Applicability to aquaculture types/ Effect on aquaculture development**
Existing and proposed National Parks, Nature Reserves, Marine Nature Reserves, Marine Parks.	Clearly defined.	All types of aquaculture. Constrains aquaculture in certain areas.
Benthic habitats (including seagrass, corals, mangroves)	Distribution of benthic habitats poorly known or doubts about the reliability of mapping. Existing policies are draft, but precedents exist for their application in most instances.	All types of aquaculture - land-based discharges may also impact benthic habitats. Constrains aquaculture in certain areas, and may limit effluent discharges in others. Aquaculture proponents will be required to provide a description of the benthic flora/fauna in their application.
Water circulation	Poorly known.	All types of aquaculture. Constrains aquaculture in certain areas (e.g. where contaminants concentrate), but can be of benefit for other types (e.g. where high salinity water is desired, such as for beta carotene production).
Existing settlements (and zoning)	Locations are known.	All types of aquaculture. Constrains or encourages aquaculture in certain areas.

World Heritage values (not already protected by environmental constraints noted above)	**Status**	**Applicability to aquaculture types/ Effect on aquaculture development**
High genetic diversity due to steep environmental gradients (e.g. snapper, venerid clams, bi-valves)	Some research gaps.	All types of aquaculture. Native species strongly preferred as candidates for aquaculture.
Coastal scenery	General areas of high scenic value known.	Constrains certain types of aquaculture in certain areas. Visual resource management would need to be undertaken in certain areas.
Important marine fauna (including dolphins, dugongs, loggerhead and green turtles, humpback whale)	Information base poor.	Aquaculture not permitted in Sanctuary Zones. Important areas for fauna may be identified as knowledge base improves. Where general occurrence known, need to do detailed work to demonstrate no adverse impacts.
Important terrestrial fauna (e.g. sandhill frog) or species of scientific interest (e.g. rufous hare-wallaby and banded hare-wallaby).	General areas of occurrence known.	Would constrain land-based aquaculture in certain locations. Where general occurrence known, need to do detailed work to demonstrate no adverse impacts.
Endangered/ threatened and rare species of flora and fauna	General areas of occurrence known.	Would constrain aquaculture in certain locations. Where general occurrence known, need to do detailed work to demonstrate no adverse impacts.
World Heritage features (e.g. Fragum beaches of Lharidon Bight, inundated birridas and lagoons such as Big Lagoon)	Boundaries appropriate to protection are dependent upon potential impacts of aquaculture type.	Would constrain aquaculture in certain locations. Where in the vicinity of these features, need to do detailed work to demonstrate no impacts.

4.3 Climatic Constraints

Most of the waters in Shark Bay are reasonably well sheltered from prevailing weather conditions and it is expected there would be few climatic constraints to aquaculture within the bay. Although Shark Bay can experience tropical cyclones during the summer months, this is not considered to be a major constraint on aquaculture, provided any significant infrastructure associated with it is designed to withstand cyclonic conditions.

4.4 Operational Constraints

The infrastructure and services in the vicinity of the town of Denham are generally good, but much of the remainder of Shark Bay has little infrastructure and few services. Many onshore sites with some potential for aquaculture development are remote and have poor access, while many of the offshore sites, in which aquaculture may be possible from a technical perspective, are accessible only by boat.

Services such as electricity and potable water are available near and in Denham. Onshore farms would generally have to provide their own equipment for electricity generation and fresh water production, and suitable sewerage and waste disposal facilities would need to be installed.

It should also be noted that Peron Peninsula, excluding Francois Peron National Park and the Denham

town site, is unallocated Crown land. The Department of Conservation and Land Management has prepared a management plan for Shark Bay's terrestrial reserves (CALM, 2000).

Another constraint is the high incidence of "hard bio-fouling" in some parts of Shark Bay. The growth of barnacles, as opposed to algae, on bivalve aquaculture lines could pose a significant operational constraint on aquaculture development in these areas.

In addition to these constraints, the Department of Fisheries' policy to maintain a minimum distance between some forms of aquaculture farms could have the effect of limiting the number of farms that could occur in a given area.

4.5 Native Title

There are currently a number of native title claims over Shark Bay lodged with the Native Title Tribunal.

The requirements of the Commonwealth *Native Title Act 1993* must be observed before any new aquaculture leases or licences can be granted. Aquaculture proponents should be made aware of this requirement and advised to allow sufficient time for the necessary consultation processes to be completed.

4.6 Conflicting Use of Resources

The conflicting demand for use of resources is another significant constraint to aquaculture development in Shark Bay. Mechanisms that can be adopted to resolve conflicts include spatial and temporal zoning, improved control of water and land resource development schemes, establishment of natural reserves, rehabilitation of degraded habitats, stock enhancement and integrated management. Some of these mechanisms are already in place in Shark Bay and others are being contemplated.

4.6.1 Competition for space

Onshore aquaculture needs relatively large areas of flat land close to the coast and must compete for space with other uses. There are growing demands for land in the Shark Bay area for conservation reserves, tourism resorts, urban expansion, salt production and other forms of mining.

Aquaculture is considered to be compatible with some of these uses, but incompatible with others. For example, some forms of aquaculture could co-exist with salt production ponds, but the visual impact of aquaculture ponds could be considered by some to detract from the amenity of a tourist resort. Conversely, aquaculture could add interest to the area and become an integral part of the visitor's experience. In some cases, the use of some land areas for aquaculture can also place restrictions on the use to which adjacent land may be put, particularly where environmental discharges are of concern.

Aquaculture also requires land and water areas that vary, according to the type of production system used**.** Frequently, given the wide range of production systems that are available today, it is possible for aquaculture to be located in comparatively limited land areas and to co-exist with a variety of other users of limited resources.

More intensive aquaculture production systems can be located in close proximity to, and co-exist with, many other uses of coastal land. For example, re-circulating systems are presently located adjacent to large cities and, in many cases, within the boundaries of ports and marinas.

Offshore, aquaculture must compete with established uses, such as commercial and recreational fishing. New marine parks and reserves and the growing tourism interest in diving and wildlife viewing are placing additional constraints on where aquaculture might be established in the future. Offshore aquaculture can be compatible with the petroleum industry - for instance, where sea cages may be supported by, or suspended from, offshore structures or platforms.

4.6.2 Wild-Capture and Recreational Fisheries

Onshore aquaculture can be incompatible with the wild-capture fishery where it competes for coastal land required for ports and port infrastructure, including processing plants. However, in most cases aquaculture and the wild-capture fishery are compatible and synergetic, with positive benefits arising from opportunities to share transportation and marketing costs, and to optimise the use of common infrastructure such as processing facilities. Offshore aquaculture can be incompatible with fisheries in cases where sea-cages and other floating and sub-surface equipment restrict or otherwise interfere with commercial fishing operations.

Onshore and offshore aquaculture operations can also conflict with recreational fishing if they restrict or otherwise prevent access to fishing spots. Conversely, as for the commercial wild-capture fishery, aquaculture can be compatible with and provide positive benefits to recreational fishing activities in cases where it can be used to enhance stocks of depleted fisheries. Sea-based structures, such as bivalve longlines, can enhance recreational fishing by acting as fish attraction devices (FADs).

Offshore recreational fishing is unlikely to conflict with aquaculture operations except on a localised basis immediately adjacent to an aquaculture facility. The area in which charter and larger boats carry out recreational fishing is large (see Figure 6) and aquaculture is unlikely to provide any major constraints to these activities in the region. Similarly, shore-based activities and near-shore netting would only be constrained by aquaculture on a local basis, i.e. if being carried out immediately adjacent to an aquaculture facility.

4.6.3 Tourism and Recreation

Aquaculture is generally considered highly compatible with tourism. The Pilbara/Gascoyne Islands Ecotourism Management Strategy (Pilbara Development Commission, 1995) outlines the synergies between tourism and aquaculture and the mutual benefits that can ensue. The southern bluefin tuna industry operating off Port Lincoln, South Australia demonstrates the high level of interest generated by onshore and offshore aquaculture activities. Local tourist operators take advantage of the opportunities to generate additional revenue by arranging visits to local aquaculture facilities. Offshore aquaculture may be incompatible in water areas reserved for, or generally used for, recreational activities such as boating, sailing and other water sports.

There are a number of areas that may be potential sites for aquaculture which are already being used as tourism and recreation sites, for example areas around Monkey Mia and Denham. In areas where tourism or recreational activities are already well established, any aquaculture proposal will need to take into account visual, odour and noise issues, with recognition given to the importance of nature-based tourism and the significant conservation values of the area. In some instances, a 'visual resource management' approach should be adopted to assess visual impacts.

Areas of scenic value in Shark Bay include the look-outs at Eagle Bluff and Cape Peron. In these major tourist sites, the visual impact of aquaculture development would need to be considered. Other sites of scenic value are Big Lagoon, Monkey Mia, Nanga Station and the camps between Denham and Nanga Station.

SECTION 5 MANAGEMENT STRUCTURE AND LEGISLATIVE ENVIRONMENT

5.1 Legislative Framework

Numerous government agencies, working in accordance with a range of legislation, have management responsibilities within Shark Bay. The role of some of the agencies most relevant to aquaculture development and the Acts they administer are summarised below.

5.1.1 State Government

5.1.1.1 Department of Fisheries

The Department of Fisheries administers the *Fish Resources and Management Act 1994* and is responsible for the long-term ecologically sustainable management of commercial, recreational and indigenous fishing in the bay. The Act provides for the establishment of Fish Habitat Protection Areas. The Department also manages aquaculture, through the provisions of the *Fish Resources Management Act* or the *Pearling Act 1990* (for *P. maxima* only).

5.1.1.2 Department of Conservation and Land Management

The Department of Conservation and Land Management (CALM) plays an important role in Shark Bay through its management responsibilities for terrestrial and marine reserves. Nature reserves and national parks are managed by CALM in accordance with the *Conservation and Land Management Act 1984.*

Marine nature reserves, marine parks and marine management areas are managed under the *Acts Amendment (Marine Reserves) Act 1997*. In addition, CALM administers the *Wildlife Conservation Act and Regulations (1980)*, which aims to conserve Western Australia's native flora and fauna.

5.1.1.3 Department of Environment

The Department of Environment (DOE) administers the *Environmental Protection Act 1986.* The Act is to provide for the prevention, control and abatement of environmental pollution.

Any aquaculture proposals that appear likely, if implemented, to have a significant effect on the environment need to be referred to the Environmental Protection Authority. A Works Approval and Licence is required from DEP, under the *Environmental Protection Act 1986* for aquaculture activities that are classed as prescribed premises.

5.1.1.4 Department of Land Information

The Department of Land Information (DOLI) administers all crown land within the region under the *Land Administration Act 1997.*

5.1.1.5 Department for Planning and Infrastructure

The Department for Planning and Infrastructure (DPI) administers the *Western Australian Marine Act 1982* and is responsible for marine safety and the administration of moorings.

5.1.1.6 Department of Industry and Resources

The West Australian Department of Industry and Resources has responsibility for management of the petroleum industry under the *Petroleum Act (1967)* and *the Western Australian Petroleum (Submerged Lands) Act 1982*.

5.1.2 Commonwealth Government

5.1.2.1 Department of Environment and Heritage

The Commonwealth government has an interest in the management of the Shark Bay World Heritage Area under the provisions of the *Word Heritage Properties Conservation Act 1983***.** The World Heritage Unit of the Department of Environment and Heritage (DEH) oversees the management of Australia's World Heritage properties and the implementation of the Shark Bay World Heritage Property Agreement (see Appendix C1 and D). Environment Australia is also responsible for administering the new *Environment Protection and Biodiversity Conservation Act 1999***,** which came into force in July 2000**.**

5.1.3 Local Government

5.1.3.1 Shire of Shark Bay

The Shire of Shark Bay, through its town-planning scheme, directs development of private land within the Shire, particularly in the township of Denham.

5.2 Policy and Planning Framework

Shark Bay has been the focus of much attention in recent years, and numerous studies, reports and planning strategies have been prepared to guide future management of this important conservation area (see Figure 10). A summary of the most relevant documents is given in Appendix C.

The *Shark Bay World Heritage Property Agreement 1997* (Appendix C1 and D) describes in broad terms how the Commonwealth and State government will work cooperatively to ensure the World Heritage values of Shark Bay are maintained. Under the terms of the agreement, a strategic plan for the World Heritage property must be prepared to provide a management framework designed to ensure the protection, conservation and presentation of the outstanding universal values of the property. The Strategic Plan is currently being prepared by CALM.

A number of management plans provide more detail on how specific elements of the World Heritage property, such as marine parks or fish resources, will be managed to ensure ecologically sustainable development.

Although the agreement was signed in September 1997, it is not widely available or understood, and its application in the approvals process is relatively recent. A copy of the World Heritage Agreement is included in Appendix D so that prospective aquaculture developers can be made aware of, and directed to, documents that essentially detail the criteria for sustainable development in Shark Bay.

Of particular relevance to aquaculture development are the recommendations of the *Shark Bay Marine Reserves Management Plan 1996* (Appendix C2) which state, amongst other things, that:

- Applications for aquaculture operations which propose to use exotic species will not be approved in the marine park or marine nature reserve;
- Aquaculture will not be permitted in recreation zones, sanctuary zones, Hamelin Pool Marine Nature Reserve, or the Blue Lagoon, Boorabuggatta, Cape Peron and Gladstone Special Purpose Zones; and
- Actual or potential damage to seagrass should be minimised.

In addition to the Shark Bay agreement, strategic plan and management plans, several government agency policies and guidelines are relevant to activities within Shark Bay. Fisheries Ministerial Policy Guideline No. 8 for the 'assessment of applications for authorisations for aquaculture and pearling in the coastal waters of Western Australia' (Appendix C9) details the consultation and approvals process for aquaculture proposals.

It is clear from a review of these documents that aquaculture is considered to have the potential to bring increased economic wealth to the area and is seen as an acceptable use of Shark Bay, provided the World Heritage values of the area are not diminished by such development.

Recommendation 1

Ensure that aquaculture development does not diminish the World Heritage Values of Shark Bay and occurs in accordance with the administrative arrangements detailed in the State/Commonwealth Shark Bay World Heritage Property Agreement.
(*DEH/DOF/CALM)*

SECTION 6 THE SHARK BAY DRAFT AQUACULTURE PLAN

6.1 Objective

The objective of the draft aquaculture plan is to:

"Provide guidance to aquaculture proponents, the community and government agencies on the future development of aquaculture activities in Shark Bay, while at the same time conserving the World Heritage values of Shark Bay for present and future generations, and minimising conflict with existing and future users of Shark Bay."

6.2 Underlying Assumptions

Given the importance of the environment in Shark Bay and its high conservation value, aquaculture development in the area will be characterised predominantly by a limited number of sites and a requirement to ensure that used water discharged from aquaculture production systems does not endanger the local environment, particularly in the more sensitive areas. Commercially-viable, and hence sustainable, aquaculture production in Shark Bay is likely to be limited to the production of high-value species using production systems that meet high environmental standards.

From the perspective of the development of sustainable commercial aquaculture, Shark Bay has several features that will govern the selection of aquaculture species and production systems. These are principally:

- The requirement for all developments to have no adverse effects on World Heritage values;
- A limited number of suitable offshore sites (none are presently permitted over seagrasses);
- A limited number of suitable onshore sites;
- Only the culture of species that utilise natural productivity and do not require supplementary feeding are likely to be acceptable in more sheltered areas within Shark Bay and in the vicinity of seagrasses; and
- The offshore production of species (that do require feeding) is likely to be in areas that are well-flushed in the northern areas of Shark Bay and near Dirk Hartog Island.

6.3 Species suitable for Aquaculture in Shark Bay

6.3.1 Species Selection Criteria

A comprehensive assessment and selection of species is usually carried out during the early planning stages of a proposed aquaculture project, as one component of a detailed feasibility study. In addition to the World Heritage values, numerous criteria need to be considered and evaluated when selecting a species of finfish or shellfish for commercial aquaculture; each criterion can be considered for a range of aquaculture candidate species, with particular reference to the region in which the proposed aquaculture project is to take place.

To facilitate the selection procedure, the criteria may be arranged into four principal categories:

i marketing;

ii culture technology;

iii production efficiency; and

iv commercial viability.

A summary of the key elements of the species selection process, with specific reference to Shark Bay, is provided below[2].

6.3.1.1 Marketing

Due to their remote locations, aquaculture projects in Shark Bay will need to have a high production capability and moderate to low unit production cost or produce a high-value product. Given the remoteness from major domestic and export markets and the small local tourism-based market, aquaculture projects would have to be structured to supply distant markets with good-quality, high-value products that command a premium price to offset the disadvantage of distance from markets.

6.3.1.2 Culture Technology

Culture technology refers to specific techniques used to rear a species in captivity, preferably under commercial conditions. More specifically, when considering the suitability of a species for aquaculture, culture technology refers to the ability of the species to reproduce in captivity and the simplicity of the larval and early juvenile phases of its life history[3]. For many of the species of marine finfish that may be suitable for aquaculture in Shark Bay, the culture technology is either poorly known or at an early stage of commercial development. Many of the marine shellfish species are better known and already used in commercial aquaculture projects.

Species selection criteria relevant to the reproduction in captivity of marine finfish and shellfish consider:

- the broodstock (their occurrence, ease of capture and adaptability to captive conditions);
- their reproductive biology, captive spawning and factors in respect of egg production and viability.

The criteria relevant to larviculture and juvenile production factors for finfish and shellfish consider the size and development of the eggs and larvae; duration of the larval phase; various nutritional and physiological requirements of larvae and early juveniles; and, generally, the available larviculture and weaning technology.

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[2] For a more detailed description and discussion of species selection criteria for aquaculture, readers are referred to publications such as Aquaculture Planning in Western Australia: Part A: Synopsis and Review (Aquaculture Development Council and Department of Fisheries, 1997).

[3] Within the context of this document, the expression *culture technology* refers to the technical procedures used to rear the larvae and early juvenile stages of finfish and shellfish, predominantly during the hatchery and nursery stages of the culture cycle. The term *grow-out*, which refers to the growing of post-hatchery or post-nursery juveniles to market size, is dealt with under the heading *Production Efficiency*.

6.3.1.3 Production Efficiency

Production efficiency refers fundamentally to productivity. Linked by definition to the commercial viability of any aquaculture project, the production efficiency of a species deals mainly with factors such as nutritional requirements and the ability generally of the species to thrive under commercial grow-out conditions. An assessment of production efficiency involves criteria such as diet, growth rate, food conversion ratio (or "FCR"), behaviour, disease resistance, and the ability to withstand stress, crowding and handling.

Given factors such as high operational costs and distance from major markets, aquaculture farms located in Shark Bay will almost certainly be characterised by high levels of production efficiency. Species which do not require supplementary feeding, such as non-*P. maxima* pearl oysters that are being cultured, will have to be placed in the most productive areas possible.

Farms growing species that require supplementary feeding, such as most finfish, will need to have access to nutritionally adequate pelletised diets that provide efficient FCRs. Offshore production systems are likely to be limited in most areas of Shark Bay, due to environmental constraints. Where they may be permitted, sea-cage production systems will need to have high production efficiency since they may be limited in scale.

Onshore production systems are more likely, due to their ability to control and treat wastewater, but the requisite land areas are likely to be limited. Accordingly, species suited to intensive culture in onshore tanks are likely to be favoured.

6.3.1.4 Commercial Viability

In simple terms, commercial viability refers to the relationship between the selling price and production cost of the product. Under the economic and environmental conditions prevailing in Shark Bay, regulatory and environmental factors will also have a major impact on commercial viability.

The species selection criteria relevant to commercial viability in Shark Bay are profitability, the potential for diversification, infrastructure requirements, competitiveness, regulatory factors, and industry commitment and support.

A farm designed to have potential to diversify by producing several species or by integrating its activities with tourism may have competitive advantages over others. One that selects a species, the culture of which requires minimal infrastructure, may have advantages in respect of reduced capital costs. A species with culture technologies and production efficiencies, compatible with automation and other means of reducing high production costs, may have significant advantages in Shark Bay.

6.3.2 Species with Aquaculture Potential in Shark Bay

Once evaluated according to predetermined selection criteria, aquaculture species can be classified according to their aquaculture potential, with specific reference to the area in which they are to be cultured and the characteristics of individual projects.

For the purpose of this plan, "current aquaculture species" are those currently or previously produced by aquaculture in Shark Bay, irrespective of the quantity. Similarly, "candidate aquaculture species" are those not in the former category, but considered to have characteristics favourable for their commercial culture in Shark Bay in the future. The latter group includes species with favourable marketing, production efficiency and commercial viability features, and for which the requisite culture

technology is well or moderately known.

The selection and classification of candidate species for aquaculture is predominantly subjective and based on other, similar planning studies undertaken for Western Australia, including *Aquaculture Planning in Western Australia* (Aquaculture Development Council and Department of Fisheries, 1997) and the *Gascoyne Aquaculture Development Plan* (Department of Fisheries and Gascoyne Development Commission, 1996).

The species considered suitable candidates for aquaculture in Shark Bay would generally have:

- Favourable marketing features;
- A well-known or moderately-known culture technology;
- A high level of production efficiency;
- A potentially-high commercial viability; and
- Aquaculture requirements compatible with production systems considered technically, environmentally and economically suitable for Shark Bay.

Further, given the environmental sensitivity and conservation values of Shark Bay, there is a strong preference for aquaculture candidates to be native species.

The species list is inclusive. While considered reasonably comprehensive at this stage, it almost certainly does not include all possible aquaculture candidates. Factors such as the development of new technologies and identification of new market opportunities will in the future qualify additional species for commercial aquaculture in Shark Bay.

6.3.3 Marine Finfish

Marine finfish species considered being candidates for aquaculture, but not presently cultured, in Shark Bay include:

- Pink snapper (*Pagrus auratus*);
- Mahimahi (*Coryphaena hippurus*);
- Yellowtail kingfish (*Seriola lalandi*);
- Trevally (*Caranx* spp., *Pseudocaranx* spp.);
- Barramundi cod (*Cromileptes altivelis*);
- Coral trout (*Plectropomus* spp.);
- Red emperor (*Lutjanus sebae*);
- Estuary cod (*Epinephelus coioides*);
- Western school whiting (*Sillago vittata*);
- Yellow-finned whiting (*Sillago schomburgkii*);
- Marine aquarium fishes (various species);
- Southern bluefin tuna (*Thunnus maccoyii*); and
- Yellowfin tuna (*Thunnus albacares*).

6.3.3.1 Pink Snapper

Pink snapper are considered separately since this is an important species for Shark Bay fisheries and there is strong support for its culture.

The species has only moderate aquaculture market prospects at this stage, but has a well-known culture technology. The production efficiency under commercial conditions is poorly known, but the commercial viability of the species under aquaculture may be acceptable if the production costs can be kept low. Snapper can be cultured in offshore and onshore systems.

There may be opportunities for restocking pink snapper in the eastern gulf of Shark Bay, where currently stocks are depleted. It has been suggested the release of hatchery-reared juveniles, produced from eggs acquired from local broodstock, could augment natural recruitment and thus improve the local commercial and recreational fisheries. However, it should be noted that the effectiveness of such restocking programs is largely undemonstrated. Furthermore, any such program should be accompanied by an education campaign, which tackles the cause of the stock depletions.

The genetic variations of pink snapper in the bay would also have to be considered in the collection of broodstock and release of hatchery-reared juveniles.

6.3.3.2 Pelagic Fish

Mahimahi and yellowtail kingfish, both of which occur in coastal waters of Shark Bay, are species that may have good prospects for aquaculture in Shark Bay. The market potential for these fish has yet to be determined, but there is anecdotal evidence to suggest that they would have high value in domestic and export markets.

Despite several attempts, mahimahi has not yet been successfully cultured at a commercial scale, although significant research has been undertaken to develop the culture technology. Yellowtail kingfish has been cultured and a closely-related species forms the basis of one of Japan’s major aquaculture industries, in which wild-caught juveniles are used as seed stock for grow-out farms. Research into the hatchery production of yellowtail kingfish is currently under way in a number of countries, including Australia and New Zealand. The commercial viability of these species has yet to be determined.

Trevally is common in all coastal waters of Western Australia. Of the numerous trevally species that exist, some may be suitable for aquaculture. While little is known about the culture of local species, numerous members of the family Carangidae are cultured worldwide and it is likely the requisite technology could be adapted or transferred relatively simply.

Marketing factors, particularly demand and price, are likely to be more important determinants in the aquaculture of trevally than culture technology and production efficiency. The commercial viability of culturing this species is likely to be determined principally by profitability and a low unit production cost. Unless a high profitability can be expected, trevally is considered a marginal aquaculture candidate for Shark Bay.

