THE AQUACULTURE DEVELOPMENT COUNCIL

AQUACULTURE PLANNING IN WESTERN AUSTRALIA

PART B: SITES AND MAPS

PREPARED BY

MAKAIRA PTY LTD

AND

***ecologia* ENVIRONMENTAL CONSULTANTS**

AUGUST 1997

Disclaimer

The information contained in this document is based on sources believed to be reliable. However, as no independent verification is possible, Makaira Pty Ltd and *ecologia* Environmental Consultants together with their members and employees give no warranty that the said base sources are correct and accept no responsibility for any resultant errors contained herein and any damage or loss, howsoever caused, suffered by any individual or corporation.

Acknowledgements

The authors wish to thank the CSIRO Division of Marine Research for providing data on seagrasses and the Department of Transport for shipping lane data.

CONTENTS

1 INTRODUCTION

Western Australia is distinguished by resources ideally suited for marine and fresh water aquaculture development. *Inter alia*, the aquaculture-oriented resources of the State include:

- tropical, sub-tropical, warm-temperate and cold-temperate aquatic environments;
- remarkably clean and pollution-free waters;
- a variety of marine and fresh-water species suitable for aquaculture;
- significant infrastructure and services;
- world-class technical and scientific research capabilities; and
- stable political, economic, legal and social systems.

Due in part to these resources, the recent growth of the aquaculture industry in Western Australia is likely to continue at an accelerating rate.

Future industry growth will be influenced by the identification and description of the principles fundamental to the development of the industry in Western Australia and the means by which these development principles are dealt with and industry needs met. Numerous planning studies with relevance to aquaculture development in Western Australia have been produced to provide the fundamental information needed by planners and administrators in government to organise and manage aquaculture. These studies provide various considerations and strategies for aquaculture industry organisation, management and development planning.

To determine the current status of aquaculture planning and development within Western Australia and to clearly identify future development opportunities, the Aquaculture Development Council has commissioned this study, entitled *Aquaculture Planning in Western Australia*, to review the existing planning studies and identify areas and species for future industry development.

Aquaculture Planning in Western Australia comprises two parts. *Part A: Synopsis and Review* provides a synopsis and review of existing and current planning studies, some details of Western Australia's coastal and inland regions and information about existing and potential aquaculture sites and species. *Part B: Sites and Maps* constitutes a stand-alone document that provides relevant maps and associated information. It contains:

- summary information about the identified aquaculture regions in Western Australia;
- more detailed information about two areas considered to have special significance for commercial aquaculture development;
- site maps for each of the identified aquaculture regions; and
- lists of species, comprising those currently produced by aquaculture and those identified as having potential, with information about the sites or regions to which each species is considered most suited.

WA Aquaculture Regions

For the purpose of this study, Western Australia is divided into a total of 14 aquaculture regions, comprising 10 coastal regions (section 2.1) and four inland regions (section 2.2). Chapter 2 summarises the general features of each region and the various categories of aquaculture sites it contains; for additional details, readers are referred to *Part A: Synopsis and Review.*

The 10 coastal aquaculture regions are divided and classified according to their geomorphological features. Three of the inland aquaculture regions are divided according to surface drainage patterns; sites included within these regions are characterised by the use of surface waters only. A fourth inland region provides a separate category for sites exclusively dependent upon ground water.

Special Significance Areas

There exist in Western Australia several sites or areas of special significance that have not yet been specifically identified for aquaculture by planning studies, but which for various reasons are considered well suited for commercial aquaculture development. Chapter 3 provides information about two Special Significance Areas, which are in the vicinity of Exmouth and Esperance.

Site Maps

Chapter 4 contains a series of maps that provide information about aquaculture sites in Western Australia. The maps identify sites or areas classified according to whether they are:

- existing or proposed;
- potential; or
- sensitive or prohibited.

The maps are numbered using a method that permits the efficient inclusion of additional maps of varying scale and detail without affecting the general page numbering of the document.

Aquaculture Species

A relatively small number of aquatic species are currently produced by aquaculture in Western Australia; many more have been identified as having potential for commercial production. Chapter 5 of *Part B: Sites and Maps* names the species considered suitable for aquaculture in Western Australia. Each species has accompanying information about its status (in respect of its aquaculture potential) and the regions to which it may be considered best suited for commercial aquaculture development.

2 WA AQUACULTURE REGIONS AND SITES

2.1 Coastal Regions and Aquaculture Sites

Extending from approximately 14°S to 35°S and from 113°E to 129°E, Western Australia's coastline is the longest of all Australian states and territories. The coastline encompasses a wide variety of physical and climatic characteristics and consequently features an impressive range of ecosystems, biological habitats and species.

The 10 coastal aquaculture regions described in this study and illustrated in map 0.0 are:

- the Kimberley Coast: from the Northern Territory border to Cape Leveque;
- the Canning Coast: from Cape Leveque to Cape Missiessy;
- Eighty Mile Beach: from Cape Missiessy to Cape Keraudrin;
- the Pilbara Coast: from Cape Keraudrin to the North-West Cape;
- the Ningaloo Coast: from the North-West Cape to Point Quobba;
- the Shark Bay Coast: from Point Quobba to Kalbarri;
- the Central West Coast: from Kalbarri to Perth;
- the Leeuwin-Naturaliste Coast: from Perth to Walpole Inlet;
- the South Coast: from Walpole Inlet to Esperance; and
- the Eucla Coast: from Esperance to the South Australian border.

2.1.1 The Kimberley Coast

The Kimberley Coast extends from the Northern Territory border to Cape Leveque on the Dampier Peninsula (map 1.0). Its coastal areas are generally affected by a macro-tidal regime, low wave energy, seasonal cyclones and large quantities of sediment transported by rivers during the wet season. The region has numerous mangrove forests, wide tidal flats and turbid waters. Main features are Cambridge Gulf, the north Kimberley coast, King Sound and numerous offshore islands and coral reefs.

While nearshore waters are muddy, conditions become increasingly oceanic towards the edge of the Kimberley Coast's relatively wide continental shelf. The oceanic islands comprise mid-shelf and shelf-edge islands, banks and reefs, many of which are built on platform coral reefs. Along the coast, species-rich fringing reefs grow on rocky substrates.

Aquaculture Sites

Many existing aquaculture operations, principally culturing *P. maxima* pearl oysters, occur on leases throughout the area, including King Sound, Doubtful Bay and Kuri Bay (maps 1.1, 1.2 and 1.3).

Numerous sites in the region's coastal and offshore areas may have future potential for aquaculture development if constraints such as the macro-tidal regime, seasonal access and remoteness can be overcome. These potential sites are located in various coastal bays, sounds, islands and reefs (map 1.0). Areas near the town sites of Wyndham and Derby have been identified as special development zones due to the services and facilities available and the areas of flats, marshes and ground water reserves that may be suited to aquaculture development.

Sensitive or prohibited areas principally include Marine and Nature Reserves.

2.1.2 The Canning Coast

The Canning Coast extends from Cape Leveque on the Dampier Peninsula to Cape Missiessy (map 2.0). Featuring a very large tidal range, moderate to low wave energy and little fluvial run-off, the Coast is characterised by long stretches of sandy beach between large, deeply-indented bays with rocky headlands, reefs and sand flats at their seaward corners and extensive mud flats that support mangroves at their heads. The open-ocean shores feature very wide intertidal sand flats with little plant growth but a rich fauna. Roebuck Bay, Lagrange Bay and the remainder of the Coast to the south contain a variety of landforms including rocky headlands, shores and intertidal platforms, extensive gravel, sand and mud flats, cliffs and open beaches.

The only offshore islands of the Canning Coast are the Lacepedes.

Aquaculture Sites

Existing aquaculture sites on the Canning Coast include pearling leases in Carnot Bay, Pender Bay, the Lacepede Islands and Roebuck Bay. The area also supports existing pearl oyster, redclaw crayfish and aquarium fish farming operations. Considered an essential component of aquaculture development in the Kimberley Region, the Broome Tropical Aquaculture Park, located on Riddell Point near Broome, will provide support for aquaculture ventures that aim to develop technology and provide seed or juveniles for stocking more remote aquaculture projects.

No potential aquaculture sites in the Canning Coast have been identified by planning studies; however, the entire region may be considered to have some potential.

Sensitive or prohibited aquaculture areas include various Nature and Marine Reserves. These include the Lacepede Islands, Roebuck Bay and Lagrange Bay (the area encompassing the shores and hinterland of Roebuck Bay south of the Broome town site is declared as a *Wetland of International Importance* for migratory shorebirds under the Ramsar Convention and although not specifically prohibited, aquaculture proposals in this area will be very sensitive from an environmental perspective.

2.1.3 Eighty Mile Beach

Eighty Mile Beach extends from Cape Missiessy to Cape Keraudrin (map 3.0). The white-sand beach, which has a very large tidal range and moderate wave energy, is approximately 220 km long and 100 m wide and slopes to muddy tidal sand flats. Its few small bays support sparse mangroves. The largely-unvegetated sand flats are very wide and extend seaward up to several kilometres.

Aquaculture Sites

Some sites occur off Eighty Mile Beach, where seeded oysters are cultured on longlines or in baskets.

No potential aquaculture sites have been identified within this sector; however, there are some sensitive areas. Eighty Mile Beach has high conservation significance as a habitat for migratory shorebirds and an area between Cape Missiessy and Cape Keraudren is designated as a *Wetland of International Importance* under the Ramsar Convention.

2.1.4 The Pilbara Coast

The Pilbara Coast extends from Cape Keraudrin to the North-West Cape (map 4.0). The shore line is dominated by long beaches and muddy tidal flats and the Coast characterised by deltas, barrier islands and lagoons with extensive mangroves backed by wide, supra-tidal flats. The climate is arid; the large rivers in the area are seasonal and flooding is infrequent. The Coast features more moderate tidal ranges, wave energy is low and the coastal environment influenced periodically by cyclones, which are relatively common in this area. Influenced by periodic run-off and strong tidal flows, the nearshore waters are fairly turbid.

The nearshore and offshore areas of the Rowley Shelf comprise numerous islands and coral reefs, the waters of which are clear. The islands include the Dampier Archipelago, Barrow Island and North and South Muiron islands. The Rowley Shoals are shelf-edge atolls that arise from deep water, are formed of coralline limestone and feature actively-growing coral reef systems, some with emergent sand cays.

Aquaculture Sites

Numerous pearling and aquaculture leases and licences have been issued for the Pilbara Coast (map 4). Pearling and aquaculture licences and leases issued in the vicinity of the Dampier Archipelago are shown in map 4.1; other leases occur in areas including the waters off Port Hedland, Dampier and the Montebello islands. Several pearling and aquaculture licences have been issued in Exmouth Gulf and a pearl oyster hatchery has been established in the area (map 4.2). A proposal has been made by the Gascoyne Development Commission and Curtin University to develop a marine research operation at Exmouth, to provide regional aquaculture research and development facilities.

The waters off Dampier, the Exmouth Gulf coastline and several areas within Exmouth Gulf have been identified as having potential for future aquaculture development using onshore and offshore production systems growing a range of marine finfish and shellfish. A coastal area in the vicinity of Exmouth is further described in this document in view of its special significance for aquaculture development (section 3.1, map 4.2).

Numerous areas in which aquaculture would be sensitive or restricted occur within the Pilbara Coast. Many of the Coast's nearshore islands support Nature Reserves that would be sensitive to the development of aquaculture operations or support facilities. The Rowley Shoals Marine Park would be highly sensitive to aquaculture development (but may provide a valuable source of broodstock) and the Montebello islands are declared as a conservation park. The Bundegi Coastal Park and the Burrup Peninsula marine area may also be considered sensitive for environmental and recreational reasons.

2.1.5 The Ningaloo Coast

The Ningaloo Coast extends from the North-West Cape to Point Quobba (map 5.0). Its dominant feature is Ningaloo Reef, one of Australia's major coral reef systems, which extends from the North-West Cape to Gnarloo Bay and is reserved as a Marine Park. The shallow waters of the Reef support highly-complex coral reefs and an abundant and species-rich coral reef community. Southwards from Ningaloo Reef to Point Quobba, the rocky shore features low to high limestone cliffs exposed to westerly winds and swells and a limited number of partially-sheltered bays.

The marine environment of the Ningaloo Coast features very clear oceanic waters with a relatively low tidal range and high wave energy. Cyclones are less common than along the north-west coast. Little sediment or fresh water enters the sea due to the low annual rainfall characteristic of the arid tropics.

Aquaculture Sites

No existing aquaculture sites currently occur within the Ningaloo Coast region. While some sites have been identified as having limited potential, the constraints that would accompany development proposals would probably be prohibitive.

Almost all of this region is considered sensitive or prohibited: the Ningaloo Coast is dominated by the Ningaloo Marine Park, which is a sensitive area due to marine habitat values and recreational use. Aquaculture has been rated as being incompatible with and is therefore prohibited within the Cape Range National Park and the Jurabi Coastal Park.

2.1.6 The Shark Bay Coast

The Shark Bay Coast extends from Point Quobba to Kalbarri and includes Bernier, Dorre and Dirk Hartog islands (map 6.0). The principal feature is Shark Bay, a large marine embayment with extensive seagrass meadows that support large populations of marine mammals and reptiles. A large part of Shark Bay is reserved as a Marine Park and Marine Nature Reserve.

Bernier, Dorre and Dirk Hartog islands form the seaward boundary of Shark Bay. Their leeward, relatively-sheltered eastern shores are exposed to moderate wave action; the cliffs of their windward, western shores are exposed to high wave action. The eastern shore of Shark Bay is a low-relief, low-wave-energy shore with mangroves and wide tidal flats. The southern portion contains the hypersaline Hamelin Pool, which supports stromatolites of high conservation value. Sheltered areas within Shark Bay comprise sandy beaches and low limestone cliffs. The Gascoyne and Wooramel rivers enter the sea on the Shark Bay Coast. The southern section of the Coast comprises steep cliffs that extend southwards to Kalbarri.

The salinity of the sea water in Shark Bay gradually increases to hypersaline levels in the inner parts of the Bay. The coral reefs and coral communities of Shark Bay are small and only moderately rich in species; however, the Bay supports the world's largest known seagrass meadow.

Aquaculture Sites

The Shark Bay Coast supports several aquaculture sites (map 6.0). At Oyster Creek in Carnarvon, an existing hatchery is licensed to culture *P. maxima* pearl oyster seed and for aquaculture. Within Shark Bay, seven aquaculture licences have been issued; six for non-*P. maxima* pearl oysters and one for marine finfish. A 5 ha area for onshore aquaculture operations, including a support area for the existing pearling industry, has been proposed within the Monkey Mia Reserve.

Potential aquaculture sites on the Shark Bay Coast have been identified in the Gascoyne Aquaculture Development Plan. In the Carnarvon area, Babbage Island is considered suitable for a growout or hatchery facility and Oyster Creek for the aquaculture of brackish-water and marine species using onshore pond production systems. Within Shark Bay, several sites are considered to have potential for aquaculture development (map 6.1).

It should be noted that the current FDWA policy is that aquaculture licences will not be issued over seagrass areas. Accordingly, the potential aquaculture sites shown in map 6.1 have been restricted to areas with no significant seagrass meadows.

Significant sensitive and prohibited areas occur in the Shark Bay Coast region. In some areas, aquaculture may be considered sensitive but is not prohibited. However, the World Heritage Area does contain several zones within the Shark Bay Marine Park and the Hamelin Pool Marine Nature Reserve in which aquaculture is not permitted. These are sanctuary zones, recreation zones and special purpose zones. In addition to the marine conservation and recreation reserves, there are several terrestrial conservation reserves within which aquaculture would not form a compatible or consistent use with management objectives. The Wooramel Seagrass Bank should be considered a sensitive area due to the potential impact of an aquaculture operation on seagrass meadows. The South Passage navigational channel must be kept open for boating purposes, hence any aquaculture development here would constitute a hazard and not be permitted.

2.1.7 The Central West Coast

The Central West Coast extends between Kalbarri and Perth and includes the Abrolhos Islands (map 7.0). The coastline has long sandy beaches with high wave energy and relatively small tides, occasional limestone cliffs and headlands. Extensive limestone reef systems run parallel to the coast. These reefs shelter the sandy coastline and permit the growth of extensive seaweeds and seagrasses, which provide an important nursery ground. The seaweeds dominate the more exposed areas and seagrass meadows occur in the more sheltered areas. Small, species-poor coral reefs occur in some areas. The sea water is usually very clear due to limited fresh water run-off from the adjacent, low-rainfall land areas.

The Abrolhos Islands are influenced by the warm Leeuwin Current and comprise a series of coral platforms and islands that support prolific coral reef development. The high-energy seaward reefs of the islands are dominated by algal beds, while seagrass meadows are present in some of the protected, shallow areas. In terms of habitat and coral species diversity, the reefs of the Abrolhos Islands are the richest of any high-latitude reefs in the world. The reef

communities are unusual in that they support a significant number of temperate as well as tropical species. The occurrence of tropical fish species and some hard corals at Rottnest Island, offshore from Perth, is also due to the influence of the Leeuwin Current.

