



**SOUTH COAST TERRESTRIAL
AND MARINE RESERVE
INTEGRATION STUDY**

PROJECT # 713
**NATIONAL RESERVE SYSTEM
COOPERATIVE PROGRAM**

FINAL REPORT
TO
ENVIRONMENT AUSTRALIA



Department of Conservation and Land Management

**MARINE RESERVE IMPLEMENTATION
SOUTH COAST**

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INTEGRATION STUDY**

**PROJECT #713
NATIONAL RESERVE SYSTEM COOPERATIVE PROGRAM**

Final Report: MRIP/SC-10/1997

A collaborative project between CALM Marine Conservation Branch and South Coast Region

A project funded by Environment Australia

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EXECUTIVE SUMMARY

Currently, there are no marine conservation reserves along the south coast of Western Australia, although most of the coastal terrestrial reserves contain marine areas between high and low water marks. In 1994, the Marine Parks and Reserves Selection Working Group published a statewide review of the marine environment, entitled *A Representative Marine Reserve System for Western Australia*. In this report the Working Group identified a number of estuaries/inlets and areas of coastal waters along the south coast, adjacent to existing terrestrial reserves, that were considered as suitable candidates for possible incorporation into the statewide representative system of marine conservation reserves.

This project commenced in October 1996, with the primary objective of gathering the necessary information to facilitate a regional classification of the marine environment along the south coast, according to ecological, economic and cultural criteria. A further objective was to establish an information base for candidate marine conservation reserve areas identified in the Working Group report. Outcomes from the project include recommendations that facilitate the integrated management of adjacent terrestrial and marine conservation reserves and ensure that the potential impacts of terrestrial and estuarine ecosystems upon their marine counterparts are understood prior to the creation of any marine conservation reserves. The project also identifies issues, opportunities and constraints affecting integrated management.

The first phase of the project consisted of a review of the available information on the nature conservation, recreation, aesthetic and economic values of the nine candidate marine conservation reserve areas within the project boundaries, and of the adjacent terrestrial national parks and nature reserves. This phase also involved a review of the estuaries and catchments across the south coast, which classified the estuaries, inlets and associated catchments, and identified major management issues affecting these systems. The Fitzgerald Biosphere Reserve and adjacent inshore marine environment were selected for more detailed study of the range of issues affecting integrated management of terrestrial and marine conservation reserves across the region. A marine biological survey of the inshore waters adjacent to the biosphere reserve was carried out, the first detailed investigation of the marine environment in this area. Preliminary analysis of the results of this survey suggest that the benthic habitats support diverse species assemblages and communities, and that the inshore marine environment of the area is in relatively pristine condition, confirming the high conservation values of these waters identified in the Report of the Marine Parks and Reserves Selection Working Group.

In recognition of these values, and of the national and international significance of the terrestrial biosphere reserve it is recommended that the area of State waters adjacent to the Fitzgerald Biosphere Reserve be considered as a marine conservation reserve priority area for the south coast region. Further assessments of the conservation, social and economic values of this candidate marine conservation reserve area are required. It is further recommended that coastal waters between Israelite Bay and Point Culver, east of the Recherche Archipelago, be considered for inclusion in the marine conservation reserve system, in recognition of the high conservation values of this area. Hauloff Rock, located between Albany and Bremer Bay should be considered for reservation within the terrestrial reserve system, in recognition of its national significance as a fur seal and sea lion breeding site.

Based on the recommendations of the Working Group Report and on a review and classification of estuaries and inlets carried out as part of this project it is recommended that permanently open and seasonally open/closed systems be considered for inclusion in the marine conservation reserve system and that normally and permanently closed systems be considered for inclusion in the terrestrial reserve system. Broke Inlet and Walpole-Nornalup Inlets are recommended as marine conservation reserve priority areas and it is recommended that the inlets surrounded by the Fitzgerald River National Park be incorporated within the park as part of the terrestrial reserve system.

A number of key management issues affecting the implementation of marine conservation reserves across the south coast have been identified. These include issues of major concern to some stakeholders and sections of some local communities across the region, such as access to marine and coastal resources through terrestrial conservation estate, and the perception that creation of reserves will totally exclude activities such as commercial and recreational fishing. A public liaison program is required, as a priority, to address these concerns, via a clear explanation of the multiple-use reserve concept, the different reserve categories and management zoning, and community and stakeholder involvement in the implementation process.

RECOMMENDATIONS

TERRESTRIAL RESERVES

RECOMMENDATION 1

- *That the management of access to adjacent marine resources, through existing terrestrial reserves, continue to be adequately considered during the development of area management plans.*

RECOMMENDATION 2

- *That the National Parks and Nature Conservation Authority consider, as a priority, reservation of Hauloff Rock, in recognition of its national significance as a fur seal and sea lion breeding site.*

MARINE CONSERVATION RESERVES

RECOMMENDATION 3

- *That the Marine Parks and Reserves Authority consider the area of State waters adjacent to the larger notional Fitzgerald Biosphere Reserve (Groper Bluff to Starvation Boat Harbour) for inclusion in a future marine conservation reserve.*

RECOMMENDATION 4

- *That the Marine Parks and Reserves Authority consider the Fitzgerald region as a marine conservation reserve priority area for the south coast.*

RECOMMENDATION 5

- *That the management of any future Fitzgerald marine conservation reserve be integrated with the terrestrial and estuarine components of the Fitzgerald Biosphere Reserve.*

RECOMMENDATION 6

- *That the status of management planning in adjoining terrestrial reserves be an important consideration in prioritising other candidate marine conservation reserves along the south coast.*

RECOMMENDATION 7

- *That the Marine Parks and Reserves Authority consider the coastal waters between Israelite Bay and Point Culver for inclusion in the statewide system of marine conservation reserves, in recognition of the high conservation values of this area.*

ESTUARIES/INLETS

RECOMMENDATION 8

- *That, of the estuaries and inlets identified in the Report of the Marine Parks and Reserves Selection Working Group, permanently open and seasonally open/closed systems be considered for inclusion in the marine conservation reserve system.*

RECOMMENDATIONS (continued)

RECOMMENDATION 9

- *That, of the estuaries and inlets identified in the Report of the Marine Parks and Reserves Selection Working Group, normally and permanently closed systems be considered for inclusion with surrounding terrestrial reserves. Legal opinion is required as to whether this can be achieved under the provisions of the Land Act.*

RECOMMENDATION 10

- *That the Marine Parks and Reserves Authority consider the Broke and Walpole-Nornalup Inlets as marine conservation reserve priority areas.*

RECOMMENDATION 11

- *That the National Parks and Nature Conservation Authority consider inclusion of the Gordon, Boondalup, St Mary's, Fitzgerald, Dempster and Hamersley Inlets with the Fitzgerald River National Park. Legal opinion is required as to whether this can be achieved under the provisions of the Land Act.*

RECOMMENDATION 12

- *That further studies be undertaken to assess the possible impacts of estuary flooding and bar opening on coastal waters adjacent to the Fitzgerald Biosphere Reserve.*

PUBLIC CONSULTATION

RECOMMENDATION 13

- *That CALM undertake, as a priority, a public liaison program to address public concerns in relation to marine conservation reserves along the south coast.*

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INTRODUCTION

The terrestrial environment of the south coast region of Western Australia is known to have exceptionally high conservation values and, in recognition of these natural attributes, a system of terrestrial reserves has been established along this coastline. By contrast little is known about the conservation values of the marine environment, although high levels of marine biodiversity and endemism has been reported from other parts of Australia's temperate marine environment (Edyvane, 1996).

A recently published statewide review of the marine environment of Western Australia, entitled *A Representative Marine Reserve System for Western Australia - Report of the Marine Parks and Reserves Selection Working Group, 1994* (CALM, 1994: known as the Wilson Report) identified a number of marine areas, offshore from existing terrestrial reserves, along the south coast that were considered as suitable candidates for possible incorporation into the statewide system of representative marine conservation reserves.

Under the *New Horizons - the way ahead in marine conservation and management* strategy (Government of Western Australia, 1998), the State Government requires biological, economic, usage and cultural assessments to be made of areas to be considered for marine conservation reserve status under the CALM Act before the Notice of Intent (NOI) is issued. This revised process was implemented with the passage into the legislation of the *Acts Amendments (Marine Reserves) Act 1997*, and is designed to reduce the level of user concern normally resulting from the release of the NOI for public comment. The data layers provide the basic information for a consultative process resulting in the determination of preliminary boundaries and zonings so that current users have a clear appreciation of how the proposed marine conservation reserve will affect their current and future activities from the outset.

The *CALM Act 1984* allows for the establishment of multiple-use marine conservation reserves for the purposes of conservation of marine flora and fauna and public recreation. Commercial activities, such as fishing, aquaculture and petroleum exploration and production, are also acceptable within specific zones of multiple-use marine conservation reserves. Commercial and recreational fisheries and aquaculture in marine conservation reserves are managed by the Fisheries Department. The CALM Act specifies the statutory process for the reservation of marine conservation reserves, including a public planning process for the development of management zoning schemes that allow for the spatial separation of incompatible activities in a marine park. In anticipation of this process the major marine resources and current uses of areas recommended for reservation in the Wilson Report, are being identified and mapped in a Geographical Information System (GIS) by CALM's Marine Conservation Branch (MCB).

Currently, there are no marine conservation reserves along the south coast of Western Australia, although most of the terrestrial national parks and nature reserves adjoining the coast contain marine areas between high and low water marks. Within the boundaries established for this project (Broke Inlet to Israelite Bay) the Wilson Report (Appendix II) identified a total of nine candidate marine conservation reserve areas, all adjacent to existing terrestrial reserves. These 21 terrestrial reserves consist of coastal national parks and nature reserves, plus offshore island nature reserves (Table 1).

The primary objective of this project is to facilitate a regional classification of the marine environment along the south coast of Western Australia, according to ecological, economic and cultural criteria, and to establish an information base for proposed marine conservation reserve areas identified in the Wilson Report. The project outcomes include recommendations that will facilitate the integrated management of adjacent terrestrial and marine conservation reserves and will ensure that the potential impacts of terrestrial and estuarine ecosystems upon their marine counterparts are understood prior to the creation of any marine conservation reserves.

In the initial stages of the project an informal project advisory committee was formed, comprised of representatives of organisations involved in the research and management of terrestrial, estuarine and marine environments along the south coast. The nine advisory committee members are:

1. Dr Jeremy Colman, CALM Marine Conservation Branch (Chairman)
2. Dr Paddy Berry, Western Australian Museum of Natural Science
3. Mr Geoff Bott, Department of Environmental Protection (DEP)

4. Mr David Deeley, Evangelisti & Associates
5. Dr Ian Eliot, Geography Department, University of Western Australia
6. Mr Kelly Gillen, CALM South Coast Region
7. Dr Hugh Kirkman, CSIRO Division of Marine Research
8. Dr Paul Lavery, Environmental Management Department, Edith Cowan University
9. Mr Guy Leyland, Western Australian Fisheries Industry Council (WAFIC)

The original geographical boundaries of the project were Denmark (western boundary) to Israelite Bay (eastern boundary). The location of this original western boundary coincides with the administrative boundary between the CALM South Coast and Southern Forest Regions. However, following discussions at the advisory committee inaugural meeting it was agreed to redefine the western boundary of the project as Broke Inlet, rather than Denmark. Broke Inlet, a seasonally open/closed estuary with similar characteristics to Wilson Inlet, is in relatively pristine condition, largely because its catchment lies wholly within the boundaries of the D'Entrecasteaux and Shannon National Parks. By comparison, Wilson Inlet, with its catchment lying within land cleared for agriculture, is severely impacted with periods of very poor water quality following nutrient enrichment. The revised project area from Broke Inlet (CALM Southern Forest Region) to Israelite Bay (CALM South Coast Region) is shown in Figure 1.

The marine component of this project is confined to the inshore marine environment in State waters, to a depth of approximately 50 metres.

The following scope items were established for the project, following discussions between the Reserve Systems Section, Biodiversity Group, Environment Australia, and CALM:

Project Scope Items

1. **Provide an overview of the nature conservation, recreation, aesthetic and economic values of potential marine reserves and associated terrestrial reserves along the south coast of Western Australia between Broke Inlet and Israelite Bay.**
2. **On the basis of 1 above, select areas for more detailed study of the range of issues facing the integration of terrestrial and marine reserves in the region.**
3. **Liaise with other relevant management organisations and the local community on the aims of the project and its methodology.**
4. **Compile all existing data on the natural values of the study areas.**
5. **Map, classify and ground truth major benthic habitats in the study areas.**
6. **Prepare listings of the flora and fauna of the marine and terrestrial components of the study areas.**
7. **Classify seaward-draining catchments associated with each study area on the basis of land-use and degree of alteration to the naturalness of surface and groundwater systems which enter the marine environment.**
8. **Identify interactions and impacts between the marine and terrestrial components of the study areas for each catchment (including physical and biological processes and land-use aspects).**
9. **Compare the results obtained in 8 above for the different catchment types identified in 7 above associated with each study area.**
10. **Use the results of 1 to 9 above to refine existing recommendations for potential marine reserves in the region, and to identify key management issues.**
11. **Prepare reports on the above scope items in accordance with the reporting schedule.**

Project scope item 1 is addressed in Part I of this report. Scope items 2, 4, 5, 6, 7, 8, 9 are addressed in Part II of the report and in the review of estuaries and catchments (see Part I, 3.4 and Appendix V). Scope items 9 and 10 are addressed in Part III. With regard to scope item 3 - an informal consultative process has been employed to facilitate liaison with relevant management organisations and the local community. Contacts have been established with a number of external state government departments within Western Australia, both to obtain information on the terrestrial, estuarine and marine environments along the south coast and also to inform them of the aims and methodology of the project, including: Fisheries WA, the Department of Transport, the Department of Environmental Protection, the Water and Rivers Commission, the WA Tourism Commission, and the WA Museum of Natural Science and the WA Maritime Museum. Dissemination of information on the project is further facilitated through the project advisory committee. Details of the project have been supplied to a NSW National Parks and Wildlife team currently working on developing and assessing integrated management strategies using the Solitary Islands and Jervis Bay Marine Parks as case studies.

An overview of the project was presented at a meeting of the Shire of Jerramungup held in Bremer Bay on 15 March 1997. The selection of the Fitzgerald Biosphere Reserve as the study area and the objectives and methodology of the marine biological survey were discussed at this meeting, which was attended by shire councillors, key local community members and government department representatives from both Albany and Perth. The local community and key user groups were further informed about the project through the publication of a comprehensive article in CALM's *Landscape* magazine (Summer 1997/98 edition). This article (Appendix IX) describes the project objectives, and the methodologies and key findings of the marine biological survey of the inshore waters adjacent to the Fitzgerald Biosphere Reserve. Reprints of this article will be distributed via the CALM South Coast Regional office in Albany and other locations, such as the new visitors centre in the Two Peoples Bay Nature Reserve.

In order to address scope item 11, a series of reports have been produced as part of the project. These are:

- first Progress Report (Colman, 1996);
- a report detailing a benthic habitat ground-truthing survey conducted in February 1997 (Colman, 1997a);
- the field program report for the marine biological survey (Colman, 1997b);
- second Progress Report (Colman, 1997c); and
- the data report for the marine biological survey (Colman, 1997d).

This project is a collaborative project between CALM's Marine Conservation Branch and CALM's South Coast Region. It was funded by a grant of \$63,000 from Environment Australia Biodiversity Group, Reserve Systems Section, under the National Reserves System Cooperative Program (Project #713). Resources including scientific supervision, technical assistance, logistical support and instrumentation were provided by the Marine Conservation Branch and resources including scientific and technical input, administrative assistance and logistical/operational support were provided by the South Coast Region. A financial statement detailing revenue and expenditure for each phase of the project is included as Appendix I.

Throughout this report the term 'project area' is applied to the overall project area of Broke Inlet to Israelite Bay, and the term 'study area' refers to the Fitzgerald Biosphere Reserve, associated estuaries and inlets and the adjacent inshore marine environment. The term 'Fitzgerald Biosphere Reserve' refers to larger notional reserve from Groper Bluff to Starvation Boat Harbour, with the Fitzgerald River National Park as its *core* zone.

PART I: OVERVIEWS OF THE MARINE, ESTUARINE AND TERRESTRIAL ENVIRONMENTS

1. THE INSHORE MARINE ENVIRONMENT

1.1 Climate and Oceanography

There is little known about the oceanography of the south coast of Western Australia. The main factors influencing the hydrodynamics along the coastline of this region are wind, tide, waves, solar radiation, large scale currents such as the Leeuwin Current and, further away from the coast, the Antarctic Circumpolar Current.

The meteorology of the south coast is dominated by the movement of the anti-cyclonic belt (high pressure systems with anti-clockwise winds) which move from west to east across the southern half of the state (Australian Bureau of Statistics, 1989). These systems are elongate in the west-east direction. In summer, the west-east axis of the belt lies to the south of the State and in winter it moves further north. Consequently, in summer easterly winds prevail over the southern part of the State (at speeds in the order of 15-25 knots), including the south coast. Superimposed on this prevailing pattern are sea breezes which are generated by differential heating between the land and adjacent ocean. Sea breeze strengths are typically in the order of 20-30 knots. Nearing summer's end the anti-cyclonic belt moves northward again and the northern fringe of the Roaring forties extends to Western Australia resulting in the prevalence of westerly gales associated with low pressure systems (with cyclonic winds) that cross the southern part of the State.

Tides are predominantly semi-diurnal along the south coast with associated ranges in water level of between about 0.5 and 1 m. In unrestricted waters, currents generated by such tides are relatively weak (approximately 0.01 m s^{-1}). A relatively consistent swell arrives, predominantly from the southwest. These wave patterns are reinforced by wind generated waves that result in a net eastward littoral drift along the south coast. Typical speeds for near-coastal currents generated by winds are in the order of 0.1 m s^{-1} , as recorded, for example, by current measurements in King George Sound during Spring 1986 and Summer 1987 (D'Adamo & Mills, 1991).

After summer the Leeuwin Current rounds Cape Leeuwin and flows eastwards towards southeastern Australia, with maximum flows that can exceed 3 knots just off the continental shelf and be up to 0.5 knots over the shelf (Pearce & Cresswell, 1997; Cresswell & Peterson, 1993; Pearce & Pattiaratchi, 1997). Although the Leeuwin Current generally flows as a narrow band (< 50 km wide) along the south coast it occasionally breaks off into large (> 50 km) offshoots and eddies and sometimes moves shoreward under favourable wind conditions. Herzfeld (in press) has investigated the dynamics of the Great Australian Bight (GAB), including the eastern portion of the Recherche Archipelago, and has shown through analyses of sea-surface temperature satellite imagery and 3D baroclinic numerical modelling that beginning in summer the western side of the GAB warms due to the differential effects of solar heating, while the eastern side of the GAB cools due to upwelling. The warmer water then progressively moves towards the east throughout summer and autumn. Herzfeld's (in press) study shows that the western side of the GAB warms ahead of the arrival of the Leeuwin Current in late autumn.

Current measurements from studies conducted near the coast in the Albany and Wilson Inlet regions by Dr Charitha Pattiaratchi and colleagues from the Centre for Water Research (University of Western Australia) indicate currents typically of around 0.1 m s^{-1} or less, but with instances of flows up to about 0.5 m s^{-1} . Off Sand Patch, near Albany, these high flow events were not necessarily correlated to the wind but rather matched changes in water temperature, suggesting the possibility of internal wave or upwelling activity (C. Pattiaratchi, CWR, University of Western Australia, pers. comm.).

1.2 Coastal Geomorphology

The coastal geomorphology of the south coast of Western Australia from Cape Leeuwin to the South Australian border is reviewed in some detail in the Wilson Report (CALM, 1994). The section of this report that describes

the coastal geomorphology, sedimentology and landforms between Point D'Entrecasteaux (40 kms west of Broke Inlet) and Israelite Bay is included in Appendix II.

A number of studies have examined beach and foredune morphology across the south coast, including an investigation of beach morphodynamics, a study of tombolos and cusped foredune systems and surveys of wave, tide and surge dominated beaches (I. Eliot, University of Western Australia, pers. comm.).

1.3 Biogeography

The temperate waters of the southern coast of Australia are recognised as a major biogeographic region, the Flindersian Province, which extends from southwest Western Australia to southern New South Wales (Edyvane & Baker, 1996). This broad biogeographic regionalisation is largely based on sea temperature, with the coastal waters varying from warm-to-cool temperate along Western Australia's south coast and in the Great Australian Bight, to cold temperate east of Robe in South Australia (Poore, 1995). The Flindersian Province is characterised by very high levels of marine biodiversity and endemism, which is partly a result of the long east-west extent of the southern coastline and a long period of geological isolation (Poore, 1995; Edyvane, 1996). Marine floral diversity is particularly high, as is the diversity and of invertebrate taxa, such as bryozoans, ascidians, molluscs and echinoderms (Womersley, 1990; Shepherd, 1991; Poore, 1995). Approximately 1,155 species of macroalgae, 22 species of seagrasses, 600 species of fishes, 110 species of echinoderms and 189 species of ascidians have been recorded in the Flindersian Province (Wilson & Allen, 1987; Womersley, 1990; Shepherd, 1991; cited in Edyvane, 1996). Another feature of this province is the very high levels of endemism, with approximately 85% of fishes, 95% of molluscs and 90% of echinoderms being endemic (Poore, 1995). The marine macroalgal diversity of the Flindersian Province is among the highest in the world, with over 800 species and 75% endemism in the red algae alone (Womersley, 1990). It has been suggested that the temperate marine environments of southern Australia could be described as the unique south, based on the biodiversity and endemism of the marine flora and fauna and the occurrence of populations of a number of rare and endangered marine mammals (Edyvane, 1996).

Since 1995 the Commonwealth Government has provided funding for a project to provide a single, ecosystem-level regionalisation of Australia's coastal and marine environments. This project, known as the *Interim Marine and Coastal Regionalisation of Australia* (IMCRA), is being coordinated by Environment Australia (Biodiversity Group) and is employing a collaborative approach between Commonwealth and State/Territory agencies. IMCRA uses a hierarchical structure to provide information and identify bioregions at two different levels: continental (*provinces*) and regional (*meso-scale regions*) (IMCRA, 1997). The Meso-scale Regionalisation (Figure 2) concentrates on the inshore waters of the continental shelf (out to the 200m isobath), with the regions being defined using biological and physical information. The south coast of Western Australia encompasses the WA South Coast (WSC) IMCRA (Version 3.1) region, which extends from Black Head in the west to Israelite Bay in the east, as well as sections of two other regions - the Leeuwin-Naturaliste (LNE) and Eucla (EUC) regions (see Figure 2). The overall project area for the South Coast Terrestrial and Marine Reserve Integration Study (Broke Inlet - Israelite Bay) falls entirely within the WSC region, and the description of this IMCRA region is shown in Table 2.

IMCRA (Version 3.1) also provides two provincial-scale regionalisations for continental shelf waters, based on classifications of demersal and pelagic fish species diversity and richness: the Demersal Provinces and Biotones Regionalisation (Figure 3) and the Pelagic Provinces and Biotones (Figure 4) (IMCRA, 1997). Biotones represent zones of transition between core provinces. As can be seen from the IMCRA (Version 3.1) map shown in Figure 3, the South Coast Project area falls entirely within the South Western Province (SWP) of the demersal provinces and biotones, with Israelite Bay on the eastern boundary line of this province. According to the pelagic provinces and biotones regionalisation (Figure 4), the western section of the project area falls into the Western Pelagic Biotone (WPB) and the eastern section into the Southern Pelagic Province (SPP), with the boundary between these two regions occurring at Albany. Tables 3 and 4 presents the descriptions of these demersal and pelagic regions.

1.4 Marine Flora and Fauna

Relatively little is known about the marine biota of the south coast of Western Australia. The influence of the Leeuwin Current on the marine life of western Australia, including the dispersal of tropical/sub tropical species to the temperate waters of the west and south coasts, are reviewed in Pearce & Walker (1991). The biota of rocky shores, seagrass meadows, algal beds and estuaries, and the marine mammals of south coast inshore waters are broadly reviewed in the Wilson Report (see Appendix II). Only one area of the south coast has been studied or surveyed in any detail - the Albany Harbours (Princess Royal Harbour, Oyster Harbour and King George Sound). The Albany area was the subject of an international marine biological workshop in 1988, organised by the WA Branch of the Australian Marine Sciences Association (AMSA). This workshop resulted in the publication of two volumes of papers on the taxonomy, ecology and physiology of local marine flora and fauna (Wells, *et al.*, 1990, 1991). In 1988 the WA Environmental Protection Authority (EPA) initiated an intensive two year investigation into the state of Princess Royal and Oyster Harbours (EPA, 1990a). The EPA made a number of recommendations to halt the rate of seagrass decline and to provide guidelines for long-term environmental management of Albany Harbours (EPA, 1990b). The Albany Waterways Management Authority (AWMA) was also formed in response to the EPA recommendations, and AWMA has been responsible for coordinating a number of programs that have been monitoring the nutrient loads entering the Harbours and the quantity and distribution of seagrasses and macroalgae (Simpson, *et al.*, 1990; Hillman, *et al.*, 1991a, 1991b; Masini, *et al.*, 1995; Seal, 1995; Bastyan, *et al.*, 1996).

Until recently little was known about the seagrasses of the south coast, apart from the Albany Harbours area, where extensive areas have been lost (Bastyan, 1986). The Southern Western Australian Seagrass Study (SWASS, 1996) nominated a total of six seagrass areas across the south coast for listing on the Australian Heritage Commission's Register of the National Estate. These areas, identified on the basis of extensive meadows of perennial, deep-rooted species such as *Posidonia* and *Amphibolis*, are:

- King George Sound;
- Two Peoples Bay;
- Hassell Beach;
- Bremer Bay and Doubtful Islands Bay to Red Island;
- Margaret Cove to Fanny Cove; and
- Recherche Archipelago - Butty Head to north of Israelite Bay.

The genus *Posidonia* dominates along the south coast, with *P. sinuosa*, *P. australis* and *P. robertsonae* forming well-defined meadows. Other species occurring are *P. angustifolia*, *P. ostensfeldii*, *P. kirkmanii*, *P. denhartogii*, *Amphibolis antarctica*, *A. griffithii*, *Halophila australis*, *H. ovalis*, *Heterozostera tasmanica* and *Thalassodendron pachyrhizum* (Kirkman & Kuo, 1996). There is a high level of endemism of seagrasses along the south coast, with nine out of 17 species being endemic, including *P. robertsonae*, *P. kirkmanii* and *P. ostensfeldii* (Kuo & McComb, 1989, SWASS, 1996). The south coast may be the centre of distribution for Australian *Posidonia* (Kirkman & Kuo, 1996). The dynamics of seagrasses in Frenchman Bay (King George Sound, Albany) have been described in Kirkman & Kuo (1990) and currently the seagrass meadows and associated fauna in Two Peoples Bay are being investigated by researchers from the CSIRO Division of Marine Research and the University of Western Australia (H. Kirkman, CSIRO Division of Marine Research, pers. comm.).

A survey of the nearshore reef fish fauna of Western Australia's west and south coasts, conducted by the Western Australian Museum between 1977 and 1993, included a number of sites between Walpole and Cheyne Beach and in the Recherche Archipelago (Hutchins, 1994). Avayzian & Hyndes (1995) investigated the surf-zone fish assemblages of a number of sandy beaches of the west and south coasts and examined the influence of nearshore habitats and the Leeuwin Current on the characteristics of the fish fauna. The population biology and reproductive ecology of greenlip abalone (*Haliotis laevigata*) populations at Augusta, Hopetoun and Esperance are described in Wells & Mullvay (1995).

Several publications provide descriptions of the benthic algae (Womersley, 1984, 1987, 1994), invertebrates (Shepherd & Thomas, 1982, 1989) and fishes (Hutchins & Thompson, 1983; Hutchins & Swainston, 1986; Gomon, *et al.*, 1994; Last & Stevens, 1994) of Australia's southern coasts. Over 1,200 species of the marine flora and fauna of Australia's temperate waters, including many of the species that occur in shallow waters of

the south coast of Western Australia, are described and illustrated in Edgar (1997). This work also includes a comprehensive bibliography for all the major phyla of marine plants and animals occurring in southern Australian waters.

The Wilson Report (Appendix II) broadly reviews the occurrence of marine mammals along the south coast and briefly describes monitoring work being carried out on southern right whale populations and the development of a whale watching industry. As part of this study a review of the marine mammal resources of the south coast has been carried out. This review (Appendix III) collates information available for pinnipeds and cetaceans across the project area, reviews research undertaken on the New Zealand fur seal, Australian sea lion and southern right whale populations, and lists inventories of species distribution and stranding events. Maps showing the distribution of fur seal and sea lion haul-out and breeding sites, as well as the areas where southern right and humpback whales frequently occur on a seasonal basis during the winter and spring months, are shown in Figures 5-8. These data have been compiled from Shaughnessy, *et al.* (1994), Gales, *et al.* (1994), from John Bannister (WA Museum of Natural Science, pers. comm.) and Peter Collins (Wildlife Officer, CALM Albany, pers. comm.). It is apparent that the area extending north-east from Israelite Bay to Point Culver is a significant coastal habitat for southern right whales (Figure 8), and that this area was not identified in the Wilson Report (see marine mammals review - Appendix III).

1.5 Benthic Habitats

Broad-scale mapping and classification of the major benthic habitats has been carried out between Albany and Twilight Cove (to the west of Eyre in the Great Australian Bight) by Dr Hugh Kirkman, CSIRO Division of Marine Research. Benthic habitats have been divided into eight broad categories or types:

1. Dense seagrass.
2. Medium seagrass.
3. Patchy seagrass.
4. Sparse seagrass.
5. Bare sand.
6. Flat platform reef.
7. Heavy limestone reef.
8. Granite reef.

Broad ground-truthing has been carried out for deep water features and islands of the Recherche Archipelago, and for the coast from Two Peoples Bay near Albany to the border with South Australia at Eucla. Full details of the mapping project are given in Appendix IV. The relevant digital data sets have been obtained from the Coastal Resource Atlas (Coastal Management Branch, Western Australian Department of Transport - DOT), and transferred to the marine GIS currently being established at the MCB office in Fremantle. Benthic habitat maps for the south coast, showing the area between Broke Inlet and Point Culver (to the north of Israelite Bay), are shown in Figures 9-12. The benthic habitats of the inshore marine environment from Point D'Entrecasteaux to Albany, including the Wilson Report areas adjacent to the William Bay, West Cape Howe and Torndirrup National Parks, have not been mapped or classified. The surveying, classifying and ground-truthing of benthic habitats across this area should be considered as a priority for any future benthic habitat mapping of the south coast.

Further ground truthing of a number of sites from the Recherche Archipelago to Albany was undertaken, using a drop-down underwater video system, during a voyage of the STS Leeuwin in February 1997 (Colman, 1997a). Additional information from Dr Kirkman's field notes for surveys of the south coast, including GPS positions of ground-truthing sites, records of seagrass and macroalgal species, water depth and codings for predicted and actual benthic habitat category, have been collated and databased as part of this study.

The benthic habitat map for the eastern portion of the project area indicates the presence of large areas of seagrass habitat extending north of Israelite Bay up to Point Culver (Figure 12). The presence of this significant habitat is not identified in the Wilson Report and no recommendations were made with reference to reservation of this area.

Only limited bathymetry data exists for inshore waters of the south coast. There are large sections of the coast (e.g. Hopetoun to Esperance and the eastern part of the Recherche Archipelago) which have been inadequately surveyed and for which no or only sparse bathymetry is available.

1.6 Social and Economic Values

1.6.1 Cultural and historical resources

Aboriginal history and land use across the south-west of the State and early European exploration of the coastline is reviewed in CALM's South Coast Region Management Plan (CALM, 1992a) and in the review of terrestrial reserves in this report (see Appendix VI). A number of early French, British and German scientific expeditions visited King George Sound and made extensive collections of marine flora and fauna (see Wilson Report - Appendix II). Consequently, King George Sound is the type locality for many southern Australian marine species, especially molluscs (Wells, 1990).

The high number of shipwrecks along the south coast of Western Australia reflects the region's rich maritime history. A listing, description and locations of all known shipwrecks off the south coast, including historic shipwrecks protected under State and Commonwealth legislation, has been obtained from the Western Australian Maritime Museum. Figure 13 shows the location of both gazetted historic shipwrecks and other known shipwrecks across the project area.

Extensive areas of the south coast are subject to Native Title Claims under the Commonwealth *Native Title Act, 1993*. The Colbung Native Title Claim extends from Cape Mentelle west of Augusta (between Capes Naturaliste and Leeuwin) to Groper Bluff at the western end of the Fitzgerald Biosphere Reserve (see Part II). This claim includes land and waters such as estuaries, inlets and inshore areas down to low-water mark and also includes a number of offshore islands including Cheyne Island, Hauloff Rock, Bald Island, Michaelmas Island, Breaksea Island and Eclipse Island within the project area of this project. Similar claims have been lodged with the National Native Title Tribunal for land and waters across the eastern end of the project area - Bremer Bay to Israelite Bay, including the Recherche Archipelago. The issue of Native Title Claims over coastal areas and the potential impacts on marine conservation reserve implementation and management are discussed in the Analysis of Public Submissions on the Wilson Report (CALM, 1997).

1.6.2 Commercial and recreational fishing

The major commercial finfisheries that exist across the south coast, between Cape Leeuwin and the Western Australian border with South Australia, are described in the Wilson Report (Appendix II).

The Fisheries Western Australia annual State of the Fisheries Report (Fisheries Department of WA, 1996) provides data on south coast fisheries, considering each species and fishing method separately. This report provides information for the following commercial fisheries that occur within the project area of this project:

- Esperance Rock Lobster Managed Fishery;
- Southern Rock Lobster Fishery;
- Zone 1 and Zone 2 Greenlip/Brownlip Abalone Fisheries;
- South Coast Inshore Trawl Managed Fishery (Scallop);
- South Coast Salmon Managed Fishery;
- Australian Herring Fishery;
- Princess Royal Harbour and King George Sound Fisheries;
- Southern Demersal Gillnet and Demersal Longline Fisheries (Shark); and
- South Coast Purse Seine Managed Fishery (Pilchard).

The fisheries that affect terrestrial reserves are those that require access through coastal national parks and nature reserves to reach shoreline sites, estuaries and inlets. The fishers involved include abalone divers, rock lobster fishermen, estuarine fishermen, and various inshore fishers in search of salmon, pilchards, shark etc. These coastal and estuarine fisheries have been described and assessed in a recent WAFIC (Western Australia

Fishing Industry Council) report (Wright, in press), which gives a very good description of coastal fisheries in the area. Permits are issued for access through and transport of catch as well as camping on CALM managed lands. Fishing camps can often be large and can cause conflict with other park or coastal users. Therefore special provisions restricting fishing activity have been made at some sites. The South Coast Regional Management Plan (CALM, 1992a) includes a table detailing the number of permits for each fishery issued in each of the CALM managed coastal reserves. Commercial fishing takes place at many sites along the coast. Further details of catch returns and numbers of fishers are available from the State of the Fisheries Report (Fisheries Department of WA, 1996).

Problems associated with commercial fishing include access, conflict with recreational fishers and other park or coastal users and ongoing conflict with seals and sea lions. Salmon beaches and estuaries (see Part I, section 3) are the main areas of conflict.

A number of marine mammals and seabirds are caught as by-catch in the south coast commercial fisheries. Dolphins can become entangled in nets and are occasionally caught in the south coast purse seine fishery. There is a reporting scheme requesting fishermen to report any dolphins pulled in as by-catch, although not all occurrences are reported. The scheme has provided some useful information on species by way of autopsies performed by Agriculture Western Australia (AgWA) veterinary pathologists. Fleshly-footed shearwaters are taken illegally in the purse seine fishery when they get caught up in the nets. The species can create difficulties for fishers when they are present in large numbers.

Fur seals and sea lions are reported as a problem in several fisheries, principally the gill net fishery in the Albany Harbours area, and also in the herring and salmon fisheries. The gill net fishery used to complain about bull sea lions being the major problem, however more reports of damage by fur seals are being received. CALM issues damage reduction permits to fishers to scare seals off. A total of 32 such permits were issued from 1990 to 1996 to commercial fishermen in Albany Harbours, Cheynes Bay, Doubtful Islands Bay and Dillon Bay and all were for sea lions (Gales, in preparation). There is certainly a problem with fur seals and sea lions being shot, and in some instances (e.g. Bald Island) it is possible that this is preventing the re-establishment of a New Zealand fur seal breeding colony (P. Collins, CALM Albany, pers. comm.). There is some concern over the killing of fur seals and sea lions by fishermen frustrated by damage incurred to nets and the perceived loss of catch to these animals.

Recreational fishing is a popular pastime throughout WA and the south coast is no exception. The most common activity in many of the national parks along the coast is fishing (Two Peoples Bay, Waychinicup, Fitzgerald, Stokes, Cape Le Grand, Cape Arid and William Bay). Local residents and visitors to the area use many sites along the coast including beaches, cliffs, headlands and inlets. Beach fishing is popular with species caught including herring, whiting, shark, skipjack and tailor. During late summer and early autumn salmon can be caught from some beach sites. Rock fishing generally produces groper, while fishing in the inlets produces black bream. Fishing from small boats launched from the coast is also popular. The major recreational fisheries of the south coast are reviewed in the State of the Fisheries Report (Fisheries Department of WA, 1996).

No specific data on numbers of people participating in recreational fishing, sites frequented or on species and numbers of fish caught, is available for the south coast. A review of recreational fishing produced by the Australian Bureau of Statistics (1987) contains some data on recreational fishing but no figures specific to the south coast region. Local Recreational Fishing Advisory Committee (RFAC) members considered that data on levels of recreational fishing would be extremely difficult and time consuming to collect. A recent review of recreational fishing made some recommendations specific to the south coast, suggesting that priority areas for recreational fishing should be established (RFAC, 1990).

There are several 'no take' areas for recreational and commercial fishing, established under fisheries legislation, on the south coast. These include the artificial reef in Esperance Harbour and the wreck of the *Sanko Harvest* (see Part I, section 1.6.4). Spear guns are not allowed in (or through) national parks or nature reserves. Outside CALM-managed reserves spearfishing is not permitted when diving on SCUBA. It is permitted when free diving, but is not at present a common activity on the south coast.

1.6.3 Aquaculture

Aquaculture sites on the south coast are slowly increasing in number. Currently, the preferred area for aquaculture development proposals is Albany Harbours. The location of all south coast aquaculture development leases can be obtained from the Fisheries Department and the Department of Transport, who declare mooring lease areas around all marine aquaculture developments. The Albany Harbours Planning Strategy (AHPG, 1997) identifies both existing aquaculture lease areas and areas suitable for further aquaculture developments within the Albany Harbours (including the proposed Great Southern Aquaculture Park in Frenchman's Bay). One major concern in relation to aquaculture in the King George Sound area is the potential effects on the whale watching industry, with concerns being expressed about the danger of whales becoming entangled in aquaculture plot moorings.

1.6.4 Shipping

The south coast of Western Australia has two major ports, at Albany and Esperance. The port activities of the Albany Harbours are reviewed in AWMA (1995a) and AHPG (1997). There are a number of issues related to shipping that are of concern for the future implementation and management of marine conservation reserves across the south coast, including pollution (particularly oil spills) and ballast water discharge (introduction of marine pests).

In February 1991, the bulk carrier *Sanko Harvest* was wrecked on a reef between Hood Island and Hastings Island in the Recherche Archipelago, releasing approximately 30,000 tonnes of agricultural fertiliser and 610 tonnes of bunker oil (Stoddart, *et al.*, 1992). The ecological effects on intertidal and subtidal communities and on local marine mammal populations are described in Stoddart, *et al.* (1992) and Gales (1991). Long-term effects from the both the mechanical impacts of the wreck and the release of fertiliser and oil were considered to be slight, as a result of the deep, well-flushed waters surrounding the wreck site and a rapid and effective clean-up operation (Stoddart, *et al.*, 1992; Gales, 1991). The wreck has become a popular dive site (Storrie & Pobar, 1994) and is also a designated no fishing zone under fisheries legislation.

The introduced marine fanworm *Sabella spallanzanii* has been discovered in two locations across the south coast - in Albany Harbours (Clapin & Evans, 1995) and in Bandy Creek Harbour in Esperance (G. Clapin, CSIRO Division of Marine Research, pers. comm.). At Albany, it has been recorded in Oyster Harbour (Emu Point Boat Harbour) and in Princess Royal Harbour (Fishing Boat Jetty) and it is considered likely to spread to other areas of Albany Harbours (Clapin & Evans, 1995). It is also likely to colonise other areas of Esperance Bay, particularly where there are man-made structures such as jetty and wharf pylons and channel markers. To date none of the other introduced marine pests that have been discovered in temperate waters in other parts of Australia (such as the Japanese kelp *Undaria pinnatifida* and the northern Pacific seastar *Asterias amurensis*) have been found along the south coast of Western Australia (G. Clapin, CSIRO Division of Marine Research, pers. comm.).

1.6.5 Recreation and tourism

1.6.5.1 Yachting and power-boating

Several inlets along the coast provide good sites for yachting and there are active yacht clubs based at Princess Royal Harbour, Denmark, Nornalup Inlet, Broke Inlet, Walpole Inlet, and Esperance. Albany Harbours and King George Sound are the most heavily used areas with some 60-70 yachts currently registered.

The main users of power boats are fishermen and divers, although some pleasure craft also visit the coastal area. There are several problems associated with boat use. Firstly, access - boat launching sites are limited and can therefore become congested, areas around launching sites can become degraded. Few fixed mooring sites exist so boat users have to anchor potentially causing damage to benthic habitats (seagrass, reef etc.). Visitors arriving at CALM managed sites by boat will not have the benefit of any information provided within the park.

Water ski-ing and jet ski-ing have all the problems associated with power boating above with the added problem of noise and disturbance. Noise from jet-skis and high powered boats can be intrusive for other coast users and this is a problem at Middleton Beach, Albany and within Princess Royal Harbour. This issue is

addressed by the Albany Harbours Planning Strategy through zoning to separate incompatible activities (AHPG, 1997).

1.6.5.2 Surfing and sailboarding

There are several sites along the south coast popular with surfers (Salmon Holes Beach at Torndirrup National Park, Ocean Beach at Denmark, Middleton Beach at Albany, Golden Gates Beach in West Cape Howe National Park, Mandalay Beach in Walpole-Nornalup National Park). Problems can occur where there is conflict between surfers and other beach users particularly where surfers camp on the beach or where car parking is limited. Erosion can also be caused by surfers accessing the beach over dunes by foot and by vehicle.

Sailboarding, although not common on the south coast, is growing in popularity particularly in some of the inlets and other areas (e.g. Walpole-Nornalup Inlet, Albany Harbours and King George Sound) which provide good conditions for sailing. Although not a problem at present increased numbers of sailboards could result in conflict with other beach users and access problems as discussed above.

1.6.5.3 Swimming and scuba diving

Swimming and wading are popular at many sites along the coast and there are no particular problems other than those associated with access and safety.

There are several sites along the coast that are considered excellent for snorkelling and scuba diving (Shelley and Dunsy Beaches in West Cape Howe National Park and the Shoal Cape area in Stokes National Park for example). As well as sites that can be accessed from the shore, divers use boats to reach more isolated areas of the coast. The South Coast Diving Club is very active and has a considerable membership. There are also charter boat operators running diving trips from both Albany and Esperance. These operators take divers, in addition to other tourists (whale watching, sight seeing etc.), as numbers of tourist divers visiting the area are not high enough to sustain a diving operation alone. The Esperance dive operator takes groups to a numbers of sites within the Recherche Archipelago and occasionally to the wreck of the *Sanko Harvest* (see Part I, section 1.6.4). The most popular sites for the Albany dive operators are the Cheynes III and the SS Cheynes - whale chasers sunk near Michaelmas Island. The deep ridge and reefs to the west of Michaelmas Island (Michaelmas Reef) are also popular dive sites. This area is reported to have diverse and spectacular benthic and fish communities. It was not included within the recommendations of the Wilson Report, although the Working Group did recommend that a survey be conducted of the area to assess its 'relative underwater scenic values and merits as dive sites' (CALM, 1994). However, it is included within the recommendations of the Albany Harbours Planning Strategy as part of a multiple-use marine conservation reserve encompassing Michaelmas and Breaksea Islands (AHPG, 1997). A proposal has been put forward to buoy local dive sites in King George Sound with fixed concrete moorings. A dive shop has recently opened in Bremer Bay and the operator commenced diving trips in the area during 1997.

1.6.5.4 Wildlife interaction

Commercial whale watching started in Albany in 1989 and has been growing since. The industry is based around the migration of the southern right whales which remain in south coast waters for several months over the winter. Humpback whales are also seen in the region during the winter period and numbers have increased noticeably in recent years. Most tours are run from Albany, taking place inside the sheltered waters of King George Sound (see Figure 5). As the number of boats operating whale watching tours has increased problems have occurred with boats approaching too close to whales. There is now a code of practice in place to guide operators conduct around the whales. Operators have tried whale watching trips in other areas. One boat worked out of Hopetoun in 1996, but did not have much success. A licence has been granted to an operator working out of Bremer Bay for the 1997 season. Whale watching from land based sites is very popular around Albany. Point Ann, in the Fitzgerald River National Park, however, is the major land-based site in the region, and is equipped with a small amount of information and a whale watching platform. Sperm whales occasionally occur in the deeper waters of the continental shelf south of Albany and interest is growing in developing charter trips to target this resource. Currently, a commercial tour operator in Albany is building a large vessel suitable for offshore voyages.

All operators carrying out whale watching trips are required to have a licence from CALM for whale interaction. As well as interaction licences for whale watching tours, licences for photographic study are regularly granted (3-4 each year).

Seal watching generally takes place as part of another activity rather than a trip on its own. Whale watching tours will also view seals. An tour operator in Esperance carries out seal watching tours on route to Woody Island on regularly operating tourist trips. Until 1997, whale tour operators have not been required to carry a seal interaction licence but all operators now must apply for both whale and seal interaction licences.

Seabird watching is generally not an intrusive activity and causes few problems. This activity is promoted by several operators who conduct general charters, particularly those who operate outside the whale watching season. There are a few problem areas where disturbance or potential disturbance to seabirds is being caused, such as the little tern colony at William Bay, the pelicans on Green Island (the most southerly breeding colony in the State and the only colony south of Shark Bay), the little penguin colony on Mistaken Island and the hooded dotterel nesting area on the sand bar at Wellstead Estuary (Bremer Bay), which is near a vehicle access route to Point Hood.

2. THE ESTUARIES AND COASTAL INLETS

Across the south coast of Western Australia there are many small rivers and creeks that form coastal lagoons and estuaries at their mouths. A broad description of these southern estuaries is included in Part I of the Wilson Report (CALM, 1994). An inventory of Australian estuaries and enclosed waters (Bucher & Saenger, 1989) collated information for 145 estuaries in Western Australia, including 11 within the project area of this project (Broke Inlet to Israelite Bay). The region includes four estuary systems that are included in the ANCA Directory of Important Wetlands in Australia (ANCA, 1996) - Broke Inlet System, Oyster Harbour, Fitzgerald Inlet System and Culham Inlet.

2.1 Geology, Landforms and Soils

The geology, landforms and soils of the coastal inlets, estuaries and associated catchments of the south coast are reviewed in detail in the WA EPA's Estuarine Studies Series (Hodgkin & Clark, 1987, 1988a, b & c, 1989a & b, 1990a & b) and summarised in the estuaries review of this project (Bancroft, *et al.*, 1997 - see Appendix V).

2.2 Estuarine Flora and Fauna

The estuarine flora and fauna of the south coast estuaries has been described in some detail (Hodgkin & Clark, 1987, 1988a, b & c, 1989a & b, 1990a & b). This information has been reviewed and summarised in the Wilson Report (see Appendix II). The saltmarsh fringing vegetation of a number of south coast estuaries is described in the Estuarine Studies Series and saltmarsh vegetation associations in Oyster Harbour, in estuaries of the Fitzgerald River National Park, in Stokes Inlet and Israelite Bay are described in Bridgewater & Cresswell (1993) The occurrence of the seagrass *Halophila decipiens* in two estuaries within the project area is described in Kuo & Kirkman (1995). A preliminary investigation has been made of the marine flora and fauna of the Waychinicup Inlet, a permanently open valley lagoonal estuary unique along the south coast (P. Lavery, Edith Cowan University, pers. comm.).

The fish fauna of Walpole-Nornalup and Wilson Inlets is described in some detail in Potter, *et al.* (1990), Potter, *et al.* (1993) and Potter & Hyndes (1994). A number of research projects are continuing to study the fish fauna of south coast estuaries, with particular focus on the life cycles of commercially important species such as black bream and mullet (I. Potter, Murdoch University, pers.comm.).

The coastal inlets and estuaries of the south coast are important habitats a diverse range of native and exotic waterfowl. The Estuarine Studies Series (Hodgkin & Clark, 1987, 1988a, b & c, 1989a & b, 1990a & b) provides comprehensive listings of waterbirds recorded for the estuaries of the project area. Halse, *et al.* (1994, 1995) details biannual counts of waterfowl numbers for a number of estuaries within the project area.

2.3 Social and Economic Values

2.3.1 Cultural and historical resources

Numerous Aboriginal sites have been identified in estuaries and coastal inlets across the south coast, including Broke, Parry and Wilson Inlets, Oyster Harbour, Gordon Inlet, Dempster Inlet and Stokes Inlet. Details of all terrestrial, estuarine and marine Aboriginal historical/cultural sites across the south coast region have been obtained from the register system of the Aboriginal Affairs Department. The locations of these sites are shown in Figure 1 in the review of terrestrial reserves (Appendix VI). This figure also shows the Nyoongar Dreaming Trails that have been identified for the south coast region (N. Nannup, CALM Aboriginal Tourism Unit, pers. comm.). A variety of different types of cultural/historical site are known, both ethnographic and archaeological, such as artefact scatters and stone-lined fish traps. Archaeological surveys have been carried out across the exposed floors, shorelines and underwater areas of Broke Inlet, Wilson Inlet, Oyster Harbour, Beaufort Inlet, Wellstead Estuary, Hunter River Inlet, the inlets of the Fitzgerald River National Park, Culham Inlet, Oldfield Inlet, Torradup Estuary and Stokes Inlet (Dortch, 1995). Several of the sites exhibit material that pre-dates sea level rise and the formation of these shallow estuarine basins.

The European history of the south coast inlets and estuaries is described in the Estuarine Studies Series (Hodgkin & Clark, 1987, 1988a, b & c, 1989a & b, 1990a & b).

2.3.2 Commercial and recreational fishing

Commercial fishing in the south coast estuaries is briefly reviewed in the Wilson Report (Appendix II) and in the estuaries review of this project (see section 3.4). The draft report of the South Coast Estuarine Fishery Working Group describes the fisheries in greater detail, reviews current fisheries management and makes a number of recommendations in relation to future management (SCEFWG, 1995). South coast estuarine fisheries are also described and assessed in a report of the Western Australia Fishing Industry Council (WAFIC) (Wright, in press).

Recreational fishing is a major activity in the estuaries and inlets of the south coast. Hodgkin & Clark (1987, 1988a, b & c, 1989a & b, 1990a & b) list the non-commercial species of fish caught in a number of estuaries across the project area but little additional data exists on annual catch levels, fish stocks etc. Currently, a joint Fisheries Department/CALM project, funded by the National Fishcare Program, is gathering anecdotal evidence on recreational fisheries in a number of south coast estuaries, including Broke Inlet, Nornalup Inlet, Wilson Inlet and Oyster and Princess Royal Harbours. This project will result in the production of an oral history of fishing activity which will identify trends and assist in future management of these fisheries.

A recreational fishery for the freshwater crayfish, or marron, occurs on some of the rivers in the south coast area (for example Deep, Walpole and Frankland Rivers in Walpole-Nornalup National Park, and the Waychinicup River). Marroning is regulated by the Fisheries Department with the help of CALM staff who assist in patrolling the area during declared and closed seasons. Marroners can cause problems along river banks, disturbing and degrading riverside vegetation, lighting camp fires and causing a fire hazard in sensitive areas. There are also problems with new tracks being created to access new areas.

One of the major problems associated with commercial and recreational fishing in the south coast estuaries is access through existing national parks and nature reserves, and associated issues such as the management of bush fires and the spread of dieback disease. This issue is discussed in detail in the review of terrestrial reserves (see Part I, section 4). Estuary/inlet bar management and the effects of human interference on the fisheries are described in some detail in the Estuarine Studies Series and in the estuaries review of this project (see Part I, section 3.4).

2.3.3 Recreation and tourism

The estuaries and inlets of the south coast are particularly important recreational and tourism resources for the region. The fishing and boating opportunities (see sections 3.3.3 and 2.6.5.1) and scenic beauty of many of the estuaries and inlets are major attractions for visitors.

Canoeists frequent several of the rivers in the coastal area. Problems are caused when people stop to camp beside rivers, causing degradation of fragile riverside vegetation and creating fire risks. River banks are often steep providing few suitable camping spots. Particular problems have occurred along the Kalgan, Frankland and Deep Rivers.

2.4 Estuaries and Catchments Review

A review has been carried out of the available information on the water quality of all coastal inlets, estuaries and associated catchments between Broke Inlet and Israelite Bay, including those not surrounded by existing terrestrial reserves. Particular attention was given to aspects of catchment land use, clearing status and runoff quality and any characteristics of estuarine systems that could have a direct influence on integrated management of adjacent terrestrial, estuarine, and marine environments.

This review (Bancroft, *et al.*, 1997) was undertaken by the Marine and Freshwater Research Laboratory (MAFRL) at Murdoch University. It is included as Appendix V of this report, and consists of three main sections:

- a review of catchment characteristics;
- a review of coastal lagoons and estuaries, including a classification of estuaries and a description of each estuary in the project area; and
- a discussion of management issues affecting integrated management.

There is considerable existing information on the status of south coast catchments. There are active Land Care District Committees (LCDCS) associated with the Manjimup, Denmark, Albany, Jerramungup, and Esperance Shires, covering the catchments of most estuaries in the project area. The Jerramungup Soil Conservation District has been active in promoting the Fitzgerald Biosphere Project, with its focus on protecting the Fitzgerald River National Park, and its unique flora, fauna and estuaries (see Part II). Soil Conservation handbooks, and summary documents have been obtained and used as a basis for providing an overview of mass transport of substances to the land margin.

Along with LCDCS, there are a number of statutory local area management authorities that have been established along the south coast, including Albany Waterways Management Authority (AWMA) and Wilson Inlet Management Authority (WIMA), covering the management of Albany Harbours and Wilson Inlet (WWC, 1992; AWMA, 1995b; Seal, 1995). An advisory committee (Walpole and Nornalup Inlet Systems Advisory Committee), based around the Walpole-Nornalup Inlet, has been established and has provided advice on a range of issues to the Manjimup Shire. Contact was made with local management authorities and advisory committees to obtain available information on issues influencing quality of runoff waters.

The Water and Rivers Commission has carried out a draft review of catchments in the Busselton to Walpole region (Muirden, 1995), and this provides hydrological information for the western portion of the review area. Hydrological information has not been summarised for catchments east of Walpole, although limited summaries are provided in the WA EPA's Estuarine Study Series (Hodgkin & Clark 1987, 1988a, b & c, 1989a & b, 1990a & b). The Estuarine Health Indicators Project, currently being completed by MAFRL, has investigated water quality for Broke, Walpole-Nornalup and Wilson Inlets, Oyster Harbour and Stokes Inlet (Deeley & Paling, in prep., Deeley *et al.*, in prep.). The available historical information becomes increasingly scarce as one moves eastward. None-the-less, some runoff quality data are available, and regression analysis has been used to make some speculative judgements about the magnitude and frequency of runoff events in the eastern portion of the review area.

The review used all available information to review catchment processes, including:

- Catchment boundary and area, catchment slope erosive conditions, drainage and riparian buffers.
- Geology, soil type, topography, water features, vegetation type and community.
- Rainfall and discharge patterns.
- Hydrology.
- Land use.
- Water quality and pollutant loads.

It should be pointed out that the basic philosophy of land management throughout the region has been on agricultural productivity on-site, and not on minimisation of off-site impacts. The Western Australia Government has until recently, advocated the use of natural and artificial drainage lines for disposal of both saline runoff from salt reclamation works and paddock runoff from low-lying coastal pastures. Both these practices promote the passage of sediment and nutrients, particularly during periods of high flow. Much of the available information still follows this basic philosophy, with an emphasis on the paddock not the estuary, and is of limited relevance for the estuaries review.

The Estuarine Study Series of eight reports by Hodgkin and Clark (1987, 1988a, b & c, 1989a & b, 1990a & b), covers all the estuaries in the project area. These reports form the basis of the review of estuarine status. There have been a number of studies undertaken in several of the estuaries in the review area. These include investigations into heavy metal contamination of sediments in Princess Royal Harbour, and seagrass and macroalgal distribution in Princess Royal Harbour and Oyster Harbour (EPA, 1990a, 1990b; Masini, *et al.* 1995; Bastyan *et al.* 1996). There have also been investigations into sediments, hydrodynamics and macrophyte communities in Wilson Inlet. These investigations have been reviewed and any relevant findings summarised.

The review has also summarised information available on commercial fisheries in the south coast estuaries, drawing on data supplied by the Fisheries Department, and the draft report of the South Coast Estuarine Fishery Working Group (SCEFWG, 1995).

The Estuarine Health Indicators Project also collected physical, chemical and biological data for Broke, Walpole-Nomalup and Wilson Inlets, Oyster Harbour and Stokes Inlet. The project involved two years of sampling of water and sediment chemistry, phytoplankton, zooplankton and benthic macro-invertebrate communities at five sites in each estuary. This quantitative information compliments the qualitative information presented in the Estuarine Study Series (Hodgkin & Clark 1987, 1988a, b & c, 1989a & b, 1990a & b), and forms the basis of the regional assessment.

There are few data on the water quality, sediment or biota for most other estuaries on the south coast. An assessment of estuarine trophic status was undertaken, using regression analysis and information from other regional estuaries, but it must be seen as being subjective in the absence of site specific data. Although speculative, the analysis of status and susceptibility of south coast estuaries has identified priority issues requiring more detailed assessment in the future.

