Draft Aquaculture Plan

for the Recherche Archipelago, Western Australia

Prepared for

Fisheries Western Australia

by

Everall Consulting Biologist

in association with

Fish Unlimited

April 25, 1999

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.

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The closing date for submissions is July 2, 1999.

Contacts

Submissions should be addressed to:

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

If you wish to discuss the content of the document or require further information, please contact Mr Greg Paust (08) 9482 7392.

DRAFT AQUACULTURE PLAN FOR THE RECHERCHE ARCHIPELAGO

AN INVITATION TO COMMENT

Fisheries WA invites people to make a submission on the issues discussed in this report - *Draft Aquaculture Plan for the Recherche Archipelago*. This plan is one of four documents which have been prepared by *Everall Consulting Biologist* in association with *Fish Unlimited*, as part of the process of planning the future direction of aquaculture in the Recherche Archipelago. The other documents are:

- Draft User Profile for the Recherche Archipelago;
- Report of Community Consultations; and
- Benthic Habitat Survey of the Remark, Mart, Mondrain, Tory and York Island Groups in the Recherche Archipelago.

The Draft User Profile has also been released for public comment and should be read in conjunction with this Draft Aquaculture Plan.

Copies of the Report on Community Consultations and the Benthic Habitat Survey are available from Fisheries WA should further detail be required.

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.

Fisheries WA will consider the submissions received and amend the Draft Aquaculture Plan and Draft User Profile accordingly.

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 the Recherche Archipelago.

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 SUBMISSION FORM
DRAFT AQUACULTURE PLAN FOR THE RECHERCHE ARCHIPELAGO

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Name: _____

Organisation
(if applicable): _____

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I would like to make the following comments on the Draft Aquaculture Plan for the Recherche Archipelago

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Fisheries Western Australia Disclaimer

This draft document was prepared by Everall Consulting Biologist in association with Fish Unlimited for Fisheries Western Australia.

The information in the document(s) are the views and recommendations of the authors and do not necessarily reflect the views of Fisheries Western Australia.

The draft documents are being released for public comment to enable the community of Esperance and other interested groups and agencies to provide comment and input.

Following the completion of the public comment period, the development of a final aquaculture plan for the Recherche Archipelago will be progressed.

Peter Rogers
Executive Director
Fisheries Western Australia

ACKNOWLEDGEMENTS

The assistance, information, advice and hospitality of the people of Esperance during the preparation of this report is gratefully acknowledged.

I would particularly like to thank:

The members of Esperance Bay Yacht Club and the Esperance Offshore Angling Club who provided their time and detailed knowledge of the Recherche Archipelago for the User Profiles.

Mr Bill Kent, President of the Esperance Professional Fishermens Association, who provided much wise advice.

Mr Ross Ainsworth MLA, Chairman, and the members of the Recherche Archipelago Consultative Group.

EXECUTIVE SUMMARY

The waters and hinterland of the Recherche Archipelago near Esperance appear to have significant potential for aquaculture development and interest in the area for aquaculture purposes is increasing. Recent public consultation on aquaculture in the area has raised concerns about the long term expansion of aquaculture activities and the need for coordinated planning.

The coastline of the Recherche Archipelago features numerous pristine beaches, headlands, islands and sheltered bays. It is a rugged, high energy coast, with spectacular white beaches between headlands dominated by dome shaped granite hills and mountains of similar origin to the islands. More than half the coastline is included in the Cape Le Grand and Cape Arid National Parks which contain large tracts of natural bushland. The remainder of the coast comprises a wide belt of vegetated and wind blown dunes backing on to cleared agricultural lands of the Esperance Coastal Plain and Sandplains.

Significant activities in the Recherche Archipelago include shipping from the Port of Esperance, commercial and recreational fishing, tourism, scenic and charter tours, diving and coastal recreation.

Biophysical Environment

The biophysical environment of the Recherche Archipelago is not well known or documented, but aspects of relevance to aquaculture include:

- Sea temperatures are favourable for the growth of many temperate finfish species;
- Strong prevailing winds, swells and storm events in the Recherche Archipelago will require special consideration in the design and location of marine aquaculture structures;
- Currents are mostly wind driven, but with low velocity reducing with depth. Special husbandry techniques will be required to deal with flushing within and around sea cages, particularly during extended calm periods;
- Many of the islands of the Recherche Archipelago have sea bird breeding areas, seal and sea lion breeding and haul out areas. Marine mammals including whales, dolphins and seals occur in the area. These will impose special management techniques on marine aquaculture operations;
- The benthic habitats of the Recherche Archipelago are not well known and detailed survey of the location and function of the benthos, including the infauna of sand areas, will be required before marine aquaculture projects can proceed.

Social Environment and Infrastructure

The investigations and consultations have indicated that in relation to the availability of infrastructure, the overall prospects for development of the aquaculture industry at Esperance and in the Recherche Archipelago are good. There are adequate water, infrastructure and labour resources to support the development of the industry for the foreseeable future. Power supply and cost, and suitably located land are likely to be initial concerns.

Concerns about the potential impact of urban development and processes on the quality of marine water and groundwater needed for use by food producing industries, including both

aquaculture and wild fisheries operating in inshore waters, are capable of resolution through strict planning and administrative control; and research and monitoring.

Land supply and land cost for aquaculture may become a limiting factor in the foreseeable future. At present, adequate appropriately zoned land is available at reasonable cost. The most prospective land for aquaculture in or near Esperance is where suitable zoned land occurs over saline groundwater aquifers or adjacent to the coast. Careful site selection would be necessary to ensure water supply, waste water disposal, services and operational space can be achieved at reasonable cost.

Community Consultation

Prior to the commencement of this study, Fisheries Western Australia had put forward a proposal to farm Southern Bluefin Tuna in Esperance Bay, which was subsequently withdrawn. Because of the controversy surrounding tuna farming, many of the consultations tended to dwell on that proposal. Many people saw a clear distinction between tuna farming, perceived as a dirty industry, and other forms of marine aquaculture or sea cage culture, even though they often have many environmental and management problems in common. Land based aquaculture was generally supported, but perhaps because of the tuna debate, there was little awareness of the benefits, or the very real environmental problems that can confront, or be caused by, those forms of aquaculture.

Community Attitudes to Aquaculture

Most of the Esperance community who were consulted, supported the development of an aquaculture industry in their region. They believe that aquaculture, particularly land-based projects, present little or no threat to the natural environment and will add to the town's social and economic base. Some agreed that the development of techniques to culture a range of popular fish species could reduce pressure on existing fish stocks.

Opinion was more divided on large scale cage farming and many saw a distinction between this and tuna farming, which was perceived by many as a problem industry.

The majority of people consulted considered that tuna farming was a high value industry which would benefit Esperance and the region, provided environmental problems could be resolved and adequate controls were in place. Others considered the perceived benefits were over stated. They were also sceptical as to whether the benefits would remain in Esperance if a non local operator developed the industry.

There were suggestions that other high value industries, such as tourism and the commercial fisheries, could be adversely affected by tuna farming, and that an economic impact study or cost benefit analysis would assist community consideration of the proposals.

The major issues raised during the community consultation included:

- The perceived economic and employment benefits of aquaculture;
- The potential negative impacts aquaculture could have on the marine environment;
- Perception of sharks and pollution from tuna farms and their effect on other Recherche Archipelago values, in particular recreational diving and Tourism;

- The pilchard deaths and the lack of knowledge as to the cause;
- Entanglements and seal interactions with cages;
- The need for open communication between all parties regarding the development of aquaculture proposals in Esperance.

Nearly every person consulted drew an analogy with the iron ore export facility in Esperance which had originally been proposed as an open loader with attendant dust problems. Community pressure saw the loader contained within a negative pressure shed and it is regarded as a good environmental outcome, which preserved the clean green image on which tourism and many of the industries in the town depend.

The message for aquaculture is that the people of Esperance are prepared to have new industry, but on their terms and only in an environmentally sustainable way.

Draft User Profile of the Recherche Archipelago and Adjacent Coast

One of the objects of the study brief was to "Identify and map other marine uses in the Recherche Archipelago and their potential to constrain future development of aquaculture." Early in the course of the study the Recherche Archipelago Consultative Group advised Fisheries Western Australia of the need to develop a user profile of the Recherche Archipelago as a first step toward management planning of the area. Because of the similar objective of the study it was decided that the consultants should work with the RACG to develop the initial draft profile.

The associated report *Draft User Profile of the Recherche Archipelago and Adjacent Coast* was an initial draft intended to provide feedback and be discussed with the RACG and other contributors in Esperance, to enable addition, refinement and correction of the data and maps presented. This document formed the basis of a second meeting with the RACG in Esperance to provide feedback and verify some of the information and data presented. Included in the User Profile are eleven charts of the main areas of interest to user groups, which have been prepared in Arc View GIS format to be used as constraints mapping for aquaculture planning.

Species with Potential for Aquaculture at the Recherche Archipelago

The species considered most prospective and potentially suitable for the Recherche Archipelago and the hinterland in the short term are:

- **Abalone**
  - Geenlip Abalone *Haliotis laevigata;*
  - Brownlip Abalone *H.conicopora;*
  - Roe's Abalone *H.roei.*

In addition to the economic advantages and environmental considerations, abalone represents an ideal species for Esperance as it could complement the existing fishery and may provide opportunities for local investment. Both land based and offshore growout should be piloted before large investment is made in hatcheries. Offshore growout should be trialled in barrel and seabed cage culture.

- **Southern Bluefin Tuna** (*Thunnus maccoyii*).

While there has been a high degree of community concern relating to the proposal to farm Southern Bluefin Tuna at Esperance, the species could develop into a highly valued industry sector if the environmental and community aspects were resolved. Given that proponents, for any cage culture, will have to carry out a high level of site assessment and develop a comprehensive monitoring plan, this project could be considered at appropriate sites. Grow-out would need to be undertaken with an increasing proportion of artificial diet and a phasing out of feedlotting if and when hatchery reared juveniles are available.

- **Seaweeds**

The market for edible seaweeds represents a significant percentage of world aquaculture production. An economic analysis of the potential for seaweeds production at Esperance would need to be undertaken prior to any development. While commercial food production is a priority, suitable species may also be used as filtration beds on shore and as nutrient stripping bands in integrated offshore systems. Various species may be suitable, for example:

- *Laminaria spp.;*
- *Porphyra spp.;*
- *Gracilaria spp.*

- **Ocean Trout** (*Onchorynchus mykiss* and *Salmo trutta*)

Both Fisheries Western Australia and Agriculture WA have been investigating the potential to trial a number of species including trout in inland saline waters. The potential to commercially grow out trout in sea cages is thought to be less than with inland saline ponds (J Trendall Pers com. 1998). Until conclusive results from inland trials are received, with respect to volume and qualities attainable, consideration could be given to trial grow-out offshore at the Recherche Archipelago.

- **Red snapper** (Bight Redfish *Centroberyx sp.* Possibly *Centroberyx gerrardi*)

Given the existing recreation and wild capture industry for this species, there may be an opportunity to complement fishing effort by culturing this species. Although the life cycle has not been closed, culturing techniques for this fish may be similar to pink snapper.

Several of the commercial fishermen from the region indicated that on the occasions when this species was transported and held live for several days, they did not appear to suffer any real signs of stress. Furthermore when caught even at reasonable depths they did not burst their swim bladders.

This species may provide an opportunity for the local commercial fishing industry to become directly involved in the development of aquaculture in the Recherche Archipelago. The commercial fishing industry has established markets for the fish. Stock enhancement may also be possible in the longer term.

Development of Culture Techniques

The report stresses that before culture techniques are developed for any of the species suggested in the report, through private or government effort, a thorough analysis should be conducted using comprehensive biological and commercial selection criteria. Fisheries Western Australia is currently compiling a candidate species list for this State and this should provide additional background for species selection for the Recherche Archipelago.

Any longer term view for Esperance and the Recherche Archipelago will require the development of a multi-species hatchery in the Bandy Creek Boat Harbour precinct. This might be facilitated through the proposed annexe of the Esperance Community College.

Potentially Suitable Areas for Future Marine and Land Based Aquaculture

At this stage it would be highly speculative to identify particular sites and areas because too little is known about the culture of suitable species for the area.

The most likely candidate species for land based aquaculture grow-out adjacent to the Recherche Archipelago are abalone. While some land may be available to the east of Bandy Creek, proponents should consider the potential environmental risks from groundwater contamination. Given this, the potential to locate land-based grow-out facilities east of Esperance at Duke of Orleans Bay should be considered.

Marine sites that are suitable for aquaculture tend also to be popular with other user groups. Sites which meet the necessary selection criteria are generally to the east of Esperance Bay. The Mart Group contains a number of sites suitable for the culture of finfish in surface cages. The development of submersible seacage technology may enable cage culture to occur in more exposed locations throughout the Archipelago. Many sites throughout the Archipelago should prove suitable for the locating of barrels and bottom cages for abalone grow-out as this form of culturing will have less impact with other user groups in terms of access and amenity.

A bathymetric survey of five potential sea cage areas was undertaken over four days between the 22nd and 25th of January 1999. The survey showed that:

- The Mondrain, York and Tory Islands are not suitable for large scale sea cage aquaculture because of inadequate protection from south east sea conditions and the presence of benthic habitats which may be adversely affected by nutrients and sediment associated with aquaculture. Small scale aquaculture projects may, however, be appropriate, particularly at Tory Island;
- The Remark and Mart Groups appear to have significant potential for large scale sea cage culture.
-

Further work on potential sites is needed, and should be undertaken by proponents and Fisheries Western Australia for both land and sea areas as firm proposals are contemplated.

Prospects for Aquaculture

Perceptions by some members of the Esperance community that aquaculture will adversely affect the Recherche Archipelago stem from the early history of aquaculture activity overseas

and to perceptions of some of the early practices at Port Lincoln. While there is no denying that poorly managed aquaculture practices present a threat to the environment, as does the effect of poorly managed land based farming, there are many instances throughout the world where advances in husbandry and nutrition have greatly reduced any environmental impacts. The current legislative framework which provides the environmental assessment and approval procedures for aquaculture development in Western Australia, is rigorous enough to ensure that proper site selection and farming practices will be sustainable, and not cause any long term negative effects to the Archipelago.

Paradoxically, a greater threat in the Recherche Archipelago may be the one to the potential aquaculture industry from pollution through contamination of groundwater sources and urban development; and the potential for pollution from shipping or accidents.

The successful integration of aquaculture into the environmental, social and economic fabric of Esperance could present a watershed in this Country's short marine farming history. Esperance is a microcosm of the real and perceived issues facing industry development in Australia. An aquaculture industry can not be developed in the Recherche Archipelago unless it has strong support from the Esperance community; and earning that support through serious consultation is the real challenge facing the industry.

Recommendations

It is recommended that Fisheries Western Australia:

1 Provide regular information and undertake ongoing consultations with the Esperance community in relation to aquaculture;

2 In consultation with the Esperance Professional Fishermens Association and the Esperance Chamber of Commerce, sponsor the formation of an Esperance Aquaculture Group to provide a focal point for industry development and community consultation;

3 In consultation with the Department of Conservation and Land Management, sponsor ongoing environmental investigations of the Recherche Archipelago;

4 Support the concept of a cold water marine research facility associated with a tertiary institution in Esperance, should such a proposal emerge;

5 Provide this draft aquaculture plan, and any subsequent research and information, to the Marine Parks and Reserves Authority for use in future planning for marine parks in the Recherche Archipelago;

6 Ensure that appropriate areas and sites for aquaculture are identified in future planning for marine parks in the Recherche Archipelago.

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1 INTRODUCTION

1.1 An Overview of the Aquaculture Industry

Worldwide, the demand for fish and fish products is increasing dramatically due to the increasing population, and the fact that wild capture fisheries are declining, with most at or near their maximum exploitable levels.

According to the Food and Agricultural Organisation of the United Nations (FAO), total production in 1995 was 27.76 million tonnes with a value of US$42.32 billion.

World aquaculture production has consistently increased its contribution of the total world fish harvest since the mid 1980's, when it provided 8.3 percent (7.9 million MT) of the total world fish harvest in 1984 (83.9 million MT). Within a decade aquaculture production had more than doubled to 16.9 percent (18.6 million MT) of the total world fish harvest (109.6 million MT) (FAO 1998).

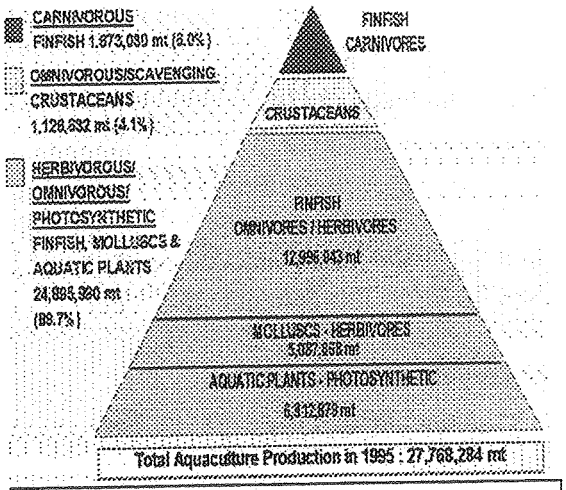


Figure 1 World Aquaculture 1995

These figures are considered conservative given they do not include enhancement of wild fish stocks, such as hatchery releases into the salmon fishery (Anderson and Spatz 1994).

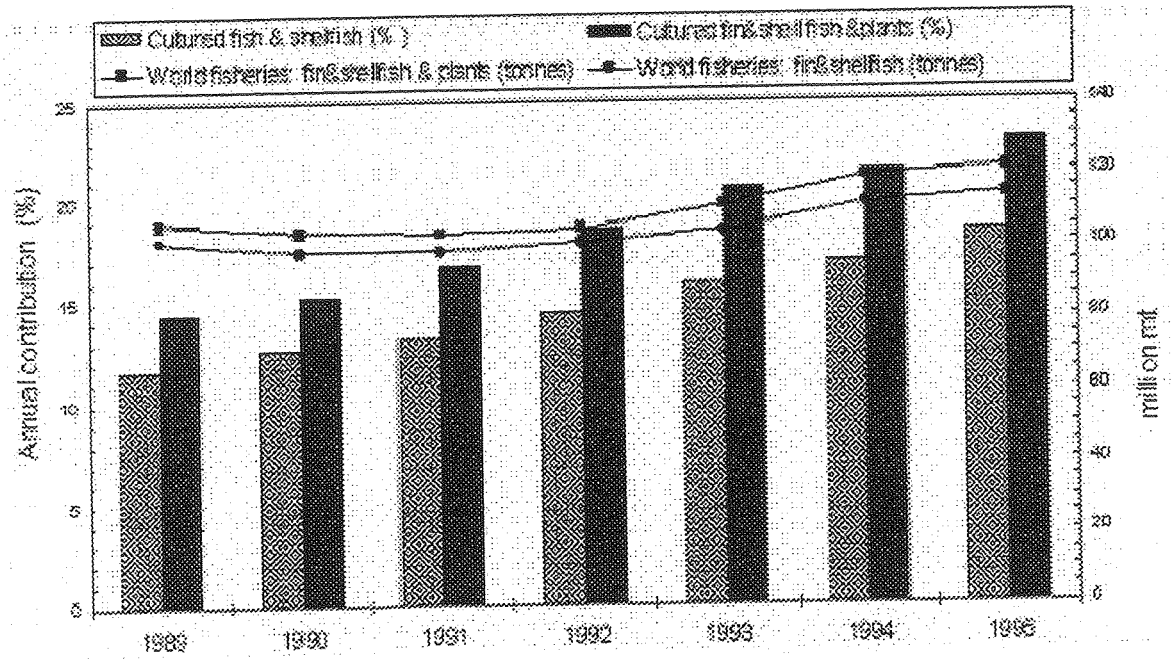


Figure 2 Annual World Aquaculture Production (Source FAO)

1.2 National Overview of the Aquaculture Industry

Australian aquaculture production in 1995 was valued at A$396 million compared to $491 in 1998 representing a 26% contribution to the total national fisheries production. The majority of the increased value in 1997-98 came from an estimated 10% increase ($18m) in the value of pearls, a 76% increase ($31m) in farmed tuna and a 9% increase in the value of farmed salmon (ABARE Australian Fisheries Statistics 1998).

1.3 State Overview of the Aquaculture Industry

Western Australia has an excellent international reputation in agriculture and commercial fishing and as we enter the next century it is from this platform that the State could become a major producer of high quality aquaculture product.

In 1994, the Minister for Fisheries announced funding of $4.5 million over three years for the aquaculture industry. Fisheries Western Australia, as the lead agency, has created an Aquaculture and Pearling Program as part of its core activity. An additional $8 million has been allocated towards future development within this parliamentary term.

There has been significant investment by the State Government for aquaculture development and considerable emphasis placed on creating an appropriate legislative and planning framework for industry development.

The effective regulatory approach by the agency provides the State with a sound base to develop an ecologically sustainable and economically viable aquaculture industry.

Western Australia has some key advantages over many other well established aquaculture industries throughout the world because it:

- Has a pristine ocean and a clean terrestrial environment;
- Provides a wide range of biogeographic zones and therefore species;
- Has a government committed at policy level to the development of aquaculture;
- Can learn from the mistakes and opportunities from others.

Already recognised as a leading producer of the highly prized South Seas Pearl with a pearling industry valued at approximately $200m annually, Western Australia is poised to further establish large scale aquaculture production.

Western Australia is establishing the necessary framework to expand on current aquaculture success and include a range of new species throughout the whole state through a close working relationship between industry and Fisheries Western Australia.

1.4 Aquaculture Industry Development

There is a significant amount of aquaculture activity currently being undertaken throughout Western Australia. Industry groups, Fisheries Western Australia , training institutions, schools and universities are engaging in a variety of projects covering a diverse range of species and culture methods.

While the *Pinctada maxima* pearl oyster remains the most valuable aquaculture product in Western Australia, other species contributing to the State's economy include mussels, microalgae, yabbies, marron, trout, barramundi and oysters.

Current research and development activity includes WA Dhufish, Barramundi, abalone, edible oysters, Pink snapper, Black bream, Silver perch and ornamental fish species.

As WA's peak industry body the Aquaculture Council of Western Australia (ACWA) plays the pivotal role in representing the needs of industry. Comprising ten regional and species associations, ACWA supports associations' activities, creates and implements strategic initiatives and provides a professional voice to all levels of government.

Fisheries Western Australia has developed a planning and approval process that allows for a highly consultative approach, ensuring that all stakeholders in the community have ownership of the development of the emerging industry. The agency has taken the proactive step of providing capital infrastructure, such as the Broome Tropical Aquaculture Park and the Albany Aquaculture Park to assist new players in the industry, as well as providing ongoing technical and policy advice.

1.5 Esperance and the Recherche Archipelago

The waters and hinterland of the Recherche Archipelago near Esperance appear to have significant potential for aquaculture development and interest in the area for aquaculture purposes is increasing. Recent public consultation on aquaculture in the area has raised concerns about the long term expansion of aquaculture activities and the need for coordinated planning.

Fisheries Western Australia has commissioned the preparation of this draft aquaculture plan for the Recherche Archipelago in response to this growing interest. Strategic planning will aim to identify areas within the Archipelago which are technically suitable for future aquaculture activities whilst also identifying other marine values and uses which may constrain these activities.

1.6 Objectives of the Plan

The Plan's objectives are to:

- Identify potentially suitable areas for future marine and land based aquaculture activities in the Recherche Archipelago and adjacent coastal areas;
- Identify potential candidate species for future marine based aquaculture in the Recherche Archipelago and adjacent coastal areas. Discussion of candidate species should include their environmental requirements, economic advantages and their compatibility with each other and the local environment;
- Identify and map other marine uses in the Recherche Archipelago and their potential to constrain future development of aquaculture;
- Identify the possible environmental impacts which might result from aquaculture activities in the Recherche Archipelago and adjacent coastal areas and identify management requirements which may mitigate these impacts;
- Undertake detailed community and stakeholder consultation.

PART A THE ENVIRONMENT

2 PHYSICAL ENVIRONMENT

2.1 Overview of the Recherche Archipelago

The Archipelago of the Recherche was discovered in 1627 by Peter Nuyts in the *Gulden Zeepard*, visited by George Vancouver in *Discovery* in 1791, and was named by Bruni d'Entrecasteaux of the ships *Recherche* and *Esperance*. Initial exploration and remarkably accurate charting of the Recherche Archipelago was undertaken by Matthew Flinders in HMS *Investigator* in 1820.

The Recherche Archipelago extends over 230 km from Figure of Eight Island, west of Esperance, to Spindle Island, off Israelite Bay in the east. It lies between Longitude 121° 30' E and 124° 15' E and comprises about 105 islands and 1500 islets and exposed reefs. The southernmost islands are Termination and Salisbury Islands, which lie about 60 km off the coast, near the edge of the continental shelf.

The islands are all nature reserves and are mostly inaccessible because of their steep dome shaped sides and heavy seas. Only two islands, Sandy Hook and Middle Islands, have beaches with easy access, and one, Woody Island in Esperance Bay, has accommodation and eco-tourism facilities.