Aquaculture Sites

Existing aquaculture sites in the Central West Coast region include onshore and offshore operations. Beta-carotene is being cultured in Hutt Lagoon. One aquaculture licence has been issued for an offshore site at Green Island, near Cervantes. Two licences have been issued for four offshore sea-cage sites near Jurien Bay. Two hatchery licences have also been issued for onshore sites near the Jurien town site. One licence has been issued for a sea cage near the Geraldton Port and one non-*P. maxima* pearl oyster licence for a site at the Abrolhos Islands.

Several sites in the Central West Coast have been assessed for potential aquaculture development. Due to a lack of suitable infrastructure, some areas in the region are considered to have low aquaculture potential, while the coast between Jurien Bay and Black Point is considered to have some potential. Preliminary site selection studies have been carried out on the sector of the Central West Coast between Greenhead and Kalbarri. Of sixteen sites originally selected for evaluation, four were considered priority sites for aquaculture (located at Geraldton Port, Hutt River, South Hutt Lagoon and the proposed Port Kalbarri development).

Sensitive or prohibited aquaculture sites within the Central West Coast include National Parks and Nature Reserves that would inhibit access to the coast for onshore support facilities. The Marmion Marine Park off the northern Perth metropolitan coast includes sanctuary and recreation zones that would be prohibited for aquaculture; the remainder of the Park is considered sensitive. Although not mapped as such, proposals within the coastal zone of the Metropolitan Area and extending south to Mandurah should be considered sensitive due to the usage pressures placed on this stretch of coastline and the extent of conflict between commercial and recreational users in this area. The waters surrounding Rottnest Island are reserved for recreational purposes and commercial aquaculture is likely to be prohibited within this zone. Several additional areas have been proposed for marine reservation within this region.

2.1.8 The Leeuwin-Naturaliste Coast

The Leeuwin-Naturaliste Coast extends from Perth to Walpole Inlet on the south coast (map 8.0). Generally characterised by sandy beaches, limestone headlands and intertidal rock platforms, the coastline is exposed to heavy wave action. The nearshore and offshore waters are clear and high in quality. Seaweeds and seagrass meadows dominate in various areas according to the degree of shelter.

The main features of the region between Perth and Bunbury are Cockburn and Warnbro sounds; Rottnest, Garden and Carnac islands; and the Swan, Peel-Harvey and Leschenault estuaries. Between Bunbury and Cape Naturaliste, the main feature is Geographe Bay, the bed of which is dominated by extensive seagrass meadows. From Cape Naturaliste to Cape Leeuwin, the coast features sandy beaches between rocky headlands and the area is dominated by seaweed. South-eastwards towards Walpole Inlet, the coast is generally exposed to heavy

swells, while more sheltered conditions prevail in some protected bays and in the estuaries and inlets; significant features include Hardy, Broke, Nornalup and Walpole inlets.

Aquaculture Sites

Existing aquaculture sites within this region are comparatively limited. There are three aquaculture zones within the boundaries of the Fremantle Port Authority and a site to the east of Garden Island in Buchanan Bay has been proposed for the relocation of some existing leases that are due to expire and are unlikely to be renewed. Several leases for mussel culture occur within Warnbro and Cockburn Sounds (map 8.1).

No potential aquaculture sites were identified by the planning studies reviewed for this report.

Sensitive and prohibited aquaculture sites include the Shoalwater islands and the Shoalwater Marine Park: commercial aquaculture development is unlikely to be compatible with the management objectives for the location. Proposals for aquaculture sites previously identified within the Leschenault Inlet and Estuary have been rejected by the Leschenault Inlet Management Authority due to the possible impact on the fragile marine environment. The Peel-Harvey system is considered sensitive for aquaculture development since it is a nominated Ramsar wetland and includes areas that lie within nature reserves and national park boundaries. Several other reserves, within which aquaculture would be sensitive or prohibited, occur in this region.

2.1.9 The South Coast

The South Coast extends from Walpole Inlet to Esperance and includes the islands in Esperance Bay (map 9.0). The coastline comprises sandy bays, inlets, rocky headlands and cliffs with few sheltered areas. The open beaches are exposed to heavy wave action. Exposed reefs are covered by seaweeds, while seagrass meadows occur in the more sheltered areas. Sea-water quality is generally good and turbidity low.

The Albany harbours, which comprise Oyster Harbour, Princess Royal Harbour and King George Sound, are a major feature of the region. The habitats in these areas, which range from open-ocean marine to protected marine inlet and estuarine, support an exceptionally rich and diverse flora and fauna. Dense seagrass beds, some of which have been depleted, are species-rich and the extensive flats support diverse burrowing communities.

Aquaculture Sites

Existing aquaculture sites in the South Coast region occur mainly within the Albany harbours. These include licences within Oyster Harbour, Princess Royal Harbour and King George Sound (maps 9.1 and 9.2). The sites are used predominantly for the aquaculture of shellfish such as mussels and abalone.

Potential aquaculture sites in the region at this stage principally involve areas in the vicinity of Albany and Bremer Bay. The Albany harbours area has been investigated in detail for potential sites that may be used for aquaculture development: five areas identified for aquaculture in a planning and management study are illustrated in maps 9.1 and 9.2. A study into the potential

for aquaculture in the Bremer Bay region investigated seven sites within Dillon and Bremer bays for onshore aquaculture (map 9.3).

A recently-completed planning study for the Albany harbours places potential aquaculture areas over identified seagrass meadows. In maps 9.1 and 9.2, the extent to which the existing seagrass meadows overlie the potential aquaculture areas is shown. As indicated earlier in this document, current FDWA policy is that aquaculture licences will not be issued over seagrass areas; it is therefore unlikely that aquaculture will be permitted in areas that feature significant seagrass meadows.

Sensitive or prohibited aquaculture sites include the numerous National Parks and Nature Reserves that occur on the South Coast. Ledge Bay within the Albany Harbours is a recognised anchorage on nautical charts. Interference and conflict may occur with port activities and commercial fishing operations as well as recreational and visual impacts.

2.1.10 The Eucla Coast

The Eucla Coast extends from Esperance to the South Australian border and principally comprises the Recherche Archipelago and the shores of the Great Australian Bight (map 10.0). The shores are characterised by high-energy wave action and are either high limestone cliffs or long, curved beaches backed by dunes. The western part of the Eucla Coast features the Recherche Archipelago. Most of the many islands of the Recherche Archipelago are exposed to moderate to high wave action from all directions and there are few protected areas.

Aquaculture Sites

No existing sites have been identified in the Eucla Coast region. Similarly, no sites have been identified within existing planning reports as having potential for aquaculture development. However, the area in the vicinity of the recherche Archipelago is considered to have special significance for aquaculture development and is described in more detail in section 3.2 of this document.

Sensitive or prohibited aquaculture sites in the region include several National Parks. The Recherche Archipelago Nature Reserve includes islands of the archipelago that are incorporated into a single A-Class nature reserve. The waters of the Recherche Archipelago and islands that are State territory have been recommended for inclusion into the marine conservation reserve system.

2.2 Inland Regions and Aquaculture Sites

Most of Western Australia has no permanent rivers and streams; only the Kimberley and south-western areas of the State have adequate rainfall to support both permanent and ephemeral rivers and streams. Generally, the rivers and streams of the Leichardtian, Greyian and Vlaminghian regions are exorheic; that is, their waters drain into the sea through river systems. The few rivers in the central and Nullarbor areas of the State are arheic: little of the rainfall that does occur is carried off superficially. The State also has significant ground-water reserves that may have some potential for aquaculture development.

The four inland aquaculture regions described in this study and illustrated in map 0.0 are the:

- Leichardtian Region: principally comprising the Kimberley region (biogeographically, this area extends beyond Western Australia through the Northern Territory and into northern Queensland);
- Greyian Region: from the De Grey River in the north to the Murchison River in the south;
- Vlaminghian Region: the inland rivers and waters of south-west of Western Australia; and
- Ground-Water Region: includes all of Western Australia, so comprises the above inland regions but is distinguished by the use of ground water only.

2.2.1 The Leichardtian Region

The Leichardtian Region principally comprises the Kimberley Region of Western Australia (map 11.0). It has a dry winter and a summer wet season characterised by thunderstorms, monsoonal rain and occasional tropical cyclones. The major landforms of the Region vary from dune fields in the southern and eastern areas near the desert to the ranges and hills of the central and northern areas and low-lying, undulating land in the western area.

A significant feature of the region is Lake Argyle, which provides water to Lake Kununurra and thence to the irrigated areas of the Ord River Irrigation Area.

Aquaculture Sites

Existing aquaculture sites in the region are limited to a pilot barramundi operation on Lake Argyle.

Potential aquaculture sites mainly include Lake Argyle and the nearby irrigation area. Lake Argyle has been identified as a site with significant potential for offshore aquaculture development. Lake Kununurra, the Irrigation Area and the Lower Ord have been identified as areas with potential for fresh water aquaculture; the area presents opportunities for integrating aquaculture with the existing agricultural and horticultural industries. The Pastoral Zone of the Kimberley Region has also been nominated as having low to moderate aquaculture potential.

Sensitive or prohibited aquaculture sites include the region's many national parks, within which aquaculture would constitute an incompatible land use. Issues of land ownership and tenure should be investigated before feasibility studies are undertaken, due to the extent of pastoral leases and Aboriginal reserves within the region.

2.2.2 The Greyian Region

The Greyian Region principally comprises the Pilbara, Gascoyne and Mid-West regions of Western Australia (map 12.0). It features a semi-arid to arid climate and, in its more northern areas, has unreliable rainfall. The northern areas are influenced by cyclonic summer rainfall and less by winter rainfall. Inland areas receive sometimes-significant but patchy rainfall from

thunderstorms. The more southern areas receive rainfall from the northern sections of large cold fronts in winter and some from tropical cyclones in summer.

The landforms comprise broad, low-lying river catchments and plains between irregular ranges and hills. The major rivers in the Region generally flood after heavy rainfall and then contract to a series of permanent pools.

Aquaculture Sites

An existing aquaculture operation occurs within the Karratha town site for the production of redclaw crayfish and other tropical fresh-water species. Sites for beta-caotene aquaculture exist near Karratha and Port Hedland.

Potential aquaculture sites located in the Carnarvon Horticulture Zone on the Gascoyne River are supplied by surface-water flows as well as fresh to brackish water in aquifers beneath the river. Potential exists in this location for the aquaculture of fresh water crustaceans from plantation water allocations, with nutrient-enriched waste water being utilised for crop irrigation.

Sensitive or prohibited aquaculture sites occur in the Carnarvon area due to issues associated with water allocation and availability. Several National Parks and Nature Reserves that occur within this region and may be considered sensitive to or prohibited for aquaculture development.

2.2.3 The Vlaminghian Region

The Vlaminghian Region principally comprises the Wheatbelt, Perth, Peel, South-West and Great Southern regions of Western Australia (map 13.0).

The Wheatbelt area has a temperate to semi-arid climate with wet winters and dry summers. The landform is slightly undulating and the main land use is agriculture. Increasing problems with soil salinity and erosion are contributing to the degradation of the surface waters in the area.

The Perth and Peel areas are dominated by the passage of rain-bearing cold fronts during winter and hot easterly winds during summer. The landform is generally flat with low-lying sand dunes and numerous wetlands. Most of the area has been cleared for agricultural and urban uses. Many of the rivers in the area have their origins in the Wheatbelt, so are affected by increasing salinity and other problems such as excessive nutrients and sediments.

The south-western area generally receives high winter rainfall from rain-bearing depressions and cold fronts during winter; dry, easterly winds predominate in summer. Drainage lines are well defined and the Darling escarpment is a major landform. State forests dominate the area and agriculture is generally confined to some river valleys.

The temperate south coast area is dominated by cold fronts in winter and mild, dry summers. Landforms comprise extensive areas of gently-undulating land with some rock outcrops and ranges. Most of the land has been cleared for agriculture. Almost all the rivers and estuaries in

the south coast areas have been affected by salinity, nutrients and sediments from the cleared land and surface-water quality is generally deteriorating.

Rivers in the Vlaminghian Region exhibit two trends: about half arise in forested areas or areas with over 1100 mm of annual rainfall and the remainder in agricultural areas with less than 900 mm rainfall. Rivers in the latter area are characterised by increasing salinity.

Aquaculture Sites

The Vlaminghian Region accommodates most of Western Australia's marron farming industry; numerous marron farming operations occur throughout this region, including approved farms in the Shires of Kalamunda, Manjimup, Harvey, Capel, Esperance and Northam. Due to the importance placed on the industry, a proposal exists to establish a demonstration marron farm at the Wokalup Research Station near Harvey. The Pemberton trout hatchery conducts basic aquaculture research into fresh water species and supplies juvenile rainbow and brown trout to replenish river systems for recreational fishing, stocking of farm dams and for commercial needs. Curtin University and Collie TAFE are undertaking research into the use of disused coal-mine pits for aquaculture development using marron and native fresh water fish.

Potential inland, fresh-water aquaculture sites have been assessed for the Shire of Dandaragan, which is characterised by limited and brackish surface water: some potential was identified for development of ponds utilising streams or shallow ground water. There is potential within the South West Irrigation Area for fresh water aquaculture development, involving the integration of marron aquaculture with existing farming operations. The Bremer Bay region is considered to have low to medium inland aquaculture potential but no specific sites have been identified.

Sensitive or prohibited aquaculture sites include the numerous National Parks and Nature Reserves that occur throughout this region.

2.2.4 The Ground Water Region

Many inland areas of Western Australia are characterised by having access to ground water, which is subterranean water stored or flowing in sand, sedimentary rock or fractured rock. Large volumes of ground water underlie much of Western Australia's surface. The quality of these waters can vary significantly; for example, the salinity ranges from fresh to hypersaline. Some aquifers contain fossil water; that is, they are no longer recharged. Others are recharged at rates governed by features such as soil permeability, surface drainage structures and evaporation and rainfall patterns.

The Ground-Water Region overlies the other inland regions described above; it comprises the Kimberley, Pilbara, Gascoyne, Mid-West, Wheatbelt, Perth, Peel, South-West, Great Southern and Goldfields-Esperance regions. Its general features are therefore those described for the Leichardtian, Greyian and Vlaminghian regions above.

Aquaculture Sites

An existing pilot operation is using ground water to grow barramundi in the Greyian Region. Other existing aquaculture sites in this region are identified in the relevant sections of the Leichardtian, Greyian and Vlaminghian regions above.

Potential aquaculture sites with potential for growout and hatchery operations utilising bore water occur near the Carnarvon town site. Two sites with potential have been identified: one within the existing industrial area and another at Bibawarra Bore. The aquaculture potential of the Gascoyne Pastoral Zone has been assessed in reference to the use of ground water, as surface water is generally lacking. Lake MacLeod has been classified as having moderate potential if aquaculture operations could be integrated with the Dampier Salt operations. Ground water from the Birdrong Sandstone in the Gascoyne Province could be used for tank and pond enclosures of marine and estuarine species. The area lacks permanent surface water, so may be suitable for quarantining or aquaculture of introduced or exotic species. The Dandaragan Aquaculture Development Plan included potential for the use of ground water, with two land systems considered suitable.

Sensitive or prohibited aquaculture sites occur in or near conservation reserves and national parks throughout the State. An additional sensitive issue is that of aquatic stygofauna, five species of which are protected, that inhabit karstic zones that occur throughout the State.

3 SPECIAL SIGNIFICANCE AREAS

Areas in the vicinity of Exmouth on the North-West Cape and Esperance on the south coast are considered to be of special significance for aquaculture development. These sites are dealt with in sections 3.1 and 3.2, which provide some relevant information about their physical, and biological features; limited information is also provided about certain economic factors.

Sections 3.1 and 3.2 provide a brief description of the special significance areas according to the site selection criteria established in chapter 4 of *Part A: Synopsis and Review.*

It is emphasised that the information provided is indicative only; any aquaculture proponent contemplating the establishment of a commercial aquaculture operation at either of these sites should proceed by carrying out a more comprehensive assessment of site suitability by way of a detailed feasibility study.

3.1 Exmouth

A coastal area near Exmouth, south of the North-West Cape and on its eastern coast, is considered to have good potential for commercial aquaculture development (map 4.2). In particular, the area has access to high-quality sea water that can be pumped from beach wells and is considered suitable for the onshore production of tropical marine finfish.

3.1.1 Physical Features

Location

The area of special significance for aquaculture development near Exmouth comprises the coastal strip of land from Point Murat to several kilometres south of the Exmouth town site; it could extend a few hundred metres inland from the shoreline.