The Western Australian Department of Environmental Protection (DEP) is currently compiling a water quality inventory for estuary catchments in the south-west of the State (G. Bott, Department of Environmental Protection, pers. comm.). Over 20,000 nutrient analyses have been carried out by the DEP, for water courses extending from Moore River to Beaufort Inlet. Some opportunistic sampling was also undertaken on rivers in the Fitzgerald Biosphere Reserve, but these data are not regarded as particularly useful as they don't pick up major flood events. Most data of interest was collected between Albany and the Hardy Inlet (Augusta), as many of the water courses in this area also had DEP gauging stations to measure streamflow and hence nutrient loads. The DEP is currently archiving these data and intends to publish the information on CD ROM by the end of 1997. Much of it compliments the data collected in the Estuarine Health Indicators project, in as much as it addresses water quality in many of the coastal tributaries and makes extrapolation of flows in ungauged creeks easier.

The estuaries review uses the available information to summarise estuarine;

Physical characteristics: estuary surface area and volume;
hydrodynamics;
bathymetry and geomorphology;
sediments: chemical and physical characteristics, distribution and accretion rates;
water quality: nutrient and particulate pollutants, salinity.

Biological characteristics: trophic status;
vegetation diversity, abundance and distribution;
faunal diversity, abundance and distribution.

There have been a number of classification schemes published for estuaries (Heath, 1975; Roy, 1984), based on geomorphology, evolutionary stage, hydrological processes, climate, water quality, habitat, land use, aesthetic factors and eutrophication risk assessment. Availability of relevant information for catchments and estuaries in the review area has governed the nature of the classification scheme. Elements of several published classification schemes were used to analyse risks to receiving waters and to identify priority issues for long-term management of south coast receiving waters. This review used the following information to undertake a risk assessment examining causes and effects,

- catchment land use and management practices;
- long-term nutrient and sediment loads;
- degree of marine flushing; and
- susceptibility to dissolved and /or particulate pollutants.

This review (Appendix V) identifies potential impediments to the long-term conservation of estuaries and potential marine conservation reserves along the south coast of Western Australia between Broke Inlet and Israelite Bay. It also provides a classification of seaward-draining catchments associated with the review area, on the basis of existing and future land-use and degree of alteration to the natural surface water and groundwater systems which enter the marine environment.

Water quality in a number of rivers, estuaries and wetlands across the south coast is to be assessed through a community-based monitoring program established under the South Coast Regional Initiative. This project will include a representative range of estuaries and inlets, including Walpole-Nornalup Inlets, Wilson Inlet, Oyster Harbour, the Beaufort Estuary, Gordon Inlet, Culham Inlet and the Oldfield Estuary (A. Sutton, Water and Rivers Commission, pers. comm.).

3. THE TERRESTRIAL RESERVES

A review has been carried out of the nature conservation, recreation, aesthetic and economic values of coastal terrestrial reserves across the project study. The national parks and nature reserves that were reviewed are those adjacent to, or surrounded by, marine areas listed in the Wilson Report (Appendix II) as worthy of consideration as future marine conservation reserves. They are:

- D'Entrecasteaux National Park.
- Walpole-Nornalup National Park.
- William Bay National Park.
- West Cape Howe National Park.
- Torndirrup National Park.
- Michaelmas Island Nature Reserve.
- Breaksea Island Nature Reserve.
- Mistaken Island Nature Reserve.
- Seal Island Nature Reserve.
- Gull Rock National Park.

- Two Peoples Bay Nature Reserve.
- Waychinicup National Park.
- Mt Manypeaks Nature Reserve.
- Bald Island Nature Reserve.
- Glasse Island Nature Reserve.
- Doubtful Islands Nature Reserve.
- Fitzgerald River National Park.
- Rocky Islets Nature Reserve.
- Stokes National Park.
- Woody Island Nature Reserve.
- Recherche Archipelago Nature Reserve.

This review consisted of a broad examination of physical/biological resources, cultural/historical values, social/economic usage and management issues in these reserves, and concentrated on resources, activities and issues that could directly or indirectly influence integrated management of estuaries/inlets and of the inshore marine environment. The review also considered the current and potential impacts on terrestrial flora and fauna from activities that gain access to water-based resources through these terrestrial reserves. The report produced from this review is included as Appendix VI, and is comprised of:

- **A review of physical/biological resources:**

- Coastal landscapes and aesthetic values
- Fauna and flora
 - Review of flora and fauna on offshore island nature reserves
 - Seabirds
 - Mammals

- **A review of cultural and historical resources:**

- Aboriginal sites
- European sites

- **A review of social and economic usage:**

- Fishing
- Beach activities
- Land-based sports
- Tourism

- **A review of management issues:**

- Coastal rehabilitation
- Aerial deposition of soil to the marine environment
- Access to estuarine and marine environments
- Visitor safety
- Community liaison and education
- Marine mammal stranding planning
- Oil spill contingency planning
- Ocean discharges
- Coastal recreational facilities
- Landscape
- Agriculture

National parks and nature reserves in Western Australia are vested in the National Parks and Nature Conservation Authority (NPNCA). The NPNCA and CALM are responsible for the preparation of area management plans for all lands vested in the Authority. There are a number of management plans for the

coastal reserves across the south coast that are encompassed within the project area of this project. These are as follows:

1. South Coast Region, Regional Management Plan (CALM, 1992a).
2. Southern Forest Region, Regional Management Plan (CALM, 1987a).
3. Shannon-DEntrecasteaux National Park Management Plan (CALM, 1987b).
4. Fitzgerald River National Park Management Plan (CALM, 1991).
5. Walpole-Nornalup National Park Management Plan (CALM, 1992b).
6. West Cape Howe National Park Management Plan (CALM, 1995a).
7. Two Peoples Bay Nature Reserve Management Plan (CALM, 1995b).

These management plans contain information on the land tenure, resources, conservation of flora and fauna, management of commercial utilisation and recreation, and research and monitoring priorities of these reserves. Additional information can be sourced from these documents. Area plans for individual national parks and nature reserves are prepared on a priority basis, and the South Coast Regional Management Plan (CALM, 1992a) identifies a desirable program for the preparation of area management plans across the region. In relation to coastal terrestrial reserves adjacent to proposed marine conservation reserves in the project area (Broke Inlet - Israelite Bay), the priorities are identified as:

Albany District

1. Waychinicup and Gull Rock National Parks.
2. William Bay National Park.
3. Torndirrup National Park.

Esperance District

1. Stokes National Park.
2. Cape Arid National Park.
3. Cape Le Grand National Park.
4. Recherche Archipelago and Rocky Islets.

Currently, the only draft management plan in preparation for coastal reserves across the south coast is the one for the Esperance Lakes Nature Reserves. This reserve includes the Lake Warden System, the only RAMSAR-listed wetland in the project area.

PART II: THE STUDY AREA

1. INTRODUCTION

On the basis of the reviews of the nature conservation, aesthetic and economic values of potential marine conservation reserves and associated terrestrial reserves within the project area (Part I) the Fitzgerald Biosphere Reserve and adjacent inshore marine environment were selected as the area for more detailed study. This area largely encompasses the range of issues facing the integration of terrestrial and marine conservation reserves in the south coast region. The selection of the Fitzgerald Biosphere Reserve as the study area is also in line with the objectives of the original project proposal. The Recherche Archipelago was included, with the Fitzgerald Biosphere Reserve, as a study area in this original proposal. However, it was decided, based on available resources and the time frames of the revised work schedule agreed with the Reserve Systems Section in October 1996, to limit the project to a single study area.

2. THE FITZGERALD BIOSPHERE RESERVE

The Fitzgerald River National Park (FRNP) is probably the most important protected area in south-western Australia, containing over 20 % of the State's described vascular plant species. (CALM, 1991). Currently, it has 1,883 identified floral taxa, of which 72 are endemics and 250 species are geographically restricted or represented by populations of less than 1,000 plants (Sanders, 1997). The FRNP also has the richest fauna of any conservation area in south-western Australia, with 17 species that are either threatened or in need of special protection. To date there are 193 bird species, 22 species of native mammal, 42 species of reptile, 12 species of frog and four species of inland fish recorded for the Park (Sanders, 1997). The Park offers the best long-term survival prospects in Western Australia for the Ground Parrot and Dibbler (CALM, 1991). It is the only conservation reserve system that contains the Heath Rat and is the largest reserve that has populations of Tamar, Red-tailed Wambenger, Woylie, Western Mouse, Western Bristlebird and Western Whipbird (CALM, 1991; Chapman & Newbey, 1995a). It contains a formally gazetted Wilderness Zone which abuts approximately 30% of the coastline, and contains a diverse range of landscapes from windswept and protected beaches, rugged sea-cliffs, the steep Barren Ranges, extensive plains and abrupt river valleys ending in inlets.

In 1978, in recognition of its high floral and faunal diversity and relatively pristine state, the FRNP was designated as one of 12 Australian Biosphere Reserves under UNESCO's Man and the Biosphere program. The Park is one of two 'model' biosphere reserves in Australia, recognised by the Australian Commission for UNESCO and the Australian Nature Conservation Agency (Parker, 1993) and has increasing international recognition as a biosphere reserve case study (Watson, *et al.*, 1995). Ideally, a model biosphere reserve has an undisturbed *core* area, surrounded by a *buffer* zone with an adjoining *transition* zone or *zone of cooperation* (Figure 14). The Fitzgerald River National Park fitted this model very well, but it was not until 1986 that moves were made by the local community to recognise the *buffer* and *transition zone* (Bradby, 1989; Fitzgerald Biosphere Project, 1989; Thomas, 1989). Since then there has been increasing awareness and acceptance within the local community of the Biosphere Reserve concept (Sanders, 1996) and the FRNP now forms the *core* zone of the larger notional Fitzgerald Biosphere Reserve, with a surrounding *buffer* zone and *zone of cooperation* (see Figures 15). In the coastal situation of the FRNP the model is truncated (Figure 16), and the Fitzgerald Biosphere Reserve is Australia's only model biosphere reserve located on the coast.

The coastal boundaries of the larger biosphere reserve are approximately Groper Bluff in the west to Starvation Boat Harbour in the east (see Figure 17) and the reserve includes the Shire of Jerramungup and about half the Shire of Ravensthorpe.

The waters adjacent to the FRNP were recommended as worthy of consideration for marine conservation reserve status in the report of the Marine Parks and Reserves Selection Working Group (the Wilson Report - see Appendix II). The specific recommendations in relation to these waters were:

"the area of State coastal waters between the mouth of Gordon Inlet and the mouth of Culham Inlet, that is the coast adjacent to the Fitzgerald River National Park, should be considered for reservation as a marine reserve for conservation of flora and fauna and recreation, and that it should be added to the Fitzgerald Biosphere Reserve;"

legal opinion be obtained on the status of Gordon, St Mary, Fitzgerald, Dempster and Hamersley Inlets and if they are be given to reservation of them as marine reserves under the CALM Act and that their management be integrated with that of the national park.” (CALM, 1994).

The area recommended as a candidate marine conservation reserve amounts to approximately 30% of the total coastline within the larger notional biosphere reserve (see Map V - 3 in Appendix II). Subsequent to the Wilson Report recommendations, it has been suggested that all of the State waters adjacent to the larger Fitzgerald Biosphere Reserve (FBR) should be considered for marine conservation reserve status, and that management of a future marine conservation reserve covering this area should be incorporated with management of the adjoining terrestrial component of the FBR (Watson, 1994). The concept of developing the FBR from a truncated’ model biosphere to a ‘complete’ model biosphere reserve has also been proposed in the recommendations of a number of reports and strategy documents (Sanders, 1996; SCRAP & SCRIPT, 1997).

If this conceptual model of a terrestrial/marine biosphere reserve is to be realised there is a clear requirement to assess the conservation, recreation, aesthetic and economic values of the FBR, of the associated estuaries and coastal inlets and of the adjacent inshore marine environment.

2.1 Resource Assessment

The conservation, recreation, aesthetic and economic values of the Fitzgerald River National Park and of the larger Fitzgerald Biosphere Reserve have been extensively described elsewhere, and it is not the purpose of this report to repeat or provide further detail of the information supplied in other documents. The sources for this information are:

- The Fitzgerald River National Park Management Plan (CALM, 1991).
- Flora and fauna surveys of the Fitzgerald and Ravensthorpe areas (Chapman & Newbey, 1995a, 1995b).
- Conservation value of Fitzgerald Biosphere Reserve buffer/transition zone (Sanders, 1996).
- South Coast Regional Land and Water Care Strategy: the Fitzgerald Biosphere sub-region (SCRAP & SCRIPT, 1997).
- Integrated vegetation management plan for the Fitzgerald Biosphere Reserve zone of cooperation (Robinson, 1997).
- A CALM *Landscape* article on the Fitzgerald River National Park (Sanders, 1997).

Data on all listed Aboriginal cultural and historical sites across the south coast project area have been obtained from the register system of the Aboriginal Affairs Department. A significant number of these sites occur within coastal areas of the Fitzgerald Biosphere Reserve (Figure 18). This figure also shows the Nyoongar Dreaming Trails that have been identified for Fitzgerald area (N. Nannup, CALM Aboriginal Tourism Unit, pers. comm.).

2.2 Management Issues

Serious land degradation problems occur in most of the catchments of the FBR (Robinson, 1997). With regards to integrated management of the FBR, the associated estuaries and coastal inlets and the adjacent inshore marine environment, the following key management issues have been identified:

- **Loss of native bushland.**
- **Increases in land salinisation and wind erosion.**
- **Water-logging.**
- **Conservation of remnant vegetation and creation of vegetation corridors.**
- **Development of individual catchment management plans.**
- **Spread of dieback.**
- **Fire management.**
- **Introduction of exotic weeds.**
- **Increased usage of pesticides.**

3. THE ESTUARIES AND COASTAL INLETS

3.1 Resource Assessment

Inventories of information on the estuaries and coastal inlets of the Fitzgerald Biosphere Reserve are provided in the following papers:

- Hodgkin & Clark (1987) - Wellstead Estuary;
- Hodgkin & Clark (1988c) - Beaufort and Gordon Inlets;
- Hodgkin & Clark (1990a) - estuaries of the Shire of Ravensthorpe and the Fitzgerald River National Park; and
- Hodgkin (in prep.) - Culham Inlet.

These documents give a detailed description of the geology, landforms, soils, physical and biological characteristics of the estuaries and inlets and identify and discuss management issues affecting each system. The estuaries and catchments review of this project (Bancroft, *et al.*, 1997 - see Part I, section 3.4 and Appendix V) summarises the available information on the Fitzgerald Biosphere Reserve estuaries/inlets and associated catchments. The catchments and hydrological systems of the Fitzgerald Biosphere Reserve (Figures 19 & 20) are described in detail in Robinson (1997). This report, which details an integrated vegetation management plan for the FBR *zone of cooperation*, also identifies the priority actions to control land degradation and improve water quality within each catchment of the FBR.

The Fitzgerald Inlet System (comprised of the Fitzgerald Inlet, Dempster Inlet, Lake Nameless and the lower and middle reaches of the Fitzgerald and Susetta Rivers that are in the FRNP) and Culham Inlet are listed in the ANCA Directory of Important Wetlands in Australia (ANCA, 1996).

3.2 Management Issues

Major management issues affecting the south coast estuaries and inlets are described in the review of estuaries and catchments (Part I, 3.4 and Appendix V). The review also details specific regional management issues for the Fitzgerald Biosphere Reserve estuaries/inlets. Hodgkin & Clark (1987, 1988c, 1990a) discuss management issues affecting each of the estuaries/inlets. With regards to integrated management of the FBR, the associated estuaries and coastal inlets and the adjacent inshore marine environment, the key management issues are:

- **Increased water salinity.**
- **Erosion and increasing sedimentation.**
- **Eutrophication.**
- **Loss of riparian buffers.**
- **Revegetation of riparian zones.**
- **Bar management.**
- **Commercial fisheries.**
- **Requirement for future research and monitoring.**
- **Tenure and responsibility for management.**

Beaufort Inlet is seriously eutrophic and has increasing sedimentation. The Wellstead Estuary has some sedimentation and nutrient pollution problems and bar management is an issue. Gordon Inlet has river salinity, eutrophication, and sedimentation problems. The Fitzgerald, Hamersley and Culham Inlets all have increased river salinity, eutrophication and sedimentation problems (Bancroft, *et al.*, 1997 - Appendix V). The catchments of the Boondalup, St Mary and Dempster Inlets and of Lake Nameless all lie entirely within the Fitzgerald River National Park and these systems are therefore considered to be in pristine condition (Bancroft, *et al.*, 1997). However, little is known about the ecology and health of these systems and there is clearly a need for further research and monitoring. The Fitzgerald Inlet is wholly within the FRNP, but a significant proportion of its upper catchment lies in cleared land in the FBR *buffer/transition zone* (Figure 19). Increasing levels of runoff and sediment deposition in this upper catchment area are causing increased salinity, nutrient and sediment loads in the inlet (Leighton & Watson, 1992). The protection of the Fitzgerald River vegetation corridor, linking the Lake Magenta Nature Reserve to the FRNP (Figure 17), is regarded as a high priority for

integrated catchment management and the prevention of further degradation in the environmental condition of the Fitzgerald Inlet (Robinson, 1997; J. Watson, CALM South Coast Region, pers. comm.).

All of the estuaries/inlets (with the exception of Lake Nameless which is permanently closed) within the Fitzgerald Biosphere Reserve open to the sea only infrequently, and in the classification of south coast estuaries described in Bancroft, *et al.* (1997), they are categorised as normally closed. This category of estuaries seldom open to the sea (and often only briefly) and may stay closed for several years at a time. Little is known about direct or indirect impacts from the discharge of estuary/inlet waters into the adjacent inshore marine environment, resulting from either natural or artificial opening of the oceanic bars. Marine flushing can have a major impact on recruitment of marine fishes to the estuaries with subsequent effects on commercial and recreational fishing. Anecdotal evidence suggests that one of the possible direct impacts resulting from a major breakout of a normally closed estuary is the deposition of large quantities of sediment into adjacent inshore waters. This may occur after periods of very heavy rain and transported sediments may originate from the estuary floor, inlet channel and the dunes of the oceanic bar. Culham Inlet broke out in 1993 and there were reports of large quantities of sediment and even foredune vegetation such as *Melaleuca* trees being deposited onto the nearshore limestone reefs that occur in this area (Figure 22). For some time afterwards recreational fishers from Hopetoun reported that areas of the low-profile limestone platforms, both east and west of the inlet mouth, were periodically covered in sand, and that this was accompanied by a deterioration of the fishing in these areas (M. True, CALM Ranger FRNP, pers. comm.). Clearly, direct mechanical effects, such as the smothering of benthic habitats, could have major impacts on marine plant and animal communities but the spatial and temporal scales of these effects need to be further investigated. More information on the physical and biological oceanography of the inshore waters is also required before the importance of these events can be assessed. Similarly, the effects of vegetation clearing and increased runoff in the catchments, and increased sedimentation in the estuaries on the frequency and duration of bar opening, and on the quantity of material potentially deposited into inshore marine waters during breakout events needs to be investigated. Increased runoff from cleared catchments may make flooding, and subsequent breaching of the bar more frequent, especially for very shallow, low-lying inlets such as Culham (Hodgkin & Clark, 1990a).

Currently, all the estuaries and inlets within the FBR are vacant crown land and no organisation is directly responsible for their management. This is true for the majority of estuaries and coastal inlets across the south coast, apart from those that have specific statutory authorities that are responsible for their management, for example Wilson Inlet (Wilson Inlet Management Authority) and Princess Royal and Oyster Harbours (Albany Waterways Management Authority). The FRNP Management Plan (CALM, 1991) recommended that Fitzgerald, St Mary and Dempster Inlets be declared as marine conservation reserves, but that they be closed to commercial fishing, and that Hamersley and Gordon Inlets also be declared as marine conservation reserves, but open to commercial fishing. As recognised in the Wilson Report the status of the estuaries is difficult to determine. The FRNP extends to low water mark and as the estuaries can hardly be classifiable as tidal it follows that they should be incorporated in to the national park. The recommendations of the Marine Parks and Reserves Selection Working Group are detailed above in Part II, section 2. Beaufort Inlet, the Wellstead Estuary, Culham Inlet and of the smaller estuaries and inlets within the FBR, the Hunter River, Kelly's Creek, and Boondalup Inlets are not included in either set of recommendations. Currently, Lake Nameless is regarded to be part of the Fitzgerald River National Park (J. Watson, CALM South Coast Region, pers. comm.). The Wilson Report included a recommendation that legal opinion be sought as to the status of the Gordon, St Mary's, Fitzgerald, Dempster and Hamersley Inlets under the provisions of the Land Act (see Part II, section 2 and Appendix II).

Given the likelihood that there may be few, if any, direct, long-term impacts on the inshore marine environment from any of these estuaries and inlets, and as their ecological health and environmental condition are inextricably linked to management practices in their catchments, the most suitable management option, with regard to the tenure of the estuaries and inlets, may be for them be incorporated within the terrestrial components of the FRNP and FBR. Integrated management would be addressed through the development of the larger conceptual biosphere reserve, incorporating the inshore marine environment, the estuaries and coastal inlets and the terrestrial reserves. Clearly, management of this 'complete' model biosphere would need to involve all organisations with management responsibilities, including government agencies such as CALM, the Fisheries Department, Agriculture WA and the Water and Rivers Commission, as well as local government authorities, LCDCs, advisory committees and local community and industry groups.

4. THE INSHORE MARINE ENVIRONMENT

4.1 Resource Assessment

4.1.1 Marine flora and fauna

As part of this project a marine biological survey was carried along approximately 250 kms of coastline adjacent to the Fitzgerald Biosphere Reserve. The survey, the first systematic and quantitative investigation of marine biota undertaken in this area, examined several of the major benthic habitats of inshore waters from Starvation Boat Harbour to Groper Bluff.

The objectives of this survey were:

Primary objectives

- quantitative description of marine biota at representative sites within the major benthic habitats;
- quantitative analysis of species diversity within the major benthic habitats;
- investigation of the influence of physical parameters, such as substrate type and wave exposure, on community diversity; and
- collection of fauna and flora density and biomass data as baseline information for long-term monitoring of communities before and after marine conservation reserve implementation.

Secondary objectives

- opportunistic collection of qualitative information on visually dominant fauna and flora; and
- opportunistic collection of salinity and temperature profile data.

The inshore marine environment adjacent to the Fitzgerald Biosphere Reserve is typical of the Albany-Frazer Oregon coastal sub-zone, recognised as one of three distinctive coastal types of the south coast zone in the Wilson Report (CALM, 1994 - see Appendix II). On the basis of geomorphological features and wave exposure, this south coast sub-zone contains a sequence of 4 coastal types:

1. Limestone shores, with narrow reefs and platforms parallel to the shore (Starvation Boat Harbour to East Mount Barren);
2. Schist/quartzite cliffs and shores of the metasedimentary Barren Ranges (East Mount Barren to Point Ann);
3. Wide bays with sandy beaches and shallow shelving seabed. These areas are generally protected from the prevailing south-westerly swell (Charles Point Bay, Point Ann Bay, Doubtful Island Bay);
4. Granitic headlands, exposed to open ocean swells, with steep wave-swept slopes and small lunate bays, boulder fields on the less-exposed eastern sides of headlands, and offshore reefs with steep or vertical walls (Doubtful Islands to Groper Bluff).

Benthic habitat classification for the survey area has been compiled by Dr Hugh Kirkman, CSIRO Division of Marine Research (see Part II, section 1.5).

During the survey benthic and fish communities were quantitatively sampled at representative sites within seagrass, limestone reef, granite reef and schist/quartzite reef habitats. As bare sand habitats typically have a low diversity of macro-epibenthic fauna and an insignificant macrophyte standing crop they were not included in the survey. Site selection was made using the benthic habitat maps (Figures 21, 22, 23), in conjunction with aerial photographs and bathymetric charts. A number of locations known to be popular as recreational diving and fishing sites (e.g. Peppermint Beach, Glasse Island and Little Boat Harbour in Bremer and Dillon Bays) were also sampled quantitatively. A number of deeper granite reef sites were also qualitatively sampled, based on reports of high diversity or abundance of flora and fauna, or presence of potentially unique species or communities.

A quantitative survey was undertaken at a total of 39 sites with the following being surveyed at each site:

- the abundance of large fishes and smaller cryptic fishes;
- the abundance of macro-epibenthic invertebrates (specimens >10mm in size);
- the density of macroalgae and seagrasses;
- the density of sponges; and
- the biomass of seagrasses.

A combination of visual censuses, quadrat sampling and benthic video transects was employed to maximize the amount of data gathered at each sampling site. Full details of the sampling methodology are given in the data report of the survey (Colman, 1997d) and the sampling site locations are shown in Figures 21, 22 and 23.

Qualitative information was also collected at each site. This entailed divers collecting specimens, and taking video footage of visually dominant flora and fauna, close-up photographs of macrophytes, invertebrates and fishes and wide-angle photographs of the habitats and any megafauna observed, such as Australian sea lions (*Neophoca cinerea*) and New Zealand fur seals (*Arctocephalus forsteri*). Voucher specimens of macroalgae and invertebrates were collected and preserved to form the basis of a reference collection.

The results of this biological survey are presented in the data report (Colman, 1997d). During the first seven days of the survey strong winds and heavy swells made working and diving conditions difficult. Consequently, sampling during this period concentrated on the more sheltered seagrass and granite reef sites around Doubtful Island Bay, Bremer Bay and Dillon Bay (Figure 21). During the second week of the survey attempts were made to sample limestone reef sites between Hopetoun and Starvation Boat Harbour and schist/quartzite reef sites between Culham Inlet and Point Ann (see Figure 23). As a result of continued poor sea conditions and extremely low in-water visibility no sites could be sampled in these areas. During the course of the survey only four limestone reef and five schist/quartzite reef sites were sampled quantitatively, compared to 18 granite reef sites and 12 seagrass sites. It is hoped that a number of limestone reef and schist/quartzite reef sites will be sampled during follow-up surveys.

Preliminary analyses of these results indicates that the four major benthic habitats sampled during this survey have diverse assemblages of marine flora and fauna. Two hundred and fifty-eight species from 10 phyla were recorded during the quantitative sampling, including 79 macroalgal species, nine seagrasses, 83 fish species and 87 invertebrate species. Additionally, a further 149 species were recorded from the 42 sites sampled qualitatively giving a total list of 407 species (Table 5). A complete species list, indicating which species were recorded during the quantitative sampling and additional species recorded during qualitative sampling, is included as Appendix VII.

The qualitative species total includes 25 species of caridean shrimp were recorded from the four major habitat types during this survey. One of these species is new to science and another (*Synalpheus* aff. *streptodactyloides*) appears to be a new record for Australia. Also, it is likely that a number of the sponge species are probably new to science (J. Fromont, WA Museum of Natural Science, pers. comm.). Other outstanding features include a rich fish fauna, with abundant numbers of some species of large fish, such as western blue groper (*Achoerodus gouldii*) and queen snapper (*Nemadactylus valenciennes*). This was particularly the case in granite reef areas. Another significant result was the discovery of a specimen of the rarely recorded large-tail cardinalfish (*Vincentia macrocauda*). Only a handful of specimens of this fish have been collected, most of them from the south coast by Dr Barry Hutchins from the WA Museum of Natural Science. The specimen collected during this survey was found inside a specimen of the ascidian *Herdmania momus*.

In general, species recorded were typical of warm-temperate waters, the northernmost limit of their range usually being the reefs of the Houtman Abrolhos Islands or Rottnest Island. A small number of subtropical species were also recorded, including fish species such as the western king wrasse (*Coris auricularis*) and the Woodward's pomfret (*Schuettea woodwardi*), both of which range from Shark Bay south to the Recherche Archipelago (Hutchins, 1994). Over 200 high quality 35mm transparencies were taken by a professional underwater photographer, including close-up and wide-angle underwater photographs of visually dominant flora and fauna, underwater photographs of the sampling procedures and above-water photographs of sample sorting, general operations on the survey vessel and coastal scenery. A number of these photographs have been used in a CALM *Landscape* article on the biological survey of the Fitzgerald (Appendix IX), which was published in the Summer 1997/98 edition of the magazine.

Further analysis is proposed for the quantitative data sets. It is intended to carry out a hierarchical classification, based on presence or absence of species and using multivariate statistical methods, to determine the relationships between sites and species. This will enable a classification of the macrobiotic communities sampled during this survey to be compiled. Any gross differences between the granite reef communities and the communities on the metasedimentary schist/quartzite rocks of the seabed adjacent to the Barren Ranges (sampling sites F3, F4, F23, F24, F25 - see Figure 22) may be indicated by this classification.

Anecdotal reports indicate that grey nurse sharks (*Carcharias taurus*) are common in area between Fosters Beach and Cape Knob, west of Dillon Bay (Figure 21).

As detailed in Part I, section 1.6.5.4, and in the review of marine mammal resources in Appendix III, the inshore waters adjacent to the FRNP, from Trigelow Beach in Doubtful Islands Bay north-east to Red Island, is the most important area for seasonal aggregations of southern right whales across the entire south coast of Western Australia. Sightings of humpback whales are also becoming more common in this area. Across the south coast there are 20 recorded breeding sites for the Australian sea lion (Gales, *et al.* 1994; see Appendix III), and four of these occur within State waters adjacent to the Fitzgerald Biosphere Reserve - on Middle Doubtful Island, on Red Island and on West and Investigator Islands east of Hopetoun (see Figures 6 & 7). Middle Doubtful Island is one of only seven islands in Western Australia where seal lions and fur seals both breed (N. Gales, CALM Wildlife Branch, pers. comm.). During the field survey a rare sighting was made of two mature male sub-Antarctic fur seals (*Arctocephalus tropicalis*) and direct observations also verified the presence of a reported haul-out site for New Zealand fur seals on the mainland. Both adults and pups were found, meaning that this site, on the east side of Cape Knob (see Figure 21), could be a breeding site. If this is so it would make it the first confirmed breeding location for this species on the Western Australian mainland. Red Island is also significant as it has a colony of little penguins and supports a small population of the threatened Recherche Cape Barren goose (P. Collins, CALM Albany, pers. comm.).

4.1.2 Benthic habitats

Additional information is required on the inshore benthic habitats of the waters adjacent to the Fitzgerald Biosphere Reserve. Further surveys are required to ground-truth the biological and spatial accuracy of the existing benthic habitat maps (Figures 21-23) and to quantitatively sample further limestone and schist/quartzite reef sites (see section 4.1.1). The deep offshore granite pinnacles that occur south of Dillon and Bremer Bays, reported to have dense and diverse communities of sponges, ascidians and cnidarians, need to be investigated. Deep offshore limestone reefs are known to occur at eastern end of FRNP (H. Kirkman, CSIRO Division of Marine Research, pers. comm.) and the benthic and fish faunas of these areas should be sampled during future surveys.

4.1.3 Social and economic values

As discussed in Part I, section 1.6.5.4, the seasonal occurrence of southern right whales in the waters adjacent to the FRNP has led to the development of a major shore-based whale-watching activity at Point Ann in the Park. During 1997, there were also some whale-watching tours on a vessel out of Bremer Bay. The granite headlands, islands and deep offshore pinnacles around the Doubtful Islands, Point Hood, Bremer and Dillon Bays offer exceptional scuba-diving opportunities. The more sheltered sites on the western side of headlands in Bremer and Dillon Bays are characterised by large colonies of the hard coral *Turbinaria* spp. These impressive multi-storey structures, up to three metres in height, support diverse fish and invertebrate faunas. Glasse Island has spectacular underwater scenery with huge granite boulders and crevices and vertical walls covered in a profuse display of sponges, ascidians and cnidarians.

Little information exists on the extent of commercial or recreational fishing in the area. There are important beach salmon fisheries in Doubtful Island Bay and Dillon Bay, and a number of vessels fish for school sharks across the area between the Doubtful Islands and Hopetoun. Commercial shark fishing vessels apparently target aggregations of gummy shark in the Point Ann area, with reports that a high proportion of the sharks caught are pregnant females. Greenlip abalone, scallop and southern rock lobster are also caught in the area. Recreational fishing is an important activity in Bremer and Dillon Bays, and at a number of other locations across the Fitzgerald region. One outstanding feature of many of the granite reef sites investigated during the field survey was the high abundance of some of large fish species, such as the western blue groper and queen

snapper. Large specimens of these species, highly prized by recreational fishers, have been greatly reduced or have largely disappeared from heavily fished temperate reefs elsewhere in Western Australia.

Bremer Bay contains the wreck of the *Agnes*, a historic shipwreck protected under commonwealth legislation, and there are extensive areas of 6,000 year old tree stumps in the surf-zone off Trigelow Beach (Dortch, 1995). The granite cliffs, headlands and offshore islands of the Dillon and Bremer Bay areas are very spectacular coastal landscapes of a type not found elsewhere in the Fitzgerald Biosphere Reserve.

4.2 Management Issues

Recreational usage of the inshore marine environment at the western end of the study area (Doubtful Islands to Groper Bluff) is increasing as the town of Bremer Bay develops. Bremer Bay is within easy reach of Albany and is only 5-6 hours drive from Perth. Consequently, it is becoming increasingly popular as a holiday destination. The new fishing boat harbour, opened in March 1997, provides sheltered boat launching facilities for small craft and there is likely to be an increase in water-based activities, particularly recreational fishing and diving. The area contains some inshore marine areas with very high conservation and social values and increasing commercial usage and recreational/tourism pressure may threaten conservation values of these areas, and also result in more frequent conflicts between different user and stakeholder groups. Little information is available on the extent of human usage, either commercial or recreational, of these inshore waters and consequently studies are required to address this issue.

The area proposed in the Wilson Report as worthy of consideration as a future marine conservation reserve extends from the Doubtful Islands to Culham Inlet (see Map V-3, Appendix II). On the basis of the information collected during the marine biological survey of the Fitzgerald region it appears that the area to be considered in any future marine reservation proposal should be extended to include all the waters adjacent to the larger Fitzgerald Biosphere Reserve (Groper Bluff to Starvation Boat Harbour). This would ensure that the four major benthic habitats of these inshore waters (granite reef, limestone reef, schist/quartzite reef and seagrass meadow), and their associated species assemblages and communities, are all adequately represented within a future reserve. These habitats are also broadly representative of the diversity of inshore marine ecosystems across the whole south coast region (see discussion on biogeographical regionalisation, Part I, section 1.3). The Fitzgerald Biosphere Reserve marine component would be an appropriate choice for consideration as a marine conservation reserve priority area in the IMCRA (V. 3.1) WA South Coast meso-scale region. Consideration should also be given to the inclusion of the two offshore islands, West and Investigator, within the boundaries of a future reserve, given their importance as habitats for marine mammals and seabirds, and Investigator

Further information is required to facilitate a better assessment of the conservation, social and economic values of this candidate area. Accurate bathymetry data and a detailed study of the oceanography of the inshore waters, ground-truthing of existing habitat maps and fine scale mapping of benthic habitats are required. Additional biological surveys are required to sample further sites, primarily within the limestone reef system, but also in the schist/quartzite substrate areas and seagrass meadows. The direct and indirect effects of estuary breakout on inshore benthic communities need to be studied, and the infrequent nature of these events will make this difficult. Human usage surveys are required to assess the levels and spatial boundaries of commercial and recreational activities.

The principles of a model terrestrial biosphere, with *core*, *buffer* and *transition* zones, as applied to the Fitzgerald Biosphere Reserve, cannot be easily translated across into adjacent marine waters. The waters adjacent to the *core* zone (the Fitzgerald River National Park), even though they have significant conservation values (particularly the seasonal aggregation of southern right whales and extensive perennial seagrass meadows), is not the only area that may require a high level of protection within a future multiple-use marine conservation reserve. Species assemblages and communities within the granite and limestone reef areas from Groper Bluff to the Doubtful Islands and from Culham Inlet to Starvation Boat Harbour undoubtedly have high conservation and recreational values and would require appropriate levels of protection and management within a future reserve. Further information would be required to determine the appropriate boundaries of a marine conservation reserve component of the Fitzgerald Biosphere Reserve and to develop criteria and priorities for management zoning.

PART III: CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS

During the public submission period that followed the release of the Wilson Report a large number of submissions were received relating to the Working Group recommendations for the south coast. During the Analysis of Public Submissions on the Wilson Report (CALM, 1997) two major issues emerged - access to the shore through existing terrestrial reserves, and the continuance of recreational and commercial fishing. It appears that these two issues are of primary concern to some stakeholders and sections of some local communities across the south coast with regard to the establishment of marine conservation reserves in the region (see Appendix VIII for the relevant extract from the Analysis of Public Submissions document).

The issue of access to the shore is one that is fundamentally linked to management of the terrestrial reserve rather than to the creation of a marine conservation reserve in the adjacent waters. Therefore, it is a major issue relating to integrated management of adjoining terrestrial and marine conservation reserves. As pointed out in the Analysis of Public Submissions, management of access to the shore for water-based activities, whether commercial or recreational, is addressed in the management planning process for the terrestrial reserve. Several key issues are linked to the issue of access, particularly erosion and the spread of dieback (e.g. the West Cape Howe National Park Management Plan, CALM, 1995a). Addressing these problems equitably requires active community involvement in the formulation of draft and final management plans for national parks and nature reserves. With regards to the effects that the issue of access has on the establishment of an adjacent marine conservation reserve, it is clear that a major requirement for effective integrated management of terrestrial and marine areas is the prior existence of an area management plan for the terrestrial component. The terrestrial reserve management plan identifies the marine-based recreational and commercial usage and also establishes appropriate controls to ensure that the conservation and other values of the terrestrial reserve are not compromised through public access to these marine resources. As pointed out in the Analysis of Public Submissions document:

“Reserve category, zoning schemes and management plans for adjacent land and marine conservation reserves must be integrated to ensure that there are no inconsistencies.” (CALM, 1997).

Thus, in the absence of other criteria, the existence of management plans for adjacent terrestrial reserves may provide a *de facto* means of prioritising the nine south coast candidate marine conservation reserve areas, as identified in the Wilson Report, within the project area. Fitzgerald River, West Cape Howe, Walpole-Nornalup, and D’Entrecasteaux/Shannon National Parks and Two Peoples Bay Nature Reserve all have gazetted management plans, and the priorities for the remaining areas are discussed in Part I, section 3. The progression of marine conservation reserve proposals for the other areas may have to be deferred until such time as management plans are prepared for the adjoining terrestrial reserves, unless there are other political or management pressures to have them established. For the reasons discussed in Part II of this report, the creation of a marine conservation reserve adjacent to the larger notional Fitzgerald Biosphere Reserve, with management of this marine component being integrated with that of the terrestrial biosphere, should be regarded as a high priority.

The second major issue that emerged in the Analysis of Public Submissions on the Wilson Report - continuance of fishing - is directly involved in the establishment and management of marine conservation reserves, and involves management of adjacent terrestrial reserves to a lesser extent. The fundamental problem appears to be a misinterpretation of the term ‘marine reserve’, which many people assumed was the same as the reserve category of ‘marine nature reserve’, and that implementation of these reserves would result in exclusion of activities such as recreational and commercial fishing. Clearly, there is a need for a reiteration of the concepts of a multiple-use marine conservation reserve system, the revised marine conservation reserve legislative framework and an unambiguous explanation of the different reserve categories and zoning provisions. This has partly been addressed through the publication of the Analysis of Public Submissions document but given the level of concern on this issue amongst some stakeholders and sections of some local communities there is a definite requirement for a public liaison program to address this issue. This process could be initiated through the publication of articles published in local newspapers across the region, followed up by a series of public meetings with key community and stakeholder groups and the general public. Community acceptance of the

Wilson Report recommendations is a very important issue that has to be addressed if marine conservation reserves are to be established in the south coast region.

Hauloff Rock, situated between Albany and Bremer Bay (see Figure 6), supports breeding colonies of both New Zealand fur seals and Australian sea lions (Shaughnessy, *et al.*, 1994; Gales, *et al.*, 1994). It is the western limit of breeding for Australian sea lions on the south coast, the nearest recorded breeding site for this species in the vicinity of Albany and one of only seven islands in Western Australia where both fur seals and sea lions breed. It is also the most westerly island along the south coast of Western Australia where the threatened Recherche Cape Barren goose occurs (Burbidge, *et al.*, 1993; P. Collins, CALM Albany, pers. comm.). The island is very close to shore and even though the coast in that area is relatively isolated, access via small boats is very easy, making the site potentially vulnerable to disturbance (N. Gales, CALM Wildlife Branch, pers. comm.).

The island has been identified as a key site for monitoring populations of both pinniped species in CALM's Draft Pinniped Management Program (Gales, in preparation) and in the National Action Plan for Australian Seals (Shaughnessy, in preparation). The island is vacant crown land and should be considered a high priority for reservation as a nature reserve, to be vested in the National Parks and Nature Conservation Authority. The surrounding waters are not covered by the recommendations of the Report of the Marine Parks and Reserves Selection Working Group (CALM, 1994) and currently the extent of interactions between sea lions, fur seals and commercial fisheries in the vicinity of the island are not known. Further assessments are required of the conservation, social and economic values of the waters surrounding Hauloff Rock are required to determine whether the area is worthy of consideration for inclusion in the statewide system of marine conservation reserves.

The benthic habitat maps (see Part I, section 1.5) for the eastern portion of the project area indicate the presence of large areas of seagrass habitat extending north of Israelite Bay up to Point Culver (Figure 12). The presence of this significant seagrass habitat is not identified in the Wilson Report and no recommendations were made with reference to reservation of this area. Additionally, it is apparent that this area (see Part I, section 1.4 and Appendix III) is a significant coastal habitat for southern right whales (Figure 8), and this important conservation value was similarly not identified in the Wilson Report. In recognition of these high conservation values this area should be considered for inclusion in the statewide system of marine conservation reserves.

The review of the estuaries and catchments, carried out as part of this project, provides information that facilitates a prioritisation of the recommendations of the Wilson Report. As to the question of whether the estuaries/inlets should be incorporated with the terrestrial reserves or become part of a marine conservation reserve system, the classification of estuaries/inlets in Bancroft, *et al.* (1997 - see Appendix V) provides a basic criterion. Systems that are permanently open or seasonally open/closed are, to some extent, tidal and have a degree of marine exchange. These estuaries/inlets potentially have direct or indirect impacts on marine communities in adjacent coastal waters and consequently should be considered for inclusion in the marine conservation reserve system. Systems that are normally or permanently closed cannot be considered as tidal and normally have no marine exchange as the bars seldom open to the sea and may remain closed for several years at a time. These systems can be considered as having few, if any, direct or indirect impacts on marine communities in adjacent coastal waters. A possible exception is the direct mechanical impacts that may occur when large quantities of sediment are deposited into inshore waters as a result of major estuary flooding and bar opening events (such as occurred at Culham Inlet in 1993 - see Part II, section 3.2). Consequently, the normally closed/permanently closed systems should be considered for inclusion with surrounding national parks and nature reserves, as part of the terrestrial reserve system. As detailed in the Wilson Report, currently it is unclear whether water bodies such as estuaries and inlets can be included in a terrestrial reserve under the provisions of the Land Act and other legislation. Legal opinion is required on this issue.

By applying the criterion described above, the south coast estuaries and inlets identified in the Wilson Report can be categorised as follows:

Estuaries/inlets to be considered as candidate marine conservation reserves

Broke Inlet
Walpole-Nornalup Inlet
Waychinicup Inlet

Estuaries/inlets to be considered for inclusion with surrounding terrestrial reserves

Gordon Inlet
St Mary's Inlet
Fitzgerald Inlet
Dempster Inlet
Hamersley Inlet

Of these there are several priorities for reservation that should be considered:

- **Broke Inlet:** as an example of a pristine, seasonally open/closed estuary in the western part of the region, with national park surrounding the inlet and its entire catchment.
- **Walpole-Nornalup Inlet:** as the best example of a permanently open basin lagoonal estuary (the only other example is Oyster Harbour) across the entire region, with very high conservation and recreation values. The Inlet has exceptional scenic qualities, is largely surrounded by national park and has increasing recreational usage. There are also concerns about the rate of development along the shores of Walpole Inlet.
- **Fitzgerald River National Park estuaries:** in recognition of the national and international conservation significance of the Park as the *core* of the Fitzgerald Biosphere Reserve, and considering the threats to some of the inlets from clearing and land degradation in their upper catchments.

It is apparent that little information exists on direct or indirect impacts on inshore marine habitats and communities from the flooding and breakout of estuaries and inlets across the south coast region. Given the exposed nature of much of the open ocean shores, and the fact that much of the coastline is exposed to strong wave and swell action, it is likely that any direct physical effects, such as sediment deposition, may be restricted both spatially and temporally. However, further studies are required to assess the possible impacts of bar opening, especially for normally or permanently closed estuaries such as Culham Inlet.

2. RECOMMENDATIONS

In line with project scope item 10 (see main introduction of this report) the following recommendations are made in order to refine existing recommendations for potential marine conservation reserves in the region, and to identify key management issues.

2.1 TERRESTRIAL RESERVES

RECOMMENDATION 1

- *That the management of access to adjacent marine resources, through existing terrestrial reserves, continue to be adequately considered during the development of area management plans.*

RECOMMENDATION 2

- *That the National Parks and Nature Conservation Authority consider, as a priority, reservation of Hauloff Rock, in recognition of its national significance as a fur seal and sea lion breeding site.*

2.2 MARINE CONSERVATION RESERVES

RECOMMENDATION 3

- *That the Marine Parks and Reserves Authority consider the area of State waters adjacent to the larger notional Fitzgerald Biosphere Reserve (Groper Bluff to Starvation Boat Harbour) for inclusion in a future marine conservation reserve.*

RECOMMENDATION 4

- *That the Marine Parks and Reserves Authority consider the Fitzgerald region as a marine conservation reserve priority area for the south coast.*

RECOMMENDATION 5

- *That the management of any future Fitzgerald marine conservation reserve be integrated with the terrestrial and estuarine components of the Fitzgerald Biosphere Reserve.*

RECOMMENDATION 6

- *That the status of management planning in adjoining terrestrial reserves be an important consideration in prioritising other candidate marine conservation reserves along the south coast.*

RECOMMENDATION 7

- *That the Marine Parks and Reserves Authority consider the coastal waters between Israelite Bay and Point Culver for inclusion in the statewide system of marine conservation reserves, in recognition of the high conservation values of this area.*

2.3 ESTUARIES/INLETS

RECOMMENDATION 8

- *That, of the estuaries and inlets identified in the Report of the Marine Parks and Reserves Selection Working Group, permanently open and seasonally open/closed systems be considered for inclusion in the marine conservation reserve system.*

RECOMMENDATION 9

- *That, of the estuaries and inlets identified in the Report of the Marine Parks and Reserves Selection Working Group, normally and permanently closed systems be considered for inclusion with surrounding terrestrial reserves. Legal opinion is required as to whether this can be achieved under the provisions of the Land Act.*

RECOMMENDATION 10

- *That the Marine Parks and Reserves Authority consider the Broke and Walpole-Nornalup Inlets as marine conservation reserve priority areas.*

RECOMMENDATION 11

- *That the National Parks and Nature Conservation Authority consider inclusion of the Gordon, Boondalup, St Mary's, Fitzgerald, Dempster and Hamersley Inlets with the Fitzgerald River National Park. Legal opinion is required as to whether this can be achieved under the provisions of the Land Act.*

RECOMMENDATION 12

- *That further studies be undertaken to assess the possible impacts of estuary flooding and bar opening on coastal waters adjacent to the Fitzgerald Biosphere Reserve.*

2.4 PUBLIC CONSULTATION

RECOMMENDATION 13

- *That CALM undertake, as a priority, a public liaison program to address public concerns in relation to marine conservation reserves along the south coast.*
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TABLES

Table 1: Candidate marine conservation reserve areas and associated terrestrial reserves within the project area.

No.	Candidate Marine Conservation Reserves	Associated Terrestrial Reserves
1	Broke Inlet	D'Entrecasteaux National Park
2	Walpole/Nornalup Inlets	Walpole-Nornalup National Park
3	William Bay	William Bay National Park
4	West Cape Howe	West Cape Howe National Park
5	King George Sound/Princess Royal Harbour	Michaelmas Island Nature Reserve Breaksea Island Nature Reserve Mistaken Island Nature Reserve Seal Island Nature Reserve Gull Rock National Park Torndirrup National Park
6	Cape Vancouver - Bald Island	Two Peoples Bay Nature Reserve Waychinicup National Park Mt Many Peaks Nature Reserve Bald Island Nature Reserve
7	Fitzgerald Biosphere Reserve	Fitzgerald River National Park Doubtful Islands Nature Reserve Glasse Island Nature Reserve Rocky Islets Nature Reserve
8	Stokes Inlet/Shoal Cape	Stokes National Park
9	Recherche Archipelago	Woody Island Nature Reserve Recherche Archipelago Nature Reserve

Table 2: Description of the WA South Coast IMCRA (Version 3.1) Meso-scale region.

<i>Region Code & Number</i>	<i>Region Name & State/Territory</i>	<i>Description</i>
WSC	WA South Coast	<i>Location:</i> Black Head to Israelite Bay
36	WA	<i>Remarks:</i> Extensive seagrass meadows in embayments and inlets. Limestone cliffs over 300m high. High energy ruggedly scenic coastline.

<i>Region Code</i>	<i>Data Attribute</i>	<i>Description</i>
WSC	<i>WSC / 36</i>	<i>WA South Coast</i>
	Climate:	Temperate with a moderate to high rainfall in the west, mostly in winter, decreasing to semiarid in the east.
	Oceanography:	Water is clear. Swept by the West Wind Drift. Tidal range is a maximum of 1m and it is a high energy coast with the headlands exposed to heavy swell.
	Geology & geomorphology:	The southern margin of the Yilgarn Craton is fringed by a zone of intense Proterozoic tectonic activity and is characterised by granites and high-grade gneisses forming prominent headlands. Between the headlands there are arcuate bays with beaches backed by Holocene dune fields. Superficial Pleistocene aeolian limestone is commonly deposited along the south western sides of the headlands. There are many semi-sheltered bays and a few (notably King George Sound) that provide good shelter. Consequently, coastal habitats are highly varied. Estuarine habitats are a feature of the sector, with large and small estuaries of the riverine and basin types, and a range of salinity regimes relating to whether they are seasonally open or closed. [Note: within this zone there is another coastal type, formed by outcropping of the Eocene sediments of the Bremer Basin. It forms a distinctive coastal type but there are only a few, small examples of it.]
	Biota	The affinities of the coastal marine and estuarine flora and fauna lie strongly with the Southern Australian region but with a significant local endemic element (the south-west endemic species). There are a few Indo-West Pacific stragglers. Extensive seagrass meadows are a feature of sheltered bays and inlets. Kelps dominate rocky substrates in the sublittoral zone. There is a rich rocky shore intertidal fauna. The estuarine floras and faunas are depauperate due to the marked seasonality of the estuaries. Many nearshore islands are haul-out and breeding sites for Australian sea lions and New Zealand fur seals. Southern right whales make extensive use of sheltered bays.

Table 3: Descriptions of IMCRA (Version 3.1) Demersal Provinces and Biotones for the WA South Coast.

<i>Code</i>	<i>Province / Biotone Name</i>	<i>Description</i>
SWP	South Western Province	<p>Area: 52,040 km²</p> <p>Location: From Perth to Israelite Bay.</p> <p>Remarks: Defined by two primary distribution types: western warm temperate species that emerge from the South Western Biotone (SWB) and extend into the Great Australian Bight Biotone (GABB) and the Gulf Provinces (GulfP); and more widely distributed elements that extend from the South Western Biotone (SWB) eastward into Bass Strait. A smaller suite of eurythermal species extend as far north as the Central Western Biotone (CWB). Major disjunctions exist at its western and eastern boundaries. Some species from the Central Western Province (CWP) extend southward to this region. Western limit of a major provincial region referred to by Whitley (1937) as the Flindersian Province.</p> <p>Meso-scale regions: Includes Leeuwin-Naturaliste and WA South Coast regions.</p>

Table 4: Descriptions of IMCRA (Version 3.1) Pelagic Provinces and Biotones for the WA South Coast.

<i>Code</i>	<i>Province / Biotone Name</i>	<i>Description</i>
SPP	Southern Pelagic Province	<p>Area: 482,000 km²</p> <p>Location: Extending from near Albany in the west to Lakes Entrance in the east and enclosing Bass Strait and the Tasmanian waters.</p> <p>Remarks: Largely comprised of Flindersian cool temperate species. The endpoint disjunctions also represent southern limits for warm temperate species in the Eastern and Western Pelagic Biotones (WPB and EPB). Intra-provincial disjunctions occur at Esperance and east of Point Dempster near the western edge of the Baxter Cliffs. In the east, disjunctions occur just east of Kangaroo Island and at Wilson's Promontory.</p>
WPB	Western Pelagic Biotone	<p>Area: 119,000 km²</p> <p>Location: Extending from near Albany in the south to just south of North West Cape.</p> <p>Remarks: A strong zone of faunal overlap representing the major termination zone for eastern tropical and temperate species. Internal disjunctions within the biotone are numerous and mimic the structure reflected in the western part of the demersal regionalisation.</p>

Table 5: Number of species of flora and fauna recorded during the marine biological survey.

Phylum	Number of species (quantitative sampling)	Number of species (qualitative sampling)	TOTAL
Phaeophyta	36	21	57
Chlorophyta	8	2	10
Rhodophyta	35	41	76
Magnoliophyta	9	-	9
Mollusca	20	14	34
Echinodermata	22	17	39
Porifera	40	-	40
Cnidaria	1	7	8
Arthropoda	4	28	32
Chordata	83	19	102
TOTAL	258	149	407

FIGURES

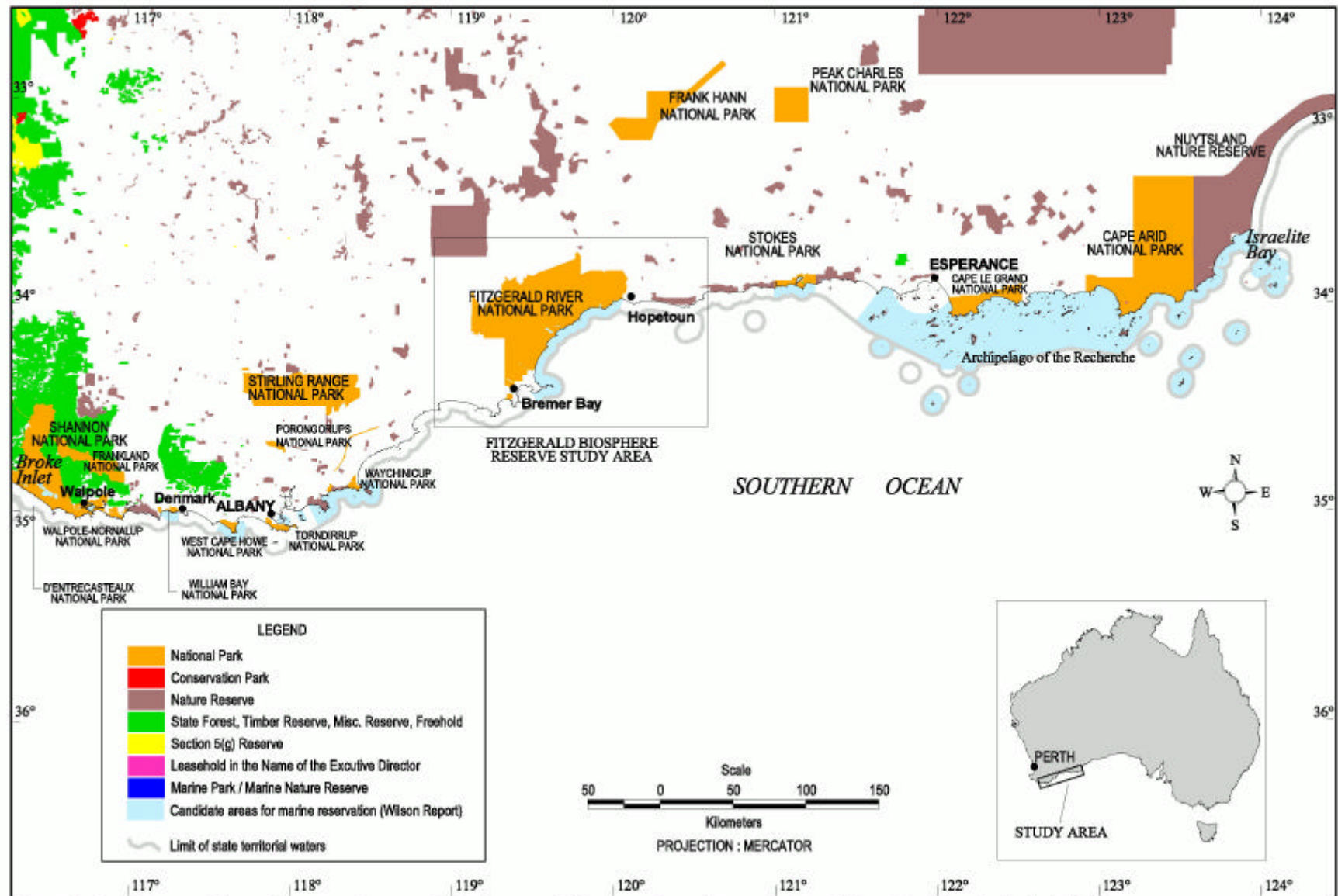
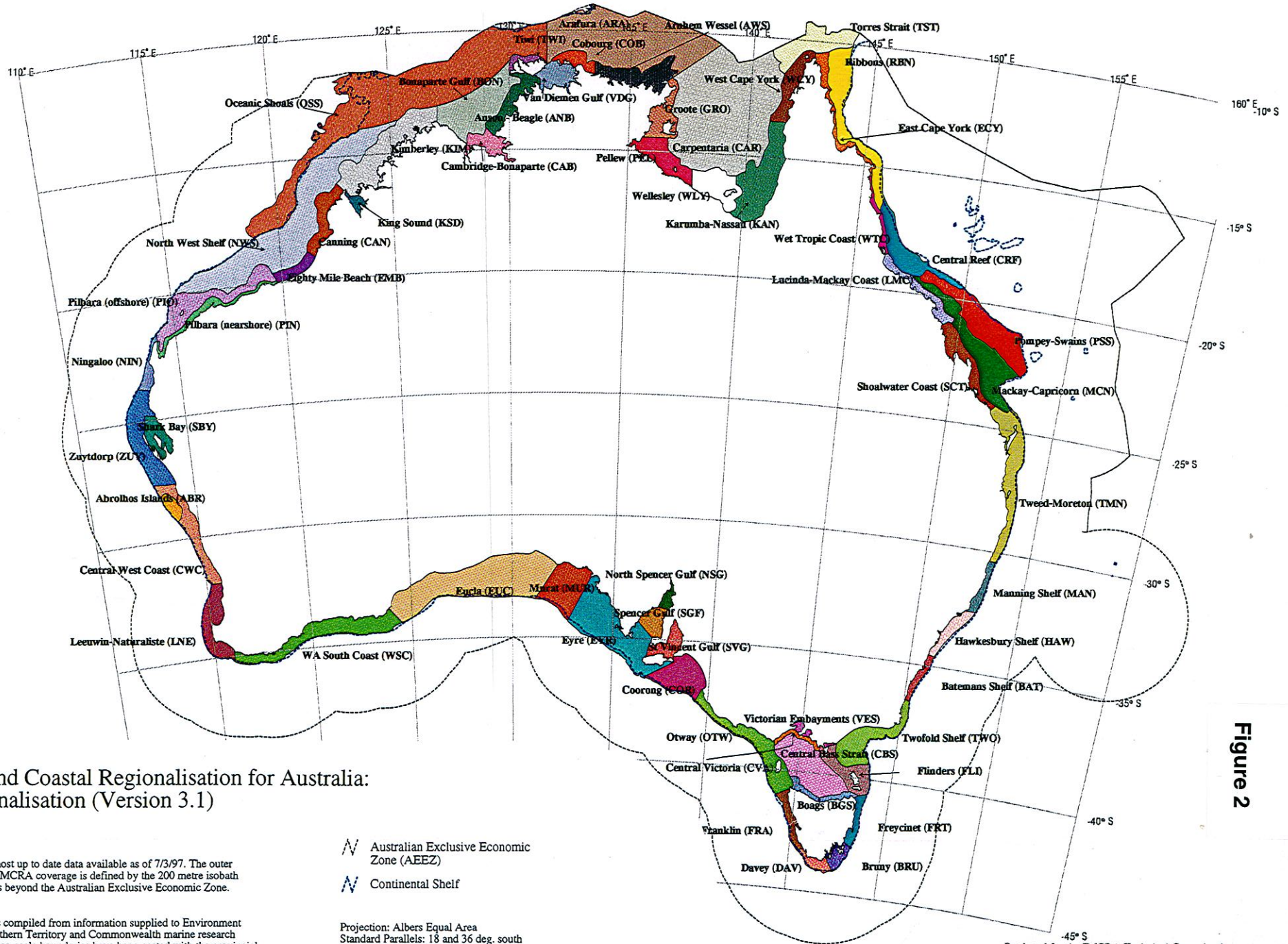


Figure 1. Locality map: The south coast project area in relation to candidate areas for marine reservation (Wilson Report) and existing CALM tenure.