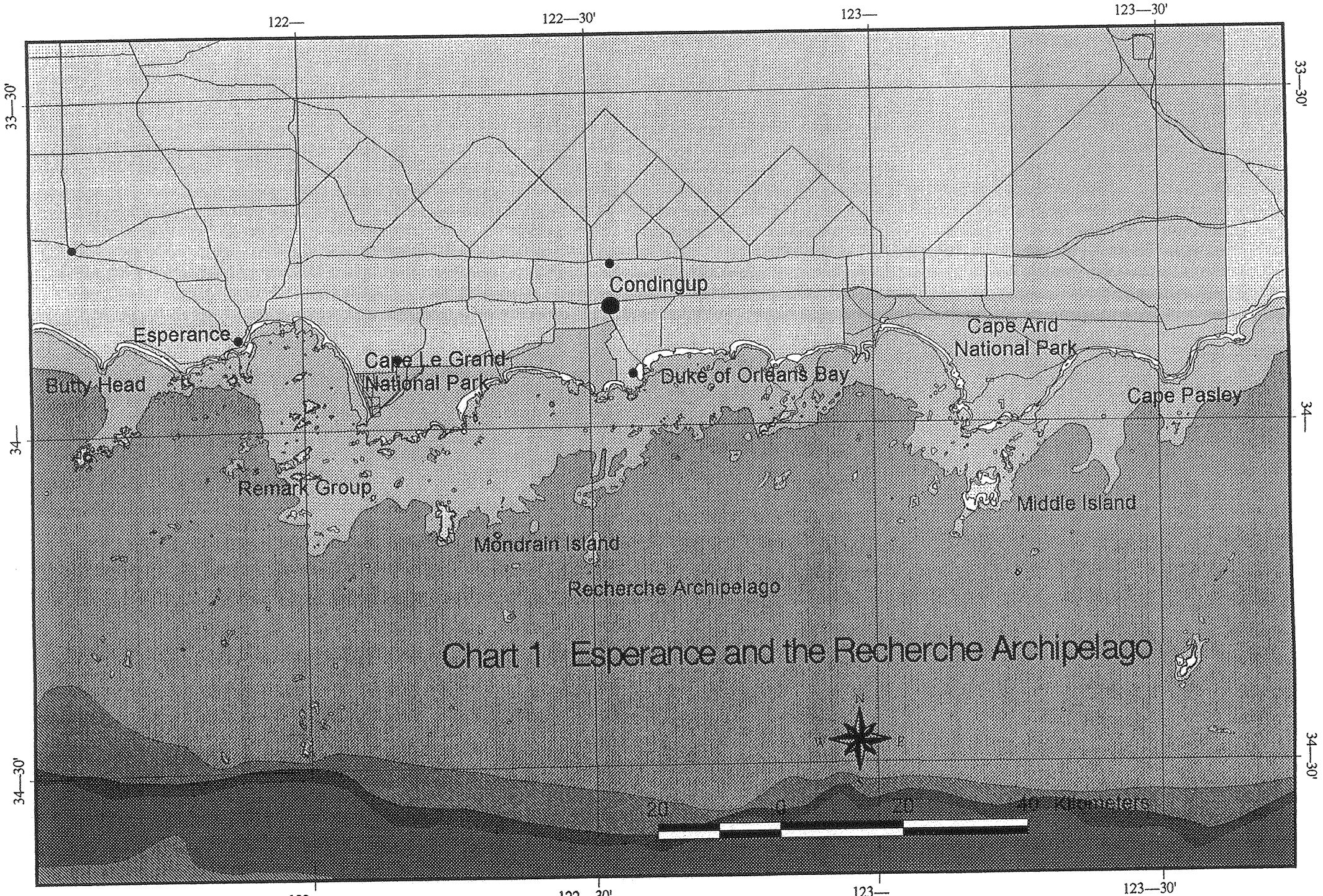
Many of the islands and islets have seabird rookeries as well as haul out and breeding sites of the Australian Sea Lion and New Zealand Fur Seal. The islands have many notable plants, birds, reptiles and mammals and there appears to be a high degree of endemism, although the flora and fauna is not well known.

The coastline of the Recherche Archipelago features numerous pristine beaches, headlands, islands and sheltered bays. It is a rugged, high energy coast, with spectacular white beaches between headlands dominated by dome shaped granite hills and mountains of similar origin to the islands. More than half the coastline is included in the Cape Le Grand and Cape Arid National Parks which contain large tracts of natural bushland. The remainder of the coast comprises a wide belt of vegetated and wind blown dunes backing on to cleared agricultural lands of the Esperance Coastal Plain and Sandplains. Several small creeks and rivers arise in the sandplain and flow to lakes and interdunal lagoons near the coast. Some occasionally flow to the sea.

Significant activities in the Recherche Archipelago include shipping from the Port of Esperance, commercial and recreational fishing, tourism, scenic and charter tours, diving and coastal recreation.

2.2 Climate and Weather

Esperance and the Recherche Archipelago has a Mediterranean type climate with mild to hot very dry summers and cool very marked wet winters. The mean annual rainfall is 623 mm with 50% of rainfall occurring between May and August. Average annual evaporation is about 1600mm and is greatest during the summer months.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Duke of Orleans Bay
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Cape Pasley
Remark Group
Middle Island
Mondrain Island
Recherche Archipelago
Chart 1 Esperance and the Recherche Archipelago
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Average minimum and maximum temperatures in summer range from 16-26°C with a maximum of 35°C in January and February while average winter temperatures from June to August range from 8-17°C, with the minimum being 7°C.

The dominant wind direction in summer is from the SE and afternoon sea breezes occur from October to March. In January and February, over 25% of sea breezes exceed 30 km/h. During winter SW winds frequently prevail and NW storm events occur, with calmer periods between fronts. Periods of calm are few, but may occur in Autumn and Winter.

Appendix 5 contains wind roses provided by the Bureau of Meteorology for 9AM and 3PM for each month of the year.

2.3 Geomorphology

The geology, hydrogeology and geomorphology of the mainland, coast and islands of the Recherche Archipelago is described in *Hydrogeology of the Esperance-Mondrain Island 1:250,000 Sheet* published by the Water and Rivers Commission, (Johnson and Baddock 1998) and in *A Representative Marine Reserve System for Western Australia - Report of the Marine Parks and reserves Selection Working Group* (The Wilson Report) (CALM 1994).

In broad terms, the physiography is characterised by a flat to gently undulating sandplain which rises gradually from sea level. The conspicuous mountains near the coast, together with the islands of the Recherche Archipelago, are composed of granites and gneisses which are remnants of an ancient Proterozoic land surface. Inland, this surface is overlain by the sands, sediments and limestones of the Esperance Coastal Plain and the Esperance Sandplain.

2.4 Water Resources

Several small streams rise in Esperance Sandplain and flow into the Coastal Plain where most end in salt lakes. Bandy Creek has a large catchment but experiences erratic seasonal flow. Elsewhere, rainfall contributes to the substantial groundwater resources of the Esperance Sandplain.

Most of the groundwater in the area is saline and there are several different aquifers, however the ones of most interest to aquaculture occur in the sediments of the Coastal Plain. The coastal dunes are best developed to the west of Esperance and contain significant fresh water resources, some of which are used for the town scheme. Underlying the fresh water in the unconfined aquifer eastward toward Cape Le Grand, and possibly beyond, is saline water that may have potential for aquaculture.

2.5 Bathymetry

Offshore, the sea floor is relatively flat with an average depth of 40 metres. The islands rise steeply from the sea floor and only two, Sandy Hook and Middle Islands, have beaches which permit easy landing. The continental shelf is about 70 kilometres from the coast. The outer islands near the edge of the shelf rise from about 70 metres depth.

Bathymetry coverage for the Recherche Archipelago is available in ArcInfo GIS digital format in the Coastal Resource Atlas maintained by the WA Department of Transport, Coastal

Management Branch. This coverage does not have the same degree of accuracy as the standard charts published by the Australian Hydrographic Service, R.A.N. Many parts of the Recherche Archipelago are shown as "unsurveyed" or "inadequately surveyed" on these charts.

2.6 Oceanography

The Recherche Archipelago is affected by a strong, relatively consistent swell from the south west for most of the year. These swells can be reinforced by wind generated waves, producing a net eastward littoral drift along the south coast.

After rounding Cape Leeuwin in Autumn, the Leeuwin Current flows eastward toward the Great Australian Bight along the outer continental shelf, with the strongest currents being just beyond the shelf break. It is characterised by strong thermal fronts as the tropical water borders cooler Southern Ocean Waters. Between October and March a nearshore current called the Capes Current (Pearce and Pattiaratchi 1997) flows westward along the south coast and northward around the Capes, under the stress of prevailing easterlies. In contrast with the winter situation where the Leeuwin Current is close inshore near Cape Leeuwin, the Leeuwin current swings offshore in summer as the Capes Current penetrates northward against the coast.

Within the Recherche Archipelago, little is known of current movements. Tides are diurnal and the maximum spring tidal range is 1.1 metres. While some tidal currents may be experienced locally between islands or other constrictions, tidal currents are likely to be insignificant compared with those generated by the wind. Current velocities near the sea bed are likely to be significantly lower than at the surface.

Some modelling of waves and currents has been undertaken by the UWA Centre for Water Research in connection with recent proposals by Fisheries Western Australia to establish tuna farming in Esperance Bay (FWA 1998).

The waters of the Recherche Archipelago are known to have low nutrient status, in common with other oceanic waters of the South West of WA, however no records were found. Sea temperatures range from 14°C in winter to 21°C in summer (L. Hudson Pers com). The surface temperature in the Remark Island Group was 19°C on 25th January 1999.

2.7 Planning Implications for Aquaculture

- Sea temperatures are favourable for the growth of many temperate finfish species;
- Strong prevailing winds, swells and storm events in the Recherche Archipelago will require special consideration in the design and location of marine aquaculture structures;
- Currents are mostly wind driven, but with low velocity reducing with depth. Special husbandry techniques will be required to deal with flushing within and around sea cages, particularly during extended calm periods;
- The main limiting factor is the extent to which marine resources can be secured for the industry, and the capability of the inshore marine environments to support marine farming in an environmentally sustainable manner.

3 BIOLOGICAL ENVIRONMENT

3.1 Biological Resources

Most of the biological information on the Recherche Archipelago has been collected during various scientific expeditions to the area, but few comprehensive surveys of the environmental resources have been undertaken. The most recent review and description of natural resources in the Recherche Archipelago is contained in "South Coast Terrestrial and Marine Reserve Integration Study" produced by the Department Conservation and Land Management (CALM 1998).

Several coverages for natural resources in the Recherche Archipelago are available in ArcInfo GIS digital format in the Coastal Resource Atlas maintained by the WA Department of Transport, Coastal Management Branch. They include:

- Bathymetry;
- Sea Bird Breeding Areas;
- New Zealand Fur Seal and Australian Sea Lion Haul out and Breeding Areas;
- Benthic Habitats ;
- National Parks;
- Nature Reserves;
- ANCA and Ramsar Wetland Areas.

3.1 Benthic Habitats

Broad scale mapping and classification of the major benthic habitats of Australia's coastline at a scale of 1:100,000 has been carried out by Dr Hugh Kirkman, CSIRO Division of Marine Research (Kirkman in CALM 1998). The maps were prepared using the blue band or band 1 of the Landsat TM satellite. Digitising of the maps in ArcInfo GIS format was undertaken by the WA Department of Transport, Coastal Management Branch for inclusion in the Coastal Resource Atlas. Ground truthing of the islands in the Recherche Archipelago was undertaken in March 1994, and was done by "bounce" diving, vertical video observation, or grab sampling of benthic material. Currently the ground truth of a particular area is about 80% accurate (Op cit). In the CSIRO mapping, the bottom types are divided into eight categories:

- Dense seagrass;
- Medium seagrass;
- Sparse seagrass;
- Patchy seagrass;
- Bare sand;
- Flat platform or low profile reef;
- heavy limestone reef;
- Granite reef.

Further ground truthing was undertaken near Mondrain Island during a voyage of the STS *Leeuwin* in February 1998, using drop down TV (Colman unpub in CALM 1998).

As part of the present study, the consultants were engaged to undertake a benthic habitat survey of five island groups within the Recherche Archipelago, which had been identified as having some potential for aquaculture, particularly sea cage culture. The aim of the field survey was to provide marine habitat information to support the following objectives:

- Identification of benthic habitat types at potential sea cage sites at the York, Mart, Remark, Tory and Mondrain Islands in the Recherche Archipelago;
- Overlay of plotted transects to provide ground truthing of CSIRO mapping;
- Increase data certainty for a future submission on aquaculture to the Marine Park study;
- Future interpretation of high resolution imagery in collaboration with CALM or CSIRO;
- Future detailed analysis of species and habitats present by Fisheries Western Australia or aquaculture proponents;
- Provide a base line record for each site.

Transect surveys of the benthic marine habitat were undertaken over four days between the 22nd and 25th of January 1999 using underwater video equipment. The benthic habitat survey was recorded at broad habitat level, however the video tape record of the survey contains a wealth of information which could be analysed at a much more detailed level with species identification and further classification of habitats into more relevant groups than the CSIRO mapping which was used for this study. The results of the survey have been reported in a paper entitled *Benthic Habitat Survey of the Remark, Mart, Mondrain, Tory and York Island Groups* (Everall 1999).

3.2 Conservation

The study area contains Cape Le Grand and Cape Arid National Parks. All of the islands of the Recherche Archipelago are nature reserves being part of "A" Class Reserve No. 22796. Woody Island is a "B" Class Reserve.

The same environmental qualities which make the Recherche Archipelago prospective for aquaculture and marine farming are also those which give the nearby offshore waters very high conservation value, such that they are proposed as a multiple purpose marine park to be representative of the temperate marine environments of the South Coast (CALM 1994).

3.3 Planning Implications for Aquaculture

- Many of the islands of the Recherche Archipelago have sea bird breeding areas, seal and sea lion breeding and haul out areas. Marine mammals including whales dolphins and seals occur in the area. These will impose special management techniques on marine aquaculture operations;
- The benthic habitats of the Recherche Archipelago are not well known and detailed survey of the location and function of the benthos, including the infauna of sand areas, will be required before marine aquaculture projects can proceed;
- Land based aquaculture and support facilities are not normally permitted on island nature reserves or coastal National Park lands.

4 SOCIAL ENVIRONMENT

4.1 Planning Context

Esperance had its origins in the pastoral industry in 1863, then as a port for the Goldfields in 1895; but following the successful development of the Esperance Sandplain for agriculture in the fifties and sixties, emerged as a significant centre. It has developed into an established rural coastal town depending on agriculture, tourism, fishing and industry for its economic viability. Industries include grain and cereal growing; wool and fat lambs; beef; cattle; pigs; fishing; fish processing; superphosphate, solar salt and cement works; abattoir; bulk petroleum storage; winery; light industry; tourism; and cottage crafts. It is a significant export port handling iron ore, grain and fertilisers. The town is also assuming a role as a retirement centre for the Goldfields and other areas.

Esperance is an important sub-regional centre of the Goldfields-Esperance Region, located approximately 725 km south east of Perth, with a population of 12,500. Esperance has a district hospital, high and primary schools, and is serviced by sealed road access, goods standard rail and an airport with regular air service to Perth and Albany. Annual population growth has been between 1.3 to 1.4% but is locally expected to reach 3% this year. The economy of Esperance is reliant on farmers for a good year, and local advice is that the town needs an extra two to three thousand people to achieve economic viability (B Thorpe pers com).

The Shire of Esperance has thirteen localities and suburbs. The township of Condingup, 67 km east of Esperance and 18 km from Duke of Orleans Bay, may have significance for future aquaculture development in the east of the Recherche Archipelago by providing for infrastructure and housing.

4.2 Shire of Esperance Local Town Planning Scheme

The Shire of Esperance administers a zoning scheme which covers the whole of its district. The Council has Rural Planning Guidelines which set development standards for development within the rural areas of the Shire. A structure plan for the town is presently being prepared by the Ministry for Planning and the Shire of Esperance because of its identification as a sub-regional centre and its potential for growth. The structure plan for the town is based on a population projection of 20,000-30,000 by 2026 (GHD 1998). There are no specific provisions for aquaculture in the planning scheme and it may be appropriate to amend it to provide for aquaculture as a permitted purpose in the Rural Zone.

4.2.1 Coastal Reserves and Zoning

The coastline of the Recherche Archipelago is very restricted from the point of view of ocean side access for land based aquaculture. The only sections of the coast not included in National Parks are:

- West of Esperance to Butty Head;
- East of Esperance from Bandy Creek Harbour to Cape Le Grand National Park;
- Duke of Orleans Bay East to Cape Arid National Park.

These three sections of coast all have local town planning scheme Parks and Recreation Reserves approximately 4 kilometres wide over the private and public lands involved. The only points at which the reserve is very narrow are;

- Fourth Beach, West of Esperance, Zoned Rural Residential;
- Between Bandy Creek Harbour and Wylie Head in Esperance Bay;
- Immediately east of Duke of Orleans Bay.

Between Bandy Creek Harbour and Wylie Head there is a narrow foreshore Crown Reserve which is reserved for Parks and Recreation. The hinterland is zoned *Harbour*, *Rural* and *Public Purposes (Land Fill Site).*

The effect of the Parks and Recreation Reserve is to limit development that is inconsistent with the purpose of the reserve. While aquaculture development may be possible, scheme rezoning may be required for a particular proposal.

4.3 Land Resources for Aquaculture

4.3.1 Esperance

The Shire of Esperance controls the development of land at Esperance and as a significant land owner, participates in land development. Residential development has increased in the last five years and land prices have risen significantly in response to market factors and the requirement for deep sewerage in new subdivisions.

There is presently a reasonable turnover of urban real estate involving people upgrading homes, people from the Goldfields buying properties for investment, retirement or rental purposes, and retired farmers. It was advised that many retirees who went to Mandurah or Bunbury are returning to Esperance because of the perception of crime and other community issues (B Thorpe pers com).

In the commercial-industrial area, it was reported that there is a shortage of industrial units, complexes and land. New commercial zoning is rare and there are few vacant commercial properties. Those that come onto the market sell straight away if offered at the right price (B Thorpe pers com). General land values off main thoroughfares is about $250,000 per hectare (R Bower pers com). Land is also available for aquaculture purposes in the commercial precinct of the boat harbour.

Rural lands have maintained good value despite recent poor seasons, weather and prices. Near Esperance, there are very few properties with water frontages which are suitable for aquaculture as most have parks and recreation reserve buffer zones or fragile environments. The few waterfront properties available are very valuable because they would be prime residential or tourism sites. Some prime residential land is likely to be redeveloped for tourism in the future (B Thorpe pers com).

A Native Title claim affects much of the land and waters of Esperance and the Recherche Archipelago (Bibliography).

4.3.2 Duke of Orleans Bay

The Duke of Orleans Bay area has great scenic beauty and is a popular tourism and recreation destination. The town site of Wharton at Duke of Orleans Bay is mostly taken up by the existing caravan park. The fishing industry has traditional associations with the area, using the boat ramp for launching, and the anchorage at Nares Island to unload fish onto refrigerated vans to Perth. Council has supported berthing and ramp facilities proposed for the anchorage at Nares Island.

The Duke of Orleans Bay area could have a future role as an access point to aquaculture projects in the eastern parts of the Recherche Archipelago, however it lacks services and infrastructure, particularly, developable land, roads and power, which would be required for industry support or in situ aquaculture development. The present power supply is a single phase supply to the caravan park. Some of the land surrounding the town site may have potential for development, however there are constraints on its availability as it has natural bushland cover and is composed of Crown Reserve for Recreation vested in Esperance Shire Council. Native title may be an issue.

4.3.3 Condingup

The township of Condingup is located 18km north of Wharton (Duke of Orleans Bay) at the junction of Fisheries Road and Duke of Orleans Bay Road. It has a population of about 140, with 40 houses, a primary school, tavern, power, water and other infrastructure. It has some vacant residential, industrial and light industrial zoned land. Industrial land values in Condingup are approximately $20,000 per hectare (R Bower pers com). Condingup appears to have significant potential for staff housing, fabrication, cold storage and other facilities which would be required by a future aquaculture industry operating out of Duke of Orleans Bay; and may be a preferable location to Wharton.

4.4 Water Supplies

The Esperance water supply is managed by the Water Corporation and is based on bore water, treatment and high level storage within the town. The bore water is abstracted by 34 bores to the west of the town, from a coastal aquifer 10m thick, which contains fresh water over a wedge of higher salinity. There are some problems with rising salinity which are being dealt with by seeking alternative sites. There are adequate water supply bores to the west of the town but other groundwater areas are available for future town growth. A bore use survey of special rural and special residential areas is being undertaken by the Water Corporation.

While the overall quality of the towns' water supply is within Australian drinking standards, potential threats exist from industry and rural activity, and urban development. In a report produced by the Water Authority in 1992, *Esperance Water Reserve Protection of Groundwater Quality,* incidents of contamination of eight production wells by the pesticide *Atrazine* was noted on some occasions.

4.4.1 Groundwater and Ocean Water for Aquaculture

The coastal plain contains significant fresh water resources, and the underlying saline water may have potential for aquaculture. Access to this water may be limited because of other demands on the aquifer and the potential for pollution close to developed areas. Pumping oceanic water to land based aquaculture projects is possible, but approval is required to cross foreshore reserves which occur in most areas. Some of these are affected by native title and the claimants' approval will also be required.

While there is no immediate evidence of water pollution in the area, Esperance is a large town reliant upon limited groundwater resources and lacking complete sewerage reticulation, particularly in industrial areas. The waste disposal site uses the landfill method and while no problems have been reported, some of the most prospective land for aquaculture is nearby. Esperance is a significant port with attendant risks of pollution events, spills, and ballast water discharge, even though controls are in place. Aquaculture, as a food producing industry, has an absolute requirement for water which is free from pollution or contamination. It also requires reliability of supply or back up water resources because of its vulnerability to contamination. Equally it is self evident that aquaculture outputs must not contribute to environment or groundwater pollution. Proponents need to carefully examine prospective water supplies and undertake risk assessment procedures for any proposed site.

4.5 Wastewater

Esperance has a reticulated sewage scheme managed by the Water Corporation, which is currently being extended under the sewage infill program. All new development is required to connect to the scheme. Sewage treatment is by primary and secondary oxidation ponds which are situated between Esperance and Castletown. Effluent discharge is to the groundwater, but rising water tables have led to plans for bore recovery for reuse on council playing fields. Local advice is that residential development is being held up by slow expansion of the sewerage scheme (B. Thorpe pers com).

Areas of potential interest to aquaculture are generally not sewered. Neither Bandy Creek Harbour or the light industrial areas in the centre of town which contain the biggest processing plants, are sewered.

There is a long term plan to place a new treatment works at the Council tip, 8km east of town, when the population level so requires. Plans in place will ensure the water supply and wastewater schemes will adequately cater for the town's expansion to at least 2026 (GHD 1998).

Stormwater drainage is disposed of on site, and recharges the groundwater.

4.6 Power Supply

The Esperance Power supply is managed by Western Power and is based on diesel generators supplemented by wind generators. The supply also services rural properties and other townships in the Shire. Nine wind generators of 225kW each, supply about 11-15% of consumption.

The permanent capacity of the power supply is 11.5MW, but demand is expected to be greater than 18 MW by the year 2002. The current nominal demand of 13 MW is growing at 9.5% pa. Demand often exceeds supply and peak demand is met by hired diesel plants (GHD 1998). Because of supply difficulties, the Esperance Port Authority has gone to its own diesel power supply which produces 5 MW. Current use is 3 - 5MW. The power supply is considered to be inadequate and fifteen years past its replacement date.

4.7 Education

There are eight primary, two secondary, one private and two pre-schools in the Shire. Condingup has a primary school with grades 1 through to 7. There are proposals to establish a second high school or senior campus/college in Esperance. These include proposals to establish an open learning community college near the high school in association with Curtin University. It was suggested to the consultants that there was potential in this proposal for the creation of a cold water research facility to assist research in connection with marine park proposals and to provide education training and research for a future aquaculture industry (R Bower pers com).

4.8 Harbour Facilities

Bandy Creek Boat Harbour, 5 km east of Esperance, is a modern harbour precinct for recreational and commercial fishing industry support, seafood handling and processing. The harbour is located within Bandy Creek and flows are controlled by a weir. The harbour entrance across the beach is protected by groynes and maintained to allow entry by larger vessels. The western side has a boat ramp, car and trailer parking, public comfort facilities and the premises of the Esperance Deep Sea Angling Club. The eastern side has commercial fuel, landing and mooring jetties, and a marina with pens, power, slipway and facilities for commercial fishing boats. An additional large slipway and hardstanding area has recently been completed.

Bandy Creek Harbour was designed for a regional purpose, which included the concentration of all the fish processing industries in one area. Because the power supply was insufficient, many industries went to industrial areas near the centre of town (B Sponberg pers com).

Approximately 30 hectares of land zoned "Harbour" is available for commercial fishing industry support, seafood handling and processing. Established facilities include the office of Fisheries Western Australia, seafood freezers and exporters, and fishing company workshops and handling facilities.

The land is currently available on lease from the Department of Transport but is being converted to freehold. Over the next two to three years, this process will include the creation of more lots and upgrading of the power supply which is currently limited.

The area could readily provide for future waterside landing facilities associated with aquaculture and marine farming operations and is appropriately zoned for aquaculture. Part of the land which is vested in the Minister for Transport within the boat harbour precinct could be made available for aquaculture purposes including a hatchery and processing facilities.