6.3.3.3 Reef Fishes

Barramundi cod, coral trout, bar-cheeked coral trout and red emperor are all reef fish characterised by a high market demand and value[4]. It is likely this list may be expanded to include other high-value reef species, such as emperors (*Lethrinus* spp.) and sea perches (*Lutjanus* spp.)[5]. Shark Bay is at the southern end of the ranges of these reef species.

Culture technology for reef fish and reef fish species is in the process of being developed in Australia, Taiwan and Japan. Given the high value, this technology is expected to be available in the near future. Based on the culture of similar species elsewhere, it is likely the production efficiency and commercial viability of these species will be suitable for their successful commercial aquaculture.

The species are considered suitable to the types of aquaculture systems that may be permitted in Shark Bay; that is, in offshore cages located at the northern end of the bay and Dirk Hartog Island, and under intensive culture in onshore systems where there is the ability to treat discharge waters.

Estuary cod inhabit areas northwards of Rottnest Island on the Western Australian coast and have a relatively high value in export markets, particularly in live form. The species is currently grown in Taiwan and the requisite culture technology is being developed in Australia. Preliminary work has been carried out on the species at a private hatchery near Carnarvon, but very limited success has been achieved to date. Estuary cod are possibly less suited to aquaculture in Shark Bay than other reef fishes, but there may be some limited potential for them to be grown in onshore systems for the live fish market.

6.3.3.4 Demersal and Benthic Species

The Western Australian dhufish is endemic to Western Australia but research indicates, from a technical perspective, the species is not suitable for commercial aquaculture production.

Western school whiting, found between Coral Bay and Geographe Bay, and yellow-finned whiting, distributed southwards from Shark Bay, are considered marginal candidates for aquaculture in Shark Bay. They are likely to be comparatively simple species to culture, but their market features are such that commercial culture in Shark Bay would possibly be marginal at best and the limited resources available would be better devoted to more profitable species.

6.3.3.5 Aquarium Fishes

Marine aquarium fish with potential for aquaculture include the species that inhabit coral reefs in tropical waters. These species have a reasonably high market value, particularly in terms of value per unit weight. At present, however, the technology required for their mass production is relatively poorly known and most marine aquarium fish supplied to domestic and export markets are captured in the wild.

Once suitable culture technology is available, the production efficiency of these fishes is likely to be

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[4] Coral trout includes the true coral trout, *P. leopardus*, and the closely related, bar-cheeked coral trout, *P. maculatus*. Both species are native to coastal waters of Shark Bay.

[5] To avoid confusion, it should be noted that red emperor, despite its common name, is actually a sea perch of the genus *Lutjanus*. It is also noted that barramundi cod is a true marine species and no relation to barramundi, a diadromous species with a more tropical distribution.

quite good, since they would be sold at an early age and for a comparatively high value per unit weight. As culture technologies are developed, the same or similar species are likely to be produced in South-east Asian countries, which have an established marketing network and other competitive advantages, such as competitive labour costs.

The commercial viability of aquaculture enterprises growing aquarium fish in Shark Bay will be governed largely by the extent to which local competitive advantages can be exploited, and the relative costs and availability of cultured and wild-caught fish in global export markets.

6.3.3.6 Tuna Species

Southern bluefin tuna and yellowfin tuna occur naturally in all oceanic waters off the Western Australian coast.[6] These species may be ideally suited for aquaculture in Shark Bay, particularly in the northern areas subject to more oceanic conditions and remote from the more environmentally sensitive locations.

At present, in Australia, tuna aquaculture is limited to the grow-out or fattening of wild-caught juvenile fish in sea cages located off the coast of the Eyre Peninsula, near Port Lincoln. The aquaculture of southern bluefin and yellowfin tuna off the western coastline of Western Australian is considered feasible from a technical perspective, by growing out wild-caught juveniles as well as hatchery-reared seed stocks.

Preliminary research in several countries has indicated the viability of tuna aquaculture using hatchery-reared seed produced from captive broodstock. Their very high market value, particularly for southern bluefin tuna, makes the commercial aquaculture of these species feasible in difficult, remote locations.

From a physiological perspective, there is no reason the tunas cannot be cultured in warmer waters than previously considered suitable; indeed, warmer waters could have significant positive effects on critical production efficiency factors such as growth rate and FCRs. The potential commercial viability of the aquaculture of southern bluefin and yellowfin tuna in Shark Bay is considered promising, despite the failure of a previous attempt to fatten wild-caught yellowfin tuna in cages in the same area.

6.3.4 Marine Invertebrates

Marine invertebrate species considered being candidates for aquaculture, but not presently cultured, in Shark Bay include:

- Artemia (*Artemia* spp., *Parartemia* spp.);
- Edible oysters (*Saccostrea commercialis*);
- Roe's abalone (*Haliotis roei*);
- Western rock lobster (*Panulirus cygnus*); and
- Saucer scallop (*Amusium balloti)*

[6] Tunas are pelagic fish; however, in this study they are considered separately from other pelagic species since they comprise a distinct group and generally have very high market values.

6.3.4.1 Artemia

Artemia or brine shrimp are produced in arid tropical and subtropical environments and used world-wide as a live food in marine and fresh water aquaculture hatcheries. Per unit weight, artemia may be considered a high-value aquaculture product. Market prices vary according to supplies, which may vary from year-to-year.

The product from this species would principally be desiccated cysts for use in hatcheries, but could also include limited quantities of biomass for sale to the aquarium trade. The culture technology for artemia is well known, however, as a rule, aquaculture operations producing the species do not have any operational inputs and hence costs. Instead, they depend on the natural productivity of salt lakes and harvest of the desiccated cysts seasonally. The production efficiency of this method is high.

The commercial viability of artemia aquaculture in Shark Bay is considered good, subject to suitable production and harvesting areas being available. In particular, opportunities exist for artemia production to be integrated with existing salt mining operations in Shark Bay.

Artemia are not native to Western Australia but are already established at the salt works in Shark Bay. Given that Artemia are already widely distributed around the State (and will continue to be distributed on water birds and the like) and have been here for some time, they are considered to be more or less 'naturalised'.

Parartemia spp. are native brine shrimp similar to artemia that may have some potential for aquaculture. Research to explore the potential of the species is at an early stage, but the genus is characterised by several features that require careful consideration if their commercial culture is to be contemplated.

The negative buoyancy of their cysts may constitute a significant disadvantage in relation to the cost of production, since harvesting methods would need to be more elaborate, and hence more expensive, than those traditionally used for artemia. Proposals to produce the species in intensive systems more conducive to harvesting would again need to consider the cost of production.[7]

6.3.4.2 Edible Oysters

Western rock oysters - the same species as the highly-regarded Sydney rock oyster - occur naturally in Shark Bay and are known for their excellent quality, due in part to limited fresh-water input and good sea-water quality. Oysters bearing the name Shark Bay would probably be well received in the market place and may receive premium prices, due to the region's pristine environment.

The culture technology for many edible oyster species is well known and the western rock oyster has previously been produced in commercial hatcheries located near Carnarvon and Albany. Subject to the availability of suitable sites and conditions, the production efficiency is high.

However, despite the evident advantages, the commercial prospects for western rock oyster aquaculture in Shark Bay are not considered good, due principally to the limited number of available intertidal or nearshore sites for rack or longline production. Further, it is anticipated that the limited number of offshore sites would be devoted to the production of blacklip pearl oysters, since pearl production is likely to be more profitable and the blacklip oyster more suited to low nutrient conditions.

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[7] By way of comparison, artemia cysts are positively buoyant and tend to accumulate at the downwind shores of drying salt lakes. Enterprises that consistently and profitably produce artemia are characterised by natural productivity in salt lakes and are those for which the only cost is the cost of harvesting, processing and packaging.

6.3.4.3 Roe's Abalone

Most abalone species, including Roe's abalone, may be considered to have good market prospects. Shark Bay is included in the natural distribution of the species, albeit approaching its northern extreme.

The culture technology for Roe's abalone is still being developed, but is similar to that currently used to successfully grow other abalone species and may be considered ready for commercial development at a pilot scale. The production efficiency and commercial viability are relatively unknown, particularly intensive, onshore production systems.

Roe's abalone have limited tolerance for salinity variations, particularly for salinities greater than that of sea water, so are not likely to be commercially viable in most areas of Shark Bay. Their aquaculture may be technically feasible in areas with access to oceanic-quality water; but these areas are very limited or remote and, consequently, expensive to develop and operate. It is likely that aquaculturists wishing to grow Roe's abalone would seek alternate, more suitable sites south of Shark Bay.

It has been suggested that tropical abalone (*Haliotis asinina*) could grow in Shark Bay. Similar seawater quality restrictions, as described for Roe's abalone would apply, given Shark Bay is at the southern extreme of the species' distribution. Any aquaculturist contemplating the production of tropical abalone would almost certainly seek a site north of Exmouth and preferably in the Pilbara or Kimberley regions.

6.3.4.4 Western Rock Lobster

Western rock lobster is Australia's most valuable single-species wild fishery that has a consistently high market demand and price. Rock lobsters are not currently produced by means of aquaculture and it will probably be some time before technology is developed for the closed-cycle production of the species. However, given the high value of the species, there are strong prospects for the grow-out of wild-caught pueruli.[8]

A Fisheries and Research Development Corporation-funded research project aimed at establishing post pueruli grow-out data for western rock lobster has recently begun. Results from this project will enable the economic potential for this form of aquaculture to be assessed. Issues in respect of access to wild stocks of larval, juvenile and adult rock lobsters are yet to be finalised.

6.3.4.5 Saucer Scallop

Saucer scallops are an important wild fishery species in Shark Bay, with annual catches ranging from around 1,000 tonnes to 20,000 tonnes (live weight). However, catches are highly variable due to the high level of variability in recruitment success, primarily as a result of environmental influences on larval survival.

[8] The puerulus is a post-larval development stage in the early life history of rock lobster that can be caught in large numbers off the Western Australian coast using purpose-built collectors.

At times of good recruitment success, scallops are found in beds of very high density (around one scallop per square metre). Scallops appear to grow and survive well at these high densities, suggesting that there may be scope for ocean ranching (bottom culture) of hatchery-supplied spat. Hanging culture (suspending scallops in baskets in the water column) has not been shown to be useful for this species because of its fragile shell.

Growth of the species is rapid (9-10 months to harvestable size), which, combined with its ability to tolerate high densities, make it an attractive aquaculture species, provided that techniques of bottom culture can be developed for the species.

6.3.5 Summary of species with aquaculture potential

Table 2 provides a summary of the respective merits of species currently produced by aquaculture and candidate species considered to have potential for commercial aquaculture in Shark Bay. Brief comments are also provided about the compatibility of the species with production systems considered suitable for Shark Bay.

The species listed as having potential should be considered suitable candidates for aquaculture in Shark Bay. The list of candidate species is inclusive, not exclusive, and, as the industry develops and the requisite technologies become available, aquaculture proponents may contemplate the production of species that may be equally suitable for aquaculture but are not included in the list.

These other species should be considered according to their merits on an individual basis. However, it should be restated that neither the Department of Fisheries nor the Environmental Protection Authority would favourably consider applications for species that are not native to, or not already established in, Shark Bay.

Table 2 Summary of the merits of current and candidate aquaculture species for Shark Bay

Species	Status	Comments
Blacklip pearl oyster *(Pinctada margaritifera*) **Wing oyster** *(Pteria penguin)*	Currently cultured in Shark Bay. Market factors are positive, culture technology is known, production efficiency and commercial viability are good.	Considered highly compatible with, and suited to, aquaculture in Shark Bay.
Shark Bay pearl oyster (*Pinctada albina)*	Have been cultured in Shark Bay. Probably less viable than blacklip oysters due to a lower market value for the product and less-well-known technology.	Suited to culture in Shark Bay, but possibly will be restricted due to availability of suitable sites.
Pink snapper (*Pagrus auratus*)	A hatchery has been established in Shark Bay. There are some uncertainties in respect of market demand, prices and hence commercial viability.	The species is well suited to production in Shark Bay, where hatchery-reared fish have been used to supplement depleted wild stocks. Maintenance of the three genetically diverse stocks will need to be a consideration.
Southern bluefin tuna (*Thunnus maccoyii*) **Yellowfin tuna** (*Thunnus albacares*)	Market prospects are very good. Production technologies are available for growing wild fish and developing for hatchery production. Commercial viability will probably be very good.	Well suited to culture in offshore cages in areas with oceanic-quality water and remote from seagrasses. Possibly the most viable marine finfish candidates, due to high value.
Mahimahi (*Coryphaena hippurus*) **Yellowtail kingfish** (*Seriola lalandi*) **Trevally** (*Caranx spp., Pseudocaranx spp.*)	Good market prospects for mahimahi and yellowtail kingfish, but market value for trevally is low. Culture technology, production efficiency and commercial viability are relatively well known for the first two species, but poorly known or unknown for trevally	Possibly suited to production in onshore systems employing water treatment or recirculating systems. Suitable offshore sites are very limited.
Barramundi cod (*Cromileptes altivelis)* **Coral trout** *(Plectropomus spp.)* **Emperors** (*Lethrinus spp.)* **Sea perches** (*Lutjanus spp.)* **Estuary cod** (*Epinephelus coioi-des)*	Market demand and values are high, particularly for live fish. Culture technologies are poorly known but being developed. Production efficiency and commercial viability will probably be good.	Possible suited to production in onshore systems employing water treatment or recirculating systems. Suitable offshore sites are very limited.
Westralian dhufish *(Glaucosoma hebraicum*) **Whitings** *(Sillago spp.)*	Domestic markets for dhufish are excellent, but production technology has not been developed. Whiting are less valuable. Production efficiencies and commercial viability are unknown.	Possible suited to onshore systems with treatment or recirculating systems. Offshore sites are very limited and likely to be used for higher-value species.
Marine aquarium species (various species)	High-value markets but poorly known culture technologies and unknown viability.	Ideally suited to onshore systems due to limited water requirements.
Artemia (*Artemia spp., Parartemia spp.)*	World-wide, high value markets, well known culture technology and production efficiencies in certain systems. Commercially viable.	Non-native to Shark Bay. Well suited to integration with salt mining operations and other evaporative salt lakes on pastoral leases.
Western rock oyster *(Saccostrea commercialis*)	Uncertain but possibly good demand and prices. Well-known technology and other production and viability factors.	Although native to Shark Bay, may not be viable due to site limitations.
Roe's abalone *(Haliotis roei)*	Good market prospects. Technology may be available soon and production efficiency and commercial viability likely to be good at suitable sites.	Unlikely to be suitable, since appropriate sites are remote and better, alternative sites available beyond Shark Bay.
Western rock lobster *(Panuliris cygnus)*	Very good market prospects. Culture technology, production efficiency and commercial viability are all poorly known or unknown.	May be well suited to culture in Shark Bay using onshore grow-out with water treatment or recycling systems. Offshore culture is less likely due to site limitations.
Saucer scallops *(Amusium balloti)*	Currently fished in Shark Bay in a wildstock fishery with highly variable recruitment.	High growth rate and capacity to tolerate densities of around $1/m^2$ suggest suitability for bottom culture ocean ranching.

6.3.6 Excluded Species

Several species identified in the various aquaculture planning studies have been excluded from the above categories because, for various reasons, they are considered unsuitable for aquaculture in Shark Bay. These species are:

- Diadromous: a fresh-water and non-native or introduced species, the successful culture of which is unlikely under the conditions prevailing at Shark Bay. This category includes eels, barramundi, salmonids, fresh-water aquarium species, silver perch and other fresh-water fishes, and kuruma prawn.
- Native marine species with a natural distribution that does not include Shark Bay. These include mangrove jack, King George whiting, large-toothed and small-toothed flounder, cobbler, greenback flounder, tropical abalone, mud crab, trepang, tiger prawn, giant clam, trochus, greenlip and brownlip abalone.
- Species native to coastal seas in the vicinity of Shark Bay but with marginal prospects for commercial aquaculture due to low market value or inappropriate current production systems and aquaculture technologies. These include western yellowfin and silver bream, sea mullet, mulloway, baldchin groper, southern Australian herring, breaksea cod and saucer scallop.

Recommendation 2

Consider the species listed in Table 2 as suitable candidates for aquaculture in Shark Bay. In the event that a proponent lodges an aquaculture application for Shark Bay involving species not included in the list, consider these other species according to their merits on an individual-case basis. *(DOF/proponents)*

Recommendation 3

Protect the biodiversity of the World Heritage Area by using only species native to, or already established in, Shark Bay. *(DOF/proponents)*

Recommendation 4

Ensure licensed aquaculturists utilise local broodstock and provide a legislative mechanism to ensure access on a sustainable basis. Any translocation of broodstock must be subject to the translocation guidelines. *(DOF)*

6.4 Aquaculture Production Systems Suitable for Shark Bay

The relative costs of establishing onshore and offshore aquaculture systems with equivalent production capabilities can vary significantly, according to certain site-specific factors. Onshore systems usually cost more to establish than equivalent offshore ones, but in some cases they can be cheaper.

The operating costs of the two are similarly influenced by site-specific factors. The principal benefits of onshore production systems include more comprehensive management and control over the stock and environment than may be within offshore systems. Furthermore, well-designed onshore systems with adequate back-up capabilities are generally far less risky to aquaculturists and permit a significantly greater degree of control over the quality of water being discharged back into the environment.

Given the high conservation value of Shark Bay, offshore production systems are likely to be generally limited to the culture of filter-feeding organisms, such as bivalve molluscs. Systems that use cages or

other offshore culture units to grow species that require feeding may be restricted to the northern areas of the bay.

Onshore production systems, which permit a high degree of control over the quality of the water that is discharged, are generally considered suitable for the production in Shark Bay of finfish and shellfish species that require feeding. Methods for the treatment of water discharged from aquaculture farms include mechanical filtration (to remove particulate wastes) and various forms of biological filtration.

6.4.1 Onshore Production Systems

6.4.1.1 Location and Water Type

Onshore locations in the Shark Bay region may be divided into inland and coastal areas.

Inland areas are considered to have some potential for aquaculture and preliminary work has been undertaken in the region to assess their viability. Production systems suited to these inland areas growing fresh water species, such as aquarium fishes and barramundi[8] would mostly use ground water supplies.

These inland production systems would not impact on the waters of Shark Bay, as they would neither extract sea water from - nor discharge used water to - the bay. Accordingly, they are not considered further in this study.

From a technical perspective, onshore coastal systems may be located in the coastal areas of Shark Bay at sites that satisfy certain physical, biological, social and economic criteria, such as water quality, topography and infrastructure. Clearly, any coastal operations would be required to comply with guidelines or regulations governing the amount of seawater drawn from the bay, the means by which the seawater is supplied and discharged, and the quality of the water being discharged.

All coastal production systems are likely to use seawater, the salinity of which would vary according to the selected site. Salinity would vary from that of normal seawater (35‰) to hypersaline.

6.4.1.2 Culture Units

The culture units that would be used in onshore aquaculture systems would predominantly include fibreglass or concrete tanks and raceways, for the production of finfish and shellfish respectively. There may also be opportunities for small, lined ponds, according to the requirements of the species under culture.

The proper planning and design of onshore aquaculture production systems will be essential to ensure their efficient management, cost-effective operations and the effective treatment of water being discharged.

[8] Barramundi is a diadromous, not fresh-water, species that can be grown in fresh-water and is considered suited to the environmental conditions that generally prevail in the Gascoyne region of Western Australia.

6.4.1.3 Water Flow

Onshore systems located in coastal areas of Shark Bay would almost certainly be flow-through and depend on pumped water.[9] For most species, recirculating systems are not considered commercially viable for use in the Shark Bay area, since they are unlikely to be competitive. The onshore production systems would usually require the availability of large volumes of high-quality seawater, as well as suitable structures for water intake and discharge.

6.4.1.4 Intensity

Due to the importance and high conservation value of the Shark Bay environment, a critical feature of any onshore aquaculture farms that may be established in the coastal areas will be the capacity to treat the water discharged from the system to meet defined quality standards. The cost of discharge-water treatment plant and equipment that would be needed for this purpose suggests that onshore, coastal aquaculture production systems in the Shark Bay region are likely to be predominantly intensive and target high-value species.

Onshore production systems in Shark Bay will probably be relatively expensive to establish. The anticipated trend towards intensive systems will therefore also ensue from the need to maximise yield, using high densities and intensive management and husbandry techniques.

The establishment of some semi-intensive systems may be feasible in areas where large land areas are available for the construction of ponds, provided that they can be structured to economically meet discharge-water quality standards.

6.4.1.5 Scale

Large-scale aquaculture developments are considered unlikely for coastal areas of Shark Bay. As indicated previously, given the high conservation value of the area, the only acceptable aquaculture production systems are likely to be those characterised by, and which can demonstrate, a high level of management and control over the aquaculture processes and the quality of water being discharged.

6.4.1.6 Integration

Most onshore systems will be characterised by some degree of vertical integration, in that they would comprise a hatchery, with the ability to reliably and consistently produce mass quantities of juveniles of the target species, and a grow-out facility. Some operations may focus on hatchery production, others on grow-out.

It is further contemplated that early diversification will be a priority in the region and that some leading operations will become multi-species producers.[10] Horizontal integration is considered likely in Shark

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[9] Some recirculation may be used in hatcheries to facilitate control over certain water quality or environmental parameters; however, the commercial grow-out of most species would almost certainly depend on the use of flow-through systems.

[10] It is worth noting an important difference between polyculture and multi-species aquaculture. Both types of aquaculture involve the production of more than one species within a single production system; however, in polyculture there is some interdependence between the species, while in multi-species aquaculture there is not and each species is produced independently of the others.

Bay in two principal areas, viz.: the integration of aquaculture with the tourism industry and the use of polyculture in the treatment of wastewater discharged from grow-out farms.

6.4.2 Offshore Production Systems

6.4.2.1 Location and Water Type

Offshore locations in the Shark Bay region may all be classified as nearshore - there are no locations in the region that can be described as 'open ocean'.

As for the onshore locations, from a technical perspective, offshore systems may be located in the nearshore areas of Shark Bay, at sites that satisfy certain physical, biological, social and economic criteria, such as water quality, hydrography, hydrology, recreational fishing areas and proximity to a shore base. Any offshore operations would be required to comply with regulations in place to protect native flora and fauna, such as seagrasses and dugongs.

It is anticipated that in some of the more sensitive areas of Shark Bay, production systems in which the culture species are filter feeders requiring no supplementary feeding may, from an environmental perspective, be more acceptable than those culture species that require pellets or other supplementary feeds.

By definition, all offshore production systems would use seawater that varies in salinity according to the site. Salinity would vary from that of normal seawater (35‰) the outer gulf areas to hypersaline in the inner gulf regions.

6.4.2.2 Culture Units

Offshore production systems in Shark Bay, which would principally include longlines and sea cages, would be subject to varying degrees of exposure, water quality and several other factors, according to their location. The main factors that need to be considered in selecting and designing the culture units include the species under culture, currents, waves, wind and exposure to storms.

Offshore production systems using longlines as culture units for filter-feeding shellfishes are likely to predominate in Shark Bay. Longlines are already used in the region to culture non-*Pinctata maxima* pearl oysters, an industry sector that holds significant promise. Clearly, these culture units are well suited for shellfish and likely to expand, subject to determinations in respect of site availability, productivity and sustainability.

The use of longlines, from which may be suspended barrels and cages for the offshore production of species that require feeding (i.e. abalone), may also present opportunities for offshore aquaculture. Due to their requirement for supplementary feeding, culture units growing these species would be subject to similar constraints as those producing finfish. In this case, offshore production systems using cages or longlines to culture non-filter-feeding species of shellfish that require supplementary feeding would be likely to compete with those growing finfish for limited space and resources.

Subject to the availability of adequate quantities of juvenile fish for seed stock, it is anticipated that cages will be established in nearshore locations. Flexible, floating sea cages are likely to predominate both as individual units and as linked, multi-cage systems in more sheltered areas.

Production systems focusing on fisheries enhancement and restocking may be developed, particularly in view of the depleted wild-capture fishery in the area and the opportunities that such developments may create for tourism.

6.4.2.3 Water Flow

Based on current technology, all production systems would be open. In the future, systems using floating tanks as production units may be introduced - these tanks would be of the flow-through type.

6.4.2.4 Intensity

Offshore aquaculture production systems in Shark Bay are likely to be intensive and semi-intensive, with the latter predominating. Intensive production, with the high stock densities and levels of feeding implicit in these systems, are unlikely to be acceptable from an environmental perspective in all but the more remote, well-flushed sites.

This may restrict the offshore, cage culture of marine finfish (and some shellfish) to these more remote areas, since their production in semi-intensive systems may not be commercially feasible. In the case of marine finfish, the intensive production of large volumes of high-value species is often necessary to justify the initially high capital costs necessary to establish suitable production systems.