Continental shelf meso-scale regionalisation:

- ABR Abrolhos Islands
- ANB Anson Beagle
- ARA Arafura
- AWS Arnhem Wessel
- BAT Batemans Shelf
- BGS Boags
- BON Bonaparte Gulf
- BRU Bruny
- CAB Cambridge-Bonaparte
- CAN Canning
- CAR Carpentaria
- CBS Central Bass Strait
- COB Cobourg
- COR Coorong
- CRF Central Reef
- CVA Central Victoria
- CWC Central West Coast
- DAV Davey
- ECY East Cape York
- EMB Eighty Mile Beach
- EUC Eucla
- EYR Eyre
- FLI Flinders
- FRA Franklin
- FRT Freycinet
- GRO Groote
- HAW Hawkesbury Shelf
- KAN Karumba-Nassau
- KIM Kimberley
- KSD King Sound
- LMC Lucinda-Mackay Coast
- LNE Leeuwin-Naturaliste
- MAN Manning Shelf
- MCN Mackay-Capricorn
- MUR Murat
- NIN Ningaloo
- NSG North Spencer Gulf
- NWS North West Shelf
- OSS Oceanic Shoals
- OTW Otway
- PEL Pellew
- PIN Pilbara (nearshore)
- PIO Pilbara (offshore)
- PSS Pompey-Swains
- RBN Ribbons
- SBY Shark Bay
- SCT Shoalwater Coast
- SGF Spencer Gulf
- SVG St Vincent Gulf
- TMN Tweed-Moreton
- TST Torres Strait
- TWI Tiwi
- TWO Twofold Shelf
- VDG Van Diemens Gulf
- VES Victorian Embayments
- VCY West Cape York
- WLY Wellesley
- WSC WA South Coast
- WTC Wet Tropic Coast
- ZUY Zuytdorp



Map 1
Interim Marine and Coastal Regionalisation for Australia:
Meso-scale regionalisation (Version 3.1)

BACKGROUND:
This map was compiled from the most up to date data available as of 7/3/97. The outer seaward extent for the meso-scale IMCRA coverage is defined by the 200 metre isobath except where this boundary extends beyond the Australian Exclusive Economic Zone.

SOURCES:
The meso-scale regionalisation was compiled from information supplied to Environment Australia by the relevant State, Northern Territory and Commonwealth marine research and management agencies. The meso-scale boundaries have been nested with the provincial level demersal regionalisation (Map 2).
AUSLIG (1995): "Australian Marine Boundary Information System (AMBIS)".
AUSLIG (1995): "Digital Coastline Dataset".

- Australian Exclusive Economic Zone (AEEZ)
- Continental Shelf

Projection: Albers Equal Area
Standard Parallels: 18 and 36 deg. south
Central Meridian: 132 deg. east
Australian Spheroid
Scale: 1:17,000,000

Figure 2

Produced for the IMCRA Technical Group by the Biodiversity Group, ENVIRONMENT AUSTRALIA.
Date: 4 September 1997
Graphic file: imcr3-4-a3.aml

Continental Shelf demersal regionalisation-names:

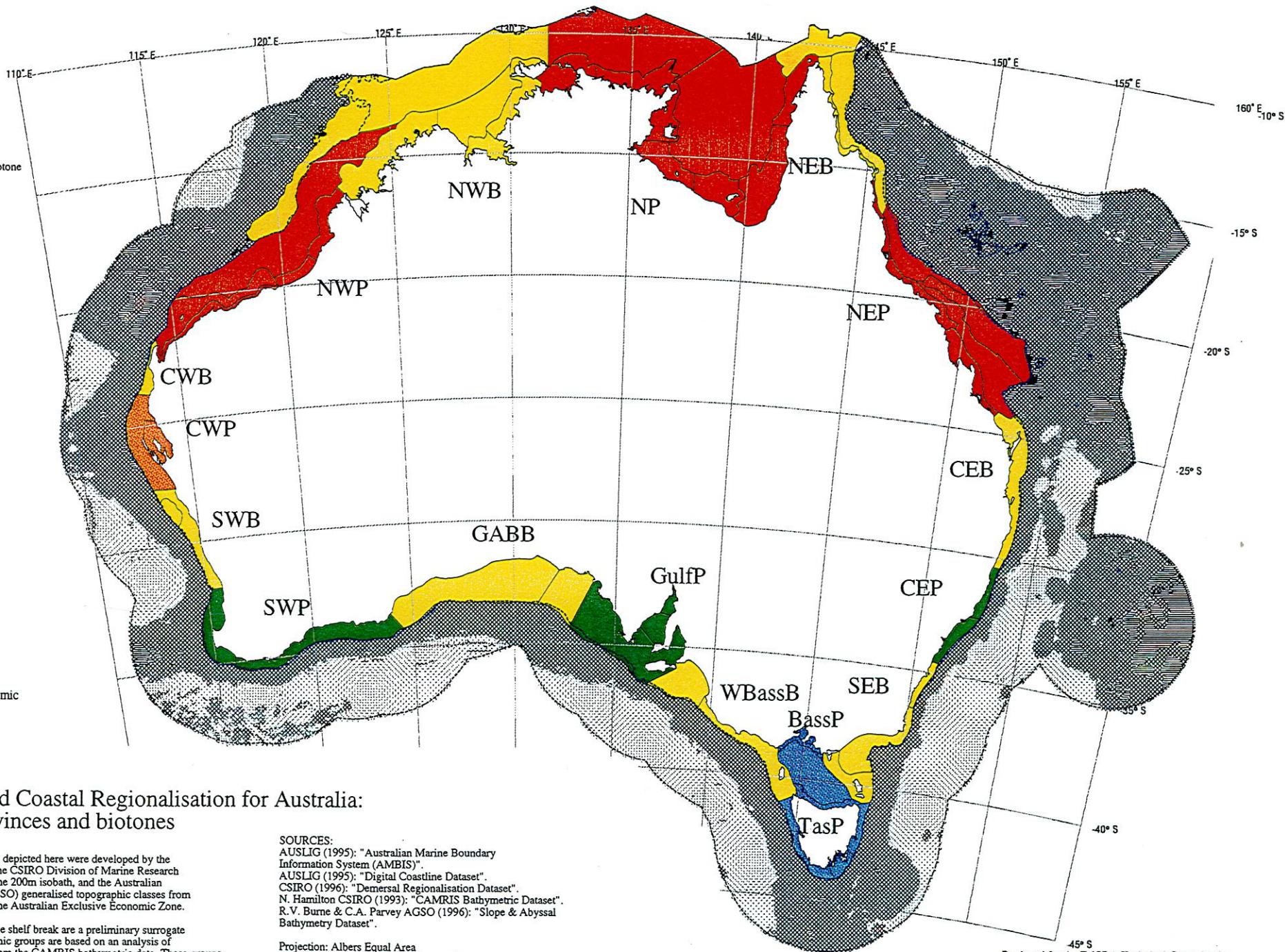
NP Northern Province
 NEB North Eastern Biotone
 NEP North Eastern Province
 CEB Central Eastern Biotone
 CEP Central Eastern Province
 SEB South Eastern Biotone
 BassP Bassian Province
 TasP Tasmanian Province
 WBassB Western Bassian Biotone
 GulfP Gulfs Province
 GABB Great Australian Bight Biotone
 SWP South Western Province
 SWB South Western Biotone
 CWP Central Western Province
 CWB Central Western Biotone
 NWP North Western Province
 NWB North Western Biotone

Continental shelf demersal regionalisation:

Tropical Waters
 Biotone
 Subtropical Waters
 Warm Temperate Waters
 Cold Temperate Waters
 Meso-scale IMCRA

Topography beyond the shelf break:

Abyssal plain/ Abyssal rise
 Deep Shelf
 Slope/ Steep Slope
 Plateau
 Australian Exclusive Economic Zone (AEEZ)
 Continental Shelf



Map 2
 Interim Marine and Coastal Regionalisation for Australia:
 The demersal provinces and biotones

BACKGROUND:
 The demersal provinces and biotones depicted here were developed by the IMCRA Technical Group, utilising the CSIRO Division of Marine Research demersal fish regionalisation out to the 200m isobath, and the Australian Geological Survey Organisation (AGSO) generalised topographic classes from the 200m isobath out to the edge of the Australian Exclusive Economic Zone.

CAVEAT:
 The topographic provinces beyond the shelf break are a preliminary surrogate of demersal provinces. The topographic groups are based on an analysis of depth and slope groupings derived from the CAMRIS bathymetric data. These groups provide a surrogate in the absence of systematic biological data for deeper waters, and have been generalised by Environment Australia for presentation purposes.

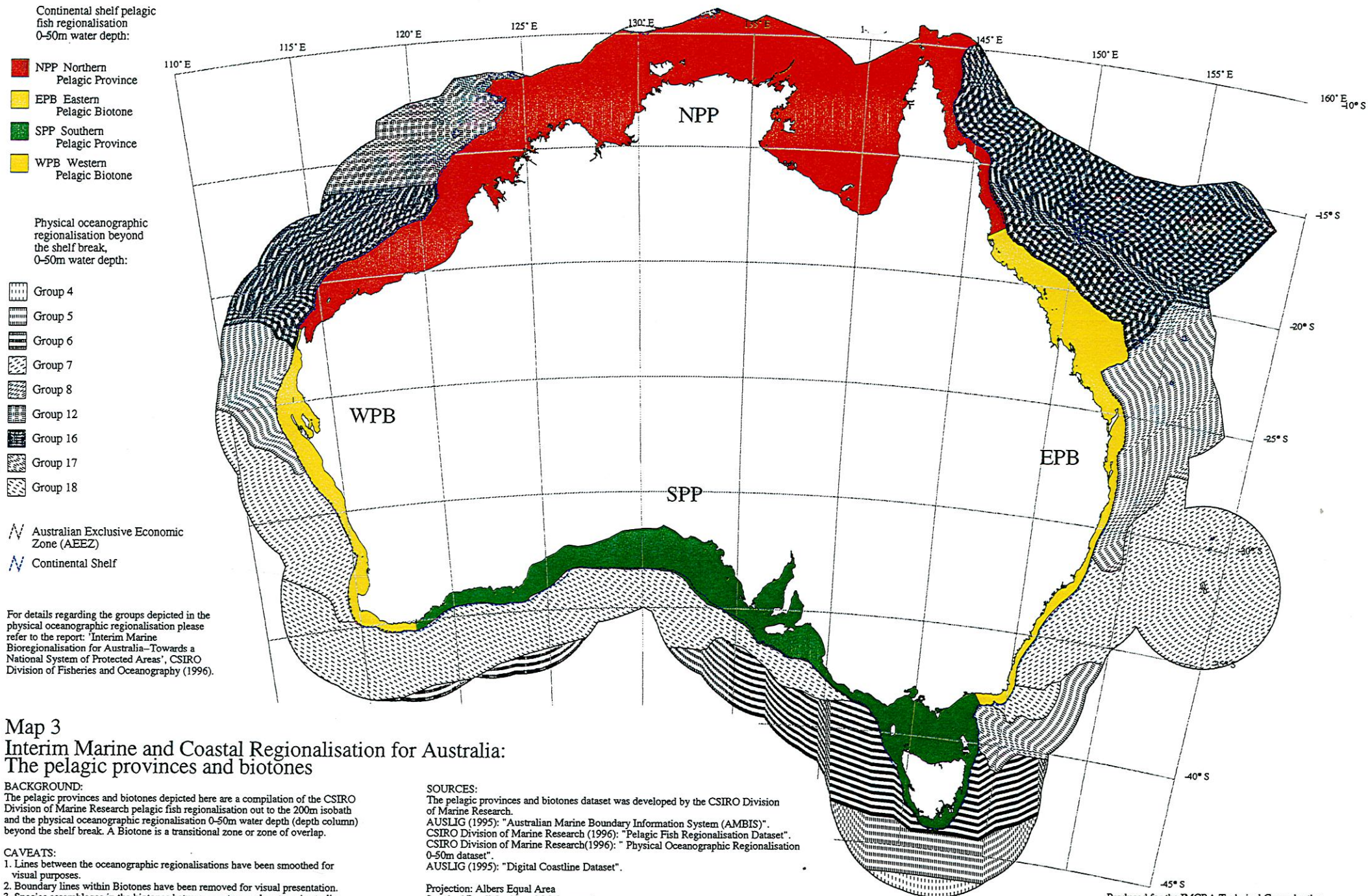
SOURCES:
 AUSLIG (1995): "Australian Marine Boundary Information System (AMBIS)".
 AUSLIG (1995): "Digital Coastline Dataset".
 CSIRO (1996): "Demersal Regionalisation Dataset".
 N. Hamilton CSIRO (1993): "CAMRIS Bathymetric Dataset".
 R. V. Burne & C.A. Parvey AGSO (1996): "Slope & Abyssal Bathymetry Dataset".

Projection: Albers Equal Area
 Standard Parallels: 18 and 36 deg. south
 Central Meridian: 132 deg. east
 Australian Spheroid
 Scale 1:17,000,000

Figure 3

Produced for the IMCRA Technical Group by the Biodiversity Group, ENVIRONMENT AUSTRALIA.

Date: 4 September 1997
 Graphic file: dem5.aml



Map 3
Interim Marine and Coastal Regionalisation for Australia:
The pelagic provinces and biotones

BACKGROUND:
The pelagic provinces and biotones depicted here are a compilation of the CSIRO Division of Marine Research pelagic fish regionalisation out to the 200m isobath and the physical oceanographic regionalisation 0-50m water depth (depth column) beyond the shelf break. A Biotone is a transitional zone or zone of overlap.

- CAVEATS:
1. Lines between the oceanographic regionalisations have been smoothed for visual purposes.
 2. Boundary lines within Biotones have been removed for visual presentation.
 3. Species assemblages in the biotones between western and eastern Australia have different species compositions.
 4. The colour gradient used in the Biotones visually depicts the species transition between northern and southern Provinces.

Figure 4

Produced for the IMCRA Technical Group by the
Biodiversity Group, ENVIRONMENT AUSTRALIA.

Date: 4 September 1997
Graphic file: pelag-4-a3.aml

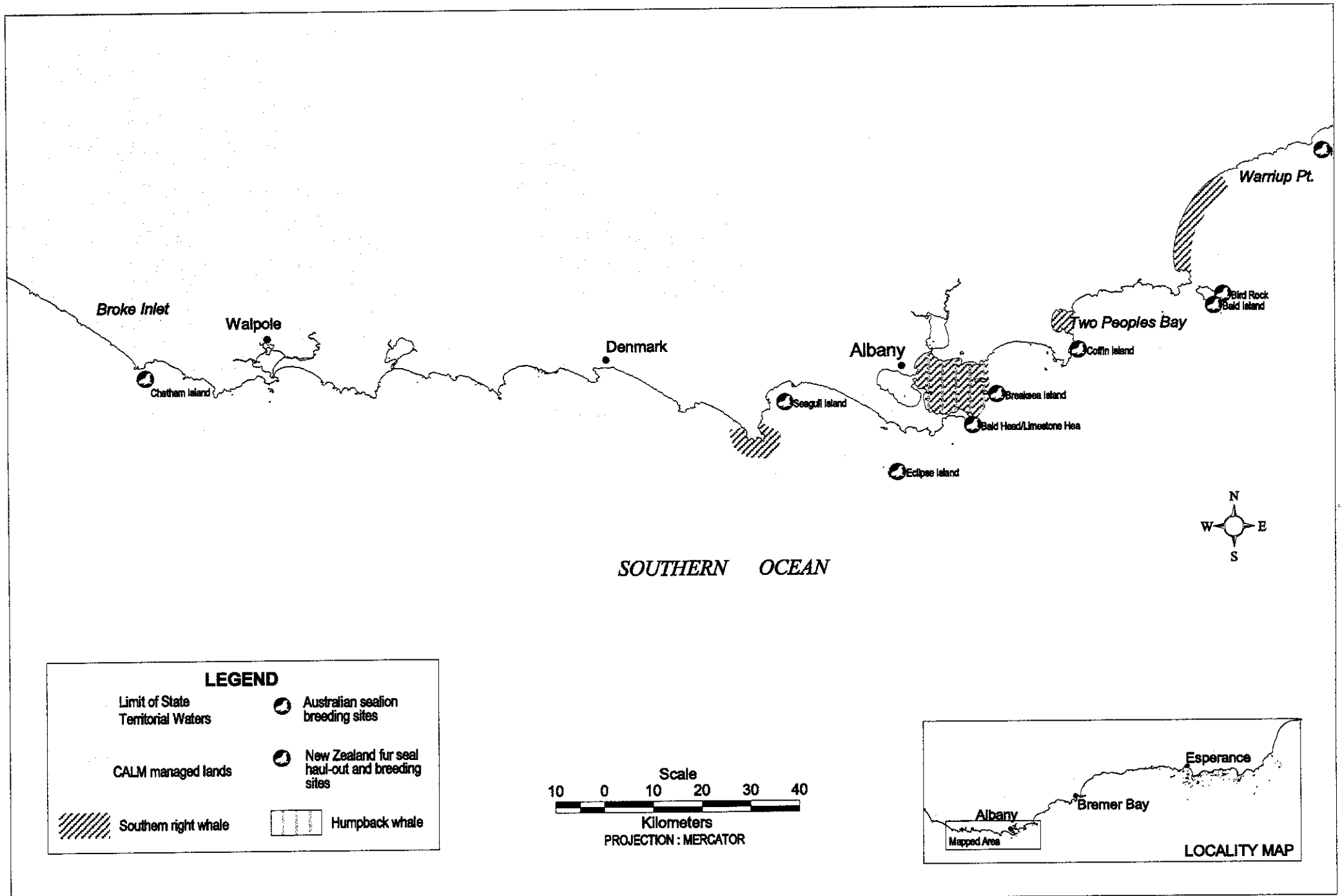


Figure 5. Marine mammal distribution: Broke Inlet to Warriup Point

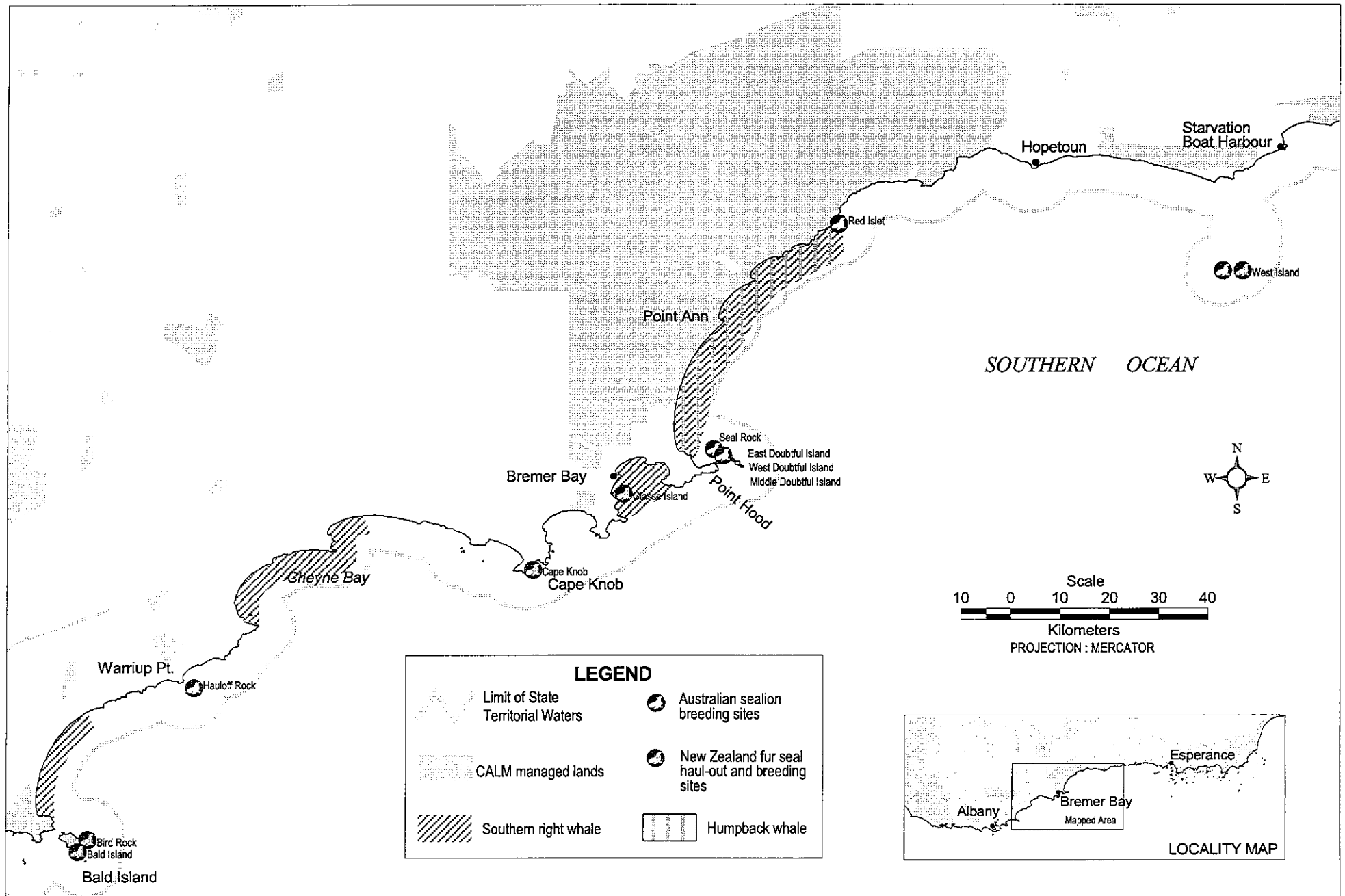


Figure 6. Marine mammal distribution: Bald Island to Starvation Boat Harbour.

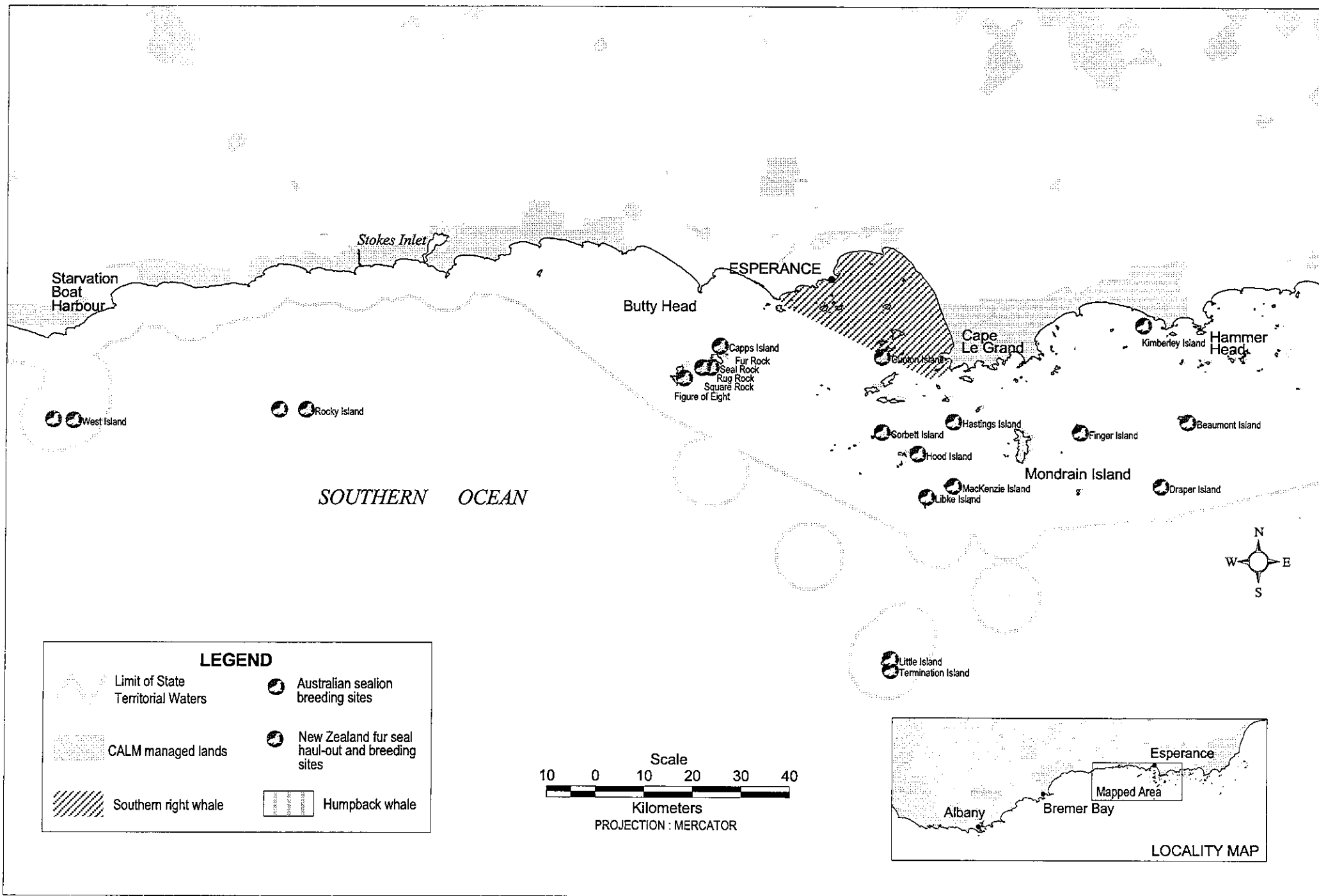


Figure 7. Marine mammal distribution: Starvation Boat Harbour to Hammer Head.

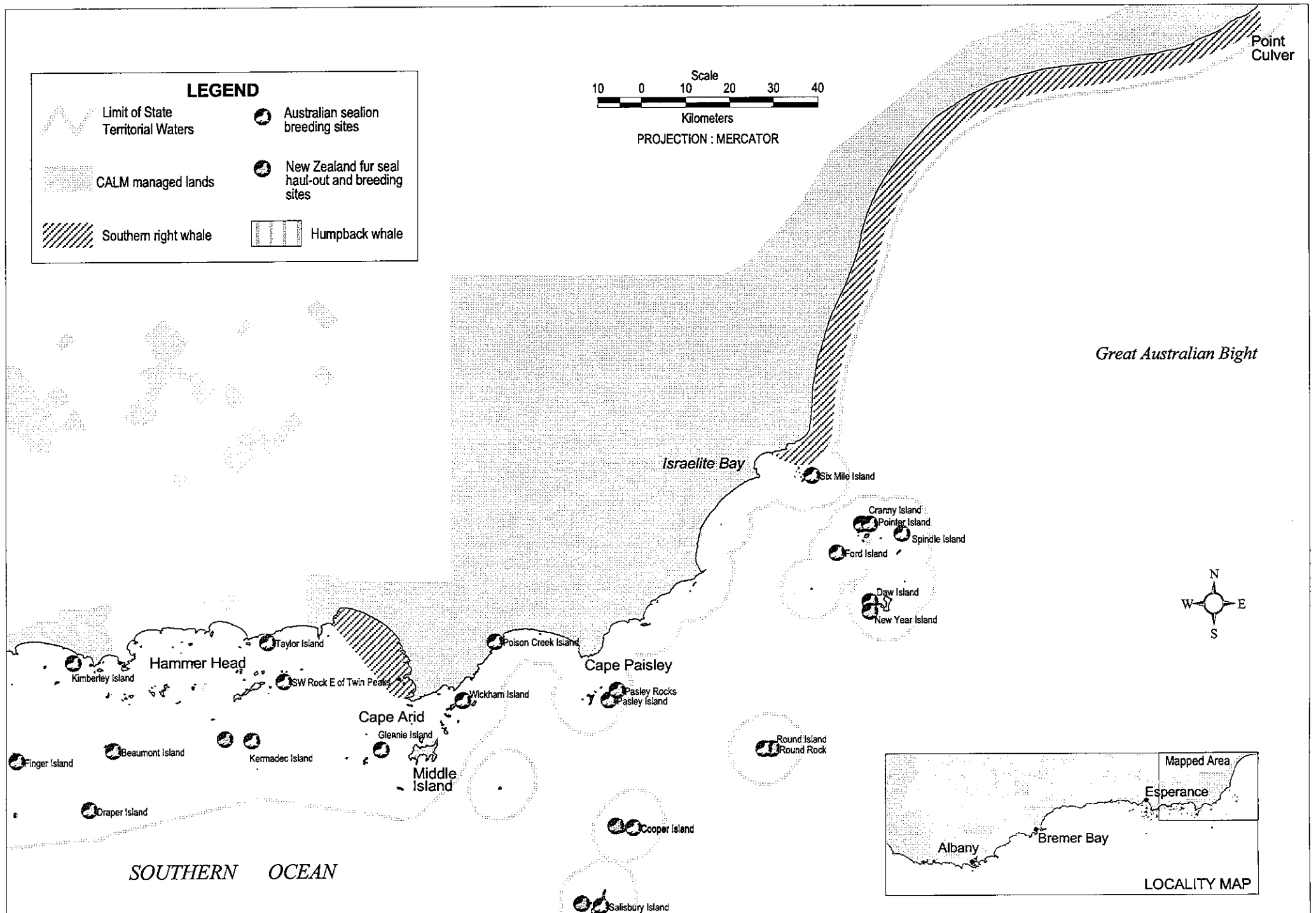


Figure 8. Marine mammal distribution: Hammer Head to Point Culver.

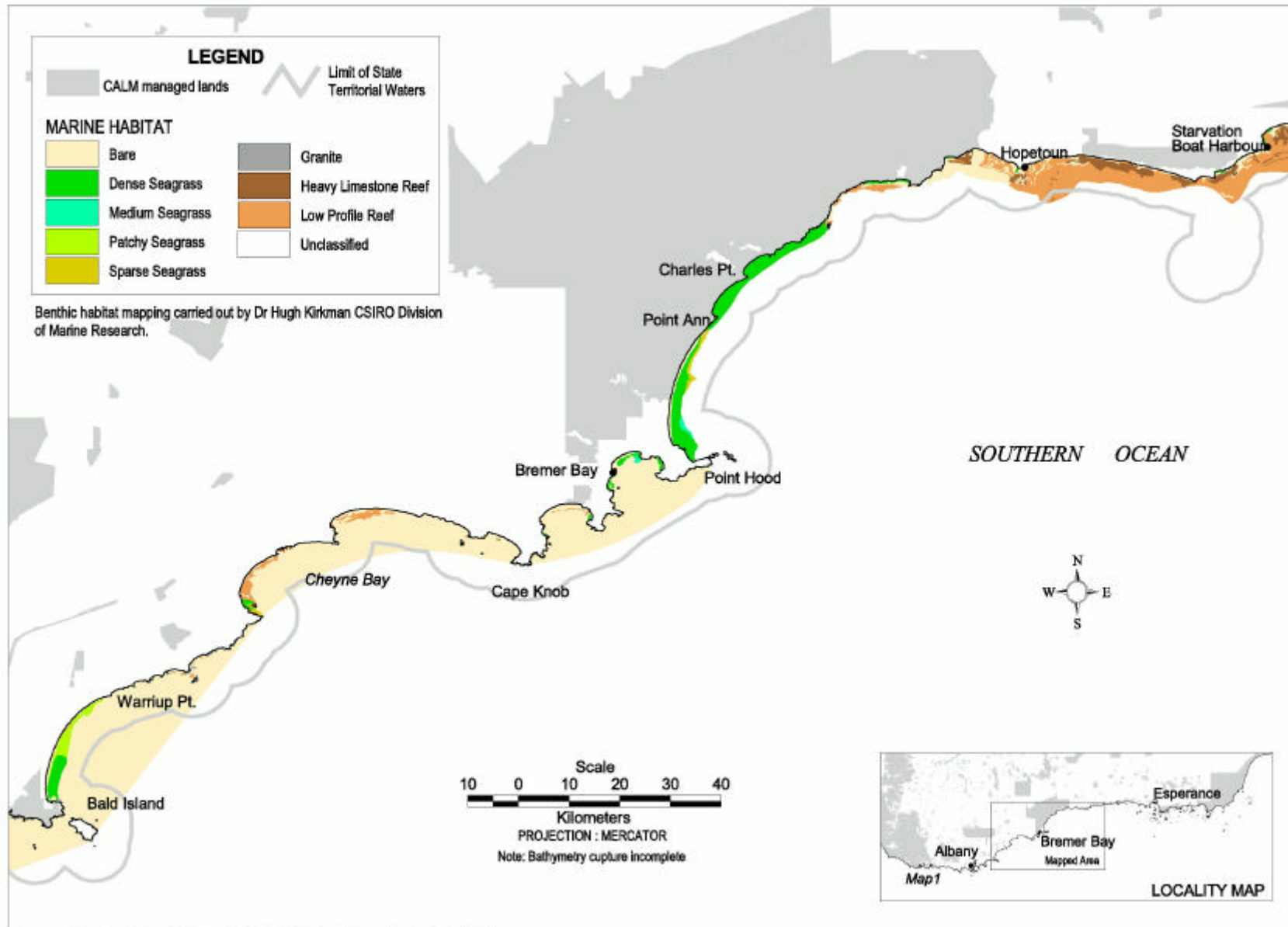


Figure 10. Benthic habitats: Bald Island to Starvation Boat Harbour.

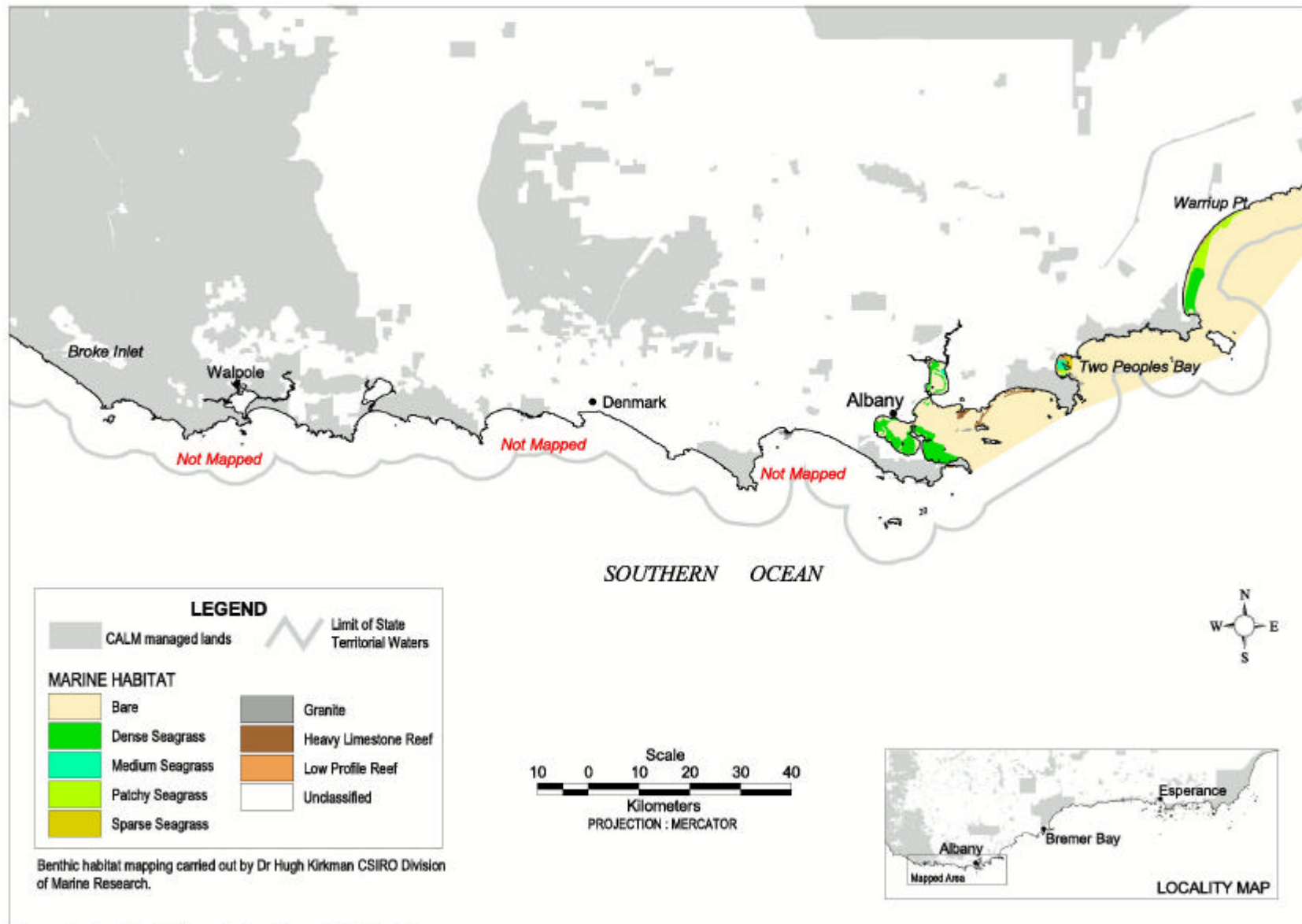


Figure 9. Benthic habitats: Broke Inlet to Warriup Point.

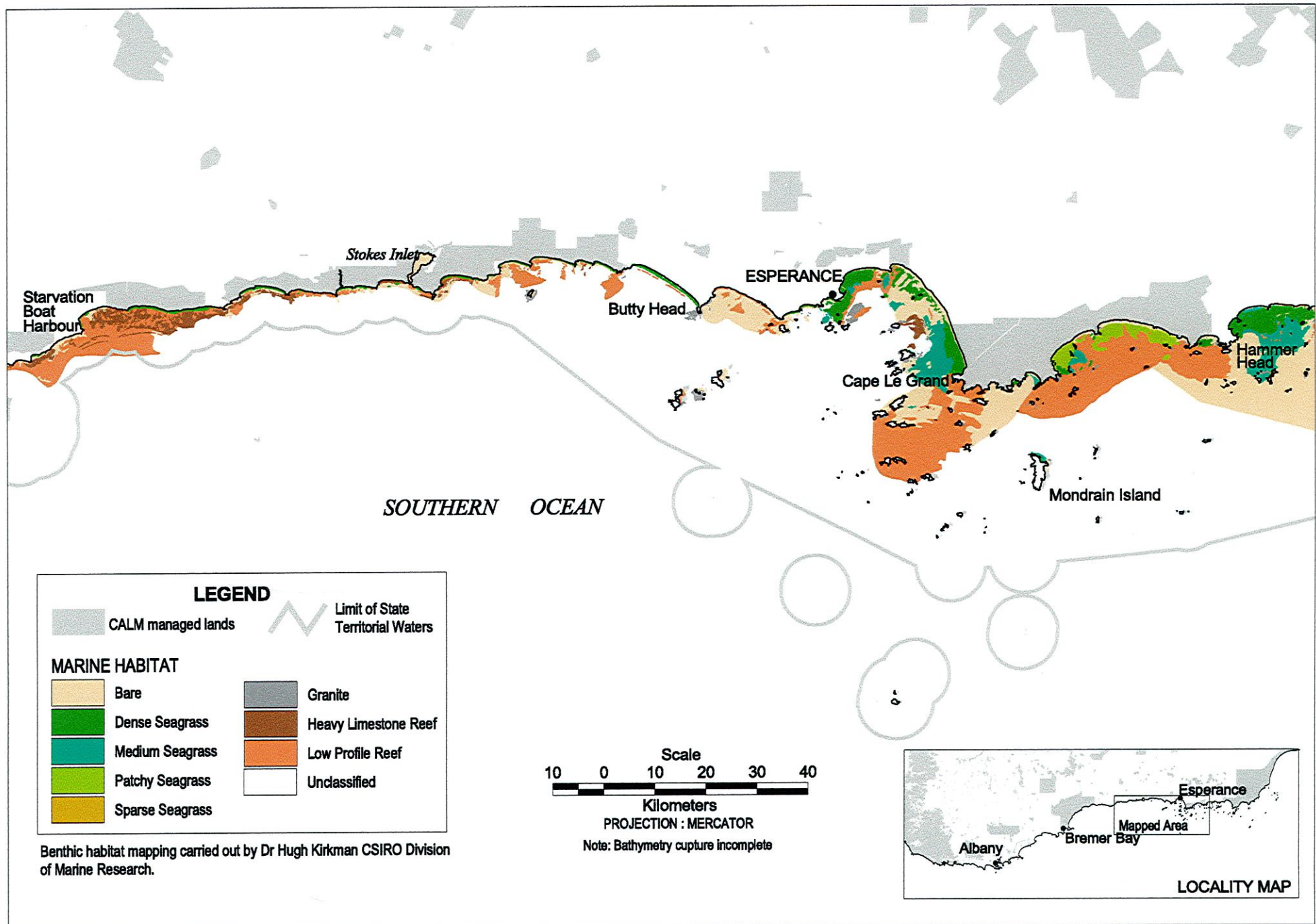


Figure 11. Benthic habitats: Starvation Boat Harbour to Hammer Head.

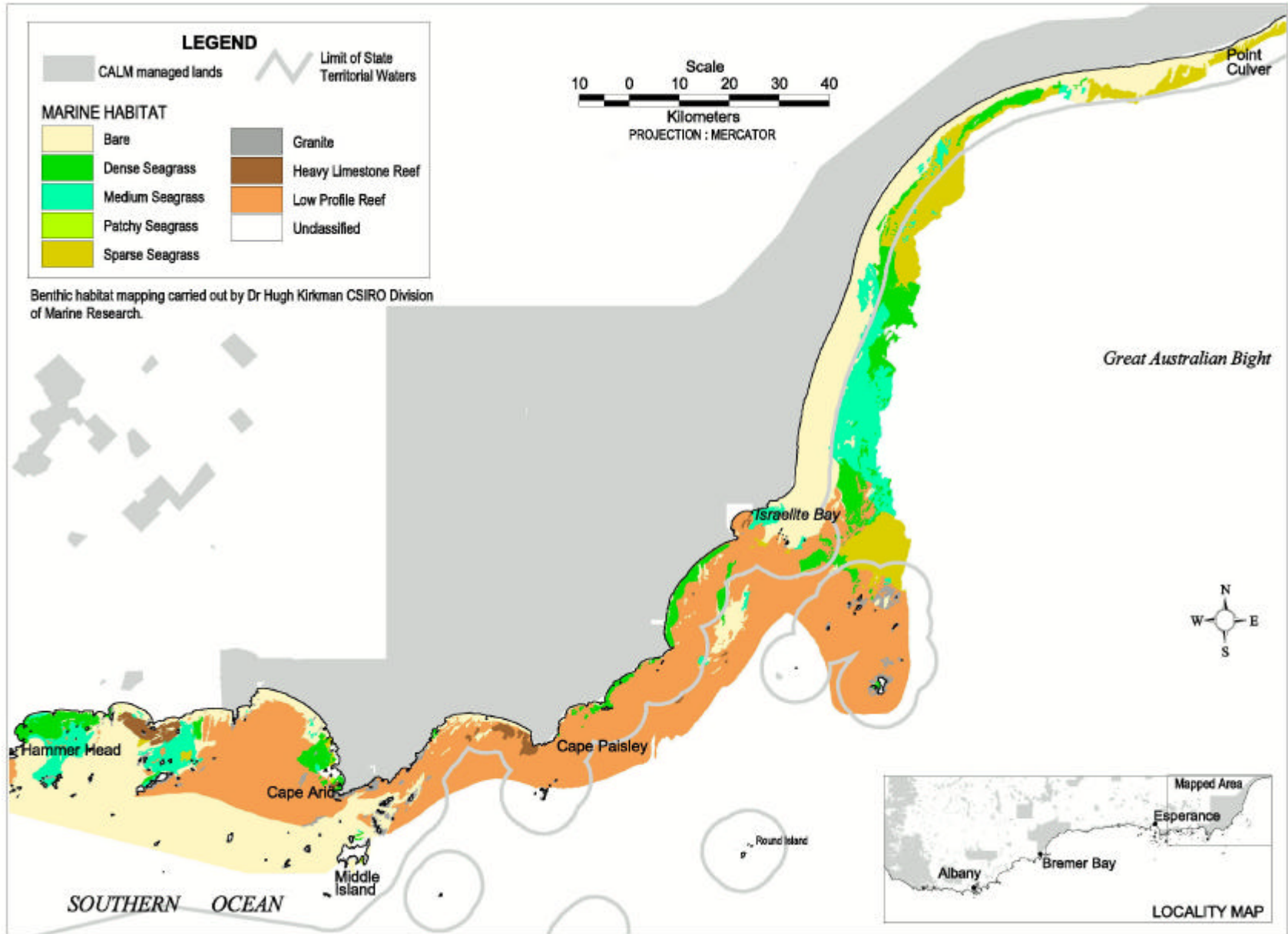


Figure 12. Benthic habitats: Hammer Head to Point Culver.

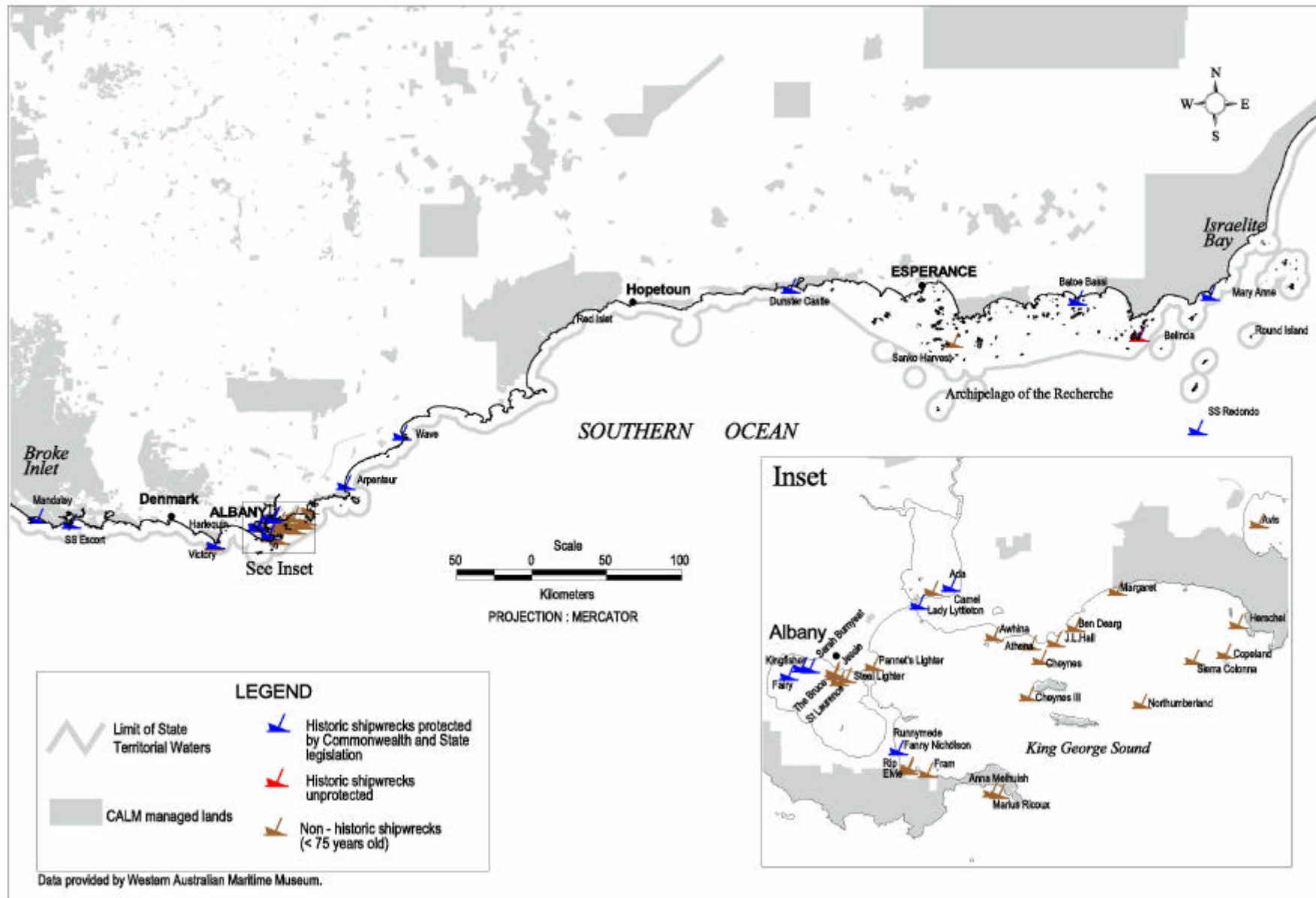


Figure 13. Shipwreck sites: Broke Inlet to Israelite Bay.

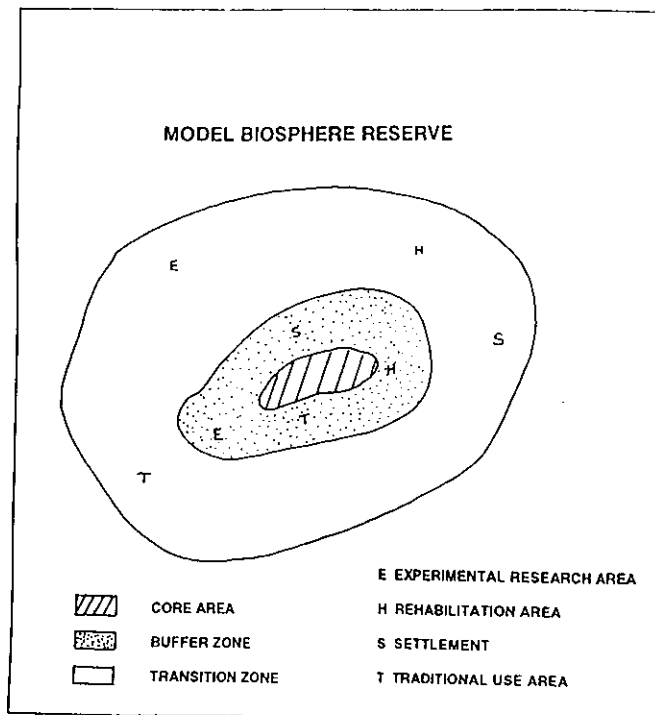


Figure 14: Model biosphere reserve.

(From Watson, 1994)

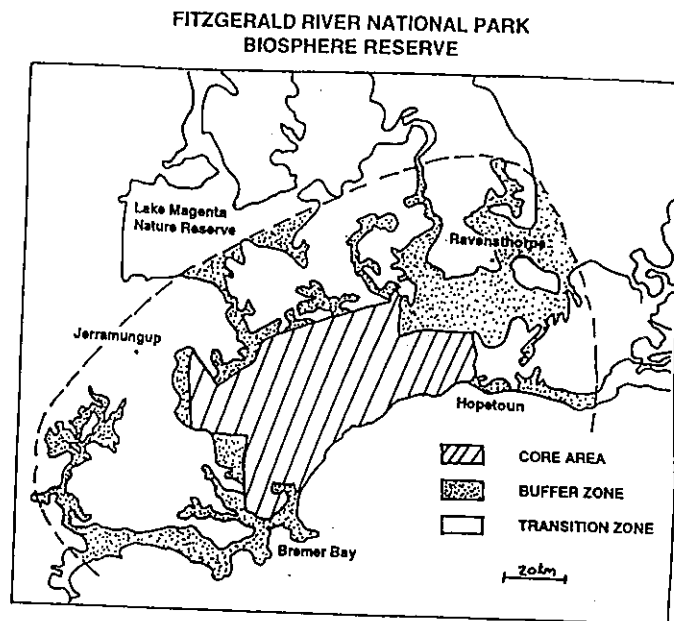


Figure 15: Core, buffer and transition zones of the Fitzgerald Biosphere Reserve.

(From Watson, 1994)

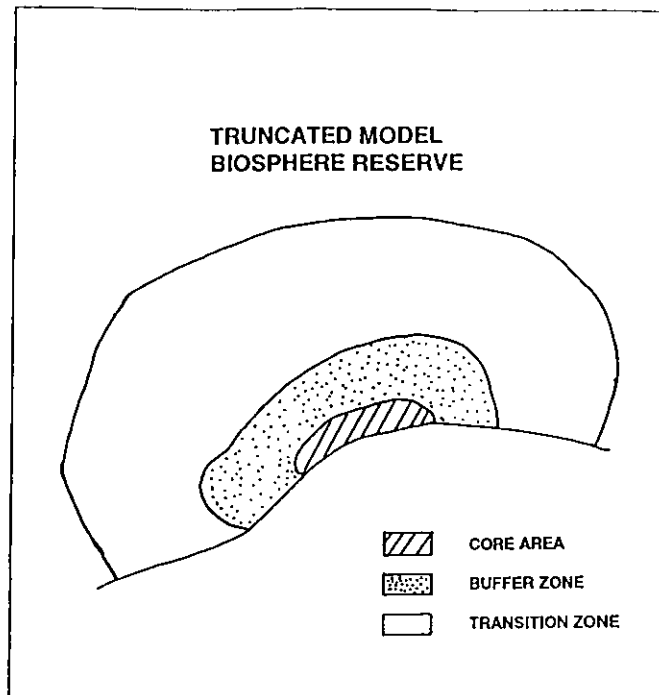


Figure 16: Truncated model biosphere reserve.