4.9 Industry Prospects

The investigations and consultations have indicated that in relation to the availability of infrastructure, the overall prospects for development of the aquaculture industry at Esperance and in the Recherche Archipelago are good. There are adequate water, infrastructure and labour resources to support the development of the industry for the foreseeable future. Power supply and cost, and suitably located land are likely to be initial concerns.

Concerns about the potential impact of urban development and processes on the quality of marine water and groundwater needed for use by food producing industries, including both aquaculture and wild fisheries operating in inshore waters, are capable of resolution through strict planning and administrative control; and research and monitoring.

4.10 Planning Implications for Aquaculture

- Adequate harbour, marine holding areas and onshore facilities are available for reasonable development of the aquaculture industry;
- Esperance Townsite and its surrounding area has ample freehold, Crown and leasehold land which is relatively flat and close to services;
- Esperance has been identified as a major sub-regional centre and the rate of growth of the town can be expected to increase, with the result that land supply and land cost for aquaculture may become a limiting factor in the foreseeable future. At present, adequate appropriately zoned land is available at reasonable cost;
- The most prospective land for aquaculture in or near Esperance is where suitable zoned land occurs over saline groundwater aquifers or adjacent to the coast. Careful site selection would be necessary to ensure water supply, waste water disposal, services and operational space can be achieved at reasonable cost;
- The availability of significant quantities of groundwater in coastal aquifers with salinities from sea water to brackish and fresh, is of potential significance to aquaculture development at Esperance provided it is carefully exploited. It is probable that many aquaculture species could be hatched or grown out in land based facilities using saline or fresh water sources from these sources. Precise quantities of water available and appropriate methods of disposal of waste water from aquaculture sites away from the coast are matters requiring further examination;
- Urban processes and port activities could present a health risk or nutrient enrichment problems to the seafood industries using adjacent waters or groundwater, unless management and monitoring procedures are strictly adhered to by operators and government agencies;
- National Parks, Crown foreshore reserves and the Parks and Recreation Reservation in the Esperance Town planning Scheme, impose restrictions on the development of land based facilities; and access to ocean waters for pumping and disposal of waters used for aquaculture;
- There is a need for the Shire of Esperance Local Town Planning Scheme to be amended to provide for aquaculture as a permitted purpose in the rural zone.

5 COMMUNITY CONSULTATIONS

5.1 Methodology

All of the organisations and individuals listed in the brief were written to and invited to submit a position paper to the study or to meet with the consultants. Consultations in Perth commenced in November 1998 with several meetings with relevant government agencies and representatives of commercial industry associations and recreational fishing and diving organisations. A summary of the issues raised is included as Appendix 2.

Consultations in Esperance were undertaken between the 8th and 15th of December 1998 and involved a series of meetings and individual consultations with Esperance Shire Council, local representatives of Fisheries Western Australia, the Department of Conservation and Land Management, local industries, community organisations and individuals. The purpose of the meetings was to:

- seek initial general comment on the area's prospects for aquaculture;
- understand the community's feeling towards the industry;
- gather information on fishing effort and locations of importance to each activity;
- seek information on planning schemes, services, infrastructure and land availability;
- discuss the future potential and size of the aquaculture industry;
- identify issues of concern.

A paper entitled *An Overview of the Aquaculture Industry In Western Australia* (Appendix 5) was available to assist discussions. During the consultations advice was sought on other persons who may have information for the study, or views which should be taken into consideration. Subsequent meetings were arranged by phone.

A meeting of the Recherche Archipelago Consultative Group, Chaired by Mr Ross Ainsworth MLA, was attended on Monday 14 December 1999. Prior to that meeting as many members as possible were met individually. In total, 53 members of the Esperance community were met personally for their views. A summary of the issues raised is included as Appendix 3. A list of persons, groups and agencies consulted is at Appendix 4.

5.2 Tuna Farming Proposal

Prior to the commencement of this study, Fisheries Western Australia had put forward a proposal to farm Southern Bluefin Tuna in Esperance Bay. Initially the consultants were briefed to concentrate their work on general aquaculture considerations rather than the tuna farming issue, however on withdrawal of the tuna proposal the consultants were asked to include consideration of that issue.

Because of the controversy surrounding tuna farming, many of the consultations tended to dwell on that proposal. Many people saw a clear distinction between tuna farming, perceived as a dirty industry, and other forms of marine aquaculture or sea cage culture, even though they often have many environmental and management problems in common. Land based aquaculture was generally supported, but perhaps because of the tuna debate, there was little

awareness of the benefits, or the environmental problems that can confront, or be caused by, those forms of aquaculture.

5.3 Draft User Profile of the Recherche Archipelago and Adjacent Coast

One of the objects of the study brief was to "Identify and map other marine uses in the Recherche Archipelago and their potential to constrain future development of aquaculture." Early in the course of the study the Recherche Archipelago Consultative Group (RACG) advised Fisheries Western Australia of the need to develop a user profile of the Recherche Archipelago as a first step toward management planning of the area. Because of the similar objective of the study it was decided that the consultants should work with the RACG to develop the initial draft profile.

The associated report *Draft User Profile of the Recherche Archipelago and Adjacent Coast* was an initial draft intended to provide feedback and be discussed with the RACG and other contributors in Esperance, to enable addition, refinement and correction of the data and maps presented. This document formed the basis of a second meeting with the RACG in Esperance to provide feedback and verify the information and data presented.

The profiles presented are largely based on meetings and interviews with informed local people and some reference to published material. The sources of the data are listed in each profile, however the data and their interpretation is the responsibility of the consultants. Use of the data for planning thus has limitations, however it highlights the dearth of information available for planning in the Recherche Archipelago. There is a need for records to be kept of the numbers of participants in the various activities; for example, boat ramp usage, creel surveys, beach surveys and the like.

The activities included in the User Profile include:

- Tourism;
- Recreational Diving;
- Recreational Boating and Fishing;
- Surfcasters;
- Charter Boats and Cruises;
- Commercial Fishing.

5.4 Constraints Mapping

Included in the User Profile are eleven charts of the main areas of interest to the above activities, which have been prepared in Arc View GIS format to be used as constraints mapping for aquaculture planning. These charts cover:

- Tourism, Beach Access and Fishing;
- Major Diving Areas;
- Main Offshore Angling Locations;
- Main Navigation Routes, Anchorages and Wrecks.

The constraints mapping and user profiles will also be useful for marine park planning in the future, particularly if they are further developed by the RACG, Fisheries Western Australia or CALM.

5.5 Information for Planning

During the consultations, many people expressed concern that too little environmental, economic and social information was available to enable aquaculture proposals, particularly tuna farming, to proceed at this time. They considered that a full environmental study and preparation of an overall plan for the Recherche Archipelago, and the proposed Marine Park, should occur before any offshore marine aquaculture proposals were further considered.

The dearth of environmental information on the Recherche Archipelago must be acknowledged, however the situation is not unique to this or other marine areas; it is a problem facing planners and proponents in many of Western Australia's unique environments. The need to proceed with a development in the absence of an overall plan is a common situation which was anticipated and included in the formulation of the Environmental Protection Act. The procedures in the Act are considered adequate to address the problem and put the onus of environmental research, site investigation and management of affects on the proponent and the regulatory authority.

In June 1998, the Environmental Protection Authority released a draft Environmental Protection Policy for State Marine Waters (EPP) which details the way the EPA proposes to manage development within the State's marine waters.

5.6 Community Attitudes to Aquaculture

Most of the Esperance community who were consulted supported the development of an aquaculture industry in their region. They believe that aquaculture, particularly land-based projects, present little or no threat to the natural environment and will add to the town's social and economic base. Some agreed that the development of techniques to culture a range of popular fish species could reduce pressure on existing fish stocks.

Opinion was more divided on large scale cage farming and many saw a distinction between this and tuna farming, which was perceived by many as a problem industry.

The majority of people consulted considered that tuna farming was a high value industry which would benefit Esperance and the region, provided environmental problems could be resolved and adequate controls were in place. Others considered the perceived benefits were over stated. They were also sceptical as to whether the benefits would remain in Esperance if a non-local operator developed the industry.

There were suggestions that other high value industries, such as tourism and the commercial fisheries, could be adversely affected by tuna farming, and that an economic impact study or cost benefit analysis would assist community consideration of the proposals.

The major issues raised during the community consultation included:

- The potential economic and employment benefits of aquaculture;

- The potential negative impacts aquaculture could have on the marine environment;
- Perception of sharks and pollution from tuna farms and their effect on other Recherche Archipelago values, in particular recreational diving and tourism;
- The pilchard deaths and the lack of knowledge as to the cause;
- Entanglements and seal interactions with cages;
- The need for open communication between all parties regarding the development of aquaculture proposals in Esperance.

Nearly every person consulted drew an analogy with the iron ore export facility in Esperance which had originally been proposed as an open loader with attendant dust problems. Community pressure saw the loader contained within a negative pressure shed and it is regarded as a good environmental outcome, which preserved the clean green image on which tourism and many of the industries in the town depend.

The message for aquaculture is that the people of Esperance are prepared to have new industry, but on their terms and only in an environmentally sustainable way.

A summary of consultations with the major stakeholders and user groups in Esperance and the Recherche Archipelago is at Appendix 3. Appendix 4 contains a list of people and organisations consulted.

5.7 Planning Implications for Aquaculture

The following issues arising from the stakeholder consultations have important implications for aquaculture planning:

- Any future aquaculture proposal will need to recognise the value of the Recherche Archipelago in terms of the importance of nature based tourism and conservation values of the area;
- The impact on benthic habitat such as seagrass meadows, coral growth, algal gardens and other substrate should be understood before the siting of sea cages;
- The interaction between birds, seals and sharks should be understood prior to placement of any structures in the waters of the Recherche Archipelago;
- The risk of disease through imported pilchards should be addressed;
- The locating of cages in places which restricts access to boating should be avoided;
- Community consultation is an essential component of aquaculture planning and the development of aquaculture proposals;
- A community based management advisory group may assist in the development and management of the aquaculture industry.

6 CONSTRAINTS TO AQUACULTURE ACTIVITIES

6.1 Overview

One approach to planning for the future development of an industry is to identify any limiting factors which may constrain any of the major components of the industry, and that is the approach adopted in this report. Planning for the aquaculture industry must identify the resources likely to be required so that realistic judgments can be made about the proper provision of appropriately zoned land and waters, community services and infrastructure. Planning must also provide guidance for statutory and policy provision at all levels of government.

An industry has many aspects including technology, production, marketing, transport, infrastructure, and primary land and water resources. Aquaculture marketing, commercial aspects and industry management are being addressed by industry support groups and government at state, national and international levels.

This report will thus address only the local and regional planning context, including infrastructure, water and land resources needed by this environmentally driven industry, with the objective of identifying any limiting factors which may exist. Some comment is provided on the perceived technological constraints and this may be of benefit to prospective proponents of aquaculture at Esperance and the Recherche Archipelago.

6.2 Constraints Mapping

Included in the *Draft User Profile of the Recherche Archipelago and Adjacent Coast* are eleven charts of the main areas of interest to the above activities, which have been prepared in Arc View GIS format to be used as constraints mapping for aquaculture planning. These charts cover:

- Tourism, Beach Access and Fishing;
- Major Diving Areas;
- Main Offshore Angling Locations;
- Main Navigation Routes, Anchorages and Wrecks.

The constraints mapping and user profiles will also be useful for marine park planning in the future, particularly if they are further developed by the RACG, Fisheries Western Australia or CALM.

6.3 Environmental Constraints

The main environmental constraints to the development of aquaculture which were identified in Esperance and the Recherche Archipelago are:

- Any proposal will need to recognise the value of the Recherche Archipelago in terms of the importance of nature based tourism and conservation values of the area;
- The impact on benthic habitat such as seagrass meadows, coral growth, and other substrate should be understood before the siting of aquaculture structures;

- Strong prevailing winds, swells and storm events in the Recherche Archipelago will require special consideration in the design and location of marine aquaculture structures;
- Many of the islands of the Recherche Archipelago have sea bird breeding areas, seal and sea lion breeding and haul out areas. Marine mammals including whales, dolphins and seals occur in the area. These will impose special management requirements on marine aquaculture operations;
- The benthic habitats of the Recherche Archipelago are not well known and detailed survey of the location and function of the benthos, including the infauna of sand areas, will be required before marine aquaculture projects can proceed;
- Land based aquaculture and support facilities are not normally permitted on island nature reserves or coastal National Park lands.

6.4 Social Constraints

6.4.1 Community Support

The process of any industry development is greatly enhanced when a community recognises the socio-economic benefits a healthy aquaculture industry can bring to its region. Conversely, a community which is not supportive of aquaculture can impede the planning progress, command unrealistic environmental restrictions and generally fail to help integrate the industry into the social and economic fabric of the community.

At an early stage, proponents should maintain open and close communications with the Esperance community and hold workshops to explain their project. With Fisheries Western Australia, proponents should ensure the community has a role in the planning process including endorsing the level of assessment and on-going monitoring programs.

6.4.2 Other Social Constraints

- National Parks, Crown foreshore reserves and the Parks and Recreation Reservation in the Esperance Town planning Scheme, impose restrictions on the development of land based facilities; and access to ocean waters for pumping and disposal of waters used for aquaculture;
- The location of aquaculture structures in places which restrict access to boating should be avoided;
- Community consultation is an essential component of aquaculture planning and the development of aquaculture proposals;
- A community based management advisory group may assist in the development and management of the aquaculture industry.

6.5 Infrastructure Constraints

Although there are adequate water, infrastructure and labour resources to support the development of the aquaculture industry for the foreseeable future, securing an adequate power supply at reasonable cost, and locating suitable land, are likely to be initial concerns.

Concerns about the potential impact of urban development and processes on the quality of marine water and groundwater needed for use by food producing industries, including both

aquaculture and wild fisheries operating in inshore waters, are capable of resolution through strict planning and administrative control; and research and monitoring.

- Urban processes and port activities could present a health risk or nutrient enrichment problems to the seafood industries using adjacent waters or groundwater, unless management and monitoring procedures are strictly adhered to by operators and government agencies;
- Great care is required to monitor and protect groundwater resources at Esperance from pollution, overpumping and stormwater because of their potential value to the food production industry;
- Land based aquaculture and marine farming has the potential to cause nutrient enrichment and pollution of inshore waters unless husbandry and monitoring procedures are strictly adhered to by operators and government agencies.

6.6 Industry Constraints

There are a number of constraints facing a proponent who wishes to participate in the development of the aquaculture industry in Western Australia. Many of these will also apply to the Recherche Archipelago. These include technology issues, availability of skilled staff, finance availability, fish health and the management of environmental problems. A summary of these aspects is presented in Appendix 7, as a checklist to assist proponents.

PART B CURRENT MANAGEMENT ARRANGEMENTS

7 MANAGEMENT AUTHORITIES

7.1 Decision Making Authorities

7.1.1 Fisheries Western Australia

Fisheries Western Australia and the Minister for Fisheries as the case may be, determine applications for licences and leases over areas of the Western Australian marine environment to enable the operations of the aquaculture industry. These decisions are made after planning and consultation processes undertaken pursuant to the *Fish Resources Management Act 1994*.

Fisheries Western Australia provides technical support to aquaculture through its regional Aquaculture Development Officers and head office research and advisory services.

Fisheries Western Australia's aquaculture package and *Ministerial Policy Guideline No 8, Assessment of Applications for Authorisations for Aquaculture and Pearling in Coastal Waters of Western Australia* (FWA 1997), provide guidance for proponents.

7.1.2 Shire of Esperance

Under the *Local Government Act 1960*, municipal authorities have the power to make by-laws with respect to matters including planning, health, zoning and land use or environmental controls to the extent that such by-laws are not inconsistent with Commonwealth or State planning.

Proponents wishing to develop aquaculture projects on land will in most cases require development approval from the local authority. Council will be interested in, inter alia, design and siting details, health and amenity, access to water supplies, disposal of wastes and noise generation.

Marine based projects need to be referred to Council for comment and conditions relating to land based support facilities and activities connected to the proposal, particularly the proponent's intentions regarding the disposal of waste and offal.

7.1.2.1 Shire of Esperance Local Town Planning Scheme

The Shire of Esperance administers a zoning scheme which covers the whole of its district. The Council has Rural Planning Guidelines which set development standards for development within the rural areas of the Shire. A structure plan for the town is presently being prepared by the Ministry for Planning and the Shire of Esperance because of its identification as a sub-regional centre and its potential for growth. The structure plan for the town is based on a population projection of 20,000-30,000 by 2026 (GHD 1998). There are no specific provisions for aquaculture in the planning scheme and it may be appropriate to amend it to provide for aquaculture as a permitted purpose in the Rural Zone.

7.1.3 Environmental Protection Authority (EPA)

Pursuant to the *Environmental Protection Act 1986* the EPA has prescribed guidelines for environmental assessment documents and provides advice to the Minister for the Environment on environmental factors relevant to the proposal and any conditions or procedures that should be applied to a proposal.

The EPA has prime responsibility for environmental protection in the State. Proposals that are likely, if implemented, to have a significant effect on the environment must be referred to the EPA for environmental impact assessment. The EPA requires a certain minimum level of information to enable it to determine whether environmental impact assessment is required and at what level it will be set.

7.1.4 Water and Rivers Commission (WRC)

The Water and Rivers Commission has the responsibility for licensing the allocation or abstraction of certain water resources, protecting and securing water resources and the preparation of water allocation plans. The Commission, as manager of WA's inland waters, aims to ensure that various land users do not create an unacceptable impact on the State's water resources. Aquaculture projects are a potential source of significant water draw, and pose the risk of release of sludges, nutrient rich wastes or exotic species into the environment.

The Commission has various powers that may relate to aquaculture projects. These include the licensing of groundwater extraction within certain proclaimed areas, and controls over disturbance to the bed, banks or foreshore of waters in declared management areas.

7.1.5 Department of Transport

The Department of Transport is concerned with the navigational aspects of aquaculture and issues Mooring Licences under the provisions of its Act. Its Coastal Management Branch is the custodian of the WA Coastal Atlas, which is a digital geographic information system (GIS) with much information on the coastal environment in mapped form.

7.1.5.1 Esperance Port Authority

The Esperance Port Authority controls the waters of Esperance Bay and the inner islands within about 15 km of Esperance. Applications affecting that area must be approved by the Authority.

7.2 Other Agencies Involved with Aquaculture Proposals

7.2.1 Department of Environmental Protection (DEP)

The DEP facilitates the preparation of assessment documents in accordance with EPA procedures and is responsible for issuing any approvals or licences pursuant to Part V of the *Environmental Protection Act 1986* following the issue of environmental approval by the Minister for the Environmental pursuant to Part IV of this Act. It also has an advisory and pollution control role of importance to aquaculture.

7.2.2 Western Australian Museum

The Western Australian Museum is responsible for the protection of historic shipwrecks.

7.2.3 Department of Aboriginal Affairs (DAA)

Under the *Aboriginal Heritage Act 1972-1980* the DAA ensures that all heritage issues in relation to a development have been addressed. Where alteration or damage to a site can not be avoided, consent to use the land may be sought under Section 18 of the Act.

7.2.3.1 The *Aboriginal Heritage Act 1972-1980*

All Aboriginal Sites in Western Australia are protected under the provisions of the *Aboriginal Heritage Act 1972-1980*. A register of known sites is maintained by the Aboriginal Affairs Department, however in areas being considered which have not been previously examined an archaeological survey may be required. There are many sites of Aboriginal significance and interest associated with the ocean, coastline and islands, including mythological sites, fish traps, middens and burial areas.

Under Section 18 of the Act, Ministerial consent is required where a development may alter or damage the significance of an Aboriginal site. If a clearance under Section 18 is required, prior to development the proponents may need to undertake ethnographic and anthropological surveys, and other work as advised by the Aboriginal Affairs Department and the WA Museum. The proponent must report to the WA Museum and propose strategies to avoid or mitigate against disturbance of sites if any were found.

Applicants for an aquaculture lease or licence should be aware of potential Aboriginal interests and would well be advised to discuss proposals with any relevant Aboriginal communities in the vicinity of their proposed site during the planning phase.

7.2.3.2 The *Native Title Act 1993*

According to the Federal *Native Title Act 1993*, offshore activities are permissible and valid provided the same procedural rights are observed regarding any native title holders as are acceptable to other persons holding corresponding rights and interests in the area.

7.2.4 Department of Conservation and Land Management (CALM)

The Department of Conservation and Land Management administers the *Conservation and Land Management Act 1984* and the *Wildlife Conservation Act 1950* which give it statutory responsibilities for the protection of flora and fauna throughout the State, including State Waters, as well as management of marine and terrestrial conservation reserves and some other lands. The *Acts Amendment (Marine Reserves) Act 1997* amends the marine reserves provisions of the *Conservation and Land Management Act 1984*, as well as the *Fish Resources Management Act 1994*, and provides a clear statutory regime governing aquaculture in marine conservation reserves. The Department's interests extend to protection of marine flora, fauna and ecosystems outside of reserved waters.

The principal vesting authorities under its legislation are the Marine Parks and Reserves Authority (MPRA) and the National Parks and Nature Conservation Authority (NPNCA).

7.3 Community and Industry Organisations

Community and industry organisations will be of great significance to the development of aquaculture in the Recherche Archipelago, because they can act as contact points for proponents and government for local knowledge and in understanding the requirements of the local community. Relevant organisations include:

- The Recherche Archipelago Consultative Group (RACG);
- Esperance Professional Fishermens Association;
- Esperance Chamber of Commerce;
- Aquaculture Council of Western Australia (ACWA);
- Esperance Regional Recreational Fishing Advisory Committee.

7.4 Future Marine Park Proposals

In June 1994 the report of the Marine Parks and Reserves Selection Working Group - *A Representative Marine Reserve System for Western Australia* (The Wilson Report)(CALM 1994) identified the Recherche Archipelago as an area worthy of consideration for reservation as a marine conservation reserve. The Working Group's recommendations were as follows:

While acknowledging the paucity of information about the marine flora and fauna of the Recherche Archipelago, the Working Group believes that reservation of these waters can be justified on the grounds that habitats are diverse and that added protection would be provided for the Sea Lion, Fur Seal and seabird colonies. Protection of areas for the purposes of recreational diving and development of the commercial dive tour industry can also be justified.

However, with the limited information available, the Working Group was unable to identify parts of the Archipelago which are particularly worthy of reservation. It was concluded that selection of specific areas would be unwise and that reservation of the entire area as a multiple-use marine reserve is warranted. Subsequent surveys in the course of preparation of a management plan would identify areas of particular importance for conservation, recreation and commercial fishing and appropriate zoning would resolve potential conflicts between these activities.

Accordingly the Working Group recommends that:

"the waters of the Recherche Archipelago between Butty Head in the west and Israelite Bay in the east extending to the limit of the State Territorial Sea, including the areas of State waters surrounding the outer islands but excluding the Port of Esperance, should be considered for reservation as a marine reserve for multiple purposes including the conservation of flora and fauna and public recreation."

7.4.1 Marine Park Planning

Recent consideration by the Marine Parks and Reserves Authority of a number of the report's recommendations, including the Recherche Archipelago, has not identified the Archipelago as a current priority, but it is envisaged that marine reserve planning may be initiated for the Archipelago within the next 5-10 years. As multiple use planning for a marine reserve will not be undertaken in the short term, Fisheries Western Australia has recognised the need to undertake planning for aquaculture within the Recherche Archipelago. This planning exercise is thus intended to provide information to input into the marine reserve planning process when it is finally undertaken. Aquaculture, commercial fishing and recreational fishing are considered to be compatible with marine parks through appropriate zoning within the park.

During the consultations Dr Barry Wilson, Chairman of the Marine Parks and Reserves Authority, indicated that it may be possible for planning to be brought forward for the Recherche Archipelago in view of the current interest in aquaculture.

7.4.2 Aquaculture in Marine Conservation Reserves

The requirements for incorporating the needs of the aquaculture industry into the marine reserve planning process are clearly established in the legislation. This will afford substantive protection for aquaculture interests. There is provision for Fisheries Western Australia and stakeholders to be included on advisory committees and be involved in the consultative process for the development of *Conservation and Land Management Act* management plans.

There are management and marketing benefits in quality control for aquaculture, as an environmentally driven industry. These benefits would include a higher level of government involvement in marine research and management than would normally be the case. The maintenance of high water quality and protection from contamination from urban or marine sources is a crucial issue for food production industries.

On the other hand, the industry works to standards set by the Department of Environmental Protection and Fisheries Western Australia, which while being firmly based on ESD principles, are not necessarily based on the same management philosophies as those of a marine conservation reserve. Breeches of standards will inevitably occur in the day to day operations of an industry, and the public perception and reaction to those occurrences may lead to unforeseen repercussions for an industry operating in a marine park.

PART C A STRATEGY FOR AQUACULTURE

8 OBJECTIVES OF THE AQUACULTURE PLAN

8.1 Objectives and Goals

The Plan's objectives as required in the Brief are to:

- Identify potentially suitable areas for future marine and land based aquaculture activities in the Recherche Archipelago and adjacent coastal areas;

- Identify potential candidate species for future marine based aquaculture in the Recherche Archipelago and adjacent coastal areas. Discussion of potential candidate species should include their environmental requirements, economic advantages and their compatibility with each other and the local environment;

- Identify and map other marine uses in the Recherche Archipelago and their potential to constrain future development of aquaculture;

- Identify the possible environmental impacts which might result from aquaculture activities in the Recherche Archipelago and adjacent coastal areas and identify management requirements which may mitigate these impacts;

- Consult widely with the community and stakeholders.