Topography

The area is dominated by the Cape Range; however, the coastal strip along the eastern shore comprises low-relief sand dunes and flats with a few limestone outcrops. The land elevation is approximately 5-10 m above mean sea level. The sand overlies karstic limestone that is well suited for the establishment of beach wells for water supply.

Hydrology

The area is sheltered from prevailing winds but occasionally affected by tropical cyclones. The maximum tidal range is about 3 m and storm surges can exceed this, particularly towards the bottom of the Gulf.

Water Supply and Discharge

Given the karstic nature of the subterranean limestone, the area is considered suited for the establishment of onshore, flow-through aquaculture operations that extract sea water from

beach wells. This water-supply system would provide hatchery and growout operations with filtered water at relatively high flow rates. After some treatment to remove waste materials, used sea water could be discharged by gravity directly into the Gulf.

3.1.2 Biological Features

Water Quality

The quality of the sea water in the vicinity of the site is generally high. Sea-surface temperatures can range from over 28°C in summer to below 18°C in winter, so the area would be suited to the production of tropical and sub-tropical species (section 3.1.4). It should be noted that the annual and daily sea-water temperature ranges can be significantly influenced by local conditions and the water source; for example, the temperature of sea water extracted from beach wells will be modified according to the ground temperature. Generally, the salinity and other variables such as pH are approximately those of sea water. Usually low at the northern end of the Gulf, turbidity increases towards its southern end.

Environmental Factors

The marine environment of the western shores of Exmouth Gulf supports a diverse fauna. Coral reef systems occur in its northern part and, further to the south, the sea bed is stony with a shallow sand cover and supports extensive beds of soft coral and sponges. It is likely that the sea water pumped through onshore aquaculture operations would require some form of primary treatment to extract suspended solids before it is discharged into the Gulf.

Little fresh water is available in the semi-arid region, so aquaculture operations are likely to be limited to those culturing marine species. Any extraction of fresh or brackish ground water may impact on the stygofauna that inhabit subterranean limestone caves.

Pollution and Contamination

The local environment is comparatively pristine and at this stage there are no significant sources of pollution or contamination.

Parasites and Predators

Onshore, intensive aquaculture production systems utilising filtered sea water extracted from beach wells are unlikely to experience significant losses as a result of parasites and predators.

3.1.3 Economic Factors

Infrastructure and Services

The infrastructure and services are generally good. The area has access to three-phase electrical power, telecommunication facilities and potable water. All the key trades such as plumbing and electrical services are available. The area is considered remote and any new

buildings or other installations are likely to be comparatively expensive: these costs need to be carefully assessed in a feasibility study.

Feed and Raw Materials

All growout feeds, hatchery diets and raw materials would have to be transported from Perth.

Processing and Packaging

Limited processing and packaging facilities are already available near Exmouth. According to the type of processing and packaging that may be required, additional facilities could be established on site or harvested products freighted to Perth for post-harvest treatment.

Transportation and Markets

A disadvantage of the site is its relatively remote location: it is approximately 1 200 km north of Perth. However, the area is well serviced by road and air transport. Learmonth Airport is soon to be upgraded and the Gascoyne Development Commission, which is undertaking a study to determine the region's future transportation requirements, anticipates that international air links to the region, stimulated by the growing eco-tourism market, will increase. Opportunities will then be available for exporting high-value products directly to Asian and European markets.

Other Factors

Exmouth is a progressive town that provides a good standard of accommodation as well as excellent social and recreational facilities. The development of a major marina near the town is stimulating development.

3.1.4 Candidate Species

The Exmouth special significance area is considered suited for the commercial aquaculture of tropical and sub-tropical marine species using onshore, intensive and semi-intensive production systems. Candidate species include (but are not necessarily limited to) the following finfish and shellfish.

Marine Finfish: barramundi cod, mangrove jack, coral trout, bar-cheeked coral trout, red emperor, southern bluefin tuna (hatchery only), estuary cod and mahimahi.

Marine Shellfish: tropical abalone, marine prawns and mud crab.

In particular, the Exmouth Special Significance Area is considered ideally suited for the aquaculture of tropical marine finfish.

3.2 Esperance

The Recherche Archipelago east of Esperance is considered to have good potential for commercial aquaculture development (map 10.0). In particular, the area is characterised by numerous islands and high-quality sea water that can be utilised for the offshore production of temperate and cold-temperate species of marine finfish and shellfish. Any development of offshore aquaculture using sea cages or longlines would need to be supported by a suitable onshore facility.

3.2.1 Physical Features

Location

The area of special significance for aquaculture development near Esperance comprises the waters of the Recherche Archipelago eastwards from the Esperance town site. It also includes the islands in Esperance Bay. The Recherche Archipelago extends for over 200 km and includes many islands.

Topography

The islands resemble the granitic headlands of the mainland coast. The rocky promontories have smooth, steep slides sloping into the sea in the more exposed areas, while the more sheltered shores have boulders and tidal pools. Some headlands shelter small beaches.

Hydrology

Most of the islands are exposed to high or moderate wave action from all directions and there are few safe anchorages or landings. The sea-floor depth averages about 40 m and most of the islands are within the 50 m bathymetric contour.

Water Supply and Discharge

Only offshore, open production systems utilising sea cages and longlines are suited for this area, so sea water supply and discharge systems for growout are irrelevant.

Onshore support facilities may include hatcheries, resources to hold or wean juvenile stock and holding tanks for harvested stock. The selection of a suitable site or sites for these facilities and a discussion of their sea water supply and discharge characteristics is beyond the scope of this document; however, these issues would form a critical part of a feasibility study for any commercial aquaculture venture proposed for this area.

3.2.2 Biological Features

Water Quality

The sea-water quality is considered excellent and is best described as oceanic. Sea-surface temperatures have not been well documented; however, the area is not influenced by the warm

Leeuwin Current, which flows further offshore, so may provide waters cold enough for the production of sea trout and would be well suited for the production of temperate and cold-temperate species (section 3.2.4). It is possible that sea-surface temperatures over 20°C could be experienced during summer and winter minima below 14°C are likely.

Environmental Factors

Most of the islands of the Recherche Archipelago are Nature Reserves. The marine flora and fauna of Western Australia's South and Eucla coasts are poorly known but probably similar to those of South Australia and Victoria. There are indications that extensive seagrass beds occur in the bays but there is no more detailed information about their composition or associated flora and fauna. Fish communities are abundant. Many of the islands support breeding colonies of Australian sea lions and New Zealand fur seals and provide nesting areas for the little penguin.

Pollution and Contamination

The local environment is considered pristine and at this stage there are no significant sources of pollution or contamination.

Parasites and Predators

The occurrence of parasites that could affect finfish and shellfish in open-water production systems is unknown at present. Large aquatic predators such as sharks and seals occur in the area, sometimes in large numbers, and would necessitate the inclusion of effective predator nets or other predator-exclusion methods with sea cages.

3.2.3 Economic Factors

Infrastructure and Services

There is no existing infrastructure on any of the islands. Excellent infrastructure and services are available at Esperance, which is the regional centre and a thriving town.

Feed and Raw Materials

All growout feeds, hatchery diets and raw materials would have to be transported from Perth.

Processing and Packaging

Esperance has some processing and packaging facilities as a result of the wild-capture fishery that the town supports. According to the type of processing and packaging that may be required, additional facilities could be established on site or harvested products can be freighted to Perth for post-harvest treatment or value adding.

Transportation and Markets

The area is well serviced by road transport and well placed for reaching the larger domestic markets in Sydney and Melbourne. Product grown for export to overseas markets by air would first have to be sent to Perth by road freight.

Other Factors

Esperance provides a high standard of accommodation as well as excellent social, educational and recreational facilities.

3.2.4 Candidate Species

The Esperance special significance area is considered suited for the commercial aquaculture of temperate and cold-temperate marine species using offshore, intensive and semi-intensive production systems. Candidate species include (but are not necessarily limited to) the following finfish and shellfish.

Marine Finfish: sea trout, snapper, Westralian dhufish, yellowtail kingfish, King George whiting and greenback flounder.

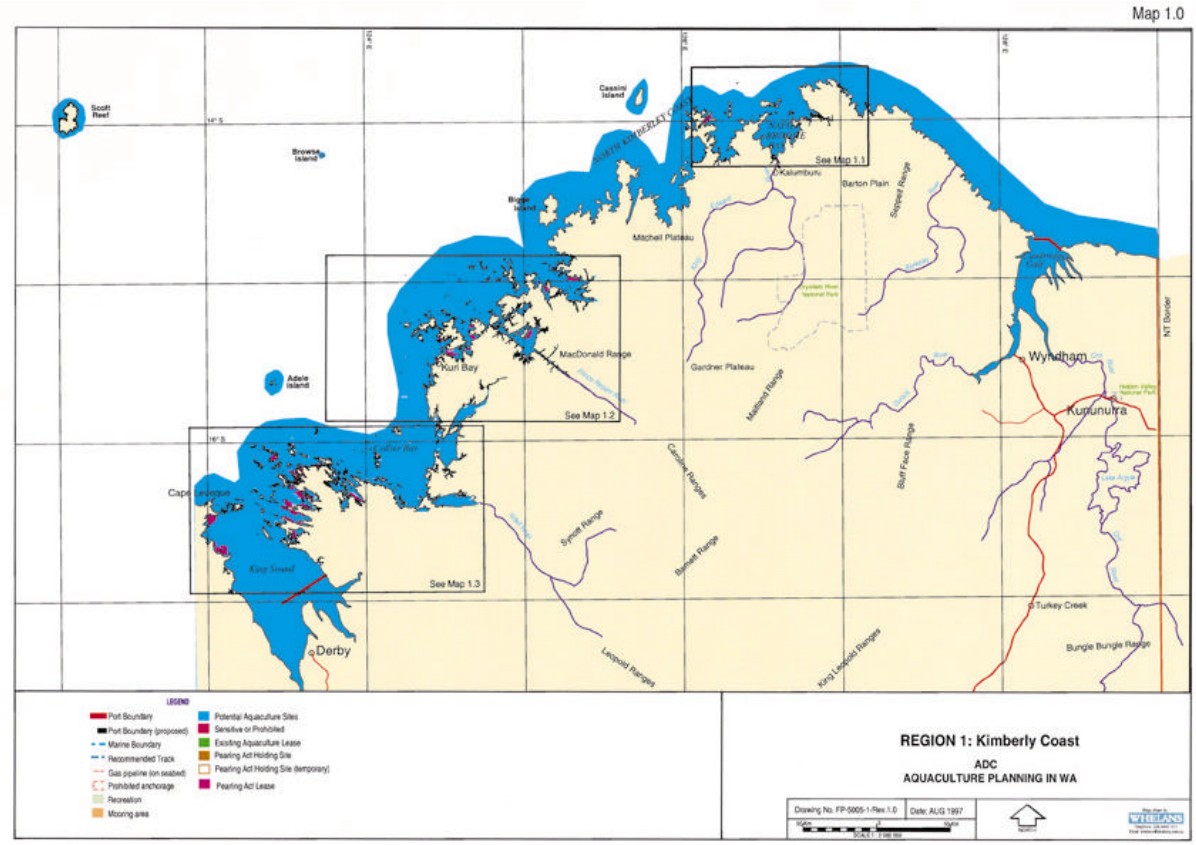
Marine Shellfish: greenlip abalone, brownlip abalone, Roe's abalone and western rock lobster.

In particular, the Esperance Special Significance Area is considered ideally suited for the aquaculture of marine shellfish such as greenlip abalone and, subject to sea water temperatures being proved suitable, finfish such as sea trout.

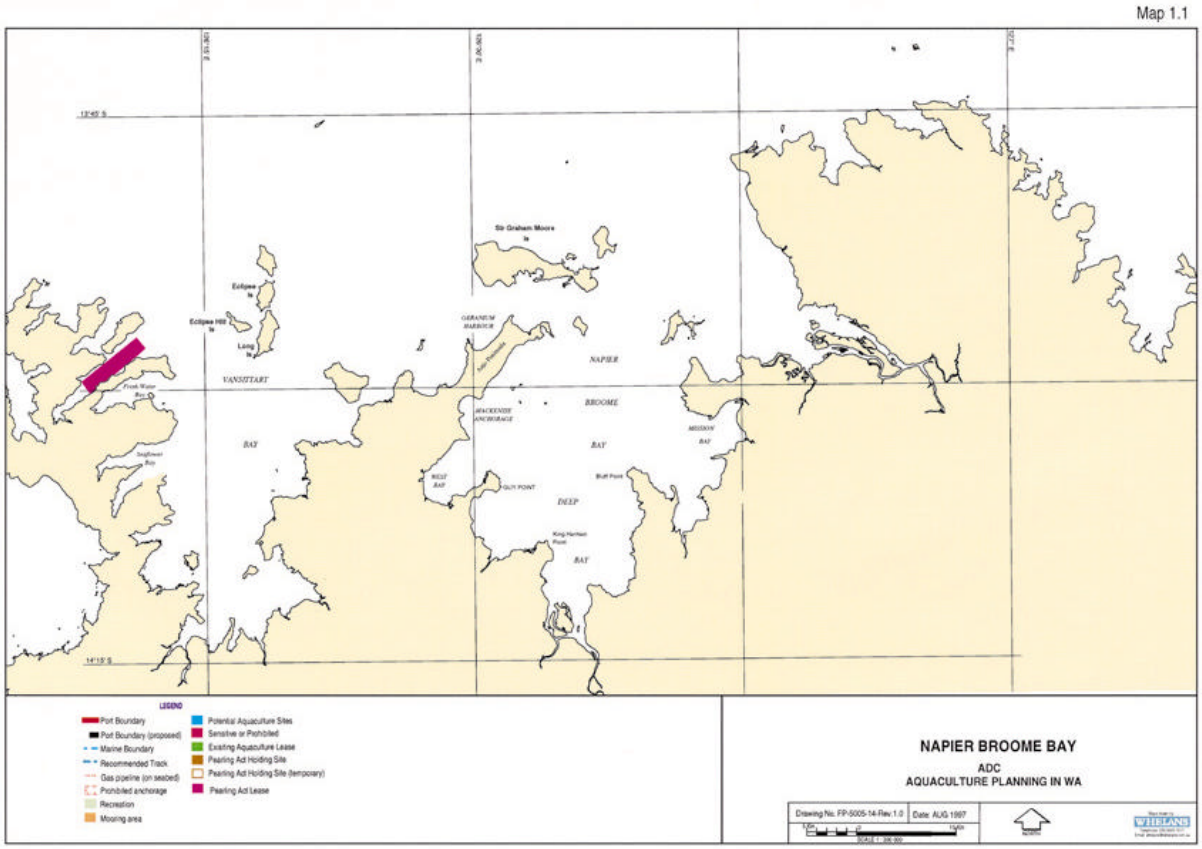
4 SITE MAPS

Site maps for each of the defined coastal and inland aquaculture regions in Western Australia are provided on the following pages. The maps are numbered as indicated below.