(From Watson, 1994)

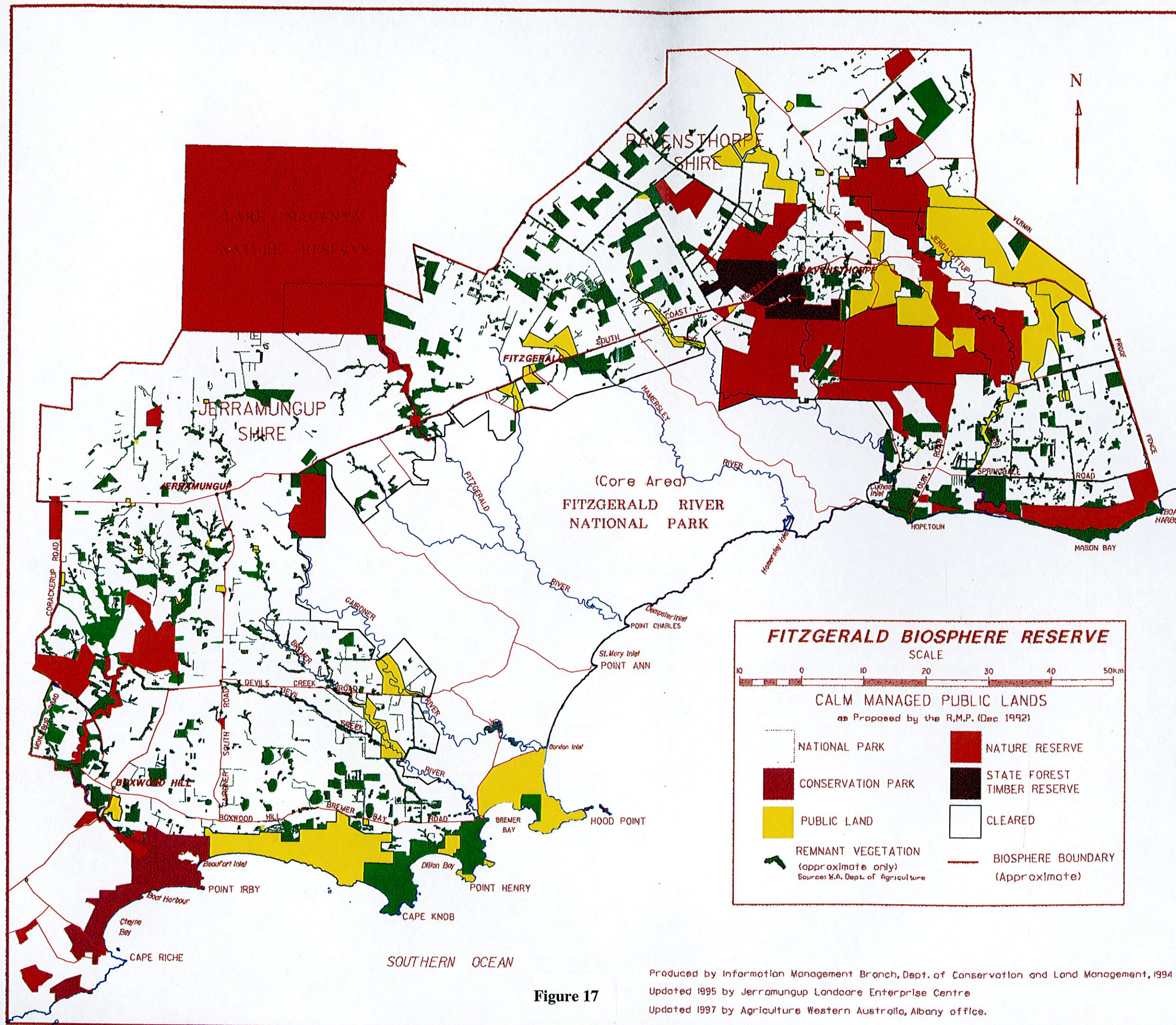


Figure 17

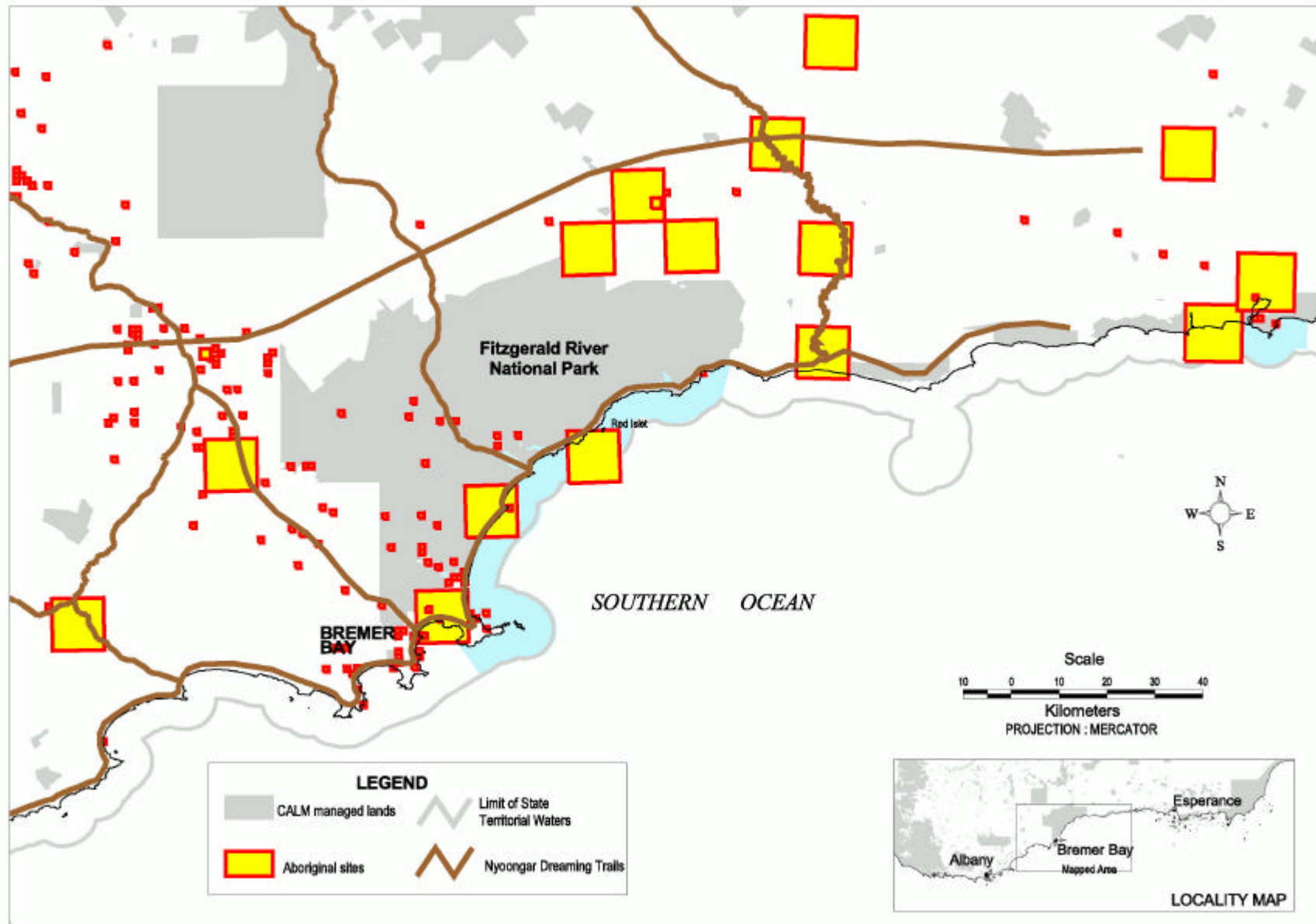
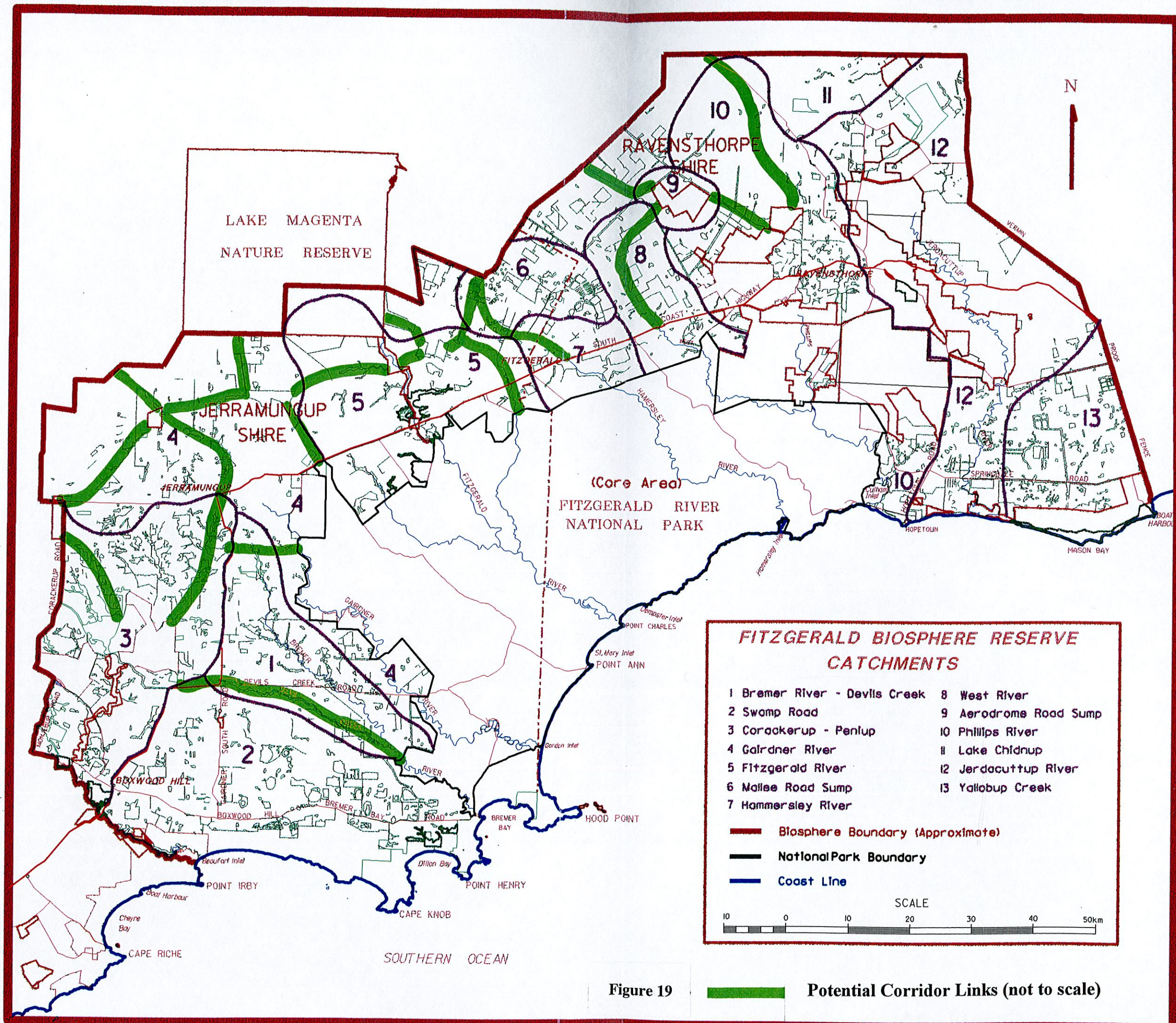


Figure 18. Aboriginal cultural /historical sites in the Fitzgerald Biosphere Reserve.



**FITZGERALD BIOSPHERE RESERVE
CATCHMENTS**

1 Bremer River - Devils Creek	8 West River
2 Swamp Road	9 Aerodrome Road Sump
3 Corackerup - Penlup	10 Phillips River
4 Gardner River	11 Lake Chidnup
5 Fitzgerald River	12 Jerdacuttup River
6 Mallee Road Sump	13 Yallobup Creek
7 Hammersley River	

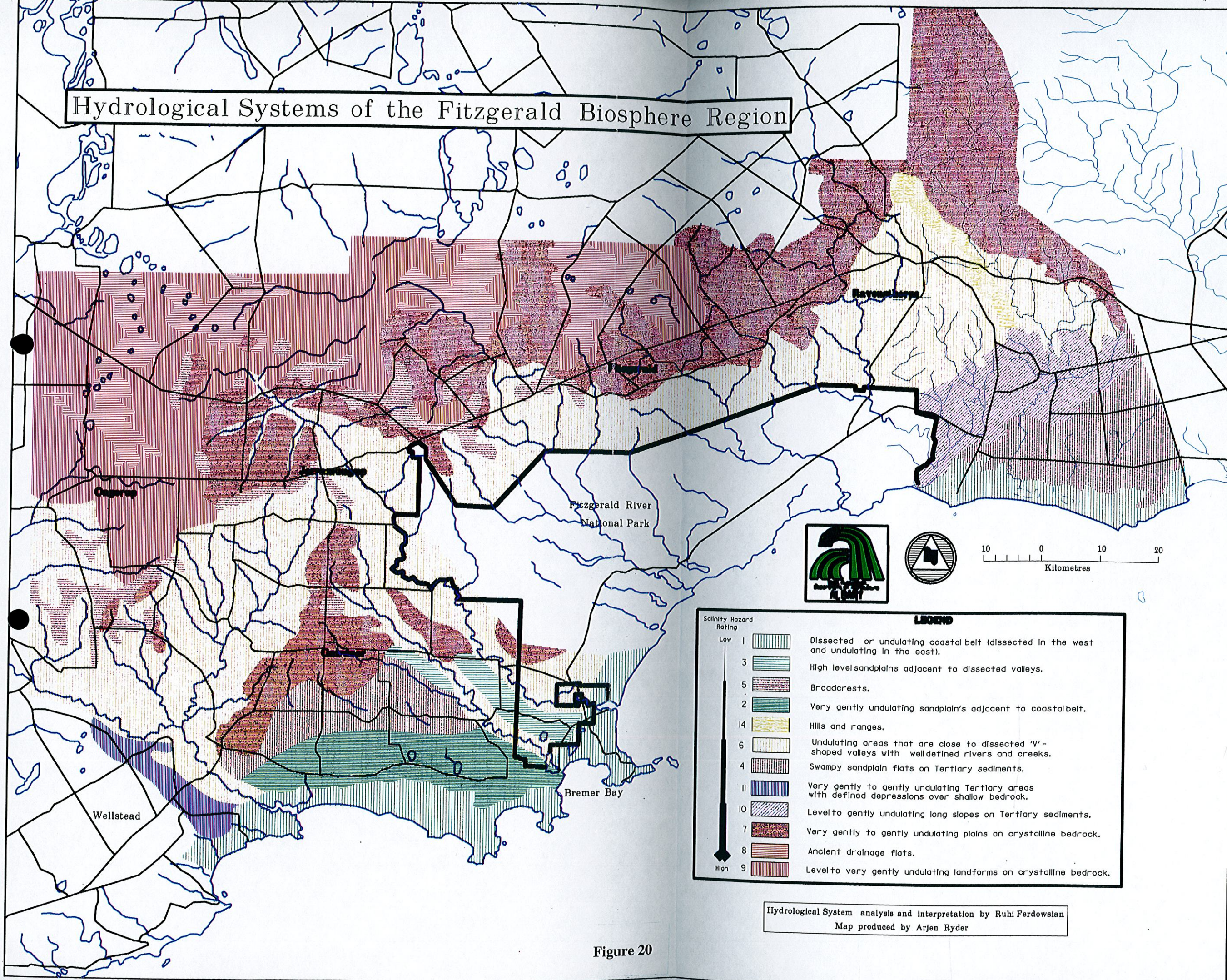
— Biosphere Boundary (Approximate)
— National Park Boundary
— Coast Line

SCALE
 0 10 20 30 40 50km

Figure 19

— Potential Corridor Links (not to scale)

Hydrological Systems of the Fitzgerald Biosphere Region



Hydrological System analysis and interpretation by Ruhl Ferdowsian
Map produced by Arjen Ryder

Figure 20

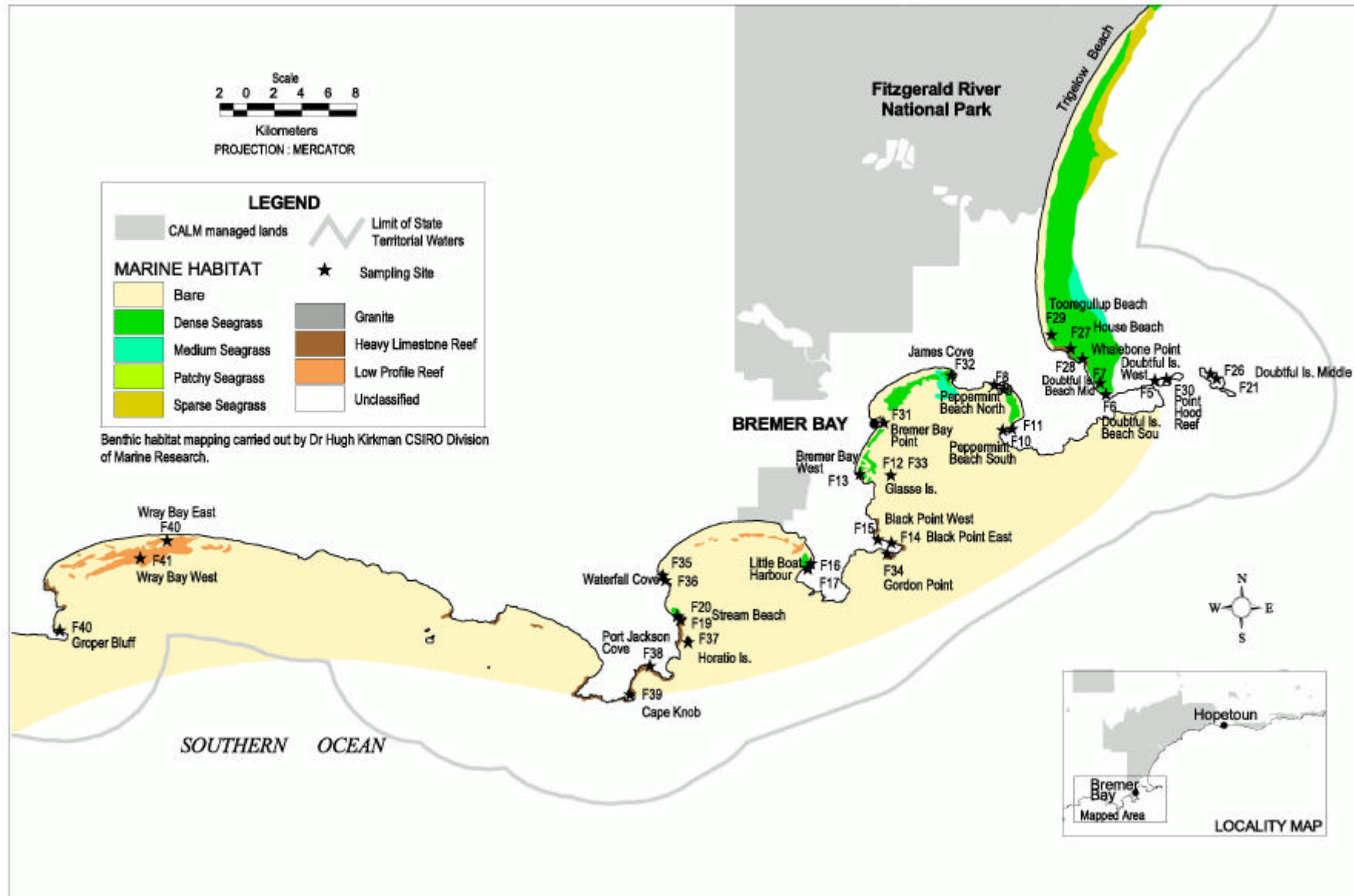


Figure 21. Marine biological survey sites, March 1997: Groper Bluff to Trigelow Beach.

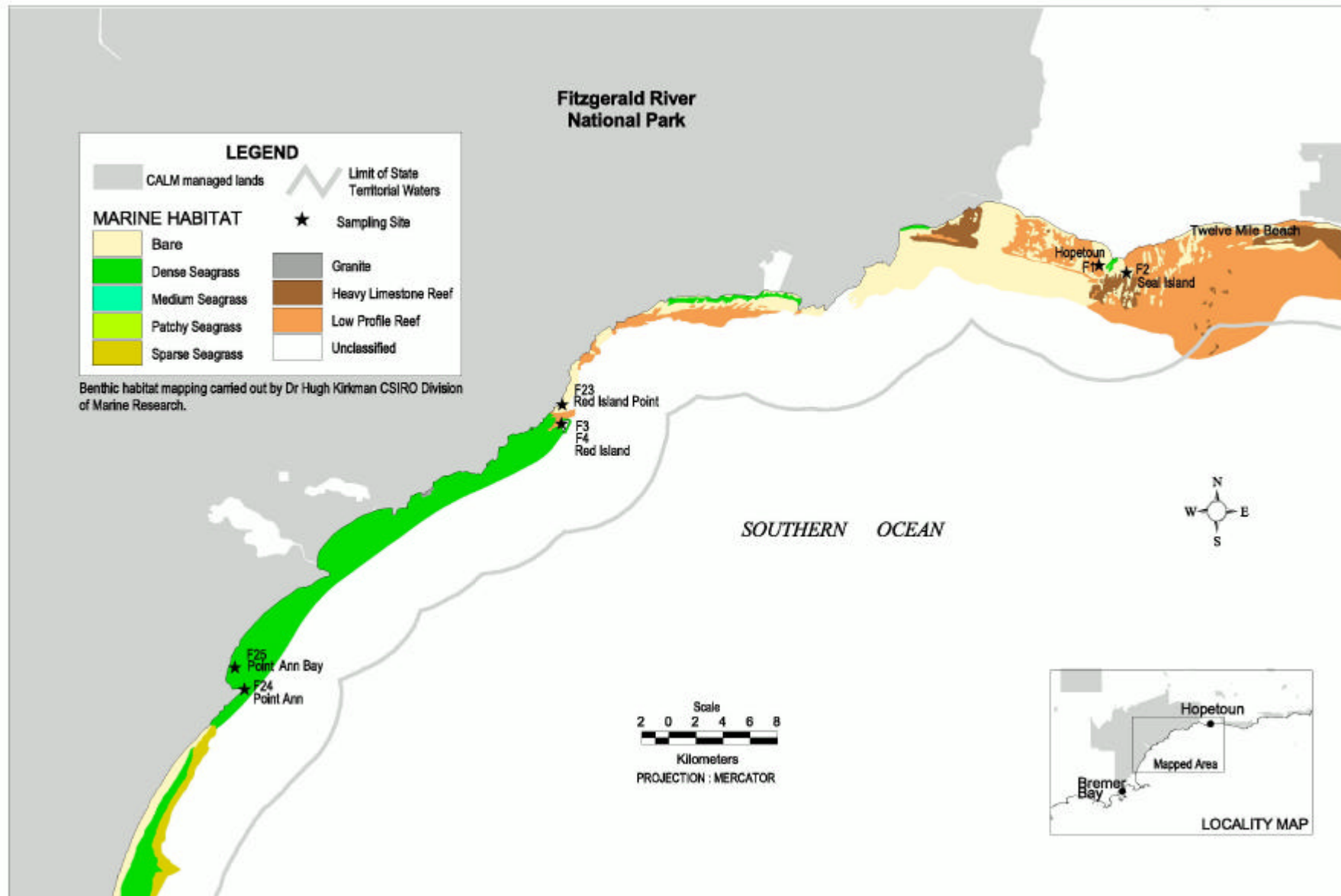


Figure 22. Marine biological survey sites, March 1997: Point Ann to Twelve Mile Beach.

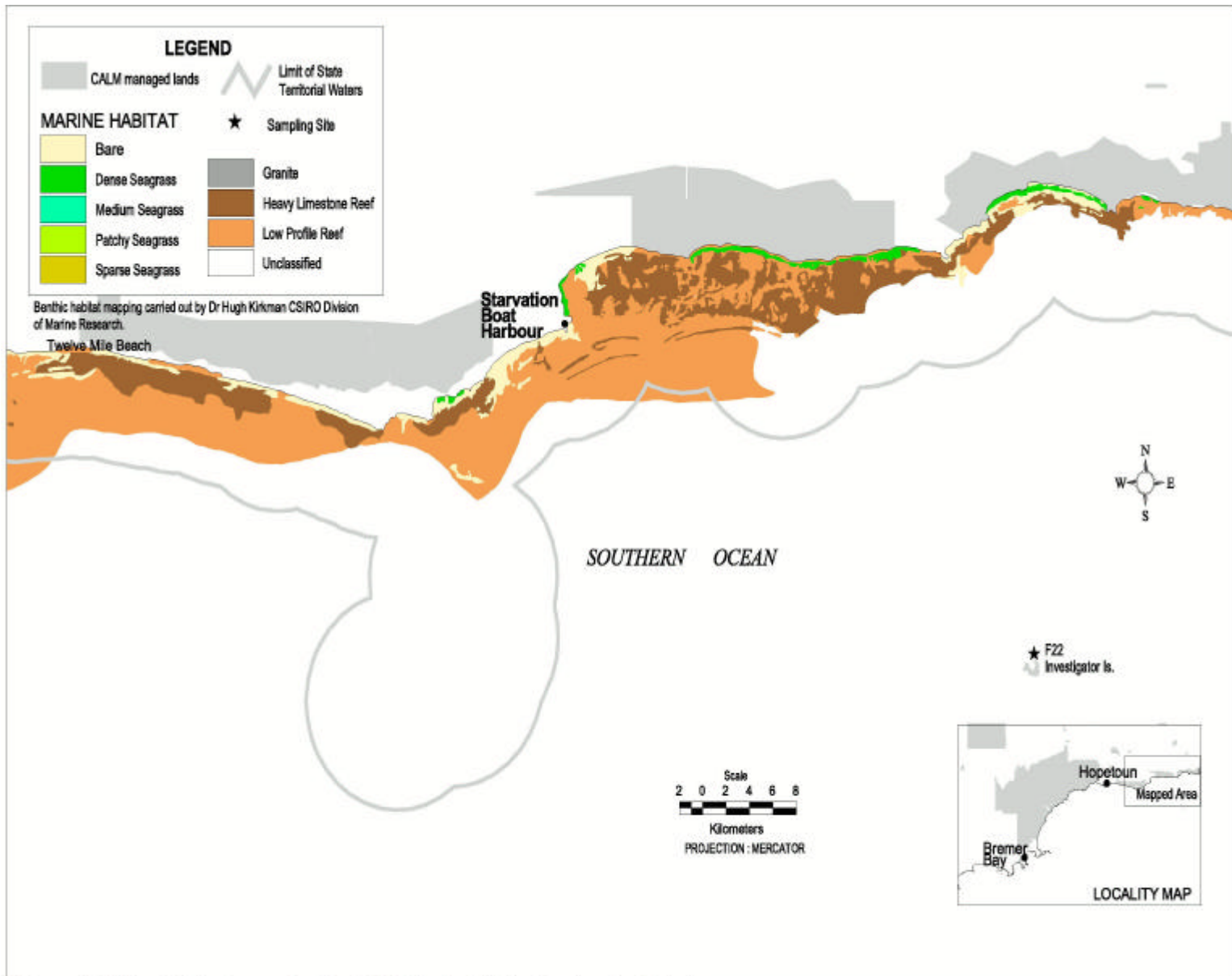


Figure 23. Marine biological survey sites, March 1997: Twelve Mile Beach to Investigator Island.

APPENDICES

APPENDIX I

FINANCIAL STATEMENT

FINANCIAL STATEMENT

To September 30, 1997

Project: South Coast Terrestrial and Marine Reserve Integration Study - funded by Environment Australia.

Environment Australia Reference: National Reserve System Cooperative Program, Project #713.

REVENUE	\$
Environment Australia (Biodiversity Group)	
Initial Payment	43,000
First Progress Payment	5,000
Second Progress Payment	5,000
Total Revenue to September 30, 1997	53,000

EXPENDITURE	\$
GENERAL	
Accommodation	629
Airfares - 1 Perth-Albany rtn @ \$239	239
Equipment purchase	5,395
Equipment hire	2,000
Consultancy fees	
Murdoch University	8,000
WA Museum	207
Materials	703
Miscellaneous (taxi fares, film processing, photocopying, binding, courier services)	552
SUB-TOTAL	17,725

VOLUNTEERS	\$
Accommodation	336
Airfares - 1 Perth-Albany rtn @ \$257	257
1 Perth-Albany rtn @ \$220	220
Food	252
Photocopying	154
Travel costs	100
Materials	100
Miscellaneous	30
Dive medical	90
SUB-TOTAL	1,590

FINANCIAL STATEMENT (continued)

EXPENDITURE	\$
FIELD SURVEY	
Vessel charter - 15 days @ \$1,500 per day	22,500
1 day @ \$1,000 per day	1,000
Sub-total	23,500
Airfares - 2 Hobart-Perth rtn @ \$531 each	1,062
1 Albany-Perth single @ \$137	137
Sub-total	1,199
Accommodation	405
Food	451
Vehicle costs -	
CALM Albany vehicle 2,797 kms @ \$0.35 per km	979
Fuel	300
Overtime/allowances (Dive Master)	500
Equipment & Consumables	2,166
Sub-total	4,800
Consultancy fees	
Murdoch University	2,592
Edith Cowan University	2,592
Sub-total	5,184
SUB-TOTAL	34,683
TOTAL EXPENDITURE to September 30, 1997	53,998
BALANCE	(-998)

APPENDIX II

EXTRACT FROM THE REPORT OF THE MARINE PARKS AND RESERVES SELECTION WORKING GROUP

A REPRESENTATIVE MARINE RESERVE SYSTEM FOR WESTERN AUSTRALIA

**Report of the Marine Parks and Reserves Selection
Working Group**

**PART V
MARINE RESERVES ON THE SOUTH COAST**

CONTENTS

PART V: MARINE RESERVES ON THE SOUTH COAST

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1. INTRODUCTION

This section deals with that area of Western Australia generally known as the South Coast, extending from Cape Leeuwin to the South Australian border. Broadly speaking the South Coast has an east-west orientation, facing the Southern Ocean, covering a distance of about 1 500 km and spanning 14 degrees of longitude. It lies entirely within the temperate climatic zone and corresponds to one of the biogeographic zones described in the Council of Nature Conservation Ministers working paper on marine protected areas (CONCOM, 1985).

The South Coast is sparsely populated. There are several coastal towns, including the regional centre of Albany. Most of the coastal land is national park, nature reserve or recreation reserve. The scenery of much of this coast is outstanding, both above and below the water. Although present levels of maritime recreational activities are moderate and localised, there is potential for significant development of the recreational and commercial tourism resources of these coastal waters and a case can be made for the reservation of several marine areas for that public purpose.

A bibliography for the natural environment of the Albany region (extending from Denmark to the Fitzgerald River National Park) has been prepared for the Heritage Council of Western Australia (Livesey, 1993).

The marine flora and fauna of the South Coast are poorly known. The biota is similar to that of South Australia and Victoria and reference must be made to the taxonomic literature of those States in order to identify many of the species. In recent years there has been some collecting of the marine fauna of the area by Western Australian Museum staff and helpful reference collections exist in that institution. However, with the exception of the estuarine biota, there have been very few ecological studies on the South Coast. For this reason the Working Group was obliged to base its assessment of areas worthy of reservation for conservation purposes mainly on geomorphological features and the assumption that areas representative of shore geomorphology are likely to be also representative of the biota.

1.1. Coastal geomorphology

The continental shelf along this section of the coast is relatively narrow, the shelf edge being as close as 35 km from shore. It is a high energy coast with heavy swells generated by the Roaring Forties wind belt in the Southern Ocean. Along the open ocean shores, south-facing headlands and beaches are exposed to strong wave action for much of the time. Sheltered conditions prevail in inlets and estuaries but most of the bays are wide and open to the prevailing winds and swells.

Exposed open ocean shores

The types of open ocean shore evident on the South Coast relate to the geology and geological history along the southern margins of the Yilgarn Craton and the sedimentary basins to the south, east and west of it. For our purpose they can be considered in four categories.

(i) Perth Basin - Cape Leeuwin to Point D'Entrecasteaux

At the western end of the South Coast sector, between Cape Leeuwin and Black Head just west of Point D'Entrecasteaux, the coast is formed by the southern boundary of the Scott Coastal Plain, the southernmost portion of the Perth Basin (Cockbain, 1990). It is separated from the Leeuwin Block in the west by the Dunsborough and Busselton-Alexander Bridge Faults and from the Yilgarn Craton and Albany-Frazer Oregon in the east by the Darling Fault. The Darling Fault crosses the coast at Black Head.

The hinterland is relatively low-lying with Quaternary sands overlying Cretaceous sediments. The shore itself consists of a wide, curving beach, more than 80 km long, and trending NW-SE. It is backed by a Holocene dune field. The beach is almost continuous, interrupted only at Black Point where there is an outcropping of the Bunbury Basalt. The basalt here forms unusual rocky shores, including columnar cliffs and boulder fields (see Cockbain, 1990, p. 516, fig. 4-158).

(ii) *Shores of the Albany-Frazer Oregon - Point D'Entrecasteaux to Israelite Bay*

The southern margin of the Yilgarn Craton is fringed by the Albany-Frazer Oregon, a zone of intense Proterozoic tectonic activity, and is characterised by granites and high-grade gneisses with some doleritic intrusions and very uneven landforms (Myers, 1990). High points of the Proterozoic land surface form hills inland, high headlands at the coast, and islands offshore. Inland, depressions in the ancient land surface are filled by flat-lying Eocene sediments of the Bremer Basin but at the coast there are fringes of Pleistocene aeolianites and Holocene dunes between the granitic or gneissic headlands.

The result of these geological structures is a ruggedly scenic coastline characterised by a repeated pattern of long, arcuate sandy beach backed by dunes (some of which are mobile) located between high, cliffed granitic, doleritic or metasedimentary headlands. The coast shares some features with that of the Leeuwin-Naturaliste Ridge. The headlands, many of which are over 300 m high, are often multiple with small lunate bays and beaches between the projecting units. The most exposed parts of the headlands, facing south and south-west, are either cliffed or fronted by steep slopes which are swept by swell surge. The south-eastern sides of the headlands, adjacent to the next wide bay and beach, are exposed to lesser wave action and tend to have granitic or gneissic boulder fields along the shore.

In the eastern part of this sector, between Esperance and Israelite Bay, much of the Proterozoic land surface of the Oregon lies below present sea level so that its high points form the Recherche Archipelago of granitic and gneissic islands. Similar but smaller and fewer islands also occur along the whole of this shore.

As well as active dune fields backing the long arcuate beaches, there are frequently perched dunes on the Proterozoic headlands. In many places older perched dunes have consolidated and formed aeolianite limestones as a fringe or rim above the Proterozoic rocks. In a few cases the aeolianites have considerable thickness and extend down to sea level where they are eroded to form limestone rock platforms between high and low tide levels.

Limestone also forms as beach rock below the surface along many of the long beaches. Frequently, the beach rock surfaces are exposed by erosion and form intertidal rock platforms, especially at the eastern ends of the beaches. Limestone shores, presumably of this origin, are a notable feature of the coast between Hopetoun and Esperance. In that area there are series of narrow limestone reefs paralleling the shore, apparently representing different positions of the shore at periods of different sea level during the Pleistocene and Holocene. A dramatic example occurs on the western side of Shoal Cape where there are three limestone ridges, one forming the shore and two forming offshore reefs, with deep gutters between them.

Thus, the open ocean rocky shores of this section of the South Coast provide a variety of habitats for marine plants and animals, including the wave-swept granitic and gneissic slopes of the headlands, the boulder fields and pools of the less exposed sides of the headlands, and the limestone rock platforms and reefs. Commonly, the headland shores are "steep to", dropping off steeply into relatively deep water, meeting the sandy sea floor at depths of 20-30 m. Vertical sublittoral rock walls are common. Offshore granitic and gneissic reefs are very common and these too usually have steep or even vertical walls. Along jointing cracks and dolerite intrusions, erosion often forms precipitous underwater canyons.

The beaches of the open ocean in this section are exposed to heavy surf and are generally of coarse-grained sand. They provide suitable habitat for only a few specialised plants and animals. Intertidal sand flats occur only in protected corners and are never very extensive. The wide bays tend to slope gently from the surf zone into the sublittoral and there is usually extensive development of seagrass beds beyond the action of the surf.

(iii) *Bremer Basin*

The larger part of this sedimentary basin lies offshore on the continental shelf but onshore elements of it infill depressions on the Proterozoic land surface between Point D'Entrecasteaux and Israelite Bay (Hocking, 1990). The infill sediments are marine deposits of Eocene age. They meet the coast at several places east of Albany (Hassell -Beach, Cheyne Bay and Doubtful Island Bay) but are usually covered

there by Quaternary dunes and the shores are long sandy beaches. The only outcrop of the Eocene rocks on the shore is at Cheyne Bay where a section of the Pallinup Siltstone forms low cliffs. These rocks are easily eroded and the shore there features a boulder field below the cliffs.

(iv) Eucla Basin - Israelite Bay to Eucla

This is a large sedimentary basin extending into South Australia and forming the shores of the Great Australian Bight. The onshore surface deposits consist of Tertiary limestones overlain along much of the coast with a veneer of Quaternary limestones, calcareous soils and dunes (Hocking, 1990). The edge of the Tertiary limestones forms a conspicuous escarpment and the Quaternary deposits have built up below this to form the Roe Plain. These features give rise to two distinctive coastal types.

The escarpment forms the shore of the Bight east of Eucla in South Australia and for a short section between Twilight Cove and west of Point Dover on the Western Australian side of the border. There the Tertiary limestones form precipitous cliffs, with either a narrow rock platform or boulder field at sea level. Where there are irregularities in the shore-line, there may be narrow fringes of beach. Elsewhere the Quaternary deposits form a shore comprising long sandy beaches backed by high dunes. In both shore types the sea bed shelves gradually seaward with little relief.

On the basis of these geomorphological features, primary and secondary divisions of the South Coast open ocean shores into major distinctive coastal types is possible (see Index to Maps V). These are:

1. southern coast of the Perth Basin (Cape Leeuwin to Black Head) - wide, arcuate beach with a shelving shore and heavy surf,
2. shores of the Albany-Frazer Oregon (Point D'Entrecasteaux to Cape Arid) - wide bays with arcuate beaches and high granitic or gneissic headlands. Within each segment there is a repeated sequence of coastal type:
 - (a) long, wide bay and beach, with shallow shelving shore, often with perched dunes or limestone cliffs and exposed limestone rock platforms at sea level (usually at the eastern end of the bay);
 - (b) high granitic or gneissic headland exposed to the open ocean swells with wave-swept slopes, steep-to shores, cliffs and sometimes small lunate bays between the projecting elements of the headland;
 - (c) eastward-facing, semi-exposed shore with granite or gneissic boulders and tide pools;
3. Great Australian Bight - shores of the sedimentary Eucla Basin which are either:
 - (a) long, curved beach with dunes; or
 - (b) high limestone cliffs.

A distinctive coastal type of limited extent occurs at Black Point where there is an outcrop of Bunbury Basalt, and another occurs in Cheyne Bay where there is an outcrop of Pallinup Sandstone, both rock types forming shores of different character to rocky shores elsewhere on the South Coast.

Inlets and estuaries

Many of the bays on the South Coast are wide and provide little protection from the prevailing winds and swell. The major exception is the King George Sound-Princess Royal Harbour-Oyster Harbour complex (Wells, 1990). These three basins are depressions of the Proterozoic land surface now flooded by the sea. Princess Royal Harbour is an almost landlocked, shallow marine inlet which is not fed by any major rivers or streams. Oyster Harbour, on the other hand, has two major rivers entering it which contribute large volumes of freshwater, at least during the winter months, and it may be regarded as an estuary.

Along the western part of the South Coast there are many small rivers entering the sea and forming estuaries at their mouths. A general description of Western Australia's southern estuaries may be found in section 3.7.6. of Part I of this report. Detailed descriptions of the South Coast estuaries have been published by Dr E. P. Hodgkin and associates in a series of Environmental Protection Authority Bulletins (see reference list).

The estuaries west of Albany have catchments in forested and agricultural lands with relatively high rainfall (greater than 1000 mm/ann.). East of Albany there is a sharp decline in rainfall. The rivers there are short and small and have catchments in semi-arid agricultural lands. East of Cape Arid there is no surface runoff and no estuaries. Because of the climatic regime South Coast estuaries are all seasonal, saline and freshwater conditions alternating. Some of the smaller estuaries on the South Coast, especially those in the drier eastern areas, may actually dry up in summer. Because of this extreme variation in salinity they form harsh aquatic environments.

Physiographically, the South Coast estuaries are of two types, riverine and lagoonal (Hesp, 1984). They may be further classified as "permanently open", "seasonally open" and "semi-permanently closed" (see Part I, section 3.7.6).

Oyster Harbour is unusual in that it is a large lagoon with a permanently open mouth. Only the upper part of this lagoon is, greatly influenced by freshwater flow from the rivers entering it, the lower part being almost permanently marine (McKenzie, 1962, 1964). The other large South Coast lagoonal estuaries which have permanently open mouths are the Hardy and Nornalup-Walpole Inlets. Both of these have an entrance bar which retards tidal flow of sea water.

Broke Inlet is a seasonally open lagoonal estuary. Its entrance bar is breached every year when the rivers flood and closes again when river flow ceases. Wilson Inlet is naturally a seasonally open estuary of the same type but it is artificially opened every year as a measure for flood control in the catchment.

The most easterly lagoonal estuary is Culham Inlet near Hopetoun. In this century it has opened only once or twice and it could be regarded as a salt lake. Recently, increased clearing in the catchment and unusually heavy rainfall have resulted in flooding and the entrance bar has been breached. A permanent spillway has now been constructed at the entrance bar and it is anticipated that it will once again convert this system to a "saline lake".

The small riverine estuaries east of Albany are all of the semi-permanently closed type. They have small catchments and their bars are breached only after exceptionally heavy rainfall.

1.2. Marine flora and fauna

Although there has been some collecting of marine plants and animals by individual scientists at many localities on the South Coast, only two areas have been studied or surveyed in any detail.

King George Sound is an important site in the history of science. Because of its magnificent harbour and access to fresh water, it was visited by many of the early voyages of exploration. The French ships of the *Baudin* (1801-03) and *Astrolabe* (1826) expeditions spent some time there and their naturalists made extensive collections of the marine life. Consequently King George Sound is the type locality for many southern Australian marine species, especially molluscs, described by 19th century French scientists. The British survey ship *Investigator* commanded by Matthew Flinders spent four weeks in the sound (December 1801 - January 1802) and botanist Robert Brown collected many terrestrial plants in the area. Charles Darwin visited the sound briefly aboard the *Beagle* (1836), but apparently made no scientific observations. The German "Hamburg Expedition" (1905) collected marine invertebrates at a number of sites in King George Sound and the nearby inlets. Most recently an international marine biological workshop was held in the area, resulting in the publication of a number of important papers on the taxonomy, ecology and physiology of local marine plants and animals (Wells *et al*, 1990; 1991). The Western Australian Environmental Protection Authority is presently engaged in a long term study of Princess Royal Harbour in the context of concern about the increasing pollution of its waters.

Cape Leeuwin is sometimes regarded as the position of a boundary zone between the temperate Southern Australian Biogeographic Region and the subtropical West Coast Overlap Zone (Wilson & Gillett, 1971; Wilson & Stevenson, 1977; Wells, 1980; Wilson & Allen, 1987). It can be argued that Cape Naturaliste is a more meaningful position for a biogeographical boundary than Cape Leeuwin, if the nature of the rocky shore habitats along the Leeuwin-Naturaliste coast are taken into account. Irrespective of precisely where the boundary is located, many species of marine flora and fauna are distributed across the southern coast of Australia from Bass Strait to the vicinity of the Leeuwin-Naturaliste coast and no further. A few northern species of tropical origin have distributional ranges which extend around Cape Leeuwin and along the South Coast. The influence of the Leeuwin Current is paramount in this, as described in section 1.2 of Part IV.

And finally there is a significant south-west endemic species element in the marine biota, many of them relics of the Tertiary Tethyan Province. Most of the endemic species have distributions which straddle the transition between the Southern Australian Region and the West Coast Overlap Zone, and live on both sides of Cape Leeuwin. One endemic gastropod of Tethyan origin is *Diastoma melanioides*, the sole living survivor of the family Diastomatidae, which lives in the seagrass beds on the South Coast of Western Australia east of Albany.

Corals are generally regarded as tropical animals although there are four species endemic to the southern coast of Australia (Veron & Marsh, 1988). In addition, five tropical species extend down the West Coast and onto the western part of the South Coast. Of these, three species of the genus *Turbinaria* cover extensive areas in King George Sound and the Recherche Archipelago.

Rocky shore faunas

Perhaps the most conspicuous marine habitats of the South Coast are the rocky shores. Intertidal communities at several South Coast localities were described by Hodgkin (1960) but otherwise there has been little study of these rocky shore communities. Granitic and gneissic slopes exposed to heavy wave action are usually rather smooth and populated with moderate to large numbers of gastropod molluscs, barnacles and macrophytes showing distinct vertical zonation. A greater diversity of species, both plant and animal, occurs in the more sheltered corners of the headlands where there are boulder fields in the intertidal and sublittoral zones.

A feature of the South Coast is the spectacular rock wall fauna of the deeper sublittoral zone. The sublittoral slopes of the exposed headlands and islands usually drop off steeply to considerable depths (as much as 40 m) before reaching the sandy sea floor. Vertical rock walls and narrow canyons are common. To depths of 20 m or so these rock surfaces are usually dominated by macrophytes, but below this sponges, ascidians and coelenterates grow in high density anywhere there is a hard substrate. They provide a very colourful display. To date there has been no study of this rock wall fauna.

Seagrass beds

Seagrass beds are extensively developed along the South Coast although there is very little known of their diversity. The genus *Posidonia* dominates both as a meadow-forming seagrass and as fringing and clumped patches. *P. australis* and *P. sinuosa* are the main meadow-forming species but *P. robertsonae* also forms well-defined meadows. Edges and blowouts usually harbour *Amphibolis* species. The smaller plants *Halophila australis* and *Heterozostera tasmanica* also often grow in disturbed areas and blowouts.

The South Coast may be the centre of distribution of the genus *Posidonia*. In addition to the dominant species noted above, *P. ostenfeldii*, *P. denhartogii* and *P. kirkmanii* are found in large quantities in some bays but their respective habitat preferences are not known. All the *Posidonia* species flower and produce fruit in summer. It is believed that some seagrass species grow to depths of at least 45 m along the South Coast. The plants are well adapted to large swells as they have deep, well developed rhizomes. The "ostenfeldii" group (*P. ostenfeldii*, *P. denhartogii*, *P. robertsonae* and *P. kirkmanii*) have rhizomes which grow vertically downwards and hence the above-ground plants appear as clumps. The "ivaustralis" group tend to spread horizontally at a rate less than 2 cm/year. *Thalassodendron pachyrhizium* has been found as drift but not growing. It is expected that it lives attached to rocky substrates.

Associated with the seagrasses there is a rich and diverse fauna. Seagrass communities in King George Sound and Princess Royal Harbour have been described in detail (Kirkman *et al.*, 1991; Walker *et al.*, 1991; Hutchings *et al.*, 1991; Wells *et al.*, 1991).

Algae and algal beds

Along the South Coast the dominant alga is the small kelp *Ecklonia radiata* which often forms dense beds in the shallow sublittoral zone. Other common brown algae include *Cystoceira*, *Scytothallia*, *Cystophora* and *Hormosira banksii*. Conspicuous green algae are various species of *Caulerpa*. The reds are represented by many cool temperate species. Generally speaking, the limestone reefs afford more protection and a better surface for attachment of algae than the granitic or gneissic rocks.

Estuarine flora and fauna

South Coast estuaries are depauperate in terms of diversity of plants and animals due to their strongly seasonal nature and the extreme hydrological conditions that result, although biological production and population density of tolerant species may be very high when conditions are favourable. Most of the estuaries are becoming progressively degraded as biological environments as a result of nutrient enrichment and sedimentation and increased frequency of flooding following extensive clearing in their catchments. An exception is Broke Inlet whose catchment lies entirely within forested land.

There is only a handful of obligate estuarine species (ie. aquatic species found in estuaries but not in marine or freshwater habitats) in the South Coast biota. Most of the animals present in the seasonally open estuaries are opportunistic marine invaders which enter with tidal inflows in early summer when the flow of freshwater decreases. Some of these species are subject to mass mortalities when the next winter floods scour the estuaries with freshwater. Even in the permanently open Hardy and Nornalup-Walpole Inlets the entrance bars restrict summer tidal flow, winter scouring is severe, and species diversity is consequently limited. In the case of the semi-permanently closed estuaries, marine species invade on those occasions when the bars open and a progressive decline in species diversity follows after the bars reclose.

Obligate estuarine molluscs on the South Coast include the gastropods *Hydrococcus brazieri*, *Salinator fragilis*, *Tatea preissii* and *Hydrobia buccinoides* and the bivalves *Fluviolanatus subtorta*, *Xenostrobus inconstans* and *X. securis*. Among the marine mollusc species which normally inhabit protected bays and inlets and invade the estuaries when conditions are suitable are the bivalves *Arthritica semen*, *Katelsysia scalarina*, *K peroni*, *Spisula trigonella*, *Mytilus edulis planulatus*, *Wallucina assimilis*, *Macomona deltoidalis*, *Soletellina donacioides*, *Sanguinolaria biradiata*, *Iris crenata* and *Theora lubrica*, and the gastropods *Nassarius burchardi*, *N. pauperatus*, *Liloa brevis* and *Philine* species. Some of this second group of molluscs may maintain populations within the estuaries for several years even if the bars remain closed. Fossil beds containing shells of these and other marine species are commonly found around the shores of the estuaries, providing evidence that seasonal conditions during earlier times in the Holocene and Pleistocene were rather less extreme than at present.

The tube worm *Ficopomatus enigmaticus* is found in most of the estuaries wherever there are hard substrates. Other common polychaetes are *Capitella capitata*, *Scoloplos simpler*, *Ceratonereis aequisetes*, *Neanthes vaali*, *Prionospio cf. ciffifera* and *Polydora* sp. Two species of benthic amphipod, *Melita* sp. and *Paracorophium* sp., are commonly present. The estuarine crab *Halicarcinus ovatus* is also usually common, especially in beds of the mussel *Xenostrobus*. The shrimp *Palaemonetes australis* seems to be everywhere. Two marine crustaceans, the blue manna crab, *Portunus pelagicus* and the barnacle *Balanus amphitrite*, invade the larger estuaries when the bars open but neither is capable of surviving prolonged winter flooding. The crab moves out of the estuaries to avoid such flooding while the fixed barnacle suffers mass mortality. Empty barnacle shells are frequently seen on rocks and timber, evidence of the transient success of this animal.

With the exception of some atherinid and gobiid species, few fishes breed in the South Coast estuaries. The most notable of those which do are the black bream and the cobbler which are target species of both the commercial and recreational fisheries. Blue-spotted flathead and southern sea garfish breed in Wilson Inlet (and possibly Nornalup-Walpole Inlet). However, there are many species which enter the estuaries from the sea as juveniles and use them as nursery areas (Lenanton, 1974a; 1974b; 1984; Lenanton & Hodgkin, 1985). Large numbers of

juveniles of fishes, such as mullet and whiting, which enter the estuaries when they are open to the sea and establish flourishing populations become isolated from the sea after the bars close again. Such populations may flourish in the semi-permanently closed estuaries for several years following breaching of the entrance bars.

Plankton blooms occur in early summer in the South Coast estuaries, developing in wedges of saline water that penetrate upstream as the summer progresses. The majority of zooplankton species are the larvae of marine species and are the source of recruitment to the estuarine fauna. However, there are a few truly estuarine planktonic animals. The most ubiquitous of these is the copepod *Cladioferens imparipes*. Also recorded are the copepods *Sulcanus conflictus*, *Acartia tranteri*, *A. clausi* and *Oithona nana*. Nearer the entrances these are usually replaced by more marine copepods such as *Cladioferens inermis*. Small medusae of the genus *Australomedusa* are also common.

Ruppia megacarpa is the only submerged aquatic plant that commonly occurs in South Coast estuaries. It is a dominant plant in the basins of the lagoonal estuaries and lower reaches of most of the riverine estuaries. It grows on sand in the shallows and is an important food resource for Black Swans. Other seagrasses occur mainly in the lower parts of those estuaries which are permanently open. For example, in Oyster Harbour the three marine seagrasses *Posidonia sinuosa*, *P. australis* and *Amphibolis antarctica* are common in the marine parts of inlet, *Halophila australis* occurs sparsely there, and *Heterozostera tasmanica* is found near the entrance. Only *Zostera mucronata* lives in the upper part of the inlet (near the mouth of the Kalgan River). In Hardy Inlet, *Z. mucronata* occurs in the lower reaches. *Halophila australis* is reported from Hardy Inlet. A newly described species, *Halophila glabra*, lives along channel banks of that estuary during summer and autumn. *Heterozostera* is recorded from Nornalup/Walpole Inlet but is not common there.

Seagrasses are vulnerable to reduced light intensity. This detrimental condition may be caused by turbidity or eutrophication which produces increased density of phytoplankton and epiphytes. Seagrass communities of many of the South Coast estuaries show evidence of decline caused by these forms of pollution (Hodgkin & Clark, 1990).

There is a variety of macroalgae and filamentous algae in the South Coast estuaries. Brown algae are not common except for *Hormosira banksii* and *Cystophyllum muricatum* in the marine parts of Oyster Harbour, and *Cystoseira trinoides* which has been found on rocks at the entrance of Nornalup Inlet. Green algae dominate most of the vegetation, including species of *Polyphysa*, *Cladophora*, *Chaetomorpha*, *Enteromorpha* and *Vaucheria*. The stonewort *Lamprothamnium papulosum* is common in most estuaries. Some of these algae are subject to spring blooms and eutrophication and may smother the seagrasses.

Marine mammals

Humpback whales (*Megaptera novaeangliae*) and sperm whales (*Physeter catodon*) occur off the South Coast but are not commonly seen in near-shore waters. However, the southern right whale (*Eubalaena australis*), once hunted to near extinction, is presently staging a recovery and is being seen more and more frequently in coastal waters along the South Coast. The humpback and southern right whales are both threatened species under the Western Australian Wildlife Conservation Act.

A monitoring program of the southern right whale begun in 1978 has shown a steady increase in the South Coast population of this animal (Bannister, pers. comm.) now estimated to number at least 81 animals. Females use the sheltered bays as birthing and nursery areas. Cows with calves may often be seen very close to shore in August and October. Several localities have recently become popular "whale watch" sites. Perhaps the best of these is Point Ann in the Fitzgerald River National Park. An observation platform has been erected at that spot and it is frequently used by tourists, including the commercial tourism industry.

Two species of pinniped use South Coast islands as resting and breeding sites. These are the Australian Sea Lion (*Neophoca cinerea*) and the New Zealand Fur-seal (*Arctocephalus forsteri*). Both are classified as specially protected species under the Western Australian Wildlife Conservation Act. The sea lions feed in the shallows and are frequently seen along the shores of the South Coast, but the fur seals feed in the open ocean and are not commonly seen except at the breeding colonies during the breeding season. A baseline survey has recently been undertaken to determine the population size and locate the breeding colonies of these animals.

1.3. Tourist potential

The South Coast has a number of popular tourist destinations although most visits relate to the scenic attractions of the coast and to date marine-based tourism is not well developed. Beach fishing is very popular and there is a small diving fraternity. Some charter boats operate dive tours, for example in the Recherche Archipelago and King George Sound. The quality of the fishing, diving and seascapes is such that there is scope for development of a marine-based tourism industry.

1.4. Fisheries

The South Coast between Cape Leeuwin and the WA/SA border supports the State's major commercial finfisheries and some important recreational fisheries.

The Demersal Gillnet and Demersal Longline fishery, primarily for gummy (*Mustelus antarcticus*), whiskery (*Furgaleus macki*) and dusky or bronze whaler (*Carcharhinus obscurus*) sharks and demersal scalefish, is the largest offshore fishery of the South Coast. This fishery, which extends offshore to the 200 m isobath, is managed in two zones, Zone 1 extending around Cape Leeuwin and eastwards to Clifly Head, and Zone 2 from Clifly Head to the WA/SA border. In Zone 2, 25 full-time and 29 supplementary access license holders landed 1080 tonnes of shark and 160 tonnes of scalefish during 1991-92. Over the past few years some of these operators have moved further offshore to target deepwater spurdog sharks (*Squalus* spp.) and scalefish such as the blue-eyed trevalla (*Hyperoglyphe antarctica*).

Scalefish are targeted by a group of line fishers (including drop and longliners) operating principally from Albany and Esperance. Key species include deepwater fishes such as leatherjackets (*Monacanthidae* spp.), hapuka (*Polyprion oxygeneios*) and grey-banded rock cod (*Epinephelus septemfasciatus*), together with species that can be taken closer inshore such as bight redfish (*Centroberyxgerradi*) queen snapper (*Nemadactylus valenciensi*) and blue groper (*Achoerodus gouldii*).

South Coast trawl fisheries are managed by State and Commonwealth agencies. The Commonwealth manages trawling seaward of the 200 m isobath and in the Great Australian Bight east of 125°. The South Coast Demersal Trawl Fishery extending offshore to the 200 m isobath between Cape Leeuwin and 125°E is managed under State jurisdiction. The target species are demersal finfish such as queen snapper, bight redfish, boarfish (*Pentacerothidae* spp.) and deepwater flathead (*Platycephalus conatus*). Presently 4 vessels have access to this fishery. The area of the Recherche Archipelago between 121° 30' E and 123° 30' E, and offshore to 34° 20' S, is excluded from general trawl fishing. However the waters of the archipelago are seasonally open (April 1 to November 30) to endorsed vessels to fish only for scallops (*Pecten* sp.). At present there are two endorsed scallop vessels. They also have access to the Commonwealth Bight Trawl Fishery for scallops in shelf waters between 125°E and 129°E.

Purse-seining, primarily for pilchard (*Sardinops neopilchardus*), is the most important inshore finfish fishery. It is managed in four zones on the South Coast, the most important being the Albany Zone which includes the King George Sound fishery where 22 vessels took a total of 4 255 tonnes in 1992.

Other nearshore resources that historically support commercial fisheries, and now also support increasingly important recreational fisheries, are stocks of Australian salmon (*Arripis ruttaccus*) and Australian herring (*A. georgianus*). At present 21 commercial teams have access to these fisheries on nominated South Coast beaches. The most westerly beach is at Windy Harbour and the most easterly at Trigalow on the western end of Doubtful Island Bay. Beach seines are used to catch salmon while fixed "G" (trap) nets and sometimes beach seines are used for herring. In 1993 totals of 2 006 tonnes of salmon and 532 tonnes of herring were taken by these limited entry fisheries.

Abalone is one of the most valuable nearshore resources harvested off the South Coast. Commercial abalone operations are managed in two zones, on either side of Shoal Cape (120°E). There is a closed area restriction in Flinders Bay. Six divers have access to the eastern zone and eight to the western zone. They take three species of abalone, Roe's (*Haliotis roei*), greenlip (*H. laevigata*) and brownlip (*H. conicopora*).

Rock lobster fishing is also an important coastal activity which is managed as two separate fisheries, each extending to the limit of the territorial sea as the offshore boundary. The Augusta-Windy Harbour fishery is located west of 116°E, and the Esperance fishery located between 120°E and 125°E. In 1991/92, 13 vessels caught 36 tonnes of western rock lobster (*Panulirus cygnus*) in the Augusta-Windy Harbour zone and 9 vessels caught 45.7 tonnes of southern rock lobster (*Jasus edwardsii*) in the Esperance zone. The viability of the Augusta-Windy Harbour fishery is enhanced by capture of deep water crabs and a variety of scalefish.