The consultations and investigations have found that Esperance and the Recherche Archipelago have significant potential for the development of aquaculture, but that community concern about tuna farming has tended to adversely impact on the perceptions of other forms of aquaculture which could be most beneficial to the region. Accordingly a further objective is proposed as follows:

- Encourage the development of a vibrant, environmentally sustainable aquaculture industry, that can co-exist with the existing and planned physical, cultural, social and historic values of the Recherche Archipelago.

"Constraints planning" invariably produces a litany of issues and problems which could easily discourage proponents. While there are some significant constraints to aquaculture in the study area, they can be managed without undue cost or difficulty, so the strategy proposed below suggests and examines ways in which aquaculture development can be encouraged.

9 AQUACULTURE SYSTEMS

9.1 General Features

As with conventional farming, aquaculture systems vary in intensity and may be described as ranging from *extensive* through to *intensive* systems. Extensive systems are characterised by having relatively few inputs by the operator.

Extensive culture, for example yabby farming, is characterised by the following features:

- Limited or no feeding;
- Low control over the systems;
- Low energy;
- Low stocking rate;
- Site critical;
- Large areas needed for economic production;
- Low yields.

Intensive Culture, for example sea cage farming, requires far greater inputs by the operator and is intended for maximum yield. The features are:

- Artificial diet;
- High level of management required;
- High energy input;
- High stocking rate;
- Site not as relevant;
- Smaller area required;
- High yields;
- Capital intensive.

Generally, as the degree of management increases so too does the yield, the potential for disease and the need for water quality maintenance. The following descriptions follow the classification of Avault (1996) and are taken from Anderson et al. (1997).

Table 1 Aquaculture Systems

Land Based Aquaculture Systems	
Pond Culture Structures additions discharges	Aquaculture ponds are typically earthen or concrete, and can be natural or artificially lined. Cultured species can be artificially fed or allowed to feed through the natural food chain. The addition of organic and inorganic fertilizers is common in non-fed ponds (Piedrahita and Giovannini, 1991). Circulation and pure oxygen injection are sometimes used to enhance water quality. Paddle wheels or other means of agitation are also used to enhance oxygenation.
Raceways Structures additions discharges	Raceways are long, narrow rectangular tracks or trenches through which water is flushed continuously. They can be constructed of various materials, including plastic, fibreglass, concrete or metal. Water flow can be maintained by flow through pumping, or through artificial means such as recirculation systems with oxygen injection.

Land Based Aquaculture Systems	
Tanks with recirculation systems Structures additions discharges	Land-based recirculation systems often involve metal, plastic, or fiberglass tanks, normally built above ground. The systems are often enclosed in warehouse type structures. Recirculating systems allow greater control of temperature and tend to minimize water use and effluent discharge. Generally, use of these systems requires highly skilled site managers.
Hydroponics Structures additions discharges	Hydroponics is the practice of raising aquatic and terrestrial plants in nutrient-rich water. Fish culture can be integrated with hydroponic systems to grow plants such as tomatoes, lettuce and basil. Fish waste is utilized as the nutrient source for the plants.
Sea Based Culture Systems	
Net-Pen Culture Structures, additions discharges	Net-pen culture involves the culture of species in floating nets that can be secured to the bottom. Submersible cages have been developed to avoid heavy sea conditions.
Sea Ranching No structures no additions no discharges	Sea ranching involves collecting and breeding from adult fish. The offspring are raised in a hatchery until release to the wild. Animals are allowed to grow in the wild, and surviving stock is harvested when it returns to the release site as with salmon, or is harvested in the commercial or recreational fisheries.
Bottom Culture No structures no additions no discharges	Bottom culture includes the culture of oysters and other molluscs on ocean or pond bottoms. Markers are used to set boundaries, but public navigation is not generally restricted
Off Bottom Culture Structures no additions no discharges	Off bottom culture of oysters and other molluscs involves techniques employing longlines floating rafts, strings, and sticks. Applications for the Recherche Archipelago may include the culture of sea weeds adjacent to cages.
Transient Gear Culture Structures additions discharges	Transient gear aquaculture refers to the use of submerged cages for containment of the animal being raised. These cages are movable and marked by buoys similar to those used by the lobster industry. The cages are raised to the surface for maintenance and harvest. This method is used for oysters and scallops.

9.2 Systems Applicable to the Recherche Archipelago

The systems described in the table above are commonly found throughout the world in varying degrees of sophistication and intensity. Given the physical and socio/cultural features of the Recherche Archipelago as described in this report the systems most likely to be suitable for industry development in Esperance are as follows.

9.2.1 Land Based Aquaculture

- Tanks deployed for fingerling production;
- Raceways and tanks deployed with grow-out of abalone and possibly finfish species;
- Pond culture will be limited to areas of suitable soils adjacent to the coast and if soils are lacking, in suitable clay lined ponds.

Recirculating and flow through systems will be necessary for both hatchery and grow-out. The design of the system should take into consideration preventing or minimising any possible effects of waste discharge from the system on the immediate environment.

9.2.2 Sea Based Aquaculture

- Sea cages that can withstand open ocean conditions either anchored to the sea bottom or when technology is fully developed, submersible cages;
- Barrel and bottom cage culture may be utilised for grow-out of abalone;
- Long lines and racks may support culturing seaweed species.

It should be recognised that the design and commissioning of hard infrastructure will require considerable financial investment by the proponents and ideally should be preceded by extensive technical research and review to avoid any costly mistakes.

The following table highlights the advantages and disadvantages between offshore seacages and landbased systems. While the information relates to the culturing of salmon in British Columbia there exists some similarities between the salmon farming industry and the potential industry in the Esperance Region. These include user conflicts, pollutive effects and the need to develop cost effective production systems.

Table 2 Comparison Of Land and Sea Based Systems

System Type	Advantages	Disadvantages
Exposed Offshore Open Marine Systems	Proven commercial viability Avoids/reduces environmental issues associated with near-shore coast (e.g., benthic smothering, potential nutrient loading of inshore waters, predator interactions) Less conflict with competing coastal resource users Potential for many new sites to become available for the industry Higher quality rearing environment, leading to a potentially healthier, higher quality product	Changes required in farming methodologies Investment in new engineering and new capital Changes required in industry corporate focus Potential for navigational conflict Uncertain government policy and regulatory environment Possible redirection of economic benefits associated with processing and services
Land-Based Saltwater Systems	Highly controlled, more optimal rearing environment for culture fish With treatment technology, avoidance of potential deleterious impacts on the marine environment associated with waste discharges Easier, safer working environment Limits or eliminates escapes and interactions with predators	Poor record of economic success – commercial viability doubtful at this time High capital and energy costs Treatment of solid wastes and waste water difficult, although technology is emerging Environmental issues associated with water intake and effluent still evident without recirculation /treatment Highly restrictive siting requirements Conflict with upland property users expected

Source: Environmental Assessment Office (1997)

10 SPECIES SUITABLE FOR AQUACULTURE

10.1 Principles of Species Selection

There are many factors to consider when deciding on which species to culture. This decision making process should begin with the purpose for culturing and progress to include biological and commercial features. A checklist of all the features desirable should then be constructed by the proponent.

The purposes for culturing aquatic organism may include:

- Food production;
- Conservation, for example restocking of black bream;
- Maintenance of wild fisheries, for example seeding of scallops;
- Recreation, termed "put and take fisheries";
- Ornamental fish and plants for the aquarium industry;
- Health foods, for example algae such as *Spirulina*;
- Feed production for aquaculture, for example brine shrimp (*Artemia).*

In order to grow stock out to a market size there has to be the juveniles available at an affordable price. The collection of juveniles from the wild is normally not allowed in Australia therefore brood stock must be available to produce juveniles and so established hatchery techniques are necessary. There are a number of distinct stages in the culture of aquatic species and for technical, biological and business reasons it is important to understand the requirements of each stage (Table 3).

Table 3 Culture Stages of Aquatic Species

Stage	Requirements
1. Spawning	• can occur in the wild • can be controlled in ponds • may be triggered by environmental cues • can be induced hormones injected into fish
2. Egg incubation	• need to provide conditions which maximise survival
3. Juvenile and Larval Rearing	• need to provide suitable conditions • need to provide suitable feed and weaning • minimise mortalities while maximising growth
4. Grow-out to market size	• minimise mortalities while maximising growth. • stocking density important • minimising losses to predation

In addition to assessing culturing techniques, other biological species selection criteria should include those shown in Table 4.

Table 4 Species Selection Criteria

Criteria	Considerations
Stock	Hatchery techniques established or feasible
Stocking density	The cultivated species must be able to grow in relatively high stocking densities. The higher the stocking density at which the fish can be maintained the greater the potential of production.
Behavior	The species being cultured should adapt well to captivity and be relatively easy to capture. Schooling species and those that are not timid are suitable for growing.
Growth	The species being cultured should exhibit a good growth rate and with as little variation as possible. This will reduce the need for grading on a regular basis and prevent the development of dominant stock within the culture system.
Feeding	Species should readily accept an artificial diet. Ease of feeding with artificial diets and the increase in growth rate is essential providing water quality is maintained.
Efficient food conversion	The ability of a species to use an artificial diet efficiently is another essential factor. Feeding costs can be as high as 50% of the total cost of production and therefore efficient utilization of diet will affect profit.
Non cannibalistic	Cannibalism will reduce the survival rate of the species and can cause disease through stress and physical damage. Feeding rates can help alleviate this.
Disease resistant	Some species are more resistant to disease than others. This factor should be considered when choosing a species or strain of species for cultivation.
High meat recovery	Species should have a relatively high meat recovery as a percentage of the total body weight. This becomes very important if the end product is to be processed as it reduces the wastage generated.
Hardiness	The ability to tolerate sub-optimum conditions is desirable in a species. Water quality parameters may change to below those that are considered optimum for short periods of time and the ability to tolerate this is desirable.
Market	A species must have a high market acceptance. The more marketable a species is, the greater the chance of establishing a consistent supply agreement with a wholesaler.

10.2 Candidate Aquaculture Species for the Recherche Archipelago

Table 5 below provides a subjective view of candidate species for the Recherche Archipelago. The decisions to include these species were based on a combination of:

- market potential;
- known culturing techniques (and all the associated considerations with this);
- level of technology required to culture new species;
- any existing (or planned) sources for fry or fingerlings from within the region;
- suitability with the culture systems predicted for the Recherche.

Table 5 Candidate Aquaculture Species for the Recherche Archipelago

Common Name	Species name	Technology required (a)	Aquaculture potential (b)	Status (c)	Culture method	States cultured
Abalone	*Haliotis* spp.	Medium	High	Cultured Fishery	Land based Sea cage	WA SA
Mussels	*Mytilus edulis*	Low	High	Cultured	Sea lines	WA SA VIC
Scallops	*Amusium* spp.	High	Medium	Cultured Fishery	Sea lines Racks	
Oysters	*Saccostrea* spp. *Ostrea* spp.	High High	High High	Cultured	Racks	WA NSW VIC SA TAS
Yabby	*Cherax albidus*	Low	High	Cultured Fishery	Land based dams	WA NSW VIC SA
Marron	*Cherax tenuimanus*	Low	High	Cultured Fishery	Ponds	WA NSW SA
Cobbler	*Cnidoglandis macrocephalus*	Medium	Medium	Developing culture Fishery	Sea cage Land based	
Dhufish	*Glaucosoma hebraicum*	High	High	Developing Fishery	Tank/cage	WA
Whiting	*Sillago* spp	Medium	Medium	Culture of similar species	Sea cage Land based	
Tailor	*Pomatomus saltator*	High	Medium	Fishery	Sea cage Land based	
Trevally	*Pseudocaranx* spp.	High	Medium	Developing	Sea cage Land based	
Yellowtail Kingfish	*Seriola* spp.	High	High	Culture of similar species	Sea cage Land based	
Black bream	*Acanthopagrus butcheri*	High	Medium	Cultured	Sea cage Land based	WA
Tarwhine	*Rhabdosargus sarba*	High	Medium	Cultured	Sea cage Land based	WA
Pink snapper	*Pagrus auratus*	High	High	Cultured	Sea cage Land based	WA

Common Name	Species name	Technology required (a)	Aquaculture potential (b)	Status (c)	Culture method	States cultured
Red Snapper (Bight Redfish)	*Centroberyx spp. (Centroberyx gerrardi* ?)	High	Medium	Culture of similar species	Sea cage Land based	
Mulloway	*Argyrosomus hololepidotus*	High	Medium	Developing	Sea cage Land based	
Sea mullet	*Mugil cephalus*	High	Medium	Cultured	Sea cage Land based	
Southern Bluefin Tuna	*Thunnus maccoyii*	High	High	Grow out	Sea cage	SA
Silver perch	*Bidyanus bidyanus*	Medium	High	Cultured	Pond	WA
Salmon	*Onchorynchus* spp.	Medium	High	Cultured	Sea cage Land based	TAS
Trout	*Onchorynchus mykiss Salmo trutta*	Medium	High	Cultured	Sea cage Land based	WA NSW VIC SA TAS
Flounder	*Pseudorhombus* spp	High	High	Developing	Sea cage Land based	
Marine aquarium spp		Medium	High	Several species cultured	Tanks	
Harlequin Fish	*Othos dentex*	High	Low		Sea cage Land based	
Blue groper	*Achoerodus viridis*	High	Low		Sea cage Land based	
Seaweeds	*Laminaria spp Porphyra spp Gracilaria spp*	low	medium	Cultured elsewhere	Sea based	
Other Algae	*Various species i.e Spirulina*	Medium	High	Cultured	Sea lines Tanks ponds	SA WA

Explanatory Notes:

a) Technology required refers to the general level of infrastructure, equipment, food requirements and technical expertise required to culture the species. The marine finfish species are generally ranked higher as they require intensive and complex operations including the production of live foods.

b) The priority rankings high, medium and low are based on a combination of market factors, understanding culture method, nutritional requirements and environmental considerations.

c) This refers to the culture status of the species. In some cases a species will have developed culture technologies and be part of a commercial fishery, such as pink snapper or abalone.

10.3 Species with Potential for the Recherche Archipelago

The brief required the consultants to identify candidate species for future marine based aquaculture in the Recherche Archipelago and adjacent coastal areas.

Given the above considerations, the species considered most prospective and potentially suitable for the Recherche Archipelago and the hinterland in the short term are:

- **Abalone**
  - Geenlip Abalone *Haliotis laevigata;*
  - Brownlip Abalone *H.conicopora;*
  - Roe's Abalone *H.roei.*

There has been considerable interest shown in culturing abalone in Western Australia and this is reflected in an increased level of investment by Fisheries Western Australia. This commitment includes the commissioning of an Aquaculture Park in Albany, recruitment of staff with abalone culturing expertise, generic mapping of potential land based sites along the Western Australian coastline, and the development of an Abalone Policy Guideline (FWA 1997).

Abalone is a high value species with developed culture techniques throughout the world and in the last ten years in Tasmania, South Australia and more recently in Western Australia.

Abalone may be grown out in land based flow through or recirculating systems or in barrels and bottom cages offshore. While land based systems will need to monitor outflow water qualities generally the effects of abalone culture is benign. Opportunities exist for the integration of seaweed species to be used as filtration systems in land based projects.

In addition to the economic advantages and environmental considerations, abalone represents an ideal species for Esperance as it could complement the existing fishery and may provide opportunities for local investment. Both land based and offshore growout should be piloted before large investment is made in hatcheries. Offshore growout should be trialled in barrel and seabed cage culture.

It is suggested that spat could be sourced from any existing operators in accordance with the *Abalone Aquaculture Management Policy* (in preparation). Both land based and offshore grow-out should be piloted before large investment is made in hatcheries. Offshore grow-out should be trialled in barrel and seabed cage culture.

- **Southern Bluefin Tuna** (*Thunnus maccoyii*)

While there has been a high degree of degree of community concern relating to the proposal to farm Southern Bluefin Tuna at Esperance, the species could develop into a highly valued industry sector if the environmental and community aspects were resolved. Given that proponents, for any cage culture, will have to carry out a high level of site assessment and develop a comprehensive monitoring plan, this project could be considered at appropriate sites. If culturing techniques for this species can be developed, Esperance with its pristine environment, could provide a clearing house for top end markets. There may also be the potential for the development of integrated offshore farming systems culturing seaweed species adjacent to cages.

Grow-out would need to be undertaken with an increasing proportion of artificial diet and a phasing out of feedlotting if and when hatchery reared juveniles are available.

- **Seaweeds**

The market for edible seaweeds represents a significant percentage of world aquaculture production. An economic analysis of the potential for seaweeds production at Esperance would need to be undertaken prior to any development. While commercial food production is a priority, suitable species may also be used as filtration beds on shore and as nutrient stripping bands in integrated offshore systems. Various species may be suitable, for example:

  - *Laminaria spp.;*
  - *Porphyra spp.;*
  - *Gracilaria spp.*

- **Ocean Trout** (*Onchorynchus mykiss* and *Salmo trutta*)

Both Fisheries Western Australia and Agriculture WA have been investigating the potential to trial a number of species including trout in inland saline waters. The potential to commercially grow out trout in sea cages is thought to be less than with inland saline ponds (J Trendall pers com 1998). Until conclusive results from inland trials are received, with respect to volume and qualities attainable, consideration should be given to trial grow-out offshore at the Recherche Archipelago. Fingerlings could be acclimatised to salt water at the proposed Community College Training Research and Development Centre or in a building with access to good quality ocean water. Grow-out trials conducted in offshore cage should be carried out to compare quality and costs with proposed inland saline trials.

- **Red snapper** (Bight Redfish *Centroberyx sp.*, possibly *Centroberyx gerrardi*)

This popular local fish was suggested as a potential candidate for aquaculture during the consultations in Esperance (W Kent pers com). Given the existing recreation and wild capture industry for this species, there may be an opportunity to complement fishing effort by culturing this species. Although the lifecycle has not been closed, culturing techniques for this fish may be similar to pink snapper, which has been cultured in WA, SA and NSW.

Several of the commercial fishermen from the region indicated that on the occasions when the fish were transported and held live for several days, they did not appear to suffer any real signs of stress. Furthermore when caught even at reasonable depths they did not burst their swim bladders.

This species may provide an opportunity for the local commercial fishing industry to become directly involved in the development of aquaculture in the Recherche Archipelago. The commercial fishing industry has established markets for the fish. Stock enhancement may also be possible in the longer term.

10.4 Development of Culture Techniques

It should be stressed that before culture techniques are developed for any of the species listed in the table, through private or government effort, a thorough analysis should be conducted using comprehensive biological and commercial selection criteria. Fisheries Western Australia is currently compiling a candidate species list for this State and this should provide additional background for species selection for the Recherche Archipelago.

Any longer term view for Esperance and the Recherche Archipelago will require the development of a multi-species hatchery, possibly in the Bandy Creek Boat Harbour precinct. This might be facilitated through the proposed annexe of the Esperance Community College.

11 AREAS SUITABLE FOR FUTURE AQUACULTURE ACTIVITIES

11.1 Site Selection

The success of an aquaculture project is dependent on many things, but one of the most important factors is the selection of a suitable site. The following is a brief view of the important factors that need to be considered when selecting a site.

11.1.1 Land Based Site Selection Criteria

All fishes and crustacea are adapted to live in selected areas and have a preferred natural range based upon the water temperature in that region. It is necessary to consider the temperature variations within a region to determine what species are suitable and how well they will do within that region.

If animals are subjected to extremes of temperature that are not lethal but outside the optimum range for that species the growth and other biological activities may be adversely affected. This will result in a lower productivity for the farmer and a decrease in the profitability of the venture. If the temperature range falls within the optimum range, then this will ensure the maximum growth rate, feeding efficiency and profit for the farmer. It is therefore essential that the species selected for culture is one that will grow efficiently within a given region.

Water

As water is the medium in which the species will be grown, the success of a venture will be determined in part by the supply and quality of the water at the site. A regular abundant supply is essential for the maintenance of healthy stock and this must be available all year round.

In a land based system the amount of water available will determine the type of culture system used and the number and type of ponds allowable. The source of the water can be from several places such as rivers, soaks, springs and bores. The size and location of the farm along with the topography will determine the water source for the venture.

The quality of the water source needs to be determined to ensure the optimum growing conditions for the stock. Poor water quality will result in a reduction in the growth and health of the stock. It must be free of nutrients, pesticides and other chemical contaminants and relatively clear. It needs to be monitored on a regular basis for water quality parameters such as temperature, salinity, dissolved oxygen and pH. Additional site selection factors are set out in Table 6.

Table 6 Land Based Site Selection Criteria

Parameters	Considerations
Water	water quality factors as discussed above
Soil	Ponds are designed to be relatively impervious to water to reduce the water loss due to seepage. To ensure this the pond sides and bottom must have a relatively high concentration of clay to retain the water. Before the construction of a farm begins the soil within the region must be surveyed to assess the clay content and its suitability for pond construction. The soil should also be tested for chemical residues such as pesticides and the pH.
Topography	The topography of the site plays an important role in determining the design of the farm. Sites should ideally be gently sloping and relatively open to take advantage of the natural aeration that will occur with the wind. The topography will determine the types of ponds that are constructed and their orientation.
Surrounding land use	The surrounding land usage may have an impact on the water quality, contamination issues and access to the site.
Legal issues	Land tenure, planning approval, native title
Access	Good access to the site is essential. It is preferred to have a sealed road that will allow truck access so that after a harvest stock can be moved quickly and efficiently.
Capital cost	The cost of the land will determine the type of culture system built and the size of the farm.
Conservation sensitive sites	Attention must be paid to any conservation issues relating to the site. If there are rare or endangered fauna or flora on the site then steps must be taken to prevent the extinction of that species on the site.
Utilities	Access to power, water and sewerage is advantageous in aquaculture. The availability of power and water will greatly reduce the costs of setting up a farm and will allow a farmer to aerate ponds without the need of a generator.
Proximity to market	Ideally a farm should be located in close proximity to a market. This reduces the transportation costs associated with the selling of stock and also reduces the risk of stock spoilage or death during transport.
Land history	The land history will reveal potential chemical contamination such as pesticides and heavy metals. This is extremely important as these may have adverse effects on the stock and may render the stock unsuitable for human consumption or even cause the death of the stock.
Expansion	Provision for the expansion of the farm must be considered during the planning stage. Ideally there should be ample room for the farm to expand as it grows in size.
Predators	Land based systems with outdoor grow-out may need to incorporate bird netting over ponds or tanks. A security system may also be necessary to prevent theft.

11.1.2 Sea Based Site Selection Criteria

Table 7 provides a general overview of the parameters to be considered when choosing an offshore site.

Table 7 Sea Based Site Selection Criteria

Parameters	Shellfish	Finfish
Water depth	For subtidal species minimum depth of 10m with more than 12m preferred	Minimum depth of 12m with more than 20m preferred
Waves	Generally maximum wave heights less than 2m.Wave period should be more than 5 seconds	Generally maximum wave height of 2-3m
Salinity	Salinity levels need to be considered for individual species	
Water Temperatures	Increased growth rates may be achieved where temperatures are at the higher end of the natural range for the species	Water temperatures directly influence physiological processes including growth. Higher end of natural temperature range is advantageous for growth, dependent on the species. Cold water species such as Ocean trout may require production strategies that minimise the impact of warmer water temperatures in summer
Contamination	Sites should not be in downstream proximity to effluent outfalls and heavy metal contaminations and faecal coliform counts should be within set limits	
Nutrient Status of Water	Prefer higher levels of algal biomass, often indicated by the presence of chlorophyll A. This generally occurs where catchment runoff has enriched the water or where up welling of ocean water has carried nutrients from bottom sediments	Not directly significant, however nutrients from other sources should be considered to ensure aquaculture operations monitoring is not influenced by external pollutants such as terrestrial runoff
Algal blooms	Areas with no known history of algal blooms preferred. Known algal bloom areas may be acceptable where there are other benefits (eg high nutrient water) and where blooms are either rare or predictable so that stock can be moved. In the latter case alternative sites would be required	
Currents and Flushing	Within range of 5-50cm per sec advantageous. Greater speeds will require more consideration of mooring	Within range of 5-50cm per sec. Problems in managing equipment at speeds greater than 50cm per second
	Flushing or (water exchange) may be less significant for shellfish compared with intensive finfish farming. Well flushed sites enable adequate oxygen exchange, dispersal of organic sediment outputs and reduce competition for nutrients (eg filter-feeding shellfish). Shellfish are liable to remove nutrients from the water while finfish are liable to add matter to the water over a localised area. For these reasons aquaculture sites should operate well within defined boundaries with adequate separation from high conservation areas.	

Parameters	Shellfish	Finfish
Wind	Areas with some protection from prevailing winds are preferred. Boat access and serviceability is limited where winds (greater than 20-30 knots) over an extended fetch generate unsuitable conditions	
Sea floor	Must not be located over sea grass (and other high value environments) Prefer sandy sea floors. Avoid areas where recovery time for any affected benthos is likely to be slow.	
Access	Areas should be in reasonable proximity to land-based infrastructure. Access is more important for finfish where generally daily operations are required. This is of particular significance to the Recherche given the number of days where sea conditions are not ideal	
Land based infrastructure	For some species (eg mussels) grading and cleaning is generally done at sea. Require port or jetty with loading and unloading facilities, vehicle access and vessel mooring	Generally more land-based infrastructure required than for shellfish. Harvest, grading and processing facilities are generally required close to port with cool store and feed storage. Bandy Creek Harbour should provide this for operations closer to Esperance while Condingup may provide sufficient land for operations out of Duke of Orleans Bay
Visual Impact	Areas should preferably be where visual impact is minimised.	