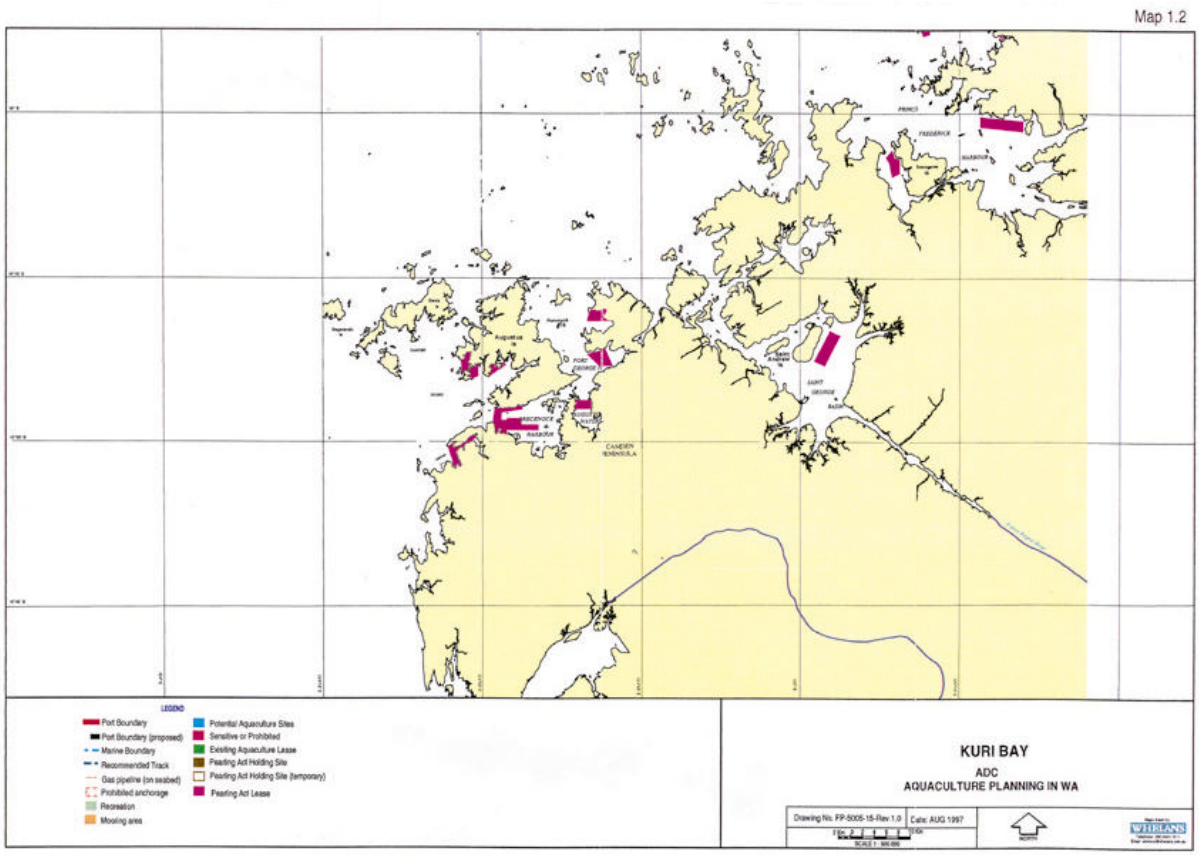
Map 0.0 Western Australia: Coastal and Inland Aquaculture Regions