Several of the South Coast estuaries (but not including Hardy Inlet) also support important commercial fisheries managed as a single, limited entry fishery. During 1992, 61 fishing units had access to this fishery. Commercial fishers can operate in all of the South Coast estuaries although netting is specifically prohibited in Wellstead, Torbay, Nornalup-Walpole and Nannarup inlets. Finfish targeted by the estuarine fishery west of Albany include King George whiting (*Sillaginodes punctata*), Australian herring, garfish (*Hyporhamphus melanochir*), trevally (*Pseudocaranx dentex*), cobbler (*Cnidoglanis macrocephalus*), flathead (*Platycephalus speculator*), leatherjacket (*Monocanthid* spp.), yelloweye mullet (*Aldrichetta forsteri*), sea mullet (*Mugilcephalus*) and black bream (*Acanthopagrus butcheri*). East of Albany catches are dominated by black bream and to a lesser extent the two mullet species. Small catches of blue manna crabs (*Portunus pelagicus*) and squid are taken in some estuaries. The bivalve mollusc *Anadara trapezia* is taken exclusively from Oyster Harbour.

Hardy Inlet is managed as a separate, small, limited entry estuarine fishery. During 1992 three units had access to this fishery. The key species are King George whiting, western yellowfin whiting (*Sillago schomburgkii*), black bream, yelloweye mullet, sea mullet and tarwhine (*Rhabdosargus sarba*).

There is an important offshore tuna fishery (mainly for southern bluefin tuna *Thunnus maccoyii*) operating from the major South Coast ports. It is managed by the Commonwealth.

A 1987 Australian Bureau of Statistics survey of recreational fishing estimated that 13.5% of about 284 000 recreational anglers operated in the South Coast region in 1986-87. About 73% of these were shore-based. The most sought after species would have been Australian herring. Other key species would have included whiting and Australian salmon. Offshore species taken by boaters would include queen snapper, bight redfish, samsonfish (*Seriola hippos*), breaksea cod (*Epinephelus armatus*), blue groper and sharks.

Netting is another important recreational activity in this region. It is mostly undertaken in estuaries for such species as sea mullet, yelloweye mullet, Australian herring, and black bream. Recreational netting in WA is currently under review. Some rock lobster potting, squid jigging and diving for abalone also occur in the region.

2. EXISTING MARINE RESERVES

There are no existing marine reserves on the South Coast.

3. RECOMMENDATIONS FOR MARINE RESERVES ON THE SOUTH COAST

Four primary geomorphological areas distinguishable in the South Coast region are described in section 1.1. One of these, the Bremer sedimentary basin, has only minor outcrops on the shore. The other three exhibit very different types of shore topography and provide a useful first division of the South Coast into major distinctive coastal types. Two of them may be further subdivided on geomorphological criteria. Estuaries are an important feature of the South Coast and these too may be classified into a range of types according to their geomorphology and hydrological conditions. The following recommendations of the Working Group attempt to take all these factors into account.

Previous, unimplemented recommendations of the EPA report on Conservation Reserves for Western Australia, Systems 12 (1975), 2 and 3 (1976) and the CALM *South Coast Regional Management Plan* (1991) are incorporated within the following recommendations of the Working Group.

3.1. Hardy Inlet (Map V-1)

In Part IV section 3.12, it is recommended that consideration be given to inclusion of an area east of Cape Leeuwin encompassing Flinders Bay and nearby offshore rocks within a Leeuwin-Naturaliste marine reserve. Such a reserve would include the waters seaward of the mouth of the Hardy Inlet. Consideration of the inlet was deferred to this Part because it is necessary to assess its recreation and conservation values in the context of the suite of South Coast estuaries. Nevertheless, should both the marine areas east of Cape Leeuwin and the estuarine areas of Hardy Inlet be reserved they should be managed as a single unit.

Hardy Inlet is the downstream basin of the Blackwood River estuary. This recommendation actually refers to the entire Blackwood estuary and not merely to its inlet. Only a brief account of the estuary and its flora and fauna is given here. Details may be found in a comprehensive report, with references to earlier publications, by Hodgkin (1978).

Tenure

The townsite of Augusta occupies the land on the western side of the inlet near its mouth. The Scott National Park and freehold land occupy the eastern shore. Upstream from the town there is freehold land on both sides of the estuary but beyond Alexandra Bridge most of the shores are State Forest.

Geomorphology and hydrology

The estuary of the Blackwood may be classified as a seasonal, permanently open estuary. Like the other large estuaries on the South Coast it is subject to weak tidal flow in summer and scouring with freshwater during winter floods. It has a catchment of about 23 000 km², much of it within an area of relatively high rainfall. The upper Blackwood River catchment lies in agricultural lands on the Yilgarn Craton. After crossing the Darling Fault the river flows westwards across the Perth Basin until it is impeded by the Leeuwin-Naturaliste Block. It then turns south and runs more or less along the fault zone that forms the junction of the Leeuwin-Naturaliste Block and the Perth Basin, entering the Southern Ocean east of Cape Leeuwin.

The Blackwood is one of the two large estuaries on the South Coast which are permanently open to the sea. It consists of two parts, a pair of downstream basins and a long upstream riverine section. The wide lower basin is the part known as Hardy Inlet which opens to the sea via a rather long and narrow entrance channel. Two lagoons, the Deadwater and Swan Lake, open into the eastern side of the entrance channel near the mouth. There are two shallow bays further upstream known as West Bay and North Bay. The smaller upper basin, into which the Blackwood and Scott Rivers discharge, is called Molloy Basin. It is almost filled by Molloy Island.

The original position of the mouth of the estuary was at its present location but the bar silted up during the period from 1925 to 1930 and the mouth moved to a new position about 2 km to the east. The Deadwater was formed during that period as the entrance channel. The bar was cut in 1945,

returning the mouth to its old position, the Deadwater remaining as a narrow lagoon. Swan Lake was originally a freshwater lagoon but became salty when it was connected to the Deadwater. Both areas are now saline lagoons relatively little affected by winter flooding and they contribute significantly to the productivity of the estuary.

The riverine parts of the estuary are unusually long. Tidal water flows upstream in the Scott River for a distance of about 8 km. The Blackwood is tidal to a point upstream from Warner Glen Bridge, a distance of more than 30 km beyond Molloy Basin.

Tidal exchange is dampened by the entrance bar. Astronomic tides in the inlet have a maximum range of only 70 cm. However, other factors (notably barometric pressure) also influence water level and the extreme range of water level may be as great as 1.3 m (Hodgkin, 1978). Mean sea level in winter may be as much as 30 cm higher than the mean summer level. There is also a build-up of flood water during winter which raises the level of water in the basins as well as in the riverine parts of the estuary.

Much of the area of the basins consists of shallow banks or "marginal platforms" at less than 1 m depth. Large areas of these are exposed at low tide and there are rush islands in the highest parts of them. Thus, although the inlet is wide, it actually holds little water compared with the other basin estuaries on the South Coast. There are clearly defined channels 2-8 m deep. The main channel extends into Molloy Basin, around the west side of Molloy Island and up the riverine part of the estuary as far as Warner Glen Bridge. That portion of it within the inlet was dredged in 1956 and again in 1973.

Flora and fauna

The most prominent aquatic plant in the estuary is the seagrass *Ruppia maritima*. This species is tolerant to a remarkably wide range of salinity and survives in the estuary throughout the year. It is now particularly abundant in the Deadwater. Another seagrass, *Zostera mucronata*, is confined to the lower part of the inlet where low salinity is experienced only briefly in winter. *Halophila glabra*, which may be Australia's first known annual seagrass, is found along the channel banks from near the mouth to Molloy Island.

The bottom fauna of the inlet is rather diverse compared with that of other South Coast estuaries. All the obligate estuarine species are present (see section 1.2). A number of marine invaders also appear to be permanent residents in at least the marine end of the inlet (Hodgkin, 1978). As might be expected with a permanently open estuary, the list of non-resident invaders is relatively long. These include many kinds of fishes that enter the estuary as larvae and establish large populations, eg whiting, herring, mullet, tailor, mulloway, tarwhine and many others much sought by both amateur and professional fishers.

The mud banks of the inlet are widely used by waterbirds, including migratory birds, as feeding areas in the summer months. The numbers present, however, are not as great as at some other estuaries. The Deadwater and Swan Lake are especially important areas for Black Swan and a variety of ducks which consume large quantities of *Ruppia*.

Recreation and tourism

Augusta has become an important holiday centre. It is popular because of its scenic and historic attractions and its proximity to first-rate fishing areas, caves, wine-growing areas and surf beaches. Hardy Inlet is an important component of the local attractions. As expansion of the town and tourism activities continues, the natural environment, especially the estuary, will come under increasing pressure.

Previous recommendations

In its report on conservation reserves on the South Coast (System 2, 1976) the EPA did not consider Hardy Inlet, although in the context of community debate at about the same time on a proposal to mine mineral sands on the eastern side of the inlet it directed that there be a study of the ecology of the estuary. This was to include an assessment of the multiple uses of the estuary for a range of recreational, conservation and commercial purposes. This was done and resulted in the report by Hodgkin (1978) which has been the main source document for the Working Group in its considerations.

Working Group recommendations

The Working Group notes the high recreational values of Hardy Inlet and the upper parts of the Blackwood Estuary and the fact that increasing activity in the area places increasing stresses on its biological resources. The estuary is one of the two large estuaries on the South Coast which are permanently open to the sea and it supports a relatively large diversity of aquatic species of plants and animals. Although the basin is wide, the volume is relatively small and there will be an increasing need to manage human activities, especially fishing, so that the aesthetic and biological values of the estuary are maintained.

Accordingly the Working Group recommends that:

“The estuary of the Blackwood River, including the Deadwater, Swan Lake, Hardy Inlet, Molloy Basin and the tidal parts of the Scott and Blackwood Rivers be considered for reservation as a marine reserve for dual recreation and conservation purposes.

“The estuarine reserve should be continuous with the eastern portion of the proposed Leeuwin-Naturaliste marine

3.2. D'Entrecasteaux (Map V-1)

With the exception of a few small enclaves, the coastal lands between Black Point and the mouth of Broke Inlet comprise the D'Entrecasteaux National Park. The coastal marine and estuarine environments are diverse along this sector but, for management reasons, the Working Group decided to treat it as a unit.

Tenure

Along most of the open ocean shore of this sector the D'Entrecasteaux National Park extends to the low water mark.

The small inlets of the Donnelly, Warren, Meerup and Gardner Rivers and Doggerup Creek are wholly or partly encompassed by the D'Entrecasteaux National Park. At the mouth of the Gardner River on the eastern shore there is a reserve (No. A15776, 283.3 ha) vested in the Shire of Manjimup.

Broke Inlet lies almost entirely within the D'Entrecasteaux National Park. Almost the entire catchment of the Shannon River is reserved within the Shannon National Park. There is a small townsite and a Shire reserve (No. 19787, 40.5 ha) at Camfield on the eastern shore. There are some residences and holiday huts at Camfield but otherwise there are no residential areas near the shores of the inlet or in the catchment.

There is difficulty in determining the present status of at least two of the small inlets under the Land Act. Although the bars of the Warren, Meerup and Doggerup inlets may be breached in some winters, allowing seawater to flood the lower reaches of the rivers, they are not tidal in any sense and it is here assumed that they are presently reserved within the national park. However, the inlets of the Donnelly and the Gardner Rivers are tidal in the sense that, for the brief period when the bars are open, seawater enters and there may be tidal flow upstream, at least in a wedge of saline water along the bottom below the freshwater. The boundary of the national park is the "low water mark" but it is problematical whether the deeper portions of the estuaries should be considered to be "below low tide" simply because they are seasonally flooded with seawater. The distinction between tidal and not tidal is quite arbitrary in cases like this. A legal opinion is needed to determine whether these water bodies are already part of the national park.

Geomorphology and hydrology

From the point of view of coastal geomorphology this stretch of coast may be divided into distinct western and eastern portions. The western portion from Black Point to Black Head is a straight, wide,

90 km long beach forming the southern shore of the Perth Basin. Black Head is the position of the Darling Fault and the coast east of it is characterised by rocky headlands alternating with arcuate bays, typical of the coastal margin of the Proterozoic Albany-Frazer Oregon.

The sector has one large estuary, Broke Inlet which is of the seasonally open, basin type, and several small inlets in the mouths of the Donnelly, Warren, Meerup, Doggerup and Gardner Rivers, some of which may be flooded with tidal water for brief periods in early summer. Of the latter, only the Donnelly and Gardner may be considered to be "tidal" in any sense and possible candidates for reservation under the CALM Act.

For the purposes of this report it is convenient to distinguish the following coastal areas within the sector:

- (i) Black Point;
- (ii) surf beaches of the Perth Basin;
- (iii) alternating rocky headlands and arcuate beaches of the Albany-Frazer Oregon;
- (iv) Broke Inlet as a representative of a large, seasonally open, basin type of estuary;
- (v) Donnelly and Gardner Inlets as representatives of the seasonally open, riverine type of estuary.

Although Black Head has geological significance as the point where the Darling Fault crosses the coast, the Working Group concluded that coastal waters at neither this location nor off the rocky headlands of Point D'Entrecasteaux and Cliff Point have particular merit as candidates for reservation. No further reference will be made to those areas. However, each of the other areas in the above list has features of special interest and they are considered separately below.

3.2.1. Black Point

Tenure

The promontory known as Black Point is at the western end of the D'Entrecasteaux National Park which extends to the low water mark.

Geomorphology

The Promontory interrupts the otherwise continuous stretch of wide beach forming the southern shore of the Perth Basin. It is a high headland of the Bunbury Basalt, and is one of the most extensive outcrops of this rock type. At the shore the outcrop has eroded into high cliffs with narrow rock platforms, large tide pools and boulder fields at sea level. Columnar and pillar formations are both present. It is assumed that the rocks extend into the sublittoral zone.

Flora and fauna

No information is available on the marine flora or fauna at this locality. However, the type of rocky shore is unusual and undoubtedly provides a variety of habitats for marine life.

Recreation

The locality is remote and access difficult. Some use is made of the shore as a recreational fishing site.

Previous recommendations

None.

Working Group recommendations

Noting that the promontory is unique in its geology and landforms and that the shore above low water mark is within the D'Entrecasteaux National Park, the Working Group recommends that:

“a survey of the marine habitats adjacent to Black Point be conducted and an assessment made of their value for conservation purposes, with a view to consideration being given to reservation of the area as a marine reserve for the conservation of marine flora and fauna.”

The Working Group considered that there would be merit in extending the proposed reserve west or east to include a section of the wide beach characteristic of the southern shore of the Perth Basin. However, not all of the hinterland of those areas is presently included within the national park and it was concluded that a representative portion of that coastal type would be better selected further east (see section 3.2.2).

3.2.2. Warren Beach

This section refers to a 20 km stretch of shore between the mouth of the Donnelly River and Black Head. The D'Entrecasteaux National Park comprises the hinterland for almost its entire length.

Geomorphology

The sector represents the straight, wide beach coastal type characteristic of the southern shores of the Perth Basin. It is backed by Quaternary dunes. The shore faces directly into the prevailing south-westerly wind and swell and is exposed to continuous heavy surf. The beach face is steep, almost reflective, and consists of coarse quartz sand. The surf zone exhibits a two bar system, that is an outer parallel-bar dispersive system and an inner transverse bar-and-rip system, with attendant mega-cusp horns and bays on the beach face (McLachlan & Hesp, 1984). Beyond the surf zone the seabed is gently shelving.

Flora and fauna

McLachlan & Hesp (1984) recorded accumulations of diatoms (comprising only a single species *Anaulus birostratus*) in the surf zone at this beach. Similar surf zone diatom blooms in other areas are known to support rich beach communities, especially of filter feeding bivalves.

Little information is available on the marine biota of this area. With exposure to such strong wave action, species diversity is unlikely to be high. McLachlan & Hesp (1984) failed to find any "large macrofauna organisms" burrowing in the beach face, in spite of the presence of diatom blooms, and interpreted this as probably due to the unsuitable, coarse-grained substrate. Nevertheless, it may be assumed that plant and animals are present, representing the surf beach and sandy substrate nearshore communities of the Southern Australian Region.

Recreation

The coast of this sector is remote with few access points. Very limited use is made of the beach by recreational fishers.

Previous recommendations

None.

Working Group recommendations

Although species diversity is unlikely to be high in this habitat, it is representative of a coastal type and ecosystem not otherwise represented or proposed in the South Coast marine reserve system. The Working Group recommends that:

“State coastal waters adjacent to the D'Entrecasteaux National Park between the mouth of the Donnelly River and Black Head be considered for reservation for the conservation of marine flora and fauna and their habitats.”

3.2.3. Broke Inlet

Broke Inlet is the only South Coast estuary, in fact the only one in southern Western Australia, with little development around its shores and virtually none in its catchment so that it remains almost unaffected by human activity.

The estuary and its flora and fauna have been described in some detail by Hodgkin & Clark (1989b) and only a brief summary is given here.

Geomorphology and hydrology

Broke Inlet is an elongate lagoonal estuary fed mainly by the Shannon River. The catchment of Broke Inlet and its rivers lies within the highest rainfall area of the south west with an annual average of about 1 300 mm. Most of the rain falls in the winter months but summer rain is sometimes experienced.

Broke is a seasonal estuary, the bar being closed for much of the year. It has brackish water in summer, rarely more than half the salinity of sea water. The bar is wide, consisting of marine sands which build up to as high as 1.8 m above sea level in summer. It is breached naturally in most years by winter floods, usually between June and September, and remains open until December or January. The dates of opening and closing vary, depending on the time and volume of the winter floods. There have been dry years when it has not opened. Sometimes fishermen have artificially opened the bar.

The main river is the Shannon which is 47 km long and rises in the forested hills of the Shannon National Park. It enters the western end of the inlet where it forms a small delta. Two small, short rivers, the Forth and the Inlet Rivers, enter from the east where they arise in swampy plains.

Broke Inlet lies in a depression of the Proterozoic landscape behind a field of Holocene coastal dunes. The basin is about 15 km long and 2 to 3 km wide. It has an area of 48 km². The entrance channel is 3.5 km long and nowhere more than 250 m wide. Its northern shore is steep and cliffed but the southern shore is low and sandy. The entrance appears to be slowly eroding its way northwards. The position and depth of the channel varies.

The basin is shallow with an average summer depth of 1.5 m but there are several deeper areas with depths of 3 to 4 m. These deeper basins are separated by wide sand banks which may be exposed at low tide or when water level is low for other reasons. When the bar is open the inlet is tidal but the astronomic tidal range is only about 10 cm. Barometric pressure effects are believed to produce water level changes as great as 30 cm. During winter floods the water level in the inlet may be as much as 2 m above sea level. It is this build-up of flood water in the inlet which breaches the bar and scours the entrance channel.

The rivers entering the inlet are tidal for only short distances upstream, the Shannon for about 3 km from its mouth.

The shallow sand banks within the inlet are composed of fine, yellow, siliceous sand. The sediment at the bottom of the deeper basins is fine sandy mud or black gelatinous mud. Along the northern and eastern shores of the inlet there are rocky outcrops with sandy beaches between, rising to vegetated dunes. The south-western shore has a narrow beach backed by swamp with paperbark trees. There are two moderately large islands in the inlet and several islets and emergent rocks.

Flora and fauna

The aquatic flora and fauna of Broke Inlet is depauperate. The river water entering the estuary is low in nutrients and biological productivity is not great. The dominant plants are the seagrass *Ruppia megacarpa*, the stonewort *Lamprothamnion papulosum*, the red alga *Polysiphonia* and the green alga *Cladophora*. Only the handful of obligate estuarine benthic animal species are normally present throughout the year. Invasion of other invertebrates sometimes occurs in spring when the bar is open but few survive the subsequent winter.

Hodgkin & Clark (1989b) list 17 commercial species of fish at Broke Inlet. Most of these are temporary invaders. Because the bar usually closes rather early in summer, only early-breeding fish species are able to colonise the estuary in most years. Fishes that breed in spring, summer and autumn such as the King George whiting, yellow-finned whiting and tarwhine, invade the inlet only in those rare years when the bay remains open until late in the season. This is one reason Broke Inlet is a less popular fishing locality than Nornalup/Walpole and Wilson Inlets where the bars are permanently open or open until mid-summer. There is both commercial and recreational fishing in the inlet but it is of limited extent.

Recreation

Broke Inlet is relatively little used for recreational purposes. Fishing and some windsurfing and canoeing are the most common activities. Access to the inlet is limited. Easy access is available only to the Camfield townsite on the eastern shore via Broke Inlet Road. There is a boat launching site at that locality. The Education Department has a camp facility at Camfield which is occasionally used for school groups on nature-oriented study camps.

Previous recommendations

In its report on Conservation Reserves in Western Australia (1976, System 2), the EPA recommended declaration of a South Coast national park, to include the land surrounding Broke Inlet and the catchment of the Shannon River. This has now been done, the parks being called the D'Entrecasteaux and Shannon National Parks. In making that recommendation the EPA did not explicitly recommend that the inlet be reserved although this was clearly implied by the following recommendation:

“2.3 (7) until legislation is enacted to allow conservation reserves to include submarine lands, the Fisheries Act be employed to protect the Broke and Walpole-Nornalup Inlets and the Director of Fisheries and Wildlife be made responsible for their protection;”.

The Shannon and D'Entrecasteaux National Park Management Plan (CALM Management Plan No. 6, 1987) recommends that Broke Inlet should be gazetted as a marine park.

Working Group recommendation

Broke and Wilson Inlets are similar in many respects. Both are large, lagoonal estuaries which are seasonally open. However, while the catchment of Broke lies within a conservation reserve, that of Wilson Inlet lies largely in agricultural lands. Broke Inlet has every chance of remaining in virtually pristine condition without eutrophication while Wilson Inlet is already eutrophic. Although Wilson Inlet has a richer flora and fauna than Broke, its status as a biological environment is less secure. For catchment management reasons as well as management of the estuary, the Wilson Inlet bar is artificially opened every year. Access to Wilson Inlet is considerably greater than to Broke and it is more extensively used for recreation. Management of Wilson Inlet and recreational use of it is presently under the control of the Wilson Inlet Management Authority, empowered by the Waterways Conservation Act.

The Working Group concluded that there would be little point in reserving Wilson Inlet for conservation purposes as it is now subject to such intensive human impact. As the inlet is already controlled by the Management Authority, neither would there be any advantage in reserving it for recreational purposes. For conservation purposes Broke Inlet is a better choice as an example of the large, lagoonal, seasonally-opened estuary because it is likely to remain in natural condition. Because of its isolation within the national park, Broke also offers the prospect of management to preserve its present peaceful character and use for passive recreation.

Accordingly the Working Group recommends that:

“Broke Inlet and the tidal parts of the Shannon, Forth and Inlet Rivers be reserved for recreation and conservation and their management integrated with that of the D'Entrecasteaux National Park.”

3.2.4. Donnelly and Gardner Inlets***Geomorphology and hydrology***

Each of these rivers has a small, riverine estuary at its mouth, described by Hodgkin & Clark (1989b). There are no lagoons. The mouth of the Donnelly River is barred by the build-up of sand but opens seasonally following winter floods. While the bar is open the river is tidal for a distance of about 12 km upstream. The sea water intrudes beneath the surface freshwater and there may be little, if any, mixing. The Gardner River has a rock bar at the mouth which remains open all year, although the bar impedes penetration of sea water except during the summer period when there is very little river flow. The catchments of both rivers lie largely within forested land although the headwaters arise in agricultural land.

Flora and fauna

As might be expected given the highly seasonal nature of the environment the aquatic flora and fauna of both inlets are depauperate. The marine seagrass *Ruppia megacarpa* and the stonewort *Lamprothamnium* are sometimes present. Even the suite of obligate estuarine benthic animals is represented by only a few species (see Hodgkin & Clark, 1989b). Only the Donnelly has significant fish populations and is fished with any regularity.

Previous recommendations

None.

Working Group recommendation

The Working Group considers that the inlets of the Donnelly and Gardner Rivers have considerable scientific and recreational value and should be managed as part of the surrounding D'Entrecasteaux National Park. It is unclear whether these areas are already included within the national park. Accordingly the Working Group recommends that:

“Legal advice should be taken on the status of the tidal parts of the Donnelly and Gardner Rivers and if they are not already reserved within the D'Entrecasteaux National Park under the Land Act, consideration should be given to reserving them under the Conservation and Land Management Act for conservation and recreational purposes.”

3.3. Walpole-Nornalup (Map V-1)

The Walpole-Nornalup estuarine system consists of two connected lagoons, that is Nornalup and Walpole Inlets, and the tidal reaches of the Deep, Frankland and Walpole Rivers. The estuary has been described by Hodgkin & Clark (1988a) and Smith *et al.* (1990).

Tenure

In 1972 the Government gazetted the Walpole-Nornalup National Park under the Land Act as a Class A reserve and included the inlets within the park. But it was later discovered that areas below low tide cannot be reserved under that Act and that inclusion of the tidal waters of the inlets within the park was not valid. When the marine reserves provisions of the CALM Act were introduced the Government directed that the inlets be reserved as marine park under the powers of this legislation. This has not yet been done.

Nornalup Inlet is entirely surrounded by the Walpole-Nornalup National Park. A small area of the park on the north-eastern shore of Nornalup Inlet is leased to the Coalmine Beach Sailing Club. The south-eastern shore of Walpole Inlet is also national park but the north eastern shore is occupied by the Walpole townsite and the north-western shore is a recreation reserve vested in the Shire of Manjimup.

The tidal parts of the Frankland and Deep Rivers are also contained within the national park except for a portion of the former in the vicinity of the Nornalup townsite.

Geomorphology and hydrology

Walpole-Nornalup is a relatively large lagoonal estuary which has two basins and a permanently open entrance. It lies between forested, granitic hills fringing the Albany-Frazer Oregon and the high Pleistocene dunes of the coast. It consists of two basins which together cover an area of about 13.2 km². Walpole Inlet is connected to the much larger and deeper Nornalup basin by a narrow channel between steep granite headlands. The entrance channel from the sea into Nornalup Inlet lies against a granite headland on its western side and the sand dunes which flank Bellanger Beach on its eastern side. The ocean bar limits tidal flow but it is always open and the estuary is always tidal.

Both the Deep and Frankland Rivers have well-defined channels, rather large deltas and discharge over shallow sand banks into Nornalup Inlet. The channels have been dredged and the rivers are navigable for some distance upstream. Their upper catchments are in agricultural lands but for much of their length they flow through State forest or national park. Rainfall in the catchment is high, with an annual fall of up to 1 400 mm near the coast.

Deep River is tidal for a distance upstream of about 6 km and the Frankland for about 12 km. The much smaller Walpole River is tidal for only a very short distance. Except for the dredged channels, Walpole Inlet is shallow with depths less than 1 m. There are shallow sand banks around the perimeter of Nornalup Inlet which shelve steeply to a central basin between 3 and 5 m deep.

The salinity regime in the estuary was studied in some detail by CSIRO from 1944 to 1951 (for references see Hodgkin & Clark, 1988a). Throughout the summer the salinity of the water in both inlets is approximately that of seawater. Marine water of oceanic salinity also penetrates far upstream in the two larger rivers during summer. In winter, when the rivers flood, a thermocline develops and the fresh water flows downstream over salty water which usually remains in the deeper parts. The saline bottom water may become deoxygenated under those conditions.

Flora and fauna

As may be expected, this permanently open estuary has a relatively rich flora and fauna. The seagrasses *Ruppia megacarpa* and *Heterozostera tasmanica* both occur in Nornaiup Inlet, the latter mainly near the entrance channel. A brown alga, *Cystoseira trinodes*, is common on rocks around the shore. Green algae of the genera *Chaetomorpha* and *Cladophora* are abundant on the muddy flats, and the green alga *Acetabularia calyculus* is common, living attached to stones and shells in the shallows. The epiphytic algae *Chaetomorpha billardieri* and *Monosporus australis* sometimes overgrow the *Ruppia*, although there is no evidence of eutrophication.

The estuarine copepod *Cladiferens imparipes* dominates the plankton of the riverine parts of the estuary but also occurs abundantly in the inlets. The marine euryhaline copepod *Acartia tonsa* is the dominant plankter in the higher salinities of the inlets. Hodgkin & Clark (1988) list other copepods taken in plankton samples within the estuary.

All of the South Coast obligate estuarine invertebrate animals occur in the estuary and there is a larger number of marine invaders than is found in any other estuary in the region (except Oyster Harbour). A faunal list is given in Hodgkin & Clark (1988a).

The fish fauna also is relatively diverse. Many species targeted by recreational fishers are present, often in large numbers, including most of the common inshore marine species. Nornalup Inlet in particular is a popular location for recreational fishing. Net fishing is prohibited.

Recreation

Ablone *et al.* (1990) summarised recreational use of the Walpole-Nornalup National Park.

The Walpole-Nornalup estuary is surrounded in many places by tall forest. It is scenically and aesthetically one of Western Australia's most spectacular estuarine environments (Hodgkin & Clark, 1988). Much of its shore remains in its natural condition and the waters are unpolluted. For these reasons the Walpole-Nornalup National Park has long been a popular area for recreational pursuits, with the inlets as a central focus. Boating and especially fishing are among the most common recreational activities. Sailing from the Coalmine Beach Sailing Club attracts visitors as well as local people. Windsurfing is becoming another popular watersport on the inlets.

The Walpole-Nornalup National Park Management Plan notes the current rate of increase in the number of visitors to the park, including those indulging in water sports, with the corresponding need for increased management to prevent degradation of the environment.

Management of boat launching sites is seen to be of particular concern. Prevention of pollution and conservation of fish stocks are also important.

Previous recommendations

Although in its report on Conservation Reserves in Western Australia (1976, System 2) the EPA did not specifically recommend marine park status for the Walpole-Nornalup Inlets, it recommended as follows:

“(7) until legislation is enacted to allow conservation reserves to include submarine lands, the Fisheries Act be employed to protect the Broke and Walpole-Nornalup Inlets and the Director of Fisheries and Wildlife be made responsible for their protection;”.

The CALM Walpole-Nornalup National Park Management Plan (Smith *et al.*, 1990) noted that the Minister for the Environment had directed that the inlets should be reserved under the CALM Act and that declaration of the marine park was "expected to occur early within the life of this [management] plan".

Working Group recommendations

The Working Group believes that the Walpole-Nornalup estuarine system has very high conservation and recreational values. Although in size it is similar to Broke and Wilson Inlets, it is quite different in that it is naturally permanently open to the sea. It is the only permanently open lagoonal estuary on the South Coast and, apart from the partly estuarine Oyster Harbour, it has the most diverse estuarine flora and fauna of any estuary in the region. It also has outstanding scenic qualities and is largely surrounded by National Park.

The Working Group notes that in 1972 the Government included Walpole-Nornalup Inlets within the national park until it was discovered later that this was not possible under the Land Act. Accordingly the Working Group recommends that:

“declaration of Walpole and Nornalup Inlets and the tidal parts of the Deep, Frankland and Walpole Rivers as marine park be implemented as a matter of high priority, and its management integrated with that of the surrounding national park.”

3.4. William Bay (Map V-2)

Tenure

William Bay National Park extends to the low tide mark in the area under consideration.

Geomorphology

This is a granite shore with beaches alternating with smooth rock surfaces. There is a chain of large, near-shore boulders and rock islets protecting the beaches and deep pools from the full force of the swells. This type of situation is uncommon on the South Coast where most open ocean rocky shores are exposed to heavy wave action.

Flora and fauna

There is very little information about the marine flora and fauna at this locality. However, the sublittoral habitats are diverse with extensive tide pools and boulders. A diverse flora and invertebrate fauna is certain to occur there. The locality is the type locality for the gastropod (cowry) *Cypraea hadnighatae*. Seagrasses, mainly species of *Posidonia* and *Amphibolis*, grow in most of the sheltered areas in the lee of the islets.

Recreation

This is one of the South Coast's most attractive sections of coast, particularly because of its relatively protected waters suitable for swimming, diving and fishing. It is of such scenic quality that photographs of it often appear in tourist promotion and other publications.

Previous recommendations

None.

Working Group recommendation

Noting the high scenic and recreational values of the locality and its likely diverse marine flora and fauna representative of the South Coast rocky shore habitat, the Working Group recommends that:

“the State waters adjacent to the William Bay National Park be surveyed and assessed for their conservation values, with a view to possible reservation as a marine reserve for dual conservation and recreation purposes.”

3.5. West Cape Howe (Map V-2)

Tenure

West Cape Howe National Park extends to the low water mark along most of the coast under consideration. At the eastern boundary of the park, that is at the western end of Torbay (Port Harding), there is a Shire reserve at the shore.

Geomorphology

This section of the coast is one of a series of repeated geomorphic units characteristic of the western part of the South Coast (see section 3.1) with Torbay Head as its central feature. It is a high doleritic promontory with perhaps the State's most dramatic sea cliffs exposed to the full force of the Southern Ocean swells. Its extremity is the southernmost point of Western Australia. To the west, between West Cape Howe and Knapp Head, there is a long, curved sandy beach backed by high Pleistocene dunes. The sea floor fronting the western beach is gently shelving but the shore of the promontory is steep-to, dropping off very steeply into deep water. On the eastern side of the promontory there is a series of small, deep, arcuate bays with narrow beaches below very steep hill slopes. Further north within Torbay the force of the swells decreases and the shore comprises boulders with some semi-protected tidal pools. Two small islets, Migo and Richards, protect a channel and boat anchorage.

Flora and fauna

No information is available on the marine flora and fauna of the shore. Inspection of aerial photographs reveals a wide range of rocky shore habitats from those with maximum exposure to ocean swells, to semi-protected pools and boulders. There are dense algal beds in the shallows on the eastern side of the promontory, especially in the shelter of the two small islets. Deeper waters offshore in the western part of Torbay support extensive seagrass beds. The aerial photographs suggest the presence of similar seagrass beds beyond the surf zone off the beach west of West Cape Howe.

Recreation

There are spectacular views from the headland although four wheel drive is necessary to gain access. Access is available to the shore on the eastern and western sides of the headland. Both areas are popular with local people for beach and rock fishing. The small, deep bay on the eastern side is one of the most popular dive sites in the Albany district, with access to deep water from the shore. The water is exceptionally clear and the rock wall fauna is extremely rich and colourful. The beach at the Shire reserve in Torbay is popular as a family swimming area and boat launching site. Until now this headland has had little attention from tourists because of its relative remoteness and inaccessibility.

Previous recommendations

None.

Working Group recommendations

Noting the high scenic values of the shore, the ready access to deep water and magnificent underwater scenery, and the variety of habitats and likely high diversity of marine flora and fauna, the Working Group recommends that:

“consideration be given to reservation of the State waters adjacent to the West Cape Howe National Park as a marine reserve for the purposes of conservation of flora and fauna and recreation, with the possible inclusion of the western part of Torbay adjacent to the Shire reserve.”

3.6. King George Sound - Princess Royal Harbour (Map V-2)

King George Sound and the two related inlets, Princess Royal Harbour and Oyster Harbour, comprise one of the principal landform features of the South Coast. Albany, the South Coast regional centre and principal port, is located on these shores.

Tenure

Land use around the shores of this area is complex with townsites, shire reserves, freehold land and national parks. The waters of King George Sound, Princess Royal Harbour and Oyster Harbour are under the control of the Albany Waterways Management Authority.

Geomorphology

A general account of the geomorphology of the Sound and inlets is given in section 1.1. King George Sound is a marine gulf, Princess Royal Harbour an enclosed marine inlet, and Oyster Harbour partly a marine inlet and partly an estuary. The waters are presently under study by the EPA and other government agencies in view of concern about eutrophication of the inlets.

King George Sound is protected from the southerly winds and swells by Flinders Peninsula which terminates at Bald Head. The southern side of the Peninsula is very exposed and features high granite and limestone cliffs. The Sound is open to the east although there are two high islands in the entrance, Michaelmas and Breaksea, both of which are nature reserves. The depth of the Sound ranges from 10 to 35 m. The deepest part is a basin at 30-35 m in Frenchman Bay west of Seal Island. A sublittoral rocky ridge connects Michaelmas Island to the northern shore of the mainland west of Herald Point and there is a chain of deep reefs west of that island.

Princess Royal Harbour is cut off from King George Sound by Vancouver Peninsula with only a narrow entrance channel. The inlet is silted and very shallow except for a small basin on the northern side just inside the entrance where the port of Albany is located. There are wide muddy sand banks around its periphery.

Oyster Harbour is similar to Princess Royal Harbour but has two rivers, the King and the Kalgan, entering it on the north side. These render the northern part of the inlet an estuary. The entrances to both inlets are permanently open and there are strong tidal flows in and out. Princess Royal Harbour and Oyster Harbour are both eutrophic while King George Sound is oligotrophic.

Flora and fauna

As noted in section 1.2, King George Sound and the two inlets were collecting sites for several early expeditions and many marine species were originally described from there. There has been a number of ecological studies in the area in more recent years, outlined by Wells (1990). McKenzie (1962) described the environment and fauna of Oyster Harbour. Roberts & Wells (1980) described the marine and estuarine molluscan faunas. An international marine biological workshop held in the area in 1988 resulted in publication of a range of important papers on the biology of the sound and the two inlets (Wells *et al.*, eds., 1990; 1991). These included detailed studies on seagrass beds and their associated fauna (Kirkman *et al.*, 1991; Walker *et al.*, 1991; Hutchings *et al.*, 1991; Wells *et al.*, 1991), spatial distribution of intertidal rocky shore invertebrates (Britton *et al.*, 1991; McMahon & Britton, 1991), foraging by opisthobranchs (Jensen, 1991), resource partitioning by intertidal snails on sand flats (Morton & Britton, 1991). Also included were taxonomic accounts of some groups of invertebrate animals in the area.

From the early and modern accounts it is clear that there is a wide range of habitat in the Sound and the two inlets. These range from open ocean marine, through protected marine inlet to estuarine. There are both limestone and granite rocky shores, intertidal mud and sand flats, deep reefs, and deep basins with fine sand and mud substrates. As a consequence this area has an exceptionally rich and diverse marine and estuarine flora and fauna.

Seagrass beds are dense and rich in plant and animal species, especially on the sandy sills on each side of Vancouver Peninsula and bordering Middleton Bay. However, the seagrass beds in Princess Royal Harbour and Oyster Harbour have suffered serious depletion in recent years as a result of eutrophication (Bastyan, 1986; Kirkman, 1987). In Frenchman Bay seagrasses grow down to 17 m. The meadow-forming species *Posidonia sinuosa* covers the largest area but along the shallow edges *P. australis* is the first seagrass seen. *P. kirkmanii* is common at Gull Rock and along the north eastern shores of King George Sound. *P. roberstsonae* is common along blowout edges and inside blowouts. Both species of *Amphibolis* occur throughout King George Sound. *Halophila australis* and *Heterozostera tasmanica* are transient members of the seagrass communities between years of large storms and years with few storms.

The intertidal sand flat faunas of Princess Royal Harbour and Oyster Harbour support diverse communities of burrowing invertebrates (Roberts & Wells, 1980; Wells & Roberts, 1980) and are of special significance as this habitat type is now of such rare occurrence on the South Coast. A notable species is a population in Oyster Harbour of the bivalve mollusc *Anadara trapezia*, a relic of former times when the species had a much wider geographical range. It is a common species in Pleistocene shell beds in southern Western Australia. The species is common in south-eastern Australian estuaries today but in Western Australia it now lives only in Oyster Harbour where it is the subject of a small fishery.

The rocky sublittoral ridge between Herald Point and Michaelmas Island has a rich and diverse fauna of attached, suspensory-feeding invertebrates, especially sponges, and associated animals. A seagrass, *Thalassodendron pachyrhizum*, grows in large quantities along this ridge. The steep-to, rocky shores of Michaelmas and Breaksea Islands also have a rich and extremely colourful wall fauna below the algal zone (that is below about 15 m).

The deep basin in Frenchman Bay has a fine sand floor with a rich burrowing invertebrate fauna.

Fisheries

An account of the fish fauna of Princess Royal Harbour and Oyster Harbour can be found in Lenanton (1974). Pilchard is the most abundant species harvested in the area. It is taken by purse-seine in King George Sound and to a lesser extent in Princess Royal Harbour. Other key species, taken by beach-seine and gill net within the area, include Australian herring, leatherjackets, cobbler, yellowtail scad, flathead, King George whiting and garfish.

Bonito and Nanarup Beaches, located east of King George Sound, are important beaches for the Australian salmon fishery. Commercial fishing for Greenlip abalone (*Haliotis laevis*) occurs off Flinders Peninsula and in King George Sound.

Recreation

The protected and semi-protected waters of the Sound and both inlets are extensively used by local people for recreation, including boating, fishing and diving. There are boat ramps at several locations. Larger vessels use the port in Princess Royal Harbour. Commercial dive tours operate from Albany, taking divers to the exceptionally scenic areas in the vicinity of Michaelmas and Breaksea Islands. Whale-watching tours also operate from Albany. The lee side of Flinders Peninsula is particularly suited for snorkellers and beginners. Torndirrup National Park, which occupies much of Flinders Peninsula, has outstanding scenery and is heavily used by sightseers.

Previous recommendations

None.

Working Group recommendations

The Working Group recognises that King George Sound, Princess Royal Harbour and Oyster Harbour are extensively used for port and recreational purposes and that the two inlets show evidence of environmental degradation. Nevertheless, these areas are of such biological importance that reservation of some parts of them for conservation purposes should be considered. There might also be merit in reservation of some parts to protect and promote recreational activities, especially diving.

Of particular importance are the seagrass beds on either side of Vancouver Peninsula and in Frenchman Bay. The sheltered deep basin in Frenchman Bay is also a rare feature on the South Coast. These areas are of special value for both conservation and recreation. The rocky sublittoral ridge and reefs in the vicinity of Michaelmas and Breaksea Islands have special attractions for recreational divers, including the commercial dive tour industry. Although similar underwater scenery and flora and fauna occurs further east around Cape Vancouver, the King George Sound sites are much more easily accessible to vessels from Albany.

Accordingly the Working Group recommends that:

“1. the western shore of Vancouver Peninsula in Princess Royal Harbour, and the eastern shore of that Peninsula in King George Sound as far east as Flat Rock, and extending seaward as far as Seal Island to include the waters of Frenchman Bay, should be considered for reservation as a marine reserve for the purposes of conservation of flora and fauna and recreation;

“2. a survey be conducted of the deep ridge and reefs in the vicinity of Michaelmas and Breaksea Islands, together with a survey of the waters around Cape Vancouver, to assess their relative underwater scenic values and merits as dive sites, with a view to selecting areas to be reserved for conservation and recreation use.”

3.7. Cape Vancouver to Bald Island (Map V-2)

This section of the South Coast has outstanding coastal scenery and a wide range of open coast habitats with high conservation values.

Tenure

The Cape Vancouver peninsula is reserved as a Class A Nature Reserve (No. 27956) notable as a refuge for the Noisy Scrub-bird and other threatened birds. Bald Island is also an important Class A Nature Reserve (No. 25869) which is especially important as an island refuge for the Quokka and the site of an introduced population of the Noisy Scrub-bird. Between the two is the Mount Manypeaks ridge incorporating the Waychinicup National Park (No. 25865 and 27502) and a Class A Nature Reserve (No. 36028). Thus, all but a few kilometres of the coast in the section under consideration is reserved for conservation or recreation purposes.

Geomorphology

This section of coast is a fine example of the repeated sequence of arcuate beach between granite headlands which is a prominent feature of the western part of the South Coast (section 1.1).

Mount Cardner (399 m) and Mount Manypeaks (565 m) are two of the high points on the South Coast. Mount Gardner forms a large, granitic promontory, terminating at Cape Vancouver, and connected to the mainland by a low, sandy isthmus. It would have been a high island when sea level was only a few metres higher than it is today. The southern side of the isthmus is the windward side. The shore there consists of a long, curved, surf beach backed by Pleistocene dunes and a fringe of aeolianite limestone cliffs. At sea level, especially at the eastern end, there is extensive beach rock development and the formation of intertidal limestone rock platforms. The northern side of the isthmus, fronting onto Two Peoples Bay, faces east and is less exposed to the southern swells. It too has an arcuate beach and a backing of Pleistocene dunes but there is less surf and no limestone. The bay is gently shelving with a sandy floor.

Mount Manypeaks is the high point on an east-west granitic ridge facing the Southern Ocean and forming a stretch of very rugged, steep-to shore with almost no access. The ridge is breached near its centre by the steep valley of the Waychinicup River which has a small but unique inlet at its mouth. The inlet is very narrow and flanked by steep granite hills. Its entrance is permanently open and sea water penetrates a short distance upstream until it is blocked by a series of rock bars. The upper portion of the inlet is estuarine. The high granite ridge terminates in the east at Bald Island, separated from a granitic headland between Mermaid and Lookout Points by a narrow and deep channel. Beyond Lookout Point the coast turns north again to Hassell Beach, the high granite giving way to another long, curved beach backed by Pleistocene dunes.

Although the sea floor slopes gradually out to 20 m in Two Peoples Bay and off Hassell Beach, elsewhere there is a rather steep slope. The granitic shores of Cape Vancouver, Bald Island and the Manypeaks ridge drop off very steeply to 50 m within 1 or 2 km from the shore. These steep-to shores are characterised by spectacular vertical rock walls in the sublittoral zone. There are reports of a deep underwater canyon off the mouth of the Waychinicup River which may be a continuation of the river valley.

Flora and fauna

The gently sloping, relatively protected seabed of Two Peoples Bay has extensive seagrass meadows of *Posidonia* and *Amphibolis* spp. There is no information on their floristic composition or the composition of their associated fauna. However it would be safe to assume that the seagrass community is rich in both density and species.

Little is known of the rocky shore flora and fauna of this shore. The steep granite shores of Cape Vancouver, the Manypeaks ridge and Bald Island are exposed to very heavy wave action. The intertidal

biota there is not diverse but well represents the flora and fauna of exposed South Coast granitic shores. The limestone rock platforms on the southern side of the Mount Cardner isthmus have not been studied but, although they provide a rather different habitat, are probably constantly abraded by sand in the heavy surf and not rich in species.

The intertidal fauna of the rocky spit at South Point at the southern end of Two Peoples Bay has been well sampled by biologists. The western side of the spit is relatively protected from the swells and consists of a field of boulders and tide pools extending down into the sublittoral zone. This is a habitat rich in macrophytic algae and invertebrate animals. There is an assemblage of molluscs, crustaceans and echinoderms typical of South Coast sheltered rocky shores. Juvenile Roe's abalone (*Haliotis roei*) are abundant and the endemic relict gastropod *Campanile symbolicum* is very common. Seagrass meadows begin at a depth of 2-3 m, beyond the limit of the boulders. They are sparse with a shoot density of about 9-11 m. The meadow-forming species *Posidonia sinuosa* is the dominant seagrass but *P. robertsonae* covers large areas. *Amphibolis* spp, *Heterozostera tasmanica* and *Halophila australis* are also present. There is a similar feature with a similar flora and fauna in the equivalent position at Cheyne Beach, at the southern end of Hassell Beach. Habitats of this type are rare on the rugged South Coast.

An unusual geomorphic feature, with an unusual flora and fauna, is the Waychinicup Inlet. The sheltered rocky shores have many tide pools and loose boulders providing invertebrate habitats. In the estuarine shallows near the head of the inlet there are dense seagrass beds of *Posidonia australis* and muddy sand flats with diverse flora and fauna. There is nothing else quite like this on the South Coast. The most similar would be parts of Oyster Harbour.

On open ocean shores the rock slopes are densely vegetated with macrophytic algae down to depths of 15-20 m. Below that depth macrophytes give way to a very diverse community of attached, suspensory-feeding invertebrate animals including sponges, ascidians and coelenterates. Sublittoral vertical walls and undercuts where there is shade are also densely covered with a wall fauna of sedentary invertebrates.

Several of the emergent rocks and islands on this section of the coast are important haul-out and breeding colonies of Australian Sea Lions and New Zealand Fur Seals. The most important of these are Coffin Island and Bald Island. Bald Island is also an important breeding area for the Little Penguin (*Eudyptula minor*).

Fisheries

Pilchard is the most abundant species harvested (by purse-seine) from the inshore waters between Cape Vancouver and Bald Island. Betty's Beach, midway between these points, is one of the most productive salmon fishing beaches on the South Coast. Greenlip abalone are taken commercially around Cape Vancouver and Bald Island. The demersal line-fish resource of this region is fished by recreational fishers operating mainly by small craft launched from Albany and Cheyne Beach.

Recreation

Local people use this area for fishing and diving but it is relatively remote and it has not yet become a popular tourist area. There is little access to the shore. The Two Peoples Bay Nature Reserve is a "prohibited area" except at the beach on the north side of the promontory where there is a picnic area and a boat launching site. There is another picnic area and boat launching site at the northern end of the bay at North Point. A track gives access to the head of the Waychinicup Inlet but only very small boats can be launched there. The only other point of access is at Cheyne Beach at the south end of Hassell Beach where there is a reasonable anchorage and a launch site.

Because of limited access, the shore and its flora and fauna are relatively pristine. Anecdotal evidence was given to the Working Group that the fish fauna around Cape Vancouver and Bald Island remains very rich with little evidence of depletion of the large and vulnerable species like Blue Groper and Queen Snapper. Local dive tour operators and abalone divers claim that locations like Coffin Island off Cape Vancouver and Bald Island, with their deep drop-offs (to 50 m in some places), spectacular rock walls and exceptionally clear-water are among the best dive sites known on the South Coast. They are relatively easily reached in good weather from the boat launching sites in Two Peoples Bay and Cheyne Beach.

Previous recommendations

None.

Working Group recommendations

Noting the wide variety of coastal types and habitats that are represented, the relative remoteness and lack of access to the shore and the degree of protection that provides, and the value of the inshore waters for public recreation, especially fishing and diving, the Working Group recommends that:

“the State coastal waters between the western boundary of the Two Peoples Bay Nature Reserve and Lookout Point, including the tidal waters of Waychinicup Inlet and encompassing Bald Island, be considered for reservation as a marine reserve for conservation of flora and fauna and recreation.”

3.8. Fitzgerald Biosphere Reserve (Map V- 3)

This section deals with the marine environment of the coast adjacent to the Fitzgerald River National Park and the estuarine environments of several small inlets within the park boundaries. A published management plan for the park (1991, CALM Management Plan No. 15) contains relevant information about the coastal features.

Tenure

The Fitzgerald River National Park consists of two Class A reserves, one (No. 31738) being a 700 m wide strip of land along the coast between Gordon and Culham Inlets, extending to the low tide mark and including a small near-shore islet known as Red Island. The national park is a Biosphere Reserve under the UNESCO Man & the Biosphere Program.

Beyond the southern end of the park, that is at the southern end of Doubtful Islands Bay, there is a prominent granitic headland, terminating in Point Hood and two small islands called the Doubtful Islands. The headland, which forms the eastern side of Bremer Bay, is Shire reserve and freehold land but the two islands are Class A Nature Reserve (No. 23516).

The Fitzgerald River National Park extends to the low water mark and the status of those inlets entirely encompassed by it is difficult to determine. As the inlets are merely flooded with sea water on rare occasions, they are hardly classifiable as "tidal" so that it can be argued that they are, by definition, included within the national park. Gordon Inlet in the west and Culham Inlet in the east form part of the boundary of the park but the location of that boundary remains ambiguous because a "low water mark" is not definable.

Geomorphology

The Fitzgerald River National Park is characterised by rolling hills and a range of higher hills, the Mount Barren Ranges. The hills are formed of metasediments of the Albany-Frazer Oregon known as the Mount Barren Group. Low parts of the landscape are filled with Eocene sediments. The Mount Barren Range lies along the coast in the eastern part of the park, forming rugged rocky shores with precipitous cliffs. Outcrops of the Mount Barren Group occur at Point Charles and Point Ann, producing high, prominent headlands. Between the headlands of the Mount Barren Range east of Dempster Inlet and Point Charles, between Point Charles and Point Ann, and between Point Ann and Point Hood, there are wide, arcuate beaches backed by Pleistocene dunes.

The seabed south of Point Hood and the Doubtful Islands drops off steeply to 50 m within 1 km of the shore but in Doubtful Islands Bay there is a gradual slope and the 50 m contour is 10-15 km offshore.

Between Point Hood and Hopetoun there is a series of inlets either contained within the Fitzgerald River National Park or bordering it. From west to east these are the Gordon, St Mary, Fitzgerald, Dempster, Hamersley and Culham Inlets. They are no longer estuaries in the conventional sense, being open to the sea on rare occasions when there are exceptional floods and the bars are breached (Hodgkin & Clark, 1990a). Nevertheless they are considered here as they sometimes support estuarine and marine flora and fauna. Detailed descriptions of these inlets have been published by Hodgkin & Clark (1990).

While acknowledging that the inlets within and bordering the Fitzgerald River National Park lie at the edge of the definition of estuary, for the present purpose they are considered to fall within the category of semi-permanently closed estuary (see Part 1, section 3.7.6). The inlets have formed where the river mouths are trapped in depressions behind rocky headlands or coastal dunes. If they were permanently closed they would be classified as saline coastal lagoons. Culham Inlet could perhaps be so regarded. The rivers that feed the inlets are saline and tend to flow intermittently. In summer some of the inlets become hypersaline as a result of evaporation or even dry out.

Gordon Inlet has a small lagoon about 4 km long but there is a meandering riverine portion extending 13 km from the mouth. The lagoon is shallow, probably not much more than half a metre below mean sea level. The entrance sand bar is low and breaks at intervals of about 3-5 years. The eastern shore of the lagoon forms the boundary of the national park and the western shore is a shire reserve.

St Mary Inlet is the smallest of the series. It is only 1 km long and 250 m wide. It has a very shallow lagoon and is filled with sediment to about mean sea level. It has a low sand bar at the entrance that breaks only in those years of unusually heavy rainfall and then remains open for only a few weeks.

Fitzgerald Inlet is the largest of the series. It has a lagoon about 6 km long and 1.5 to 2 km wide, lying in a valley of Pallinup Sandstone with cliffed shores at several locations. There is a narrow inlet channel barred by low dunes. The lagoon is very shallow, that is seldom more than 1 m, and the floor is at about mean sea level. Water level in the lagoon may build up to nearly 2 m during a heavy winter flood, before the bar bursts and the water is released. The bar does not stay open for more than a few weeks. The inlet dries completely in prolonged dry periods.

Dempster Inlet is a small elongate lagoon, about 4 km long, lying in a valley of metamorphic schists. It is fed by small streams that rise within the park. The floor of the lagoon is silted to about mean sea level. The entrance channel is narrow and there is a high sand bar. There are no records of the frequency of opening but it does not seem to be often.

Hamersley Inlet lies in a deep valley between metamorphic rocks. Its upper reaches lie in a meandering gorge and the lagoon has rocky shores. Overall the inlet is about 7 km long but it is narrower than the Fitzgerald. It is deeper than any other of the series with the lagoon floor at about 2 m below mean sea level near the mouth. It dries completely only rarely. The sand bar at the entrance has broken only about seven times since 1923, that is an average of about once in ten years.

Culham Inlet is a wide, shallow coastal lagoon cut off from the sea by a stable coastal dune system. Its western shore abuts the steep slopes of East Mount Barren in the park. Its eastern shore is lower and bordered by Shire reserve and agricultural land. The inlet is fed by the Phillips and Steere Rivers, both of which are saline. There are rich fossil beds around the lagoon showing that it was a true estuary during the Holocene. The inlet is now so shallow that it dries up completely during prolonged dry periods. It fills with saline river water in most winters. The last time the bar is known to have broken naturally was in 1849 (Hodgkin & Clark, 1990a) but it was opened artificially in about 1920 and again in 1993 following heavy floods.

Flora and fauna

There is very little information about the marine flora and fauna along this stretch of coast. The metasedimentary rocks of the Mount Barren Group form rocky shores of rather different type to the granite shores more typical of the South Coast but there have been no surveys of their flora and fauna. Aerial photographs indicate that there is extensive development of seagrass beds beyond the surf zone in Doubtful Island Bay but again no information about their floristic composition or associated fauna is available.

The steep-to shores of Point Hood and the Doubtful Islands are reported to be spectacular dive sites with vertical sublittoral walls and prolific growth of attached invertebrates and large fish populations. Doubtful Island Bay is an important beach for the Australian salmon and Australian herring fisheries.

Southern Right Whales are frequently seen in Doubtful Island Bay during winter and spring. The highest reported numbers of this whale have been from the vicinity of Point Ann (Bannister, pers. comm.). The Doubtful Islands are important breeding colonies of Australian Sea Lions and New Zealand Fur-seals.

The inlets within and bordering the Fitzgerald River National Park are very depauperate in terms of aquatic flora and fauna, as might be expected in view of their semi-permanently closed condition. However, when the bars break and seawater floods the lagoons many marine animals invade them and may survive there for brief periods.

The seagrass *Ruppia megacarpa* and the stonewort *Lamprothamnium* establish in most of the inlets when salinity conditions are favourable. Some of the obligate estuarine invertebrates are present. Black bream survive throughout the year in deeper riverine pools. Sea mullet and a few other marine fishes that enter while the entrances are open may also survive for some months and grow to fishable size, especially in Hamersley Inlet. At those times they are fished by both commercial and recreational fishers. The commercial fishers make the point that if these fish are not taken they die anyway when the water becomes unsuitable for them and a valuable resource is wasted.

Recreation

The coastline of the Fitzgerald River National Park is classified by CALM for management purposes as having high or moderate scenic value. The central area of the park is a wilderness zone without access for vehicles. Vehicle access to other parts of the shore is sited to minimise visual impact. Consequently the scenic quality of this very beautiful section of the South Coast will be maintained.

Most park visitors are sightseers. Recreational fishers use vantage points on the accessible rocky shores and beaches but the intensity of use is low. There is a boat launching site at the southern end of Doubtful Island Bay.

The inlets within and bordering the Fitzgerald River National Park are an important element in the scenic value of the park. Dempster Inlet lies within the wilderness zone of the park and Fitzgerald and Hamersley within natural environment zones. The park is becoming increasingly used for recreational purposes.

Previous recommendations

The EPA made no recommendations regarding the marine areas adjacent to the Fitzgerald River National Park or the inlets within the park boundaries in its report on Conservation Reserves in Western Australia (1976, System 3).

In the CALM Management Plan (1991, No. 15) for the Fitzgerald River National Park it was recommended that the Gordon, St Mary, Fitzgerald, Dempster and Hamersley Inlets be declared marine reserves. It was also recommended that commercial fishing be permitted in Gordon and Hamersley Inlets but not in Fitzgerald, Dempster or St Mary Inlets.