Source: Environment Conservation Council, Victoria 1998.

11.2 Potentially Suitable Areas for Future Marine and Land Based Aquaculture

One of the objectives of the study brief was to identify potentially suitable areas for future marine and land based aquaculture activities in the Recherche Archipelago and adjacent coastal areas.

At this stage it would be highly speculative to identify particular sites and areas because too little is known about the culture of suitable species for the area. A better approach is to consider the land and sea areas in terms of the constraints that affect them, and have regard for those areas where aquaculture:

- Would not be acceptable, such as in navigation routes, marine conservation reserves or key environmental areas; or on land with incompatible zoning or adjacent uses, or polluted areas;
- Would be unlikely to be approved, such as important community resource areas, tourism and recreation areas with high usage, national park or nature reserves, or important conservation resources.

Other areas could be regarded as potentially available for aquaculture, subject to the necessary investigations and controls discussed elsewhere in this document. The constraints mapping in the accompanying *Draft User Profile of the Recherche Archipelago* indicates the potential constraints to the future development of aquaculture. Further work on potential sites is needed, and should be undertaken by proponents and Fisheries Western Australia for both land and sea areas as firm proposals are contemplated.

11.3 Marine Aquaculture Potential

Part of the study required consultations with regard to the proposal to farm Southern Bluefin Tuna at Esperance and specially at the Frederick, Remark, Long and Sandy Hook Island Group. The objectives included the identification of other potential sites for large scale cage culture, with particular focus on the areas around Duke of Orleans Bay.

Five potential sea cage sites were identified at the York, Mart and Remark Groups and Tory and Mondrain Islands (Chart 2). This was based on consultations with local people and the limited bathymetric and benthic data available.

A bathymetric survey of these areas was undertaken over four days between the 22nd and 25th of January 1999. The aim of the field survey was to provide marine habitat information to support the following objectives:

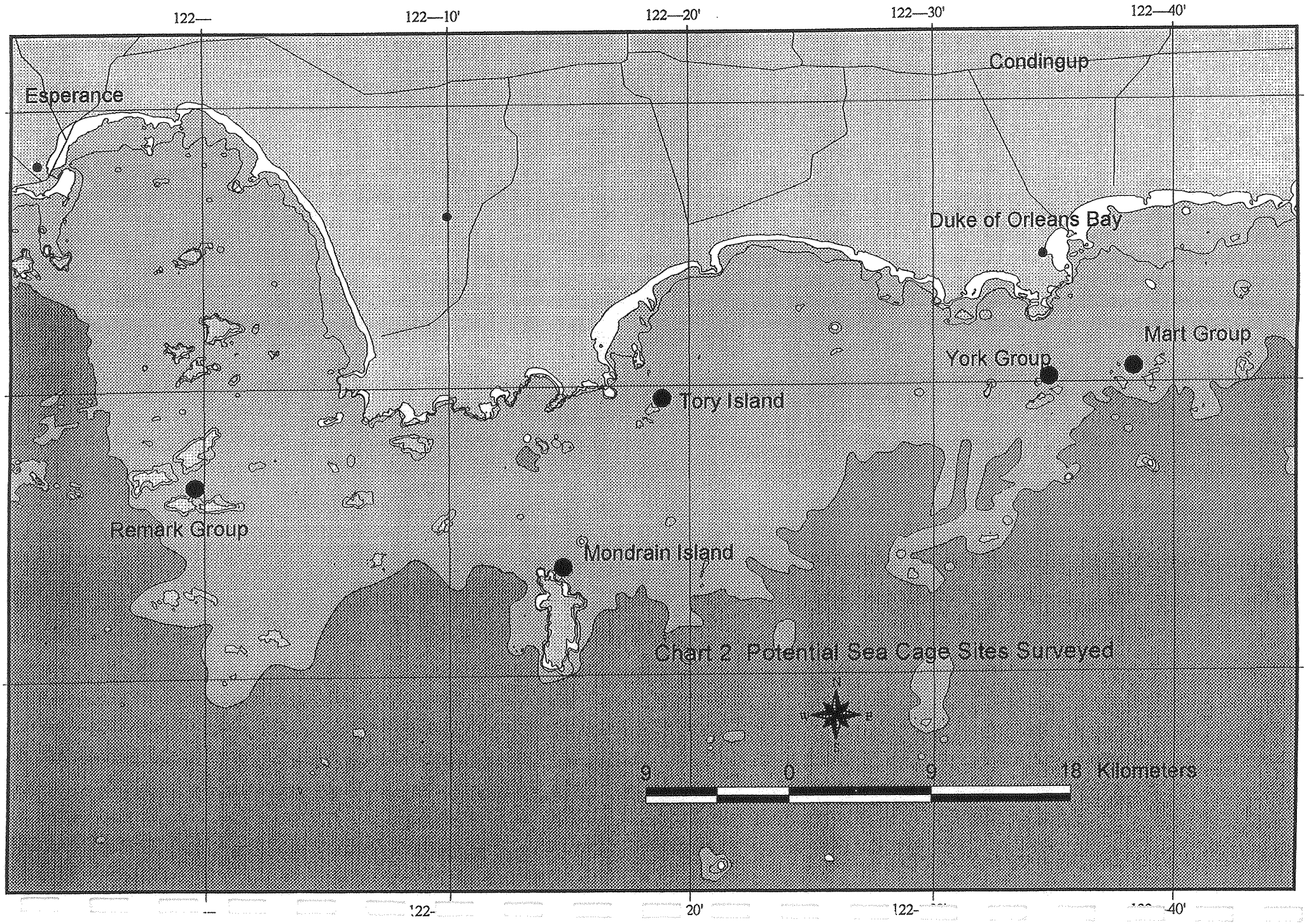
- Identification of benthic habitat types at potential sea cage sites at the York, Mart, Remark, Tory and Mondrain Islands in the Recherche Archipelago;
- Overlay of plotted transects to provide ground truthing of CSIRO mapping;
- Increase data certainty for a future submission on aquaculture to the Marine Park study;
- Future interpretation of high resolution imagery in collaboration with CALM or CSIRO;
- Future detailed analysis of species and habitats present by Fisheries Western Australia or aquaculture proponents;
- Provide a base line record for each site.

The survey showed that, using present technology, the Mondrain, York and Tory Islands are not suitable for large scale sea cage aquaculture because of inadequate protection from south east sea conditions. The York Group has benthic habitats which may be adversely affected by nutrients and sediment associated with aquaculture. Small scale aquaculture projects may, however, be appropriate in more sheltered sites, particularly at Tory Island.

The Remark and Mart Groups appear to have significant potential for large scale sea cage culture.

The Remark Group appears to have superior protection from adverse sea conditions, but is remote from land based facilities. Currents, and habitats identified as "sparse seagrass", require further investigation. Conflict with other users, particularly charter diving, would be expected.

The Mart Group is closer to shore, appears to have a stronger current regime, but may be less protected. Community use of the group is not well known, but the bare sand of the main lagoon appears to have little potential for recreational fishing. Reef and seagrass communities surrounding the lagoon require further study, as do oceanographic aspects.


122—
122—10'
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122—40'
33—50'
34—
34—10'
Esperance
Condingup
Duke of Orleans Bay
Mart Group
York Group
Tory Island
Remark Group
Mondrain Island
Chart 2 Potential Sea Cage Sites Surveyed
9 0 9 18 Kilometers

12 ENVIRONMENTAL MANAGEMENT OF AQUACULTURE

12.1 Ecologically Sustainable Development

The principal criterion for the assessment of areas and sites for marine farming is that they should comply with the principles of ecologically sustainable development (ESD). These principles, embraced by the Government and the Fisheries Western Australia at policy level, are the maintenance of biodiversity, ecological integrity, and equity, both within and between generations. For marine farming this means the avoidance of significant long term environmental change resulting from the activities of the industry, and the establishment of agreed resource sharing principles with the community.

12.1.1 Equity and Resource Sharing

As marine farming involves the use of publicly owned waters and can preclude or affect other uses, equity and resource sharing questions need to be resolved through planning procedures. In the present case this is done at three levels, through:

- consultation with affected groups and individuals as part of this study;
- the formal planning and consultation processes of Fisheries Western Australia and proponents under *Ministerial Guideline No 8*;
- subsequent assessment of applications for marine farming authorisations.

12.1.2 Maintenance of Biodiversity and Ecological Integrity

Many forms of aquaculture have the potential to cause pollution and alter the surrounding environment as a result of metabolic wastes and uneaten food, in the form of particulate matter and dissolved nitrogen and phosphorus compounds, which are plant nutrients. This is particularly so beneath and immediately around high volume finfish sea cages. Currents carrying nutrients or turbidity can also cause downstream effects on marine communities which can be temporary effects such as more lush growth of seaweed; or can lead to permanent change. Seagrass communities have been found to be particularly vulnerable to these effects (DEP 1996) and permanent loss of seagrass meadows is possible. In broad terms, seagrass is susceptible to light reduction due directly to increased turbidity, or indirectly due to nutrient loads causing increased growth of epiphytic algae on the seagrass and thus reducing light to the plants. Seagrass meadows are important in the food chain and as breeding areas for many species. They are a significant component of the benthic communities at the Recherche Archipelago. Their sensitivity to change means that they require protection; also they can be regarded as a predictive ecological tool and used as an indicator of ecological change.

The widespread loss of seagrass communities in Cockburn Sound (DEP 1996) and other places in the world due to nutrient pollution from human activities is of concern. There is a particular community sensitivity to protect seagrass communities, and their loss is not normally considered acceptable.

In practical terms, this means that to comply with ESD principles, areas, zoning and sites for marine farming should be sited to ensure that they do not impact on seagrass meadows, unless

there is a particular scientific reason, such as the measurement of the ecological effects of marine farming, to do so.

12.1.3 Aquaculture Industry Environmental Objectives

In order to maximise returns and in response to increasing opposition from conservation movements the aquaculture industry is continuously seeking new and better ways to improve its operations and achieve higher levels of ecological sustainability. According to Costa Pierce (1997 p103) "Sustainable ecological aquaculture is the development of aquatic farming systems that preserve and enhance the form and functions of the natural environments in which they are situated. It incorporates a shift of the mode of inputs from energy and material subsidies to photosynthetic, waste reuse and natural energy sources to produce net protein gains to society without degradation of natural ecosystems. It is community based, having positive societal impacts not just economic impacts..."

Some of the characteristics of ecologically sustainable aquaculture are that it:

- preserves the form and functions of natural ecosystems;
- derives most of its energy from renewable resources (solar, wind, water, biomass);
- is a net protein producer, relying on waste animal or plant based protein for feed;
- does not produce nutrient or chemical pollution;
- develops a system approach to nutrient recycling and regeneration;
- plans for ecosystem rehabilitation and enhancement;
- is integrated with agriculture;
- does not use chemicals or antibiotics harmful to human or ecosystem health
- uses native or resident species;
- is integrated with communities to maximise job creation in local industries;
- develops enhanced fisheries;
- is a global partner, producing information for the world.

12.2 Environmental Effects of Aquaculture

There are three levels of concern regarding the potential for aquaculture, particularly marine finfish farming in sea cages, to cause pollution at the Recherche Archipelago:

- the effect at or near a site, in terms of accumulation of detritus below cages, changes in sediment oxygen status, and changes in the assemblage of benthic organisms;
- downstream effects on important benthic communities such as seagrass, where the ambient nutrient load is often taken up immediately; and
- the nett input of nutrient into the inshore environment and the time taken to flush and dissipate to the open ocean, including the potential for retention of nutrients in deeper areas with little or no current.

Table 8 depicts other possible effects that aquaculture may have on the environment and summarises the practices carried out in minimising or avoiding the effects of aquaculture on the environment.

Table 8 Aquaculture and the Environment

Problem Area	Nature of Problem	Prevention/
Waste and Nutrient Loadings	Output of solids, N, P, vitamins, minerals, husbandry/disease, chemicals, antibiotics; impacts of waste materials on the adjacent benthos and the water column; on species/community diversity, quality indices	Use high quality feeds and ensure good feeding practices; ie don't overfeed, use appropriate size and nutritionally balanced pellet. Use excess nutrients to grow other crops eg seaweeds Ensure good site selection Minimise use of antibiotics Engage environmental monitoring and abide by water quality standards
Water Exchange	In intensive land based systems, or flushing through freshwater or marine cage or enclosures; quantities required, effects of abstraction, dilution with "low grade" wastes, at concentrations sufficient to diminish measured quality but too low for simple treatment	Ensure good site selection Design recirculating or flow through systems that have sound waste management principles such as filtration and sediment removal
Degradation of Terrestrial Environment	In coastal areas, caused by salinisation of soils, affecting adjacent agricultural practices, coastal fringes; excessive clearances of mangroves and protective cover	Through proper site selection and facility design ensure that there is no physical degradation of surrounding environment.
Escaped Stocks	From damaged systems, or through flooding, damaged or ineffective discharge screens, risks of competition with genetic contamination of local stocks, disease transmission, directly or indirectly reduced biodiversity	Ensure that facilities are maintained at a high standard. Ie Predator nets kept tight, flooding levy banks are clear of debris. Use disease free stocks. Abide by translocation policy ie don't raise non-native stocks. Establish strict hygiene and sanitation procedures
Predation by conservation sensitive species	Causing damage, loss, stress related disease to farmed stocks, requiring controls without compromising conservation interests	To avoid predation (and minimse impacts on farmed stock and conserve fauna)- land based; increase water depth of culture system, bird net ponds, remove dead fish promptly, use visual harassment devices; sea based; keep predator nets tight, remove dead fish and spilt feed promptly, maintain strict hygiene and feeding regimes
Social/amenity disturbance	Visual, noise, activity disruptions	Ensure site selection considers the potential conflicts with other users of the resources

Source: Adapted from Muir (1996)

12.3 Environmental Management

The possible consequences of marine farming and aquaculture mentioned above can be avoided or managed to minimise adverse effects in several ways. These include:

- rotation of sea cages to allow areas to lie fallow;
- research to improve the food conversion ratio (FCR) of feed;
- improvement and automation of feeding to avoid wastage;
- improvement of husbandry techniques;
- towing or aeration of cages at times of low currents or oxygen stress;
- reduction of stocking density in cages;
- relocation of cages where downstream environments of importance become affected;
- seasonal reduction of stocking rates;
- movement of high production units to offshore areas; and
- continuing research and development of husbandry and monitoring techniques.

In order to develop a commercially viable industry while working towards the level of ecological sustainability as outlined above, it will be necessary for relevant agencies and proponents to follow a series of well constructed steps including:

- Categorise the project, for example land or sea based, the type of culture system to be deployed and the species to be cultured;
- Develop an understanding of the effects aquaculture can have on the immediate natural environment;
- Carry out a baseline study of current environmental features to determine the carrying capacity of the sites/system;
- Based on an assessment of the carrying capacity determine what level of environmental impact the project may have;
- Based on an environmental impact assessment source techniques and management practices that can prevent or minimise polluting effects and set these practices in the terms of the proponents licence;
- Develop monitoring guidelines.

While it is true that poorly planned and managed aquaculture projects could have a negative impact on the Recherche Archipelago, there is sufficient consideration within the existing regulatory environment to establish world's best practice at Esperance. The following information examines several of the steps listed above in more detail.

While this report has outlined various opportunities and constraints facing the development of aquaculture in the Recherche Archipelago there must be further work carried out by relevant government agencies, the proponents and in some cases the Esperance community themselves before sites are allocated.

13 OPPORTUNITIES FOR AQUACULTURE IN ESPERANCE

13.1 Land based Aquaculture

As highlighted in Section 10.3, the most likely candidate species for land based aquaculture grow-out adjacent to the Recherche Archipelago are abalone. While land may be available to the east of Bandy Creek, proponents should consider the potential environmental risks from industrial contamination. Should this be found to be a real problem, the potential to locate land-based grow-out facilities east of Esperance at Wharton should be considered.

The proposal to freehold sites at the Bandy Creek Boat Harbour could allow for the development of a multi species hatchery which will be necessary if culturing of marine finfish species is to occur. The use of either ocean intake or saltwater bore systems should take into consideration land based water quality issues such as contamination and ocean intake issues such as water depth, turbidity and storm occurrences.

13.2 Marine Aquaculture

As discussed in this report sites that are suitable for aquaculture tend also to be popular with other user groups. The Remark Group is important to the diving, pilchard and abalone industries. Other sites which appear to meet the necessary selection criteria are generally to the east of Esperance Bay. The Mart Group appears to contains a number of sites suitable for the culture of finfish in surface cages. The development of submersible seacage technology may enable cage culture to occur in more exposed locations throughout the Archipelago.

Many sites throughout the Archipelago should prove suitable for the locating of barrels and bottom cages for abalone grow-out as this form of culturing will have less impact with other user groups in terms of access and amenity.

Opportunities exist for the trialling of integrated offshore farming systems whereby seaweeds and or molluscs are cultured in rafts or longline systems adjacent to sea cages.

13.3 Stock Enhancement

Aquaculture could potentially be used for the enhancement of shellfish and fish stocks, such as abalone. Stock enhancement programs can often gain support from the community, local school programs, volunteer groups, and commercial fishermen. Aquaculture species enhancement is often accompanied by habitat restoration. For example, a successful habitat restoration program in Connecticut in the United States has helped increase the state's oyster harvest. Between 1987 and 1993, $4.8 million was raised to restore 3,000 acres of seed beds with clean oyster shell cultch (Bush and Anderson 1993).

The State purchases the spat, but the fishermen provide the labour and equipment at no cost. As a result of such programs, the oyster harvest in Connecticut has grown from 30,000 bushels in 1960 to 654,800 bushels in 1993, with a farm gate value of $32.1 million (Blake 1994).

Aquaculture may be used to restore stocks of fish and shellfish destroyed as a result of an oil spill, or other marine/coastal damage, or by overfishing. Environmental damage mitigation may be accomplished through stocking of full-grown adults or juvenile animals, and may accompany habitat restoration techniques discussed above. Such damage mitigation potential may be of significant value to the Recherche Archipelago, as the high traffic nature leaves the coastline vulnerable to damage from oil spills and other man made disasters. The recent chemical spill at Belmont Racetrack caused massive fish kills in the Swan River and aquaculture techniques have been deployed to rear 300,000 fingerlings for release into the river.

13.4 Support Industries

The availability of aquaculture-related opportunities in Esperance will depend on several factors, including:

- the demand for aquaculture products;
- the ability to identify and produce products in high demand;
- the capacity of aquaculture to coordinate with existing uses of the region's land and water resources in particular the commercial fishing sector;
- the existence of programs that promote aquaculture in the state and the existing regulatory environment.

Given a supportive regulatory and economic environment and the community, opportunities related to aquaculture in Esperance may include the following:

- Direct supply of aquaculture food products;
- Production of equipment used by local, regional and interstate aquaculture operations;
- Enhancement of wild stocks of fish and shellfish (including tuna);
- Mitigation of disasters that impact upon wild stocks of fish and/or shellfish;
- Supply of expertise/education to potential aquaculture producers.

Each of these opportunities offers potential benefit to the state economy, and employment for residents. The following sections discuss these opportunities as they apply to Esperance.

13.5 Demand for Aquaculture Products

Recent studies of seafood demand and consumer seafood perceptions suggest that demand for seafood products, in general, and aquaculture products, specifically, will continue to increase. For example, Parker (1995) estimates that global seafood demand will increase by more than 60 percent over the next 30 years. Aquaculture techniques allow producers to tailor the characteristics of a product to meet consumer demand or expectations such as consistent quality and continuity of supply.

13.6 Production of Potential Aquaculture Technologies and Equipment

Many of the species noted above are best cultured using one or more specific types of technology or production methods. Many species can only be effectively cultured using one method. These technologies include the following:

- Offshore / Coastal Net-Pens;
- Recirculation Raceways and Tank Culture;
- Flow-Through Raceways and Tank Culture;
- Pond Culture;
- Bottom Culture;
- Transient Gear (e.g., temporary, movable cage culture);
- Sea-Ranching;
- Floating Net Pens / Cage Culture;
- Off-Bottom Culture.

These aquaculture systems require operating equipment and supplies, including various types of pumps; fibreglass tanks; sea cages; filtration equipment; electrical equipment and feed for aquaculture species. Currently, few of these products are manufactured in Esperance. The need for aquaculture related industrial supplies and infrastructure offers two potential opportunities to Esperance firms. Firstly, development of an aquaculture industry in Esperance could create business opportunities for those providing aquaculture-related infrastructure and supplies. Secondly, these firms could develop export markets for the products.

Either option would create a source of economic growth and employment in Esperance. Potential opportunities include aquatic equipment design, the supply and/or manufacture of aquaculture equipment, and the distribution of aquaculture products. The following list is indicative of the type of support industries companies currently in Esperance that could potentially accommodate the needs of a developing or existing aquaculture industry:

- Plastic fabrication;
- Haulage;
- Agricultural supplies;
- Banking;
- Employment services;
- Environmental services;
- Air supply;
- Charters;
- Marine supplies;
- Fuel supply;
- Waste removal.

13.7 Opportunities for Aquaculture Related Training, Research and Development

A significant number of institutions in Western Australia offer education and/or research programs related to aquaculture at the vocational and tertiary level. In addition to providing a

range of training courses in fishing and aquaculture, the Fremantle Maritime Centre's Aquaculture Development Unit (a campus of the South Metropolitan College of TAFE) has taken a lead role in the development of several important aquaculture projects in this State including the development of cost effective culturing techniques for the following species:

- Black bream;
- Pink snapper;
- WA Dhufish;
- King george whiting.

Fisheries Western Australia is collaborating with the Fremantle Maritime Centre in several R&D projects and it is becoming evident that the State will benefit greatly from joint venture arrangements between the relevant agencies and institutions. Both the Broome and Albany Aquaculture Parks are also providing opportunities for combining training, research and development for the industry in a number of projects.

Given the pressures on the natural environment from current and potential uses, there is a critical need for relevant agencies, industry groups and the Esperance community to acquire greater and more scientific knowledge of the natural environment and its ability to sustainably accommodate the various user groups for future generations.

It is widely accepted by several agencies that there is dearth of information on the Recherche Archipelago. In addition to developing a sounder knowledge base for the existing industries there is also a need to provide support for the development of new technologies in commercial fishing and the emerging aquaculture industries.

In recognition of these needs, the Esperance Community College wishes to undertake a feasibility study to investigate the establishment of an annexe facility which will specialise in research, training and development across all current and future marine interests within the Recherche Archipelago.

It is hoped that should this facility be established it would continue with the philosophy of providing collaborative arrangements between relevant interested institutions, agencies and the community.

14 PROCEDURES FOR APPLYING FOR AN AQUACULTURE LICENCE

14.1 Application Procedures

The application and consultation procedures for an aquaculture licence are set out in *Ministerial Policy Guideline No 8, Assessment of Applications for Authorisations for Aquaculture and Pearling in Coastal Waters of Western Australia* (FWA 1997). Fisheries Western Australia also has an application pack to assist applicants.

14.2 Pre Application Investigations and Procedures

While this report has outlined various opportunities and constraints facing the development of aquaculture in the Recherche Archipelago there must be further work carried out by relevant government agencies, the proponents and in some cases the Esperance community themselves before sites are allocated.

Proponents should bear in mind that a proposal in a sensitive environmental area such as the Recherche Archipelago may require assessment by the Environmental Protection Authority, and will certainly be the subject of close environmental scrutiny by Fisheries Western Australia.

Broadly speaking, the quality of pre application investigations and procedures will determine the success of an application for an authorisation for aquaculture. Conscientious environmental investigations and community consultations are at least as important as the economic and technical aspects of a business plan, and project budgetting should allow for these aspects.

14.3 Overview of Typical Pre-Application Procedures

In order to determine the most appropriate site for an aquaculture project it is necessary to map features of the area. Aquaculture relevant mapping should show:

1. Physical Characteristics:
- Temperature;
- wind direction and velocity;
- direction and velocity of currents;
- maximum wave height/wave direction;
- velocity overwash zones;
- bathymetry;
- surface water designations;
- mean low water/mean high water;
- barrier beaches;
- shoreline changes.

2. Areas with biological management designation:
- endangered species and critical habitats;
- identifiable nursery areas and haul out sites;
- sea grass;

- plankton density.

3. Cultural features:

- community values;
- importance to Aboriginal people;
- importance to other users.

Following this mapping exercise further survey work and detailed evaluation of factors including carrying capacity of the area should be undertaken. The following flow diagram (Figure 7) depicts the stages and information requirements for modelling and estimation of carrying capacity.

Prior to allocation of sites the proponent should carry out an environmental impact assessment (EIA). This should include:

- video diver survey;
- sediment and infauna analysis (Benthos must be characterised in terms of sediment structure/community structure and basic hydrology);
- water quality sampling;
- hydrographic data collection.