In offshore locations, semi-intensive production systems culturing filter-feeding shellfish are more likely to be acceptable from an environmental view. These systems may be located over sandy bottoms but not in the vicinity of seagrass meadows, which occupy much of the offshore areas of Shark Bay.

6.4.2.5 Scale

It is anticipated that most production systems in Shark Bay will be small-scale to medium-scale.[11] The size of most systems would be limited physically by the occurrence and extent of seagrass meadows. Further, from a social perspective, the visual impact of anything larger than medium-scale systems would probably be unacceptable.

6.4.2.6 Integration

Some degree of vertical integration will be necessary, since offshore production systems invariably need to be supported by onshore facilities or bases. Horizontal integration is likely to be limited to the tourism operators - polyculture systems are unlikely.

6.5 Types of Aquaculture for Shark Bay

6.5.1 Aquaculture

Given the high conservation value of Shark Bay, proponents of any aquaculture ventures proposed for the area would have to demonstrate that their activities would have minimal impact on the local environment. This could be achieved by including equipment and processes in the farm design that

[11] Some licences or leases may be issued for areas in excess of 200 ha; however, within the context of this study, the scale refers to the area the production system physically occupies, not the total site area.

permit efficient control over the culture environment and by effective waste treatment. Therefore, aquaculture in Shark Bay will almost certainly be characterised by intensive and semi-intensive production systems that allow the requisite control and treatment levels.

Similarly, the commercial returns from aquaculture ventures will need to be such that the additional capital and operating costs are warranted. Accordingly, it is anticipated that these production systems, whether onshore or offshore, will be used to grow high-value species.

Aquaculture in onshore locations is expected to use intensive systems and feature efficient processes for the treatment of water discharged from the growing units. Offshore production systems are anticipated to be semi-intensive to intensive, varying according to site and species.

The different elements of aquaculture production systems may be combined in a variety of ways to provide the combination that will best suit the species under culture, the environment and the aquaculturist. The combination will have a significant influence on the long-term environmental and commercial sustainability of an aquaculture operation.

Table 6 provides a summary of the respective merits of the various elements, with specific reference to the environment and other conditions prevailing in Shark Bay. Table 7 links candidate aquaculture species with production systems and provides relevant comments. Species currently being cultured in Shark Bay are not included, since their production systems are already developed.

Table 6 Summary of aquaculture production systems considered suitable for Shark Bay

Element	Onshore	Offshore
Water type	Marine and hypersaline, limited opportunities for fresh water.	Marine.
Culture unit	Tanks will provide the most suitable culture units, particularly near the more environmentally sensitive areas of the bay. Ponds may be useful where larger land areas are available, provided that more intensive systems are used.	Principally longlines and sea cages. Longlines will be used within the bay for culturing filter-feeding species such as blacklip oysters. Sea cages will be used in more remote areas with oceanic-quality seawater for the culture of high-value finfish species. Floating tanks may be used in sheltered areas in the future, if they prove commercially viable.
Water flow	Flow-through systems will be used. Recirculating systems are unlikely for all species other than, possibly, marine aquarium fish.	Principally open. If floating tanks are used, flow-through would be employed.
Intensity	Intensive systems will probably be necessary due to the limited land areas available and the need to maximise return from invested capital. Intensive systems will also optimise efficiency for water treatment activities.	Semi-intensive systems will be used for pearl oysters and the culture of other bivalves, if these are grown. Sea cages remote from seagrasses will use semi-intensive to intensive systems, according to the species under culture.
Scale	Small-scale operations occupying less than 20 ha.	Small to medium scale operations. The sites may be fairly large, but the areas occupied by the culture units comparatively small.
Integration	Most operations would require some degree of vertical integration. Exceptions include hatcheries established to provide seed stock to growers. Opportunities exist for integration with tourism.	Offshore systems may be integrated to varying degrees with onshore hatchery, processing and other facilities. Good opportunities exist for integration with tourism, particularly for finfish in cages.
General	Water treatment systems will almost certainly be required for onshore production systems. These would focus predominantly on the removal and concentration of particulate waste material.	Sites will be limited, particularly in the vicinity of seagrasses. High operating costs may be associated with cage operations in more remote sites. Accordingly, only high-value species are likely to be commercially viable.

Table 7 Summary of aquaculture species for Shark Bay, in relation to likely culture units.

Species	Production system	Comment
Pink snapper	Intensive, onshore, flow-through systems, using tanks located in the vicinity of Denham or other areas with access to infrastructure and services. Possible stock enhancement to supplement depleted stocks, particularly in the eastern gulf.	Cage culture in offshore systems is considered unlikely, unless the commercial viability can be proven. Alternate sites exist that would have lower production costs.
Southern bluefin tuna Yellowfin tuna	Semi-intensive to intensive offshore systems using large-diameter cages located remote from environmentally sensitive areas and in oceanic-quality water. Intensive, onshore production in tanks may be possible if and when hatchery-reared stocks become available for aquaculture.	Seed stock would have to be acquired from the wild or, in the future, a hatchery that may be established.
Mahimahi Yellowtail kingfish Trevally	Intensive, onshore, flow-through systems, using tanks located in the vicinity of Denham or other areas with access to infrastructure and services. Semi-intensive to intensive offshore systems using cages may be feasible, subject to market prices and commercial viability being confirmed.	Offshore systems are less likely than onshore ones, due to limited site availability and preference at available offshore sites for higher-value tuna species. Onshore systems have the added advantage of being able to treat discharge water.
Barramundi cod Coral trout Emperors Sea perches Estuary cod	Intensive, onshore, flow-through systems, using tanks located in the vicinity of Denham, or intensive to semi-intensive offshore systems using cages.	The high value of these species would override many constraints applied to other marine finfish species grown in Shark Bay. Additional investment would be warranted in intensive onshore systems to treat discharge water.
Whiting species	Intensive, onshore, flow-through systems, using tanks located near Denham, or intensive to semi-intensive offshore systems using cages.	Limited potential for aquaculture as whiting species are low value.
Marine aquarium species	Intensive to semi-intensive, onshore, flow-through systems, using tanks and small ponds, located near Denham.	Shark Bay is considered an excellent location for marine aquarium fishes. Production systems are suited to intensive water treatment systems and minimal environmental risk.
Artemia	Extensive systems using evaporative salt lakes. Successful production systems are likely to be characterised by minimal or no production costs and efficient harvesting and processing methods.	Significant potential for artemia cyst production, due partly to the arid environment and high evaporation rates. Potential for integration with existing salt mining operations. The name *Shark Bay* on cysts would confer a marketing advantage.

Species	**Production system**	**Comment**
Western rock oyster	Semi-intensive, offshore systems using longlines or racks.	Sites available for racks are limited; those for longlines are likely to be devoted to more profitable species.
Roe's abalone	Semi-intensive to intensive offshore systems, using barrels or other containers suspended from longlines. Semi-intensive to intensive onshore systems, using tanks and raceways.	Onshore systems would need oceanic-quality seawater, so are less likely than offshore systems, due to limited sites being available. Alternate locations south of Shark Bay are likely to be preferred for this species.
Western rock lobster	Semi-intensive to intensive onshore systems, using raceways and possibly tanks. Intensive offshore systems using cages are equally likely, due to the high value of the species. Systems have yet to be developed, but may be based on current recirculating technology used to hold wild-caught rock lobsters.	The high value of the species would warrant significant investment in onshore and offshore production systems. Commercial production will be preceded by research and development to establish the requisite technology and systems.
Saucer scallop	Bottom culture ocean ranching in defined areas. Low movement levels allow good definition of grow-out area. Grow-out would be in 'beds', probably 2-3 km long by 0.5 km wide, simulating natural beds and in a configuration suitable for harvest. Harvest would be by traditional wildstock fishery methods.	The grow-out methodology effectively duplicate natural high-density settlement – but uses hatchery-produced spat. A national review committee on scallop aquaculture is currently examining economics and mechanics of supplying adequate numbers of spat.

6.5.2 Management of Aquaculture-Related Activities

Applications may be made from time to time to replenish wild stocks of existing fish resources, either through reseeding or stock enhancement. Provision of hatchery stock for such purposes is accepted as a potentially viable aquaculture activity. Management policies for reseeding and stock enhancement within Western Australia are currently being developed and proponents should consult with the Department of Fisheries to ascertain what guidelines and regulations are in place.

***Recommendation 5**:*

Consider applications for wild stock reseeding and enhancement on a case-by-case basis.
(DOF)

6.6 Environmental Management of Aquaculture

6.6.1 Aquaculture and the Environment

The sheltered waters of Shark Bay, combined with the good water quality and lack of coastal development, make it an attractive location for aquaculture. However, if the aquaculture industry is to expand within Shark Bay, it must occur in a manner that does not cause adverse environmental impacts, nor diminish the World Heritage values of the area.

The environmental impacts of aquaculture relate to the type and location of the aquaculture 'farm' and impacts may occur as a direct, or indirect, result of its operation. The nature of the environmental risk associated with aquaculture depends on a range of factors, including whether the operation is located onshore or offshore; whether the species farmed are native or introduced to the area; and whether the animals are passive filter-feeders or require food to be added to the water. These factors are discussed in more detail below.

6.6.1.1 Onshore production

Onshore aquaculture development involves the construction of ponds, impoundments or tanks on land adjacent to the coast. Intensive aquaculture systems may consist of tanks and raceways with high feeding rates and high stocking densities, while semi-intensive and extensive systems utilise larger areas of land, with lower stocking densities.

Environmental impacts that may be associated with onshore aquaculture vary, depending on the location of the aquaculture farm. Pond construction in some organic-rich soil types in tropical and sub-tropical areas may disturb acid sulfate soils, which, if not appropriately treated, can leach sulfuric acid into waterways, lowering the pH and potentially causing adverse effects on marine life and coastal infrastructure.

The discharge of nutrient-rich waters from onshore aquaculture farms can also impact on the marine environment. However, if properly managed, wastewaters can be readily contained and treated and/or re-used before being released to the sea.

The cost of pumping high volumes of water through the tanks or ponds is a limiting factor that determines the size of the aquaculture operation and its proximity to the coast. Onshore

aquaculture ponds may also raise the local water table and create soil salinity problems, which may constrain future use of the land.

Extensive clearing of mangroves and salt marsh for pond construction has occurred in South-east Asia and the Philippines. This is not an issue in Australia, as clearing of such vegetation is generally strictly controlled by State and Local Government agencies. However, small-scale, incremental loss or decline of mangrove or salt marsh communities may be associated with some onshore aquaculture ponds, owing to clearing for infrastructure development, and/or changed water levels, salinities or water circulation patterns.

6.6.1.2 Offshore production

Aquaculture located offshore generally involves either longlines and racks or sea cages floating or temporarily fixed to the seabed. Longlines and racks are used for the grow-out of bivalve and other shellfish.

In general, these animals are filter feeders and extract all their dietary needs from the water column. The environmental impact of such farms is considered to be relatively low and of a localised nature. For example, seagrass in the immediate vicinity of a set of longlines or racks may be affected by shading from the racks.

Faecal matter from the animals can accumulate under the racks, smothering seagrass and adding nutrients to the water column. In some instances, there are concerns that the introduction of large numbers of filter feeders may strip the water of detritus and plankton, reducing the food availability of wild filter feeders living downstream from the aquaculture farm. However there has been little scientific study to confirm this situation.

Sea cages are used primarily for the production of a variety of finfish. The fish are fed formulated diets and stocking rates can be high. The main environmental concerns associated with finfish culture relate to nutrient-rich waste from unused food and faecal matter; the risk of fish escaping to the wild; and the consequent impact on other wildlife and the threat of disease. Good water circulation is a crucial factor in determining the location of sea cages.

There have been significant improvements in fish farming practices in recent years, with farmers now adopting feeding strategies involving low impact diets that are highly digestible, resulting in a reduction in uneaten feed.

6.6.1.3 Loss of biodiversity

Aquaculture could contribute to a loss of biodiversity if it is not suitably located or not undertaken in a sustainable manner. For example, shading or smothering of corals or seagrass associated with offshore aquaculture could cause localized impacts on biodiversity.

Changes in nutrient levels in the marine environment attributed to either onshore or offshore aquaculture could have direct and indirect effects on the ecosystem. Higher nutrient levels could result in the growth of epiphytic algae on seagrass leaves, which may reduce light levels to the leaves to the extent that the seagrass dies.

The translocation of exotic species for the aquaculture trade could also have an impact on biodiversity through the introduction of disease, or, if the animals escape to the wild, possible competition of introduced species with wild fish stocks and the modification of habitat to favour the introduced species. Similarly, the genetic variations of a species in the natural environment

would be adversely affected by the introduction of animals of a different genetic stock.

Three genetically different populations of pink snapper have been identified in Shark Bay. The source of pink snapper broodstock for large-scale sea cage aquaculture would therefore be a consideration in assessment of the likely environmental impacts of proposed ventures to farm pink snapper in the bay.

6.6.1.4 Disease and genetics

Community concern regarding intensive fish farming in sea cages and the risk of diseases spreading to the natural environment has been heightened, following recent episodes of widespread die-off of pilchards on the southern Australian coast. Imported fish feed used by bluefin tuna farmers at Port Lincoln in South Australia has been raised as a possible source of pathogens, but this has not been proven.

The long-term impact of the use of antibiotics and other chemicals to maintain some species of aquaculture stock in a healthy state needs to be considered. However, it should be noted that the use of such chemicals is strictly regulated in Australia.

The West Australian pearling industry suffered substantial pearl mortality in the late 1970s and early 1980s, due primarily to poor farm management practices leading to a concern about the transmission of disease from one pearl farm to another. The Department of Fisheries has since adopted a precautionary policy of maintaining a minimum distance between aquaculture farms, in an attempt to minimise the risk of spread of any disease.

However, diseases from organisms cultured onshore are unlikely to threaten wild stocks. Farmed fish may be at-risk from the wild population, but there are no documented instances of cultured fish causing disease epidemics among wild fish. The cultured fish are comparatively crowded and under stress, so they are more likely to be predisposed to disease. In their natural environment, wild fish are not under stress and are less likely to be affected by pathogens that may be released from aquaculture operations.

The accidental transfer of aquatic pathogens with finfish and shellfish translocations has been a cause for some concern. In some areas, stock movements have led to the introduction of parasites and bacterial pathogens. However, it is important to note that these pathogens may lead to losses in cultured stocks and there is little evidence that they adversely affect wild stocks. In any case, controls already in place concerning the translocation of stocks would minimise the threat of diseases being introduced.

The introduction of exotic or non-native species can reduce productivity and diversity in native stocks. The aquaculture of non-native species is unlikely to be permitted in Shark Bay. Accordingly, environmental threats from a genetics perspective are unlikely to be a major cause of concern.

Nonetheless, the maintenance of genetic diversity could be still an issue with native species, where different genetic populations exist.

Recommendation 6

Maintain the genetic diversity of species endemic to Shark Bay and undertake appropriate risk assessments of translocation of animals where different genetic populations of species are known to exist. *(DOF/proponents)*

6.6.1.5 Interaction with marine wildlife

Aquaculture operations have the potential to impact on marine wildlife in both a positive and negative manner. Experience in Tasmania and overseas shows that seals may be attracted to salmon farms as an easy source of food, causing conflict with the salmon farmers.

Research on the bottlenose dolphin populations at Monkey Mia suggests that the dolphins avoid oyster leases containing floating long lines. The reason for this is not known, and some conservationists hold concerns that the loss of access to shallow water sites, as they become taken up for aquaculture, may have a negative impact on dolphin populations.

The research data collected to date shows that female dolphins with calves spend a large proportion of their time in shallow water less than 7m deep, but no conclusions can be drawn on whether aquaculture or other activities, such as tourism or fishing, are having a negative impact on the dolphins (Mann, J. and Janik, M., 1999).

6.6.1.6 Visual impacts

Some people find aquaculture infrastructure unsightly and consider that aquaculture farms can detract from the scenic amenity of an area. Consideration should be given to the landscape and seascape values of a site when determining a suitable location for aquaculture farms.

It may be necessary to avoid locating farms adjacent to popular viewing areas or tourism sites, or to ensure that aquaculture infrastructure is designed to minimise its impact on the landscape.

6.6.1.7 Positive benefits

Aquaculture has the potential to have both positive and negative impacts for the environment and the community. Examples of where aquaculture can have positive benefits, include:

- Protection of endangered species through cultivation;
- Integrated agri-aquacultural operations (e.g. as occurs with rice growing in many Asian countries);
- Utilisation of waste products from other industries (e.g. warm water from power stations);
- Monitoring of aquaculture operations can give an early warning of deterioration in local environments;
- Provision of an economic base reliant on the maintenance of good water quality;
- Provision of regional employment opportunities; and
- Re-stocking of depleted fisheries.

6.6.2 Environmental Impacts from Aquaculture Activities in Shark Bay

No specific information exists on environmental impacts arising from existing aquaculture operations within Shark Bay.

At present, blacklip oyster (*Pinctada margaritifera*), Shark Bay pearl oyster (*Pintada albina*) and wing oyster (*Pteria penguin)* are the only species grown commercially in Shark Bay. These species are filter feeders and are usually suspended from long-lines. The environmental impact of these operations is considered to be minimal.

Marine finfish are not currently produced by offshore aquaculture in Shark Bay. There is one land-based hatchery with marine finfish.

During the initial consultation process, many people expressed concerned about the environmental risks associated with offshore finfish production in Shark Bay. Experience from overseas has shown that unless this type of aquaculture is appropriately managed, there is the potential for such farms to cause adverse impacts on the environment.

The environmental impacts of offshore finfish farms need to be thoroughly assessed and appropriate conditions placed on lease or licence conditions, in order to ensure that negative effects do not occur and World Heritage values are maintained.

Large-scale land-based aquaculture operations could discharge large nutrient loads into the marine environment, unless appropriate waste management practices are adopted. Applications for large-scale land-based operations should be referred to the Department of Environment, with a recommendation that the Environmental Protection Authority formally assess the application.

Recommendation 7

Refer any aquaculture proposals that are likely to discharge into or have a significant impact on Shark Bay to the Environmental Protection Authority (EPA) under section 38 of the *Environmental Protection Act 1986*.
(DOF/EPA)

6.6.3 Management of Aquaculture Wastes

Waste management in aquaculture refers to the minimisation and removal of particulate and soluble waste materials from the used water discharged from the culture units. Fundamentally, waste management involves two processes, *viz*.:

- *Waste minimisation* - the aim of which is to optimise the feed conversion efficiency by improving feeds and feeding strategies; and
- *Waste water treatment* - the treatment of the discharge water by including the relevant modules in the production system.

The processes are interdependent - more efficient food conversion ratios (FCRs) per unit of biomass result in lower waste material production. This means that for a given yield, any treatment system that may be implemented to treat the discharge water would be more effective and less costly to operate.[12]

The most effective way to reduce nutrient loading in waste water is to optimise the FCR by improving feeds and feeding strategies - processes that are effective for both offshore and onshore production systems. The continuous improvement of the FCR is fundamental to contemporary aquaculture practices, from both an environmental and an economic perspective, and significant research efforts are generally devoted to that purpose.

[12] The food conversion ratio, or FCR, is a convenient unit of measurement commonly used in aquaculture that combines feed quality and feeding practices. The FCR is the ratio of the total dry weight of feed offered to the total harvested wet weight of the species under culture.

6.6.3.1 Waste Management in Onshore Aquaculture

Onshore production focuses predominantly on waste management by treatment of discharge water. Modern onshore aquaculture operations that discharge water into the sea, particularly in environmentally sensitive areas, frequently employ wastewater treatment systems. These systems vary according to the application, but generally comprise various physical elements for removing and concentrating particulate wastes.

The early and efficient removal of particulate waste material from discharge water reduces the time available for leaching of soluble material from solid wastes, thus significantly reducing the level of dissolved wastes that can occur downstream.

Biological filtration, which can also be employed to reduce soluble wastes, is usually unnecessary in flow-through operations with efficient physical water treatment systems and is generally used only in recirculating systems. However, it may be a requirement for development for aquaculture proposals in environmentally sensitive areas of Shark Bay.

Water treatment in recirculating systems can also include sterilisation, oxygenation, aeration, degassing, cooling or heating and pH control. Physical waste treatment systems typically employ filters or sieves with intermittent back flushing and tanks for sludge thickening and stabilisation. The more efficient treatment systems usually have filters fitted with screens that remove particles greater than 200 microns in size.

6.6.3.2 Waste Management in Offshore Aquaculture

Wastewater treatment varies significantly according to location. Offshore aquaculture production systems generally have very restricted capabilities for treating wastewaters, due to the open water flow characteristics. Offshore systems using floating tanks are an exception to this general rule.

Waste materials produced in offshore aquaculture systems are usually dispersed on the seabed beneath the cages or other culture units used and depend on natural processes for their treatment and assimilation. Hence, for offshore production systems, the assimilative capacity of the environment will govern the maximum yield that can be sustained.

Waste management systems that are applied to offshore aquaculture most commonly include rotation of sites, adopting a single-cage mooring method to aid dispersal and the removal of waste materials that accumulate beneath cages by suction or other means.

There was a strong preference through the initial public consultation for land-based aquaculture in preference to sea-cage aquaculture in Shark Bay because it enabled better control of aquaculture wastes. Proponents seeking approval for onshore systems will need to demonstrate, to the satisfaction of the Minister of the Environment, that waste products can be appropriately managed through the incorporation of adequate sediment and/or wastewater filtration systems.

It should be noted that sea-based sites allow for better dilution of released nutrients than land-based ones and do not involve an identifiable outlet pipe/point source.

6.6.4 Regulatory Mechanisms

6.6.4.1 Fish Resources Management Act 1994

The aquaculture of species other than *P. maxima* pearl oysters is managed under the provisions of

the *Fish Resources Management Act 1994* (FRMA). Prior to granting an aquaculture licence, the Executive Director of the Department of Fisheries must be satisfied that:

- The person is 'fit and proper' to hold such a licence;
- The proposal is in the better interests of the aquaculture industry;
- The activities to be conducted under the licence are unlikely to adversely affect other fish or the aquatic environment; and
- The application has been approved by other relevant agencies.

Applications for the aquaculture of pearl oysters *P. maxima* are assessed under the provisions of the *Pearling Act 1990*.

In its assessment of aquaculture applications, the Department of Fisheries takes into account matters such as disease management, translocation of non-endemic species, health management protocols, and water quality monitoring. Licence conditions may be imposed as relevant.

To ensure applications are considered in the context of World Heritage Property values, the Department of Fisheries refers all applications in the Shark Bay World Heritage Area for comment to:

- The Department of Environment (DOE);
- The Department of Conservation and Land Management (CALM);
- The Marine Parks and Reserves Authority (MPRA);
- The Shark Bay World Heritage Scientific Advisory Committee; and
- The Shark Bay World Heritage Community Consultative Committee.

Approval is required from the Minister for the Environment in accordance with Section 92 (5) (a) of the FRMA for all proposals in an area of a marine park where aquaculture is permitted and in marine management areas. Once all other clearances for an application have been obtained, the Minister for Fisheries seeks approval from the Minister for the Environment.

Details of the Department of Fisheries processes for assessing applications are dealt with in section 7 below.

6.3.4.2 Environmental Protection Authority (EPA) and Department of Environment

The EPA has lead responsibility for ensuring that the environment is protected in Western Australia and provides input to Department of Fisheries concerning the ecologically sustainable development of aquaculture in Western Australia.

The proposed aquaculture development may need to be referred to the EPA if it:

- Involves land clearing of remnant or native vegetation; and/or
- Could impact on adjacent waterways and the marine environment; and/or
- Would result in discharge of pollutants (including nutrients in effluent) in excess of the Water and River Commission guidelines for aquaculture; and/or
- Requires works approval and a licence from the DOE.

In these cases proponents are required to provide information on the potential environmental impacts of the project and the proposed management mechanisms to minimise these impacts.

The DOE, the Local Government Authority, the Department of Fisheries or any other party can refer proposals to the EPA.

The DOE takes into account the document "Guidance for the Assessment of Environmental Factors - Assessment of development proposals in Shark Bay World Heritage Property" when assessing applications in the Shark Bay area.

Given the World Heritage value of the area, few proposals (if any) would not require referral to the EPA. The EPA then determines the level of assessment, which is usually either:

- Not assessed;
- Not assessed, but public advice given; or
- Formal environmental impact assessment under the *Environmental Protection Act 1986.*

In the Shark Bay World Heritage Area, a formal environmental impact assessment under the *Environmental Protection Act 1986* enables setting of environmental conditions by the Minister for the Environment (in consultation with the Commonwealth). In determining the level of assessment, the EPA is seeking support of decision-making authorities to manage the proposal in accordance with its advice. There is provision to appeal the level of assessment that is set.