Working Group recommendations

While acknowledging the lack of information about the marine flora and fauna on the shores of the Fitzgerald River National Park, the Working Group believes that reservation of the coastal waters adjacent to the park would have merit for recreation and management reasons. With limited access to the shore, significant human impact on the marine flora and fauna is unlikely. Reservation would be consistent with the principal uses of the coastline, that is sight-seeing and recreational fishing, and a logical extension of the International Biosphere Reserve status of the coast.

The importance of Doubtful Island Bay as a nursery area for Southern Right Whales is in itself a reason for reservation. Assuming that care is taken to avoid interference with the whales, the existing

commercial Australian Salmon fishery would be readily accommodated within marine park management programs.

The Working Group notes the greater public access to the coast on the north side of Point Hood and the presence there of housing but believes that there is a case for extending the proposed marine reserve to encompass the Doubtful Islands and Point Hood providing additional protection to the Sea Lion and Fur Seal colonies and adding a significant area of rocky shore to the reserve.

The small inlets of the Fitzgerald River National Park, impoverished though they are in terms of aquatic flora and fauna, nevertheless represent a type of semi-permanently closed "estuary" peculiar to the eastern part of Western Australia's South Coast. They have considerable scenic merit and contribute significantly to the scenic and recreational values of the Fitzgerald River National Park and to the integrity of the status of the area as an International Biosphere Reserve. Culham Inlet is hardly claimable as an estuary at all and it is now highly modified by human activity and has less value as a potential reserve for either conservation or recreational purposes.

For the above reasons the Working Group recommends that:

“the area of State coastal waters between the mouth of Gordon Inlet and the mouth of Culham Inlet, that is the coast adjacent to the Fitzgerald River National Park, should be considered for reservation as a marine reserve for conservation of flora and fauna and recreation, and that it should be added to the Fitzgerald Biosphere Reserve;

“consideration also be given to reservation for the same purposes of the southern part of Doubtful Island Bay encompassing the Doubtful Islands and Point Hood;

“legal opinion be obtained on the status of Gordon, St Mary, Fitzgerald, Dempster and Hamersley Inlets and if they are judged to be 'tidal' and therefore excluded from the national park as declared under the Land Act, consideration should be given to reservation of them as marine reserves under the CALM Act and that their management be integrated with that of the national park.”

3.9. Stokes Inlet (Map V-4)

The section of the coast here under consideration is adjacent to the Stokes National Park encompassing Margaret Cove, Dunster Castle Bay and Fanny Cove and includes Torradup and Stokes Inlets. The geomorphological and biological features of the inlets were described by Hodgkin & Clark (1989a) and are summarised here.

Tenure

The national park extends to the low water mark. Stokes Inlet is entirely surrounded by the national park but the extreme upstream part of Torradup Inlet lies beyond the park's northern boundary. As in the case of the inlets enclosed within the Fitzgerald River National Park, there is question whether Torradup and Stokes Inlets are "tidal" and therefore excluded from the national park by the terms of the Land Act.

Geomorphology and hydrology

The repeated sequence of granitic rocky headlands alternating with arcuate beaches backed by Quaternary dunes is represented along the coast of the Stokes National Park by three units. The headlands here are low and not as scenically spectacular as those in the western part of the South Coast. The largest is Shoal Cape at the western end of Fanny Cove. Similar but much smaller headlands form the western ends of Dunster Castle Bay and Margaret Cove. Fanny Cove is moderately protected from ocean swells except during easterly weather.

The southward-pointing toe of the Shoal Cape headland is exposed to heavy wave action on both its western and eastern sides. Its shores are typical of exposed granitic shores with smooth, wave-swept rock slopes.

West of Shoal Cape the shore is beach and Quaternary limestone. For a distance of over 1 km immediately west of the headland the beach is protected from the ocean swells by three parallel, nearshore limestone reefs. The reefs appear to be formed of old beach rock deposits and to represent previous positions of the shore. The two inner reefs break the surface but the top of the outer one is several metres deep. There are deep channels between the three reefs and between the inner reef and the shore. The outer channel has a maximum depth of over 25 m. The inner sides of the reefs are deeply undercut and cavernous and there are underwater scree slopes of limestone slabs. Similar offshore limestone reefs occur further west but are less continuous and provide less protection to the shore.

Torrakup Inlet, formed at the mouth of the Torrakup River, is the most easterly of the South Coast riverine estuaries. It is small, being about 3.5 km long and nowhere more than 200 m wide, with an area of about 0.4 km². Most of the inlet is shallow with marginal sand flats and depths of 2 m in the narrower parts. It always holds water, which may be almost fresh when the river flows and is probably seldom much more salty than sea water. The entrance bar breaks every year but remains open only briefly, for about a week.

Stokes Inlet is the most easterly of the South Coast lagoonal estuaries of moderate size. It is only arguably an estuary. It may be classified as of the lagoonal, semi-permanently closed type. The inlet lies in a deep valley and is fed by the Lort and Young Rivers, both of which are saline. Although the rivers arise in agricultural lands, the lagoon is entirely encompassed by the park. It has an area of about 14 km². It has relatively deep water and is not known to dry out. The entrance channel has a depth of up to 10 m. The entrance sand bar may be as much as 2 m high and breaks infrequently. It remained closed for the thirty year period to 1967 but since then has opened on average at about 5 year intervals. The more frequent opening in recent years appears to relate to the clearing of much of the catchment and the resulting increased flooding. Salinity in Stokes Inlet is rarely less than that of sea water. Even winter flood water is brackish and evaporation in summer may raise the salinity to hypersaline levels. There is some evidence of minor nutrient enrichment derived from the catchment.

Flora and fauna

Very little information is available on the marine flora and fauna of this shore. Inspection of aerial photographs indicates that the gently shelving seabed, especially in the coves, has dense *Posidonia* and *Amphibolis* seagrass beds but little is known of their floristic composition or associated fauna.

The Working Group was given reports from abalone divers and commercial shell collectors that the channels between the limestone reefs west of Shoal Cape are the habitat of an extremely rich and diverse invertebrate and fish fauna. This is consistent with the physical nature of the habitat.

The aquatic biota of Stokes Inlet is impoverished. The seagrass *Ruppia megacarpa*, the stonewort *Lamprothamnium* and the attached green alga *Polyphysa peniculus* are the dominant plants and all may be abundant in suitable water conditions. The suite of obligate estuarine invertebrates normally found in South Coast estuaries is present. In addition a number of marine invader invertebrates have been recorded. A species present in this inlet but not recorded in inlets further west is the inland salt lake snail *Coxiella* sp. Black bream are permanent residents in the inlet but during the years following opening of the bar a number of marine fishes establish there, including Australian herring, pilchard, yelloweye mullet, sea mullet, King George whiting, cobbler, tarwhine and many others.

The aquatic flora and fauna of Torrakup Inlet is even more impoverished than that of Stokes. The only invertebrates recorded (Hodgkin & Clark, 1989a) are the bivalves *Arthritica semen* and *Sanguinolaria biradiata*, a salt lake gastropod *Coxiella* sp, and an unidentified polychaete worm.

Recreation

The Stokes National Park has high scenic qualities but it is remote and as yet it is not a popular tourist destination. Yet the coastal vegetation and scenery is of high quality and fishing in the inlet and on the coast is excellent. Increasing use of the park and the inlet for recreational purposes may be expected in future.

Fanny Cove is used mostly by local people as a camping and fishing location. Boats may be launched there. Although little used at present, the western side of Shoal Cape has considerable potential as a recreational diving site with the protection from the swells provided by the near-shore limestone reefs.

Previous recommendations

None.

Working Group recommendations

The repeated sequence of rocky headland-beach present on this section is representative of the South Coast except that the headlands are low and without high cliffs. The near-shore limestone reefs which are a common feature at the eastern ends of the bays east of Hopetoun are very well represented here. The deep channels between the reefs on the western side of Shoal Cape are a unique feature and undoubtedly provide habitat for a diverse marine flora and fauna. The coast has excellent potential for sightseeing, recreational fishing and diving which would add significantly to the recreational opportunities of the Stokes National Park.

Stokes and Torradup Inlets have high conservation values as representatives of the South Coast semi-permanently closed lagoonal and riverine estuaries. Stokes is the most easterly of the lagoonal inlets of any size. It has relatively deep water and does not dry out. Undoubtedly for that reason, it supports a more diverse aquatic flora and fauna than other estuaries of similar type further west. The inlet has high scenic value and is an important element of the scenic quality of the surrounding national park. It also has considerable value for its recreational fishing.

The Working Group recommends that:

“State coastal waters adjacent to the Stokes National Park, encompassing Margaret Cove, Dunster Castle Bay and Fanny Cove, and including the tidal parts of Stokes Inlet and Torradup Inlet, be considered for reservation as a marine reserve for the purposes of conservation of flora and fauna and public recreation, and managed in conjunction with the national park.”

3.10. Recherche Archipelago (Map V-4)

The Recherche Archipelago is one of the major features of the South Coast, stretching for a distance of more than 200 km and including many islands. The port of Esperance, located in Esperance Bay at the western end of the archipelago, is the district centre.

Tenure

Most of the islands of the archipelago are incorporated in a Class A Nature Reserve (No. 22796). Woody Island in Esperance Bay is a Class B Nature Reserve. Cape Arid National Park and Cape Le Grand National Park include the shores of most of the adjacent mainland. All the nature reserves and the national parks extend to the low water mark. Several of the outer islands lie beyond the State three mile limit (that is three nautical miles from the baseline). They are State territory and therefore each is surrounded by its own area of State waters.

Geomorphology

The islands of the archipelago represent the high points of the Proterozoic land surface (Albany-Frazer Oregon) now flooded by the ocean. Most of the islands are exposed to high or moderate wave action from all directions and there are few safe anchorages or landings. In form and character the islands resemble the granitic headlands of the mainland coast. Their high rocky promontories have smooth, steep sides sloping into the sea in the most exposed areas. More sheltered shores have boulders and tide pools. Between some of the headlands there are arcuate beaches backed by low dunes or granite hill slopes.

The depth of the sea floor within the archipelago averages about 40 m. Most of the islands are within the 50 m bathymetric contour although the outer islands rise from depths of 70 m or more. Typically the rocky shores are steep-to with an abrupt change in substrate where the rock slopes meet the sandy floor. There are many vertical rock walls in the sublittoral zone.

Flora and fauna

The only studies of the marine flora and fauna of the archipelago were published over 30 years ago by members of the Australian Geographical Society Expedition. There is little other information available. Inspection of aerial photographs indicates that there are extensive seagrass beds in the bays but there is no information on their floristic composition and associated flora and fauna. *Posidonia sinuosa* has been collected from individual clumps as deep as 47 m in the Archipelago.

Recreational divers and commercial abalone divers and shell collectors have informed the Working Group that the upper parts of the rock slopes, that is above about 20 m, are dominated by macrophytic algae but below that depth there are spectacular growths of attached invertebrates, most notably sponges and coelenterates. Fish communities are very diverse and even the vulnerable residential species like Blue Groper and Queen Snapper are abundant.

Many of the islands and emergent rocks in the archipelago are haul-out sites and breeding colonies of Australian Sea Lions and New Zealand Fur Seals. The breeding colonies include the largest in the State for both species. There are also important nesting areas for the Little Penguin on several of the islands.

Fisheries

The lower rock slopes of the islands are an important Zone I area for the greenlip and brownlip abalone which are fished commercially.

Gummy shark, and to a lesser extent whiskery shark and dusky shark (bronze whaler), are extensively fished by demersal gillnet and longline in these waters. The waters of the archipelago also support a large proportion of the fishery for the southern rock lobster. A small demersal trawl fishery for saucer scallops also operates seasonally within the area. There is a regionally important, developing, purse-seine fishery for pilchard.

Recreation

Because of the remoteness of these islands, the paucity of safe anchorages and the difficulty of landing ashore, they are not well suited for recreational use. With one exception they are reserved exclusively for nature conservation and, although landing is not prohibited, camping on the islands is approved only for special purposes. The exception is Woody Island where shore accommodation is available. Nevertheless, the waters around the islands provide excellent opportunities for fishing and quite spectacular sites for diving and the archipelago is becoming increasingly used for those purposes, including commercial dive tours.

Previous recommendations

None.

Working Group recommendations

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 conservation of flora and fauna and public recreation.”

3.11. Twilight Cove (Map V-5)

The section of the coast considered here takes in the western shores of the Great Australian Bight, extending approximately 50 km east and west of Twilight Cove.

Tenure

The adjacent coast is a Class A Nature Reserve (No. 27632) which extends to the low tide mark.

Geomorphology

Geologically the area lies within the Eucla Basin and straddles the two major coastal types characteristic of the shores of that sedimentary basin. In the east the shore is beach backed by high, often mobile Pleistocene dunes, including the Eyre Sandpatch. In the west the shore is formed by the Baxter Cliffs, high limestone cliffs with narrow, limestone rock platforms, boulder fields or narrow beaches at their base. They are similar to the Nullarbor Cliffs on the South Australian side of the border. The sea floor along this stretch of coast is gently shelving and relatively featureless.

Flora and fauna

There is very little information about the marine flora and fauna of this area. Inspection of aerial photographs indicates that there are extensive seagrass beds off the beach, protected by coastal limestone reefs. The seagrass meadows consist mainly of *Amphibolis* but their associated fauna has not been determined. Nothing is known of the rocky shore biota along the base of the Baxter Cliffs.

The Little Penguin has been reported nesting at sites along the coast in the vicinity of Twilight Cove, the only mainland breeding area known for this species in Western Australia. There have also been reports of a breeding colony of the Australian Sea Lion on rocks at the base of the Baxter Cliffs (pers. comm. B. Haberley). The colony is small but it too is the only record of the species breeding on the mainland.

Fisheries

No significant use is made by commercial fishers of this area. The shallow coastal limestone reefs and seagrass beds between Twilight Cove and Eucla are currently being considered as a protected nursery area for the commercially important gummy shark.

Recreation

This is a very remote part of the coast with limited access. It is used only rarely by sight-seers and recreational fishers.

Previous recommendations

None. However, it should be noted that the South Australian Government has proposed the establishment of a marine reserve at the Head of the Bight extending as far west as the Western Australian border.

Working Group recommendations

This section of the coast is selected for consideration by the Working Group because it represents the two coastal types characteristic of the shores of the Eucla Basin and not because it has any known special conservation or recreation values. The Working Group recommends that:

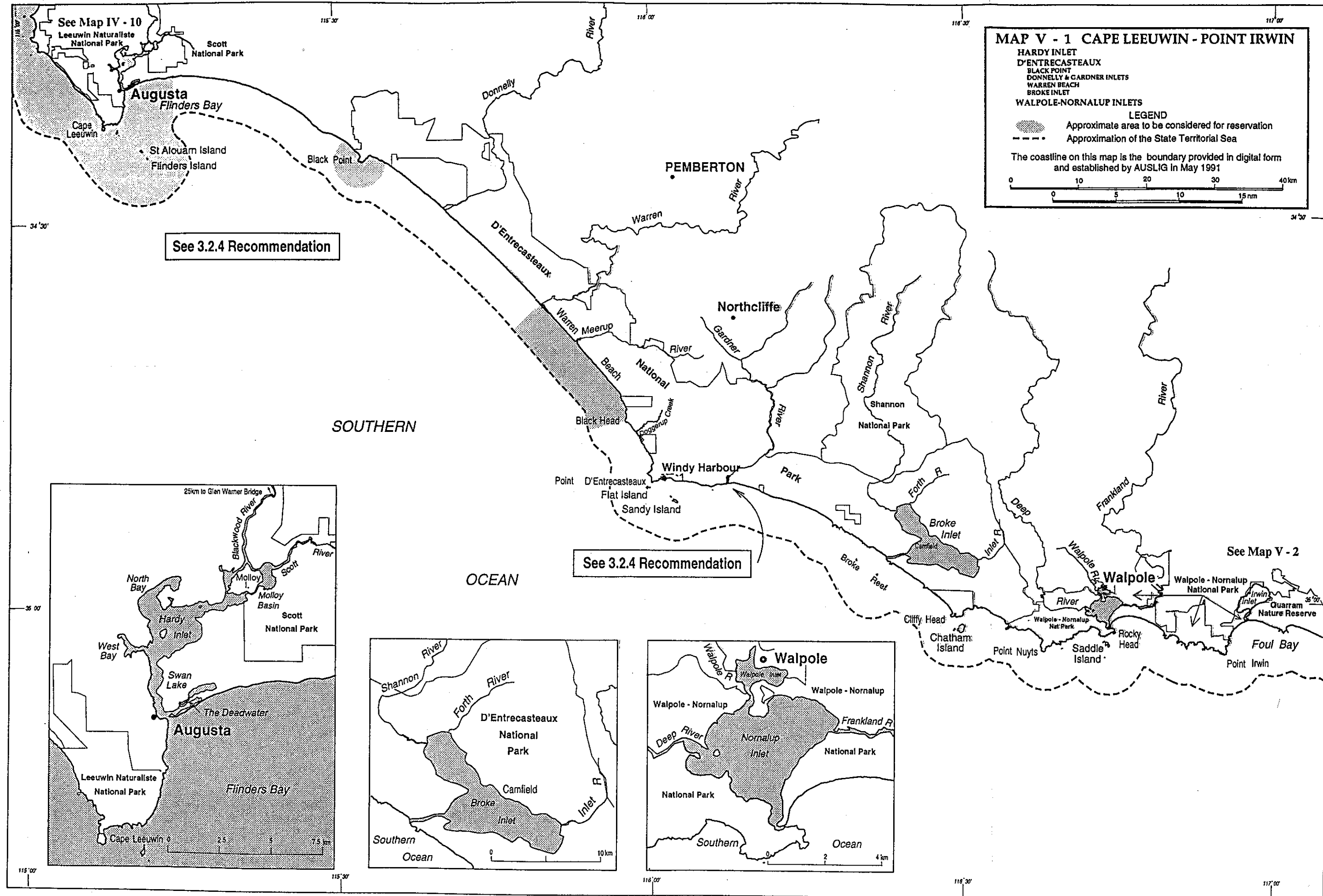
“a survey of the coast between about 50 km east and west of Twilight Cove should be conducted to assess the value of the area as a marine reserve for the protection of marine flora and fauna and coastal landforms.”

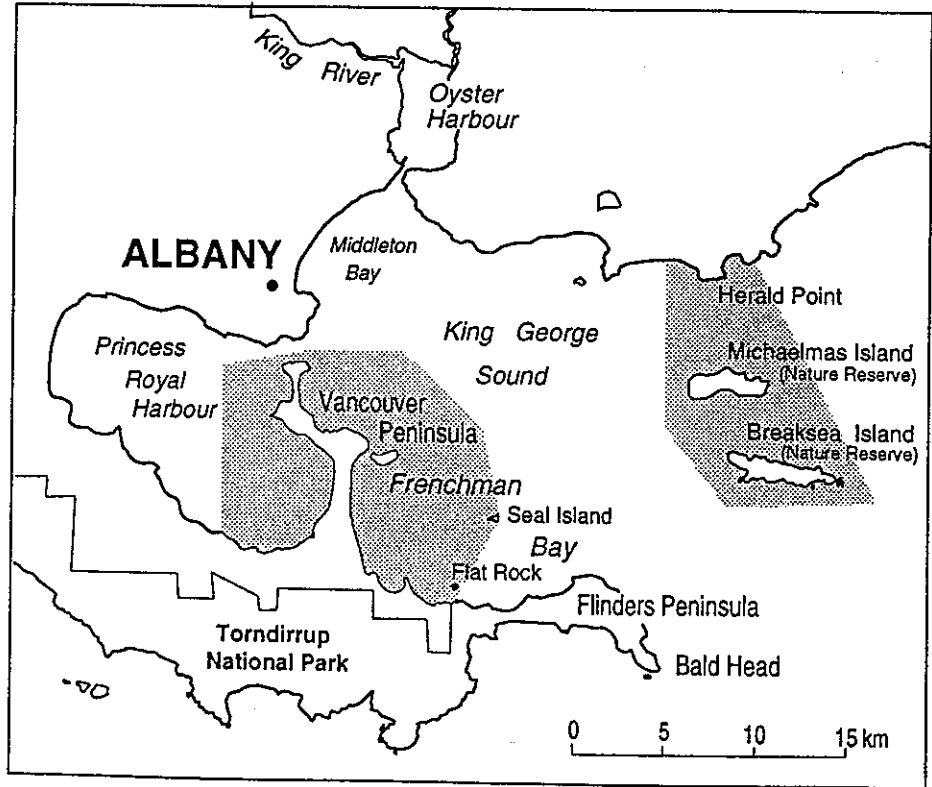
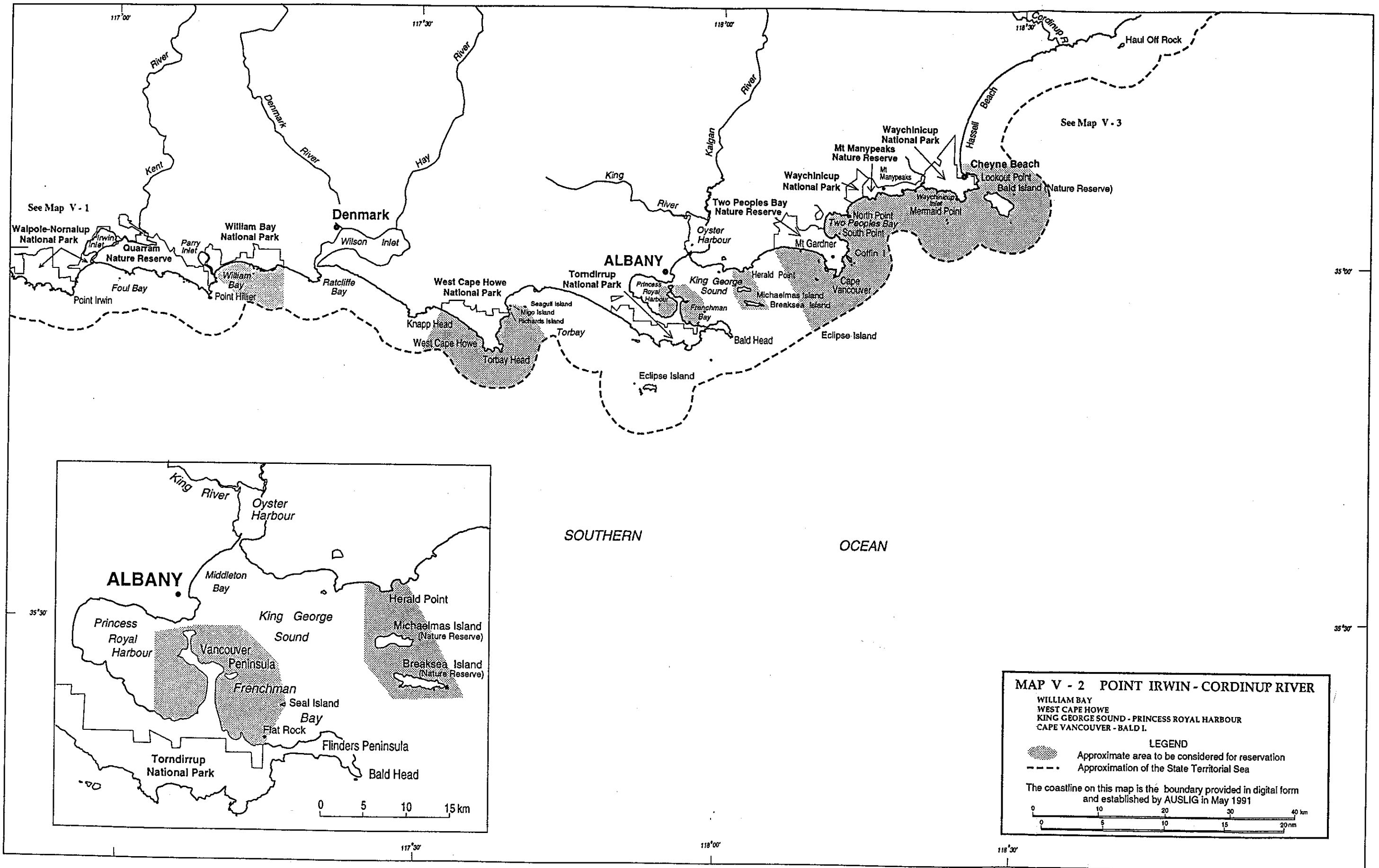
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MAP V - 2 POINT IRWIN - CORDINUP RIVER

WILLIAM BAY
WEST CAPE HOWE
KING GEORGE SOUND - PRINCESS ROYAL HARBOUR
CAPE VANCOUVER - BALD I.

LEGEND

- Approximate area to be considered for reservation
- Approximation of the State Territorial Sea



The coastline on this map is the boundary provided in digital form and established by AUSLIG in May 1991

0 10 20 30 40 km
0 5 10 15 20 nm

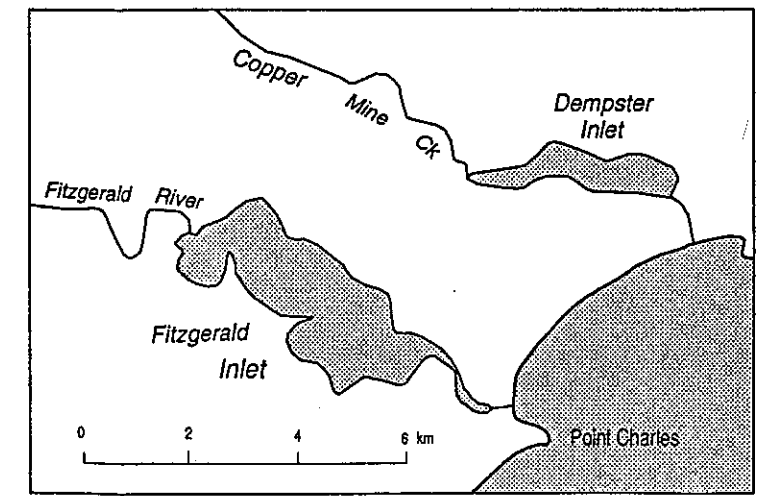
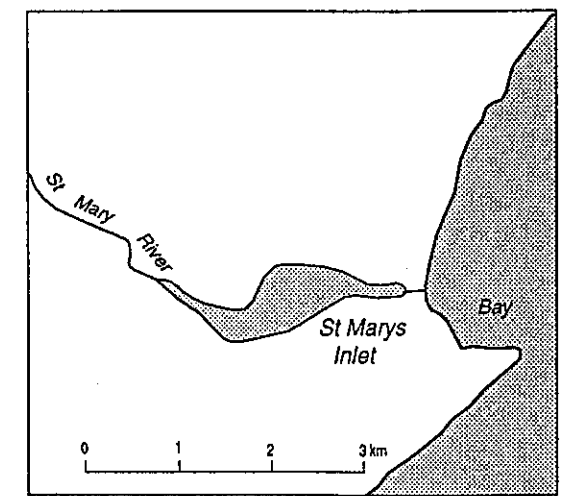
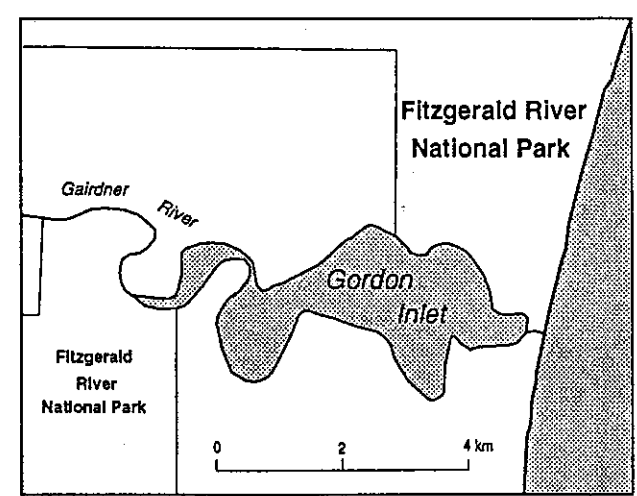
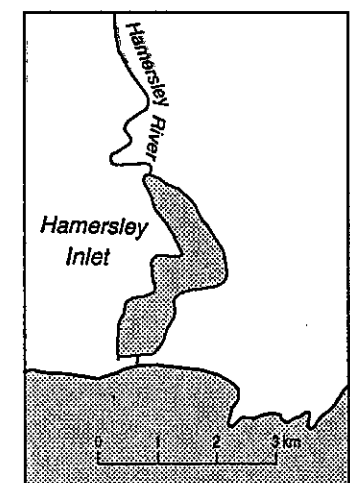
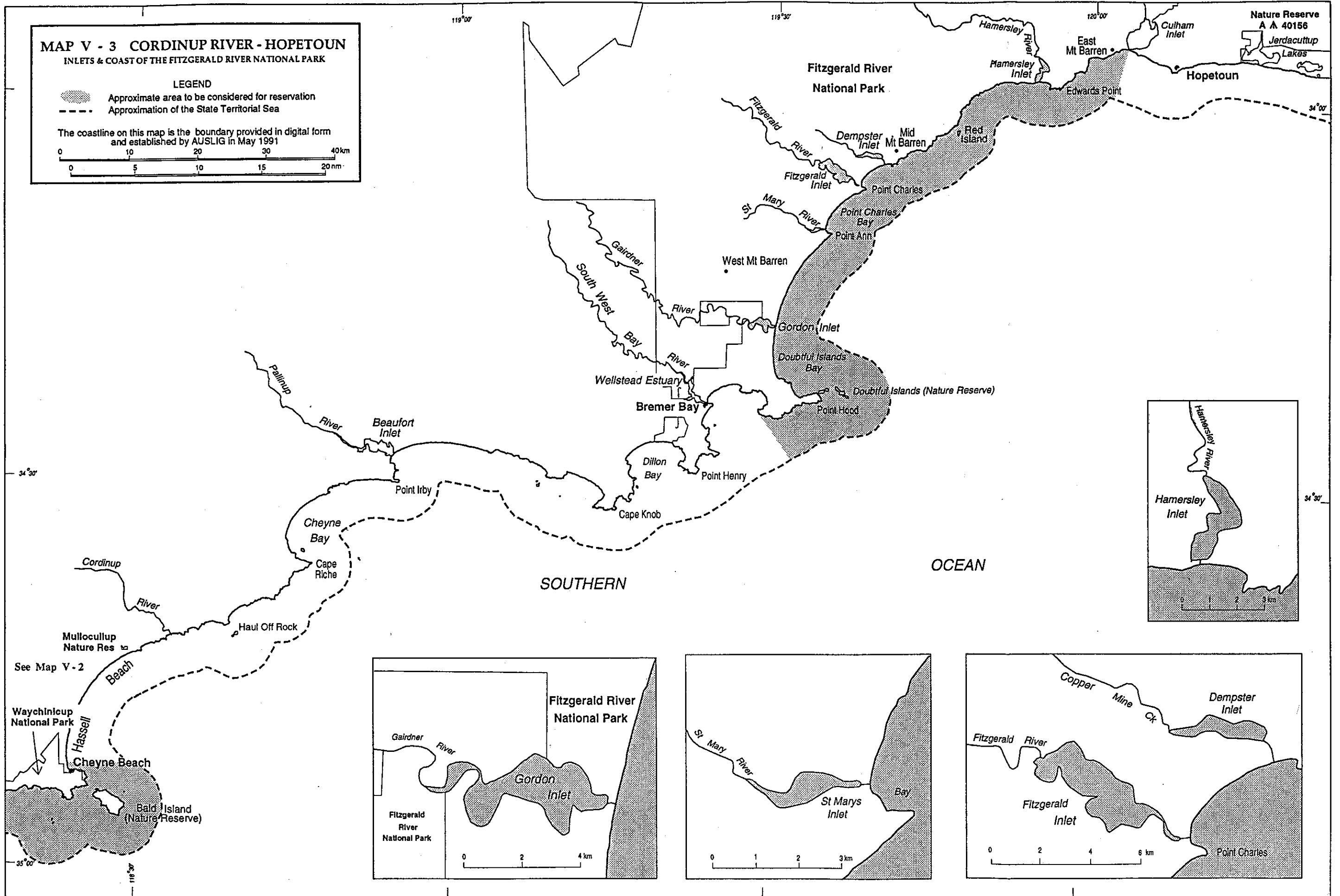
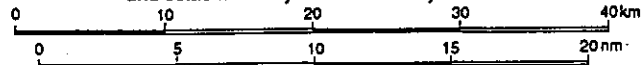
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MAP V - 3 CORDINUP RIVER - HOPETOUN
INLETS & COAST OF THE FITZGERALD RIVER NATIONAL PARK

LEGEND



-  Approximate area to be considered for reservation
-  Approximation of the State Territorial Sea

The coastline on this map is the boundary provided in digital form and established by AUSLIG in May 1991

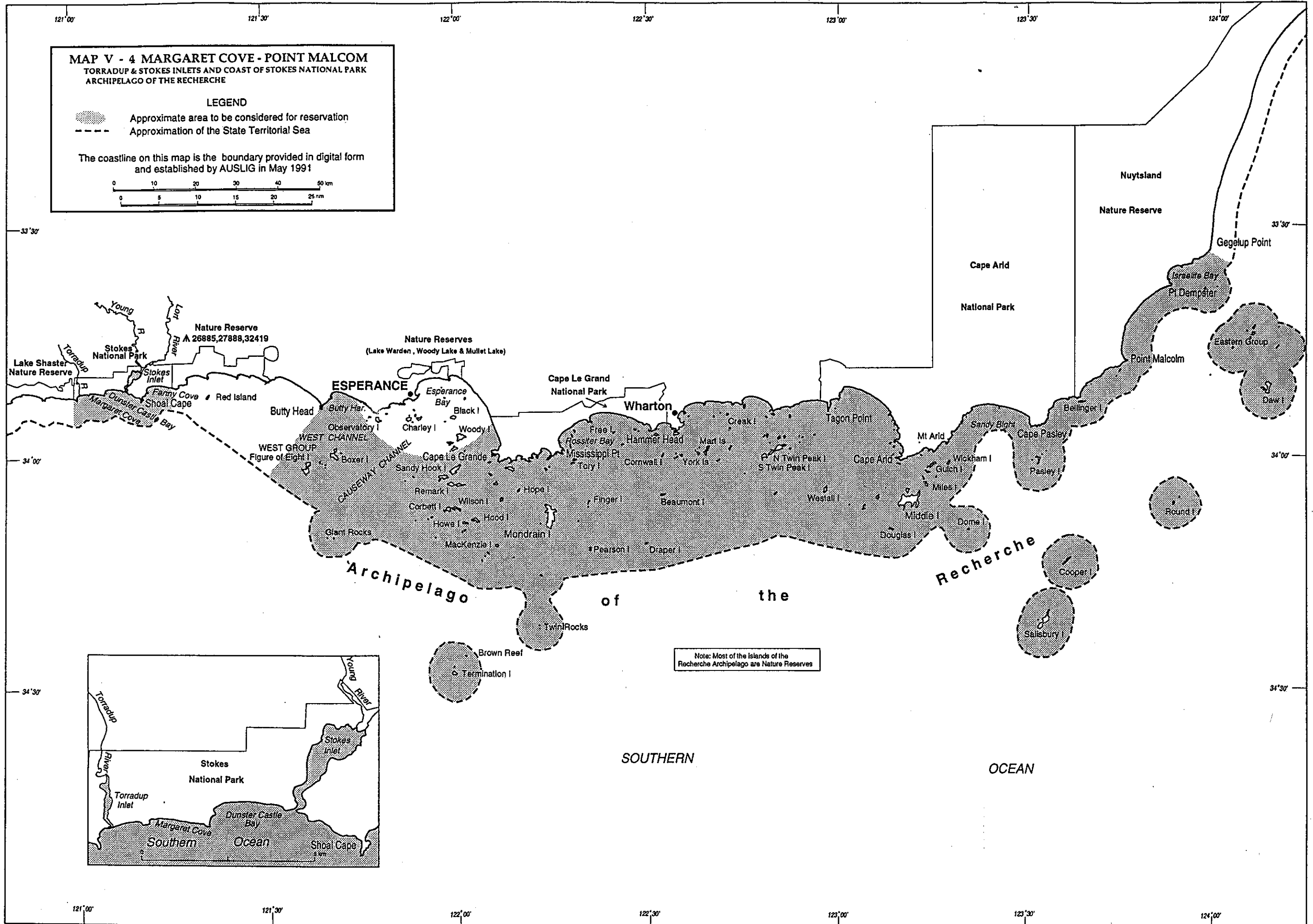
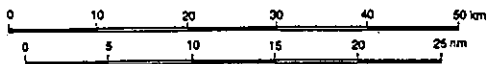


MAP V - 4 MARGARET COVE - POINT MALCOM
 TORRADUP & STOKES INLETS AND COAST OF STOKES NATIONAL PARK
 ARCHIPELAGO OF THE RECHERCHE

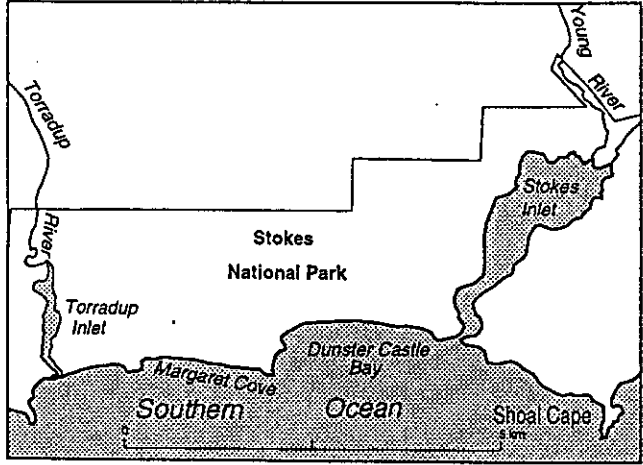
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-  Approximate area to be considered for reservation
-  Approximation of the State Territorial Sea

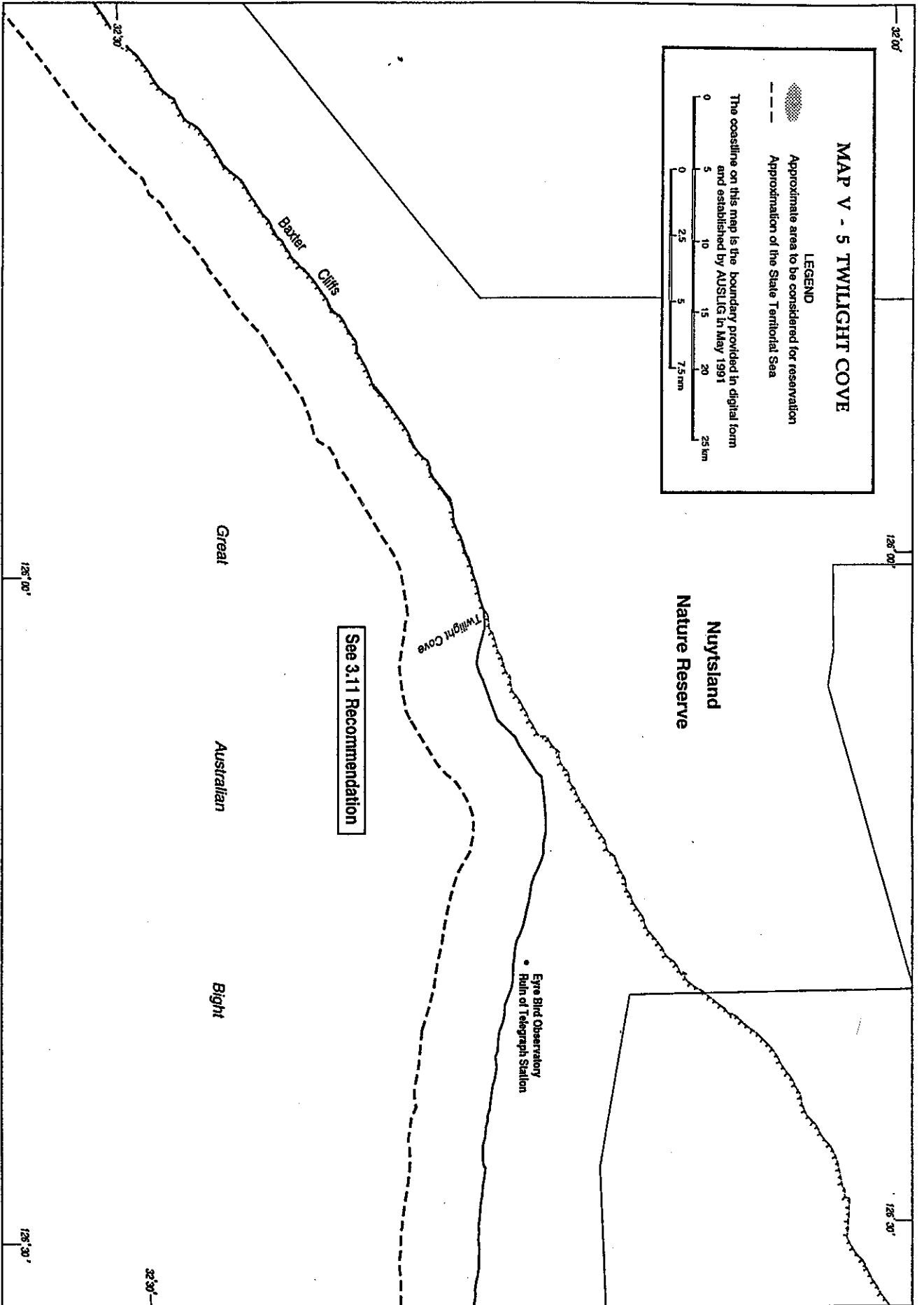
The coastline on this map is the boundary provided in digital form and established by AUSLIG in May 1991



Note: Most of the islands of the Recherche Archipelago are Nature Reserves



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APPENDIX III

A REVIEW OF MARINE MAMMALS

**South Coast Terrestrial and Marine Reserve
Integration Study**

A Review of Marine Mammals

Heidi Oswald
CALM Volunteer

February 1997

Marine Conservation Branch
Department of Conservation and Land Management
47 Henry St

Fremantle, Western Australia, 6160

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1. INTRODUCTION

This report presents the results of an extensive review of the marine mammals of the south coast of Western Australia, carried out as part of the South Coast Terrestrial and Marine Reserve Integration Study. This review collates information available for pinnipeds and cetaceans across the study area (Broke Inlet to Israelite Bay), reviews research undertaken on the New Zealand fur seals, Australian sea lion and southern right whale populations, and lists inventories of species distribution and stranding events. This information has been compiled mainly through literature searches, a review of all published material and examination of CALM South Coast Region data from marine mammal censuses and stranding events and sightings records.

2. PINNIPEDS

2.1 New Zealand Fur Seal (*Arctocephalus forsteri*)

In 1953, an expedition to the Recherche Archipelago noted only one party of 50 adult New Zealand fur seals, on Salisbury Island (Serventy, 1953). Surveys carried out in 1974 to 1977 suggested that fur seals distribution and abundance had contracted. The total New Zealand fur seal population of Western Australia was estimated at 400 to 500 animals (Abbott, 1979). In May 1979, Salisbury Island was classified as a Class A reserve in the Recherche Archipelago Nature Reserve, under the Western Australian Wildlife Authority. A 1982 biological survey of the island counted 500 New Zealand fur seals, of which 70% were pups. The colony was estimated to consist of approximately 1,000 animals, making it the largest known breeding colony of this species in Western Australia (Anon, 1982).

Increasing numbers of New Zealand fur seals were recorded in 1982 on a rocky outcrop 300m south of Flinders Island, 8km south east of Cape Leeuwin. This represents the first recorded sighting of this species in this area since Irwin in 1832 and Clark in 1842. The first sighting of seals in the Cape Leeuwin area was in July 1982. This group of animals consisted primarily of sub-adults with several adult females and young bulls but there was no evidence of any breeding activity (Gales & Lambert, 1985).

In the summer of 1989-1990, Shaughnessy carried out a survey of the distribution and abundance of New Zealand fur seals from Eclipse Island near Albany across to the eastern group of the Recherche Archipelago (Shaughnessy, 1990). It was discovered that fur seals haulout on many islands and breed on a total of 13 islands. Eighty-five percent of fur seals sighted during the survey were on these 13 islands and 11% were on another five important haulout (non-breeding) islands. The population size for Western Australia was estimated at 4,600 animals, two thirds of which are from three colonies (Salisbury Island, Seal Rock and Cooper Island) in the Recherche Archipelago (Shaughnessy, 1990).

Another survey was conducted in the Recherche Archipelago soon after the pupping season of summer 1990-1991 (Shaughnessy, 1991). A total of 16 islands were visited and fur seals were recorded on nine of these islands. Individual counts were made for West Island, Libke Island, Finger Island and Draper Island and these latter two islands were confirmed as breeding colonies. As expected breeding activity had ceased by the time the survey was conducted in early February. At Finger Island during July 1990 approximately 40 small animals were seen which were judged to be less than one year old. A few of these were still nursing. It is likely that most of these animals came from nearby colonies (Beaumont and Draper) since the pup production on Finger Island is so small. Paisley Island appears to be a haulout site only (Shaughnessy, 1991).

This survey added three additional fur seal colonies - Libke, Finger and Draper Islands - to the 13 colonies in Western Australia visited in the 1989-1990 breeding season. The three newly discovered colonies account for 192 pups. Of these three colonies, the one on Libke Island is substantial, ranking third in size in Western Australia behind Salisbury Island and Seal Rock. Maximum pup numbers for all sixteen colonies total 1,434 pups, an increase of 274 on the total of pups for 1989-1990 season (Shaughnessy, 1991).

On 14 February 1991 the bulk carrier vessel Sanko Harvest ran aground and sank on a reef midway between Hood and Hastings Islands in the Recherche Archipelago. A quantity of bunker oil was released from the wreck and washed ashore onto Hood Island, Seal Rock and nearby islands. Clean-up crews were sent to Seal Rock and Hood Island to remove oil from fur seal pups. A report on the Sanko Harvest clean up operations was made by Gales (1991). At the time of the oil spill pups were aged between two weeks and two months and these were the

only age class of seal contaminated. Thirty nine pups on Hood Island and up to 172 pups on Seal Rocks were contaminated. All affected pups were captured and restrained in pens while the oil was removed from the fur seals pelage. Fouling of this pelage with oil leads to thermoregulation and energetic imbalance, the insulative value to the pelt being reduced by as much as 50%. The degree of oil-fouling of the fur seal pups on Seal Rocks was less than those from Hood Island. Clinical assessment of contaminated fur seals during the clean-up operation gave little indication of significant, acute toxicology. Furthermore, analysis of haematology and blood biochemistry reflected mainly a general physiological stress rather than significant, systematic, toxic challenge (Gales, 1991).

In 1994 a survey was conducted to determine the distribution and abundance of New Zealand fur seals in South Australian and Western Australian waters (Shaughnessy *et al.*, 1994). Pups were counted and in more accessible and larger colonies, numbers of pups were estimated by a mark-recapture technique. The latter technique gave higher estimates than counting and was considered more accurate. The Western Australia survey covered islands on the south coast, from the Recherche Archipelago to islands near Cape Leeuwin (Tables 1 & 2). There were 29 breeding localities in total, 13 in South Australia and 16 in Western Australia. Eighteen of these had not been reported previously. Estimates of the number of pups for the 1989-1990 breeding season were 5,636 in South Australia and 1,429 in Western Australia. This leads to a population estimate of approximately 34,600 seals in these two states (multiplier of 4.9). Most of the population, 77 %, is in central South Australian waters (Kangaroo Island to the southern end of Eyre Peninsula). One fifth of the pup population is found in colonies on Kangaroo Island and nearby Casuarinas (Shaughnessy *et al.*, 1994).

In conclusion, Shaughnessy found the New Zealand fur seal population in Australian waters to be 34,600 and rising (Deeker, 1994). Most of the surveys took place in late January or early February, when large adult males are out of the way. The total population size is then calculated from pup numbers, although adjustment must be made for whether the populations are decreasing, increasing or steady, since the proportion of pups to adults varies accordingly. In February 1992 Libke Island had 240 pups, making it the second largest colony in Western Australia (Deeker, 1994).

In 1994 a report was released on the breeding biology and haul-out pattern of the New Zealand fur seals at Cape Gantheaume in South Australia (Goldsworthy & Shaughnessy, 1994). In 1988-1989, pups were born between late November and mid-January, 90% of them over 34 days between 3 December and 6 January. Re-analysis of data from three breeding seasons at the Open Bay Islands (South Island, New Zealand) indicates that the breeding season at Cape Gantheaume occurs 3-5 days later than at the Open Bay Islands. In addition, the timing and duration of the pupping season varied with the Cape Gantheaume colony, it being later in recently colonised areas. It is suggested that this pattern is a consequence of changes in the age distribution of females through the colony (Goldsworthy & Shaughnessy, 1994). In 1995 a survey was carried out to investigate the changes in the abundance of New Zealand fur seals on Kangaroo Island in South Australia. At three colonies pup numbers had increased. The rates of increase in the first two colonies were similar to those at the most rapidly increasing fur seal populations in the southern hemisphere. As space does not appear to be limiting in these colonies, fur seal numbers may continue to increase at these sites (Shaughnessy *et al.*, 1995).

2.2 Australian Sea Lion (*Neophoca cinerea*)

In 1953 an expedition to the Recherche Archipelago discovered Australian sea lions on several of the islands, including Figure of Eight, Boxer, Mondrain, Termination, Round, Wedge, Combe, Goose, Douglas, Salisbury, Christmas and Thomas Islands. The largest colony of 65 animals was found on Christmas Island followed by a colony of 40 animals on Wedge Island (Serventy, 1953).

A review of the past and present distribution and status of sea lions and fur seals in Western Australia was carried out in 1979 (Abbott, 1979). It was found, when comparing the distribution and abundance of seals in Western Australia from accounts by early navigators and colonists with records from surveys in 1974-75, that the fur seal population had declined in distribution and abundance, whereas the Australian sea lion population had declined only in abundance. The total population size of Australian sea lions in Western Australia was estimated to be approximately 700 animals (Abbott, 1979).

In 1982 a biological survey was carried out on Salisbury Island in the Recherche Archipelago. The island was found to support a breeding colony of Australian sea lions. Between 30 and 40 animals were sighted on the island, including 2 pups. The animals, single and in groups, were basking and resting all around the island up

to 300m from the sea and 50m above sea level (Anon, 1982). In 1989-1990 the first survey of fur seals and sea lion populations in Western Australia and South Australia was undertaken. The survey found several new breeding locations in the Recherche Archipelago. It was realised that an estimate of pup numbers would not be possible until the survey is repeated, possibly twice, to enable pups on all breeding islands to be counted (Shaughnessy & Gales, 1990).

A survey carried out in 1989-1990 established the abundance of Australian sea lions in Western Australia (Gales, 1990). A total of 13 islands along the south coast were found to support breeding populations. A further 16 islands were listed as possible breeding sites. An estimate of the total number of pups born on south coast islands confirmed as breeding sites was 429. Including a further 180 pups that were estimated to be born on the west coast of Western Australia, the state pup production each 1.5 years was estimated as 609 for 1990. The predictive multiplication factor used for this estimate was 5.09 times the pup production. Therefore, the estimate for total population size in Western Australia was 3,100, which represents the first attempt to provide an accurate documentation of the population size of *N. cinerea*. Previous studies have indicated that the breeding seasons are asynchronous between island locations. There is no seasonal, longitudinal or latitudinal pattern to this asynchrony. The pupping season lasts 4-5 months on each island. Surveys were conducted every six months for three consecutive surveys. With the exceptions of *N. cinerea* colonies at The Pages, Kangaroo Island and Dangerous Reef in South Australia, all island pupping sites have been found to support relatively small populations, all producing less than 100 pups per season, and most producing less than 50 (Gales, 1990).

In 1991 a study was made on the milk composition of Australian sea lions and the variability in lipid content. The data was consistent with the general pattern for otariid seals. Species which make short trips to sea and have long periods of pup dependency tend to have relatively low fat milk. For example, *N. cinerea* females typically spend 1.5-2.5 days at sea and produce milk that is 25% lipid, on average. In contrast, polar species which must travel farther to foraging grounds and leave their pups fasting onshore for extended periods have milk with higher fat content (Kretzmann *et al.*, 1991).

A 1992 survey of the breeding biology and movements of the Australian sea lion off the west coast of Western Australia revealed that on islands in this region the Australian sea lion has a 17-18 month breeding cycle. Buller Island, North Fisherman Island and Beagle Island are the main pupping sites, with several very small colonies ($n > 3$) at the Abrolhos Islands. The 4-5 month pupping seasons are synchronised at North Fisherman and Beagle Island, but the sea lions from Buller Island breed one month later (Gales *et al.*, 1992). Also in 1992, a survey was carried out on the diet composition of the Australian sea lion using scat analysis. This research tested the validity of using identifiable prey remains in scats to quantify the diet by analysis of scats from free-ranging sea lions and feeding trials on captive sea lions. Identifiable remains in the scats of free-ranging animals occurred infrequently. These limited data, combined with analysis of contents of five stomachs indicated that the sea lions have a broad diet and feed on some benthic species. Feeding trials on two captive sea lions demonstrated that scats were not representative of the diet (Gales & Cheal, 1992).

The non-annual, non-seasonal breeding cycle of the Australian sea lion was investigated by Higgins (1993). A population of sea lions was found to have a breeding cycle of 17.6 months with a pupping period of 5 months. Comparison of these data to census data collected since 1973 showed that breeding events shift forward in time, 13.8 days earlier, every 18 months. Linked with the extended breeding cycle is a prolonged period of lactation. The females at Seal Bay in South Australia suckle their pups for 15-18 months with an average weaning time of 26 days before the birth of the next pup. The necessity of a long breeding cycle possibly relates to survival of pups. However, it is interesting that Australian Sea lion pups do not grow at a significantly slower rate than other otariids, given that the breeding cycle is 17-18 months long (Higgins, 1993).

Gales *et al.* (1994) produced a summary report on the distribution, abundance and breeding cycle of the Australian sea lion. Surveys were conducted throughout the sea lion's range between December 1987 and February 1992. Sea lions were found to breed on at least 50 islands, 27 in Western Australia and 23 in South Australia (Table 3). Of the 50 breeding sites, 31 had not been reported previously. A further 19 islands may also support breeding colonies. A total of 1,941 pups were counted and pup production was estimated at 2,432. Only five colonies produced more than 100 pups each and they accounted for almost half of the pup production. Most of these colonies are near Kangaroo Island, South Australia. A predictive model was developed to estimate the population size from pup production figures. It indicates that pup numbers should be multiplied by a factor of 3.81 and 4.81 to estimate the total population size just before the pupping season begins. This results in estimates of 9,300-11,700 for the total population, considerably greater than earlier estimates. Causes of the

unique 17-18 month asynchronous reproductive cycle of *N. cinerea* are unknown, but it is hypothesised that it results from living in a temperate climate in some of the most biologically depauperate waters of the world. It is also clear that day length and water temperature cannot act as exogenous cues for the implantation of the blastocyst; the physiological events of gestation must, rather, be cued endogenously (Gales *et al.*, 1994).

Although there is no clear pattern of site selection for pupping on the south coast, an important criterion is the existence of protected shallow pools in which pups congregate and presumably learn to swim (Bennett, 1996/97). Sea lions, unlike New Zealand fur seals, do not like to breed on exposed rocky headlands. Sea lions breed on at least 27 islands in Western Australia. The shallow, on-shelf waters frequented by the sea lion yield a limited diet of crayfish, squid, cuttlefish, octopus, small shark and fish. The New Zealand fur seal, which ventures further from the coast into deeper waters off the continental shelf, has access to a more plentiful food supply. This may help to explain why the New Zealand fur seal can sustain an annual breeding cycle while the sea lion cannot. The sea lion may be exercising adaptations evolved over thousands of years to survive in one of the most nutrient poor environments in the world, each aimed at minimising the food requirements of the population as a whole. For example, a wide distribution of small colonies minimises competition for a limited food supply. Other adaptations that may serve this survival strategy include:

- an 18 month breeding cycle;
- extended lactation and lower energy milk compared with other otariids;
- a five to seven month breeding season; and
- an asynchronous breeding cycle (neither seasonally nor graphically dependent).

The Australian sea lion's extended gestation might result from an unusually long delay between fertilisation and the first stage of embryo development (implantation of the blastocyst). Thus this species actually has a prolonged placental gestation of 14 months, much longer than in any other pinniped (Bennett, 1996/97).

2.3 Diseases

Tuberculosis was diagnosed in three otariid seals found dead along the south coast of Western Australia between May 1990 and March 1991. This confirms that tuberculosis is present in the both New Zealand fur seals and Australian sea lions. Since the disease has been found in these two species over a period of 10 years, it is believed that tuberculosis is endemic in these species (Cousins *et al.*, 1993).

2.4 Strandings

A number of pinniped strandings and sightings across the south coast region have been recorded by CALM Wildlife officers from the Albany and Esperance Districts in the last five years. These are listed in Table 4.

2.5 Other Species

Of the 34 different species of pinnipeds in the world, 11 occur in the Australian and Australian Antarctic regions (King, 1988) and could be expected to be found in coastal waters along the south coast. These are:

OTARIIDAE

Australian sea lion	<i>Neophoca cinerea</i>
New Zealand sea lion	<i>Phocarctos hookeri</i>
Australian fur seal	<i>Arctocephalus pusilli doriferus</i>
New Zealand fur seal	<i>Arctocephalus tropicalis</i>
Antarctic fur seal	<i>Arctocephalus gazella</i>

PHOCIDAE

Southern elephant seal	<i>Mirounga leonina</i>
Leopard seal	<i>Hydrurga leptonyx</i>
Weddell seal	<i>Leptonychotes weddelli</i>
Crab-eater seal	<i>Lobodon carcinophagus</i>
Ross seal	<i>Ommatophoca rossi</i>

2.6 Recommendations

Breeding populations of *N. cinerea* are highly susceptible to disturbance. This is particularly true during the pupping season. Disturbance at this time can lead to an increase in pup mortality and can also be dangerous to humans who enter such an area. Whilst the isolation of the small offshore islands where sea lions breed has afforded some degree of protection to the animals, they remain vulnerable to malicious or innocent disturbance. Typically, sea lions breed in the protected areas of these islands where people most often come ashore. The most straightforward method of protecting the colonies is to give them a prohibited area status by establishing key islands as nature reserves. The high frequency of observations of entangled and drowned sea lions in cray pots in Western Australia indicates that some protection is also required for this species in the waters surrounding the breeding and haul-out sites. The creation of marine reserves is a possible a management strategy that should be considered. In the meantime activities such as shark netting very close to major breeding locations and baiting the water to attract sharks close to sea lion colonies should be prohibited (Gales, 1990).