At this point consideration should be given to providing community representatives input and endorsement of the results of the EIA prior to the development of monitoring guidelines. Aquaculture proponents should also consider possible negative effects on the aquaculture operation from:

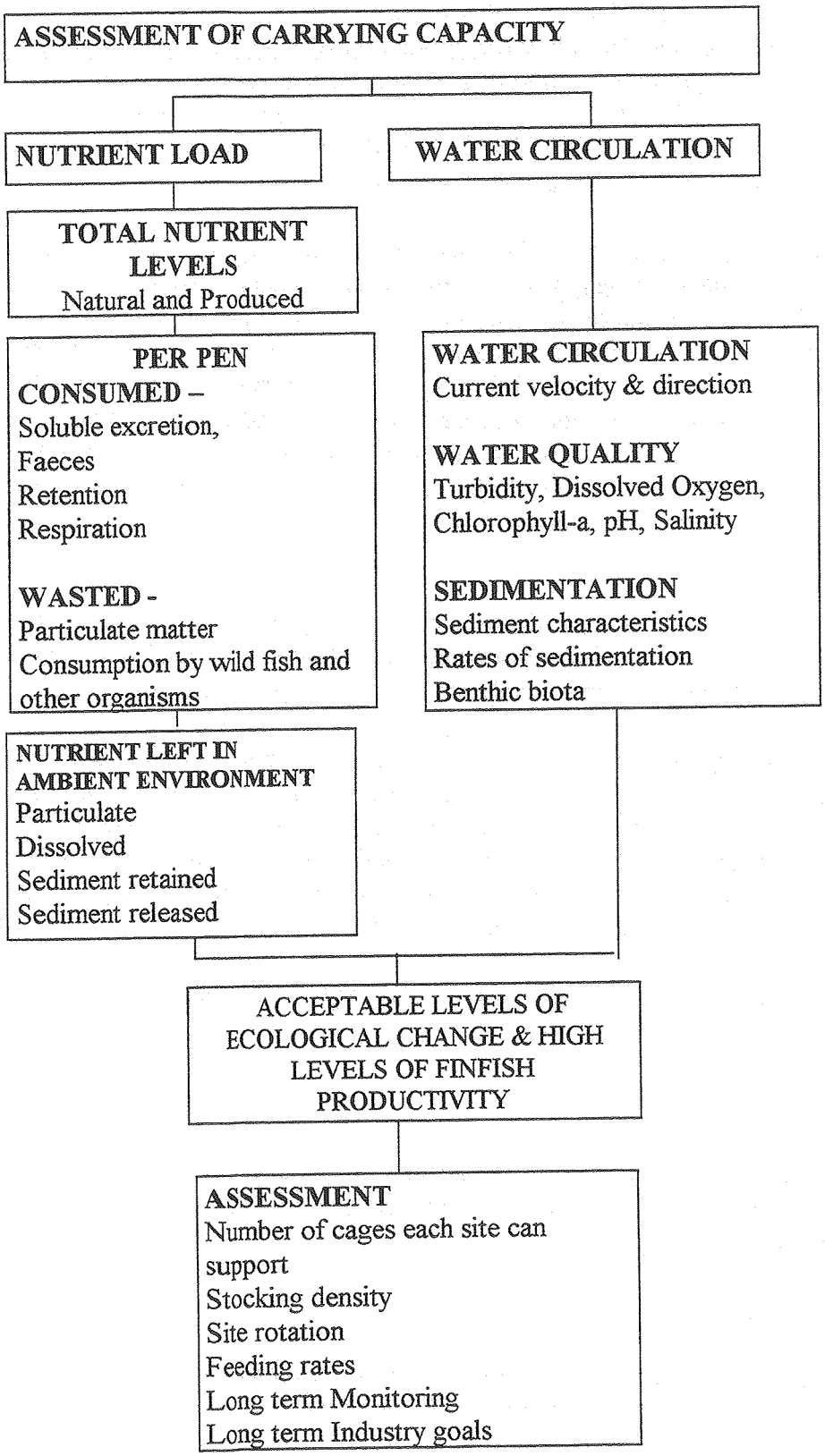
- agricultural runoff;
- commercial fishing;
- recreational fishing;
- diving;
- charter operators;
- commercial shipping;
- port operations (pollution).

14.4 Community Support

The process of any industry development is greatly enhanced when a community recognises the socio-economic benefits a healthy aquaculture industry can bring to its region. Conversely, a community which is not supportive of aquaculture can impede the planning progress, command unrealistic environmental restrictions and generally fail to help integrate the industry into the social and economic fabric of the community. At an early stage, proponents should maintain open and close communications with the Esperance community and hold workshops to explain their project. In accordance with *Ministerial Policy Guideline No 8*, proponents should ensure the community has a role in the planning process including endorsing the level of assessment and on-going monitoring programs.

Figure 5 **Stages And Information Requirements For Modelling And Estimation Of Carrying Capacity**

(Anonymous Source ACWA 1998)



15 PLAN IMPLEMENTATION

15.1 Prospects for Aquaculture

The strong stewardship that the Esperance community displays over the Recherche Archipelago provides an ideal platform to build an ecologically sound aquaculture industry. While there is no disputing the world demand for seafood, an increasing number of discerning markets are commanding high quality, disease free product. Esperance is in the enviable position of boasting one of the world's most pristine ocean environments and is well placed to become a source for high quality aquaculture product.

Perceptions by some members of the Esperance community that aquaculture will adversely affect the Recherche Archipelago stem from the early history of aquaculture activity overseas and to perceptions of some of the early practices at Port Lincoln. While there is no denying that poorly managed aquaculture practices present a threat to the environment, as does the effect of poorly managed land based farming, there are many instances throughout the world where advances in husbandry and nutrition have greatly reduced any environmental impacts. The current legislative framework which provides the environmental script for aquaculture development in Western Australia is rigorous enough to ensure that proper site selection and farming practices will be sustainable, and not cause any long term negative effects to the Archipelago.

Paradoxically, a greater threat in the Recherche Archipelago may be the one to the potential aquaculture industry from pollution through contamination of groundwater sources and urban development; and the potential for pollution from shipping or accidents.

The successful integration of aquaculture into the environmental, social and economic fabric of Esperance could present a watershed in this Country's short marine farming history. Esperance is a microcosm all of the real and perceived issues facing industry development in Australia. An Aquaculture Industry can not be developed in the Recherche Archipelago unless it has strong support from the Esperance community; and earning that support through serious consultation is the real challenge facing the industry.

It is hoped that this report can stimulate a challenging opportunity to create an aquaculture industry which:

- creates jobs;
- generates investment;
- maintains a high standard of environmental management;
- is prepared to challenge those whose practices threaten the natural integrity of the Recherche Archipelago.

15.2 Initial Steps

For a strong and viable aquaculture industry to be established in Esperance there needs to be community involvement and acceptance. To facilitate this an Esperance Aquaculture Group should be formed to provide a focal point for industry development and community

consultation. Membership could include the Esperance Chamber of Commerce, Professional Fishermens Association, the Esperance Regional Recreation Fishing Advisory Committee, local environmental groups, the Shire of Esperance and the Goldfields-Esperance Development Commission.

The proposed Esperance Aquaculture Group should organise local aquaculture workshops to inform the general community of the key issues facing the development of aquaculture in their region. The Group's role should include informing the public of the benefits of aquaculture and help attract investment. It should also provide input into aquaculture proposals and monitoring plans. An Esperance Aquaculture Information Pack comprising this report, relevant Fisheries Western Australia guidelines, other agencies' aquaculture guidelines could be developed and distributed by the Group.

During the consultations, the Aquaculture Council of WA suggested there is a strong need for natural resource mapping to be available to aquaculture proponents. The maps produced for this study are intended to be included in the Coastal Atlas maintained by the Coastal Management Branch of the Department of Transport. This Atlas could be made accessible to the public as part of a statewide digital mapping service and be available on a user pay basis.

15.3 Recommendations

It is recommended that Fisheries Western Australia:

1 Provide regular information and undertake ongoing consultations with the Esperance community in relation to aquaculture;

2 In consultation with the Esperance Professional Fishermens Association and the Esperance Chamber of Commerce, sponsor the formation of an Esperance Aquaculture Group to provide a focal point for industry development and community consultation;

3 In consultation with the Department of Conservation and Land Management, sponsor ongoing environmental investigations of the Recherche Archipelago;

4 Support the concept of a cold water marine research facility associated with a tertiary institution in Esperance, should such a proposal emerge;

5 Provide this draft aquaculture plan, and any subsequent research and information, to the Marine Parks and Reserves Authority for use in future planning for marine parks in the Recherche Archipelago;

6 Ensure that appropriate areas and sites for aquaculture are identified in future planning for marine parks in the Recherche Archipelago.

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17 GLOSSARY OF TERMS

Aquaculture: Aquaculture is defined as the farming of aquatic organisms including finfish, molluscs and crustaceans and aquatic plants. Farming implies some form of human intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators etc. Farming also implies individual or corporate ownership of the stock being cultivated (Food and Agricultural Organisation of the United Nations 1988).

Benthic Associated with the bottom of water body such as pond, lake or ocean.

Broodstock Captured fish (or other aquatic organisms) which are conditioned in a hatchery and kept for breeding purposes.

Cage Culture The rearing of aquatic organisms in cages placed either on or just below the surface of the water.

Food Conversion Ratio (FCR)
The utilisation of feed (generally dry) by cultured species and expressed as a ratio of feed input versus weight gain

Husbandry The application of skills, knowledge and technique to the systematic rearing of aquatic organisms.

Non-endemic A species that is not "native" to the region in which it is located.

Puerulus Leaf like early larval stage of a rock lobster.

Purse-seining Method of fishing (from a boat) for quickly surrounding fast moving fish in a purse like action.

Ranching The release of fingerlings (or other juvenile aquatic organisms) into the wild

Reseeding The "planting" of aquatic organisms (usually molluscs such as abalone) into the wild.

Translocation Movement of native or introduced species from their natural habitat.

Wet feeds Diet given to cultured fish or other aquatic organisms where it is predominately made up of unprocessed protein such as fish and molluscs.

Wild Capture Fisheries
The capture of fish and aquatic organisms from the wild using various techniques.

18 LIST OF ACRONYMS

CALM	Department of Conservation and Land Management
DEP	Department of Environmental Protection
DOT	Department of Transport
EPA	Environmental Protection Authority
EPP	Environmental Protection Policy
FCR	Food Conversion Ratio
FWA	Fisheries Western Australia
LEAF	Local Environmental Action Forum
MPRA	Marine Parks and Reserves Authority
RACG	Recherche Archipelago Consultative Group
RFAC	Recreational Fishing Advisory Committee
SBT	Southern Bluefin Tuna
SERTS	South East Regional Tourism Strategy
WATC	Western Australian Tourism Commission

Appendix 1 Consultancy Brief

DRAFT AQUACULTURE PLAN RECHERCHE ARCHIPELAGO
CONSULTANCY BRIEF

BACKGROUND

The Recherche Archipelago located on the south coast of Western Australian stretches approximately 200 kilometres from Esperance in the west to Israelite Bay in the east. The Archipelago contains numerous islands and sheltered bays.

Interest in the Recherche Archipelago for aquaculture purposes is increasing. Fisheries WA is currently investigating the area for the aquaculture of southern bluefin tuna and an application for the culture of ocean trout has also been received by Fisheries WA. Recent public consultation on aquaculture in the area has raised concerns about the long term expansion of aquaculture activities and the need for coordinated planning.

In June 1994 the report of the Marine Parks and Reserves Selection Working Group - "A Representative Marine Reserve System for Western Australia" (Wilson Report) identified the Recherche Archipelago as an area worthy of consideration for reservation as a marine conservation reserve. Although recent consideration of a number of these recommendations, including the Recherche Archipelago, by the Marine Parks and Reserves Authority, has not identified the Archipelago as a current priority, it is envisaged marine reserve planning may be initiated for the Archipelago within the next 5-10 years.

As multiple use planning for a marine reserve will not be undertaken in the short term, Fisheries WA has recognised the need to undertaken planning for aquaculture within the Recherche Archipelago. Such a planning exercise will provide valuable information to input into the marine reserve planning process when it is finally undertaken.

Strategic planning will aim to identify areas within the Archipelago which are technically suitable for future aquaculture activities whilst also identifying other marine values and uses which may constrain these activities. The outcome will be the preparation of a plan which provides an agreed position between Government, industry and the community on future aquaculture activities in the Recherche Archipelago. The plan will be prepared in conjunction with the aquaculture industry and the local community and will include detailed community consultation. It is anticipated that the draft plan will be released for public comment late in 1998.

SCOPE OF CONSULTANCY

The consultant will be required to prepare a draft aquaculture plan for the Recherche Archipelago and adjacent coastal areas for release for public comment.

Preparation of the plan should include:

- community consultation;
- identification of potential candidate species and potential areas for future aquaculture;

- identification of potential environmental impacts;
- consideration the constraints placed on aquaculture by other marine uses; and
- development of management requirements for aquaculture activities within the Archipelago.

The study area for the draft aquaculture plan includes:

1 the area recommended by the "Report of the Marine Parks and Reserves Selection Working Group - A Representative Marine Reserve System for Western Australia" (known as the Wilson Report) for consideration as a marine reserve.

2 all waters within the limits of the Port of Esperance

The plan should also consider coastal areas immediately adjacent to this study area which may be suitable for land based aquaculture.

Fisheries Western Australia recognises that the potential for aquaculture development in this area will, in the short term, be highly dependent on available infrastructure, particularly road access and power and as a result is expected to be confined, in the short term, to the western sector of the Archipelago. In response the consultant will be required to focus attention on the area from Butty Head, west of Esperance to Duke of Orleans Bay, approximately 60 kilometres east of Esperance. Areas considered suitable for future aquaculture development east of this sector should still be identified, however using a broader, less detailed planning approach. Further investigation of these areas may be undertaken in the future as a separate exercise.

CONSULTANCY TASKS

1 Identify potentially suitable areas for future marine and land based aquaculture activities in the Recherche Archipelago and adjacent coastal areas.

2 Identify potential candidate species for future marine based aquaculture in the Recherche Archipelago and adjacent coastal areas. Discussion of candidate species should include their environmental requirements, economic advantages and their compatibility with each other and the local environment.

3 Identify and map other marine uses in the Recherche Archipelago and their potential to constrain future development of aquaculture.

4 Identify the possible environmental impacts which might result from aquaculture activities in the Recherche Archipelago and adjacent coastal areas and identify management requirements which may mitigate these impacts

5 Consult in detail with the following stakeholders:

State Organisations/ Agencies
WA Fishing Industry Council
RECFISHWEST

Recreational Fishing Advisory Committee (RFAC)
Aquaculture Council of WA
Aquaculture Development Council
AMWING Pearl Producers Association
Conservation Council of WA
Department of Conservation and Land Management
Department of Transport
Department of Commerce and Trade
Department of Environmental Protection
Ministry for Planning
Department of Tourism

Local organisations/agencies
Goldfields Esperance Development Commission
Shire of Esperance
Esperance Port Authority
Esperance Chamber of Commerce
Esperance Goldfields Regional Fishing Advisory Committee
Esperance Game Fishing Club
Esperance Surf Casters Club
Esperance Sailing Club
Zone 1 and Zone 3 Abalone Divers Association
Esperance Professional Fishermen's Association
Albany Professional Fishermen's Association
Baywatch (local community group)
Local Environment Action Forum (LEAF) Local Fisheries WA Officers
Local Department of Conservation and Land Management Officers

6 Prepare a draft aquaculture plan for Recherche Archipelago and adjacent coastal areas detailing all of the above.

Appendix 2 Consultations In Perth - Summary Of Issues Raised

The following is a summary of issues raised during the consultations in Perth and from the written submissions received.

1 Department of Environmental Protection (DEP)

The DEP advised the main issues of concern in relation to aquaculture development in the Recherche but would prefer to give detailed comments on the draft Aquaculture Plan when it is developed. The main environmental issues relate to:

- Effluent from land based aquaculture developments. The water circulation and water quality of the receiving waters will need to be known to ensure the potential environmental impacts can be managed. All effluent will need to comply with the appropriate water quality guidelines to minimise the potential impacts;
- The impacts on benthic habitat such as seagrass meadows, coral growth, algal gardens and sand/mud substrate will also need to be understood prior to implementation of any aquaculture development;
- The use or movement through an area by penguins, dolphins, turtles etc should be understood prior to placement of any structures in the waters of the Recherche Archipelago that may impact on the use of the area;
- If any species proposed to be used is not endemic to the area, the application will need to comply with the requirements of the memorandum of understanding between Fisheries Western Australia and the Environmental Protection Authority for the translocation of non-endemic species for aquaculture. The issue of disease risk through imported feed should also be addressed, particularly in relation to concerns raised linking pilchard deaths to bluefin tuna farming in South Australia;
- Any land clearing associated with land based proposals will need to take into account the conservation value of the surrounding vegetation. Any clearing in excess of 1 ha will require authorisation from the Commissioner for Soil and Land Conservation;
- Amenity. Any proposal will need to take into account visual, odour and noise issues in relation to their proposal, with recognition of the importance of nature based tourism and conservation values of the area;
- Any aquaculture development plan should attempt to quantify the extent to which the industry can develop in the area. This should take into account cumulative impacts from other activities and the multiple and often competing uses of the area;
- All proposals should gather enough baseline monitoring information prior to implementation of the project to determine the potential impacts; and
- All proposals will need to gain the appropriate approvals prior to implementation. This should be conducted in a manner that allows for an integrated agency response to proposals, where appropriate.

There should also be a recognition of the high environmental values of the Archipelago (proposed Marine Reserve) while also recognising the lack of detailed information on many of the areas and processes occurring in the Archipelago.

Reference should be made to the Environmental Protection Authority's draft Environmental Protection Policy for State Marine Waters (EPP) released in June 1998 when developing the plan.

The EPP details the way the EPA proposes to manage development within the State's marine waters and is based on the national water quality framework to which Western Australia is a co-signatory. The EPA is committed to the principles of ecologically sustainable development and has based the State Marine Waters EPP on the following underlying principles of water resource management and protection:

- *waste minimisation* - encouraging and assisting action by industry, public authorities and the community aimed at promoting a hierarchy of waste avoidance or elimination, minimisation, reuse and recycling and treatment to protect the environment;
- *intergenerational equity* - ensuring that the environment is used sustainably or enhanced for the benefit of existing and future generations; and
- *the precautionary principle* - giving consideration in all development where threats of irreversible environment damage are suspected that lack of full scientific certainty should not be used as a reason for postponing, measures to prevent environmental degradation.

The environmental values of marine waters to be protected under this policy include their value for fishing and aquaculture. However harvesting aquatic flora and fauna, either through fishing or aquaculture, is also identified as an activity which may have the potential to degrade marine waters.

2 Western Australian Tourism Commission

The WATC recognises the importance of aquaculture to the economy of Western Australia and the role it plays in the sustainability of the fish stocks in the State's waters. There have been occasions when aquaculture operators have worked with the tourism industry to provide added value to an area through interpretation of the operation. The issues raised included:

- **Visual Amenity.** Western Australia is targeted as a destination for people who wish to experience its pristine environment, Esperance is a prime example of the kind of environment which WA has to offer. This group of islands is a popular destination for charter boat operators and aquaculture operations may have a negative effect on visual amenity and the feeling of being in a pristine environment.
- **Perceptions**. The success of a tourism destination is often based on the consumer's perception of that destination. This perception deals with many aspects of the area's characteristics including such things as the pristine environment, safe diving and swimming waters, friendly locals and "wilderness experiences". Most of these things are intangible and subjective. It is important therefore, that a destination is seen to offer the attributes which the consumers are demanding. There is a perception that tuna farms have the propensity to attract predators such as sharks, whether or not this is a fact the perception is still strong enough to deter people from swimming or diving in the vicinity of a tuna farm. This will have a strong impact on the attractiveness of the area from a tourism and recreational point of view.

- **Effluent from aquaculture**. This would have the effect of raising nitrate levels in the water and thus effect the clarity and quality of the water around both of these islands.
- **Feeding** There has been some concern regarding the effect of uneaten feed on the surrounding environment. As well as attracting predators there is a concern that fish feed pellets could have an effect on the water quality and that rotting fish could be washed up on other beaches. Seabird deterrent methods involving the use of bamboo poles and sirens are likely to affect the attractiveness of the island as a tourism destination.
- **Harvesting** One of the major concerns held by the local tourism industry is that there is insufficient information regarding the harvesting methods to be used and how it is proposed to dispose of the blood and offal which may result. There are also concerns that harvesting in the bay area will lead to pollution of the pristine environment and attract predators such as sharks.
- **Recommendation.** It is the recommendation of the WATC that Fisheries Western Australia (FWA) liaise with the local community, paying particular attention to the concerns of the tourism industry who rely heavily on the pristine and unique nature of the waters of the archipelago for the success of their operations.

3 The Department of Conservation and Land Management

At the time of preparation of this report the consultants had met with CALM officers in Esperance and with officers of the Marine Conservation Branch but had not received a formal submission from CALM. This section is based on discussions and information provided so far, as well as previous correspondence between CALM and Fisheries Western Australia.

The Department of Conservation and Land Management is playing an increasingly important role in the planning and management of aquaculture in the marine environment with particular regard to development in and adjacent to Marine Parks.

The Wilson Report (CALM 1994) has identified the Recherche Archipelago as an area worthy of consideration for reservation as a marine conservation reserve.

The Department's response to Fisheries Western Australia's draft Tuna Farm proposal was generally supportive of the approach taken by that agency. The two major issues raised by the Department were:

Interactions

There is widespread agreement throughout the aquaculture industry that seals, dolphins, birds and fish species are attracted to sea cages. According to Pillay (1992) the major impacts on bird life are:

- Physical damage by protective devices and deliberate killing;
- Disturbances by farming activity and scaring devices;
- Disruption of natural habitats.

The damage inflicted on mammals is similar to the list above and includes:

- Deliberate killing and live trapping by farmers;
- Accidental trapping in cages, predator nets and fencing;
- Disruption of habitats.

CALM indicated that the presence of significant populations of New Zealand Fur Seals, Australian Sea Lions, bottlenose dolphins, common dolphins and possibly Humpback and Southern Right Whales, will require proponents, from the outset, to establish sophisticated exclusion techniques and maintain their cages and predator systems to a high standard, with regular maintenance. CALM also considers that mesh size for predator systems will be an important consideration in the effectiveness of minimising entanglements. An acceptable mesh for seal exclusion would be 100mm, kept taut, and regular diving inspections of nets should be undertaken to detect entanglements every 1-2 days.

CALM believes that the use of bamboo poles and sirens as a deterrent to birds, particularly at feeding times, is ineffective and that proponents will have to install bird netting over cages. It stipulated that netting which is visually obvious to the birds should be used in preference to monofilament.

CALM recommends that a carcass recovery protocol should be followed in the event of a death of a marine mammal and should include the body being taken to the CALM office for determination of species, sex and size prior to disposal.

Environmental Impact

CALM's assessment requirements relating to pollutive impacts from sea cages on the marine environment are:

- Prediction of contaminant concentration zones both in the benthos and the water column in relation to distance from the nutrient source, ie the cages;
- What happens if cage rotation by the farmers does not solve an environmental problem;
- contaminant concentration zones should be predicted to determine the distance between cages and seagrass;
- CALM requires quantitative assessments of issues such as sedimentation and other pollutive effects.

4 RECFISHWEST

RECFISHWEST is the peak body representing the interests of over 600,000 recreational fishers throughout Western Australia. This industry is estimated to be worth over $500 million dollars to the Western Australian economy, making it a significant contributor to the overall gross domestic product of this state.

RECFISHWEST is vitally interested in ensuring that quality recreational fishing will be available for current and future generations. It in general supports the development of aquaculture in Western Australia on the basis of maximising returns from fish production which does not increase competition within wild capture fisheries.

The issues raised include:

- **Access**. No diminution or incremental loss of recreational fishing access should occur through aquaculture or other development. Of particular concern are proposals which relate to reef top reseeding or the establishment of sea cages or ranching of species such as abalone. If exclusive access is being sought, direct or indirect compensation to the value of the community resource foregone should be included. For example the proponent may supply buoys or other platforms for recreational fishing or boating in the vicinity of, but not impacting upon the lease. In a number of instances, aquaculture leases increase the overall production of the surrounding environment and provide quality fishing in the immediate vicinity.
- **Fish Health Issues** - Under aquaculture conditions, animals are under low or higher levels of stress. Disease outbreaks and management are major considerations for any aquaculture establishment. The aquaculture industry has been implicated in the introduction of diseases and there have been further impacts from the escape of animals specifically approved for the aquaculture or aquarium industry. It is important that any aquaculture proponent have public liability insurance sufficient to cover the loss of recreational fisheries should a disease introduction be attributed to a source or the industry.
- **Clean up or removal of aquaculture facilities**. - The problems with fish health are exacerbated by poor husbandry and hygiene. Fisheries WA should have an obligation to ensure that the risk to wild fisheries is minimised by good aquaculture practices. There should be a requirement for a sufficiently large bond to ensure that the site is fully cleaned by other persons should an aquaculture venture fail.
- **Environmental Impacts**. -The potential for phosphate burning of seagrass beds is a particular issue with intensive aquaculture in sea cages. RECFISHWEST recommends an independent site survey by a party not engaged by the proponent.
- **The capture of broodstock** for aquaculture ventures must be carefully undertaken. The wild stocks which are a community resource must not be compromised to benefit individual aquaculture ventures at the expense of community interests.
- **The on-growing of any undersize individuals taken as part of the by-catch** of any commercial fishing activity or specifically captured from the wild for this purpose will be strongly opposed. This has proven to be disastrous for wild fisheries where it has been permitted (such as eels in South-east Asia) and cannot be justified under any circumstances (apart from perhaps puerulus grow-out) in Western Australia.