6.3.4.3 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) requires that, notwithstanding relevant State approval processes, any action that has the potential to affect a 'matter of National Environmental Significance' (whether this action is undertaken in Commonwealth land/water or otherwise) be approved under the EPBC Act. The EPBC Act defines these matters as:

- World Heritage properties;
- Ramsar wetlands;
- Nationally threatened species and ecological communities;
- Migratory species;
- Commonwealth marine areas; and
- Nuclear actions (including uranium mining).

The Act provides the opportunity for bilateral agreements to be established between the Commonwealth and State, which would accredit the State environmental assessment and/or approvals processes. State Government is currently considering these opportunities.

In the meantime, a person proposing to take an action, which has the potential to affect a matter of National Environmental Significance, must refer the proposed action to the Commonwealth Environment Minister. An action does not require approval if it is a lawful continuation of a use of land, sea or seabed that was occurring before the commencement of the Act. All new applications and variations (which may be interpreted as enlargements, expansions or intensifications) to existing operations will be required to meet the requirement of the EPBC Act.

As a consequence of the EPBC Act, all applicants for authorisations in the Shark Bay World Heritage Area are advised to refer their proposal to the Commonwealth Environment Minister.

6.7 Categorisation of Areas for Aquaculture Potential

Based on an analysis of the above information Shark Bay has been categorised into three areas, namely:

- *Areas where aquaculture may not occur* - due to statutory constraints;
- *Areas with significant known constraints* - which make approval of aquaculture unlikely, based on current technology and government policies; and
- *Areas with no known constraints* - which do not preclude aquaculture but in which it is recognised that site specific investigations may uncover constraints which would prevent the Executive Director of the Department of Fisheries from approving an aquaculture lease or licence.

6.7.1 Area where aquaculture may not occur

The following areas (see Figure 11), which have statutory protection, are identified as areas where aquaculture may not occur:

- Terrestrial Nature Reserves, including Nature Reserves on islands;
- National Parks and Conservation Parks;
- Marine Nature Reserves (Hamelin Pool);
- The following Marine Park Management Zones:
  - Sanctuary Zones;
  - Recreation Zones; and
  - the Blue Lagoon, Boorabuggatta, Cape Peron and Gladstone Special Purpose Zones.
- Gazetted navigation channels; and
- Shipwrecks protected by State and/or Commonwealth legislation.

Channels identified by markers are not necessarily gazetted channels. Such channels have been identified as areas with 'significant known constraints.'

6.7.2 Areas with significant known constraints

Areas with significant known constraints include:

- 'Benthic primary producer habitats' as defined by the Environmental Protection Authority, where this type of habitat includes reef communities, seagrass, mangroves, corals and algal mat communities;
- Areas which are important breeding or feeding grounds for marine wildlife, such as dugongs or dolphins;
- Marked channels used by boat and ship traffic or areas with high levels of boat traffic; and
- Areas of high use recreational and commercial fishing activities and tourism operators.

With respect to benthic primary producer habitats, proponents should note the following information:

- The Marine Parks and Reserves Authority, Department of Conservation and Land Management and the Department of Environment have clearly stated in submissions that

there should be no impacts from aquaculture on sensitive habitats (which include seagrass, corals, mangroves and algal mat communities).

- Using the Environmental Protection Authority's draft policy (Appendix C7.2), the majority of Shark Bay would be classed 'Category B' (areas of high conservation significance, e.g. the majority of zones in existing or proposed marine parks and marine management areas), where no loss of seagrass is considered acceptable. In the remainder of Shark Bay the existing cumulative losses of seagrass would already exceed 10 per cent so no further loss of seagrass would be acceptable.
- In its assessment of mining lime sands in Cockburn Sound, the Environmental Protection Authority considered that its draft policy applied in areas with seagrass coverage of greater than 25 per cent.

6.7.3 Areas with no known constraints

Areas with no known constraints for aquaculture development are shown in Figure 11. However, proponents should recognize that site-specific investigations of areas in this category might uncover constraints that would prevent the Executive Director of the Department of Fisheries from approving an aquaculture lease or licence. These constraints would normally become apparent during site investigations by the proponent or through the aquaculture approvals process.

It should be noted that broad-scale information on water circulation patterns and maps of the distribution of important biological resources (e.g. dugongs, corals, etc.) is lacking for Shark Bay. Further research on water flushing rates around Denham and offshore is considered a priority to enable the potential and cumulative impacts of future sea cage aquaculture to be adequately assessed. Mapping the distribution of biological resources is also considered to be a priority.

Proponents should refer to Figures 3 to 9 in the first instance to create a preliminary listing of the potential interests or constraints in an area. Figures 3 to 9 are based on the best information available in 2003, but are not all inclusive and other matters such as Aboriginal and petroleum interests in the area would need to be investigated as these may change over time.

Furthermore. different aspects mapped have different levels of accuracy. For example, the seagrass mapping should always be verified in the field, while the location of shipwrecks can be accurately determined from maps.

Recommendation 8

Use the criteria listed in Section 6.7 and Figure 11 in determining where potential aquaculture lease or licence sites may be located within Shark Bay.
(proponents/DOF)

SECTION 7 APPLICATION PROCEDURES FOR AQUACULTURE

As this draft aquaculture plan does not have a statutory basis, applications for aquaculture authorisations will continue to be considered on a case-by-case basis, taking into account the plan and other relevant guidelines/information.

In the absence of adequate baseline information, proponents need to provide adequate information, to the satisfaction of the Minister for Environment. Given the World Heritage status of Shark Bay, adequate monitoring to ensure that environmental impacts can be quantified is essential.

It should be noted that for applications for species such as finfish that need formulated diets, the proponent would be required to provide more detailed information on water circulation and water quality impacts. Proponents should refer to the document prepared by the Marine Conservation Branch of the Department of Conservation and Land Management for guidance (CALM, 1998a).

Prior to submitting an application to the Department of Fisheries for an Aquaculture Lease or Licence, proponents should examine the plan and discuss their proposal with an officer from the Department of Fisheries Aquaculture Program.

Assessment of applications for aquaculture authorisations submitted to the Department of Fisheries is undertaken by one of three processes, depending on the location of the proposed site and the nature of the proposed activities.

7.1 Freehold land sites

Proposals that are located wholly on private (freehold) land may require approval from several authorities, including the relevant Local Government Authority. The relevant approvals are generally submitted with the application to the Department of Fisheries.

Once competency checks have been completed and the relevant approvals have been obtained, the application can be determined.

7.2 Non-freehold land sites

Proposals located on non-freehold or unallocated Crown Land require a broader consultation process than ones for freehold land.

An application is submitted to the Department of Fisheries to determine competency and to assess whether all reasonable information to enable determination has been provided. It is then referred to relevant decision-making authorities for comment within a specified period. Industry and community groups may also be consulted, if appropriate.

Relevant agencies provide approval/clearance to the Department of Fisheries or alternatively advise of the processes required to assess an application. Once all the agencies have completed their processes, and the relevant clearances have been obtained, the Department of Fisheries is in a position to determine the success (or otherwise) of the application.

7.3 Marine sites

All aquaculture proposals for marine sites are assessed taking into account Ministerial Policy Guideline No. 8 *"Assessment of applications for authorisations for Aquaculture and Pearling in coastal waters of Western Australia"* (MPG8). The assessment and consultation process set down in the Guideline includes consultation with relevant decision-making authorities and other involved agencies, community and interest groups, and provides an opportunity for public comment through public advertisement.

Where the proposal is in accordance with a plan which has been duly adopted within the last five years by a competent authority or authorities after public consultation, public comment may not be specifically sought, although the public will be notified of the proposal (see MPG8 4d(i)). Consultation will be undertaken with relevant decision-making authorities, other involved agencies and representative community and industry groups.

Applications for aquaculture licences in the Shark Bay will not be automatically approved simply because they are in accordance with the recommendations outlined above. This plan provides only a guide to proponents to aid the decision-making process. Prior to lodging an application, proponents should examine the plan and discuss their proposal with the Department of Fisheries' Officers.

Recommendation 9

Ensure proponents provide the following information in their applications:

- A map of the major benthic habitats (e.g. seagrass meadows, coral or limestone reef, bare sand, mud) in and around the lease sites.
- A qualitative description of water movement or map of general water circulation in and around the lease, especially where sensitive marine communities are located within or close to lease sites.
- A map of the important biological resources (e.g. bird rookeries, seal or turtle nesting/haul-out beaches) in the proposed lease and surrounding area.
- A description of the potential environmental impacts from the proposal and details of how those impacts are to be minimised.
- A detailed description of site works (including water-based construction) and other processes which are likely to impact on the environment.
- Details of monitoring that will be carried out, including baseline monitoring, prior to project commencement so that environmental impacts can be adequately quantified.
- Details of contingency plans, if the World Heritage values of Shark Bay are compromised.

(proponents/DOF/DOE/EPA)

Recommendation 10

Ensure that lease and/or license conditions for aquaculture include:

- A commitment to monitoring for the life of the project to enable environmental impacts to be adequately quantified;
- Conditions relating to the removal of infrastructure and reinstatement of the area disturbed by any environmental impact; and
- Performance criteria to measure whether the lease and/or license is being used in the manner for which it was intended. *(DOF/DEP/EPA)*

SECTION 8 PLAN IMPLEMENTATION AND REVIEW

8.1 Review of the plan

The Shark Bay Aquaculture Plan will provide a guide for prospective aquaculture proponents. Although not a statutory plan, it will also guide decision makers when assessing applications for new or extended aquaculture ventures in Shark Bay.

This Draft Aquaculture Plan, once approved for circulation by the Minister for Fisheries, will be made available for public comment. After that period has concluded and the plan amended as necessary, the Minister will approve the Plan for implementation.

This plan will be in effect for five years from the date it receives Ministerial approval, and will remain in effect until the management plan for the subsequent five years is approved. Amendments can be made to the management plan while it is in effect, but only after a mandatory public consultation process.

Some of the recommendations will have budgetary implications for the Government of Western Australia and will need to be considered in the context of government priorities.

The five-year review should evaluate:

- The successes and failures of the first five-years of the plan.
- New information with the potential to affect management practices and strategies for aquaculture in Shark Bay.
- New proposals for the management of aquaculture in Shark Bay.

Recommendation 11

Review the success and appropriateness of management strategies contained in the Plan in five years *(DOF/DEH)*

8.2 Areas for Further Research

Broad-scale information on water circulation patterns and maps of the distribution of important biological resources (e.g. dugongs, corals, etc.) is lacking for Shark Bay. Further research on water flushing rates around Denham and offshore is considered a priority to enable the potential and cumulative impacts of future sea cage aquaculture to be adequately assessed. Mapping the distribution of biological resources is also considered to be a priority.

Three of the plans listed in Appendix C, namely the Shark Bay Region Plan, Shark Bay Marine Reserves Management Plan and the Draft Shark Bay Terrestrial Reserves Management Plan include recommendations for a range of studies, from investigating opportunities for diversification on pastoral properties through to undertaking studies of water circulation and fauna. Many of these studies can potentially provide information of significant value to aquaculture.

The Shark Bay Scientific Advisory Committee (established within the Shark Bay World Heritage Property Agreement) is charged with the responsibility of determining scientific research priorities for Shark Bay. Research proposals should be developed in consultation with the Advisory

Committee.

Recommendation 12

Support further research and monitoring in Shark Bay, particularly for water circulation studies around Denham and offshore, and for distribution mapping of biological resources.
(*DEH/CALM/DOF)*

SECTION 9 GLOSSARY OF TERMS AND ACRONYMS

animals hermatypic	reef-building corals which accumulate large amounts of calcium carbonate
broodstock	mature animals used for spawning to produce young animals to raise
CALM	Department of Conservation and Land Management
DEH	Department of Environment and Heritage
diurnal	daily
diodromous	fish that spend part of their cycles in freshwater, part in marine/estuarine waters
DOE	Department of Environment
DOF	Department of Fisheries
endemic species	species which occur naturally in an area
EPA	Environmental Protection Authority
haul-out area	a rock or island where marine mammals or birds rest out of water
hypersaline	very salty, with a salinity of greater than 60 thousand parts per million
isosaline	the salinity does not vary with depth
metahaline	moderately salty, with a salinity of 40 - 50 thousand parts per million
salinocline	a salinity gradient

SECTION 10 ACKNOWLEDGEMENTS

This draft aquaculture plan could not have been written without the valuable input of community members and key stakeholder groups with an interest in the Shark Bay area. A preliminary report was prepared for Department of Fisheries by consultants Makaira Pty Ltd and *ecologia* Environmental Consultants, which formed the basis of the draft plan.

Many Department of Fisheries staff, particularly Mrs Jo McCrea, Ms Robin Clark, Ms Tina Thorne, Ms Eve Bunbury, Mrs Jane Borg, Mr Greg Paust and Mr Colin Chalmers provided valuable assistance throughout the project.

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APPENDIX A SUMMARY OF STAKEHOLDERS INVOLVED TO DATE

Aboriginal Affairs Department
AMWING Pearl Producers Association
Aquaculture Council of Western Australia
Aquaculture Development Council
Aristocat Sailing Tours
Australian Marine Conservation Society
Australian Petroleum Production & Exploration Association Ltd
Bealwood Pty Ltd
Bellotti Aquaculture Aboriginal Corporation
Blue Lagoon Pearls
Cape Peron Pearls
Clough Engineering Ltd
Conservation Council of Western Australia
Conservation Society
Denham Professional Fisherman's Association
Denham Recreational Fishing Advisory Council
Department of Commerce and Trade
Department of Conservation and Land Management
Department of Environmental Protection
Department of Fisheries
Department of Minerals and Energy
Department of Transport
Department of Transport Maritime Division
Dr Paul Anderson
Elmwood
Explorer Charters
Department of Fisheries
Gascoyne Development Commission
Heritage Community
Heritage Council of WA
Heritage Pearls
Heritage Scientific
Managed Fishery
Marine Parks and Reserves Authority
Ministry for Planning
Monkey Mia Wildlife & Sailing
Museum of Western Australia
Nanga Station
Nor-West Seafoods Pty Ltd

Pearl Producers Association
Recfishwest
Recreational Fishing Advisory Committee
Shark Bay Charter Service
Shark Bay Prawn Managed Fishery Management Advisory Committee
Shark Bay Prawn Trawler Operators Association Inc.
Shark Bay Scallop Managed Fishery Management Advisory Committee
Shark Bay Snapper Fishermen's Association
Shark Bay Tourist Bureau
Shark Bay Tourist Committee
Shark Bay Trawl Operators Association
Shark Bay Tuna Farms
Shark Bay Under Sail
Shark Bay World Heritage Community Consultative Committee
Shark Bay World Heritage Scientific Advisory Committee
Shire of Carnarvon
Shire of Shark Bay
Terry Maxwell
Topday Tours & Charters
WA Ocean Park
Water and Rivers Commission
Western Australian Fishing Industry Council
Western Australian Museum
Western Australian Tourism Commission
Yamatji Land and Sea Council

APPENDIX B ISSUES RAISED DURING PRELIMINARY CONSULTATIONS

Thirty-seven written or verbal submissions were received during the preliminary consultation phase in 1997/98. The submissions contain a diverse range of comments and it is evident that in many cases different stakeholders hold contradictory views. A brief overview of submissions is presented below. The comments have been sorted under the following broad headings:

- The environment;
- Management arrangements; and
- Future aquaculture.

The Environment

The following matters pertaining to environmental issues were raised during the preliminary consultation phase.

1. Many submissions stated that World Heritage values should be identified and protected.
2. There was general agreement amongst stakeholders that only indigenous species should be used for aquaculture, and a strong preference for land-based rather than sea-cage aquaculture was expressed.
3. Many stakeholders indicated a reluctance to support or undertake aquaculture, due to the lack of critical baseline information necessary for successful aquaculture and environmental protection. There is a view that little use is made of the information which is available.
4. A range of fauna and fauna habitats were identified as important, including dugongs, turtles, and prawn nursery areas. Potential impacts from aquaculture on these fauna were detailed in the submissions. The maintenance of genetic diversity, particularly in relation to the different genetic populations of pink snapper, was considered to be important.
5. Some stakeholders disagreed with the seagrass policies of the Department of Conservation and Land Management, Marine Parks and Reserve Authority and the Environmental Protection Authority, which essentially say there should be no impacts on perennial seagrass.
6. Waste, in particular effluent from land-based operations and rubbish from marine operations, was identified in several submissions as an area which needed management input.
7. The need to manage the visual impact of aquaculture was raised.

Management Arrangements

The following matters relating to management arrangements for aquaculture were raised:

1. At the meeting in Denham there was support for a locally-driven and chaired Aquaculture Committee to provide advice regarding aquaculture applications to the Inter Departmental Committee (Aquaculture).
2. The annual licence renewal system was seen to be a significant constraint to aquaculture development. There was general agreement to a 21-year licence of three times seven years.
3. Local government, the Department of Minerals and Energy and petroleum lessees sought

wider consultation.

4. Some stakeholders held the perception that there was a 'water-grab' taking place, and that the current approach is *ad hoc*. Some stakeholders considered an *ad hoc* approach inappropriate in a World Heritage Area, and that planning should take place that considers cumulative impacts. Others thought there were already too many management plans for Shark Bay.
5. Some people considered that the current access provisions over licence areas should be reviewed.
6. It was suggested that a decision-support system be established, which permits new information (e.g. monitoring information) to be immediately incorporated into management decisions.
7. Other matters raised included:
   (i) Baseline monitoring should occur prior to aquaculture proposals commencing development;
   (ii) Site visits by relevant government officers should be an essential part of the approval process.
   (iii) Fisheries Officers should audit aquaculture licences.
   (iv) Fragmentation of licences to avoid environmentally sensitive areas can cause a significant administrative and cost burden.
   (v) Failed projects and projects with much 'red tape' discourage aquaculture development.

Future Aquaculture

There is a degree of overlap with matters raised under this heading and those already discussed. In particular, the need to protect World Heritage values by adopting a conservative approach and providing close scrutiny of proposals is raised in several submissions. Arguments for and against an *ad hoc* aquaculture planning approach also appear under this heading.

The following matters were raised which are particularly relevant to the future development of aquaculture in Shark Bay:

1. There was general support for the 5/2 pearling rule to apply to aquaculture, although there was disagreement if this should be species-specific. For land-based aquaculture, there were differing views on grouping, or not grouping, aquaculture.
2. Detail was provided regarding the compatibility of aquaculture with the petroleum, mining, fishing and tourism industries and the provision of transport (i.e. providing navigation channels). In general, it was considered that compatability could be achieved through careful siting of aquaculture and the adoption of particular management measures.
3. Some submissions stated that there are no identifiable incentives to prompt development of the aquaculture industry. Some stakeholders felt aquaculture has many potential benefits for Shark Bay.

APPENDIX C SUMMARY OF SHARK BAY PLANNING DOCUMENTS

C.1 Shark Bay World Heritage Property Agreement

In 1997 an agreement was signed between the Western Australian and Commonwealth governments on administrative arrangements for the Shark Bay World Heritage Property (Appendix D). Key aspects of that agreement include:

- Western Australia will ensure that "actions which are inconsistent with the protection, conservation and presentation of the Property's outstanding universal values are not permitted."
- A Ministerial Council will be established which consists of equal representation of Western Australia and the Commonwealth, with up to two members from each, and which is chaired by the Western Australian Minister responsible for the *Conservation and Land Management Act 1984*. Advice is provided to the Ministerial Council by a Scientific Advisory Committee and a Community Consultative Committee. The Ministerial Council's role does not include consideration of new proposals, but focuses on the Strategic Plan, policy and management.
- A Strategic Plan will be prepared to "provide a management framework designed to ensure the protection, conservation and presentation of the outstanding universal values of the Property." The Strategic Plan is currently being prepared by CALM.
- Management of the Property will provide for the continuation of commercial activities and new developments, provided they comply with State legislation and Local Government By-laws and do not threaten the outstanding universal values.
- In relation to activities which are proposed to be carried out other than in accordance with an accredited management plan, the parties have agreed on a single process for ensuring environmental protection. That process is detailed in Schedule 1 to the agreement and essentially reflects Western Australia's environmental impact assessment process modified to permit Commonwealth involvement at several stages, including appeals on the level of assessment and the setting of environmental conditions.
- The Western Australian Government will prepare a number of more detailed management plans for land use planning, fisheries management and management of the marine and terrestrial reserves within Shark Bay.

Under schedule 1 of the Agreement, the Commonwealth Government has endorsed the State's fisheries and marine reserve management plans. Schedule 1 of the Agreement states that "Fishing, aquaculture and pearling will be managed in accordance with the Shark Bay World Heritage Property Management Paper for Fish Resources (1996) prepared by the Fisheries Department with public consultation, and in accordance with the relevant portions of the Shark Bay Marine Reserves Management Plan (1996-2000)".

C.2 Management Paper for Fish Resources (1996)

The Shark Bay World Heritage Property Management Paper for Fish Resources (1996) considers commercial fisheries, recreational fisheries and aquaculture in the context of ecologically sustainable development, with minimal impacts on the World Heritage Property.

The Management Paper lists possible impacts from aquaculture on marine World Heritage values in a table, which is reproduced on the next page.

Table 8 Possible impacts from aquaculture on marine World Heritage values

		Level of impact				
	World Heritage Value	**No impact**	**Minimal**	**Potentially significant**	**Unknown**	**Comments**
1	Undisturbed ecosystem			•		Potential for significant impacts if uncontrolled.
2	Visual resource			•		Can be significant for certain types of operations. Planning and consultation required.
3	Flora and Fauna diversity		•			By using only indigenous species, impacts should be minimal.
4	Seagrass		•			Resultant increase in nutrient levels should be monitored.
5	Mangroves				•	Likely to be minimal but requires assessment.
6	Fish diversity and abundance		•			
7	Corals			•		Effects of nutrients and other wastes need to be determined.
8	Benthic diversity and abundance		•			There may be local effects. Requires monitoring.
9	Major nursery area		•			Operations should be sited to avoid these areas.
10	Genetic variability			•		The industry must be made aware of the potential threats to genetic variability.
11	Marine mammals		•			Entanglement in submerged equipment is possible but unlikely to be significant.
12	Marine reptiles		•			Entanglement in submerged equipment is possible but unlikely to be significant.
13	Seabirds	•				

The report makes the following recommendations in relation to aquaculture:

- That existing aquaculture operations in the World Heritage Property be monitored to ensure that the activities are conducted in accordance with the World Heritage values.
- That future applications for aquaculture operations be assessed with a view to ensuring the ongoing maintenance for the Property's marine World Heritage values and fishing opportunities.
- That aquaculture projects be permitted in the World Heritage Property, in accordance with the marine park zoning and the future Fish Habitat Protection Area.
- That appropriate measures be taken to reduce the risk of disease or parasite infestation on those species being cultivated, and on other species in Shark Bay, by controlling the translocation or movement of any aquaculture stock in accordance with the Department of Fisheries' translocation policy.
- That education programs be introduced to increase public awareness about the aquaculture industry in Shark Bay. Topics should include boating, fishing and navigation in and adjacent to leased areas.

The Management Paper also makes a number of recommendations for further study, which are supported in this draft Aquaculture Plan. There are also a number of recommendations that specify recommended management arrangements that affect aquaculture and these have been incorporated into this draft Aquaculture Plan.

C.3 Shark Bay Regional Strategy Review (1998)

A regional land-use planning strategy for Shark Bay was prepared in 1988. This strategy was reviewed in 1998 to reflect the World Heritage listing of Shark Bay and address the increasing demands for growth and development in the area.

The Shark Bay Regional Strategy 1998 provides a Strategic Policy Statement and Land Use Plan for the region. A 12-member Review Steering Committee that included a wide range of interests - although the Department of Fisheries was not represented - prepared the strategy for the Minister of Planning and Western Australian Planning Commission.

Review of the 1988 strategy was deemed necessary to allow the area's unique qualities to be utilised without detrimentally affecting World Heritage values. The regional strategy review offered an opportunity to better coordinate the activities of government in the region, reduce duplication and direct resources to areas requiring the most attention.

The revised Regional Strategy recognises the potential for building on existing industries such as tourism and fishing, whilst diversifying the economic base through pastoral and marine activities such as aquaculture to provide an economically viable future for the region. Aquaculture is seen as an important component in aiding the further growth of the region's economic viability.

The revised strategy also provides a regional planning context, integrates existing government initiatives, and suggests development that would not compromise World Heritage values.

Key actions proposed in the revised Regional Strategy in regard to aquaculture development include:

- Implement the management plan for fish resources in Shark Bay World Heritage Area (when finalised), and ensure continued involvement of recreational and commercial fishers.