Hauloff Rock, situated between Albany and Bremer Bay, supports breeding colonies of both New Zealand fur seals and Australian sea lions. It is also the nearest recorded breeding site of Australian sea lions in the vicinity of Albany and is the most westerly island along the south coast of Western Australia where the Cape Barren goose occurs (Shaughnessy P.D. & Collins P. pers. comm.). Hauloff Rock is vacant crown land and should be considered for protection as a nature reserve. Consideration should also be given to reservation of the surrounding waters as a part of a representative system of marine reserves along the south coast.

3. CETACEANS

Australia's government policy regarding the preservation and protection of cetaceans is embodied in the *Whale Protection Act 1980*. The Act prohibits the killing, injuring, capturing or harassment of cetaceans within the Australian Fishing Zone, from three nautical miles offshore to the 200 nautical mile limit. State regulation is enforced within three nautical miles of the shoreline (Kaufman *et al.*, 1993).

A total of 35 cetacean species have been recorded off Western Australia, which is more than 80% of the 43 species found in or close to Australian waters. Two whales especially significant in the State's history since European settlement have been the Southern right whale and the Humpback whale. These two species are both baleen whales. In the southern hemisphere they feed almost exclusively on small shrimps close to the sea surface, known as krill. They gather their food by literally sieving it from the sea through a set of fringed horny plates known as baleen (Bannister, 1994a).

3.1 Humpback Whale (*Megaptera novaeangliae*)

Bannister (1994a) presents a summary of the studies of the humpback and southern right whale populations off Western Australia. There are three different breeding populations of humpbacks in the Australasian region. There is the population off Western Australia, the Australian east coast, and north of New Zealand. Those breeding off New Zealand and off eastern Australia are more closely related to each other than those off Western Australia. Humpback whales have a maximum length of approximately 16 metres and weigh around 45 tonnes. As with all baleen whales, the female is a little larger than the male and they can live for more than 50 years. Humpbacks mate and give birth in tropical waters from June to November in the southern hemisphere, where the water temperature is approximately more than 25 degrees. Calves are then born 11 months after mating and weaned after a further 11 months. Most whales flippers are short and paddle-like, usually mostly for steering and maintaining stability in water. The humpback's flippers are long and oar-like, up to one third of the body length and remarkably mobile, they may be used to row the animal through the water and sometimes waved about at the surface. The humpback's blow is distinctive, rising in a single bushy cloud up to 3m. When migrating the humpback will blow once every minute approximately five times and then dive for 15 minutes. The humpback has a distinctive behaviour - they breach clear of the water, they 'lobtail' where their tail or flipper slaps the water and they 'spyhop' where they bring their head out of the water and look around.

In 1976 a series of aerial surveys was initiated after a number of sightings were reported. Comparing the sighting rates with those in 1963, when the population may have been little more than 600, the population numbers were at least 3,000 in 1994 (Bannister, 1994a). In 1994 a report on the aerial survey and photoidentification of humpbacks was produced (Bannister, 1994b). The survey was carried out in the Shark

Bay area to provide information on the Southern Hemisphere Group IV population. Photoidentification has been carried out since 1982 to provide information on stock identity, migrations, distribution and reproductive biology of individually identified animals from the Group IV population. The total number of humpbacks were 595 animals in 287 pods, which is by far the greatest number recorded so far. In 1991, 283 animals were recorded in 115 pods, and in 1988 170 animals were recorded in 76 pods. Ninety-two percent of all sightings occurred as single animals, pairs or threes. Eighty-nine percent of the pods were recorded heading north, or with a mainly northward component. When analysing the results of this survey and previous surveys, a significant increase in population numbers may be seen. The minimum figure for the net annual rate of increase was calculated to be approximately $10.0\% \pm 4.6\%$ (Bannister, 1994b).

In conclusion, the humpback whale does not seem to have particular areas of higher concentration, although it has been reported more frequently as numbers increase. The humpback whale is expected off the south coast on its northern migration, between May and August, from summer feeding grounds in the Antarctic to their winter breeding grounds off northern Western Australia. Animals are unlikely to stay for long in any particular south coast locality, although there have been recent reports of animals been seen in Albany for some time (Bannister J., pers. comm.).

3.2 Southern Right Whale (*Eubalaena australis*)

The southern right whale received its name as it was known to be the 'right' whale to catch, as it was easily approached in open boats, did not sink when dead, and had greater quantities of oil and whale bone. The species is bulky and slow moving, it grows up to 17.5m long and weighs around 80 tonnes. Females are sexually mature at 9 to 10 years and have one calf approximately every 3 years. Southern right whales, like other baleen whales, are presumed to live up to 50 years or more. They feed in colder waters and migrate to warmer waters, but their movements are not as large scale or well defined as for humpback whales. In winter and spring they can be found close inshore along the coast of Southern Australia. They are often seen first as single animals which may be accompanied soon after by a small calf. Most visitors are adult females, coming in to give birth and suckle their young close to the coast. Southern right whales can be seen often between Albany in Western Australia and Ceduna in South Australia. Some places are more favoured than others, for example, Doubtful Island Bay (particularly near Point Ann in Fitzgerald River National Park), along a stretch of coast east of Israelite Bay, at Twilight Cove (in WA), and at the Head of the Bight. Southern right whales are easy to identify as they have no dorsal fin and they have a very distinctive V-shaped blow. Also, they have a series of whitish wart-like excrescences, known as callosities, on the top of the head, near the eyes and along the lower jaws. The highest number of southern rights seen in 1993 was 182 animals, including 63 cows. Between Cape Leeuwin and Twilight Cove, there were 128 animals with 39 cow-calf pairs (Bannister, 1994a). To obtain an increase rate for animals in the whole of the extended area the survey will have to continue for at least six years to cover at least 2x3 year breeding cycles. Despite the encouraging results from the aerial surveys, the number of animals in the population is still very small, perhaps no more than 800. The total number of right whales in the Southern Hemisphere may not yet be more than 3-4,000. The increase rate of the southern right whales in Western Australia from 1977-1993 was averaging 10% per year (Bannister, 1994a).

Aerial surveys have been carried out off the Western Australian coast since 1976 (Bannister, 1994b, 1994c). Up to and including 1992, the surveys demonstrated a significant increase in the number of animals approaching Western Australia in winter and spring. They have also provided information on distribution, movements, biology and relationships to neighbouring populations. The point rate of increase observed in the Western Australian data to 1992 (averaging 10% or more for a range of data sets) was higher than might be expected for this species. In 1993, and in earlier years off the southern Western Australian coast, there were concentrations in the Doubtful Island Bay area (Gordon Inlet - Point Ann - Point Charles) and east of Israelite Bay. Peak numbers in both areas occurred in September. An additional feature of the 1994 results was the higher number than usual reported from King Georges Sound, Albany and westwards towards Cape Leeuwin. In the South Australian sector there was a usual concentration of animals at the Head of the Bight. Bannister estimated a minimum total population size of some 800 animals from which those animals approaching the coast between Cape Leeuwin and Ceduna would be derived (Bannister, 1994c).

Aerial surveys of the southern right whale population from Cape Leeuwin to Israelite Bay have been carried out since 1976. Surveys are flown three times a year, in August, September and October. The surveys count all whales spotted up to 2 kilometres from shore. A 10% increase per year has been indicated, as in 1976 c.20 were spotted, and 1993 c.100 were spotted. This may be a result of migration of whales from South Australia. Since

1993 surveys included areas from Ceduna in SA to Cape Leeuwin and also from Cape Leeuwin to Twilight Cove. Animals with calves are seen to come every 3 years, in accordance with their breeding cycle. Some photo-identification has been done, from the pattern of callosities on the whales' head, and there are now approximately more than 100 animals on a database. The general movement of the southern right whale population tends to be largely east to west (Bannister J., pers. comm.).

The southern right whale is currently the only species for which there are good data on coastal habitats. There are several localities where females accompanied by calves can be expected around June to October. Greatest numbers are currently recorded in the Doubtful Island Bay area, east of Bremer Bay. Smaller numbers have recently been recorded regularly near Albany, off Cheynes Beach, near the Pallingup Estuary, near Esperance and to the west of Cape Arid. A particularly high concentration is now regularly found to the east of Israelite Bay, along the long stretch of coastline towards Point Culver. While the length of stay in the coastal waters is variable, it can be as long as 12 weeks. The animals occur very close to the shore, sometimes right on the surf line, in very shallow water, venturing out at times into deeper water, but not normally more than a kilometre or so from the coast. In addition to cows accompanied by calves of the year, more ephemeral concentrations of non-calving animals are reported. These are likely to be aggregations of males, often apparently pursuing a single female, in which mating behaviour is frequently observed. Such groups are much less predictable in their occurrence and behaviour than the calving females, although the concentrations recorded for the last 2-3 years in King George Sound have been of this kind, and in the past they have been found regularly at Doubtful Island Bay and Tagon Bay (Bannister J., pers. comm.).

3.3 Bottlenose Dolphin (*Tursiops truncatus*)

In 1994 a study was carried out on the level of heavy metals and organochlorine in marine mammals in Australia (Kemper, 1994). The research found that adult bottlenose dolphins inhabiting the inshore gulfs of South Australia had considerably higher levels of cadmium compared with other regions. Although information on organochlorine levels was sparse, with only approximately 39 specimens, the results suggested low levels of organochlorine in Australia when compared to other parts of the world (Kemper, *et al.*, 1994).

3.4 Strandings

A number of cetacean strandings and sightings across the south coast region have been recorded by CALM Wildlife officers from the Albany and Esperance Districts in the last six to twelve years. These are listed in Tables 5 and 6.

3.5 Other species

Of the 38 species of whales and dolphins recorded from this State, 27 occur, or could reasonably be expected to do so, off the south coast. By far the majority of those are oceanic animals, widely distributed and not truly coastal (Table 7). Very few are truly coastal in the sense that they spend much of, or regular periods of, their lives in inshore waters (Bannister J., pers. comm.).

3.6 Recommendations

Protection should be given to the southern right whales in the area between Bremer Bay and Red Island, to the east of Point Charles. This is the area adjacent to the Fitzgerald River National Park where the highest numbers of this species occur on a seasonal basis. Protection could be afforded by the creation of a multiple-use marine reserve that incorporates this significant coastal habitat for the southern right whale, as recommended in the Report of the Marine Parks and Reserves Selection Working Group (CALM, 1994). It is also strongly recommended that protection, via inclusion of the area in a state-wide system of representative marine reserves, should be considered for the area extending east from Israelite Bay to Point Culver. The importance of this area as a significant coastal habitat for southern right whales was not identified in the report of the Marine Parks and Reserves Selection Working Group (CALM, 1994). However, it should be noted that southern right whales only frequent such areas for a limited period each year, almost exclusively from June to October (Bannister J., pers. comm.).

5.0 OTHER SPECIES

Other very important species which can occasionally be found along the south coast of Western Australia are loggerhead and leatherback turtles. These turtles get picked up in the strong south-flowing Leeuwin Current and are carried hundreds of miles from their home territory. These species of turtle are usually found in the warmer northern waters of Western Australia. CALM plays a major part in the conservation of these species by rehabilitating and relocating individuals back to northern areas of the State. From 1989 to 1995 there have been 6 loggerheads and 2 leatherbacks found along the south coast, the majority in the Albany area (Collins P., pers. comm.).

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Table 1: New Zealand fur seal pups in breeding colonies during four successive seasons, 1987-88 to 1990-91.

(Dead pups are included. A dash indicates not visited.)

Location	1987-88	1988-89	1989-90	1990-91
Daw Island	-	-	73	70
New Year Island	-	-	32	21
Cranny Island	-	-	60	50
Cooper Island	-	-	123	-
Salisbury Island	-	-	451	-
Beaumont Island	-	-	39	75
Draper Island	-	-	-	22
Finger Island	-	-	0	4
Libke Island	-	-	0	166
Hood Island	32	-	33	40
Seal Rock (Recherche)	5a	-	187	172
Rocky Island	-	-	27	-
West Island	-	-	2a	43
Doubtful Islands	49	31	49	-
Hauloff Rock	-	-	51	-
Eclipse Island	-	24	33	-
TOTAL	86	55	1160	663

a. Partial count, landing impossible.

(From: Shaughnessy *et al.*, 1994).

Table 2: New Zealand fur seals in breeding colonies and haul-out sites during four successive seasons, 1987-88 to 1990-91.

(A dash indicates not visited.)

Location	1987-88	1988-89	1989-90	1990-91
Daw Island	-	-	-	133
Daw colony	-	-	124	-
Daw coast	-	-	96	-
New Year Island	-	-	81	42
New Year coast	-	-	4	-
Cranny Island	-	-	126	113
Pasley Island	-	-	-	12
Pasley Rocks	-	-	20	-
Beaumont Island	-	-	99	128
Draper Island	-	-	-	127
Finger Island	-	-	17	18
Libke Island	-	-	13	261
Hood Island	82	-	65	73
Seal Rock (Recherche)	50	-	307	172
West Island	-	-	21	98
Pointer Island	-	-	33	-
Round Rock	-	-	13	-
Round Island	-	-	135	-
Cooper Island	-	-	286	-
Salisbury coast	-	-	105	-
Salisbury colony	-	-	792	-
Westall Island	-	-	1	-
Kermadec Island	-	-	9	-
Hastings Island	-	-	1	-
MacKenzie Island	-	-	2	-
Termination Island	-	-	58	-
Little Island	-	-	90	-
Corbett Island	-	-	5	-
Fur Rock	1	-	7	-
Rug Rock	25	-	10	-
Square Rock	-	-	22	-
Figure of Eight	20	-	13	-
Rocky Island	-	-	94	-
East Doubtful Island	17	-	47	-
Middle Doubtful Island	145	212	148	-
West Doubtful Island	12	-	1	-
Hauloff Rock	-	-	212	-
Bird Rock	-	-	9	-
Bald Island	15	-	26	-
Coffin Island	-	-	9	-
Eclipse Island	-	85	98	-
Chatham Island	-	-	12	-
Flinders Island	-	-	12	-
Gunton Island	1	-	-	-
Capps Island	2	-	-	-
TOTAL	370	297	3223	1177

(From: Shaughnessy *et al.*, 1994)

Table 3: Australian sea lion pup counts and estimated pup production at known breeding localities.

Location	Date	Max. number pups counted	Estimated pup production
Houtman Abrolhos	June 89	11#	20
Beagle Island	23 Mar. 91	79#	79#
North Fisherman Island	7 Nov. 89	63#	63#
Buller Island	6 Nov. 89	39#	39#
• Hauloff Rock	2 Sep. 89	29	35
• Middle Doubtful Is.	11 Sep. 89	10	20
Red Islet	11 Sep. 89	27	40
• West Island	12 Feb. 91	20	25
• Rocky Island	13 Sep. 89	17	25
Little Island	15 Jan. 90	1*	5**
Mackenzie Island	6 Feb. 92	5	38***
Kimberley Island	9 Feb. 92	42	50
Kermadec Island	10 Feb.	4	6
Taylor Island	9 Feb. 92	7	7
SW Rock E of Twin Peaks	21 Jun. 90	1	1
Glennie Island	10 Feb. 92	24	30
Wickham Island	19 May 89	18	20
Poison Creek Island	24 Sep. 88	2	5
• Salisbury Island	22 Jun. 90	14	25
• Cooper Island	22 Jun. 90	3	4
• Round Island	28 Jun. 90	20	25
Six Mile Island	7 May 91	43	50
Ford Island	28 Jun. 90	24	30
Spindle Island	9 Jan. 90	53	60
TOTAL		556	702

* Dead pups

** Mean pup production for colonies in Western Australia with < 20 pups per season

*** Mean pup production for colonies in Western Australia with 20-100 pups per season

Data from Gales *et al.* (1992)

• Breeding sites of *A. forsteri* (Shaughnessy *et al.*, 1994)

(From: Gales *et al.*, 1994)

Table 4: Pinniped strandings and sightings recorded for the south coast from October 1992 to January 1997.

SPECIES	DATE	STATE OF HEALTH	LOCATION	SEX & LENGTH
Elephant seal	23/01/97	hauling out	Oyster Harbour	
Australian sea lion	08/10/96	wounded and died 13/10/96	Fanny Cove	
Leopard seal	01/09/95	euthanased	Princess Royal Harbour	F 3.2m
Leopard seal	04/09/95	euthanased	Mutton Bird Beach, Torbay	M 2.2m
Australian sea lion	28/08/95	death unknown	Parry's Inlet, Walpole	Juvenile F
New Zealand fur seal	14/03/95	tuberculosis positive	Two Peoples Bay	M
Sub-antarctic fur seal	17/11/94	starvation	Cheyne's Beach	Juvenile
Sub-antarctic fur seal	14/04/93	ensnared in shark net, rescued and swam away	William Bay National Park	
New Zealand fur seal	24/03/93	died before release	Hauloff Rock	Juvenile
New Zealand fur seal	19/02/93	emaciated and died	Cheyne's Beach	F mature
Australian sea lion	22/02/93	death unknown	Oyster Harbour	M
Australian sea lion	13/02/93	emaciated, ensnared in shark net, euthanased	Norman's Beach	
New Zealand fur seal	14/01/93	advanced decomposition	Dillon Bay Beach	
Crabeater seal	03/02/93	hauling out, then disappeared	Princess Royal Harbour	2.6m
Subantarctic fur seal	22/12/92	starvation	Princess Royal Harbour	Juvenile
Subantarctic fur seal	08/09/92	euthanased 11/09/92	Peaceful Bay	Juvenile
New Zealand fur seal	22/09/92	advance decomposition		
Subantarctic fur seal	07/10/92	death unknown	Point Possession	Juvenile F
Elephant seal	1992	alive and disappeared	King George Sound	

There were 18 recorded seal strandings and sightings from October 1992 to January 1997. Of these, the majority of the seals were in an advanced state of emaciation and were either euthanased or died soon after being found (Collins P., pers. comm.).

Table 5: Whale strandings and mortalities recorded for the south coast from July 1984 to October 1996.

SPECIES	DATE	HEALTH	LOCATION	SEX & LENGTH
Sperm whale	18/10/96	cause of death unknown	West Beach, Hopetoun	17m
Southern right whale	10/10/96	dead ~ 4-5 weeks	east Fitzgerald River	7.8m
Humpback whale	23/08/96	decomposing, cause of death unknown	west Miles Beach	3.5m male
whale skeleton/head	08/01/96		Seal Is., Goodie Beach	
whale	09/01/96	badly decomposed	Aldridge Cove, Walpole	6m+
	08/12/95	death unknown	Cable Beach, Torndirrup	immature female
Shepherd's beaked whale	12/06/95	death unknown	east of Parry's Inlet	female
Sperm whale	03/06/95	death unknown	east of Banksia camp	newborn female 4m
Minke whale	19/09/94	alive	Cheyne's Beach	5.1m female
Strap-toothed beaked whale	25/12/93	4 originally, now 2 (1 dead 1 alive)	west of Wilson Inlet	
Sperm whale	08/11/93	death unknown	Madfish Bay	15m
Pygmy sperm whale	23/04/93	death unknown	Mutton Bird Beach	1.8m
Humpback whale	18/11/91	death unknown	Two Peoples Bay	5.5m juvenile
Pilot whale	25/06/91	death unknown	Hamersley Beach	1.7m male
Sperm whale skeleton	29/01/91		Dunster Castle Bay, Stokes National Park	4.5m skull
2 x true beaked whale	15/10/90	death unknown	Foster's Beach	
Whale	05/08/90	decomposed	Sinker Reef, Two Peoples Bay	approx 20m
Minke whale calf	09/09/89	sent out to sea OK	Two Peoples Bay	3.8m
Arnoux's beaked whale	01/01/89	death unknown	Kordenup Beach	8.4m male
Sperm whale	13/11/88	death unknown	Chynes Beach	10.0m female
Long-finned pilot whale	13/01/88	death unknown	Dingo Beach	4.45m female
Minke whale	23/08/87	found alive, died 24th, death due to stress	Princess Royal Harbour	3.0m new born male
Minke whale	21/09/86	death unknown	Hassel Beach	3.06m
Sperm whale	10/12/85	advanced decomposition	Prescotvale Road Beach	10.4m female?
Pygmy sperm whale	02/08/85	alive and sent back, but found dead the next day	Windy Harbour Beach	1.46m
Short-finned pilot whale	20/11/84	mild decay	between Gull Rock and Ledge Beach	2.78m
Pygmy right whale	19/07/84	death unknown	Mutton Bird Beach	1.59m
Total of 27 whales		13 different species		

(Collins P., pers. comm.)

Table 6: Dolphin strandings and mortalities recorded for the south coast from November 1990 to July 1996.

SPECIES	DATE	HEALTH	LOCATION	SEX & LENGTH
Common dolphin	15/07/96	advanced decomposition	Ledge Beach	
Common dolphin x 2	29/01/91	advanced decomposition	Peppermint Beach, Bremer Bay	1.85m
Common dolphin	16/06/94	drowned in net	Bremer Bay	1.9m male
Common dolphin	21/02/94	caught in mulie net	Bremer Bay	2.24m male
Common dolphin	16/04/94	caught in mulie net	Bremer Bay	1.2m juv. female
Common dolphin	12/02/94	drowned in mulie net	Bremer Bay	1.65m male
Common dolphin	05/10/93	drowned in net	Bremer Bay	2.25m male
Common dolphin	10/12/93	drowned in net	Bremer Bay	1.93m female
Common dolphin x 2	06/02/91	death unknown	Peppermint Beach, Bremer Bay	
Dolphin	13/05/93	drowned in mulie net, carcass lost overboard		
Common dolphin	28/01/93	drowned in mulie net	Bremer Bay	
Common dolphin	28/04/93	death unknown	Middleton Beach	1.7m female
Bottlenose dolphin	27/04/93	death unknown	Middleton Beach	1.8m male
Common dolphin	21/04/93	death unknown	Ledge Beach and Gull Rock	1.45m juvenile
Common dolphin	28/01/93	drowned in net	Bremer Bay	mature male
Bottlenose dolphin	01/01/93	death unknown	Fitzgerald Inlet Beach	8 feet 6 inch
Bottlenose dolphin	21/02/92	deep decomposition	Rossiter Beach, Esperence	2.5m
Common dolphin	03/04/92	drowned in net	Dillon Bay	1.68m male
Common dolphin	20/03/92	drowned in net	Dillon Bay	1.75m female
Dolphin	28/01/92	drowned in net, carcass lost overboard	Bremer Bay	
Common dolphin	30/01/92	badly decomposed	Middleton Beach	1.0m juvenile
Common dolphin	19/01/92	drowned in net	Bremer Bay	2.21m
Common dolphin	02/01/92	drowned in mulie net	Bremer Bay	2.0m female
Common dolphin	24/05/91	death unknown	Banksia Beach	1.25m male
Common dolphin x 2	29/01/91	advanced decomposition	Peppermint Beach, Bremer Bay	
Bottlenose dolphin	19/11/90	death unknown, advance decomposition	Princess Royal Harbour	
Total 26 dolphins				

(Collins P., pers. comm.).

Table 7: Cetacean species which may occur off the south coast of Western Australia.

(Those species that are truly coastal, at least at some stage in their life cycle, are indicated).

Common name	Scientific name	Coastal species
Dusky dolphin	<i>Lagenorhynchus obscurus</i>	
Bottlenose dolphin	<i>Tursiops truncatus</i>	Yes
Striped dolphin	<i>Stenella coeruleoalba</i>	
Common dolphin	<i>Delphinus delphis</i>	Yes
Southern right whale dolphin	<i>Lissodelphis peronii</i>	
False killer whale	<i>Pseudorca crassidens</i>	
Killer whale	<i>Orcinus orca</i>	
Long-finned pilot whale	<i>Globicephala melas</i>	
Short finned pilot whale	<i>Globicephala macrorhynchus</i>	
Shepherd's beaked whale	<i>Tasmacetus shepherdi</i>	
Arnoux's beaked whale	<i>Berardius arnuxii</i>	
Strap-toothed beaked whale	<i>Mesoplodon layardii</i>	
Gray's beaked whale	<i>Mesoplodon grayi</i>	
True's beaked whale	<i>Mesoplodon mirus</i>	
Cuvier's beaked whale	<i>Ziphius cavirostris</i>	
Southern bottlenose whale	<i>Hyperoodon planifrons</i>	
Sperm whale	<i>Physeter macrocephalus</i>	
Pygmy sperm whale	<i>Kogia breviceps</i>	
Dwarf sperm whale	<i>Kogia simus</i>	Possibly
Southern right whale	<i>Eubalaena australis</i>	Yes
Pygmy right whale	<i>Caperea marginata</i>	Yes
Minke whale	<i>Balaenoptera acutorostrata</i>	Yes
Sei whale	<i>Balaenoptera borealis</i>	
Bryde's whale	<i>Balaenoptera edeni</i>	Yes
Blue whale	<i>Balaenoptera musculus</i>	Possibly
Fin whale	<i>Balaenoptera physalus</i>	
Humpback whale	<i>Megaptera novaeangliae</i>	Yes
TOTAL	27 species	7 yes, 2 possibly

- Of those marked 'possibly', the dwarf sperm whale is believed to be a more coastal animal than its close relative the pygmy sperm whale, which occurs in more oceanic waters.
- A pygmy subspecies of the blue whale, the pygmy blue whale, has been recorded inshore along the west coast, eg. near Busselton, and could well occur inshore on the south coast.
- Of the 7 'yes' records, the two dolphins (bottlenose and common dolphin), can be expected anywhere along the coast, although the bottlenose is reported more frequently than the common dolphin.

(Bannister J., pers. comm.)

APPENDIX IV

BENTHIC HABITAT MAPPING

MAPPING AUSTRALIA'S UNDERWATER FEATURES

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ABSTRACT

Australia's coastline was first mapped at the beginning of the 19th century. Now the underwater features are being mapped with extensive ground truth, satellite technology and computer mapping and digitising techniques. Landsat TM imagery is processed to enhance underwater features. The enhanced imagery is then taken into the field for strategic ground truth verification of features seen in the imagery. GPS position fixing is used to find a position of interest or to position a site where verification takes place. Once an image has been verified the ground truth points are placed on an outline of the coast and these points placed on the image. Eight categories of habitat are used in the map but these may vary depending on where in Australia the mapping is done. The features are traced onto the image and digitised and the map presented, at 1:100,000 on Arc Info. The success of this project relies on the collaboration and cooperation of State Government departments, so far, most of South Australia and Western Australia from Exmouth Gulf to the border of South Australia has been completed, the Victorian government has bought the satellite images and preliminary interpretations have been done. New South Wales has bought the first of about ten images and Tasmania has made a commitment to assist in mapping that state. The aim is to complete all of Australia within three years.

OBJECTIVE

To prepare a map at a scale of 1:100,000 of underwater features of the Australian coastline and separate those features into categories that can be used for coastal management and making decisions on choices of marine protected areas.

BACKGROUND

The underwater features of the Australian coastline are poorly known apart from areas around centres of population. Underwater features are seagrass meadows, reefs of different morphology and geology, unvegetated sand and, in the tropics, coral reefs, coral debris and muddy deltaic areas. There are a number of reasons that underwater features should be mapped.

- Selection of Marine and Estuarine Protected Areas (MEPA's). Once the features of the offshore coast have been mapped and an estimate of the biodiversity made, decision makers have an informative baseline upon which to choose bioregions or areas of biological similarity and hence select marine parks or reserves.
- Assist with decisions concerning coastal development - where to put marinas, harbours, effluent outfalls and exploratory. mining. Seagrass meadows are particularly vulnerable to above ambient nutrient concentrations caused by effluent discharges. Coral reefs are also affected by high sediment concentrations caused by land clearing. If the extent of these biological features is known decision makers can protect them or decide to sacrifice parts of them.
- Location of vulnerable areas if an oil spill occurs. Reefs and coral reefs are particularly vulnerable to oil pollution, if these habitats are well defined the clean up of oil can concentrate around these areas and limited resources can be deployed at strategic places to reduce impact.
- Assist with decisions as to the location of mariculture development. Aquaculture cages release nutrients into the sea and shade the underlying substrate. The positioning of these cages should be planned to have as little impact as possible on the benthic biota.
- Assist with locating where heavy machinery can approach the water/land interface for pollution clean-up and military purposes. Cliffs, exposed beaches and shallow offshore reefs are places that are difficult to approach for clean-up whereas shallow estuaries and gently sloping beaches are more suitable.

- Assist with coastal management. Once an atlas of resources has been prepared, strategic monitoring will help detect changes to the various ecosystems that have been distinguished.

METHODS

The maps are being prepared at a scale of 1:100,000 using the blue band or band 1 of the Landsat TM satellite. The key to mapping these areas is obtaining satellite imagery that has penetrated the water and then enhancing the raw imagery so that the best is made of the benthic features in the scene. The high water clarity in southern Australia has allowed us to identify features to 50m depth, but in many cases because of poor light penetration, this depth is much reduced. Completed maps, therefore, do not have an offshore limit, but rather a line exists at the extremity of what can be seen through the water by the Landsat TM imagery.

Each image is selected from microfiche reproductions provided by the Australian Centre of Remote Sensing (ACRES), a division of the Australian Land Information Group (AUSLIG) situated in Canberra, as being on a cloud-free day and with a sun elevation above 45°. Because of the sun elevation restriction, only images taken between mid-October and April are chosen. The weather pattern for the previous three days is then examined from the Bureau of Meteorology data to determine if storms or strong wind might have disturbed sediment in the target area. Even with these constraints it is difficult, because of water turbidity, to find a suitable image.

Once an image has been acquired it is rectified to level 9, ie rectified to the AUSLIG topographic map at a scale of 1:100,000, with Australian Map Grid positions and checks at every 10km on the photographic image. The position of any feature can then be determined for later field ground truthing. The photographic image is laminated in plastic so that it is waterproof for field work. The discernible underwater features are traced on the image, and these are verified in the field.

The ground truthing of the images, to verify the presence of underwater features, is a major operation on a scale as large as the coastline of Australia. In southern Western Australia and in South Australia this has been done from ocean going vessels capable of spending extended time at sea. In the case of Western Australia, a shark fishing vessel was chartered from Esperance on two occasions. On the first cruise from 9 - 13 March 1994 we concentrated on deep water features and the islands of the Archipelago of the Recherche. On the second cruise from 6 - 13 April, 1994 we moved along the coast from Two Peoples Bay near Albany to the western end of the cliffs of the Great Australian Bight. In South Australia all ground truth was accomplished from the research Vessel "Ngerin" courtesy of the South Australian Research and Development Institute (SARDI) on five cruises. The first, from 16 - 29 June 1994, of these was from the Head of the Bight to Ellison and the second, from 9 - 19 October 1994, was to Kangaroo Island and the adjoining mainland. Spencer Gulf, the east coast to Portland in Victoria and the Eyre Peninsula were the remaining cruises.

Ground truthing was done by either "bounce" diving, hanging a video camera from the ship or by using a small grab. For the "bounce" diving part of the work, the crews take small inflatable dinghies to predetermined places of interest along the coast. These places are chosen on their representativeness of other areas or as being unusual in shape or position on the image. Before going into the water, an estimate of the bottom type expected is recorded on data sheets for each ground truth site. At the chosen site a GPS position is recorded and the field worker makes a dive, usually with scuba, to determine what is on the bottom. If a seagrass habitat is encountered a handful of seagrass with roots and rhizomes and fruiting parts, if available, is taken and the depth, density of seagrass, species and other observations are recorded on a field slate. If a reef is encountered, the depth and type of reef is recorded and the dominant seaweeds collected and returned for later pressing. If unvegetated sand is encountered, the diver may abort the dive and record "bare" on the field slate.

The bottom types are divided into eight categories: dense seagrass, medium seagrass, sparse seagrass, patchy seagrass, bare sand, flat platform reef, heavy limestone reef and granite reef. Dense seagrass is seagrass that completely covers the bottom, medium seagrass is a density where two fingers held together can be placed between shoots and sparse is the density of seagrass where a hand can be placed between shoots. Flat platform reef is flat reef that is easily covered in mobile sand and therefore does not have a heavy growth of large seaweeds. In Western Australia this category often had *Scaberia* or *Dictyopteris* growing on it. Limestone reef has a cover of kelp (*Ecklonia radiata*) or other large brown seaweeds and granite reef also has kelp but has a smoother surface and has steeper edges.

The video camera and grab are usually used from the mother ship which, while the inflatables are engaged closer to the shore in shallower water, will be steaming to chosen sites where it may not be necessary to dive, is too deep or is thought to be unvegetated sand. At these sites a GPS position is recorded and the video or grab deployed. If scenes or samples of interest are found, a diver may collect a sample from the bottom.

Once the inflatables return to the mother ship, the data from the field slates are recorded on data sheets, and field note book, specimen plants are pressed and labelled and the actual bottom type compared with the estimated one.

After the cruise, the position of every ground truth site is plotted onto an AUSLIG, 1:100,000 outline of the coast as a number related to the data sheets and as a colour related to the category of bottom detected. Information from the field note book and data sheets are used to label pressed samples and these are stored for later use.

The coast outline is then laid over the satellite image (they are at the same scale) and a pin is pushed through at each ground truth point. The category of the bottom type is noted on the satellite image and the tracings are revised using the ground truth data. The satellite images with their tracings are then digitised and put into Arc Info for presentation as a map. Each of the completed maps is accompanied by a statement as to the quality of the mapping. The quality control comes from a comparison of the expected bottom type compared to the actual bottom type. Currently the ground truth estimate of a particular area is about 80% accurate.

REQUIREMENTS FROM COLLABORATORS

A close liaison and co-operation with state government departments has been of vital importance to the whole project. Table 1 lists the collaborators in this project.

ORGANISATION	DEPARTMENT
Western Australian Government	Land Administration
	Fisheries
	Transport
	Environmental Protection
	Conservation and Land Management
South Australian Government	SA Research and Development Institute
	Environment and Natural Resources
Victorian Government	Fisheries Research Institute
	National Parks
NSW Government	National Parks and Wildlife Service
	Fisheries
Tasmanian Government	Fisheries
	National Parks and Wildlife
CSIRO	Division of Fisheries
	Division of Wildlife and Ecology
Royal Australian Navy	Hydrographers
AGSO	Marine Geology

CSIRO does not have a large budget for this work, however with the collaboration and co-operation of a number of State Departments the mapping in South Australia, Victoria and Western Australia has progressed quickly and economically. The state departments provided the satellite imagery (band 1 only) which was chosen by CSIRO from the catalogue at ACRES. The State Departments provided technical help in enhancing the imagery and producing a photograph with AMG and 10 km grid. The tracings were digitised and map

produced by State Departments which provided the maps in digitised form to the CSIRO Division of Wildlife and Ecology for the CAMRIS GIS. The completed maps are owned by CSIRO and the state.

CURRENT STATUS

The southern coasts of Australia are in the process of being mapped. Arc Info maps have been prepared from Perth to the cliffs of the Great Australian Bight. The underwater features of the coast from Perth to Exmouth Gulf and from the cliffs of the GAB to Portland in Victoria are in preparation. Other areas of the Australian coastline eg. GBR, Moreton Bay, the estuaries of NSW and the Gulf of Carpentaria, have been mapped for various organisations for different purposes at different scales, but most of these maps can be brought to the scale required for this project and their categories made compatible with those of this project and then put into the underwater features data base.

The coast of Victoria has been mapped from satellite imagery but ground truth has been done only for Port Phillip Heads to Wilson's Promontory. For NSW satellite imagery seems inappropriate so that aerial photos are being scanned from which the maps will be prepared. The ground truth for the Tasmanian coast will be done during two cruises in February and April 1997.

FUTURE DIRECTIONS

It is anticipated that during 1996/97 the current study will be extended to the ground truth of the Victorian coast, and Tasmania. The NSW government has shown some commitment to mapping its coastlines.

The northern parts of Australia are a different matter as far as obtaining satellite images with sufficient water penetration. The water in northern Australia generally contains enough sediment to prevent light penetration beyond a metre. This sediment comes from seasonal rivers and the very large tides of the Kimberley to Darwin coast and the Gladstone to Rockhampton coast of Queensland.

Although the plant communities will not be as deep as in southern areas of the continent because of the lower light reaching benthic plants, it is just as important to map the reefs and substratum here as elsewhere. It is planned to use a series of transects to determine the composition of the benthic habitats. These transects would be at right angles to the coast and to a distance where, either a continuous substrate is obvious or it is believed that further data would be of limited use. This form of mapping requires much more field work and relies on a statistically sound number of samples ie transects, being taken. Further collaboration with the RAN, WA Dept of CALM, CSIRO Division of Marine Research at Cleveland through a FRDC Grant and Australian Customs Service will be anticipated.

END PRODUCT

Completed mapping is in an Arc Info format on disc or on hard copy at a scale of 1:100,000. These maps are available to State Government Departments and institutions that have given assistance in preparing the maps.

MILESTONES

Oral Presentations:

CZP meeting. Oct 1994
ANZECC committee meeting Nov 1994
Vic Govt Departments Nov 1994
Perth Dive Academy Dec 1994
Underwater World June 1995

Written Reports

CZP Report Oct 1994
Ecos article Autumn 1995
South Australian Fisheries article May 1995

- Kirkman, H. and Kuo, J. 1996. Seagrasses of the southern coast of Western Australia. Proceedings of the International Workshop on the Biology and Ecology of Seagrasses. Rottnest Island. Eds. Kuo, Kirkman, Phillips and Walker.
- Hamdorf, I. and Kirkman, H. 1995. Status of Australian Seagrass. Issue Paper Fisheries Pollution and Marine Environment Committee 32pp.
- Kirkman, H. In press. State of Environment Report on Seagrasses. National State of the Environment Reporting System. Commonwealth Environment Protection Agency. 43 pp.
- Kirkman, H. In press. Baseline and monitoring methods for seagrass meadows. Journal of Environmental Management.

Presentations

- Plenary Talk at the International Symposium of Remote Sensing, Seattle Washington. Held in September 1995.
- Talk at Estuarine Research Foundation Biannual International Meeting. Corpus Christi, Texas Nov 12-19.

Committee Responsibilities due to this project.

- Advisory Committee of Western Australian Land Information System (WALIS)
- Visiting Committee Department of Geography, The University of Western Australia

APPENDIX V

A REVIEW OF ESTUARIES AND CATCHMENTS

APPENDIX VI

A REVIEW OF TERRESTRIAL RESERVES

**South Coast Terrestrial and Marine Reserve
Integration Study**

A Review of Terrestrial Reserves

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March 1997

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1. INTRODUCTION

The following review is a broad summary of physical/biological resources, cultural/historical values, social/economic usage and management issues in coastal terrestrial reserves between Broke Inlet and Israelite Bay. It covers resources and activities that may influence the integrated management of estuaries/inlets and of the nearshore marine environment adjacent to terrestrial reserves.

Each issue, resource or activity has been considered separately with a brief description. Key sites associated with particular issues have been highlighted. All references used while collating this information have been entered on to the South Coast Terrestrial and Marine Reserve Database, held at CALM Marine Conservation Branch, with a brief description of the content of each paper or report.

2. REVIEW OF PHYSICAL AND BIOLOGICAL RESOURCES

2.1 Coastal landscapes and aesthetic values

The South Coast region is renowned for its outstanding flora, spectacular landscapes and beautiful and varied coastline. The region contains areas of undisturbed coastline with a diversity of landscape features including cliffs, beaches, reefs, offshore islands, headlands and mountain peaks. The coastline is dominated by hard granitic and gneissic headlands surrounding curved sandy beaches. The soils in the region are either unconsolidated sands or thin skeletal soils on granite and limestone headlands and cliffs. Three Botanical Districts (Darling, Eyre and Roe) are represented along the coastal strip, with vegetation varying from forest and coastal heath to sandplains with scrub and mallee heath.

2.2 Fauna and flora

Common fauna of the area include western grey kangaroo, southern brown bandicoot, yellow footed antechinus, bush rat, honey possum, dugite, tiger snake, bardick, whistling kite, nankeen kestrel, Port Lincoln parrot, western rosella, elegant parrot, grey fantail, red wattle bird, New Holland honeyeater, kookaburra, moaning frog and banjo frog. Listings of terrestrial reptile and mammal species recorded for a number of areas across the south coast study region have been obtained from the terrestrial vertebrate and invertebrate databases at the Western Australian Museum of Natural Science.

Currently, no databased floral inventories are available for the south coast region. Lyons & Gibson (1994) have compiled a bibliography of location-based biological studies in Western Australia, which lists both published and unpublished material containing flora and fauna inventories for a number of areas across the south coast region.

2.2.1 Review of flora and fauna on offshore island Nature Reserves

Island fauna varies with size, topography and location of the island. Vertebrate species commonly found on islands include Australian sea lion, New Zealand fur seal, fleshy-footed shearwater, great-winged petrel, little penguin, pied oyster catcher, sooty oyster catcher and death adder.

The following island nature reserves are included in the study area:

Shelter Island
Mistaken Island
Seal Island
Chatham Island
Michaelmas Island
Breaksea Island
Coffin Island (included within the Two Peoples Bay Nature Reserve)
Bald Island
Cheyne Island
Glasse Island
Doubtful Islands

sites for these species (see marine mammals review - Appendix III).

Shelter Island (Mutton Bird Island) - Evidence of use as a seal/sea lion haul-out site. Breeding site for little penguins and shearwaters (not clear whether they are fleshy-footed shearwaters or great-winged petrels). Fauna includes, brown falcon, rock parrot, king skink, sooty oyster catcher. The island is infested with black rats.

Mistaken Island - Fauna includes little penguin (breeding colony with minimum numbers of approximately 40 pairs each year), sooty oyster catcher, osprey, king skink, rock parrot, Pacific gull, silver gull, little pied cormorant and carpet pythons. There has been a problem with the introduced plant *Taylorina (Psoralea pinnata)* which is periodically removed.

Seal Island - No information was found for this nature reserve.

Chatham Island - Haul-out site for New Zealand fur seals, and the rare fern *Asplenium obtusatum* (shore spleenwort) grows on the island.

Michaelmas Island - Fauna includes sooty oyster catcher and Pacific gull. Little penguin, fleshy-footed shearwater and great-winged petrel are all thought to breed on the island. In the mid 1980s a tour operator was keen to place a small jetty on the island to allow access for visitors transported on company vessels. This was not supported by CALM.

Breaksea Island - Important haul-out site for both Australian sea lions and New Zealand fur seals. An important historical site (see historical/cultural review section). Considerable work has been done on the island and lists of both flora and fauna are available (Wolfe, 1994a). Major impacts have been caused by both introduced weeds and feral animals (rabbits).

Coffin Island - This island is part of the Two People's Bay Nature Reserve, which also includes Inner Island, Black Rock and Rock Dunder to the west of Cape Vancouver. Coffin Island is an important haulout site for New Zealand fur seals and Australian sea lions. It is the nearest Australian sea lion haul out site to Albany.

Bald Island - Haul-out site for both New Zealand fur seals and Australian sea lions. Possible breeding site for little penguin, great-winged petrel and white-faced storm petrel. Fauna observed includes quokka, Australian goshawk, Australian raven, silver gulls, crested terns, grey fantails, New Holland honeyeaters (Abbott, 1981a; Storr, 1959). The island is a translocation site for the rare noisy scrub bird (Danks *et al.* 1996). There are anecdotal reports of a seal breeding colony on the eastern side of the island.

Hauloff Rock - Currently, this island is not a nature reserve. It is an important haul-out and breeding site for Australian sea lions (closest recorded breeding location for this species near Albany) and New Zealand fur seals. The island is also the most westerly location for the Recherche Cape Barren Goose.

Cheyne Island - This nature reserve is located in Cheyne Bay. It is one of very few islands in the area that has an accessible sandy beach for landing and is within very easy boating distance of Cape Riche. There is a substantial colony of little penguins on the island but there is some conflict between its status as a nature reserve and public usage. It has problems that are very similar to the problems originally encountered on Penguin Island (west of Rockingham in the Shoalwater Islands Marine Park), with little management control and extensive public usage.

Glasse Island - Regular haul out site for Australian sea lions and New Zealand fur seals, possible breeding site for crested terns and little penguins. Other fauna observed includes Pacific gull. The island is very close to the new Fishing Boat Harbourn in Bremer Bay and is popular for fishing and diving.

Doubtful Islands - Supports the invasive plant African boxthorn, which requires an ongoing eradication programme. It is an important haul-out and breeding site for Australian sea lions and New Zealand fur seals. The fleshy-footed shearwater nests on the island. Other fauna observed include rock parrot, stubble quail, sooty oyster catcher, Pacific gull, little penguin, king skink, silver gull, white-breasted sea eagle and yellow-footed antechinus (CALM records).

Rocky Islets (Investigator Island) - Breeding site for Australian sea lions and New Zealand fur seals. Other fauna observed include, sooty oyster catcher, bridled tern, rock parrot, crested tern, white-breasted sea eagle and king skink.

Woody Island - The only island in the Recherche to which there is any public tourist access at present. Both day and overnight visitors are brought to the island by a local tour operator.

Islands of the Recherche Archipelago Nature Reserve:

Middle Island - Access on Middle Island has become an issue as visitors have been degrading the foredune by crossing it to reach the lake. CALM are installing a boardwalk across the dune to provide a route for visitors and to halt the erosion. There is no tour operator with access to the island, however it is visited by fishermen/yachtsmen and private boat owners. Tourism development on the island is not being encouraged although proposals have been put forward. A description of the islands cultural resources, history and brief descriptions of flora and fauna is given in Bindon (1996).

Cull Island - Problems exist with both feral goats and boxthorn.

Remark Island - Fauna include little penguin, great-winged petrel, fleshy-footed shearwater, Pacific gull, sooty oyster catcher, little black cormorant and king skink (Lane, 1982a).

Hood Island - Haul-out site and breeding site for New Zealand fur seals. Breeding fauna includes little shearwater, great-winged petrel, Recherche Cape Barren goose (Tingay & Tingay, 1982a).

Sandy Hook Island - The island has a sandy beach and is in close proximity to Esperance making it accessible and at risk from disturbance by visitors. Breeding birds include little penguin and fleshy-footed shearwater (Tingay & Tingay, 1982b).

Mondrain Island - Fauna includes little penguin, fleshy-footed shearwater, Pacific gull, Recherche Cape Barren goose, silver gull, caspian and crested terns, sooty oyster catcher, king skink, carpet python, death adder and rock wallaby (Abbott, 1981b).

There are several other islands in the south coast region proposed as nature reserves. These include Migo, Richards and Stanley Islands (CALM, 1992a).

2.2.2 Seabirds

In 1953 an expedition to the Recherche Archipelago carried out a survey of the seabird fauna of the islands. Fifty seven different species of birds were seen on the 22 islands visited and the bird nesting habitats and field observations of behaviour were recorded (Serventy, 1953). In 1976 Serventy produced a monograph on the birds of Western Australia. This publication covers all the birds which are likely to be found along the south coast and describes their nesting habitats, distribution and islands which they are known to occur on (Serventy & Whittell, 1976).

A 1976 expedition to Eclipse Island surveyed the seabird fauna of the island. Twelve species were suspected to breed on the island, but it was found that 11 breed and it was suspected that the remaining species is a vagrant.

The distribution of these breeding species on the island was described and nesting habitats recorded. An additional 25 seabird species were recorded off Eclipse Island and the surrounding seas (Fullagar & Van Tets, 1976). In 1980 a survey was carried out on the transition from mainland to island, illustrated by the flora and landbird fauna of headlands, peninsulas and islands near Albany. A list of species of plants and landbirds present on 11 islands and 17 coastal mainland sites was produced and used in a regression analysis to study how the floras and landbird faunas of islands come to differ from those of coastal mainland areas. It is suggested that most landbird extinctions on these islands result from the action of storm waves and continual deposition of seaspray, and the presence of colonially-nesting seabirds. A general pattern was seen where the number of landbird species decreases in the following sequence - sheltered mainland, sheltered island, exposed mainland, exposed island (Abbott, 1980).

In 1982 a survey of the avifauna of the islands off Esperance was carried out (Lane, 1982b). Ten islands were visited - Nares, Lorraine, Ram, MacKenzie, Frederick, Remark, Long, Cull, Observatory and Figure of Eight Islands. The species recorded off these islands were as follows:

- Little penguin *Eudyptula minor*, was found on all but Nares, Frederick and Long Islands.
- Great-winged petrel *Pterodroma macroptera*, was found only on Remark Island.
- Flesh-footed shearwater *Puffinus carneipes* - this is the common shearwater of the area and these birds were found at sea often. However, birds were found in burrows on Ram, Frederick, Remark and Long Islands. Remains of birds were found on MacKenzie, Observatory and Figure of Eight Islands.
- Short-tailed shearwater *P. tenuirostris*, nineteen adults were found on Figure of Eight Island.
- Little shearwater *P. assimilis*, was found on MacKenzie Island.
- White-faced storm-petrel *Pelagodroma marina*, was found on Nares, Lorraine, and Frederick Island. Remains were found on Remark, Long, Cull, Observatory and Figure of Eight Islands where possible predation from the Pacific Gull may be a concern.
- Black-faced shag *Leucocarbo fuscescens*, was seen only on Nares, Figure of Eight and Remark Islands.
- Little black cormorant *Phalacrocorax sulcirostris*, was seen on Remark Island only.
- Recherche Cape Barren goose *Cereopsis novaehollandiae*, was recorded on Lorraine, MacKenzie, Frederick, Long, Cull and Figure of Eight Islands.
- White-bellied sea eagle *Haliaeetus leucogaster*, was seen over Ram, MacKenzie, Remark, Long, Observatory and Figure of Eight Islands.
- Peregrine falcon *Falco peregrinus*, was seen on Cull Island only.
- Australian krestrel *F. Cenchroides*, were seen on Ram and Figure of Eight Islands.
- Brown quail *Coturnix australis*, was seen only on Figure of Eight Island.
- Sooty oystercatcher *Haematopus fuliginosus*, was recorded on all islands visited and nesting on MacKenzie Island.
- Common sandpiper *Tringa hypoleucos*, was seen on Nares and Lorraine Islands.
- Silver gull *Larus novaehollandiae*, was recorded on all islands visited but only in small numbers.
- Pacific gull *L. pacificus*, was recorded on Nares, Lorraine, Ram, MacKenzie, Frederick, Remark and Long Islands.

In 1982 Lane produced another report on a survey of 14 islands in the Recherche Archipelago (Lane, 1982c). The report included a map of the islands, conservation status of the islands, landing areas, history, and seabird status. The islands surveyed were Middle, Nares, Lorraine, Ram, MacKenzie, Hood, Frederick, Sandy Hook, Remark, Long, Cull, Observatory, Canning and Figure of Eight Islands. The seabird fauna recorded is shown in Table 1.

Lindsay's publication on the seabirds of Australia, published in 1986, lists the species of seabird that might be expected to occur along the south coast of Western Australia (Lindsey, 1986). For the south coast region there is one species of penguin, 7 albatrosses, 19 petrels and shearwaters, 1 storm petrel, 2 diving petrels, 1 pelican, 1 gannet, 1 darter, and 5 cormorant species which may be seen in this area (Table 2). A total of 39 out of 90 Australian seabird species occur in the south coast region (Lindsey, 1986). A 1987 book on the shorebirds of Australia gives a list of species which may be found in the south coast region (Pringle, 1987). A total of 43 out of 106 species of birds that live on or near the coasts, beaches, reefs and tidal mudflats of Australian seashores are found along the south coast (Table 3). The majority of the shorebirds that occur in Australia spend approximately half the year in the northern hemisphere. They inhabit an environment where the cycle of the tides, rather than the cycle of night and day, is the major influence. Australian shorebirds include waders on

one hand, and skuas, gulls and terns on the other. The waders are notable for their spectacular migrations, while gulls and terns are among the most familiar birds of Australian harbours and coasts. Shorebirds tend to be extremely gregarious, wary and unapproachable, they fly strongly and seldom swim (Pringle, 1987).

In 1987 a survey was carried out on breeding colonies of the short-tailed shearwater in the Recherche Archipelago. The survey found two breeding colonies, one on Inshore Island and another on Ben Island. Inshore Island had about 200 burrows, while 3,000 burrows were found on Ben Island (Johnstone & Smith, 1987). This was followed by a 1988 survey of Eclipse Island at Albany. This survey was mainly for the purpose of updating historic records of the island and of the lighthouse. However, it was noted that the type of birds which inhabit and breed on the island were restricted to those that venture out to sea, such as the Little penguin, Great-winged petrel, Fleshy-footed shearwater and Little shearwater, as well as the Silver gull. Other varieties which are known to visit the island are the White-faced storm petrel, Red-tailed tropic bird, Sooty oystercatcher and Pacific gull (Scott, 1988).

The action plan for Australian birds was published in 1992 (Garnett, 1992). The Cape Barren goose was listed as endangered, with numbers being small and subject to catastrophes. This species had a former distribution which covered the south coast of Western Australia, being centred in the Recherche Archipelago, but occurring in small numbers on the mainland from Busselton to the Nullarbor Plain. Its current distribution is confined to the Recherche Archipelago with infrequent records from nearby promontories. All islands in the Recherche Archipelago and other nearby islands where the Cape Barren goose has been recorded are listed as Nature Reserves (Garnett, 1992). In 1993 a survey was carried out on the Cape Barren goose in the Recherche Archipelago. The Recherche Cape Barren goose (*Cereopsis novaehollandiae grisea*) breeds only in the Recherche Archipelago. It is currently listed by ANZECC as 'vulnerable' nationally, and is listed under the Western Australian *Wildlife Conservation Act 1950* as fauna which is likely to become extinct, or is rare. For this study a helicopter survey was conducted to estimate goose numbers. The total population was estimated at approximately 650 birds with 631 actually being counted. The average number of birds per island was 8.5 in 1993 compared with 6.5 in earlier surveys. 1991 was considered to be a year of low abundance, and Garnett suggested that local drought and hot weather caused a shortage of food available on the islands. In 1991 40% of geese found were dead, apparently from starvation. Meteorological data showed that January and February 1991 were exceptionally hot and dry, with temperatures reaching 44°C. However, the population would appear to have recovered within two years. Possibly the greatest threat to the Cape Barren goose status are national catastrophes, such as drought (Burbidge, *et al.*, 1993a, 1993b).

The Western Australian Wildlife Resource Center (WAWRC) has recently compiled a bird database of the Western Australian coastline (WAWRC, 1996).

2.2.3 Mammals

Abbot & Burbidge (1995) summarises the occurrence of mammal species on islands around Australia and provides a bibliography for the each of the records. This summary includes listings for the following islands within the south coast study area: Bald, Breaksea, Chatham, Cranny, Cull, Daw, Eclipse, Figure of Eight, Finger, Hauloff Rock, Hood, Kermadec (=Wedge), Libke, Mackenzie (=Round), Michaelmas, Middle, Middle Doubtful, Mistaken, North Twin Peak, Pasley, Rocky (=Investigator), Round, Salisbury, Seal Rock, Termination, West and Woody Islands. Further information on the occurrence of terrestrial mammals in the mainland national parks and nature reserves is available from both published and unpublished material listed in Lyons & Gibson (1994).

The locations of New Zealand fur seal and Australian sea lion breeding and haul-out sites across the study area are described in the marine mammals review (see Appendix III).

3. REVIEW OF CULTURAL AND HISTORICAL RESOURCES

Areas of Aboriginal and European cultural importance occur on many lands managed by CALM across the south coast study area.

3.1 Aboriginal sites

Aboriginal people have occupied the south-west of Western Australia for at least 40,000 years. Numerous Aboriginal sites have been identified in the region. A complete listing exists for all Aboriginal sites along the south coast and this information gives site locations and a brief description of the type/importance of each site. The digital data has been obtained from the Department of Aboriginal Affairs and transferred to the marine GIS system at CALM's Marine Conservation Branch. Figure 1 shows the location of these sites for the south coast study area. This figure also shows the Nyoongar Dreaming Trails that have been identified for the south coast region (N. Nannup, CALM Aboriginal Tourism Unit, pers. comm.). A variety of different types of site are known, both ethnographic and archaeological. Most archaeological sites are artefact scatters on the coast or islands or associated with estuaries and water courses. Several of the sites exhibit material that pre-dates sea level rise. References covering archaeological finds on the south coast have been entered in the South Coast Terrestrial and Marine Reserve Database, a large proportion of the work on the south coast having been carried out by the Western Australian Museum (Dortch, 1995).

3.2 European sites

European coastal and maritime sites include those used as whaling and sealing stations, fishing sites and coastal aids to navigation such as light houses. During the early 1800s whaling and sealing were widely practised activities. A record and assessment of Albany's maritime sites, concentrating on terrestrial sites including whaling stations, jetties etc., is given in a chronological record of the maritime heritage of the area by Wolfe (1994a). Sites of the major bay whaling stations in the south coast region have been found at the following locations - Middle Island, Doubtful Island Bay, Two Peoples Bay, Barker Bay, Torbay, Cheyne Beach, Cape Arid, and Cape Riche. Other sites which are likely to have been used as whaling sites include Duke of Orleans Bay and Waychinicup Inlet (McIlroy, 1987). The remains of the whaling station at the Middle Island site are described by Pearson (1988) in a report on an archaeological survey of some islands in the Recherche.

Eclipse Island Lighthouse - The lighthouse was first built in 1926 it is now automated. The Eclipse building at the Albany Residency Museum displays the old optic from the light house with information on the history of the site. A description of the lighthouse and the island, including flora and fauna, is given in Scott (1988).

Breaksea Island Lighthouse - The old light was built in 1858, and the new light in 1902. The Point King and Breaksea Island lighthouses were the second set of lighthouses built in WA. The Albany Maritime Heritage Museum have an ongoing project on Breaksea Island to restore the buildings on the island. This is a long term community project, details of which are given in Wolfe (1994b).

4. REVIEW OF SOCIAL AND ECONOMIC USAGE

The most popular land-based activity along the south coast is probably sight seeing, particularly in West Cape Howe, Torndirrup, Waychinicup, Fitzgerald River and William Bay National Parks. Other activities are listed below.