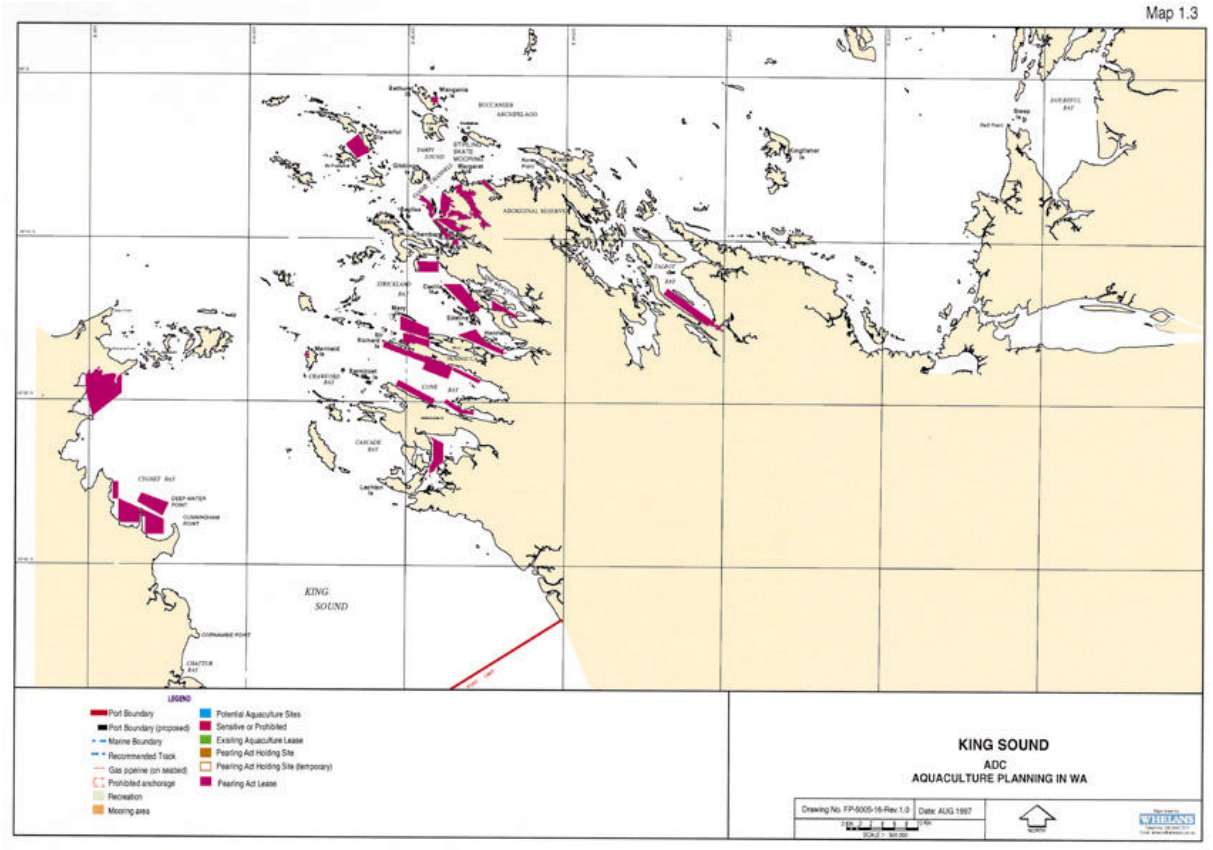
Map 1.0 Kimberley Coast



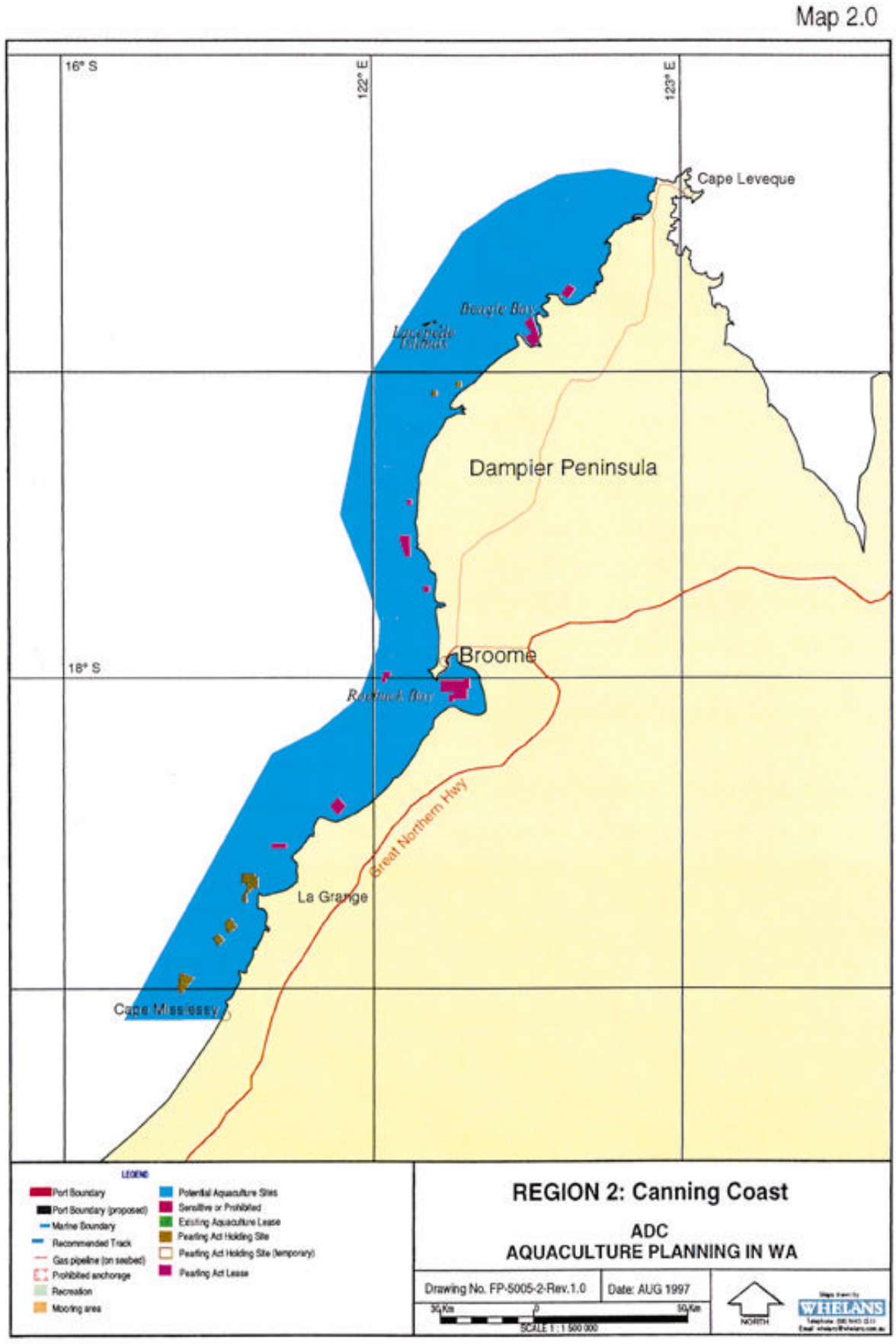
Map 1.1 Napier Broome Bay



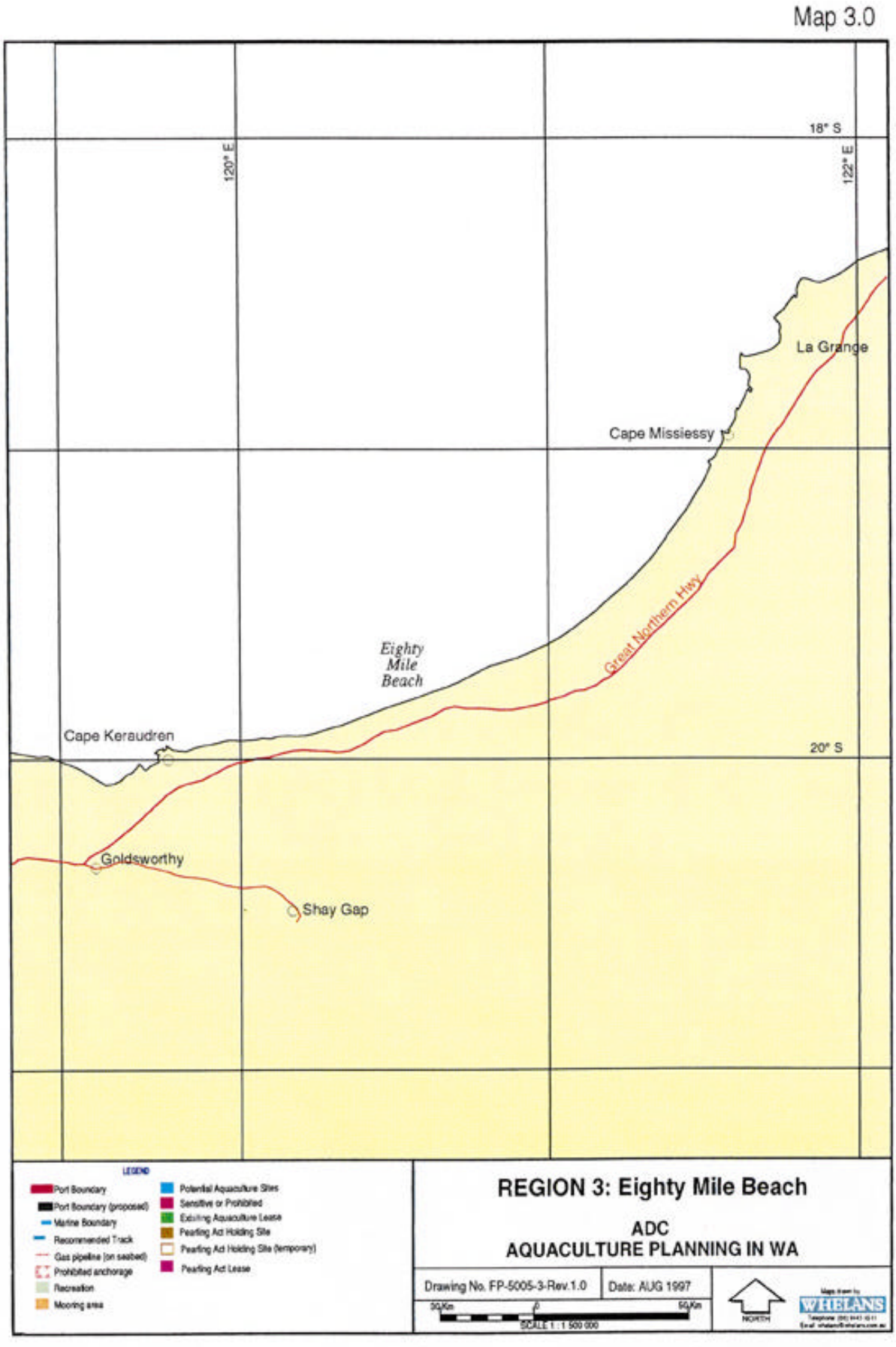
Map 1.2 Kuri Bay



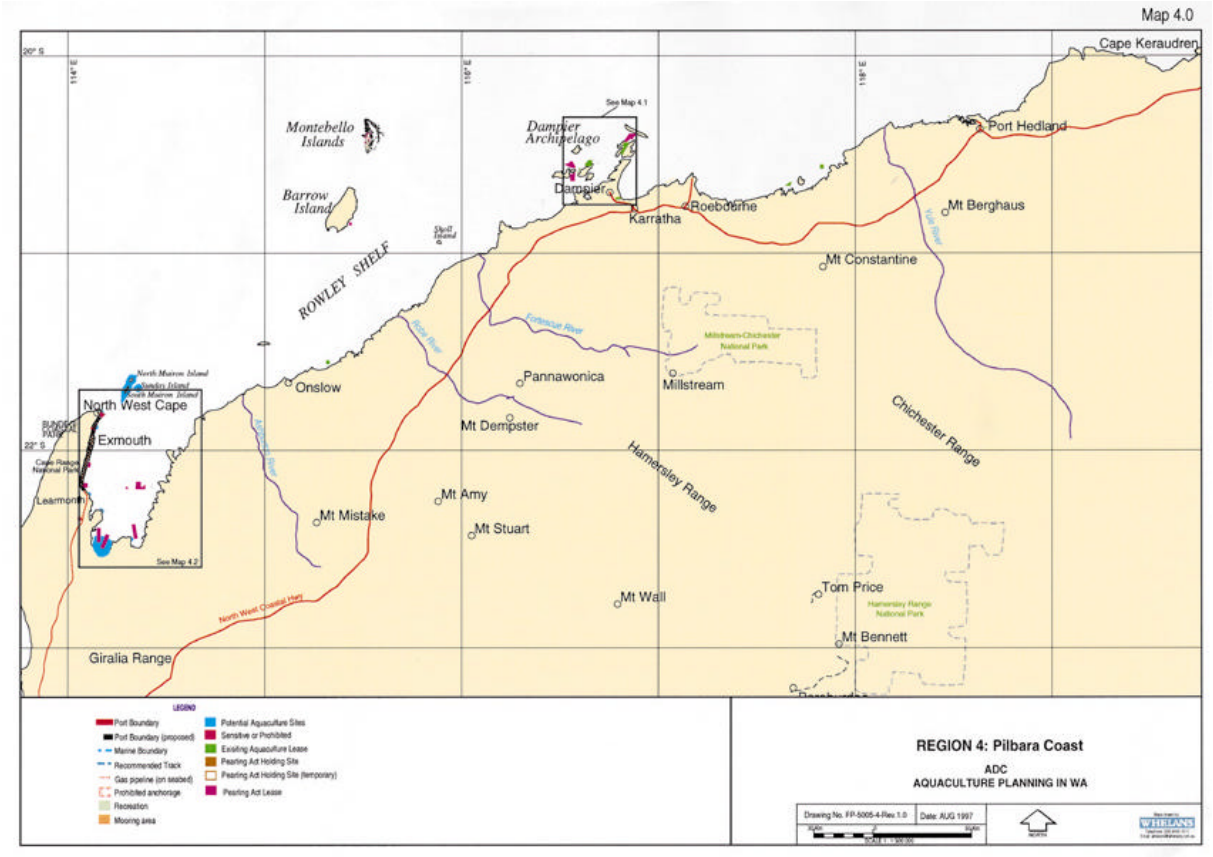
Map 1.3 King Sound



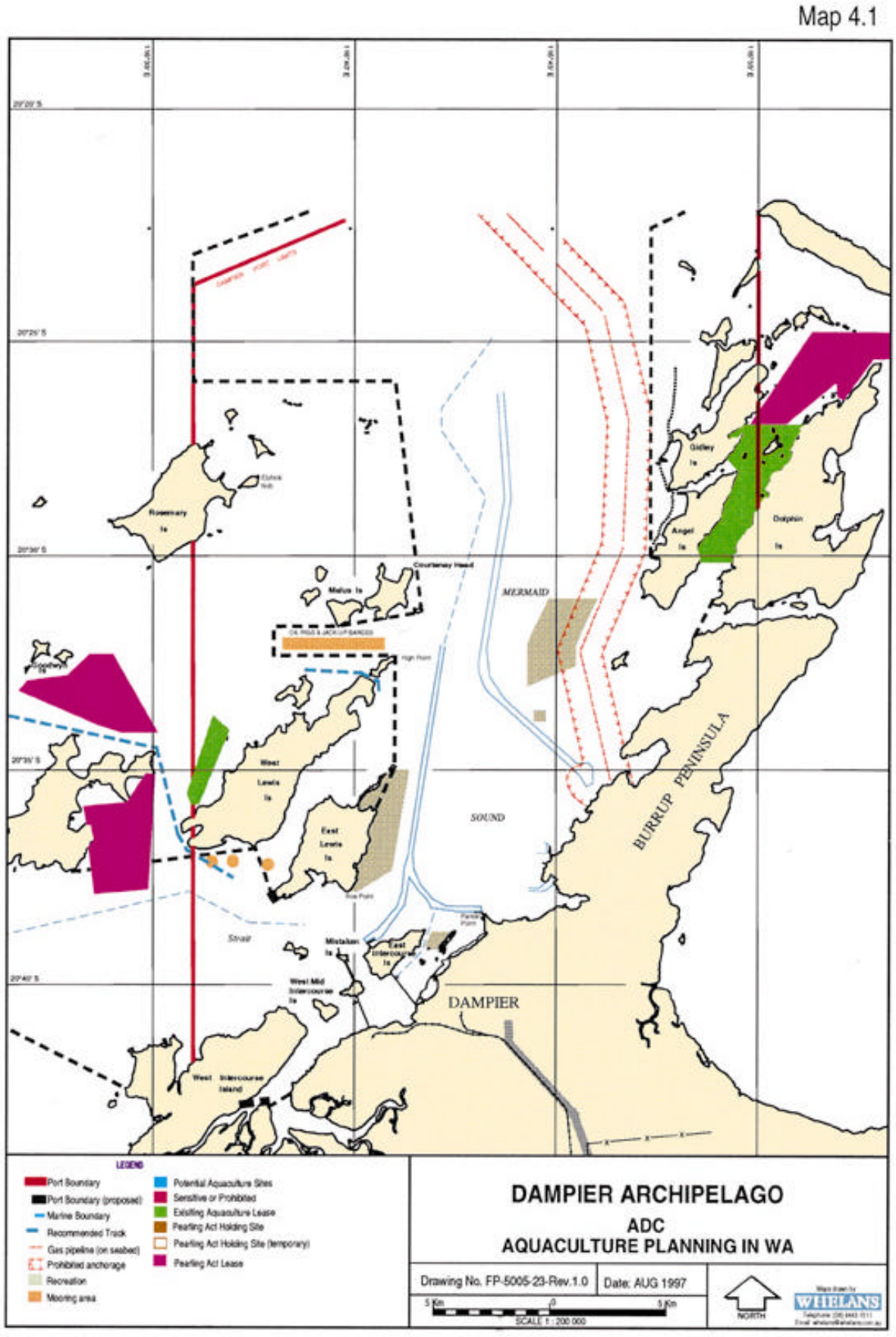
Map 2.0 Canning Coast



Map 3.0 Eighty Mile Beach

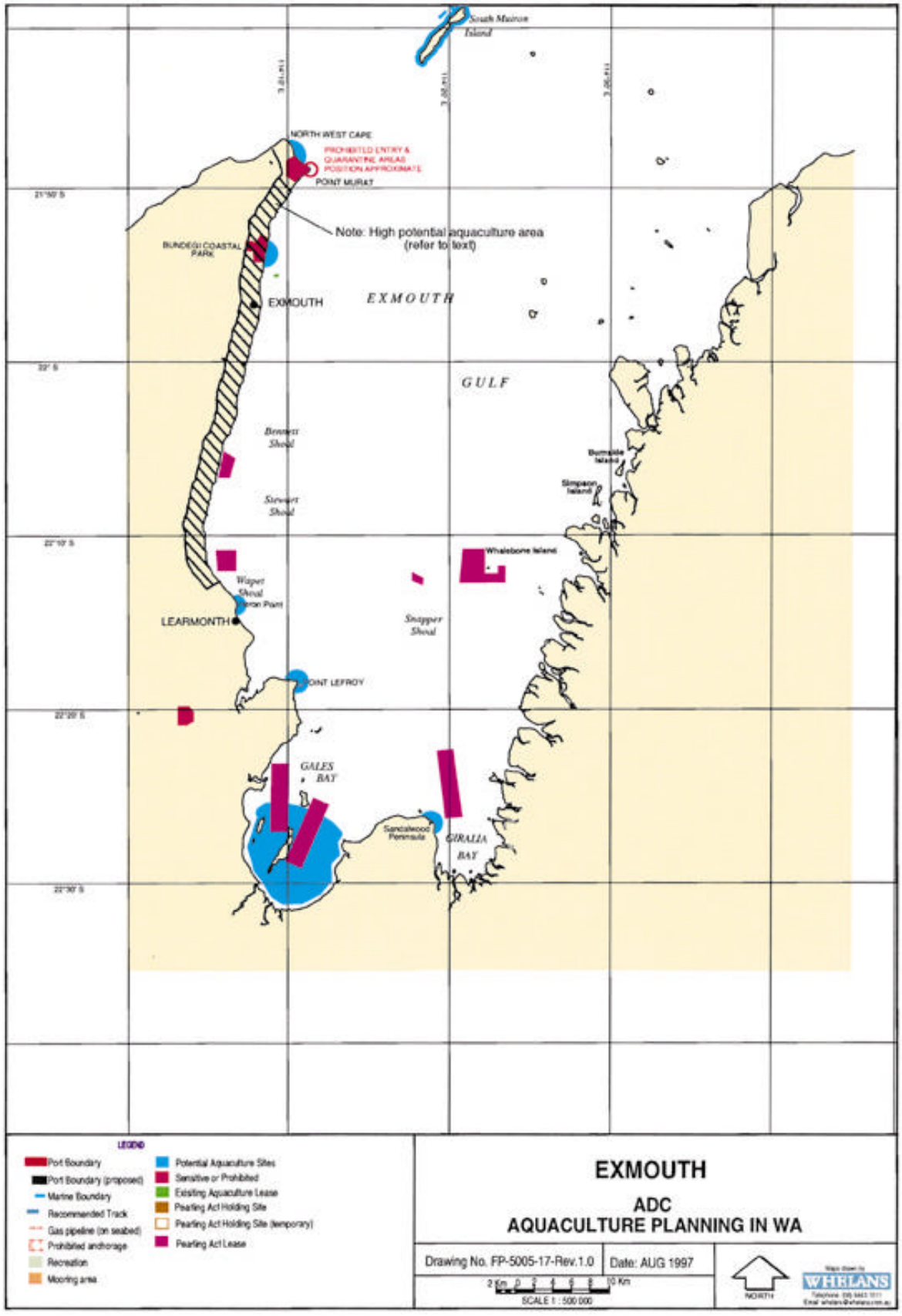


Map 4.0 Pilbara Coast

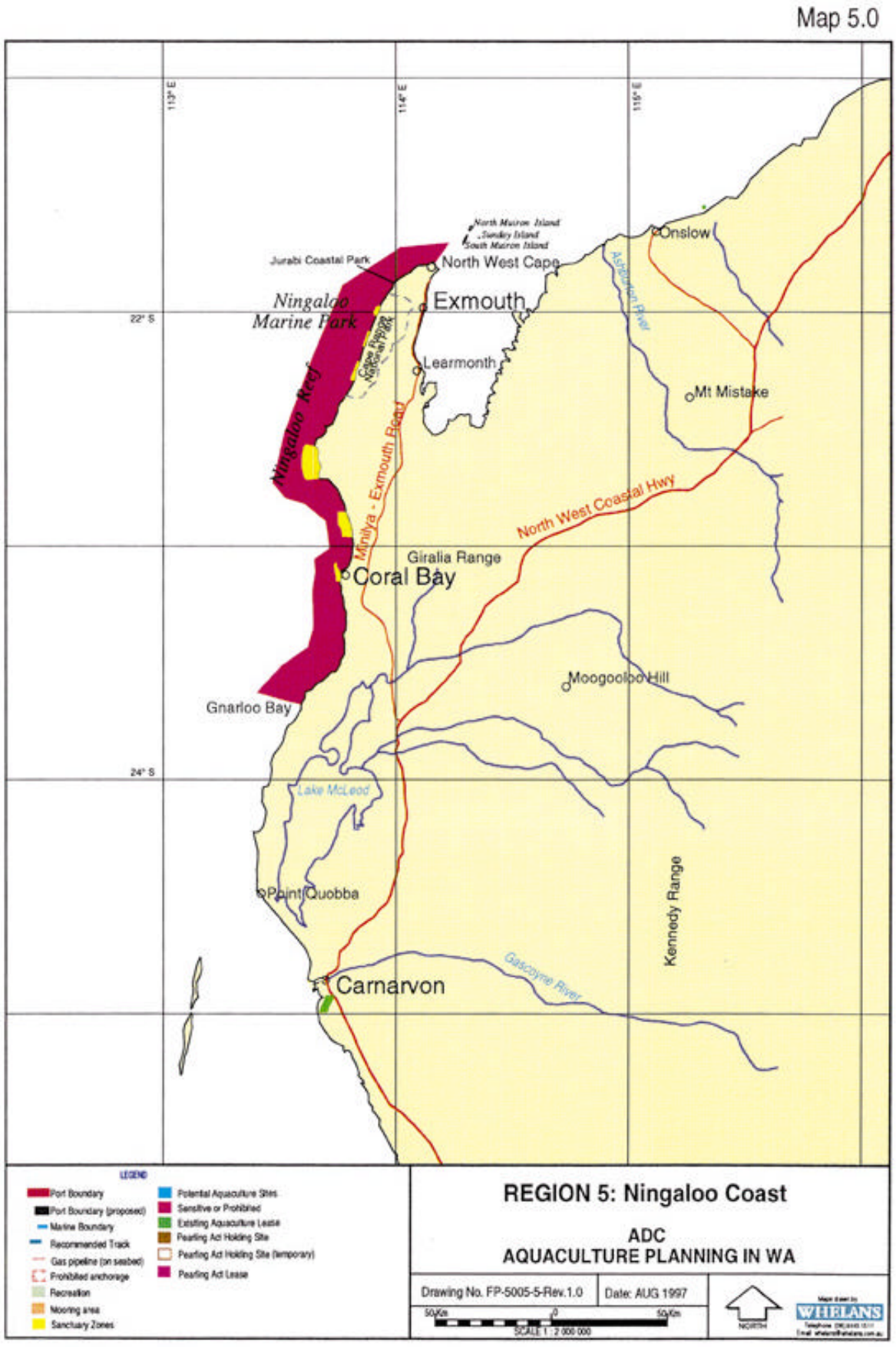


Map 4.1 Dampier Archipelago

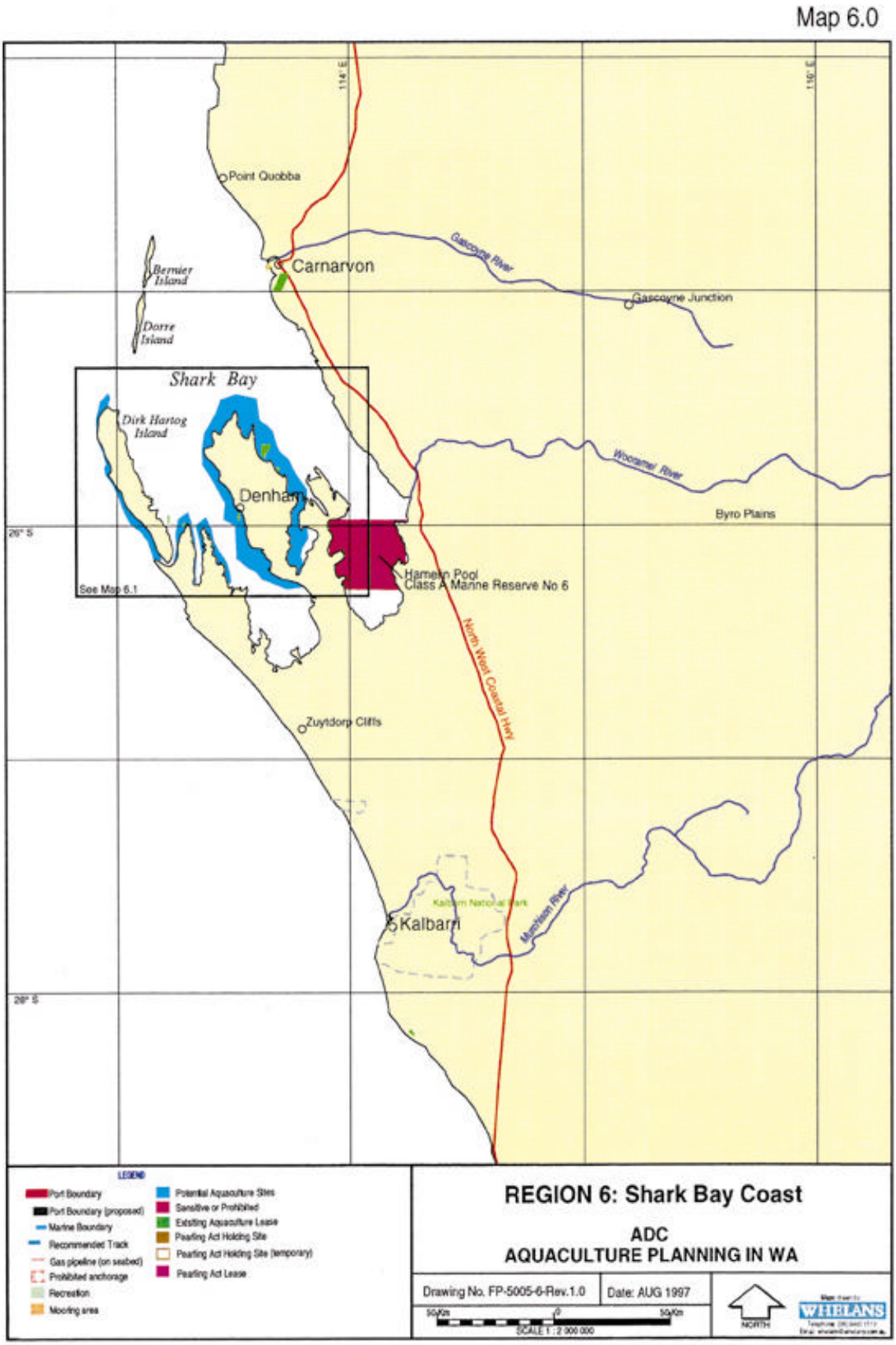
Map 4.2



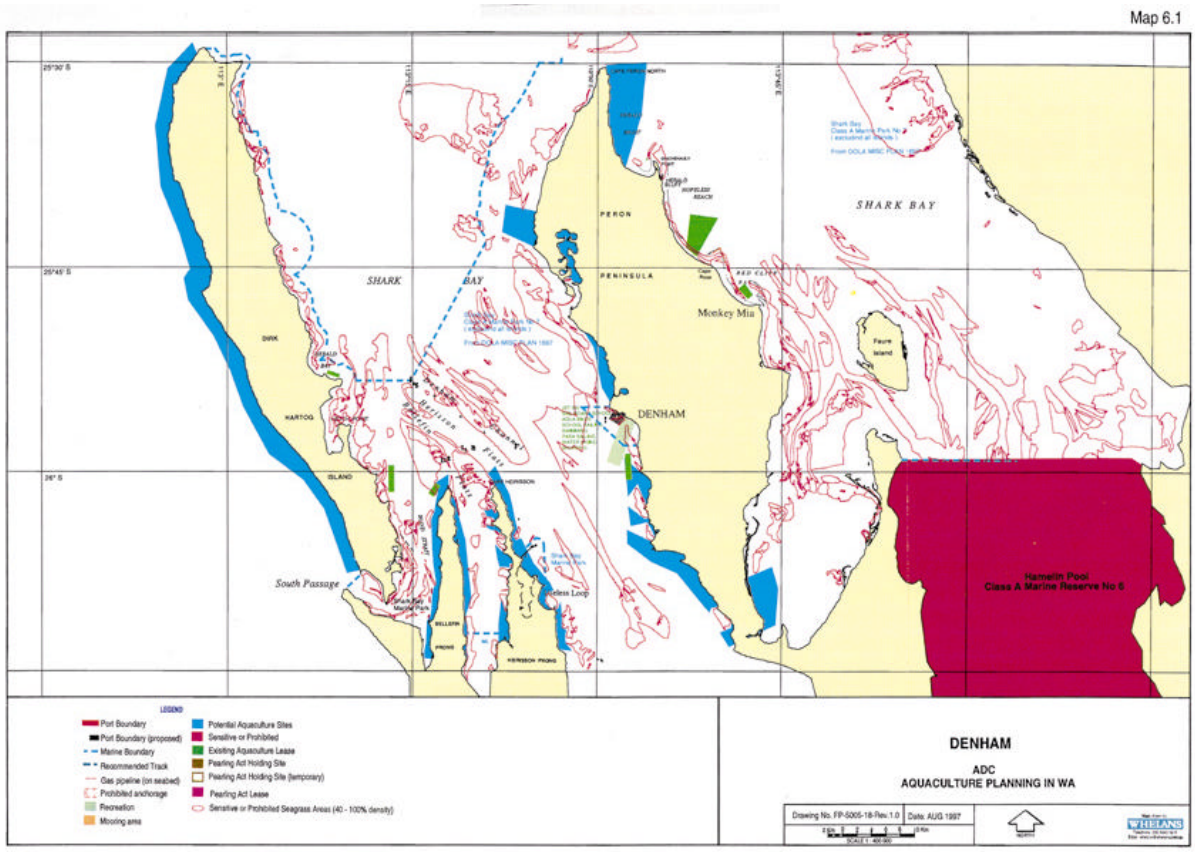
Map 4.2 Exmouth Gulf



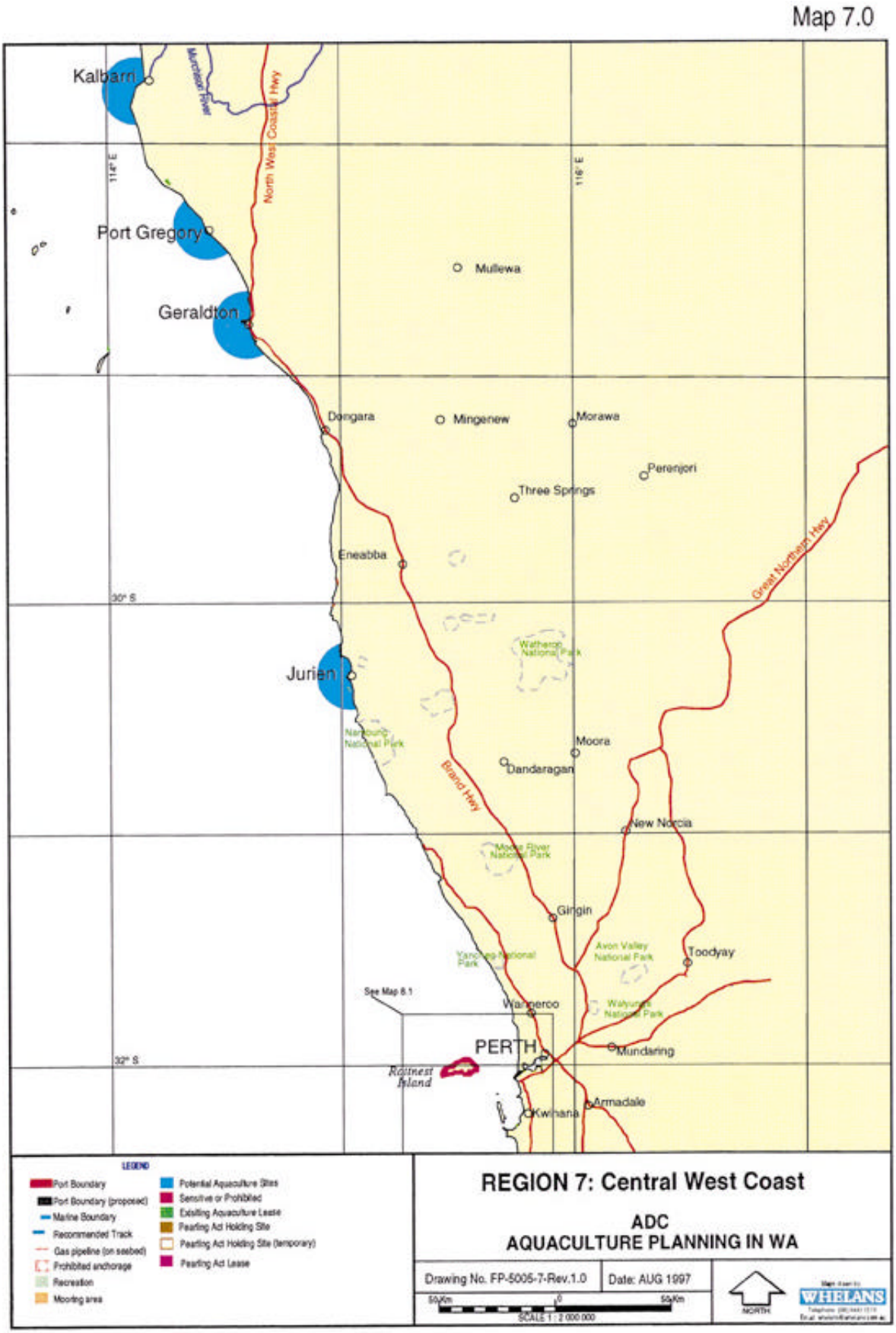
Map 5.0 Ningaloo Coast



Map 6.0 Shark Bay Coast

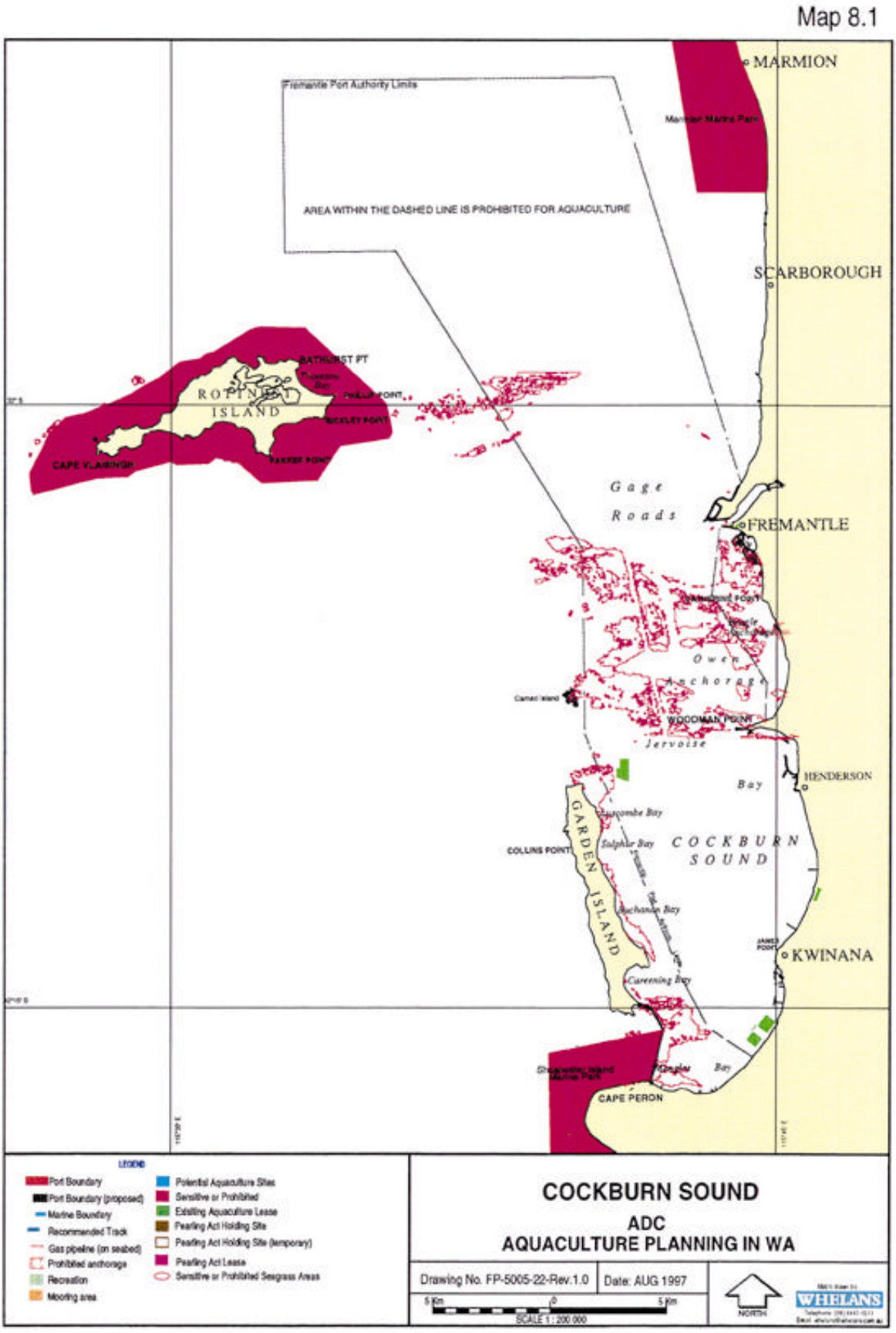


Map 6.1 Denham

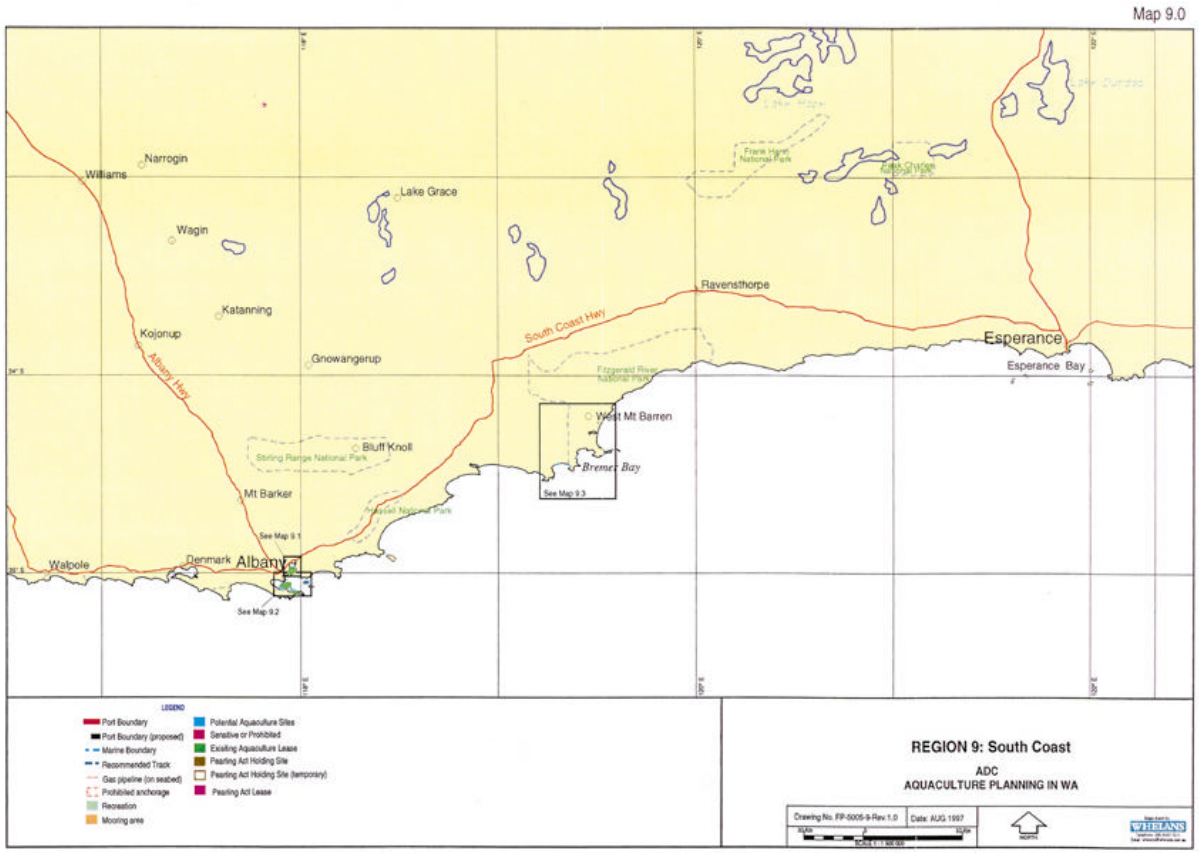


Map 7.0 Central West Coast

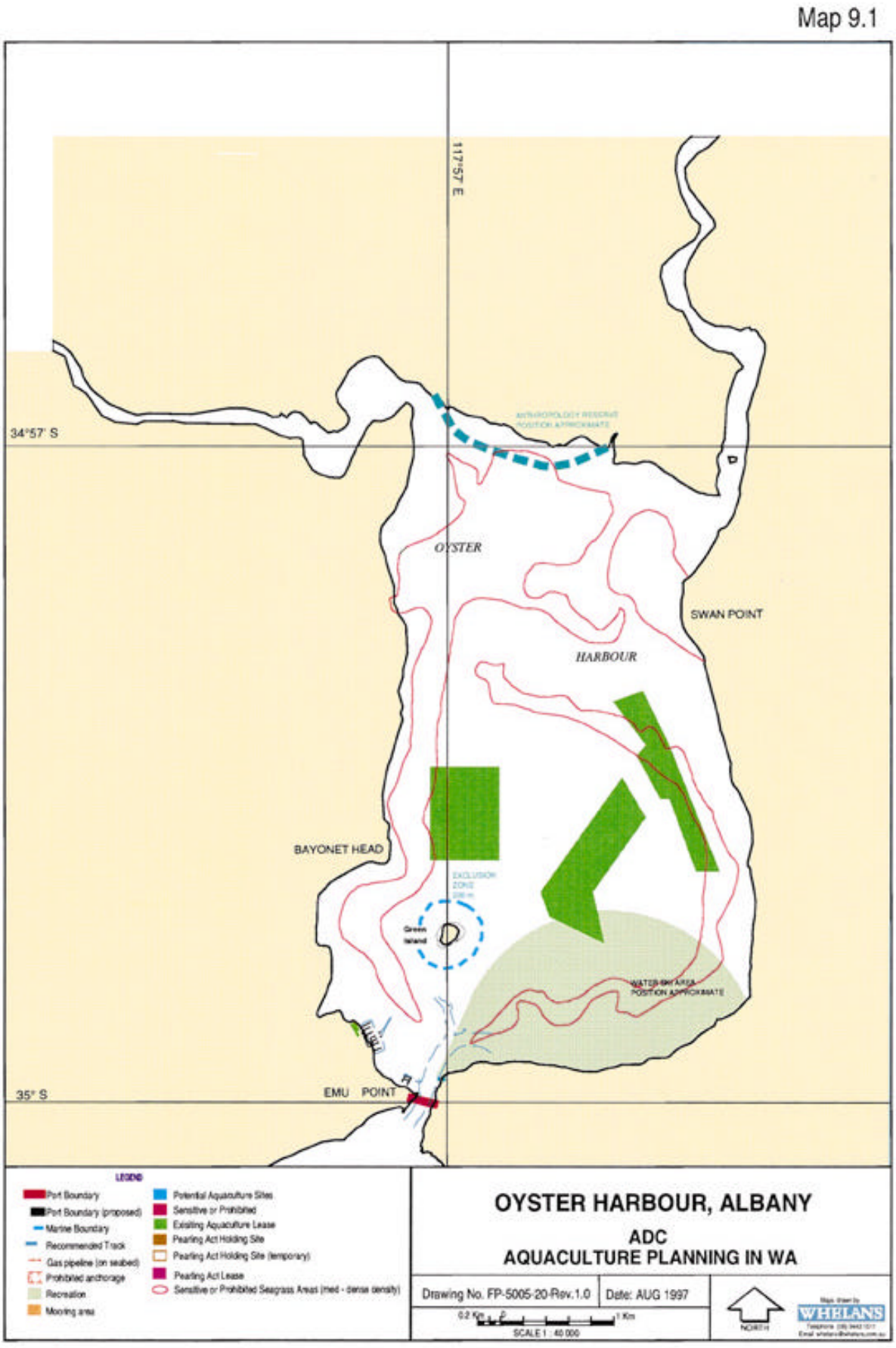
Map 8.0 Leeuwin-Naturaliste Coast



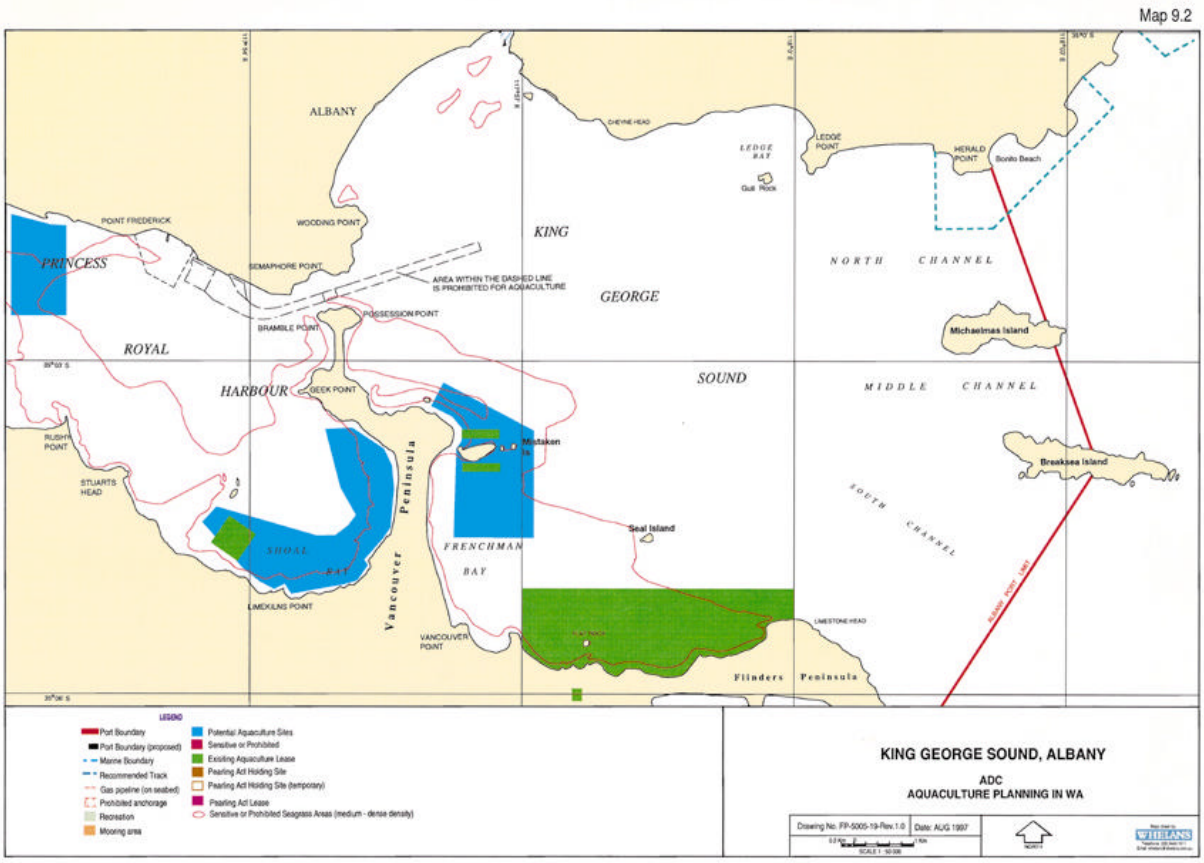
Map 8.1 Cockburn Sound



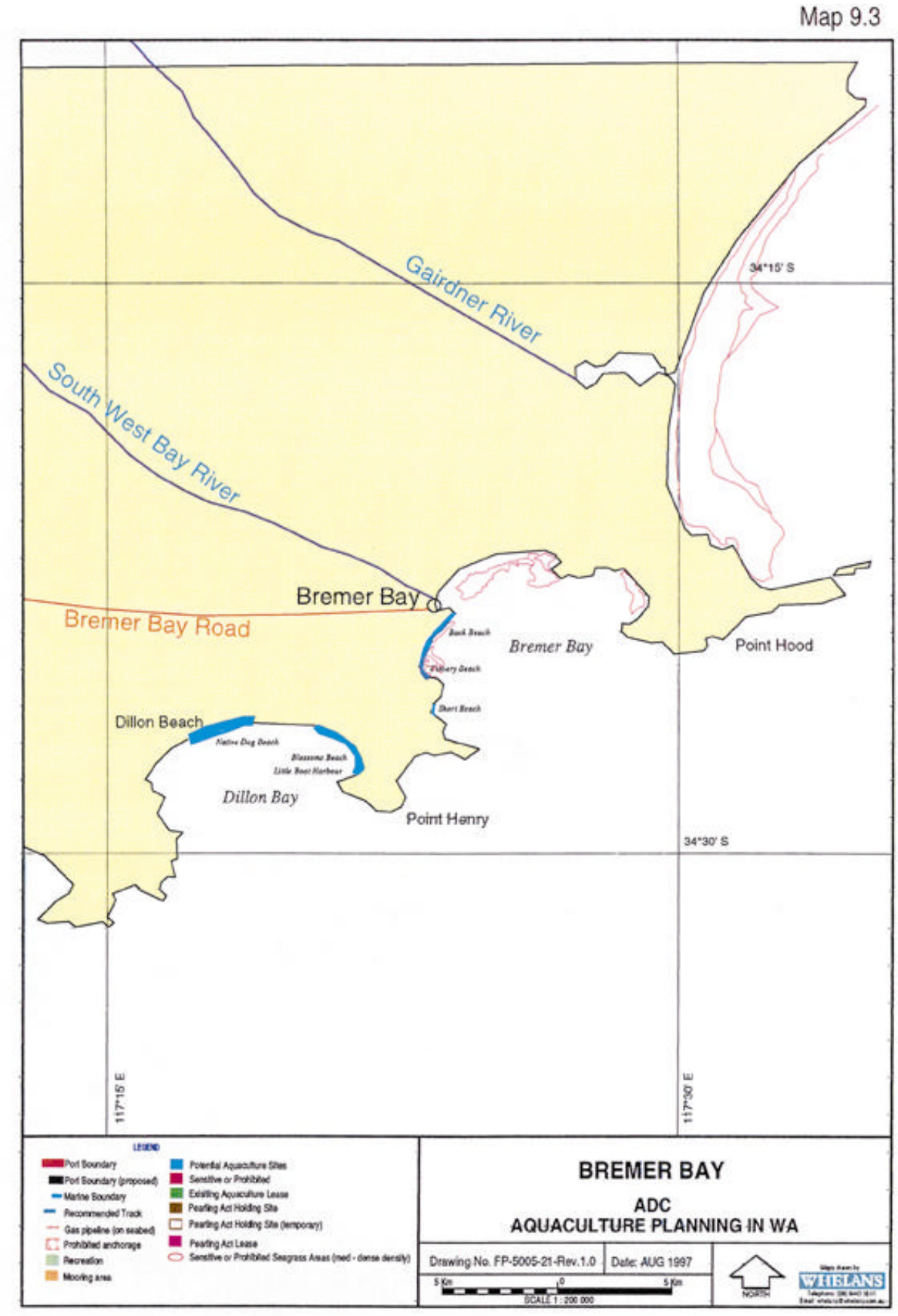
Map 9.0 South Coast



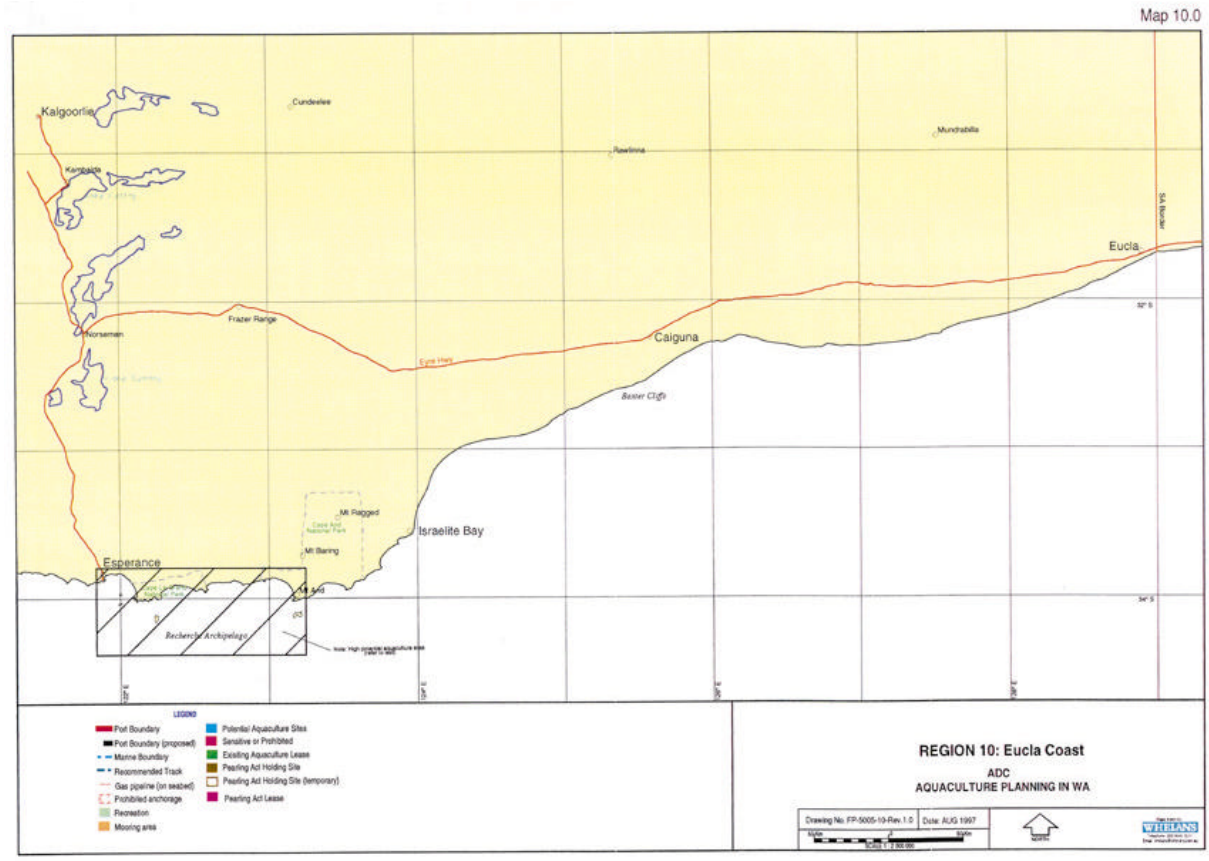
Map 9.1 Oyster Harbour, Albany



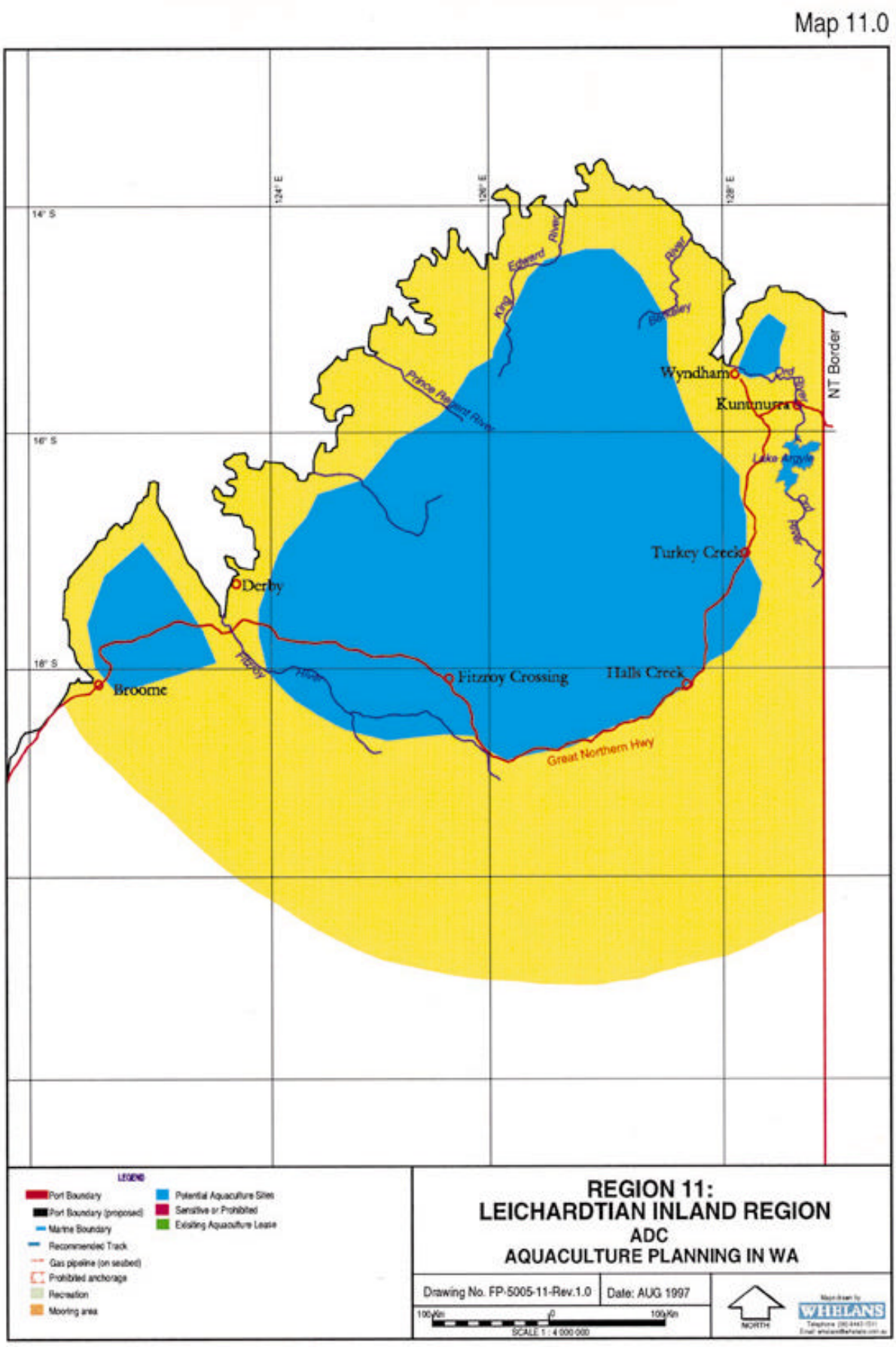
Map 9.2 King George Sound, Albany



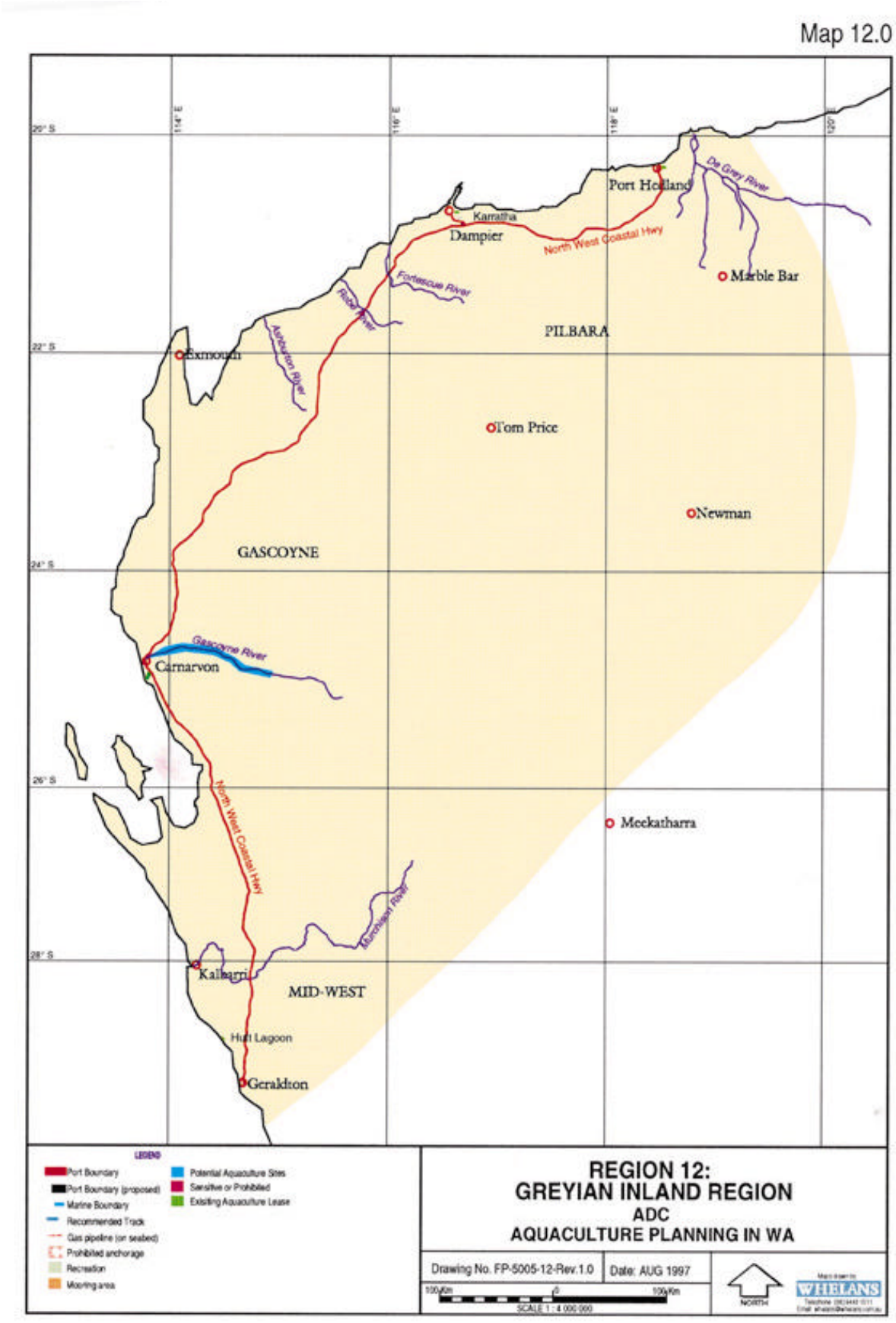
Map 9.3 Bremer Bay



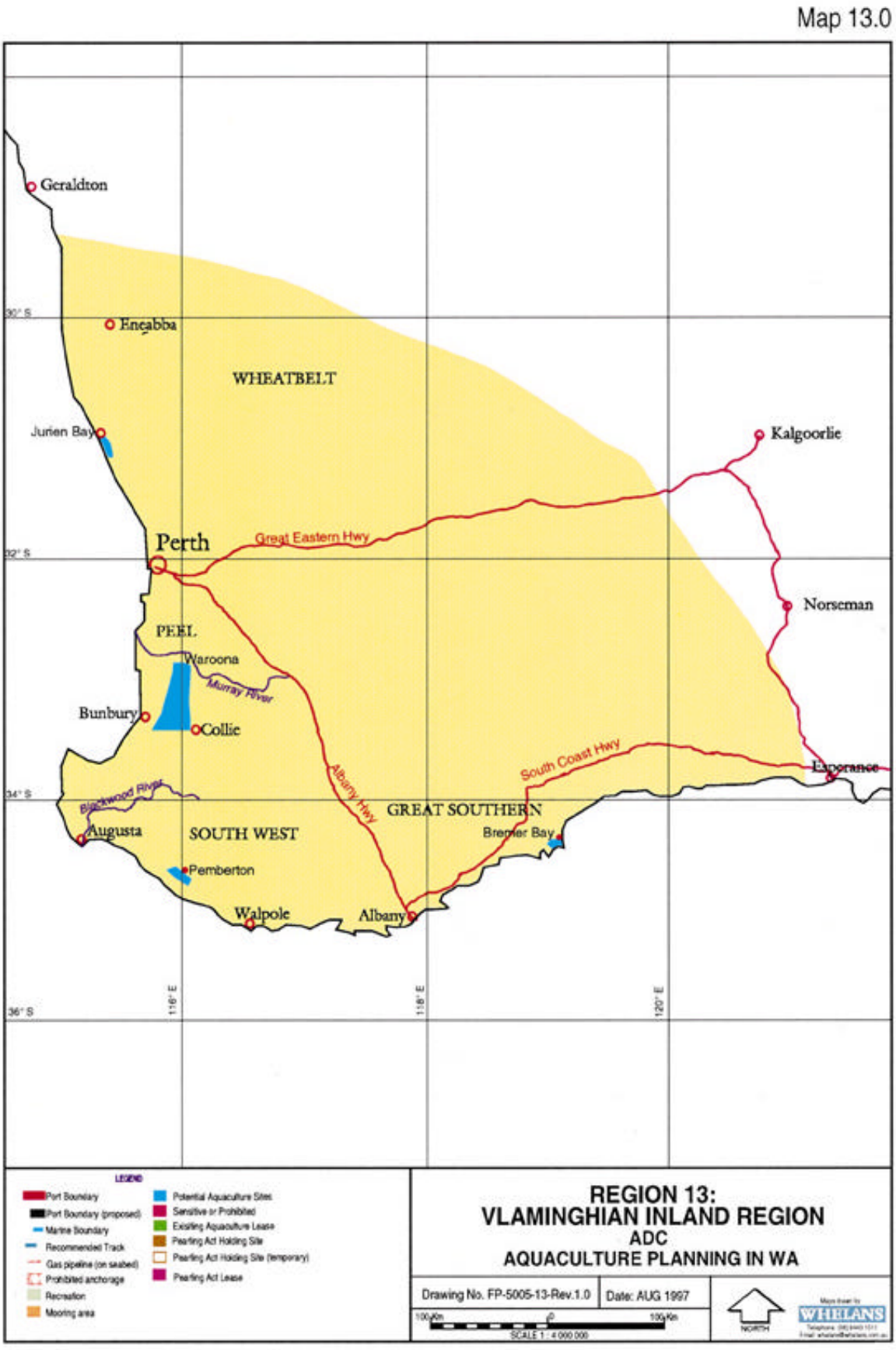
Map 10.0 Eucla Coast



Map 11.0 Leichardtian Region



Map 12.0 Greyian Region



Map 13.0 Vlaminghian Region

5 AQUACULTURE SPECIES

Numerous aquatic species have been identified in various planning studies as having potential for commercial aquaculture in Western Australia. Lists of species currently produced by aquaculture and those identified as having potential are provided in chapter 5, *Part A: Synopsis and Review.* The chapter further divides the potential species according to defined criteria into primary, secondary and tertiary categories.

Each aquatic species may be characterised by a set of physical and biological conditions that collectively constitute the ideal growing or culture environment for that species. Specific biogeographical areas can be identified that provide these conditions. An indication of the coastal and inland regions in Western Australia considered best suited for the aquaculture for each of the species identified in *Part A: Synopsis and Review* is provided in the tables below.

It should be noted that it is technically possible to culture species well outside their natural range by using recirculating systems or similar technologies that permit aquaculture in a controlled environment. For example, it would be possible to culture barramundi or redclaw crayfish in an onshore system near Esperance on the south coast by heating the culture water to the required temperature. The following information does not take into account recirculating and other similar production systems; it places species in the regions where the ambient conditions are considered suitable for their aquaculture.