- Implement the provisions of the Gascoyne Aquaculture Development Plan relevant to the Shark Bay region.
- Insert provisions into town planning schemes to assist in the control and guidance of aquaculture developments in the region.
- Identify suitable sites for the development of land and sea-based aquaculture operations, subject to environmental and planning.
- Encourage the development of appropriate aquaculture activities (with an emphasis on low-key laboratory facilities, research pilot projects and associated business incubation) in the aquaculture precinct identified for Monkey Mia, subject to appropriate planning, environmental and fisheries assessments for individual proposals.
- Determine potential precincts and sites for commercial-scale aquaculture development in the Denham town site, according to specific requirements of different types of aquaculture ventures and the suitability of location according to surrounding uses and the location of infrastructure.
- In consultation with the proprietors of the Useless Loop salt operations, investigate the possibility of establishing aquaculture ventures in Useless Loop and the surrounding areas.
- Ensure that the ongoing development and implementation of management plans for conservation reserve systems and World Heritage values allow for sustainable development of aquaculture in suitable locations in the region.
- Introduce monitoring procedures for the impact of aquaculture on the natural environment.

C.4 Shark Bay Marine Reserves Management Plan (1996)

Most of Shark Bay is a Marine Park or Marine Nature Reserve under the *Conservation and Land Management Act 1984*, which is managed in accordance with the Shark Bay Marine Reserves Management Plan.

The Shark Bay Marine Reserves Management Plan has six principle goals, namely:

- Conservation;
- Recreation compatible with conservation and other goals;
- Improve community relations by community involvement and education;
- Management of commercial and other uses of the reserve;
- Improve our knowledge of the environment; and
- Promote cooperation with nearby landholders and users of the waters around the marine reserve.

Part of achieving these goals includes zoning the Marine Park into four main zones:

- General Use;
- Recreation;
- Sanctuary; and
- Special Purpose.

Figure 9 shows the location of the zones.

The Management Plan makes the following recommendations with respect to aquaculture in the

marine reserves:

- Allow aquaculture operations in areas where there will be minimal impact on the Marine Park's values. Operations will not be allowed in the Marine Nature Reserve and in the Sanctuary and Recreation Zones.
- Assess applications for aquaculture operations through the Interdepartmental Committee for Aquaculture (IDCA) and other relevant organisations with regard to impacts on the park's conservation, commercial, recreation and social values.
- Support the review and application assessment criteria as determined by the IDCA in the consideration of new aquaculture proposals.
- The Department of Fisheries will continue to licence and manage aquaculture operations in liaison with CALM.
- Applications for operations that propose the use of exotic species will not be approved.

The Plan identifies aquaculture as not permitted in:

- Recreation Zones;
- Sanctuary Zones;
- Hamelin Pool Marine Nature Reserve; and
- The Blue Lagoon, Boorabuggatta, Cape Peron and Gladstone Special Purpose Zones.

Subject to assessment, the Marine Management Plan identifies aquaculture as permitted in:

- The General Use Zone; and
- The Feycinet and Wooramel Special Purpose Zones.

Other key recommendations relating to the protection of marine habitats that would affect aquaculture proposals include:

- Minimise actual or potential damage to seagrasses (Section 5.4.2 of Marine Reserves Management Plan); and
- Assess potential impacts of aquaculture activities, coastal development and recreation and other proposals likely to impact on mangrove communities, and act to minimise those impacts (see Section 5.4.3 of Marine Reserves Management Plan)

The Marine Reserves Management Plan suggests a number of strategies for further study, many of which would also provide important baseline information for aquaculture. Some of these strategies are supported in this Aquaculture Plan.

It is understood that there are currently plans to extend the Shark Bay Marine Park north to Bernier and Dorre islands.

C.5 Shark Bay Terrestrial Reserves Draft Management Plan (1998)

The Shark Bay Terrestrial Reserves Draft Management Plan sets out a series of objectives for the protection, enhancement, and restoration of the area's land-based conservation resources. Figure 9 shows the location of existing and proposed aquatic reserves.

Key management strategies for the Shark Bay terrestrial reserves are outlined in the report and pertain to each of the existing or proposed nature reserves. The draft plan makes no mention of aquaculture.

C.6 Gascoyne Aquaculture Development Plan (1996)

The Department of Fisheries and the Gascoyne Development Commission prepared the Aquaculture Development Plan. The Plan identifies aquaculture species and locations, along with the aquaculture potential of these, for the Gascoyne Region, including Shark Bay.

The Aquaculture Plan considers that large sections of Shark Bay that are sheltered offer excellent sites for the use of sea-cages for the growth of finfish. On-growing of wild caught fish so that they may be sold at premium prices outside the typical harvest season is also suggested. The Plan notes that aquaculture opportunities may also exist in the solar salt ponds for brine shrimp and beta carotene, or in the expansion of the existing edible oyster and pearling activities.

The Aquaculture Development Plan acknowledges that development will be restricted from the areas dominated by seagrasses and that conflict could develop between the aquaculture operations and recreational activities. The limits of coastal access and competition for sites are also seen as constraints to aquaculture development.

The Plan recommends that aquaculture operations within the Shark Bay Marine Park undergo stringent monitoring to ensure that any detrimental effects are minimised.

Other than an assessment of site and species potential for aquaculture the report includes only one specific recommendation for the Shark Bay Region, namely:

- *Examine the possibility of utilising a portion of the Monkey Mia Reserve (Reserve No 1686) as an aquaculture precinct.*

The Shire of Shark Bay is currently progressing the establishment of an aquaculture precinct at Monkey Mia to service the existing pearling industry.

In 1996 the Gascoyne Development Commission also published the Gascoyne Region Economic Development Strategy, which included broad strategies to "foster the development of a commercially significant aquaculture sector at appropriate locations throughout the region." Some of the strategies proposed included:

- Appoint an Aquaculture Development Officer in the Gascoyne Region to promote aquaculture across the region.
- Publish a full inventory of suitable marine and terrestrial aquaculture sites within the region.
- Promote the Gascoyne Region as a centre of excellence for future pearl, shell-fish and fin-fish developments.
- Link commercial expansion of the industry to an appropriate learning institution to achieve technology-transfer and to provide information relating to the identification of marketable species.
- Develop a finfish hatchery in the region, targeting high value fish product.
- Provide for the establishment of aquaculture activities in local government planning schemes throughout the region.

C.7 Environmental Protection Policy Framework

The Environment Protection Agency (EPA) has developed a number of policies and guidelines which are relevant to aquaculture development in Shark Bay.

C.7.1 EPA Guidance Statement No. 49: Guidance Statement for the assessment of development proposals in Shark Bay World Heritage Property

This document provides guidance to potential proponents of development proposals in the Shark Bay with respect to the values of the area and the issues that are likely to be of concern should the EPA receive a development proposal within the Shark Bay World Heritage Property Area for consideration.

C.7.2 Draft Environmental Protection (WA Marine Waters) Policy

The Environmental Protection Authority's draft State Marine Waters Environment Protection Policy (EPP) aims to provide a consistent regulatory framework to protect Western Australia's marine environment. The policy considers activities that have the potential to degrade the State's marine waters, the environmental values of marine waters and the beneficial uses that are supported by those values. It also establishes a program to protect environmental values.

The EPP specifies default environmental values to be protected, which includes sustainable aquaculture. The policy applies up to three nautical miles off the coast.

C.7.3 EPA Draft Guidance No. 29 Benthic Primary Producer Habitat Protection

This guidance statement intends "to maintain the ecological integrity and biodiversity of the marine ecosystems of Western Australia" and "to maintain the integrity of the marine ecosystems of Western Australia to support the widest possible range of environmental values while recognising the current and projected future uses."

The guidance note details a means of assessing the impacts related to the development of aquaculture on the loss of the primary producer habitat areas. The evaluation utilises a series of questions which consider the biophysical environment, previous ecosystem impacts and how much more will be lost if the development goes ahead. Criteria are also provided for the evaluations to be ranked in a system detailing acceptable levels of disturbance.

Of particular interest to aquaculture is that:

- In Category B areas (which include the majority of zones in existing or proposed marine parks) "development proposals should conform with the operational objectives of minimum indirect disturbance and *no loss of benthic primary producer habitat*."
- In Category C areas, (i.e. areas not identified as having high conservation significance) "Development proposals should conform with the operational objectives of preventing the avoidable destruction of benthic primary producer habitat, and cumulative (total) losses should be kept within strict limits (see Table 1) whilst recognising uses designated prior to the formulation of this guidance."

Table 1 specifies that for any given "management unit" *the maximum cumulative (total) impact of irreversible change should be less than or equal to five per cent* and for reversible changes, less than or equal to 10 per cent. A management unit "*is a specific geographical area which provides the most effective boundaries for management of cumulative impacts on marine habitats*."

Note - 'Benthic primary producer habitat' includes reef communities, seagrass, mangroves, corals and algal mat communities.

C.7.4 EPA Guidance Statement No. 34

EPA Guidance No. 34 explains the linkage between EPA assessment and management strategies, policies, scientific criteria, guidelines, standards and measures adopted by National Councils. In essence, the Guidance Statement endorses the spirit of existing and future management strategies, policies, scientific criteria, guidelines, standards and measures adopted by bodies including the:

- Council of Australian Governments (COAG);
- Australian and New Zealand Environment and Conservation Council (ANZECC);
- National Environment Protection Council (NEPC); and
- National Health and Medical Research Council (NH&MRRC).

For aquaculture, this gives proponents guidance on:

- Air quality impacts;
- Ecologically sustainable development;
- Waste management;
- How water quality impacts should be addressed using the concept of environmental values and the water quality standards associated with each environmental value.

C.8 Fisheries Management policies and guidelines

C.8.1 Translocation Policy

The translocation of a species to an area in which it does not occur naturally for the purpose of aquaculture or stock enhancement is regulated according to Regulation 176 of the *Fish Resources Management Regulations 1995*, according to which a person may only translocate a non-endemic species into or within Western Australia subject to the written approval or authority of the Executive Director of the Department of Fisheries or through an aquaculture licence.

The principal issues that need to be considered in relation to the translocation of non-native species include the potential of the species to impact on genetic diversity, introduce disease and impact on the natural environment and the biodiversity of native species.

Issued pursuant to Section 246 of the *Fish Resources Management Act 1994*, Ministerial Policy Guideline No. 5, entitled *The aquaculture and recreational fishing stock enhancement of non-endemic species in Western Australia* (Department of Fisheries, 1997a), was prepared to assist in the consideration of an application for the translocation of non-endemic species into and within Western Australia for aquaculture or stock enhancement purposes. The five policy guidelines may be summarised as follows:

- Authorisation of the translocation of non-native species will be subject to a risk management assessment being carried out.
- The assessment would be undertaken by the Department of Fisheries within the context of an application and translocation synopsis provided by a proponent. Authorisation of the translocation would be conditional upon the assessment showing the translocation would present a low risk to the environment.
- The risk assessment must be based on the best scientific data available for the species and the

environment into which it is to be introduced.

- The translocation application would be referred to relevant industry groups for consultation and public comment sought before any decisions are made.
- The translocation decision should balance significant economic and social benefits with biological and environmental risks.

The assessment procedure that deals with applications for the translocation of non-native species for aquaculture and stock enhancement purposes has been developed by way of a Memorandum of Understanding between The Department of Fisheries and the Environmental Protection Authority.

Species for which translocation policies have already been developed are redclaw crayfish (*Cherax quadricarinatus*), silver perch (*Bidyanus bidyanus*) and the South Sea pearl oyster (*P. maxima*). Discussion papers for the translocation of barramundi (*Lates calcarifer*) and various salmonid species are currently being written. The Department of Fisheries is considering the preparation of a discussion paper on *Artemia* spp (Chappell, *pers. comm.*).

C.8.2 Ministerial Policy Guideline No. 8 For Aquaculture And Pearling Licenses

The issue of a license to establish an aquaculture or pearling operation in Western Australian waters is governed by two separate pieces of legislation, the *Fish Resources Management Act 1994* and the *Pearling Act 1990* respectively. Ministerial Policy Guideline No. 8 aims to clarify the process for the assessment of applications for aquaculture or pearling and to provide for consistency in public consultation procedures.

C.9 Other policies and approvals

A number of other policies and approvals apply to aquaculture in Shark Bay. These include:

Town Planning Schemes

The Shire of Shark Bay Town Planning Scheme lists aquaculture as a permitted use in Rural Zones.

Water and Rivers Commission

The Water and Rivers Commission has advised that discharges to Shark Bay of less than 5,000 litres of waste water per day, which meet certain water quality criteria, would be in accordance with their water quality standards. For larger-scale projects, waste water should be fully contained within the project site or be treated to a standard acceptable to the Department of Environmental Protection and the Water and Rivers Commission, prior to discharge.

Department of Conservation and Land Management (CALM)

CALM is currently preparing environmental guidelines and procedures in relation to its provision of advice on the marine aspects of aquaculture and pearling proposals. The guidelines advocate a sustainable development framework for the assessment of aquaculture proposals, which will consider:

- Maintenance of biodiversity and ecological integrity
- The ‘precautionary principle’ (i.e. avoidance of irreversible impacts); and
- Maintenance of intra-generational equity (i.e. equity among current users).

Proposed information requirements are also being drafted and may include:

- Mapping of benthic habitats at aquaculture sites;
- Information about water circulation, bathymetry, tidal range etc; and
- Mapping of existing and proposed activities in the vicinity of the aquaculture site.

Brief location guidelines are also being drafted.

APPENDIX D AGREEMENT BETWEEN THE STATE OF WESTERN AUSTRALIA AND THE COMMONWEALTH OF AUSTRALIA ON ADMINISTRATIVE ARRANGEMENTS FOR THE SHARK BAY WORLD HERITAGE PROPERTY IN WESTERN AUSTRALIA

1. PREAMBLE

1.1 The Shark Bay World Heritage Property ('the Property') was inscribed on the World Heritage List, established under the Convention for the Protection of the World Cultural and Natural Heritage ('World Heritage Convention') on 13 December, 1991.

1.2 This Agreement explains the administrative arrangements for protection and management of the Property, which:

(a) recognise Australia's interests and obligations as a party to the World Heritage Convention and Governments' roles and responsibilities under the 1992 Intergovernmental Agreement on the Environment, or subsequent revisions thereof:

(b) reflect a cooperative approach between the Commonwealth and Western Australia; and

(c) provide for protection and management of the Property, primarily by the Western Australian Government, in accordance with Australia's obligations under the World Heritage Convention.

1.3 Implementation of this Agreement on behalf of Western Australia shall be the responsibility of the Minister responsible for the Conservation and Land Management Act 1984 (WA) ('Western Australian Minister').

1.4 Implementation of this Agreement on behalf of the Commonwealth shall be the responsibility of the Minister responsible for the World Heritage Properties Conservation Act 1983 ('Commonwealth Minister').

2. PARTIES TO THE AGREEMENT

2.1 The parties to this Agreement are the State of Western Australia and the Commonwealth of Australia.

3. NATURE OF THE AGREEMENT

3.1 The parties acknowledge that this Agreement is not intended to give rise to any legally enforceable rights or obligations, and places no limitations on the legal or constitutional rights or obligations of the parties, including in relation to Australia's obligations under international law.

4. THE WORLD HERITAGE CONVENTION

4.1 The World Heritage Convention was adopted by the General Conference of the United Nations Educational, Scientific and Cultural Organisation in 1972 and was ratified by Australia in 1974.

The World Heritage Convention is included as Appendix 1 to this Agreement.

4.2 The World Heritage Convention provides for the protection and management of cultural and natural heritage of 'outstanding universal value'. As a party to the World Heritage Convention, Australia is obliged to ensure the identification, protection, conservation, presentation and transmission to future generations of Australia's heritage of outstanding universal value, particularly that which has been included on, or nominated for inclusion on, the World Heritage List established in accordance with Article 11 of the World Heritage Convention.

4.3 It is recognised in Articles 4 and 5 of the World Heritage Convention that determination of the appropriate measures for implementing Australia's obligations under the World Heritage Convention is a matter for Australia, and Article 6 provides that Australia's sovereignty is fully respected. Western Australia and the Commonwealth, through the consultative processes outlined in this agreement, will determine how best to protect and manage the 'outstanding universal values' of the Property.

5. VALUES OF THE PROPERTY

5.1 Shark Bay was inscribed on the World Heritage List on the basis of its 'natural heritage' values. The definition of 'natural heritage' is in Article 2 of the World Heritage Convention. A natural heritage site consistent with Article 2 is considered to be of outstanding universal value for the purposes of the World Heritage Convention, when the World Heritage Committee finds that it meets one or more of the criteria defined in the Operational Guidelines for the Implementation of the World Heritage Convention. At the time of inscription, Shark Bay was found to meet each of the following criteria (UNESCO, Operational Guidelines for the Implementation of the World heritage Convention, December 1988, Appendix 2), namely that sites should:

(i) be outstanding examples representing the major stages of the earth's evolutionary history; or

(ii) be outstanding examples representing significant ongoing geological processes, biological evolution and man's interaction with his natural environment; as distinct from the periods of the earth's development, this focuses upon ongoing processes in the development of communities of plants and animals, landforms and marine areas and fresh water bodies; or

(iii) contain superlative natural phenomena, formations or features, for instance, outstanding examples of the most important ecosystems, areas of exceptional natural beauty or exceptional combinations of natural and cultural elements; or

(iv) contain the most important and significant natural habitats where threatened species of animals or plants of outstanding universal value from the point of view of science or conservation still survive.

5.2 The Property must also fulfil conditions of integrity as described at paragraph 36(b) of the Operational Guidelines for the Implementation of the World Heritage Convention (1988).

5.3 The outstanding universal values (natural) for which Shark Bay is listed are described in the nomination document, in particular Part 5 of that document (Appendix 3). The key evidence of these values, as defined by the criteria in clause 5.1, includes:

Criterion (I)

Stromatolites and microbial mats of Hamelin Pool.

Criterion (ii)

Marine: Evolution of Shark Bay's hydrologic system; the distinct zonation of salinities and biotic communities; the hypersaline environment of Hamelin Pool; the largest seagrass meadows in the world; the role of seagrass in modifying the physical, chemical and biological environment as well as the geology of the Bay; carbonate sedimentation; and the biological processes of ongoing speciation, succession and the creation of refugia.

Terrestrial: Transition zone between two major botanical provinces; habitat of many plant and animal species at the end of their range; five threatened mammal species on Bernier and Dorre islands; and a rich reptile and avian fauna.

Criterion (iii)

Hamelin Pool stromatolities; the hypersaline environments; the Faure Sill; Wooramel Seagrass Bank; the great diversity of landscapes with some exceptional coastal scenery; and the abundant marine fauna.

Criterion (iv)

The occurrence of many species of plants and animals that are rare, vulnerable or threatened, including five species of terrestrial mammals on Bernier and Dorre islands, a number of terrestrial reptiles and birds, the dugong, the humpback whale, the green and loggerhead turtles, and fifteen species of terrestrial plants.

5.4 The Commonwealth may renominate the Property to reflect new knowledge about the area's outstanding universal values, following consultation with and agreement of Western Australia, in accordance with the procedures in this Agreement.

5.5 In this Agreement, 'outstanding universal values' means the characteristics of the Property that determined its inclusion on the World Heritage List, and comprise both the essence and integrity of the values for which the Property is inscribed on the World Heritage List.

6. BOUNDARY OF THE PROPERTY

6.1 A Technical description of the Property boundary is included as Appendix 4 to this Agreement. As detailed in Appendix 4, the following areas are excluded from the Property:

(a) Denham town site (with the exception of Reserve No. 30899 and adjacent land and waters;

(b) Shark Bay Salt Joint Venture, including the area proposed for expansion in accordance with the Shark Bay Solar Salt Industry Agreement Act 1983 (WA) together with an area around the Slope Island loading facility and around Heirisson Prong; and

(c) the area of former Mining Leases M09/6 and M09/21-24 near Useless Loop.

7. ADMINISTRATION, PROTECTION AND MANAGEMENT OF THE PROPERTY

Management Plans

7.1 For the purposes of this Agreement, a reference to the term 'management plan/s' is to include a reference to management plans and other relevant and appropriate plans for the Property.

7.2 Western Australia and the Commonwealth will develop a Shark Bay World Heritage Property Strategic Plan ('the Strategic Plan'). The Strategic Plan will provide a management framework designed to ensure the protection, conservation and presentation of the outstanding universal values of the Property. The Strategic Plan is subject to approval by the Ministerial Council.

7.3 Western Australia will, given it has primary management responsibility under this Agreement, ensure that management plans for the Property are prepared under applicable Western Australia legislation. Such management plans must be consistent with the Strategic Plan.

7.4 Management plans must be consistent with Australia's obligations under the World Heritage Convention and, in particular, must ensure the protection, conservation and presentation of the Property's outstanding universal values. Management plans should provide for appropriate monitoring and reporting mechanisms for the Property.

7.5 Western Australia, will in discharging its primary management responsibility under this Agreement, ensure that actions which are inconsistent with the protection, conservation and presentation of the Property's outstanding universal values are not permitted. In particular, the parties agree that management plans will be implemented in accordance with the World Heritage Convention. For example, any decisions made, or approvals given, under management plans will be consistent with the protection, conservation and presentation of the Property's outstanding universal values.

7.6 Management plans will be prepared by Western Australia and revised with public consultation. The Commonwealth is to be consulted throughout the preparation of each management plan. The parties will agree on their respective involvement in the development of management plans affecting the Property.

7.7 Management of the Property will provide for both the continuation of commercial activities and new developments, provided they comply with State legislation and Local Government by-laws and do not threaten the outstanding universal values for which the Property is included on the World Heritage List.

7.8 Each management plan will be review 10 years after it comes into force. However, the Ministerial Council may request the review of a management plan at any time within 10 years of it coming into force.

Accreditation

7.9 Western Australia may request, in writing, that a management plan be accredited by the Commonwealth. (For the purposes of section 7 of this Agreement, a reference to a

management plan includes a reference to a section of a management plan).

7.10 The Commonwealth may accredit a management plan if the Commonwealth is satisfied that it is consistent with the World Heritage Convention. If the Commonwealth decides to accredit a management plan, it will give written notice to Western Australia identifying the management plan and confirming that the management plan has been accredited.

7.11 If the Commonwealth decides not to accredit a management plan, it will give written notice to Western Australia identifying the reasons why it has decided not to accredit the management plan.

7.12 Western Australia may request that amendments to an accredited management plan be accredited by the Commonwealth. The process outlined in clauses 7.10 and 7.11 will apply to such a request.

7.13 The Commonwealth may revoke the accreditation of a management plan where the Commonwealth no longer believes that the management plan is consistent with the World Heritage Convention. Before revoking the accreditation of a management plan, the Commonwealth must consult with Western Australia. In particular, the Commonwealth must advise Western Australia why it no longer believes the management plan is consistent with the World Heritage Convention.

Consequences of Accreditation

7.14 For activities that are carried out in accordance with an accredited management plan, the relevant processes agreed in the management plan will be followed. The parties agree that management plans will primarily rely upon WA processes. Schedule 1 identifies the applicable Western Australian processes.

7.15 The Commonwealth acknowledges that (to the extent consistent with Commonwealth legislation) it does not intend to regulate, under Commonwealth legislation, action that is carried out in accordance with an accredited management plan.

7.16 If the Commonwealth considers that action taken under an accredited management plan may, contrary to clause 7.4 or 7.5 of this Agreement, be inconsistent with the protection, conservation and presentation of the Property, then the Commonwealth may request that Western Australia demonstrate that the proposed action is consistent with the protection, conservation and presentation of the Property. If, after considering the views of Western Australia, the Commonwealth believes the action is not consistent with the protection, conservation and presentation of the Property, then the Commonwealth may revoke the accreditation of all or part of the management plan.

Proposed activities not consistent with an accredited management plan

7.17 In relation to activities which are proposed to be carried out other than in accordance with an accredited management plan, the parties will, consistent with the provisions of Commonwealth and Western Australian legislation, agree on a single process for ensuring environmental protection, including environmental impact assessment.

7.18 To the extent necessary to ensure management of the Property is consistent with the World Heritage Convention, the Commonwealth may regulate under Commonwealth legislation activities which are proposed to be carried out other than in accordance with an accredited

management plan. For example, Commonwealth legislation may require that such activities be subject to environmental impact assessment and may prohibit, or impose conditions on, the carrying out of such activities.

7.19 Before the Commonwealth takes action under Commonwealth legislation, the Commonwealth Minister will, so far as is practicable and consistent with the provisions of Commonwealth legislation and the World Heritage Convention:

(a) consult the Western Australian Minister; and

(b) give full faith and credit, as that term is defined in clause 1.5 of the intergovernmental Agreement on the Environment (1992), or in subsequent revisions thereof, to the outcome of any assessment of a proposal undertaken under Western Australian legislation.