5 Recreational Fishing Advisory Committee

The Recreational Fishing Advisory Committee (RFAC) is generally supportive of the development of the aquaculture industry and has similar concerns to RECFISHWEST. It regards access as the main issue and would oppose any diminution of access to public resources to recreational fishers.

Issues of concern include:

- Tuna- waste problems, disease, exclusion of fishers;
- Pilchards are overfished already and are not favoured as feed source for tuna. There are also food chain issues relating to other recreational species;
- RFAC has no problems generally with filter feeders such as molluscs and land based operations provided they do not limit access;
- Abalone culture looks interesting provided there is no exclusion of access;

- Ocean trout are considered a potentially suitable species for marine aquaculture;
- RFAC is strongly against the use of pilchards as tuna feed. There is already excessive demand on fishing and the food chain;
- Stock enhancement is considered possible; King George Whiting was cited as an obvious early candidate.

Appendix 3 Consultations In Esperance - Analysis Of Issues Raised

The following is a summary and analysis of issues raised during the consultations with stakeholders in Esperance.

1 Esperance Shire Council

Esperance Shire Council is generally supportive of aquaculture development, both land based and within the Recherche Archipelago. Council in principle supports sea cage culture provided there is enough base line data and adequate environmental controls. Tuna farming could be considered beyond Woody Island, outside the Port Authority area.

Council is currently considering a proposal to establish a land based abalone and aquaculture park facility on Council land adjacent to the waste disposal site. Council is considering a 10ha short term lease, but there is concern about the environment effects of using groundwater in close proximity to the tip. There may also be an issue regarding access for sea water across the nearby foreshore reserve which is subject to two native title claims.

Proposals for tuna farming and marine farming must include details of the methods proposed for processing and disposal of offal, and not assume the local authority would take responsibility once it is brought ashore. Strict guidelines for such matters should be placed on licence applications.

The Duke of Orleans Bay is an area considered suitable for aquaculture and the fishing industry and a more desirable location than Esperance Bay for tuna in the longer term. Nares Island has an excellent anchorage which has been used to unload fish to refrigerated vans going to Perth. Council has supported the provision of berthing facilities near Nares Island, however the main problem is the lack of infrastructure, including roads and electricity. The township of Condingup has available land and infrastructure which could support the aquaculture industry, particularly for staff residences.

2 Recherche Archipelago Consultative Group

The Recherche Archipelago Consultative Group (RACG) was formed following a three day fact finding delegation to Port Lincoln, led by Mr Ross Ainsworth MLA, Member for Roe, to examine aspects of the Southern Bluefin Tuna Farming Industry. Membership of the Group is shown in Appendix 4. The RACG was formed to ensure that consensus was maintained through a unified approach to the tuna farming issue, rather than through a number of representative groups. The RACG will not supercede other community groups involved in issues attached to the Southern Bluefin Tuna proposal. The position statement of the RACG is:

1 That the current tuna farm proposal is unacceptable primarily due to location;
2 No future tuna or finfish aquaculture proposal will be accepted within the Port Authority boundary;
3 Two criteria are essential prior to any future aquaculture proposal in the Recherche Archipelago being considered~

a. A full environmental impact study, which includes adequate baseline data being available for any proposed site;
b. A management plan must be drawn up with the assistance of a local consultative group, which includes user group representatives.

The RACG believes that the ideal outcome is to find a place for both industries by implementing these recommendations and therefore locating any planned tuna or other aquaculture enterprise where it will not have any detrimental impact on the tourism industry and the environment generally.

The development of aquaculture in the Recherche Archipelago could benefit from the approach taken by the Esperance community. The RACG has the ability and the capacity to evolve into a community based management tool providing an ongoing monitoring role for all users of the Archipelago including aquaculture proponents.

The Chair of the RACG, Mr Ross Ainsworth MLA, Member for Roe indicated that he would like to see the aquaculture industry continue the town's industry development theme whereby Esperance "adopts world's best practice and makes it better".

Planning Implications for Aquaculture

- Community consultation is an essential component of aquaculture planning and the development of aquaculture proposals;
- A community based management advisory group may assist in the development and management of the aquaculture industry.

3 The Environmental Movement; LEAF and Baywatch

Baywatch was formed specifically in response to tuna farming proposals in Esperance Bay. Both environmental groups support proposals to create a marine park in the Recherche Archipelago. They consider it is valuable as an ecological wilderness and that ecotourism provides the most sustainable use for the future. Ecotourism relies on the widely acknowledged "clean green" image of the area. The groups oppose all caged fish in the Recherche Archipelago. They are generally supportive of land based aquaculture, but perceive that aquaculture in general has problems, and that the industry needs to get it right before proceeding with proposals, particularly in environmentally sensitive areas. The groups believe a cost benefit analysis is desirable where the use of public assets is proposed. Wide consultation is necessary, for example, a sea trout proposal at Cull Island was opposed by recreational boating people because it was proposed for the best anchorage in the Bay.

The environmental movement in Esperance indicated that aquaculture had an important role to play in the future of fisheries management providing it was done correctly. They were not opposed to aquaculture providing it could prove itself worthy of the mantle "clean and green".

The environmental movement considers that tuna farming has specific problems including:

- The general inefficiency of tuna farming and the effects of uneaten pilchards and nitrogenous metabolic wastes on the marine environment;

- the content of feeds, eg antibiotics;
- entanglements and seal interactions with cages;
- Perception of sharks and their effect on other Recherche Archipelago values;
- bird nuisance, entanglements and change in seabird populations, potential to carry disease;
- Aesthetics. It was noted that a sea cage proposal at Kangaroo Island had been refused on the grounds of actual or perceived amenity loss, creating a significant precedent;
- The pilchard deaths and the lack of knowledge as to the cause;
- The notion of taking any tuna from the wild given the state of the fishery.

The main issues identified by this group are:

- Access to popular areas of the Recherche should not be restricted by aquaculture activity; The natural beauty of the Recherche should not be impacted by aquaculture operations;
- The potential negative impacts aquaculture could have on the marine environment;
- The interaction between birds, seals and sharks with cages structures and potential entanglement.

Analysis of Environmental Issues

The environmental concerns and issues raised are valid and must be addressed by proponents if a marine farming proposal is to proceed. The Department of Environmental Protection (DEP) has published Consultative Environmental Review (CER) Guidelines for the earlier tuna proposal (DEP 1998) and these indicate the level of research, investigation and modelling for many biophysical, pollution management and social surroundings factors, which must be undertaken before a CER can be assessed. The CER process establishes the environmental criteria and limits for nutrients and other impacts; and defines the management measures and safeguards required as proponent's commitments. Commitments made under a CER are legally binding on the proponent and the regulatory authorities.

Concern about the likely interaction between birds and marine mammals and cages can be addressed by the application of strict management conditions developed with the assistance of CALM's expertise.

It is difficult, however, to adequately address the unfortunate perceptions of tuna farming which have arisen from mistakes and problems at Port Lincoln. Scientific interest in the impacts of nutrient pollution from aquaculture operations has risen dramatically over the last ten years as the industry has become one of the fastest growing agriculture sectors in the world. (Davlin 1991) While significant research has been carried out on tuna farming a great deal of work remains to be done to bring it to a level similar to best practice sea cage farming of other species.

Planning Implications for Aquaculture

- Any proposal will need to recognise the value of the Recherche Archipelago in terms of the importance of nature based tourism and conservation values of the area;
- The impact on benthic habitat such as seagrass meadows, coral growth, algal gardens and other substrate should be understood before the siting of cages;

- The interaction between birds, seals and sharks should be understood prior to placement of any structures in the waters of the Recherche Archipelago;
- The risk of disease through imported pilchards should be addressed.

4 Surfcasters and Beachside Recreation

A profile of this activity is provided in Section 5 of the *Draft User Profile of the Recherche Archipelago and Adjacent Coast*, attached. The information was provided by officers of Fisheries Western Australia, Esperance Surfcasters and individual members of the community. The surfcasters recognised that aquaculture development in the Recherche Archipelago could provide increased angling opportunities through the attraction of fish species to cages and outflow pipes from land based facilities. The main issues identified by this group are:

- The relationship between offshore aquaculture operations and the surfcasters is minimal given the activity takes place near shore. According to Mr Graham Gath, President of Esperance Surfcasters and Chair of the Regional Recreational Fishing Advisory Committee, cages may provide an advantage by way of attracting more fish to the areas surrounding the cages. An additional benefit may also be the improvement of access into some of the more remote fishing areas if aquaculture operations were to take place. However he mentioned that if the access was improved too much then this may have a negative impact on the "remote appeal" of the fishing location.

- Access to popular fishing spots is the major concern the surfcasters have in regard to land based aquaculture. The surfcasters would be concerned if a large scale facility was developed and ocean intake and discharge pipes were located in a manner to restrict access to fishing locations. Mr Gath also indicated that the discharge pipes may also prove to be popular fishing sites with the likely attraction of fish to the pipe and discharge.

Planning Implications for Aquaculture

- Any decision to locate an aquaculture project adjacent to or near shore from existing popular fishing locations must consider access to recreational shore based fishers;
- Prevention of onshore pollution from large-scale aquaculture cage operations within 5 nautical miles of popular beaches and fishing spots should be an important consideration.

5 Recreational Boating and Fishing

A profile of this activity is provided in Section 4 of the *Draft User Profile of the Recherche Archipelago and Adjacent Coast*, attached. The information was provided by members of the Esperance Offshore Angling Club and individual members of the community. The recreational boating and fishing community of Esperance are supportive of land based aquaculture and some forms of marine farming. They acknowledge the role aquaculture could play in supporting recreational fishing in the Recherche Archipelago through stock enhancement.

The main issues identified by this group are:

- Recreational fishing in the Recherche Archipelago is highly valued and protected by this group and they are concerned that any aquaculture development must not pollute the Recherche Archipelago and in turn threaten fish stocks;
- Sea cages must be marked properly so as not to cause a threat to navigational safety;
- The first episode of pilchard deaths at the Recherche caused members of the Angling Club to become concerned regarding the difficulty of catching previously targeted species. They are also concerned regarding the effect pilchard deaths may have on other fish species;
- Having access to safe anchorages in the event of rough conditions was an important issue and the locating of cages reducing such access would be of great concern;
- The locating of cages in places which restricted access to recreational boat fishing would concern members of the Deep Sea Angling Club although some members indicated that they simply wouldn't go there.

Analysis of Access and Equity Issues

Marine farms need only restrict access for recreational boating and fishing to the extent of the cages themselves, and the near vicinity. Farm leases, which cover a much greater area, do not give the operator the right to exclude others. Standard conditions applied to any aquaculture proposal ensure that sea cages are marked properly so as not to cause a threat to navigational safety. It would be beneficial if permanent moorings were installed to provide safe anchorages in the event of rough conditions.

Planning Implications for Aquaculture

- The locating of cages within close proximity to popular boat access fishing sites should not restrict access either to fishing locations or safe anchorages;
- Sea cages must be marked properly so as not to cause a threat to navigational safety;
- A code of conduct may need to be developed between recreational fishers and aquaculturists to minimise conflict or interference when fishing occurs adjacent (not alongside) to cages;
- Measures are required to ensure that aquaculture operations do not pollute the environment or cause the loss of marine fauna or habitat.

6 Recreational and Charter Diving

A profile of this activity is provided in Section 3 of the *Draft User Profile of the Recherche Archipelago and Adjacent Coast*, attached. The information was provided by Mr Peter Hudson of Esperance Diving and Fishing, Ms Marie Northcoat of Wildwest Sports in Kalgoorlie, charter operators and individual members of the community.

The main issues identified by this group are:

- Esperance is ranked by *Scuba Diving* and *Dive Log* magazines as being one of the top ten diving locations in Australia. Recreational diving, diving charters and tourism are linked through reliance on the Recherche Archipelago's reputation for crystal clear waters and high environmental quality. Aquaculture operations may have a negative effect on water quality, visual amenity and the feeling of being in a pristine environment. The diving

market is sensitive to changes in the environment and the market place. For example, a key diving site is the wreck of the *Sanko Harvest*, which is the second largest diveable wreck in the world; however the sinking of HMAS *Swan* as a dive site at Geographe Bay substantially damaged local bookings;

- There is a perception that aquaculture, particularly tuna farming, has the propensity to attract dangerous sharks. Whether or not this is a fact, the perception is strong enough to deter people from swimming or diving in the vicinity of a tuna farm. This will have a strong impact on the attractiveness of the area from a tourism and recreational diving point of view. There were several cancellations after the recent Hopetoun shark fatality, even though local public relations efforts emphasised the tragedy was not associated with Esperance;
- The Remark, Frederick, Sandy Hook and Long Island Group is of major importance to diving, particularly the charter sector, because of its protected nature and proximity to Harvest Reef. Other factors are the variety of aspects for all sea and wind conditions, biological interest and diversity of diving experiences. If tuna farming was developed in the Group then it could not be used the because of shark potential and duty of care issues, and would have a damaging impact on the industry.

Analysis of Increased Shark Danger

Mr Bill Kent, Chairman of the Esperance Professional Fishermens Association, advised that up to five great white sharks are encountered by professional fishers in the Recherche Archipelago each year. Bronze Whalers and other species are frequently encountered in nets.

Information on the interaction between sharks and cages is based more on knowledge of shark behaviour rather than actual recorded interactions. Despite considerable national and international interest in the topic there are very few recorded examples of shark interaction.

According to Dr B. Bruce (CSIRO Marine Research Branch, Hobart) white sharks are the least likely to interact with farm operations. His conclusions were:

- There is currently insufficient information to adequately assess either the nature or extent of shark interactions with either tuna farm operations or similar operations worldwide;
- There is a need to clearly identity the specific issues of concern of both the aquaculture industry as well as other users of the waterway and examine those concerns in light of the nature and extent of interactions;
- It is important to note that sharks normally occur naturally in many in shore areas independent of aquaculture operations and may normally occur with fish schools;
- The responsiveness of sharks, their activity and hence the nature of interactions may vary between species, years, seasons and time of day.

The perception that tuna farming has the propensity to attract dangerous sharks is held by many people in Esperance and the region. Whether or not this is a fact, it is widely believed the perception is strong enough to deter people from swimming or diving in the vicinity of a tuna farm and that this will have a strong impact on the attractiveness of the Recherche Archipelago from a tourism and recreational diving point of view. Should tuna farming

become established in the Recherche Archipelago it would be essential for the community to get behind the industry and counter the perception through marketing strategies.

Duty of care refers to the legal liability of operators to do all that can reasonably be expected to be done to prevent accidental harm to their clients in the course of their activities. In the case of white pointers it is difficult to envisage any kind of disclaimer or preventative measure that an operator could employ to enable him to offer diving experiences in the vicinity of tuna cages.

Commercial Abalone Divers Association in Esperance advised that divers would be concerned if they had to dive within 5-10km of tuna cages and such advice must be regarded as authoritative until more is known.

For planning purposes, it must be accepted that tuna farming will prevent, or adversely affect, recreational and commercial diving, including abalone diving, within a radius of 5 kilometres. This will have implications for any tuna or sea cage proposal at the Remark Group of islands, and conflict resolution procedures may be required.

Ideally, any tuna farming and finfish cage culture needs to be perceptually far enough away from Esperance Bay that divers using charter diving services do not have a heightened fear of sharks.

Planning Implications for Aquaculture

- Aquaculture operations should be sited and managed to ensure there is no negative effect on the values of water quality, visual amenity and the feeling of being in a pristine environment;
- For planning purposes, it must be accepted that large scale sea cage farming will prevent, or adversely affect, recreational and commercial diving, including abalone diving, within a radius of 5 kilometres. In addition, Tuna farming needs to be perceptually far enough away from Esperance Bay that divers using charter diving services do not have a heightened fear of sharks;
- Duty of care becomes an issue for the dive charter operator when placing divers in the water knowing that increased predator encounter may be possible.

7 Tourism

A profile of this activity is provided in Section 2 of the *Draft User Profile of the Recherche Archipelago and Adjacent Coast*, attached. The main issues identified by this industry are similar to those listed for the environment and leisure sector above, and in the WATC summary, Appendix 2. They Include:

- Tuna farming may affect the visual amenity of the Recherche Archipelago. Western Australia is targeted as a destination for people who wish to experience its pristine environment, Esperance is a prime example of the kind of environment which WA has to offer;
- The perception of pollution from tuna farms may affect the environmentally based tourism values of Esperance and the Recherche Archipelago;

- The real or perceived increase of shark danger and its effect on commercial and recreational diving and the environmental and tourism values of the Recherche Archipelago.

Analysis of Tourism Issues

The issues of visual amenity, the perception of pollution and the perceived increase of shark danger, which are of concern to the industry, have been dealt with in the sections above. As the WATC has pointed out, the success of a tourism destination is often based on the consumer's perception of that destination. This perception deals with many aspects of the area's characteristics including such things as the pristine environment, safe diving and swimming waters, friendly locals and "wilderness experiences".

If tuna farming were to occur in the Recherche Archipelago, the industry could be confident that the issues are more perceived than real, and use its considerable marketing resources to provide reassurance.

Planning Implications for Aquaculture

- Aquaculture planning and future proposals need to have regard for the key issues of importance to tourism development, which are landscape and amenity, environmental quality, access, and market perceptions. Close consultation with the tourism industry should be maintained.

8 Charter Operators

A profile of this activity is provided in Section 6 of the *Draft User Profile of the Recherche Archipelago and Adjacent Coast*, attached. The information was provided by charter operators and individual members of the community.

It was noted that Fisheries Western Australia has recently published Fisheries Management Paper No. 116, *Future Management of the Aquatic Charter Industry in Western Australia,* which may have a significant bearing on charter operations in the Recherche Archipelago. The future management of the aquatic charter industry in Western Australia has been addressed by the Tour Operators Fishing Working Group and is detailed in the Fisheries Management Paper No:116. In an effort to manage the industry and protect the integrity of the natural aquatic environment the Report recommends that new licencing categories under the *Fish Resources Management Act 1994* be introduced. It is anticipated by the working group that this may limit the number of operators and provide for sustainable localised industries.

The main issues identified by this group were:

- All charter operators, irrespective of the nature of their clients' activities agreed that the Recherche Archipelago represents an unique wilderness experience for visitors and any aquaculture development must not threaten the environmental integrity of the area;
- The fishing charter operators did not believe that cages located within sheltered areas would affect their fishing operations as they tended to fish in more open sea. One operator

indicated that if he felt a client may be offended by the intrusiveness of an unnatural structure he simply would avoid the site;

- One operator believed that an opportunity may exist for cage operators to provide an unique fishing opportunity where his clients could use barbless hooks and fish for tuna. Another charter operator felt that cage culture could provide his company with an expanded role and was seeking to buy a new multi purpose vessel that could service the new industry;
- Several of the charter operators indicated that there would be less opposition to cage culture if the development occurred a further distance from the more popular recreational sites, that is, areas east of the Esperance Bay;
- While all agreed that the pristine nature of the Recherche Archipelago was too valuable to lose most concurred that aquaculture development should occur providing it did not take place in popular areas and that adequate measures were in place so as to ensure the protection of the aquatic environment and its inhabitants.

Planning implications for aquaculture

- Any decision to locate a large-scale offshore aquaculture operation should consider the value of the current and future aquatic charter industry in the Esperance Region and not restrict access or adversely affect natural and amenity values;
- The implementation of recommendations outlined in the Fisheries Management Paper No. 116, *Future Management of the Aquatic Charter Industry in Western Australia* (at the regional level) should involve input from agencies and companies involved with aquaculture development in Esperance.

9 Commercial Fishing and Processing

A profile of this activity is provided in Section 7 of the *Draft User Profile of the Recherche Archipelago and Adjacent Coast*, attached. The information was provided by Mr Bill Kent, President of the Professional Fishermens Association, Mr Marcus Grey, Mr Chris Unwin, other professional fishers and processors, and individual members of the community.

The commercial fishermen of Esperance were generally supportive of aquaculture development in the Recherche Archipelago, however there are clearly differing opinions on the proposal to farm Southern Bluefin Tuna.

The major opposition for the tuna proposal came from the pilchard fishermen and abalone divers. The pilchard fishermen expressed the following major concerns:

- There is scientific uncertainty relating to the cause of the pilchard deaths and any relationship with tuna farming in South Australia. That is, whether the deaths were caused by a virus brought in by imported pilchards for the tuna farm. The closure of the fishery for the second time as a result of pilchard deaths has exacerbated these concerns. The notion of using locally caught pilchards for tuna farming was not considered as it is generally an inferior product and therefore attracts a lower price;
- Feeding pilchards to tuna may have a possible adverse effect on the local pilchard population. There is a theory that dead pilchards in the water cause a "graveyard effect"

on adjacent fishing areas, causing pilchard schools to avoid the area. Nearly 75% of the sea bottom at Sandy Hook Island is considered "user friendly" for purse seining pilchards and if the graveyard effect was a real threat then this could impact greatly on future fishing effort;

- Losing access to fishing ground is possible if sea cages were placed over sandy bottoms of up to 40m depth. It was indicated that 90% of the pilchard catch came from the Remark group of islands this year (normally 30%) and loss of access to the fishery by exclusion zones around cages would cause great concern.

Mr Ralph Walsh, a spokesman for the Commercial Abalone Divers Association in Esperance, expressed concern about the potential for sharks being attracted to tuna cages by oil slicks emanating from the use of wet feed (pilchards) and from additional seal activity around cages. He indicated that divers would be concerned if they had to dive within 5-10km of tuna cages. The majority of their diving takes place in up to 40m of water.

The commercial fishermen all agreed that no cages should be placed within a 10 nm radius of the Bandy Creek Harbour mouth.

Analysis of Pilchard Issues

Two episodes of pilchard deaths have occurred along the southern coastline in the last four years. The cause of the mortalities was attributed to a herpes virus of unknown origin (FWA 1997) and the source of the virus remains unresolved. The weight of local opinion at Esperance and in the industry, apportions the blame to imported pilchards used at Port Lincoln tuna farms. Pilchard fishers consider that tuna farming proposals are premature; they should be deferred until the cause and origin of the current pilchard mortality is known.

The industry is worried that effluent from tuna farming will cause damage to the pilchard fishery through direct exclusion by sea cages, inadequate disease control and by interaction between dead product and pilchard schools. This is the so called "Graveyard Effect" where the presence of dead fish in the water is thought to cause fish to avoid the area.

Advice on the "Graveyard Effect" was sought from the literature and people in the industry, however little information could be obtained. It was suggested by some professionals that shark fishers never clean their catch on the fishing ground, and there may thus be "something in it". On the other hand, it was pointed out that "rolling" during purse seining operations resulted in pilchard mortality.

The pilchard fishery would not favour a greater TAC for tuna farm feed because the quota would be inadequate to meet demand and current prices are 70 cents for bait fish but only 35 cents for tuna feed. They point out that tuna need pilchards in winter, whereas the Esperance Pilchard Fishery is a summer fishery.

The points made and issues raised by the Pilchard Industry can not be easily resolved. It is considered that Fisheries Western Australia should continue its research program and resolve these issues through consultations with the industry.

Planning Implications for Aquaculture

- Aquaculture operations should be sited to ensure minimal disruption to existing commercial fishing operations;
- Tuna farm operations will adversely affect commercial abalone diving within 5 nautical miles from the cages;
- The use of imported pilchards as a feed for tuna will not be accepted by many in the commercial fishing industry until the source of the cause of pilchards deaths is known and either an acceptable prevention is implemented or an alternative food source is developed.

10 Tuna Farming Proposal

There is little doubt that the majority of the people consulted were opposed to the proposal to farm tuna near Woody Island, put forward by Fisheries Western Australia. Their concerns were fuelled by emotive and factual arguments based on Port Lincoln's perceived track record. They believe that tuna farming techniques would need to improve significantly for the industry to have a place in the Recherche Archipelago. The perception of shark attacks was a concern and it was considered that cages would need to be located perceptually far enough away from popular recreation and commercial, swimming and diving sites.

People in Esperance have pointed out that there is an apparent conflict between Fisheries Western Australia's dual roles of proponent and regulator. If tuna farming is to be further considered, it would be useful for Fisheries Western Australia to publish the regulatory framework and environmental criteria and conditions it is likely to apply to any tuna farming proposal. These would be based on the requirements of the EPA, but be sufficiently specific to allay community concerns. This would also benefit proponents contemplating tuna farming, as they also have to research the commercial aspects of a venture.

The major issues raised during the community consultation included:

- The perceived economic and employment benefits of aquaculture;
- The potential negative impacts aquaculture could have on the marine environment;
- Perception of sharks and pollution from tuna farms and their effect on other Recherche Archipelago values, in particular recreational diving and Tourism;
- The pilchard deaths and the lack of knowledge as to the cause;
- Entanglements and seal interactions with cages;
- The lack of large freezers and other infrastructure in Esperance;
- Steaming distance to the proposed sites may be too great. Distance to the Port Lincoln sites is 1/2 hour - 40 minutes. Tuna need feeding twice a day and feed may have to be kept on the farm site, which may involve having extra equipment and people on site;
- The towing distance from good congregations of tuna east of 130°E is 2/3 times the distance to Port Lincoln and may take up to six weeks, requiring more feed, which will need to taken out to vessels en route. Three weeks is the longest haul to Port Lincoln. If smaller fish are taken, they will have to be kept for a much longer fattening period;
- The need for open communication between all parties regarding the development of aquaculture proposals in Esperance.