Tables 1-5 provide respectively the aquaculture status and suitable aquaculture regions for marine finfish, marine shellfish, diadromous species, fresh water species and algae. For an explanation of the primary, secondary or tertiary status attributed to these aquaculture candidate species, refer to chapter 5 in *Part A: Synopsis and Review.*

Table 1 Marine finfish: aquaculture status and suitable regions

Species	Aquaculture status	Suitable aquaculture regions
Barramundi cod (*Cromileptes altivelis*)	Secondary	Kimberley Coast, Canning Coast, Eighty Mile Beach, Pilbara Coast, Ningaloo Coast, Shark Bay Coast
Mangrove jack (*Lutjanus argentimaculatus*)	Secondary	Kimberley Coast, Canning Coast, Eighty Mile Beach, Pilbara Coast
Coral trout (*Plectropomus* spp.)	Secondary	Kimberley Coast, Canning Coast, Eighty Mile Beach, Pilbara Coast, Ningaloo Coast, Shark Bay Coast, Central West Coast
Bar-cheeked coral trout (*Plectropomus maculatus*)	Secondary	Kimberley Coast, Canning Coast, Eighty Mile Beach, Pilbara Coast, Ningaloo Coast, Shark Bay Coast, Central West Coast
Red emperor (*Lutjanus sebae*)	Secondary	Kimberley Coast, Canning Coast, Eighty Mile Beach, Pilbara Coast, Ningaloo Coast, Shark Bay Coast
Milkfish (*Chanos chanos*)	Tertiary	Kimberley Coast, Canning Coast, Eighty Mile Beach, Pilbara Coast
Yellowfin tuna (*Thunnus albacares*)	Secondary	Shark Bay Coast, Central West Coast
Southern bluefin tuna (*Thunnus maccoyii*)	Primary	Leeuwin-Naturaliste Coast, South Coast, Eucla Coast
Estuary cod (*Epinephelus coioides*)	Primary	Kimberley Coast, Canning Coast, Eighty Mile Beach, Pilbara Coast, Ningaloo Coast, Shark Bay Coast, Central West Coast

Species	Aquaculture status	Suitable aquaculture regions
Mahimahi (*Coryphaena hippurus*)	Primary	Pilbara Coast, Ningaloo Coast, Shark Bay Coast
Bald chin groper (*Choerodon rubescens*)	Tertiary	Ningaloo Coast, Shark Bay Coast, Central West Coast, Leeuwin-Naturaliste Coast, South Coast
Western yellowfin bream (*Acanthopagrus latus*)	Secondary	Ningaloo Coast, Shark Bay Coast, Central West Coast, Leeuwin-Naturaliste Coast
Black bream (*Acanthopagrus butcheri*)	Currently cultured	Central West Coast, Leeuwin-Naturaliste Coast, South Coast
Snapper (*Pagrus auratus*)	Currently cultured	Shark Bay Coast, Central West Coast, Leeuwin-Naturaliste Coast, South Coast
Silver bream (*Rhabdosargus sarba*)	Secondary	Ningaloo Coast, Shark Bay Coast, Central West Coast, Leeuwin-Naturaliste Coast, South Coast
Sea mullet (*Mugil cephalus*)	Secondary	Entire WA Coast
Westralian dhufish (*Glaucosoma hebraicum*)	Primary	Shark Bay Coast, Central West Coast, Leeuwin-Naturaliste Coast, South Coast, Eucla Coast
Yellowtail kingfish (*Seriola lalandi*)	Primary	Shark Bay Coast, Central West Coast, Leeuwin-Naturaliste Coast, South Coast, Eucla Coast
King George whiting (*Sillaginodes punctata*)	Secondary	Central West Coast, Leeuwin-Naturaliste Coast, South Coast, Eucla Coast
Western school whiting (*Sillago vittata*)	Secondary	Ningaloo Coast, Shark Bay Coast, Central West Coast, Leeuwin-Naturaliste Coast, South Coast
Yellow-finned whiting (*Sillago schomburgkii*)	Secondary	Shark Bay Coast, Central West Coast, Leeuwin-Naturaliste Coast, South Coast