8. SHARK BAY MINISTERIAL COUNCIL

Terms of Reference

8.1 The Shark Bay Ministerial Council will:

(a) co-ordinate policy between Western Australia and the Commonwealth on all matters concerning the Property;

(b) approve the Shark Bay World Heritage Property Strategic Plan and any revisions of it;

(c) provide advice to both Government on:

(i) management requirements;

(ii) management plans;

(iii) research and education;

(iv) presentation and promotion;

(v) boundary modifications;

(vi) community consultation and liaison; and

(vii) financial matters;

(d) refer matters to the Community Consultative Committee and Scientific Advisory Committee and consider reports from these bodies; and

(e) resolve any dispute that might arise between the two Governments.

Membership

8.2 Membership of the Council will comprise equal representation of Western Australia and the Commonwealth, with up to two members from each.

Operation

8.3 The Council will operate according to the following procedures:

(a) it will be chaired by the Western Australian Minister responsible for the Conservation and Land Management Act 1984 (WA);

(b) a quorum shall be one Minister from each Government;

(c) it will meet on an as required basis, provided that at least one meeting is held per calendar year;

(d) decisions are to be made on a consensus basis; and

(e) secretariat support for the Council will be provided by Western Australia.

9. SHARK BAY COMMUNITY CONSULTATIVE COMMITTEE

Terms of Reference

9.1 The Shark Bay Community Consultative Committee will provide advice, either at the request of the Ministerial Council, or at its own volition, to the Ministerial Council on matters relating to the protection, conservation, presentation and management of the Property from the view point of the community.

Membership

9.2 The Committee will comprise:

(a) a majority of members who are residents of the Property or live in the vicinity of the Property; and

(b) members with knowledge or background in fields such as conservation, heritage, local government, fishing, tourism, Aboriginal matters, park management and/or agriculture; and

(c) the Chair of the Scientific Advisory Committee, or nominated representative.

Appointments

9.3 Members will be appointed by the Chair of the Ministerial Council. Members will be appointed in their own right and not as representatives of particular organisations, for a period of up to three years, with members eligible for re-appointment.

9.4 The Chair of the Shark Bay Community Consultative Committee is to be agreed by both Governments.

9.5 Other than the Chair of the Shark Bay Community Consultative Committee, up to four members will be appointed on the nomination of the Western Australian Minister and up to four on the nomination of the Commonwealth Minister.

9.6 Employees of the Western Australian and Commonwealth Governments may attend meetings of the Committee as observers.

Termination

9.7 Other than by resignation, terminations of membership of the Shark Bay Community Consultative Committee will be by the Chair of the Ministerial Council with the written agreement of the Commonwealth Minister, at their discretion.

Operation

9.8 The Consultative Committee will operate according to the following procedures:

(a) a quorum will be a simple majority of members;

(b) the Committee will meet as necessary, or at the request of the Ministerial Council, or if a majority of members request a meeting, provided that at least one meeting is held each calendar year;

(c) secretariat support for the Committee will be provided by Western Australia;

(d) business will be conducted by consensus. Where consensus is not possible, the Committee will indicated in its report of meetings the number of members supporting a particular view and note the alternative views of members not supporting a recommendation.

(e) a report of each meeting will be forwarded to the Chair of the Ministerial Council and the Chair of the Scientific Advisory Committee within 21 days of each meeting;

(f) in the absence of the Chair, members present will elect a temporary Chair; and

(g) members will be paid sitting fees and allowances as prescribed in the Remuneration Tribunal determinations or a Western Australian equivalent.

10. SHARK BAY SCIENTIFIC ADVISORY COMMITTEE

Terms of Reference

10.1 The Shark Bay Scientific Advisory Committee is to provide advice either at the request of the Ministerial Council, or at its own volition, to the Ministerial Council on:

(a) scientific research priorities which will contribute to the protection and conservation of the Property and understanding of its natural history;

(b) new information or developments in science relevant to protection, conservation or presentation of the Property;

(c) the scientific basis of management principles and practices;

(d) appropriateness of research funded by agencies in terms of scope, quality and relevance to management of the Property; and

(e) maintenance of outstanding universal values and integrity of the Property.

Membership

10.2 The Committee will comprise persons with qualifications relevant to, and/or special interest in, the protection and conservation of the Property (eg. botany, zoology, ecology, marine science, geomorphology), and the Chair of the Community Consultative Committee, or nominated representative.

Appointments

10.3 Members will be appointed by the Chair of the Ministerial Council. Members will be appointed in their own right and not as representatives of particular organisations, for a period of up to three years, with members eligible for re-appointment.

10.4 The Chair of the Scientific Advisory Committee is to be agreed by both Governments.

10.5 Other than the Chair of the Shark Bay Scientific Advisory Committee, up to three members will be appointed on the nomination of the Western Australian Minister and up to three on the nomination of the Commonwealth Minister.

10.6 Employees of the Western Australian and Commonwealth Governments may attend meetings of the Committee as observers.

Termination

10.7 Other than by resignation, terminations of membership of the Shark Bay Scientific Advisory Committee will be by the Chair of the Ministerial Council with the written agreement of the Commonwealth Minister, at their discretion.

Operation

10.8 The Scientific Advisory Committee will operate according to the following procedures:

(a) a quorum will be a simple majority of members;

(b) the Committee will meet as necessary, or at the request of the Ministerial Council, or if a majority of members request a meeting, provided that at least one meeting is held each calendar year;

(c) secretariat support for the Committee will be provided by Western Australia;

(d) business will be conducted by consensus. Where consensus is not possible, the Committee will indicate in its report of meetings the number of members supporting a particular view and note the alternative views of members not supporting a recommendation.

(e) a report of each meeting will be forwarded to the Chair of the Ministerial Council and the Chair of the Community Consultative Committee within 21 days of each meeting;

(f) in the absence of the Chair, members present will elect a temporary Chair; and

(g) members will be paid sitting fees and allowances as prescribed in the Remuneration Tribunal determinations or a Western Australian equivalent.

11. ADDRESSING IMPACTS

11.1 Social and economic impacts having a detrimental effect on third parties and arising out of decisions, made in accordance with the management plans referred to in clause 7, to protect the outstanding universal values of the Property, will be jointly considered by the Commonwealth and Western Australia. Where appropriate, the Commonwealth and Western Australia will consider the taking of measures by both parties (including in special circumstances, the making of act of grace payments) to address the detrimental effect of any such impact.

11.2 If the Commonwealth takes action under the World Heritage Properties Conservation Act 1983 (Cth) to protect the outstanding universal values of the Property, the Commonwealth will consider, in consultation with Western Australia, the taking of measures (including in special circumstances, the making of act of grace payments) to address any resulting social and economic impacts having a detrimental effect on third parties. the parties note that s.17 of the World Heritage Properties Conservation Act 1983 (Cth) provides for the payment of compensation where, but for that section, the operation of the Act would result in the acquisition of property otherwise than on just terms.

11.3 The consideration of the taking of measures to address the social and economic impacts referred to in clauses 11.1 and 11.2 will be solely a matter of Western Australia and/or the Commonwealth. It will not be a matter within the purview of the Shark Bay Ministerial Council or the committees referred to in this Agreement.

12 FINANCIAL ARRANGEMENTS

12.1 Both Governments will allocate appropriate resources to ensure the effective administration of this Agreement.

12.2 Article 5 of the World Heritage Convention requires, inter alia, that there be 'effective and active measures taken for the protection, conservation and presentation' of the Property. Both Governments will allocate appropriate resources to satisfy this obligation, subject to appropriation by the respective Parliaments and in accordance with such written arrangements as are agreed from time to time by the respective Ministers and endorsed by Ministerial Council.

12.3 Subject o appropriation by the Parliament of Western Australia, the Western Australian Government, through the Department of Conservation and Land Management and its other relevant agencies, will provide funds for the management of the Shark Bay World Heritage Property to ensure its outstanding universal values are maintained.

12.4 Subject to appropriation by the Parliament of the Commonwealth, and to compliance by Western Australia with the provisions of this Agreement, the Commonwealth will provide financial assistance to Western Australia to ensure appropriate protection and management of the outstanding universal values of the Property.

12.5 Expenditure reports by each Government will be provided annually to the Ministerial Council.

13. REVIEW OF MANAGEMENT AND ADMINISTRATIVE ARRANGEMENTS

13.1 The Ministerial Council may review the effectiveness of the management and administrative regime and this Agreement. The Ministers, as identified in clauses 1.3 and 1.4, may agree on changes to the regime or this Agreement, to improve effectiveness or to keep the Agreement up to date.

14 ENTRY INTO EFFECT

14.1 This Agreement enters into effect upon signature by both parties, and remains in effect until termination by either party, or by agreement between the parties.

APPENDICES

1. 'Convention for the Protection of the World Cultural and Natural Heritage' (UNESCO)

2. 'Operational Guidelines for the Implementation of the World Heritage Convention' (Intergovernmental Committee for the Protection of the World Cultural and Natural Heritage; UNESCO; December 1988)

3. Extract from 'Nomination of Shark Bay, Western Australia by the Government of Australia for inclusion in the World Heritage List' (Department of the Arts, Sport, the Environment, Tourism and Territories, 1990)

4. Technical description of the Shark Bay World Heritage Property Boundary

5. List of Conservation Reserves in the Shark Bay World Heritage Property

SIGNED:

(Robert Hill)	(Cheryl Edwardes)
…….	……..
SENATOR THE HON ROBERT HILL	HON CHERYL EDWARDES, MLA
COMMONWEALTH MINISTER FOR THE	WEST AUSTRALIAN MINISTER
ENVIRONMENT, SPORT AND TERRITORIES	FOR THE ENVIRONMENT
	EMPLOYMENT AND TRAINING

Dated this …….12th…….day of ……September …….1997

Schedule 1 (clause 7.14)

Western Australian Administrative Arrangements

Department of Conservation and Land Management

1.1 CALM is the lead management agency for the Property. In this respect, CALM is responsible for:

(a) overseeing development of management plans;

(b) liaising with agencies and other parties to ensure that development and management activities do not threaten the Property's outstanding universal values;

(c) conducting or arranging for the conduct of research;

(d) compiling and maintaining a comprehensive database for management purposes; and

(e) implementing promotional activities.

1.2 CALM is responsible for the management of conservation reserves, including preparation and implementation of management plans, in accordance with the Conservation and Land Management Act 1984 (WA). Conservation reserves in the Property are listed at Appendix 5.

1.3 CALM is also responsible for the conservation of wildlife (flora and fauna) in the Property in accordance with the Wildlife Conservation Act 1950 (WA) and for the regulation of the quantity of sandalwood that me be pulled or removed from Crown or other land in accordance with the Sandalwood Act 1929 (WA) and the conservation and Land Management Act 1984 (WA), Sandalwood harvesting will continue in the Property as provided for in the Shark Bay Regional Strategy.

1.4 CALM will compile annual reports on protection, conservation, presentation, rehabilitation and transmission to future generations of the Property, and provide them to the Ministerial Council in order to help satisfy the requirements of Article 29 of the World Heritage Convention.

Environmental Protection

2.1 Proposals that appear likely, if implemented, to have a significant effect on the environment of the Shark Bay World Heritage Property will be referred to the Western Australian Environmental Protection Authority (EPA) under s.38 of the Environmental Protection Act 1986 (WA). The EPA will determine whether or not a proposal should be assessed and if so at what level under s.40 of the Act, and keep a public record of each proposal as required under s.39 of the Act.

2.2 Consistent with the Agreement between the State and the Commonwealth, concerning arrangements for cooperation in the environmental assessment of proposals the party first notified of such a proposal will advise the other party at the earliest practicable stage, and the parties will exchange information relevant to the proposal as soon as practical after notification. When the current Review of the Commonwealth-State Roles and Responsibilities for the Environment is concluded, the relevant processes set out in that

Review will apply, as appropriate, in relation to this clause.

2.3 The EPA will advise the Commonwealth (Environment Australia) of its decisions whether or not to assess a proposal and if so, the level of assessment, as soon as practicable after its determination. The parties note that there is a fourteen (14) day appeal period to the WA Minister for the Environment on the EPA's decision. The Minister can either dismiss or remit the decision for further assessment or reassessment more fully or publicly or both.

2.4 The Commonwealth may exercise its right of appeal under s.100 of the Environmental Protection Act 1986 (WA) on the EPA's decision and the WA Minister for the Environment shall have full regard for the view of the Commonwealth in determining any appeal made by the Commonwealth.

2.5 The EPA will ensure that the Commonwealth's advice regarding any proposal subject to environmental impact assessment under the Environmental Protection Act 1986 (WA) is taken into account. In particular, for proposals subject to formal assessment, provision for Commonwealth involvement will be made at the following stages in the assessment process:

(a) comment on the preparation of guidelines shaping the assessment;

(b) comment on the draft environmental impact assessment review document prepared by the proponent regarding its suitability for public review;

(c) comment on the environmental impact assessment review document during the public comment period; and

(d) liaison with the WA EPA during the preparation of the assessment report.

2.6 Prior to setting conditions on a proposal for it to proceed or not under s.45 of the Environmental Protection Act 1986 (WA), the WA Minister for the Environment will consult with the Commonwealth Minister regarding the environmental factors relevant to that proposal.

2.7 Where actions are being considered under the Environmental Protection Act 1986 (WA), full account will be taken of the potential environmental impacts of proposals on the outstanding universal values of the Property.

Urban and Regional Planning

3.1 The Western Australian Planning Commission and the Ministry for Planning will be responsible for subdivision control, regional and strategic land use planning and evaluation of local town planning schemes. The planning process as it affects the Shark Bay World Heritage Property is determined by the Town Planning and Development Act 1928 (WA) and the Western Australian Planning commission Act 1985 (WA). The Shark Bay Regional Strategy provides the planning framework for land use in the World Heritage Property. Where relevant, town planning schemes, scheme amendments and statutory regional planning schemes affecting the Shark Bay World Heritage Property will be referred to the WA Environmental Protection Authority for environmental assessment as required under s.48A-48J of the Environmental Protection Act 1986 (WA) and the WA EPA will notify the Commonwealth of all known activities or proposals that may have a significant impact on the Property or its World Heritage values, or be at variance with agreed management plans or arrangements, at the earliest possible opportunity, or as

otherwise agreed under the current Review of Commonwealth-State Roles and Responsibilities for the Environment.

Fisheries

4.1 The Fisheries Department of Western Australia will manage recreational and commercial fishing, including aquaculture, and fish resources in accordance with the Fish Resources Management Act 1994 (WA) in conjunction with the Conservation and Land Management Act 1984 (WA) in marine conservation reserves. The Fisheries Department will manage pearling under the Pearling Act 1990 (WA).

4.2 Fishing, aquaculture and pearling will be managed in accordance with the Shark Bay World Heritage Property Management Paper for Fish Resources (1996) prepared by the Fisheries Department with public consultation, and in accordance with the relevant portions of the Shark Bay Marine Reserves Management Plan (1996-2006).

Agriculture and Pastoralism

5.1 The Pastoral Board constituted under the Land Act 1933 (WA) will administer the pastoral lands within the Property. Management oversight for pastoral activities will be through Agriculture Western Australia, in accordance with relevant legislation including the Soil and Land Conservation Act 1945 (WA) and the Agriculture and Related Resources Protection Act 1976 (WA).

5.2 Agriculture and pastoral activities will continue in the Property as provided for in the Shark Bay Regional Strategy.

Mining and Petroleum

5.3 The Department of Minerals and Energy will manage mineral exploration, mining and subject to clause 5.4 of this Schedule, any petroleum exploration and development in accordance with the Mining Act 1978 (WA), the Petroleum Act 1967 (WA), the Petroleum Pipelines Act 1969 (WA) and the Petroleum (Submerged Lands) Act 1982 (WA). Mineral exploration, mining and, subject to clause 5.4 of this Schedule, petroleum exploration and development may proceed in the Property, subject to the Environmental Protection Act 1986 (WA) procedures and so long as these activities do not threaten the Property's outstanding universal values.

5.4 The Western Australian Minister will seek advice from the EPA under s.16(e) of the Environmental Protection Act 1986 (WA) regarding environmental aspects of petroleum exploration and development activities within the Shark Bay World Heritage Property. Having received advice from the EPA, the Western Australian Minister will refer his advice to the Commonwealth Minister. The Ministerial Council will then decide whether petroleum exploration and development activities are compatible with the protection, conservation and presentation of the Property and, if so, will agree on a framework for the administration and regulation of these activities.

5.5 The Shark Bay Salt Joint Venture and associated loading facilities, and some former gypsum mining leases near Useless Loop, are excluded from the Property. Because the State has specific obligations under the Shark Bay Solar Salt Industry Agreement Act 1983 (WA) to ensure Shark Bay Salt Joint Venture operations are maintained, the passage of ships will continue through the Property and any marine activities necessary to maintain the adequacy and safety of the shipping channels will continue in the Property.

Local Government

6.1 The Shires of Shark Bay and Carnarvon, in regard to their respective portions of the Property, are responsible for decision making and management in respect to those activities prescribed in the Local government Act 1995 (WA) or delegated under other State legislation, in consultation with the State.

Figure 1 Location map of Shark Bay

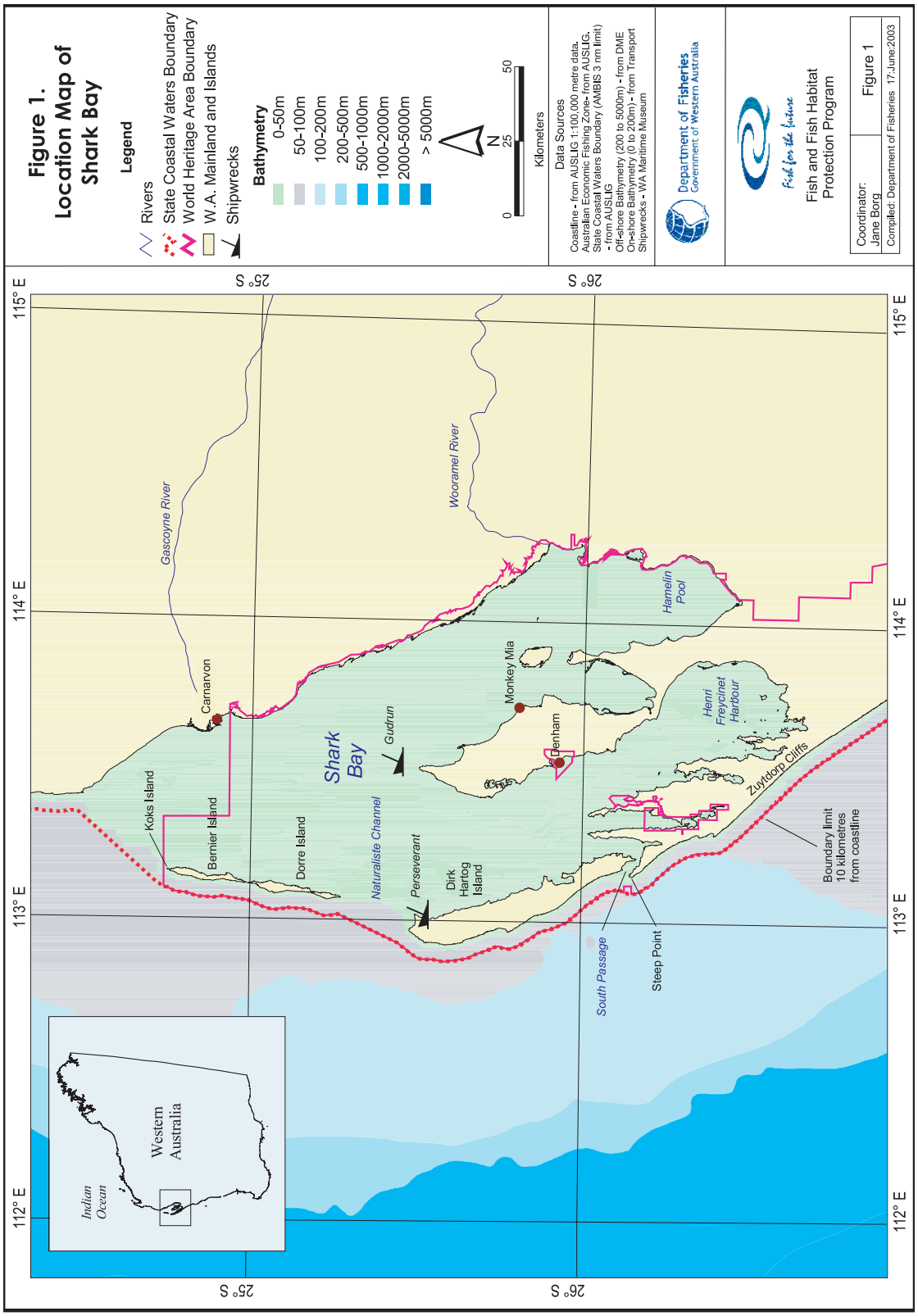


Figure 2 Proposed consultation process

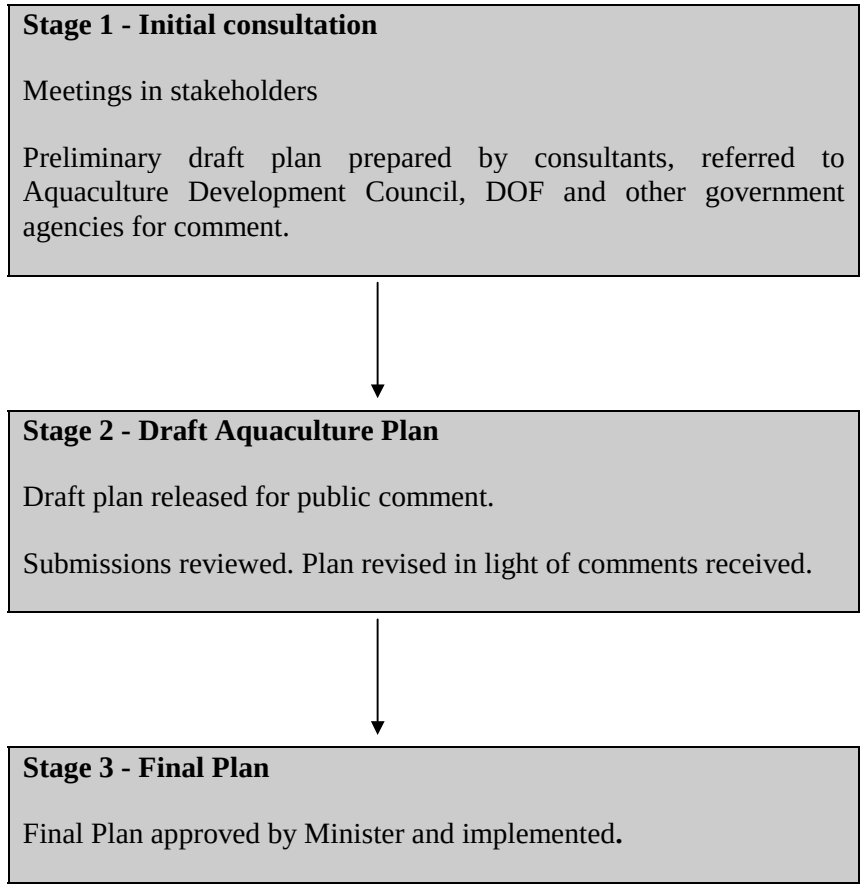


Figure 3 Seagrass habitats in Shark Bay

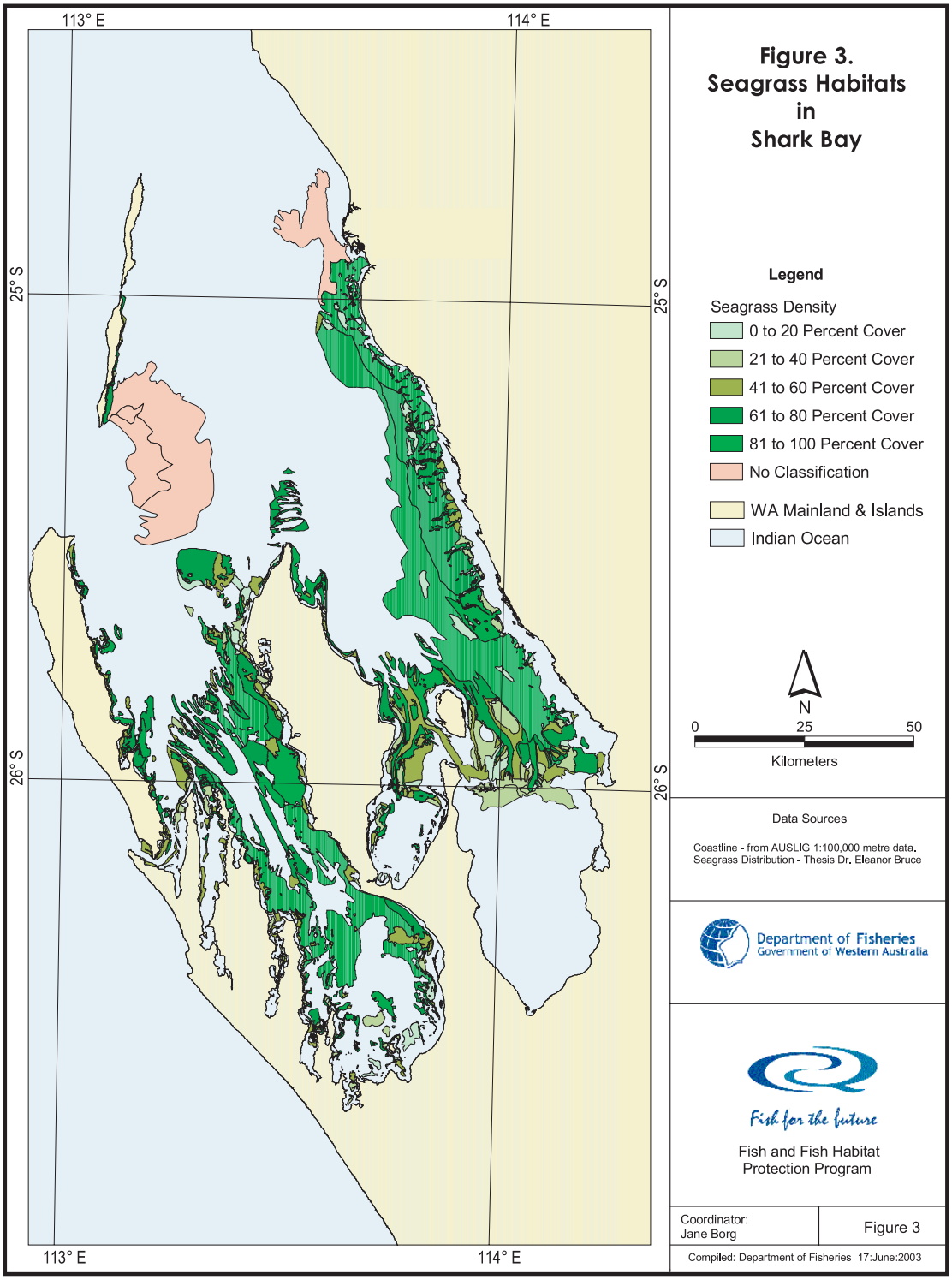


Figure 4a Current commercial use in Shark Bay – trawl managed fisheries (Shark Bay Scallop and Shark Bay Prawn)