Analysis of Tuna Farming Issues

Any future tuna farming proponent need to address the issues raised by the community, and resolve the key issues. Ultimately, best practice tuna farming can only be achieved by operator diligence; and strict monitoring, reporting and enforcement of conditions applied to the management of a farm. These would include the definition of:

- farm management and feeding requirements;
- water quality limits which will be applied to the downstream outflow at the boundary of a farm;
- limits to changes in sediments and the infauna beneath cages;
- limits to changes in the environment and benthic habitats at specified locations near a farm.

Many people in Esperance formerly worked in the Esperance Tuna Fishery and have a very good knowledge of the practical aspects of the industry. Some still have tuna quota which is leased to others, and retain an ongoing interest in the industry. If it is intended to proceed with a tuna farming proposal, the proponent would benefit from detailed consultation on these practical aspects. Some of the issues raised are commercial considerations which would have to be taken into account by any future proponent in the preparation of a business plan.

Implications for Aquaculture Planning

- Any further tuna proposal will need to recognise the value of the Recherche Archipelago in terms of the importance of nature based tourism and conservation values of the area;
- The impact on benthic habitat such as seagrass meadows, coral growth, algal gardens and other substrate should be understood before the siting of sea cages;
- The interaction between birds, seals and sharks should be understood prior to placement of any structures in the waters of the Recherche Archipelago;
- The risk of disease through imported pilchards should be addressed.
- The locating of cages in places which restricted access to boating should be avoided;
- Community consultation is an essential component of aquaculture planning and the development of aquaculture proposals;
- A community based management advisory group may assist in the development and management of the aquaculture industry.

Appendix 4 List Of People Consulted

Consultations in Esperance

Keith Archer	LEAF
Graeme Baesjou	Goldfields Esperance Development Commission
Nicholas (John) Bonnitcha	Member of Esperance Yacht Club
Mr Ralph E Bower, AOM	Community College
Graham Cooper	Training Officer Esperance Sea Rescue
Ray Croker	Shire Councillor and Caravan Park owner
Dept of Transport	
Robin Dicks	Goldfields Air Charter
Steve Drewe	Charter Operator
Des Evans	Member Esperance Deap Sea Angling Club
Vince Evans	President Esperance Deep Sea Angling Club
Fisheries WA	
Graeme Gath	President, Recreation Fishing Advisory Committee (South)
Ken Gittins	Fisheries WA Esperance
Michelle Gray	Pilchard processor
Marcus Gray	Pilchard fisherman
Bernie Haberlie	CALM Esperance
Peter Hudson	Esperance Diving and Fishing
Leslie Hudson	Esperance Diving and Fishing
Barry Jeitz	Member of Esperance Yacht Club
Mike Kahlor	Esperance Shire Engineer
Bill Kent	President Esperance Professional Fishermen Assoc
Monica Kraft	Charter Operator
Roy Kraft	Charter Operator
Eric Loughton	Fisheries WA Esperance
Jon Lipscombe	Member Esperance Deap Sea Angling Club
Fud MacKenzie	Owner Mackenzie Tours
Hugh MacKenzie	Hugh MacKenzie
D'Arcy Madgen	Skipper, *Real Action*
Colin Maloney	Member of Esperance Yacht Club

Ian Mickel	Esperance Shire President
Victor Nicoleho	Esperance Deep Sea Angling Club
Marie Northcoat	Wild West Sports Kalgoorlie
Matthew Payne	Goldfields Esperance Development Commission
Buck Rodgers	Shire Councillor/ Duke of Orleans Caravan Park
Rob Rollond	Esperance Air Charter
Brad Scoble	Crews for Mackenzie's Island Tours
Chris Seimer	Conservation Movement
Elaine Seimer	Conservation Movement
David Smallwood	Farmer - Duchess Downs
Barry Sponberg	Esperance Shire Planner
Mike Spragg	Baywatch
Roger Stewart	Manager of Esperance Yacht Club
Brett Thorpe	President Esperance Chamber of Commerce
Klaus Tiederman	CALM Esperance
John Totterdell	Fishing Industry Consultant
Chris Unwin	Pilchard Fisherman
Ralph Walsh	Esperance Professional Abalone Divers Assoc
Rod Warne	Member of Esperance Yacht Club
Lee Warner	Abalone Processor
David White	Member of Esperance Yacht Club
Nigel Worth	Esperance Deep Sea Angling Club

Consultations in Perth

Simon Bennison	Aquaculture Council of WA
Allen Carman-Brown	Ministry for Planning
Dr Jenny Cary	Department of Conservation and Land Management
Gary Hanstead	Esperance Regional Tourism Association
Lindsay Harbord	Chair, Recreational Fishing Advisory Committee
Ben Hollyock	Department of Environmental Protection
Dr Robert Kaye	Department of Transport
Guy Leyland	WA Fishing Industry Council
Frank Prokop	RECFISHWEST
Claire Savage	Department of Tourism
Cane Spaseski	Ministry for Planning
Dr Barry Wilson, FTSE	Chair, Marine Parks and Reserves Authority
Ian Taylor	Chair, Aquaculture Development Council

An overview of the Aquaculture Industry in Western Australia

Fish Unlimited
PO Box 558
Jolimont WA 6913

2 December, 1998

Aquaculture Industry Overview

Definitions

Aquaculture as a science, farming activity and as a business may be described by the following range of activities:

Aquaculture is the farming and husbandry of freshwater and marine organisms;
Aquaculture is the propagation and cultivation of aquatic animals and plants for profit or social benefit;
Aquaculture is the controlled cultivation and harvest of aquatic plants and animals.

The following working definition is provided by the Food and Agricultural Organisation of the United Nations:

Aquaculture is defined as the farming of aquatic organisms including finfish, molluscs and crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators etc. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquatic organisms which are harvested by an individual or corporate body which has owned them throughout their rearing period contribute to aquaculture, while aquatic organisms which are exploitable by the public as a common property resource with or without appropriate licences are the harvest of fisheries. (FAO 1988)

Range of Activities

Purposes of aquaculture include:

- Food production;
- Conservation (to augment declining stocks);
- Maintenance of commercial wild capture fisheries;
- Recreation;
- Aquarium fish;
- Production of pharmaceuticals, other industrial products and jewellery.

Demand for Product

Global Issues:

- World population continues to grow;
- Food shortages (particularly for cheap protein) continue to occur;
- Wild capture fisheries production has reached (and in many cases exceeded) maximum sustainable yields;
- Demand for gourmet items among wealthy populations is growing;
- Supplementation of wild stocks is necessary under some circumstances (enhancement of wild capture and recreational fisheries);

- Demand for ornamental fish is strong;
- Health food markets are strong;
- Demand for jewellery is strong.

Worldwide, the demand for fish and fish product is increasing dramatically due to the declining wild capture fishery (most are either at or near their maximum exploitable levels) and the increasing population.

According to the FAO total production in 1995 was 27.76 million tonnes with a value of US$ 42.32 billion. The capture industry production in 1995 was estimated to be 92.0 million tonnes and is expected to plateau at around 100 million tonnes by the year 2000.

The majority of aquaculture production is comprised of freshwater finfish (Chinese and Indian carps 45.6%).

Australian production in 1995 was estimated to be 26 117 tonnes and was valued at A$ 396 million. It should be noted the pearl oyster industry contributed over A$ 150 million to this total.

While the Western Australian industry contributed over A$ 124 million to this total only $ 3 million was food production aquaculture.

Culture Systems

As with conventional farming, aquaculture systems vary in intensity and may be described as ranging from extensive through to intensive systems. Extensive systems are characterised by having relatively few inputs by the operator.

Extensive culture: (eg yabby farming in farm dams: marron farming is regarded as semi-intensive as purpose built ponds are used)

- No feeding;
- Low control over the systems;
- Low energy;
- Low stocking rate;
- Site critical;
- Large areas needed for economic production;
- Low yields;
- Labour intensive.

Intensive Culture (eg sea cage farming, land based raceways)

- Artificial diet;
- High level of management required;
- High energy input;
- High stocking rate;
- Site not as relevant;

- Smaller area required;
- High yields;
- Capital intensive.

Generally as the degree of management increases:

- Yields increase;
- Potential for disease increases;
- Water quality maintenance needs increase.

To intensify an aquaculture operation one can:

- Increase the nutrient supply;
- Increase clean water input;
- Choose efficient species which grow quickly.

Stages of Culture

There are a number of distinct stages in the culture of aquatic species and for technical, biological and business reasons it is important to understand the requirements of each stage.

Stage 1. Spawning:

- can occur in the wild;
- can be controlled in ponds;
- may be triggered by environmental cues;
- can be induced hormones injected into fish.

Stage 2. Egg incubation:

- need to provide conditions which maximise survival.

Stage 3. Juvenile and Larval Rearing:

- need to provide suitable conditions;
- need to provide suitable feed and weaning;
- minimise mortalities while maximising growth.

Stage 4. Grow-out – to market size(s)

- minimise mortalities while maximising growth;
- stocking density important as is minimising losses to predation.

Stage 5. Harvest and handling

- grading/handling;
- packaging;

- storage;
- transport.
-

Choices of Species for Aquaculture

This will depend on purpose of the culturing such as:

- Food product;
- Conservation (restocking black bream);
- Maintenance of wild fisheries (seeding of scallops);
- Recreation (put and take fisheries);
- Ornamentals for the aquarium industry;
- Healthfoods (algae such as *spirulina);*
- Feed production (*artemia).*

Species selection criteria from a biological perspective should include:

- Established hatchery techniques;
- Ability to be held at high densities;
- Rapid and uniform growth;
- Appropriate dietary requirements;
- Amenable to artificial diets;
- Efficient food conversion ratios (no more than 2:1);
- Non cannibalistic;
- Disease resistant;
- High meat recovery.

Criteria for site selection should include:

Site selection is critical to the success of an aquaculture venture and consideration should be given to the following factors:

1. Land Based

- Climate;
- Water;
- Topography;
- Soil types (depth of clay);
- Predators;
- Access;
- Power and other utilities;
- Proximity to markets;
- Value of real estate;
- Surrounding land use;
- Capacity to expand;

- Legal issues (Native Title).

2. Sea based

- Climate;
- Water quality parameters;
- Competing users (tourism, commercial and recreational fishing,);
- Currents;
- Predators;
- Available land based infrastructure;
- Sea grasses;
- Legalities;
- Tenure;
- Steaming distance;
- Energy action of the ocean.

Criteria for investment decisions in commercial aquaculture

The major additional considerations for *commercial* aquaculture are:

- Access to sites;
- Tenure over sites;
- Access to water;
- Access to capital;
- Cost effective production systems;
- Market knowledge;
- Marketing knowledge;
- High demand in the marketplace;
- Acceptable regulatory environment.

The following species are commercially produced in WA:

- Trout;
- blue mussels;
- silver perch;
- black bream;
- barramundi;
- ornamental fish;
- pink snapper;
- yabbies;
- marron;
- edible oysters.

Appendix 6 Wind Roses for Esperance

Wind Frequency Analyses and Wind Roses

The included set of wind frequency analysis tables and/or wind roses show the frequency with which winds of various strengths are observed coming from various directions. These notes should help you to use the information.

Data

Wind speed and direction are measured by a number of means. In some cases, they are only estimated. To find out exactly which method has been used, a search of the appropriate station history file would be required.
The data are collected by the National Climate Centre in the Bureau of Meteorology's Melbourne head office. They are stored in ADAM (the Australian Data Archive for Meteorology), an extensive computer database of meteorological observations.
As the observations are stored, basic checks are performed. Any observations that fail these tests (specifically, any whose quality flag is poorer than "4 - estimated, medium certainty") are excluded from the frequency analyses that follow.

Analysis

The data are collated in a number of ways, depending on the nature of your request.
To group by hour, the observations are assigned to the closest standard three-hour reporting time. For example, all observations between 7:30 am and 10:30 am local standard time are labelled "9 am".
If a seasonal grouping has been requested, then "autumn" is March, April and May, "winter" is June, July and August, "spring" is September, October and November, and "summer" is December, January and February.
The observations are then grouped by speed. The exact number of speed ranges and their size depends on your request. When the speed ranges are labelled, "1 - 10" is used for all speeds greater than 0 but less than or equal to 10, "11 - 20" means greater than 10 but less than or equal to 20.
The data are then grouped by direction: into 8 or 16 bins as requested. When doing this, observations that fall on a bin boundary are split equally between the two bins. For example, when grouping into 8 bins, a direction of "NE" covers all observations with directions strictly between NNE and ENE; "E" covers from ENE to ESE. If the direction is exactly ENE (67.5°), then it will be placed half in the "NE" bin and half in "E" one.

Tables

If you have requested wind frequency tables, then you will get a separate table for each time group. Each table shows the time to which it applies, and the total number of observations used at that time. The percentage frequency with which calm conditions (that is, no wind) are observed are displayed at the top left of the table.
The rest of the table is laid out with directions across and speeds down. To find the frequency with which winds of a given speed and direction occur, follow down the appropriate direction column and across the speed row until they intersect. The value printed there is the frequency you require. For example, a value of "14" indicates that this speed/direction group occur about 14% of the time. "0" indicates the range has occurred but less than 0.5% of the time.
The last column, labelled "All", gives the frequency of each speed range regardless of direction. Similarly, the last row gives the frequency of each direction, regardless of speed.

Roses

Wind Roses seek to make the data in a wind frequency table easier to digest. Although not ideal for quantitative work, they are good for providing a quick visual impression of the wind regime.
Like the tables, there is one wind rose for each time group that you requested. Each rose consist of a central circle, surrounded by branches, each made up of a number of petals.
The circle represents the frequency of calm conditions. The size of the circle is proportional to the number of calms; a scale is given in the legend at the top of the page.
Each branch represents the wind coming from that direction. North is to the top, and the other directions are shown in the legend. In each case, the wind is blowing from that direction toward the calms circle. Each petal corresponds to a speed range from that direction. The length of the petal is proportional to the frequency of that wind; the scale is shown in the legend. The thickness of the petal is used to indicated which speed range it represents.

Copyright and Disclaimer

More Information

Prepared by Climate and Consultancy Section in the Western Australian Regional Office of the Bureau of Meteorology

Contact us by phone on (08) 9263 2222, by fax on (08) 9263 2233, or by email on climate.wa@bom.gov.au

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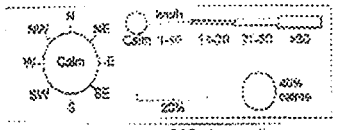
Wind Roses using available data between 1969 and 1998 for Esperance

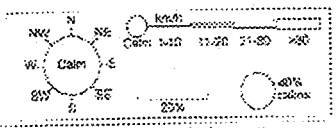
Site Number 009789 • Locality: Esperance • Opened Jun 1969 • Still Open
Latitude 33°49'51"S • Longitude 121°53'27"E • Elevation 25m



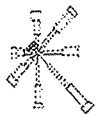
3 pm January	892 observations	3 pm February	811 observations	3 pm March	886 observations
3 pm April	869 observations	3 pm May	897 observations	3 pm June	872 observations
3 pm July	929 observations	3 pm August	930 observations	3 pm September	898 observations
3 pm October	928 observations	3 pm November	899 observations	3 pm December	913 observations

Wind Roses using available data between 1969 and 1998 for Esperance

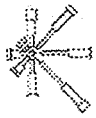
Site Number 009789 • Locality: Esperance • Opened Jun 1969 • Still Open
Latitude 33°45'51"S • Longitude 121°53'27"E • Elevation 25m



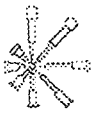
9 am January 898 observations



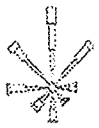
9 am February 819 observations



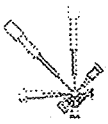
9 am March 898 observations



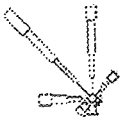
9 am April 870 observations



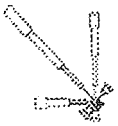
9 am May 886 observations



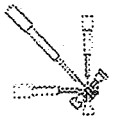
9 am June 872 observations



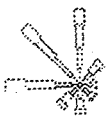
9 am July 929 observations



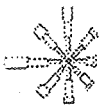
9 am August 930 observations



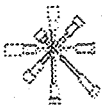
9 am September 898 observations



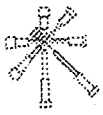
9 am October 928 observations



9 am November 889 observations



9 am December 915 observations



Appendix 7 Industry Constraints

There are a number of constraints facing the development of the aquaculture industry in Western Australia which also apply to the Recherche Archipelago. While these constraints are presently affecting the pace of development it is encouraging to note that many of the issues are being addressed by Fisheries Western Australia, the Fremantle Maritime Centre and a range of institutions and private companies. The constraints include:

Technology

The current level of technical knowledge in Western Australia will constrain the development of the industry in the Recherche Archipelago in a number of different ways including:

- limited choice of suitable species available;
- diets;
- knowledge of disease and treatment;
- lack of personnel with commercial aquaculture experience;
- lack of practical knowledge in cage culture techniques in Western Australian conditions.

Species Choice

There is a danger that a decision to grow a particular species is often based more on the basis of availability rather than a more comprehensive selection criteria. For example, while pink snapper have been cultured and are available (in part) this may not be the best finfish species to grow in a particular region. Therefore a commercial operator (or government) will have to develop culturing techniques for the selected species.

Diets

When developing culturing techniques for marine species a vital part of the work includes creating the best nutritional requirements for the various stages of production and getting this right requires additional human and financial resources.

Despite the fact that there is considerable research and development investigating alternative protein sources for fish feed (including a lupin trial at the Fremantle Maritime Centre) the aquaculture industry is still a net protein consumer (through the use of Atrash≅ fish for meal) and comes under criticism from the environmental movement worldwide when it champions its role as easing world fishing pressures. There is encouraging results being achieved at Port Lincoln with the artificial diet developed for Southern Bluefin Tuna.

Knowledge of Disease and Treatments

While there is considerable knowledge throughout the world on the various diseases fish and other aquatic organisms are subject to, from a fish farming perspective there is a critical need to know why, how and what to look for when they manifest. It is also imperative to know how to treat the fish and mitigate the reasons for the disease. Generally speaking the majority of disease problems in fish farming are attributable to husbandry and management.

Lack of Personnel

Although there are excellent education and training opportunities being made available to the state, including practical hands on learning, there is a dearth of large food aquaculture projects employing significant numbers of people. This can result in a small relatively inexperienced workforce. As the industry develops, providing operators are prepared to give commercially inexperienced technician level staff a chance, this problem should reduce. Alternatively experienced staff are imported.

Lack of Practical Knowledge in Cage Culture Techniques in Western Australian Conditions

Despite the advances being made in the hatchery aspects of creating skill and knowledge, there is very limited practical, commercial experience in handling cage culture in Western Australia. This is simply due to the lack of projects.

The lack of commercial technical experience in a developing industry can seriously impede its progress. There are a range of complex issues to deal with when developing culture techniques for new species, as well as the ongoing challenges that arise such as improving survivability and maximising growth rates.

Proponents should not underestimate the level of technical knowledge required to achieve long term success. Furthermore this demand for knowledge is not static and the operator should always be seeking ways to achieve better results in an industry that must not be economically viable but increasingly ecologically sustainable.

Market Knowledge

To date there has been relatively little work carried out on the market potential for most candidate species in Western Australia and while several private companies have undertaken studies related to their particular operations the findings are commercially sensitive and are not in the public domain.

A lack of knowledge of the dynamics of the seafood market and how to differentiate or position aquaculture product in the market place may lead to incorrect assumptions about price needed, volume required and how best to promote the product. Proponents in the Recherche developing projects should carry out a thorough market analysis of candidate species as part of their business planning.

Marketing

Aquaculturists often require a premium price for their products to offset high production costs, and must actively develop high-value niche markets. This process is both time consuming and costly. While aquaculture operations have the distinct advantage of controlling the size of the product and the time of harvest, the highest-value size and time of harvest may conflict with existing fisheries therefore effort is needed to ensure that well planned marketing can maximise the advantages of aquaculture product over wild caught product.

Aquaculture proponents should include a thorough marketing plan as an integral component of their overall development strategy and if necessary seek professional expertise to carry out the work.

Transport

Although the infrastructure surrounding the regional hub of Kalgoorlie-Boulder has resulted in a sophisticated transport system that serves Esperance well (This includes sealed roads, rail freight capacity, regular air services and a major port), the majority of the aquaculture industry=s transport requirements will be serviced by a seven hour road trip.

While there is no shortage of transport capacity it should still be recognised that the seven hour road distance may affect have a constraining effect on the industry in terms of additional cost of transporting materials to Esperance. This should be offset be the fact that chillers and freezers are sent to Perth empty 6 days per week and cheaper backloading rates should apply to the transport of product.

Proponents should be aware of potential increased project costs associated with transport and where possible and competitive, utilise local suppliers.

Finance and Investment

Financial institutions lend money when they believe there is a reasonable return subject to the risk of the venture. In aquaculture, there is a relatively high degree of regulatory, environmental (weather, temperature, water quality), disease, predation, and market risk.

Because of the risky nature of aquaculture enterprises, traditional banks may be unlikely to lend to potential or existing operations and given the lack of private financing, there are limited financing options available to potential aquaculturists.

The industry needs to approach leading financial institutions and make presentations on the status of the industry, level of government commitment and support and the opportunities it presents

Community Support

The process of any industry development is greatly enhanced when a community recognises the socio-economic benefits a healthy aquaculture industry can bring to its region. Conversely, a community which is not supportive of aquaculture can impede the planning progress, command unrealistic environmental restrictions and generally fail to help integrate the industry into the social and economic fabric of the community.

At an early stage, proponents should maintain open and close communications with the Esperance community and hold workshops to explain their project. With Fisheries Western Australia proponents should ensure the community has a role in the planning process including endorsing the level of assessment and on-going monitoring programs.

Water Quality and Quantity

Land based systems will require an initial fill, water reserves to offset losses from harvests, seepage, evaporation and flushing. While the quality and quantity of large volumes of fresh water may be a limiting factor for some industries in Esperance the availability of oceanic water for the development of marine species in land based systems should not present major problems. However the cost and approval processes of ocean intake supply and drainage can be significant.

While it is likely that the majority number of land based projects adjacent to the Recherche Archipelago will comprise marine species requiring large quantities of good quality oceanic water these projects will also need some freshwater for operations including cleaning of tanks, treatments for fish and production of rotifers (Kennerly D.1999 pers comm).

Open Ocean Aquaculture

Carrying Capacity

In order to develop a sustainable industry the carrying capacity of the site should be determined. Given the lack of scientific research on the Recherche to date, establishing carrying capacity will require additional resources to provide a detailed account of:

< current nutrient loadings;
< water quality;
< hydrographical features such as currents, wave actions;
< benthic status and habitat.

Without this baseline data it is difficult to judge whether carrying capacity will constrain the scale of industry being proposed in the Recherche Archipelago. Proponent need to undertake an environmental impact assessment of the site after determining carrying capacity.

A proponent needs to develop and implement (with FWA/CALM/DEP assistance) a monitoring program that can provide an indication of change in selected water quality and benthic characteristics, and whether this change is within the acceptable pre-determined parameters set for that specific farm.

Predation and Entanglements

There is no doubt that sea cages will attract the curiosity of birds and seals and can inflict considerable economic harm on operators. Stock losses can occur through direct prey, wounded fish attract lower market prices and stress may cause fish to reduce feeding and become more susceptible to disease (EOA 1997).

The entanglement of seals, birds and other marine mammals, while of significant concern to government agencies (Fisheries Western Australia, CALM) and the community, can also cause damage to predator nets and cages. It is in the best interest of the operator to install good quality predator nets and adopt a feeding management regime that minimises the opportunities for scavenging. Acoustic deterrent devices have been found to become ineffective over time as

the seals become accustomed or deafened by them. There is also evidence that the devices may interfere with animal communications.

Given the level of concern raised by members of the Esperance community and CALM regarding interactions between birds, seals and other coastal mammals it would be prudent that the operator takes all reasonable precautions to minimise entanglement and possible subsequent deaths. At the same time farmers must adopt anti predator strategies to minimise stock loss. Fisheries Western Australia and CALM would provide assistance to industry to identify (and if necessary develop) the best available net predator systems.

Fish Health

Aside from the economic losses a farmer may face from disease outbreaks in farmed stocks there are additional issues to consider in respect of fish health that should be considered. These include the risk of importation of non-indigenous pathogens and parasites, transfer of disease between farmed and wild stock and the potential for biological pollution from drugs and pesticides.

The impact of introduced pathogens, threat of disease in wild fish and the pollutive effects from over and improper use of drugs and pesticides has dogged aquaculture in the past. Aside from the risk of financial damage caused by an adverse fish health issue such as disease, the proponent is part of an ecologically sensitive environment with a community who in part are distrustful of aquaculture. Any early problems may result in the development of the industry being seriously impeded.

There should be serious consideration given to the range of practices aquaculture operators should adopt in order to prevent these occurrences. These practices should become part of the operators licence conditions.