Large-toothed flounder (*Pseudorhombus arsius*)	Secondary	Ningaloo Coast, Shark Bay Coast, Central West Coast, Leeuwin-Naturaliste Coast
Small-toothed flounder (*Pseudorhombus jenynsii*)	Secondary	Ningaloo Coast, Shark Bay Coast, Central West Coast, Leeuwin-Naturaliste Coast, South Coast, Eucla Coast
Greenback flounder (*Rhombosolea tapirina*)	Primary	Central West Coast, Leeuwin-Naturaliste Coast, South Coast, Eucla Coast
Mulloway (*Argyrosomus hololepidotus*)	Secondary	Pilbara Coast, Ningaloo Coast, Shark Bay Coast, Central West Coast, Leeuwin-Naturaliste Coast, South Coast, Eucla Coast
Cobbler (*Cnidoglanis macrocephalus*)	Secondary	Central West Coast, Leeuwin-Naturaliste Coast, South Coast, Eucla Coast
Southern Australian herring (*Arripis georgianus*)	Tertiary	Shark Bay Coast, Central West Coast, Leeuwin-Naturaliste Coast, South Coast, Eucla Coast
Trevally (*Pseudocaranx* spp.)	Secondary	All WA coastal waters
Breaksea cod (*Epinephelides armatus*)	Tertiary	Shark Bay Coast, Central West Coast, Leeuwin-Naturaliste Coast, South Coast, Eucla Coast
Marine aquarium species	Primary	All WA coastal waters

Table 2 Marine shellfish: aquaculture status and suitable regions

Species	Aquaculture status	Suitable aquaculture regions
Pearl oyster (*Pinctada maxima*)	Currently cultured	Kimberley Coast, Canning Coast, Eighty Mile Beach, Pilbara Coast, Ningaloo Coast, Shark Bay Coast
Blacklip oyster (*Pinctada margaritifera*)	Currently cultured	Kimberley Coast, Canning Coast, Eighty Mile Beach, Pilbara Coast, Ningaloo Coast, Shark Bay Coast
Shark Bay pearl oyster (*Pinctada albina*)	Currently cultured	Kimberley Coast, Canning Coast, Eighty Mile Beach, Pilbara Coast, Ningaloo Coast, Shark Bay Coast
Wing oyster (*Pteria penguin*)	Currently cultured	Kimberley Coast, Canning Coast, Eighty Mile Beach, Pilbara Coast, Ningaloo Coast, Shark Bay Coast
Trochus (*Tectus niloticus*)	Primary	Kimberley Coast, Canning Coast
Tropical abalone (*Haliotis asinina*)	Secondary	Kimberley Coast, Canning Coast, Eighty Mile Beach, Pilbara Coast
Trepang or sea cucumber (*Holothuria* spp.)	Secondary	Kimberley Coast, Canning Coast, Eighty Mile Beach, Pilbara Coast
Tiger prawn (*Penaeus monodon*)	Secondary	Kimberley Coast, Canning Coast, Eighty Mile Beach, Pilbara Coast, Ningaloo Coast, Shark Bay Coast
Kuruma prawn (*Penaeus japonicus*)	Secondary (non-native species)	Ningaloo Coast, Shark Bay Coast, Central West Coast
Artemia or brine shrimp (*Artemia* spp.)	Primary	Pilbara Coast, Ningaloo Coast, Shark Bay Coast
Mud crab (*Scylla serrata*)	Secondary	Kimberley Coast, Canning Coast, Eighty Mile Beach, Pilbara Coast
Giant clam (*Tridacna gigas*, other *Tridacna* spp.)	Primary	Kimberley Coast, Canning Coast, Eighty Mile Beach, Pilbara Coast, Ningaloo Coast, Shark Bay Coast
Western rock oyster (*Saccostrea commercialis*)	Currently cultured	Ningaloo Coast, Shark Bay Coast, Central West Coast
Other edible oysters (*Crassostrea* spp., *Ostrea* spp.)	Primary	Various regions along the WA coast according to species
Blue mussel (*Mytilus edulis*)	Currently cultured	Central West Coast, Leeuwin-Naturaliste Coast, South Coast, Eucla Coast