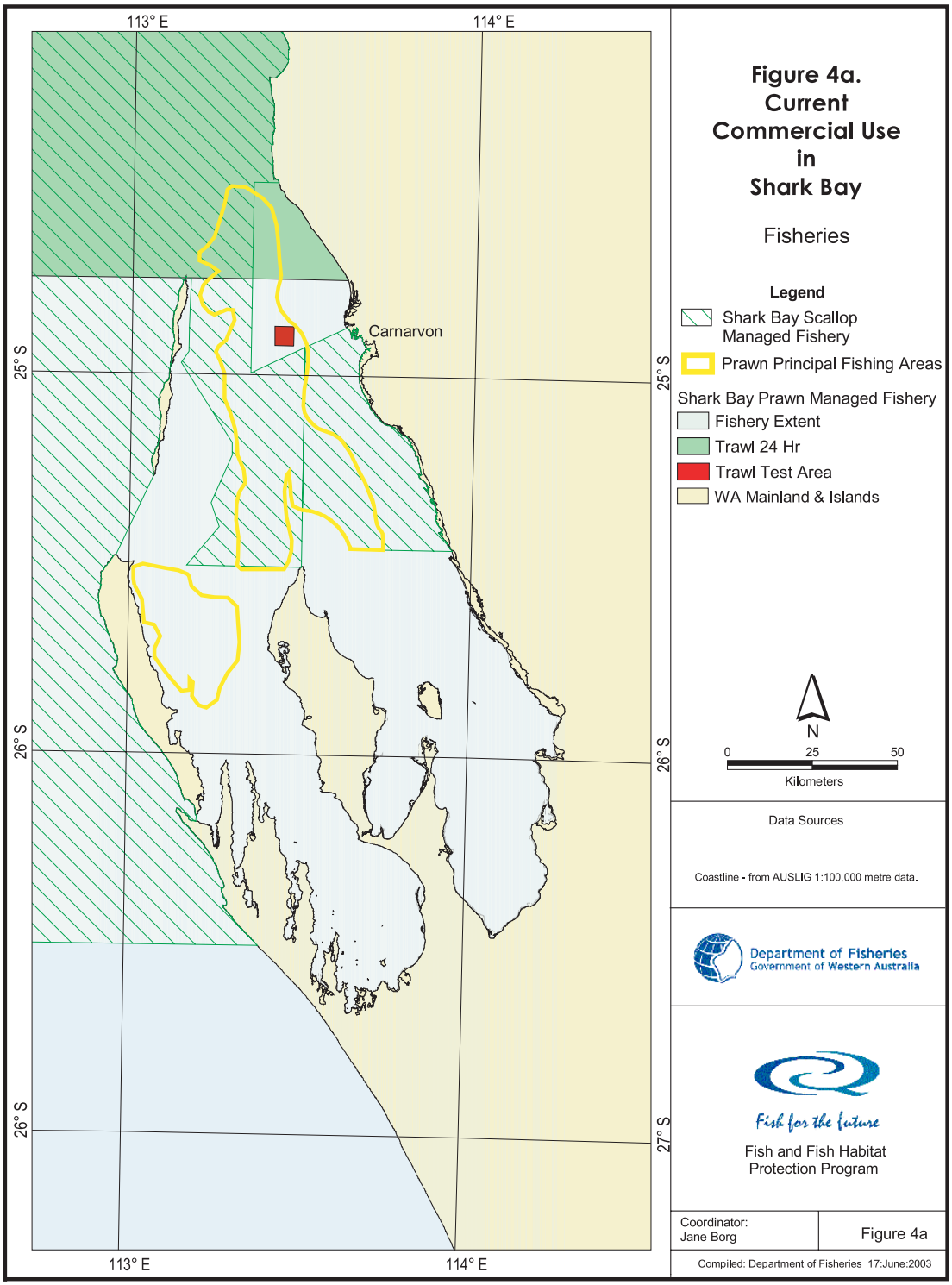


Figure 4b Current commercial use in Shark Bay - beach seine fishery

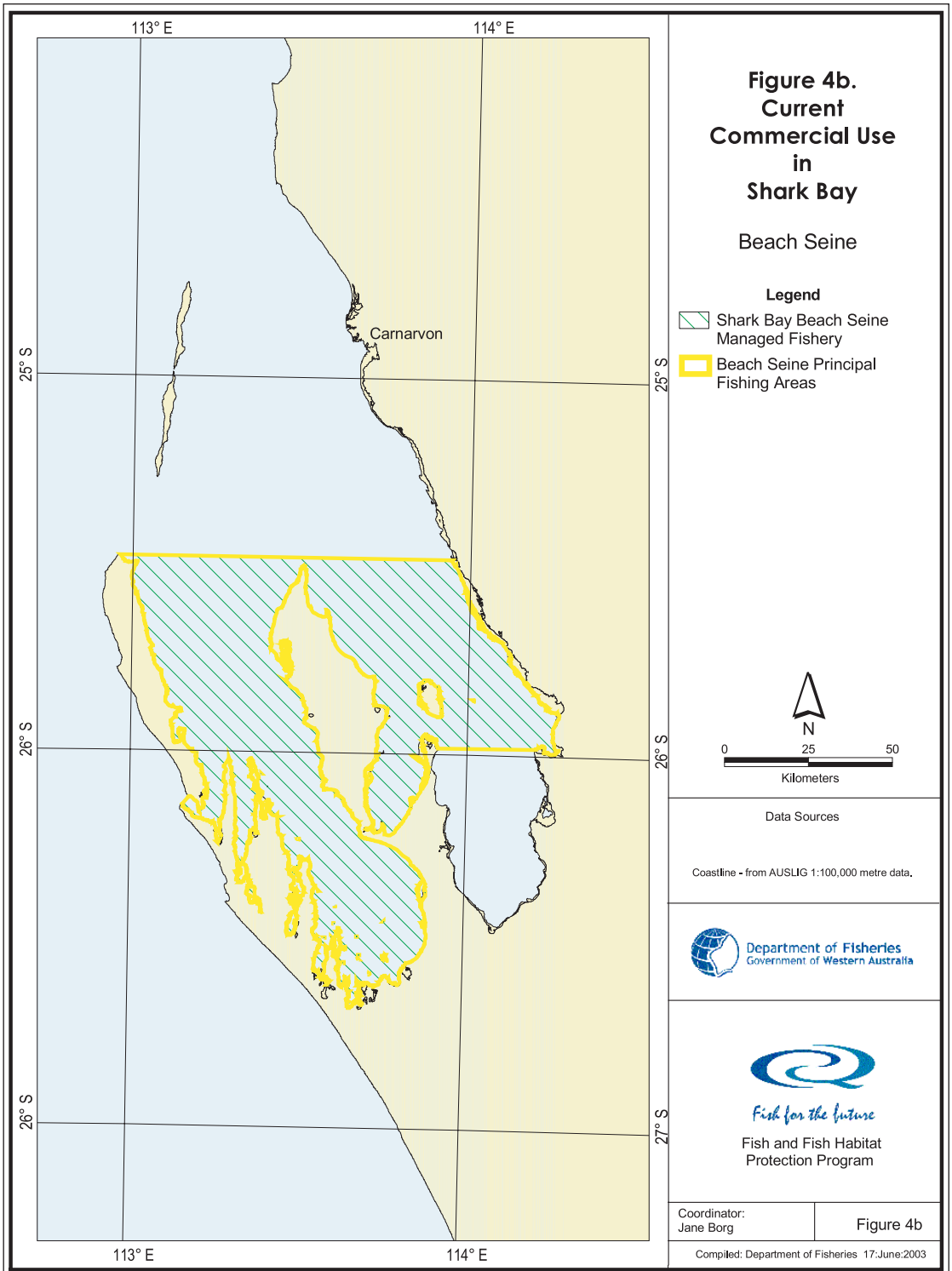


Figure 4c Current commercial use in Shark Bay – pink snapper fishery

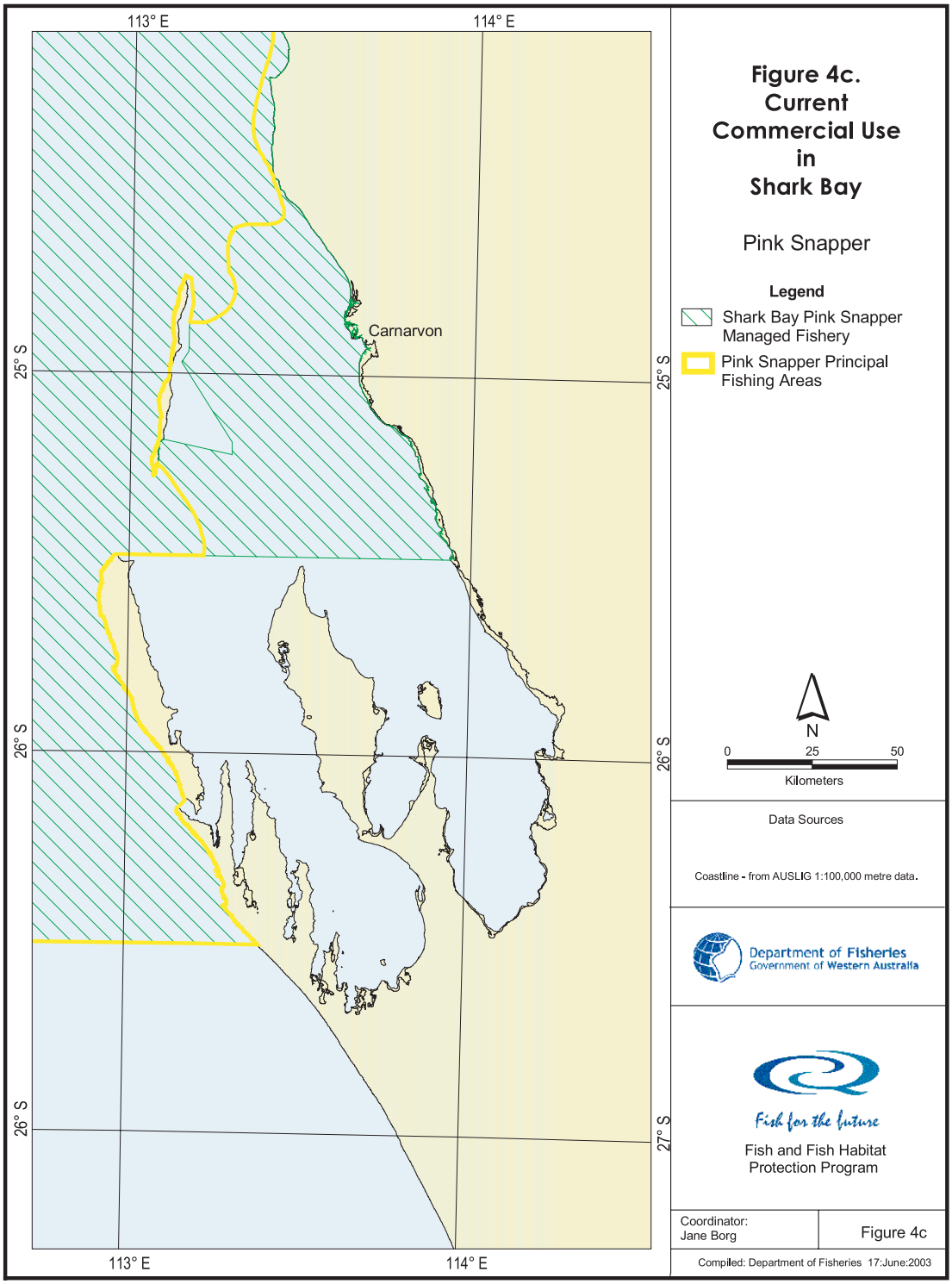


Figure 5 Current aquaculture use in Shark Bay

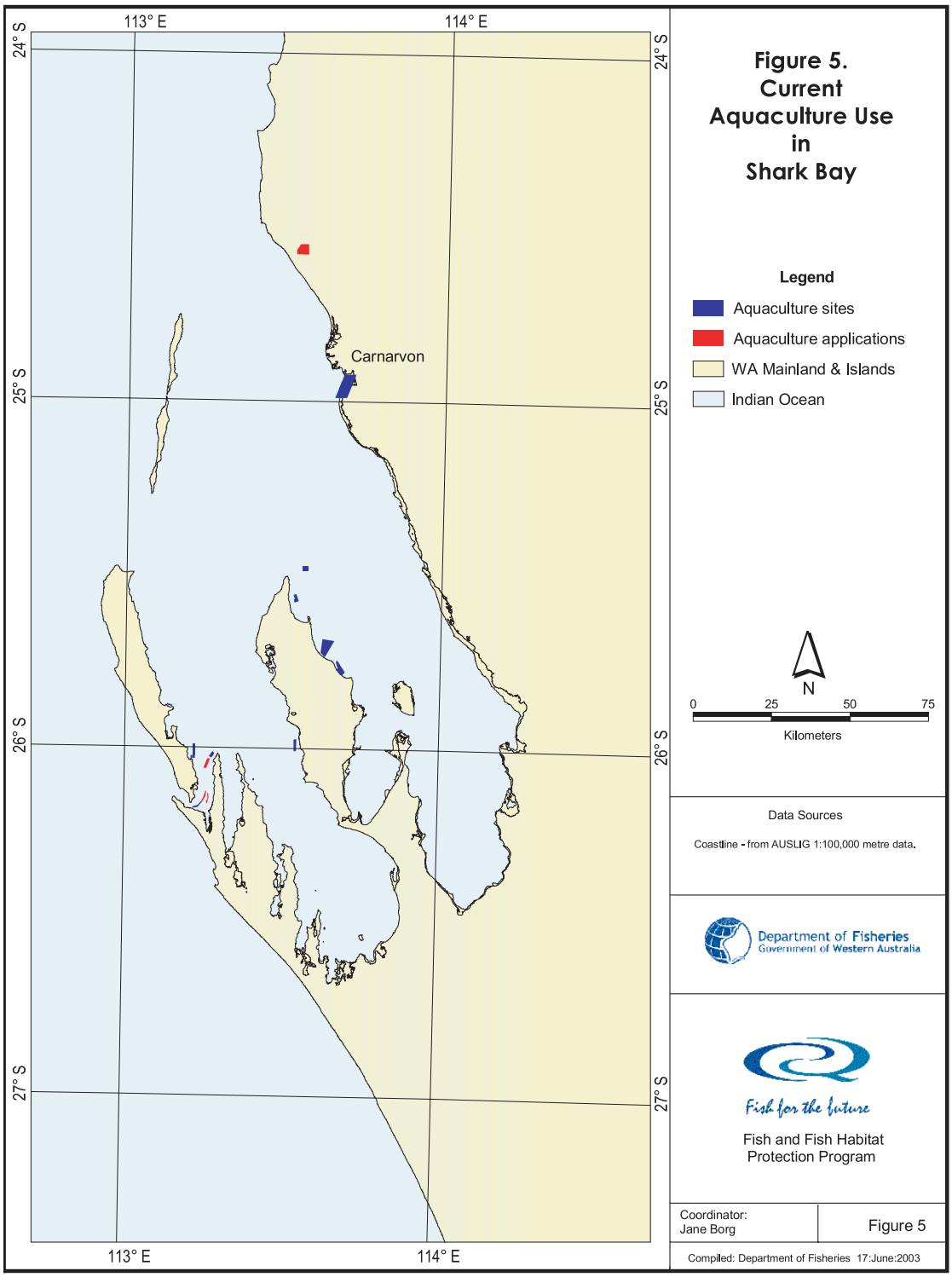


Figure 6 Current recreational fishing activity in Shark Bay

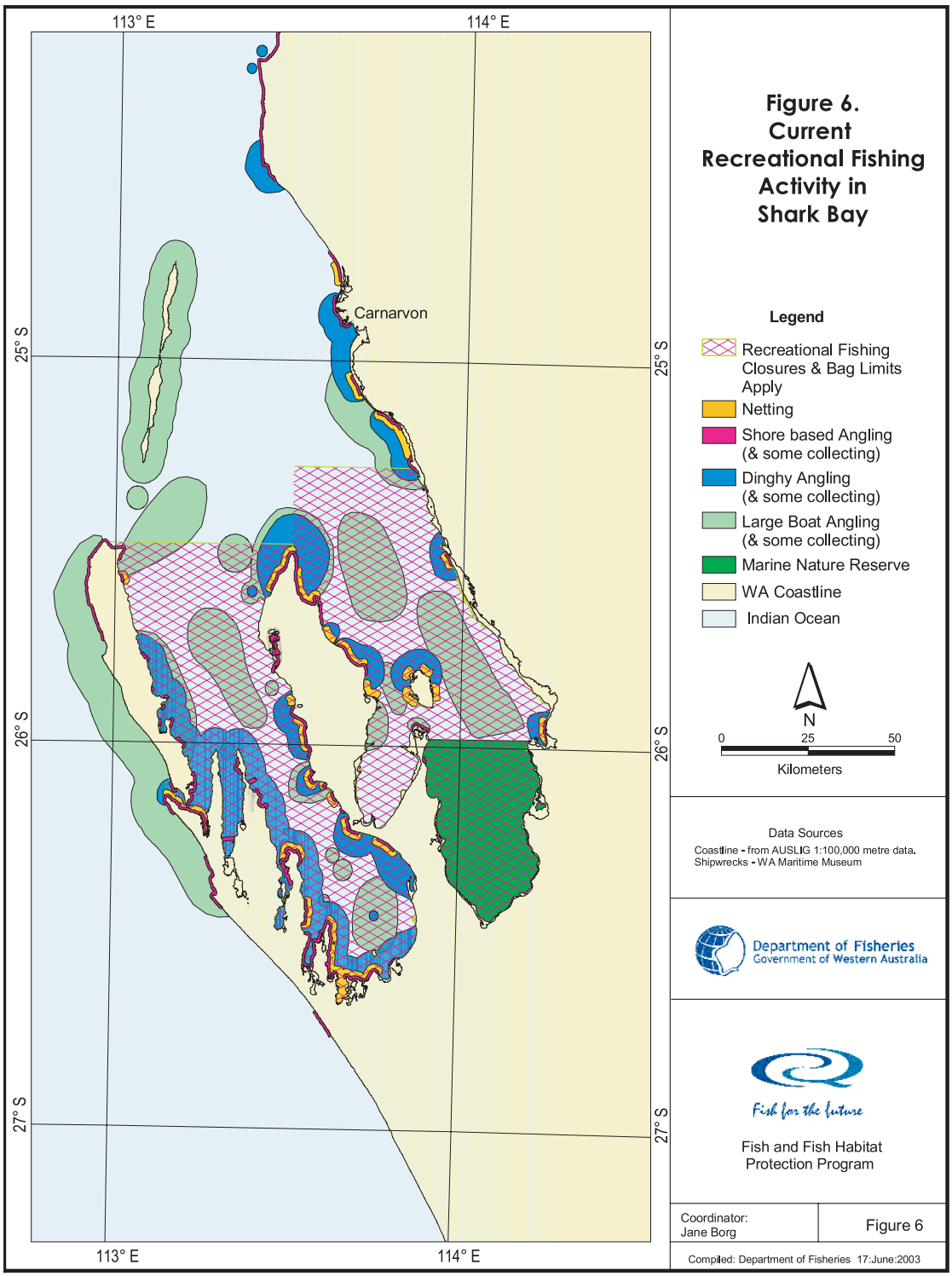


Figure 7 Current recreational use in Shark Bay

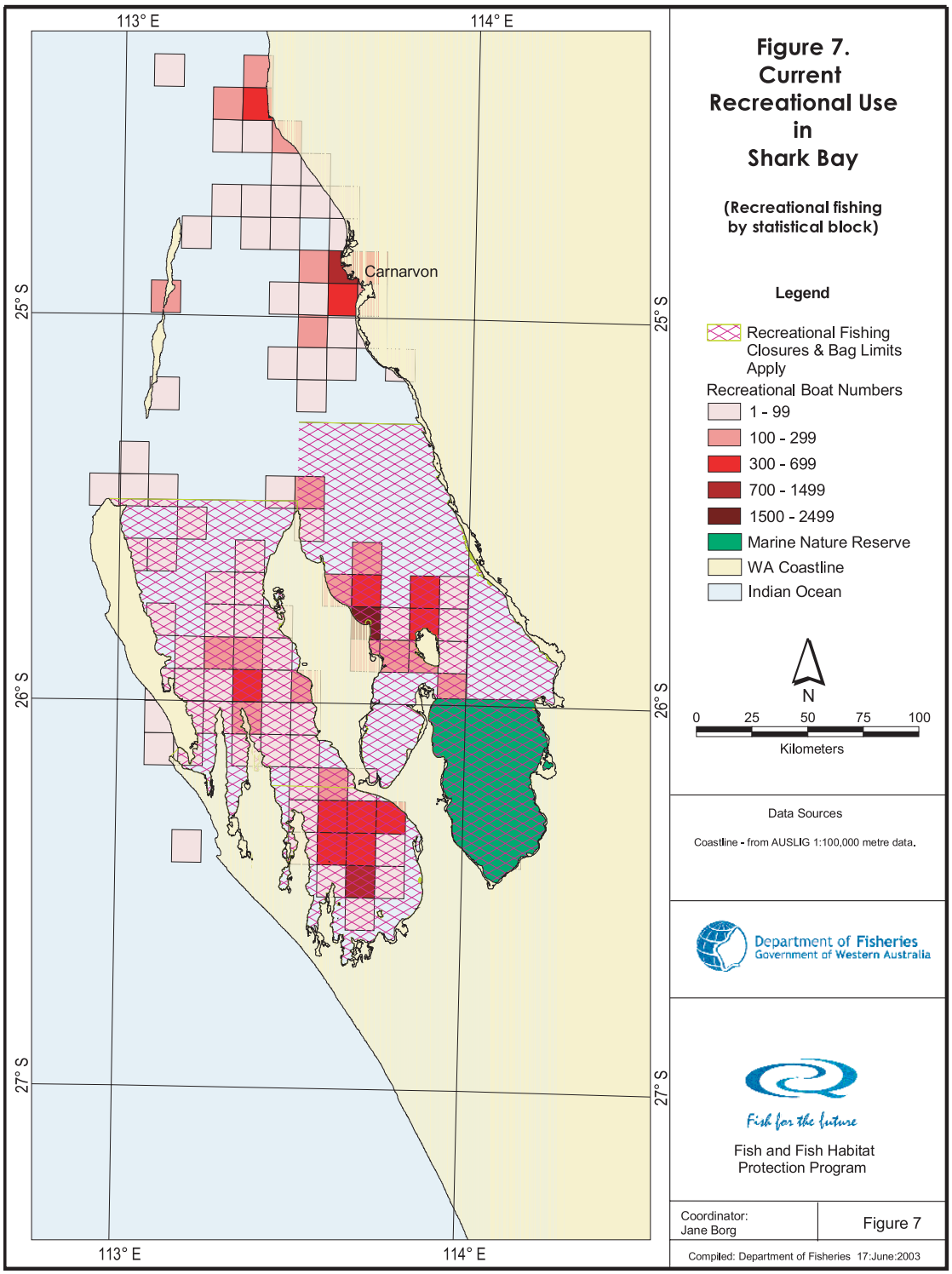


Figure 8 Current commercial use in Shark Bay - petroleum and mining tenements

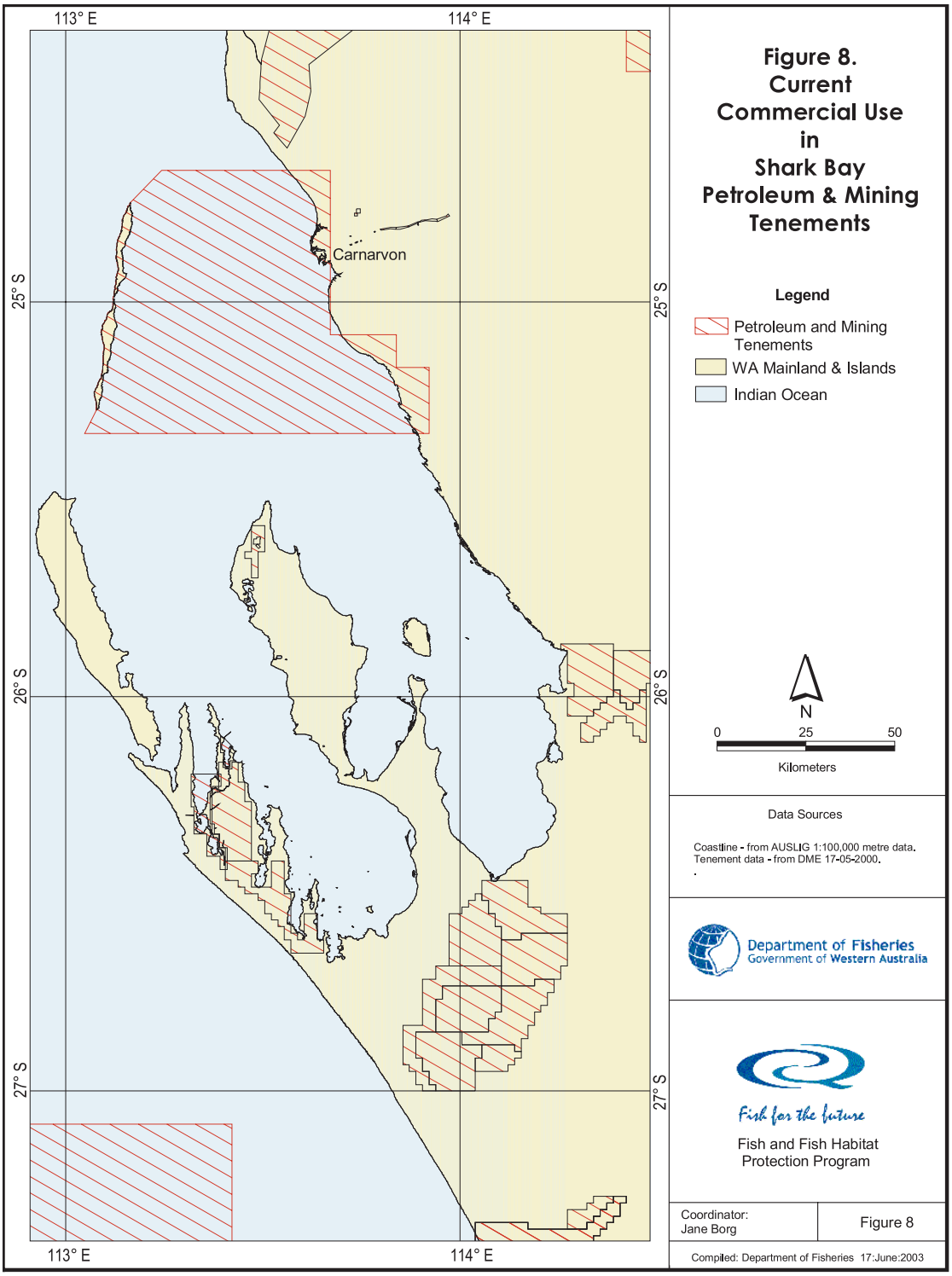


Figure 9 Conservation tenures in Shark Bay

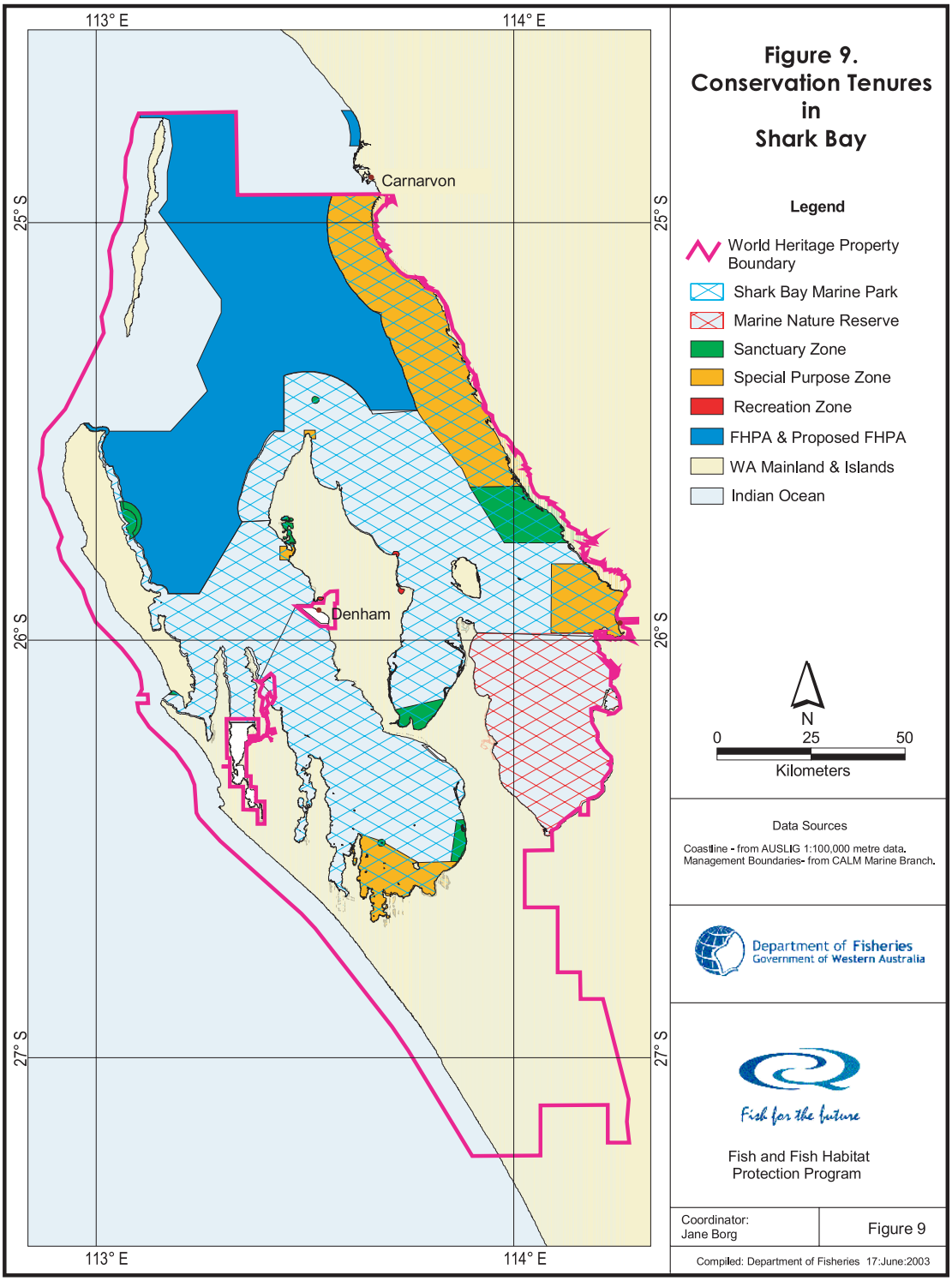


Figure 10: Shark Bay Planning Framework

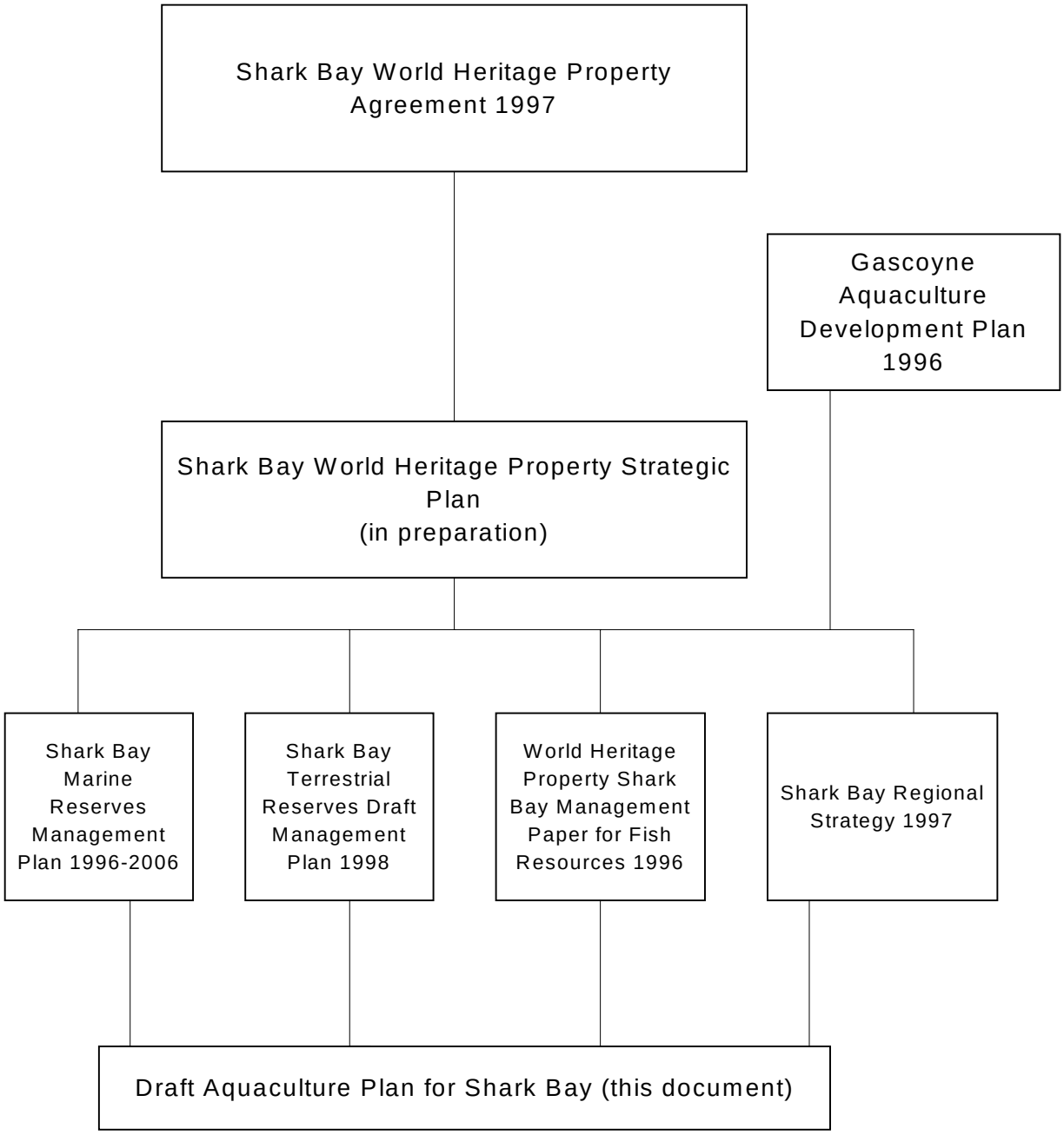
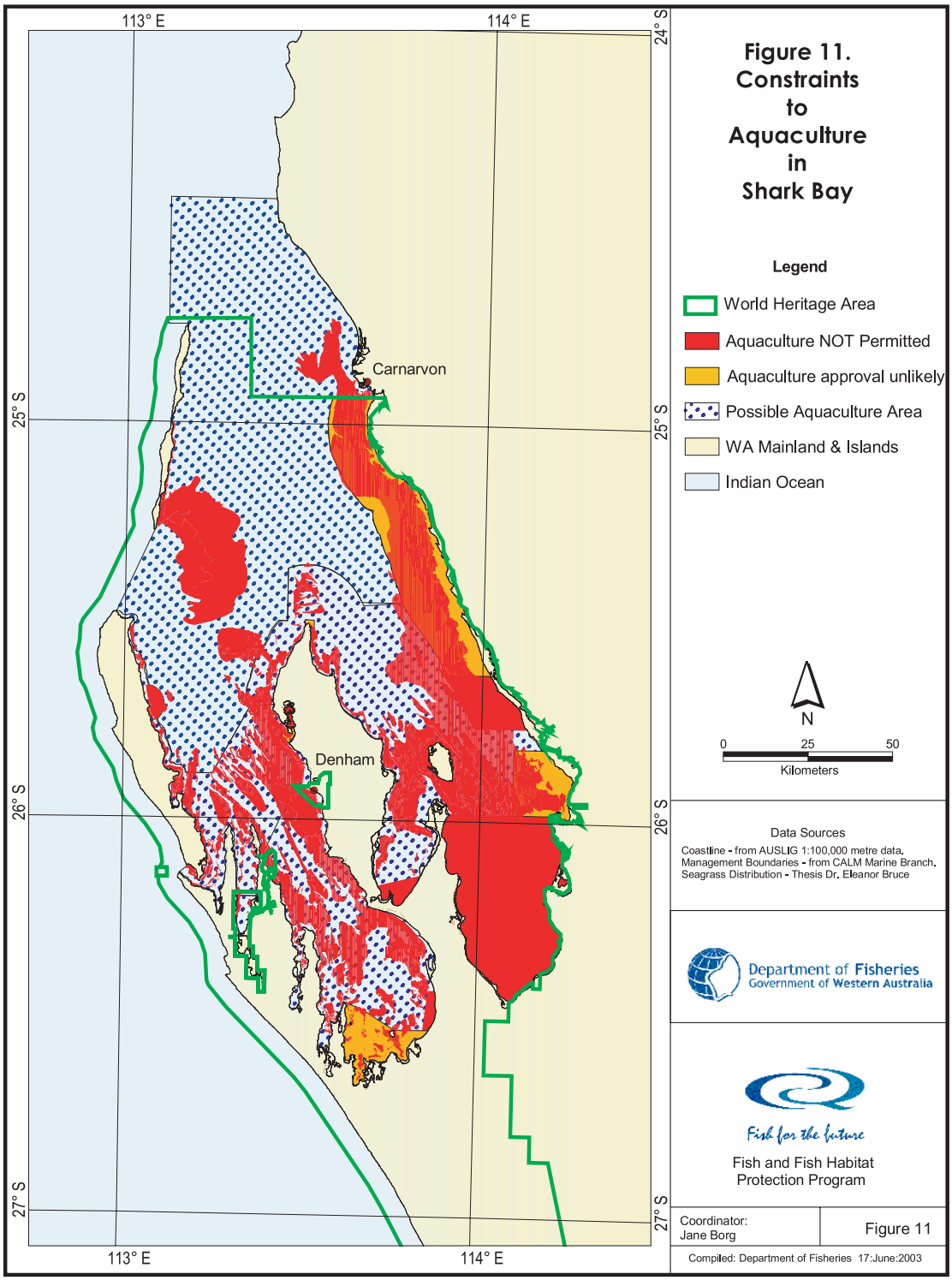


Figure 11 Constraints to aquaculture in Shark Bay



FISHERIES MANAGEMENT PAPERS

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No. 1 The Report of the Southern Western Australian Shark Working Group. Chairman P. Millington (1986).

No. 2 The Report of the Fish Farming Legislative Review Committee. Chairman P.Rogers (1986).

No. 3 Management Measures for the Shark Bay Snapper 1987 Season. P. Millington (1986).

No. 4 The Esperance Rock Lobster Working Group. Chairman A. Pallot (1986).

No. 5 The Windy Harbour - Augusta Rock Lobster Working Group. Interim Report by the Chairman A. Pallot (1986).

No. 6 The King George Sound Purse Seine Fishery Working Group. Chairman R. Brown (1986).

No. 7 Management Measures for the Cockburn Sound Mussel Fishery. H. Brayford (1986).

No. 8 Report of the Rock Lobster Industry Advisory meeting of 27 January 1987 . Chairman B. Bowen (1987).

No. 9 Western Rock Lobster Industry Compensation Study. Arthur Young Services (1987).

No. 10 Further Options for Management of the Shark Bay Snapper Fishery. P. Millington (1987).

No. 11 The Shark Bay Scallop Fishery. L. Joll (1987).

No. 12 Report of the Rock Lobster Industry Advisory Committee to the Hon Minister for Fisheries 24 September 1987. (1987)

No. 13 A Development Plan for the South Coast Inshore Trawl Fishery. (1987)

No. 14 Draft Management Plan for the Perth Metropolitan Purse Seine Fishery. P. Millington (1987).

No. 15 Draft management plan, Control of barramundi gillnet fishing in the Kimberley. R. S. Brown (1988).

No. 16 The South West Trawl Fishery Draft Management Plan. P. Millington (1988).

No. 17 The final report of the pearling industry review committee . F.J. Malone, D.A. Hancock, B. Jeffriess (1988).

No. 18 Policy for Freshwater Aquaculture in Western Australia. (1988)

No. 19 Sport Fishing for Marron in Western Australia - Management for the Future. (1988)

No. 20 The Offshore Constitutional Settlement, Western Australia 1988.

No. 21 Commercial fishing licensing in Western Australia. (1989)

No. 22 Economics and marketing of Western Australian pilchards. SCP Fisheries Consultants Pty Ltd (1988).

No. 23 Management of the south-west inshore trawl fishery. N. Moore (1989)

No. 24 Management of the Perth metropolitan purse-seine fishery. N. Moore (1989).

No. 25 Rock Lobster Industry Advisory Committee report to the Minister for Fisheries November 1988. (1989)

No. 26 A report on marron fishing in Western Australia. Chairman Doug Wenn MLC (1989).

No. 27 A review of the Shark Bay pearling industry. Dr D.A.Hancock, (1989).

No. 28 Southern demersal gillnet and longline fishery. (1989)

No. 29 Distribution and marketing of Western Australian rock lobster. P. Monaghan (1989).

No. 30 Foreign investment in the rock lobster industry. (1989)

No. 31 Rock Lobster Industry Advisory Committee report to the Hon Minister for Fisheries September 1989. (1989)

No. 32 Fishing Licences as security for loans. P. Rogers (1989)

No. 33 Guidelines for by-laws for those Abrolhos Islands set aside for fisheries purposes. N. Moore (1989).

No. 34 The future for recreational fishing - issues for community discussion. Recreational Fishing Advisory Committee (1990).

No. 35 Future policy for charter fishing operations in Western Australia. P. Millington (1990).

No. 36 Long term management measures for the Cockburn Sound restricted entry fishery. P. Millington (1990).

No. 37 Western rock lobster industry marketing report 1989/90 season. MAREC Pty Ltd (1990).

No. 38 The economic impact of recreational fishing in Western Australia. R.K. Lindner, P.B. McLeod (1991).

No. 39 Establishment of a registry to record charges against fishing licences when used as security for loans. P. Rogers. (1991)

No. 40 The future for Recreational Fishing - Forum Proceedings. Recreational Fishing Advisory Committee (1991)