The primary issue with all water-based activities is access to the coast, how this is gained and whether the coastal environment is being degraded as a result. User conflict is also an important issue. Watson (1982) produced a summary of water-based recreational activities in south coast National Parks. The Water and Rivers Commission (Waterways Commission) produced a review of recreational usage of water bodies in Busselton and Walpole (Madden, 1995), which highlights the Walpole-Nornalup Inlet as the major recreational centre in this area. Information on recreational activities has been sourced from National Park management plans and gathered from local user groups and CALM staff. The Albany Harbours Planning Strategy (AHPG, 1997) details water-based activities within the harbours area.

4.1 Fishing

Conflict between recreational and commercial fishers often causes problems particularly in south coast inlets (e.g. Culham, Hamersley and Stokes Inlets). Recreational fishers often feel fish stocks are being depleted by commercial fishermen operating under very different restrictions (see estuaries review - Appendix V).

The majority of fishing sites within coastal national parks and nature reserves are accessed by vehicle and many on four wheel drive tracks. Vehicle access to fishing spots can have adverse impacts on the environment. If vehicles leave existing roads and tracks it encourages others to follow leading to a profusion of tracks and associated erosion problems, particularly in sandy soils and dune systems. Keeping fishers to recognised and maintained tracks is important in preventing erosion of fragile dune systems and the spread of fungal plant disease (*Phytophthora*). In some areas foot access only may be allowed to remote fishing spots in zones of high conservation value. Fishermen often camp at fishing sites particularly when in more remote areas, this can lead to problems as fires are often lit, rubbish and discarded tackle may not be removed.

4.2. Beach activities

Beach driving (4WD)

Several of the water-based activities undertaken from within terrestrial reserves require access to and along beaches by four wheel drive. There are two main issues associated with 4WD vehicles. The first is physical damage to the environment, damaging vegetation, causing erosion, disturbing wildlife and spreading diseases such as dieback. Spread of dieback is unlikely to occur along beaches but can be a problem with 4WD access to beach areas. The second is conflict with other user groups where the peace and tranquillity of remote areas is disturbed by vehicles, and visitor safety is put at risk. These issues are tackled in coastal parks by management of access, keeping tracks maintained, closing unsuitable areas to vehicles and providing information to vehicle owners. Outside National Parks beach driving and access to the coast can be a greater problem, as these areas are often not managed.

Boat launching

There are several problems associated with boat use. Primarily the most difficult issue is access - boat launching facilities are limited and can therefore become congested and areas around launching sites can become degraded.

Beach camping

Beach camping is often associated with water-based recreation, surfing, fishing etc. and is carried out at a number of CALM-managed sites. Problems include access (as discussed above), degradation of vegetation, erosion, lighting fires and leaving rubbish.

Squatter camps

There are several areas along the coast where shacks and squatter camps are located. Some camps are legal, some have lease agreements and some are illegal. Within National Parks these camps are dealt with in the respective management plans. On vacant crown land there are many illegal camps.

4.3 Land-based sports

Hang gliding

One of the premier hang gliding sites in WA is located near Shelley Beach in West Cape Howe National Park and sites in Torndirrup National Park are also popular. Sporadic use is also made of other areas in the coastal region. Hang gliding participants camp at Shelley Beach in numbers as high as 40-50 in the peak season. All pilots are registered with the Hang Gliding Association of Western Australia. The association has approval from CALM to use specific sites under agreed conditions and site use is then managed by the Hang Gliding Association.

Rock climbing

Major coastal rock climbing areas are located at West Cape Howe National Park where the climbing is renowned at a national level. Height, aspect and quality of climb are all thought to be exceptional. Other popular sites include Torndirrup and Waychinicup and some less frequently used sites along the Fitzgerald

coastline. All climbers are asked to adhere to the Climbing Association of Western Australia's Code of

Sand boarding

Currently, this activity is not thought to be a major problem. There are occasional reports of sand boarding at Two Peoples Bay Nature Reserve.

4.4 Tourism

Tourism is a major industry in many areas on the south coast, with many coastal towns relying in part on visiting tourist trade. The network of national parks and nature reserves, the spectacular coastal scenery and pristine beaches, the maritime heritage, the marine mammal watching opportunities and the fishing are major attractions that draw increasing numbers of visitors to the south coast (Sandiford, 1988). The south-east region of the south coast (Hopetoun to east of Esperance) is one of the fastest-growing tourism regions in the State, with more than 200,000 visitors during 1996 (Western Australian Tourism Commission data). Tourist activities on CALM managed lands include coach tours, 4WD off road 'safari' types tours, and active adventure tours. With increasing facilities and activities for tourists more people are coming to the region and it is expected that the number of tourists will double by the year 2005. CALM records vehicle numbers at selected points in the South Coast Region to provide information on visitation levels at several national parks and nature reserves (CALM South Coast Region visitor figures 1993/94).

A variety of visitor facilities and recreation opportunities are available within the south coast national parks and nature reserves. Information on these facilities and opportunities is detailed in CALM management plans (CALM, 1987, 1991, 1992a, 1992b, 1995a, 1995b). A recreation guide to the terrestrial reserves of the south coast is also available on CALM's Nature Base web page on the Internet. A list of the major recreational sites in the study area is shown in Table 4.

5. REVIEW OF MANAGEMENT ISSUES

5.1 Coastal rehabilitation

Since the early 1980s, a major effort has taken place within coastal national parks and at Two Peoples Bay Nature Reserve to rehabilitate blowouts and other erosion caused by earlier unmanaged use and poor location of facilities and footpaths near the coast. Major projects have occurred at William Bay National Park, West Cape Howe National Park, Torndirrup National Park (numerous sites), Two Peoples Bay Nature Reserve, Fitzgerald River National Park, Stokes National Park, Cape Le Grand National Park (numerous sites) and Cape Arid National Park. Careful coastal, planning is necessary to prevent repeated erosion problems. Access is again a major issue.

5.2 Aerial deposition of soil to the marine environment

Large quantities of soil are deposited to the marine environment in many areas along the coast. AgWA in Albany has estimated soil moving in two major wind erosion events as being in the order of millions of tonnes (Carter, 1995). In the Gascoyne region seabed cores have been taken showing a considerable amount of terrestrial dust in marine deposits. To date no similar work has been done on the south coast. The wind erosion problem is most severe east of Albany to Esperance, with hot spots around the Bremer Bay area. The erosive winds causing most dust storms are north westerlies, blowing dust straight out to the ocean.

5.3 Access to estuarine and marine environments

Access is an issue associated with many recreational and commercial uses of coastal areas (as discussed above). Access to the coast can be either by foot, 2WD, 4WD or by boat. Riverine, estuarine and coastal environments are often fragile and susceptible to erosion, particularly from the impacts of vehicles, and boats. Access to the coast has to be controlled to prevent creation of new tracks risking erosion and spread of dieback disease, which is a major issue. CALM aims to provide a range of access to the coast options whilst ensuring that park and other coastal users are not adversely affected. Access is probably the most difficult management issue that

coastal parks face. It can at least be addressed in National Parks and Nature Reserves, but greater problems generally occur on shire reserves or vacant crown land where access is often uncontrolled.

5.4 Visitor safety

In addition to dangers inherent in any natural area, the southern coastline presents some particular safety problems for visitors. These are king waves, which are really unusually large swells that pose a considerable threat to people fishing from rocky shores, and fragile or unstable cliff areas. Arrangements for cooperation between CALM, the Police and the State Emergency Service (SES) in the Albany area are detailed in an inter-agency agreement which is revised annually. Rescue equipment is held by the SES. CALM maintains some equipment at Torndirrup National Park, which is the area with the highest level of accidents due to the rugged nature of the coastline and the high level of visitor use. The *Occupier Liability Act* requires a very high level of safety awareness on all CALM managed lands. Staff are regularly trained in safety management, regular safety audits are carried out and clear safety warnings are displayed at visitor sites.

Several high risk recreational activities are carried out in the area, these include rock climbing, hang-gliding, surfing and diving. Accidents associated with adventure activities are low in comparison to accidents among general visitors. This probably reflects the small numbers of people undertaking these activities and the degree of training and safety measures required for these adventure activities.

5.5 Community liaison and education

Most national parks and several nature reserves of the South Coast Region have a high public profile for both local residents and tourist visitors. There are excellent opportunities to promote an awareness of conservation, land management and natural systems and processes in both the local community and visitors. All CALM personnel in the region have some involvement with community education and interpretation work, through provision of information to visitors, informal contact with visitors and talks to community and school groups. A visitor centre will be completed at Two Peoples Bay Nature Reserve in 1997.

A network of interpretive trails has been established at key sites throughout the region, with a regional guide book to the heritage network (Sandiford, 1988). A range of other publications on recreation facilities and activities and technical information is available from Departmental offices and ranger out-stations throughout the region.

CALM has a statutory requirement to include a public participation process in the preparation of management plans. In addition to this CALM aims to cooperate with local communities and establish projects of mutual interest. Examples of community involvement in the south coast region include:

- Staff involvement on local tourist committees;
- Advice about landscaping, tree planting and assistance to bodies such as 'Greening Australia';
- Cooperation with schools, e.g. on Arbor Day and through provision of work experience opportunities;
- Public workshops, seminars and talks to interested groups;
- Involvement with various advisory committees, Friends of the Park and volunteer groups;
- Involvement with land conservation district committees (LCDCs) and catchment management advisory groups; and
- Liaison with bush fire brigades.

A number of community projects have been associated with Fitzgerald River National Park including the 'community-CALM link project' which involved CALM staff working with residents in the area around the national park. The Fitzgerald River National Park Association and CALM have jointly established a number of walks and produced associated interpretive publications. The Association also runs the Twertup field centre, located in the north-western part of the park on the edge of the Fitzgerald River valley. The center is run on a volunteer basis and provides a number of courses including botany, geology, ornithology etc. It is used by universities, schools, independent organisations and as a research centre.

The Fitzgerald Biosphere Project committee is interested in education and research in the broader context of the park and adjacent lands, promoting the biosphere concept to result in better land management practices, particularly on agricultural land.

5.6 Marine mammal stranding planning

A departmental plan dealing with strandings is being produced. At present strandings on the south coast are dealt with by the district offices on a case-by-case basis using a team of CALM staff and experienced volunteers, such as the West Whales group.

5.7 Oil spill contingency planning

The state-wide Department of Transport contingency plan covers the south coast area. In addition to this each major harbour area has its own oil spill contingency planning.

5.8 Ocean discharges

The Department of Environmental Protection (DEP) controls the licensing of industrial discharges into state marine waters. The DEP licences a number of discharges into Albany Harbours (Princess Royal Harbour), including those from Albany Spinning Mills, Vital Foods, Princess Royal Seafoods and CSBP who discharge via a drain. Every coastal town has waste water treatment. All south coast towns have secondary treatment, and some (Denmark at present and others to follow) have secondary treatment with nutrient removal, followed by soakage into the ground.

5.9 Coastal recreational facilities

Many recreation sites used by day and overnight visitors have been established on the coast (Table 4). These are often at the end of old fishing tracks associated with scenic sites, beaches or headlands. Establishment of recreational and particularly camping sites on the coast has led to problems in some areas due to poor site selection, over-use and site degradation. Many sites are located on fragile soils that erode easily, such as unconsolidated sands. Camping often focuses on small stands of melaleucas which provide shade. Many of these stands have been stripped for fire wood or damaged by vehicles. Once vegetation is damaged, sandy soils are exposed and readily erode. Coastal sites, therefore, have to be managed according to their fragility.

5.10 Landscape

Coastal activities have the potential to cause significant landscape impact. Such impacts are often, though not always, linked to vehicle access. Poorly sited tracks, roads and car parks can degrade the visual amenity of coastal areas. Uncontrolled vehicle activity can lead to erosion that is difficult and expensive to rehabilitate and which severely degrades the visual resource, such as at West Cape Howe and Gull Rock National Parks.

The location and maintenance of facilities, such as foot paths, is also critical. Poorly located paths in fragile coastal areas can rapidly lead to blow-outs which are difficult to revegetate and whose presence attracts further use.

5.11 Agriculture

The South Coast Region (defined by AgWA as the area encompassing catchments of all southerly flowing rivers between the Frankland Gordon in the west and Cape Arid in the east) covers some 5.4 million hectares. Most of the region has been developed in the past 50 years and relies heavily on agriculture. The sandy nature of south coast soils makes them liable to erosion, water repellance, acidification and compaction. Major wind erosion events are not uncommon east of the Pallingup River.

Agriculture practices across the South Coast Region have lead to extensive clearing of the native vegetation, particularly east of Albany. Considerable areas of the coastline however, still support native vegetation. These areas are mostly in National Parks and Nature Reserves and some areas remain as vacant crown land.

Almost all the rivers discharge into estuaries which are closed by sand bars or into wetlands that are rarely flushed. As a consequence eutrophication and siltation are major issues in most estuaries across the region (see estuaries review - Appendix V). A land and water care strategy covering the south coast has been developed, based on six identified subregions. This has been further developed into a Regional Initiative which has been funded by the Commonwealth Government through the Natural Heritage Trust (SCRIPT, 1996). Sustainable

rural development is the primary objective of agriculture in the the region whilst best practice coordination and integration of natural resource management is encompassed in the Regional Initiative.

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Table 1: Seabird species occurring on islands in the Recherche Archipelago in 1982.

Common name	Scientific name	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Great-winged petrel	<i>Pterodroma macroptera</i>	+					+		+	+					+
Black-faced shag	<i>Leucocarbo fuscescens</i>	+					+		+	+					
Silver gull	<i>Larus novaehollandiae</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Pacific gull	<i>Larus pacificus</i>	+	+		+	+	+	+	+	+	+	+	+	+	+
Great cormorant	<i>Phalacrocorax carbo</i>	+					+								
Eastern reef egret	<i>Egretta sacra</i>	+		+											+
Sooty oystercatcher	<i>Haematopus caspia</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	
Fairy tern	<i>Sterna nereis</i>	+													
Caspian tern	<i>Hydroprogne caspia</i>		+		+	+	+						+	+	
Crested tern	<i>Sterna bergii</i>		+			+	+		+					+	+
White-faced storm petrel	<i>Pelagodroma marina</i>		+	+				+		+	+	+	+	+	+
Little penguin	<i>Eudyptula minor</i>			+	+	+	+		+	+		+	+		+
Cape Barren Goose	<i>Cereopsis novaehollandiae</i>			+		+	+	+	+		+	+	+	+	+
Flesh-footed shearwater	<i>Puffinus carneipes</i>				+	+		+	+	+	+		+		+
Little shearwater	<i>Puffinus assimilis</i>					+	+								
White-bellied sea-eagle	<i>Haliaeetus leucogaster</i>				+	+			+	+	+		+		
Australian raven	<i>Corvus coronoides</i>				+	+		+			+				
Little black cormorant	<i>Phalacrocorax sulcirostris</i>									+					
Yellow-nosed albatross	<i>Diomedea chlororhynchus</i>								+						
Peregrine falcons	<i>Falco peregrinus</i>											+			
Short-tailed shearwater	<i>Puffinus tenuirostris</i>														+
Total 21 species	Total species on Islands:	8	6	6	8	11	11	7	11	11	8	7	9	8	9

Note: Not all birds were breeding on the islands, and some birds were identified by remains on the island (From: Lane, 1982b).

- 1- Middle Island
- 2- Nares Island
- 3- Lorraine Island
- 4- Ram Island
- 5- MacKenzie Island

- 6- Hood Island
- 7- Frederick Island
- 8- Sandy Hook Island
- 9- Remark Island
- 10- Long Island

- 11- Cull Island
- 12- Observatory Island
- 13- Canning Island
- 14- Figure of Eight Island

Table 2: Seabird species which may occur off the south coast of Western Australia.

Common name	Scientific name
PENGUINS 1/12	
Little penguin	<i>Eudyptula minor</i>
ALBATROSSES 7/9	

Wandering albatross	<i>Diomedea exulans</i>
Black-browed albatross	<i>D. melanophrys</i>
Grey-headed albatross	<i>D. chrysostoma</i>
Yellow-nosed albatross	<i>D. chlororhynchos</i>
Shy albatross	<i>D. cauta</i>
Sooty albatross	<i>Phoebetria fusca</i>
Light-mantled albatross	<i>P. palpebrata</i>
PETRELS AND SHEARWATERS 19/41	
Southern giant petrel	<i>Macronectes giganteus</i>
Northern giant petrel	<i>M. halli.</i>
Cape petrel	<i>Daption capense</i>
Great winged petrel	<i>Pterodroma macroptera</i>
White headed petrel	<i>P. lessonii</i>
Kerguelen petrel	<i>P. brevirostris</i>
Soft-plumed petrel	<i>P. mollis</i>
Blue petrel	<i>Halobaena caerulea</i>
Salvin's prion	<i>Pachyptila salvini</i>
Antarctic prion	<i>P. desolata</i>
Slender-billed prion	<i>P. belcheri</i>
Fairy prion	<i>P. turtur</i>
White-chinned petrel	<i>Procellaria aequinoctialis</i>
Flesh-footed shearwater	<i>Puffinus carneipes</i>
Sooty shearwater	<i>P. griseus</i>
Short-tailed shearwater	<i>P. tenuirostris</i>
Fluttering shearwater	<i>P. gavia</i>
Huttons shearwater	<i>P. huttoni</i>
Little shearwater	<i>P. assimilis</i>
STORM PETRELS 1/7	
Wilson's storm petrel	<i>Oceanites oceanicus</i>
DIVING PETRELS 2/2	
White faced storm petrel	<i>Pelagodroma marina</i>
Black bellied storm petrel	<i>Fregetta tropica</i>
PELICANS 1/1	
Australian pelican	<i>Pelecanus conspicillatus</i>
GANNETS AND BOOBIES 1/6	
Australian gannet	<i>Morus serrator</i>
DARTERS 1/1	
Darter	<i>Anhinga melanogaster</i>
CORMORANT 5/6	
Black-faced cormorant	<i>Leucocarbo fuscescens</i>
Great cormorant	<i>Phalacrocorax carbo</i>
Pied cormorant	<i>P. varius</i>
Little-black cormorant	<i>P. sulcirostris</i>
Little-pied cormorant	<i>P. melanoleucos</i>

Total of 39 out of 90 Australian seabird species are found in the south coast region. (From: Lindsey, 1986).

Table 3: Shorebird species which may occur along the south coast of Western Australia.

Common name	Scientific name
OYSTERCATCHERS 2/2	
Pied oystercatcher	<i>Haematopus longvostris</i>
Sooty oystercatcher	<i>H. fuliginosus</i>
DOTTERS, PLOVERS & LAPWINGS	
Banded lapwing	<i>Vanellus tricolor</i>
Grey plover	<i>Pluvialis squatarola</i>
Pacific golden plover	<i>P. dominica</i>
Red-kneed dotterel	<i>Erythrogonys cinctus</i>
Hooded plover	<i>Charadrius rubricollis</i>
Mongolian plover	<i>C. mongolus</i>
Double banded plover	<i>C. bicinctus</i>
Large sand plover	<i>C. leschenaultii</i>
Red-capped plover	<i>C. ruficapillus</i>
Black-fronted plover	<i>C. melanops</i>
Inland dotterel	<i>Peltohyas australis</i>
STILTS AND AVOCETS 3/4	
Blackwinged stilt	<i>Himantopus leucocephalus</i>
Banded stilt	<i>Cladorhynchus leucocephalus</i>
Red-necked avocet	<i>Recurvirostra novaehollandiae</i>
SANDPIPERS, SNIPE, CURLEWS & GODWITS 15/44	
Ruddy turnstone	<i>Arenaria interpres</i>
Eastern curlew	<i>Numenius madagascariensis</i>
Whimbrel	<i>N. phaeopus</i>
Wood sandpiper	<i>Tringa glareola</i>
Grey-tailed tattler	<i>T. brevipes</i>
Common sandpiper	<i>T. hypoleucos</i>
Greenshank	<i>T. nebularia</i>
Black-tailed godwit	<i>Limosa limosa</i>
Bar-tailed godwit	<i>L. lapponica</i>
Red knot	<i>Calidris canutus</i>
Sharp-tailed sandpiper	<i>C. acuminata</i>
Red-necked stint	<i>C. ruficollis</i>
Long-toed stint	<i>C. subminuta</i>
Curlew sandpiper	<i>C. ferruginea</i>
Sanderling	<i>C. alba</i>
SHEATHBILLS 1/1	
Lesser sheathbill	<i>Chionis minor</i>
SKUAS AND JAEGERS 2/5	
Southern skua	<i>Catharacta antarctica</i>
Arctic jaeger	<i>Stercorarius parasiticus</i>
GULLS AND TERNS 9/28	
Silver gull	<i>Larus novaehollandiae</i>
Pacific gull	<i>L. pacificus</i>
Kelp gull	<i>L. dominicanus</i>
Whiskered tern	<i>Chlidonias hybridus</i>
Gull-billed tern	<i>Gelochelidon nilotica</i>
Caspian tern	<i>Hydroprogne caspia</i>
Arctic tern	<i>Sterna paradisaea</i>
Fairy tern	<i>S. nereis</i>
Crested tern	<i>S. bergii</i>

Total of 43 shorebird species found along the south coast of Western Australia (From: Pringle, 1987).

Table 4: Major recreational sites in the south coast study area (west to east)

*Walpole-Nornalup National Park - recreational facilities.
Boat Harbour West - recreational site west of William Bay National Park.
William Bay National Park - swimming and recreation site with boat launching facilities.
Denmark (Wilson Inlet) - boat launching and recreational facilities.
Ocean Beach - boat launching and recreational facilities.
Rudyard Beach (Wilson Inlet) - caravan park, chalets, recreational facilities.
*West Cape Howe National Park - recreational facilities.
Torbay (Cosy Corner) - commercial fishing camp, recreational site, camping, boat launching, moorings.
Mutton Bird Island - fishing, swimming, boat launching.
Sand Patch - fishing, surfing.
Torndirrup National Park - recreational facilities.
Salmon Holes Beach - fishing, surfing.
Frenchman's Bay - boat launching and beach facilities.
Albany - town, accommodation, tourist attractions and numerous facilities.
Gull Rock - recreational facilities.
*Two Peoples Bay Nature Reserve - recreational facilities.
Waychinicup National Park - camping, fishing swimming, day use, marroning in the river.
Cheyne's Beach - township with caravan park, fishing, boat launching
Cape Riche - boat launching, camping.
Reef Beach - South Coast Recreational Fishermen's Associations shack.
Fisheries Beach (Bremer Bay) - new development fishing boat harbour, recreational facilities.
Point Ann - day use whale watching platform and recreational facilities.
St. Mary's - campsite for Point Ann.
Point Charles - campsite.
*Fitzgerald River National Park - recreational facilities.
Two Mile Beach - campsite.
Hopetoun - jetty, shops, caravan park etc., shire beach sites east of the town.
Mason Bay - fishing, boat launching.
Starvation Boat Harbour - boat launching, fishing.
Stokes National Park - recreational facilities.
Warrenup Beach - surfing.
Esperance - town, tourist attractions and numerous facilities.
Cape Le Grand National Park- beach, day use, recreational facilities.
Lucky Bay - campsite in the National Park.
Duke of Orleans Bay - holiday camp, boat launching.
Cape Arid National Park - recreational facilities.

*(Complete lists of recreational sites for Walpole-Nornalup, West Cape Howe and Fitzgerald River National Parks and for Two Peoples Bay Nature Reserve are given in their respective management plans).

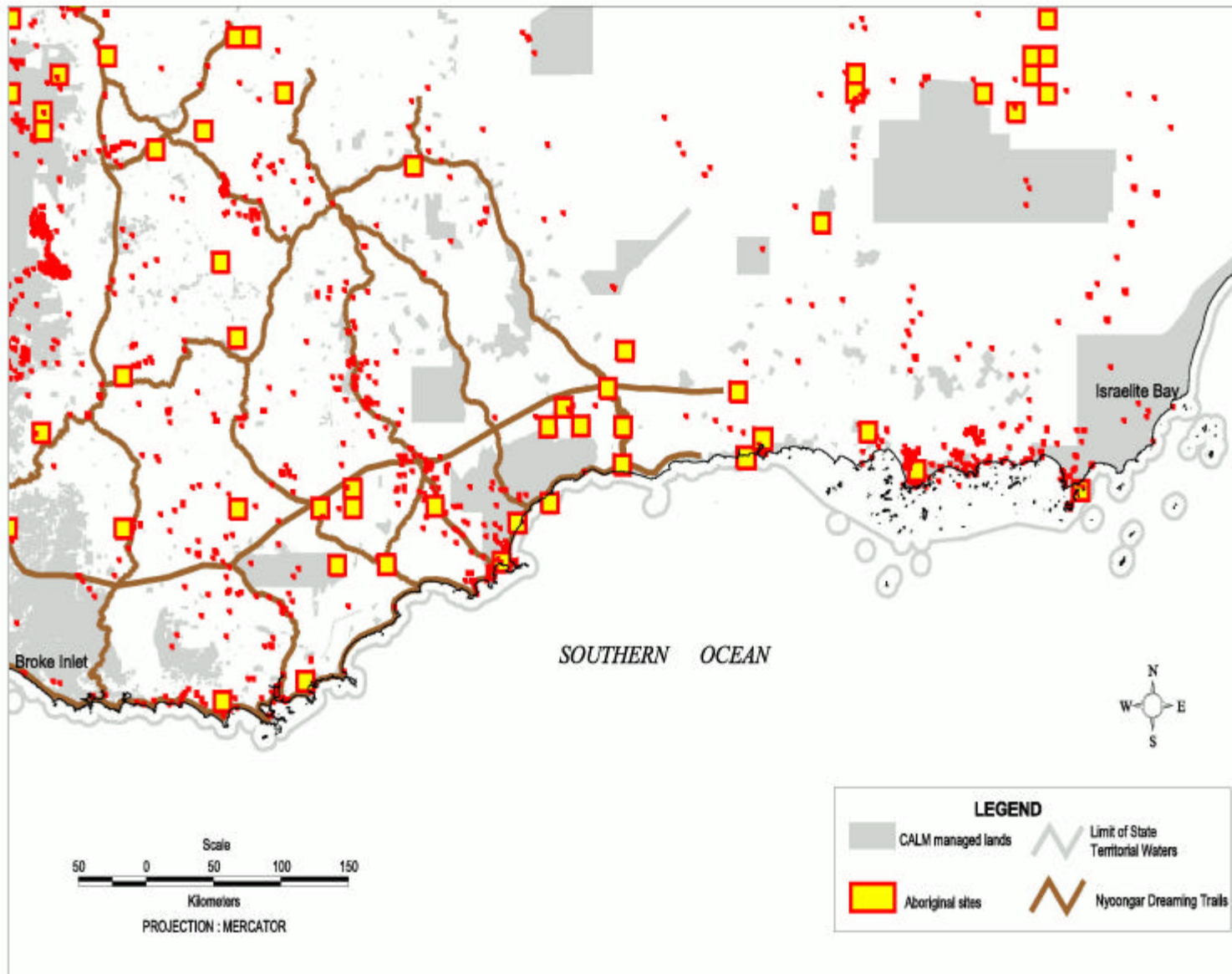


Figure 1. Aboriginal cultural /historical sites: Broke Inlet to Israelite Bay.

APPENDIX VII

MARINE FLORA AND FAUNA OF THE STUDY AREA

QUANTITATIVE SURVEY SPECIES LIST

Phaeophyta (Brown Algae)

?*Dictyota* (wide)
Acrocarpia robusta
Caulocystis uvifera
Cystophora botryocystis
Cystophora expansa
Cystophora gracilis
Cystophora harveyi
Cystophora monilifera
Cystophora moniliformis
Cystophora pectinata
Cystophora racemosa
Cystophora retorta
Cystophora retroflexa
Cystophora spp.
Cystophora subfarcinata
Dictyopteris muelleri
Dictyopteris-like (thick)
Dictyota (fine)
Dilophus marginatus
Ecklonia radiata
Halopteris spp.
Lobophora variegata
Lobospira bicuspidata
Padina sp.
Platythalia quercifolia
Sargassum decipiens
Sargassum heteromorphyum
Sargassum spp.
Sargassum varians
Sargassum verruculosum
Scaberia agardhii
Scytothalia dorycarpa
Sporochnus sp.
 Unidentified brown alga
Zonaria spiralis
Zonaria turneriana

Chlorophyta (Green Algae)

Caulerpa brownii
Caulerpa cactoides
Caulerpa cf *brownii* (v. fine ramuli)
Caulerpa distichophylla
Caulerpa obscura
Caulerpa racemosa
Caulerpa scalpelliformis
Codium pomoides

Rhodophyta (Red Algae)

?*Dictyosphaeria serica*
 ?*Jania*
 ?*Latropiscis purpurissatus*
 ?*Sarconema*
Amphiroa
Botryocladia obovata
Callophycus
Champia sp.
Claudea elegans
 Corallines
Dasya
Delisea spp.
Erythroclonium
 Filamentous red alga
Griffithia sp.
Haliptalon
Haloplegma preissi
Hypnea ramentacea
Laurencia spp.
Metagoniolithon sp.
Metagoniolothon stelliferum
Metamastophora sp1
Metamastophora sp2
Osmundaria
 Other thallos red alga
Phacellocarpus peperocarpus
Plocamium angustum
Plocamium cartilagineum
Plocamium dilatatum
Plocamium mertensii
Plocamium pressianum
Rhodopeltis
Rhodymenia sp.
Sarcomenia delesseriodes
 Unidentified red alga

Magnoliophyta (Seagrasses)

Amphibolis antarctica
Amphibolis griffithi
Halophila australis
Heterozostera tasmanica
Posidonia australis
Posidonia denhartogi
Posidonia kirkmanii
Posidonia robertsoniae
Posidonia sinuosa

Mollusca

Aplysia gigantea
Cabestana tabulata
Calliostoma ciliaris
Campanile symbolicum
Charonia rubicunda
Cymatium parthenopeum
Haliotis emma
Haliotis laevigata
Haliotis roei
Haliotis rubra
Pinna bicolor
Ranella australasia
Sassia subdistorta
Scutus antipodes
Sepia apama
Thais orbita
Trochus sp. (blue aperture)
Turbo jordani
Turbo sp. (denticular operculum)
Turbo torquatus

Echinodermata

Anthaster valvulatus
Cenolia trichoptera
Centrostephanus tenuispinus
Echinaster arcystatus
Echinaster glomeratus
Echinaster varicolor
Fromia polypora
Heliocidaris erythrogramma
Holopneustes porosissimus
Nectria macrobrachia
Nectria multispina
Nectria saoria
Nectria wilsoni
Nepanthiaroughtoni
Patiriella brevispina
Pentagonaster duebeni
Petricia vernicina
Phyllacanthus irregularis
Plectaster decanus
Stichopus mollis
Tosia australis
 Unidentified echinoderm

Porifera

Ancorinidae sp1
 Ancorinidae sp5
 Ancorinidae sp6
Antho (antho)? sp
 Aplysinidae sp1
 Calc sp1
 Calc sp2
 Calc sp3
Chondrilla austaliensis
 Coppatidae sp1
 Coppatidae? sp2
Cymbastella sp
Cymbastella sp3
 Desmacellidae sp3
 Desmacellidae? sp2
 Dysideidae sp1
Echinoclathria (Holopsamma) sp1
Echinoclathria sp
Haliclona sp1
 Irciniidae sp1
 Irciniidae sp3
 Irciniidae sp4
 Irciniidae sp7
 Irciniidae sp8
 Microcionidae sp 2
 Microcionidae sp 4
 Microcionidae sp6
 Microcionidae sp7
 Mycalidae sp1
 Niphatidae sp2
Oceanapia sp2
Oceanapia sp3
Oceanapia sp5
 Poecilosclerida? sp
Spirastrella? sp
 Spongiidae sp1
 Spongiidae sp1
 Spongiidae sp3
Tethya ingalli
Tethya sp1

Cnidaria

Phlyctenactis tuberculosa

Arthropoda

Jasus edwardsii

Paguristes frontalis
Plagusia chabrus
 Unidentified Pagurid

Chordata

FISHES

Achoerodus gouldii
Anoplocapros amygdaloides
Anoplocapros lenticularis
Aplodactylus westralis
Arripis georgianus
Austrolabrus maculatus
Bodianus frenchi
Caesioscorpis theagenes
Caranx dentex
Caranx wrightii
Centroberyx lineatus
Cephaloscyllium laticeps
Cheilodactylus nigripes
Cheilodactylus rubrolabiatu
Chelmonops curiosus
Chironemus georgianus
Chromis hypsilepis
Chromis klunzingeri
Cnidoglanis macrocephala
Conger verreauxi
Contusus brevicaudus
Coris auricularis
Dactylophora nigricans
Dinolestes lewini
Dotalabrus alleni
Dotalabrus aurantiacus
Enoplosus armatus
Epinephelides armatus
Eupetrichthys angustipes
Girella tephraeops
Girella zebra
Halichoeres brownfieldi
Heterodontus portusjackson
Hypoplectrodes nigrorubrum
Kathetostoma laeve
Kyphosus sydneyanus
Maxillicosta scabriceps
Meuschenia flavolineata
Meuschenia freycineti

Meuschenia galii
Monacanthus chinensis
Neotypus obliquus
Nemadactylus valenciennes
Neodax balteatus
Notalabrus parilus
Odax acroptilus
Odax cyanomelas
Omegophora armillata
Omegophora cyanopunctata
Ophthalmolepis lineolatus
Othos dentex
Paraplesiops meleagris
Parapriacanthus elongatus
Parascyllium variolatum
Parequula melbournensis
Parma mccullochi
Parma victoriae
Pelsartia humeralis
Pempheris klunzingeri
Pempheris multiradiatus
Penicipelta vittiger
Pictilabrus laticlavus
Pictilabrus sp.
Pseudolabrus biserialis
Schuettea woodwardi
Scobinichthys granulatus
Scorpis aequipinnis
Scorpis georgiana
Seriola lalandi
Siphamia cephalotes
Siphamia sp.
Siphognathus attenuatus
Siphonognathus beddomei
Siphonognathus caninus
Siphonognathus radiatus
Tilodon sexfasciatum
Trachichthys australis
Trachinops brauni
Trachinops noarlungae
Trachurus novaezelandiae
Trygonoptera ovalis
 Unidentified fish
Upeneichthys vlaminghii

OTHER SPECIES RECORDED

Phaeophyta (Brown Algae)

Caulocystis
Cystophora grevillei
Dictyopteris plagiogramma
Dictyota sp 1
Dictyota sp 2
Dictyota sp 3
Dictyota sp 4
Dilophus intermedius?
Dilophus sp 1
Lobospira
Padina elegans
Sargassum sp1
Sargassum sp2
Sargassum sp3
Sargassum sp4
Sargassum sp5
Sargassum sp6
Sargassum sp7
Sargassum sp8
Sporochnus radicumformis
Styopodium

Laurencia filiformis

Laurencia sp1
Laurencia sp2
Laurencia sp3
Laurencia sp4
Laurencia sp5
Laurencia sp6
Laurencia sp7
Melanamansia
Metagoniolithon radiatum
Metamastophora flabellata
Myriodesma
Myriodesma quercifolium
Osmundaria prolifera
Osmundaria spiralis
Pachydictyon
Polysiphonia
Polysiphonia decipiens
Pterocladia lucida
Rhodopeltis australis
Rhodymenia sonderi
Spyridia
 Unidentified red alga sp1
 Unidentified red alga sp2

Chlorophyta (Green Algae)

Caulerpa flexilis
Struvea plumosa

Rhodophyta (Red Algae)

Areschougia congiuta
Botryocladia sonderi
Callophycus harveyanus
Callophycus oppositifolius
Carpopeltis elata
Chondria sp 1
Chondria sp 2
Cystoseira
Ganonema farinosum
Gracilaria
Haliptilon roseum
Hennedyia crispa
Heterosiphonia muelleri
Hypnea sp1
Hypnea sp2
Laurencia clavata
Laurencia elata

Mollusca

Charonia lampas
Cryptoplax striata
Cypraea friendii
Dicathais orbita
Dicathais sp.
Eucrassatella kingicola
 Gastropod sp.
Glycymeris radians
Lamellaria australis
Malleus meridianus
Opisthobranchia sp.
Phasianella australis
Prothalotia lehmani
Thais sp.

Echinodermata

Allostichaster polyplax
Amblypneustes leucoglobus
Antedon incommoda
Astroboa ernae
Ceto cuvieri
Comanthus gislensii
Coscinasterias muricata
Goniocidaris tubaria
Goniodicaster seriatus
Holothuria ludwigi
Holothuroidea sp.
Nectria pedicelligera
Nepanthia crassa
Ophiothrix (Placophiothrix) spongicola
Ophiuroidea sp. 1
Ophiuroidea sp. 2
Patiriella gunnii

Pontophilus intermedius victoriensis
Processa australiensis
Rhynchocinetes aff. *serratus*
Rhynchocinetes serratus
Synalpheus aff. *streptodactyloides*
Synalpheus echinus

Synalpheus fossor
Synalpheus harpagatrus
Synalpheus iocasta
Synalpheus lophodactylus
Synalpheus neptunus germanus
Synalpheus streptodactylus
Synalpheus tumidomanus
Upogebia tractabilis

Cnidaria

Actiniaria sp.
Isaurus cliffoni
Phlyctenactis australis
Phlyctenactis tuberculosa
Scolymia australis
Stauromedusae sp.
Turbinaria spp.

Arthropoda

Alope orientalis
Alpheus parasocialis
Athanas granti
Chlorocotella spinicaudus
Hippolyte australiensis
Hippolyte caradina
Latreutes compressus
Macrobranchium intermedium
Majidae sp.
Notopontonia platycheles
Periclimenes aesopius
Periclimenes aff. *obscurus*
Periclimenes n.s.
Pontophilus flindersi

Chordata

ASCIDIANS/TUNICATES

Botrylloides perspicuum
Campichthys sp.

FISHES

Halichoeres biocellatus
Herdmania momus
Meuschenia hippocrepis
Parupeneus chrysopleuron
Pentapodus vitta
Phyllopteryx taeniolatus
Polycarpa clavata
Pseudocaranx dentex
Pyura sp.
Scorpaena sumptuosa
Sillago schombergkii
Trachinops caudimaculatus
Tripterygiidae sp.
Vincentia macrocauda

MAMMALS

Arctocephalus forsteri
Delphinus delphis
Neophoca cinerea

APPENDIX VIII

EXTRACT FROM THE ANALYSIS OF PUBLIC SUBMISSIONS ON THE WILSON REPORT

A REPRESENTATIVE MARINE RESERVE SYSTEM FOR WESTERN AUSTRALIA

**REPORT OF THE MARINE PARKS AND RESERVES SELECTION
WORKING GROUP**

ANALYSIS OF PUBLIC SUBMISSIONS

OCTOBER 1997

Department of Conservation and Land Management
Locked Bag 104, Bentley Delivery Centre,
COMO, W.A. 6983

PART III

SUMMARY OF SUBMISSIONS RELATING TO AREA RECOMMENDATIONS

Many submissions commented on specific aspects of the Working Group report relating to areas recommended as worthy of consideration as marine conservation reserves. It should be noted that the report does not constitute the published notice of intent to reserve required before reservation of a marine area. A notice of intent to reserve must be published specifically for each reserve proposal, with a period for public comment. The submissions are however indicative of public attitudes and concerns relating to the reservation of those areas and therefore will be useful information for consultation and planning purposes. These submissions are summarised here.

Many of the comments made in these submissions on area recommendations relate to issues that were discussed, in general terms, in earlier parts of this analysis. Rather than duplicate that discussion, in most cases the response here is simply to note the relevant section numbers where the issue has been addressed. Where the submissions raise matters that are locality specific, or express views or raise details that were not considered in the earlier general discussions, supplementary notes are given.

D. SOUTH COAST

Two issues emerged from both the written submissions and the public meetings as of prime concern to the people of the south coast, that is, access to the shore and continuance of fishing.

Access to the shore has been a contentious issue on the south coast for many years. It is not an issue that relates to establishment of marine conservation reserves. Rather, it relates mainly to management of the adjacent land much of which, on the south coast, is reserved as national park or nature reserve (Part II - 2.1.2, 4.9). Questions of access to coastal waters, be they marine conservation reserves or not, are governed by management plans of the land reserve management authority which, in the case of national parks and nature reserves is the National Parks and Nature Conservation Authority. Local Government and other landholders are responsible elsewhere. Access across land to marine conservation reserves will continue to be a policy matter for the vested authority of the land reserves, whether marine conservation reserves are established or not.

As discussed in Part II - 2.1.2, 9.1.2 in regard to fishing in marine conservation reserves, there has been a serious misunderstanding in south coast communities about the marine conservation reserve categories. A widely promoted but erroneous view was that recreational fishing would be prohibited in marine reserves. The recommendations of the report were commonly opposed on that ground, however, most south coast recommendations in the report acknowledged the extent of fishing in the recommended areas and proposed reservation so as to accommodate recreational fishing.

In the introduction to the report it is made clear that recreational fishing would be a legitimate activity in recreation and general purpose zones of marine parks. For those areas where recreational (or commercial) fishing is an important activity, marine park would be the appropriate reserve category. Only three remote areas (at Black Point, Warren Beach and Twilight Cove) were recommended for reservation solely for conservation of marine flora and fauna. The high level of opposition to marine conservation reserves on the south coast may lessen when the management criteria for the different reserve categories are better understood. There is now the possibility that some of the areas recommended would be better suited as marine management areas, the new marine reserve category.

This will be addressed, with public consultation, during preparation of the relevant indicative management plans prior to publication of a notice of intent to reserve.

Recommendation V.3.1 - Hardy Inlet

No submissions.

Recommendation V.3.2 - D'Entrecasteaux

3.2.1 Black Point

One submission; supportive.

The submission was supported but as a marine park, thereby allowing for recreational fishing.

Reserve category would be a central issue in public discussion prior to reservation should the recommendation proceed to implementation (Part II - 3.9, 9.1).

3.2.2 Warren Beach

Two submissions; both conditionally supportive.

The submissions supported the proposed reservation but as a marine park, thereby allowing for recreational fishing.

Reserve category would be a central issue in public discussion prior to reservation should the recommendation proceed to implementation (Part II - 3.9, 9.1).

3.2.3 Broke Inlet

Ten submissions; eight supportive, two implicitly opposed.

All the submissions supporting reservation noted that the inlet has been used for many years for commercial and recreational fishing and sought assurance that this would continue. Both the submissions expressing concern at the recommendation were based on the assumption that it might mean the closure of fishing operations.

Given the intent of the recommendation, marine park would be the appropriate reserve category, within which commercial and recreational fishing could continue though subject to a public management planning process that might result in zoning areas for particular purposes (Part I - 4.2; Part II - 5.3).

One submission noted the existence of Aboriginal fish traps in the inlet and expressed anxiety that the Aboriginal community has a co-management role.

Aboriginal communities with a traditional interest in coastal areas reserved for public purposes will have opportunities to participate in management planning and operations (Part II - 6.1).

Two submissions noted that fish stocks are determined by seasonal conditions and opening of the sand bar at the mouth of the inlet. One other submission expressed concern at artificial opening of the bar when the full consequences are not understood.

The merits of opening the bar, and the timing of that opening, are the subject of widely divergent views. This would be a central issue in the public management planning process should establishment of the reserve proceed (Part II - 5.3).

One submission, while supporting the recommendation, expressed concern that the term “passive recreation” used in the report was not defined. Another suggested that all types of recreational activity should be permitted in the reserve but that wildlife areas should be made out-of-bounds at sensitive times.

The term “passive recreation” refers to activities that do not disturb the environment. For example, sailing may not disturb the environment but water-skiing may. Recreational activities that are equitable and sustainable as well as other environmental values are balanced through a public management planning process (Part II - 5.3).

3.2.4 Donnelly and Gardner Rivers

One submission; supportive.

The submission supported the recommendation providing the reserve category was marine park, allowing recreational and commercial fishing and there was adequate community representation on management committees, including a representative of the Local Government.

Marine park status would be consistent with the recommendation. Most existing marine parks have local management advisory committees and, as a general rule, so will marine conservation reserves declared in the future (Part II - 5.4).

Recommendation V.3.3 - Walpole-Nornalup Inlets

Five submissions; three supportive, two with implicit support subject to further community consultation.

One submission noted that current local controversy about development on the coast of this area will make reservation a sensitive issue.

Reservation of coastal or estuarine waters does not of itself impact on development approvals on adjacent land but is likely to result in closer public consideration of potential environmental impacts of development on natural values (Part II - 3.12, 3.14).

Recommendation V.3.4 - William Bay

Eleven submissions; one supportive, nine opposed, one non-committal.

Three submissions opposed reservation because of a belief that entry fees would be charged.

This concern relates to entry fees for access through the William Bay National Park. This is not a marine reserve issue (see Part II - 4.9).

Three submissions opposed the recommendation because of concern about the impact of reservation on commercial fishing. The significance of the area as a Proclaimed Fishing Zone was noted.

Commercial fishing is compatible with general use and some special purpose zones of marine parks and with marine management areas (Part II - 3.6, 9.2).

Four opposing submissions believed that additional management was unnecessary, one claiming that the area is not rich in marine fauna. One supported additional management but opposed reservation.

The Working Group identified the area as having diverse marine habitats representative of the south coast and very high scenic and recreational values. These are both criteria making an area worthy of special protection. Reservation, bringing with it public management planning, is a proven means of achieving that aim (Part I - 3.).

One of the opposing submissions was concerned that commercial developments (“resorts and the like”) might deny public access to the shore.

The adjacent land is already national park and resort development is unlikely. In any case, this has no bearing on protection of the waters as a marine conservation reserve.

The sole supporting submission was qualified by a suggestion that declaration of the marine conservation reserve should be deferred until management plans are considered for the adjacent national park.

A similar suggestion was made in relation to Stokes Inlet. This proposal would allow the issues of local concern to be considered through an appropriate consultative process.

Recommendation V.3.5 - West Cape Howe

Three submissions; two supportive, one opposed.

One of the supporting submissions suggested extension of the reserve eastwards to Mutton Bird Island due to the use of that area by southern right whales. The other suggested that further assessment of the area should be done at the same time as assessment of the V.3.6 and V.3.7 recommendations as these areas have much in common.

These suggestions will be taken into account when the recommendation is given further consideration.

The opposing submission was concerned at the lack of reference to commercial fishing in the area.

The information about commercial fishing in the area has been noted. Commercial fishing is compatible with general use and some special purpose zones of marine parks and with marine management areas (Part II - 3.6, 9.2).

Recommendation V.3.6 - King George Sound-Princess Royal Harbour

Nine submissions; five supportive (at least in part), three opposed, one non-committal.

Two of the supportive submissions drew attention to the vesting of control of the area in the Albany Port Authority and to planned port developments. One stressed the need for unrestricted use of the anchorage areas and the three shipping channels but, notwithstanding the current vesting of control, suggested that areas of Princess Royal Harbour, not infringing on port operations, could be reserved as a marine park. The other expressed concern at proposed port development and pollution.

The role of the Albany Port Authority was acknowledged in the report. Obviously, reservation of any part of the area for conservation, recreation or other purposes would require detailed prior consultation with the Albany Port Authority (and local government and community groups as well) to resolve issues relating to environmental protection, boundary and zoning and appropriate management arrangements, taking account of existing and planned port operations (Part II - 5.1, 10.).

While supporting the recommendation, one submission noted that consideration should be given to aquaculture leases granted by the Albany Port Authority.

Aquaculture is compatible with general use and some special purpose zones of marine parks and with marine management areas and is accommodated in two existing marine parks (Shark Bay and Shoalwater Islands) (Part II - 3.6, 9.3). Questions about public access to lease areas do arise and are dealt with through the public management planning processes and zoning arrangements.

Two submissions objected to the recommendation because the area includes important fishing grounds, one arguing that reservation is unnecessary as most marine fauna there are on the increase. However, one of these submissions acknowledged that a marine conservation reserve might not interfere with fishing operations if managed in consultation with professional fishermen and suggested an alternative area further east (Haul Out Rock to Cape Riche) where there is little fishing.

Commercial fishing is compatible with general use zones of marine parks and with marine management areas (Part II - 3.6, 9.2). If the recommendation was implemented, local users of the area, including professional fishermen, would be key stakeholders with direct participation in management planning and operational decisions through standard consultative procedures and provisions for management advisory committees (Part II - 5.4).

The observation that marine fauna are on the increase relates to sea-lions, fur-seals and whales. (There are inadequate data on other elements of the marine fauna.) This circumstance is regarded by the tourism industry as welcome although, in the case of sea-lions and fur-seals, it may adversely affect some fishermen. These animals are already protected under the *Wildlife Conservation Act 1950*, but marine park status would add to protection of their habitat.

One submission supported reservation of the area around Michaelmas and Breaksea Islands but not the area around Cape Vancouver.

Boundaries and zoning would be central issues for public consideration during preparation of an indicative management plan prior to publication of a notice of intent to reserve, should the recommendation proceed (Part II - 3.13, 3.14).

One of the submissions opposing the recommendation noted that consideration is given in the report to recreational use which can have significant impact on flora and fauna, while consideration was not given to commercial users.

The impact on environmental values of recreational activities is acknowledged and is a reason for introducing appropriate management seeking to balance recreational and commercial activities in an equitable and sustainable way by means of public management planning (Part II - 8.).

Several of the supportive submissions were conditional on continuance of recreational fishing and there being adequate public consultation prior to reservation.

Recreational fishing, managed under fisheries legislation, is an accepted activity in general purpose, recreation and some special purpose zones of marine parks and in marine management areas (Part II - 3.6, 9.1). Prior public consultation is essential and required practice (Part II - 5.).

One submission that supported the recommendation suggested that further assessment relating to boundary definition could be undertaken at the same time as assessment of recommendation V.3.7.

The suggestion will be taken into account when the recommendation is given further consideration.

Recommendation V.3.7 - Cape Vancouver-Bald Island

Five submissions; three opposed (at least in part) and two supportive (at least in part) of the recommendation.

The opposing submissions objected to the recommendation because the area includes important fishing grounds, one arguing that reservation is unnecessary as the numbers of most marine fauna in the area are increasing. One of these objected specifically to inclusion of the south Cheyne Beach area but made no comment on other areas. One acknowledged that a marine conservation reserve might not interfere with fishing operations if managed in consultation with professional fishermen and suggested an alternative area further east (Haul Out Rock to Cape Riche) where there is little fishing.

Commercial fishing is compatible with general use and some special purpose zones of marine parks and with marine management areas (Part II - 3.6, 9.2). Professional fishermen would be key stakeholders with direct participation in management planning and operational decisions through standard consultative procedures and provisions for management advisory committees (Part II - 5.4).

One of the submissions opposing the recommendation noted that consideration is given in the report to recreational use which can have significant impact on flora and fauna, while consideration was not given to commercial users.

The impact on environmental values by recreational activities is acknowledged and is a reason for introducing appropriate management seeking to balance recreational and commercial activities in an equitable and sustainable way by means of public management planning processes (Part II - 8.).

One of the submissions specifically supported reservation of waters adjacent to Waychinicup but made no reference to the other areas. The other suggested that further assessment of the area should be conducted during a forthcoming management planning project for the adjacent terrestrial reserves.

The latter suggestion will be taken into account when the recommendation is given further consideration (Part II - 3.13).

Recommendation V.3.8 - Fitzgerald Biosphere Reserve

Sixteen submissions; seven supportive (at least in part), nine opposed to the recommendation (4 of the latter were identical pro-forma submissions).

Five submissions specifically supported proposed reservation of the inlets, although one of these objected to inclusion of the south bank of Gordon Inlet and two argued that Culham Inlet should be included. One submission suggested that Hamersley Inlet should be zoned exclusively for amateur fishing with no closed season. Another argued that current commercial bream fishing in Culham Inlet decimates the stocks months before hyper-salinity would have done so and that close monitoring of inlet fish stocks is essential.

The south bank of Gordon Inlet is within a local government reserve and there is no proposal that it should be included in a future marine conservation reserve but, as noted in the report, the location of the boundary is ambiguous because of difficulty in defining the low water mark.

The inclusion of Culham Inlet could be considered if it can be demonstrated that the public recreational facility and security of purpose there would be improved by reservation and more intensive management of the waters as well as the shores.

Zoning (Part I - 4.2) and management of fish stocks would be central issues of a public management planning process if the recommendation were to be implemented.

Two submissions noted the international importance of the area in terms of the Biosphere Reserve status of the adjacent land. Both suggested that the western and eastern boundaries of a marine park should be located at the boundaries of the Biosphere Reserve area. One submission supported reservation of the waters around the Doubtful Islands but objected to reservation of Doubtful Bay while another supported reservation of the Bay provided that it is not made inaccessible to the public.

If the recommendation were to be implemented, boundaries of the marine conservation reserve would be a central issue in further public consultation prior to reservation (Part II - 3.13).

Objections were mainly from the fishing industry and were based on a perception that additional marine management is not necessary and that reservation would threaten continued commercial fishing operations. This included a view that, once an area is reserved, Government may classify the entire area as an exclusion zone and thus prohibit commercial and recreational fishing.

Commercial fishing is compatible with general use and some special purpose zones of marine parks and with marine management areas (Part II - 3.6, 9.2). If the recommendation was implemented, zoning would be subject to formal public management planning and local users of the area, including recreational and professional fishermen, would be key stakeholders with direct involvement (Part II - 5.).

One of the opposing submissions noted that there is no mention in the report of how marine conservation reserves would be funded and was concerned that funds would end up coming from commercial fishermen and other users.

As marine conservation reserves are public property, most management costs are funded from public funds. Government policy is that the user-pays principle is applied where a particular service is provided (Part II - 4.10). A fee may be charged to commercial operators because the environmental resources of marine conservation reserves are regarded as public assets and there are management costs in ensuring that the asset is not diminished by a commercial activity. Licence fees for commercial fishing in marine parks are, and will continue to be, paid under fisheries legislation.

Recommendation V.3.9 - Stokes Inlet

Five submissions; one supportive, four opposed.

The supportive submission suggested that consideration of the recommendation should be deferred until a management plan for the adjacent national park is prepared.

A similar suggestion was made in relation to William Bay. This proposal would allow the issues of local concern to be considered through an appropriate consultative process.

The opposing submissions were based mainly on the following grounds.

It was claimed that reservation is unnecessary as the area is remote and the weather conditions provide protection (against excessive use), and that reservation would result in restrictions on access.

Reservation would ensure that, as the inevitable increase in use of the area occurs, appropriate management would be in place, rather than have to put it in place after the pressure had reached critical levels (Part II - 4.2). Marine park reservation is not aimed at restricting access but at facilitating and managing it through the statutory public management planning processes (Part I - 3.).

It was claimed that marine fauna is already adequately protected under fisheries legislation administered by the Fisheries Department and that marine conservation reserve management by CALM would be a duplication.

Protection of marine fauna is but one purpose of reservation. The Government's marine reserves policy provides for a dual role for the Fisheries Department and CALM, the former responsible for fishing, aquaculture and pearling and the latter for overall management including conservation, recreation and commercial activities other than fishing, aquaculture and pearling (Part II - 3.5, 3.6).

It was claimed that entry fees might be introduced which would have a detrimental effect on local people and the tourism industry, and that reservation would result in licensing restrictions and restrictions on access.

Government policy is that the user-pays principle is applied wherever a particular service is provided (Part II - 4.10). A fee may be charged to commercial operators in marine conservation reserves because there are management costs in ensuring that the public asset is not diminished by a commercial activity. Licences for fishing in marine conservation reserves are issued under fisheries legislation, with appropriate license fees.

Recommendation V.3.10 - Recherche Archipelago

Fourteen submissions; one supportive, eleven opposed, two non-committal pending further information.

The supportive submission believed that the recommendation should be given urgent attention.

The opposing submissions were based mainly on the ground that reservation is unnecessary as there is no evidence of any threat to wildlife or any need for additional management. One submission argued that the main threats to the south coast are from oil spills and discharge of ship ballast, neither of which would be within the jurisdiction of the reserve management authority.

Reservation would ensure that, as the inevitable increase in use of the area occurs, appropriate management would be in place, rather than have to put it in place after the pressure had reached critical levels.

Marine park status increases the onus on shipping operators to act responsibly.

It was claimed that reservation would give CALM the power to close areas without consultation with local people.

This claim is incorrect. The legislation stipulates comprehensive public consultation processes (Part II - 3.13, 5.).

It was claimed that fish stocks are already adequately protected under fisheries legislation administered by the Fisheries Department.

Management of recreational and commercial fisheries would continue to be the responsibility of the Fisheries Department under fisheries legislation (Part II - 3.6, 9.).

It was claimed that CALM might be forced to introduce entry fees which would have a detrimental effect on local people and the tourism industry.

Government policy is that the user-pays principle is applied wherever a particular service is provided (Part II - 4.10). Recreational use of marine parks may involve provision of services such as boat ramps. A fee may be charged to commercial operators in marine conservation reserves because there are management costs in ensuring that the public asset is not diminished by a commercial activity.

One submission asserted that the recommendation for reservation was made without adequate information and that a survey should have been conducted first.

The lack of adequate information about this area was acknowledged in the report. The recommendation for a multiple-use reserve was made on the basis of the agreed high environmental and recreational values of the area, with a commitment to survey the natural resources prior to declaration of management zones (Part II - 3.14).

One submission opposed the recommendation because areas might be lost to the aquaculture industry.

Aquaculture is compatible with general use and some special purpose zones in marine parks and with marine management areas (Part II - 3.6, 9.3).

Two submissions opposed the recommendation because the islands are already declared nature reserves.

Reservation of the islands does not protect or provide a management framework for the surrounding waters, which are the subject of the recommendation.

Recommendation V.3.11 - Twilight Cove

Three submissions; one supportive, one opposed, one opposed if reservation prohibited fishing.

The opposing submission was based on a view that there is no demonstrated need for reservation, that the threats to the environment are from shipping and oil spills, and that funding for management would end up coming from fishermen.

Reservation was recommended for this area because it was identified as being representative of an unusual habitat type and as having high conservation values. Reservation is preferable prior to appearance of threats rather than after that event (Part II - 4.2). Fishermen presently pay fees through fisheries legislation and no change to that arrangement is contemplated.

APPENDIX IX

CALM *LANDSCOPE* ARTICLE