Roe's abalone (*Haliotis roei*)	Primary	Shark Bay Coast, Central West Coast, Leeuwin-Naturaliste Coast, South Coast, Eucla Coast
Greenlip abalone (*Haliotis laevigata*)	Primary	Leeuwin-Naturaliste Coast, South Coast, Eucla Coast
Brownlip abalone (*Haliotis conicopora*)	Primary	Central West Coast, Leeuwin-Naturaliste Coast, South Coast, Eucla Coast
Western rock lobster (*Panulirus cygnus*)	Secondary	Shark Bay Coast, Central West Coast, Leeuwin-Naturaliste Coast, South Coast
Saucer scallop (*Amusium balloti*)	Tertiary	Canning Coast, Eighty Mile Beach, Pilbara Coast, Ningaloo Coast, Shark Bay Coast, Central West Coast, Leeuwin-Naturaliste Coast, South Coast, Eucla Coast
Blue swimmer crab (*Portunus pelagicus*)	Secondary	Central West Coast, Leeuwin-Naturaliste Coast, South Coast, Eucla Coast

Table 3 Diadromous species: aquaculture status and suitable regions

Species	Aquaculture status	Suitable aquaculture regions
Barramundi (*Lates calcarifer*)	Currently cultured	Kimberley Coast, Canning Coast, Eighty Mile Beach, Pilbara Coast, Leichardtian Region, Greyian Region
Sea trout (*Oncorhynchus mykiss*)	Currently cultured in WA in fresh water only	South Coast, Eucla Coast
Eels (*Anguilla* spp.)	Currently cultured in the eastern states; species native to WA have not been cultured	Leichardtian Region, Greyian Region, Vlaminghian Region

Table 4 Fresh water species: aquaculture status and suitable regions

Species	Aquaculture status	Suitable aquaculture regions
Argyle bream (*Hephaestus jenkinsi*)	Currently cultured	Leichardtian Region
Aquarium species (various)	Primary or secondary, according to species	Leichardtian Region, Greyian Region, Vlaminghian Region
Catfish (*Arius* spp.)	Secondary	Leichardtian Region
Redclaw crayfish (*Cherax quadricarinatus*)	Primary (introduced species)	Leichardtian Region
Cherabin or fresh water shrimp (*Macrobrachium rosenbergii*)	Secondary	Leichardtian Region
Marron (*Cherax tenuimanus*)	Currently cultured	Vlaminghian Region
Yabby (*Cherax destructor*)	Currently cultured	Vlaminghian Region
Rainbow trout (*Oncorhynchus mykiss*)	Currently cultured (introduced species)	Vlaminghian Region
Brown trout (*Salmo trutta*)	Currently cultured (introduced species)	Vlaminghian Region
Silver perch (*Bidyanus bidyanus*)	Currently cultured (introduced species)	Vlaminghian Region
Redfin perch (*Perca fluviatilis*)	Tertiary (introduced species)	Vlaminghian Region
Murray cod (*Maccullochella peeli*)	Secondary (introduced species)	Vlaminghian Region
Golden perch (*Maquaria ambigua*)	Secondary (introduced species)	Vlaminghian Region
Australian bass (*Maquaria novemaculeata*)	Tertiary (introduced species)	Vlaminghian Region
Fresh-water aquarium species	Secondary	Leichardtian Region, Greyian Region, Vlaminghian Region

Table 5 Algal species: aquaculture status and suitable regions

Species	Aquaculture status	Suitable aquaculture regions
Beta-carotene (*Dunaliella salina*)	Currently cultured	Leichardtian Region, Greyian Region

Species	Aquaculture status	Suitable aquaculture regions
Spirulina (*Spirulina* spp.)	Secondary (introduced species)	Leichardtian Region, Greyian Region