No. 41 The future for Recreational Fishing - The Final Report of the Recreational Fishing Advisory Committee. Recreational Fishing Advisory Committee (1991).

No. 42 Appendix to the final report of the Recreational Fishing Advisory Committee. (1991)

No. 43 A discussion of options for effort reduction. Southern Gillnet and Demersal Longline Fishery Management Advisory Committee (1991).

No. 44 A study into the feasability of establishing a system for the buy-back of salmon fishing authorisations and related endorsements. (1991)

No. 45 Draft Management Plan, Kimberley Prawn Fishery. (1991)

No. 46 Rock Lobster Industry Advisory Committee, Chairman's report to the Minister (1992)

No. 47 Long term management measures for the Cockburn Sound restricted entry fishery. Summary of submissions and final recommendations for management. P. Millington (1992).

No. 48 Pearl oyster fishery policy guidelines (Western Australian Pearling Act 1990). Western Australian Fisheries Joint Authority (1992).

No. 49 Management plan, Kimberley prawn fishery. (1992)

No. 50 Draft management plan, South West beach seine fishery. D.A. Hall (1993).

No. 51 The west coast shark fishery, draft management plan. D.A. Hall (1993).

No. 52 Review of bag and size limit proposals for Western Australian recreational fishers. F.B. Prokop (May 1993).

No. 53 Rock Lobster Industry Advisory Committee, Chairman's report to the Minister for Fisheries. (May 1993)

No. 54 Rock Lobster Industry Advisory Committee, Management proposals for 1993/94 and 1994/95 western rock lobster season (July 1993).

No. 55 Rock Lobster Industry Advisory Committee, Chairman's report to the Minister for Fisheries on management proposals for 1993/94 and 1994/95 western rock lobster seasons (September 1993).

No. 56 Review of recreational gill, haul and cast netting in Western Australia. F. B. Prokop (October 1993).

No. 57 Management arrangements for the southern demersal gillnet and demersal longline fishery 1994/95 season. (October 1993).

No. 58 The introduction and translocation of fish, crustaceans and molluscs in Western Australia. C. Lawrence (October 1993).

No. 59 Proceedings of the charter boat management workshop (held as part of the 1st National Fisheries Manager Conference). A. E. Magee & F. B. Prokop (November 1993).

No. 60 Bag and size limit information from around Australia (Regulations as at September 1993) F. B. Prokop (January 1993).

No. 61 Economic impact study. Commercial fishing in Western Australia Dr P McLeod & C McGinley (October 1994)

No. 62 Management arrangements for specimen shell collection in Western Australia. J. Barrington, G. Stewart (June 1994)

No. 63 Management of the marine aquarium fish fishery. J. Barrington (June 1994)

No. 64 The Warnbro Sound crab fishery draft management plan. F. Crowe (June 1994)

No. 65 Not issued

No. 66 Future management of recreational gill, haul and cast netting in Western Australia and summary of submissions to the netting review. F.B. Prokop, L.M. Adams (September 1994)

No. 67 Long term management strategies for the Western Rock Lobster Fishery. (4 volumes) Evaluation of management options Volume 1. B. K. Bowen (September 1994)

No. 68 Long term management strategies for the Western Rock Lobster Fishery. (4 volumes) Economic efficiency of alternative input and output based management systems in the western rock lobster fishery, Volume 2. R.K. Lindner (September 1994)

No. 69 Long term management strategies for the Western Rock Lobster Fishery. (4 volumes) A market-based economic assessment for the western rock lobster industry, Volume 3. Marec Pty Ltd (September 1994)

No. 70 Long term management strategies for the Western Rock Lobster Fishery. (4 volumes) Law enforcement considerations, Volume 4. N. McLaughlan (September 1994)

No. 71 The Rock Lobster Industry Advisory Committee Chairman's Report, October 1994, The Western Rock Lobster Fishery - Management proposals for the 1994/95 and 1995/96 seasons (November 1994)

No. 72 Shark Bay World Heritage Area draft management plan for fish resources. D. Clayton (November 1994)

No. 73 The bag and size limit review: new regulations and summary of submissions. F. Prokop (May 1995)

No. 74 Report on future management options for the South West trawl limited entry fishery. South West trawl limited entry fishery working group (June 1995)

No. 75 Implications of Native Title legislation for fisheries management and the fishing industry in Western Australia. P. Summerfield (February 1995)

No. 76 Draft report of the South Coast estuarine fishery working group. South Coast estuarine fishery working group. (February 1995)

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