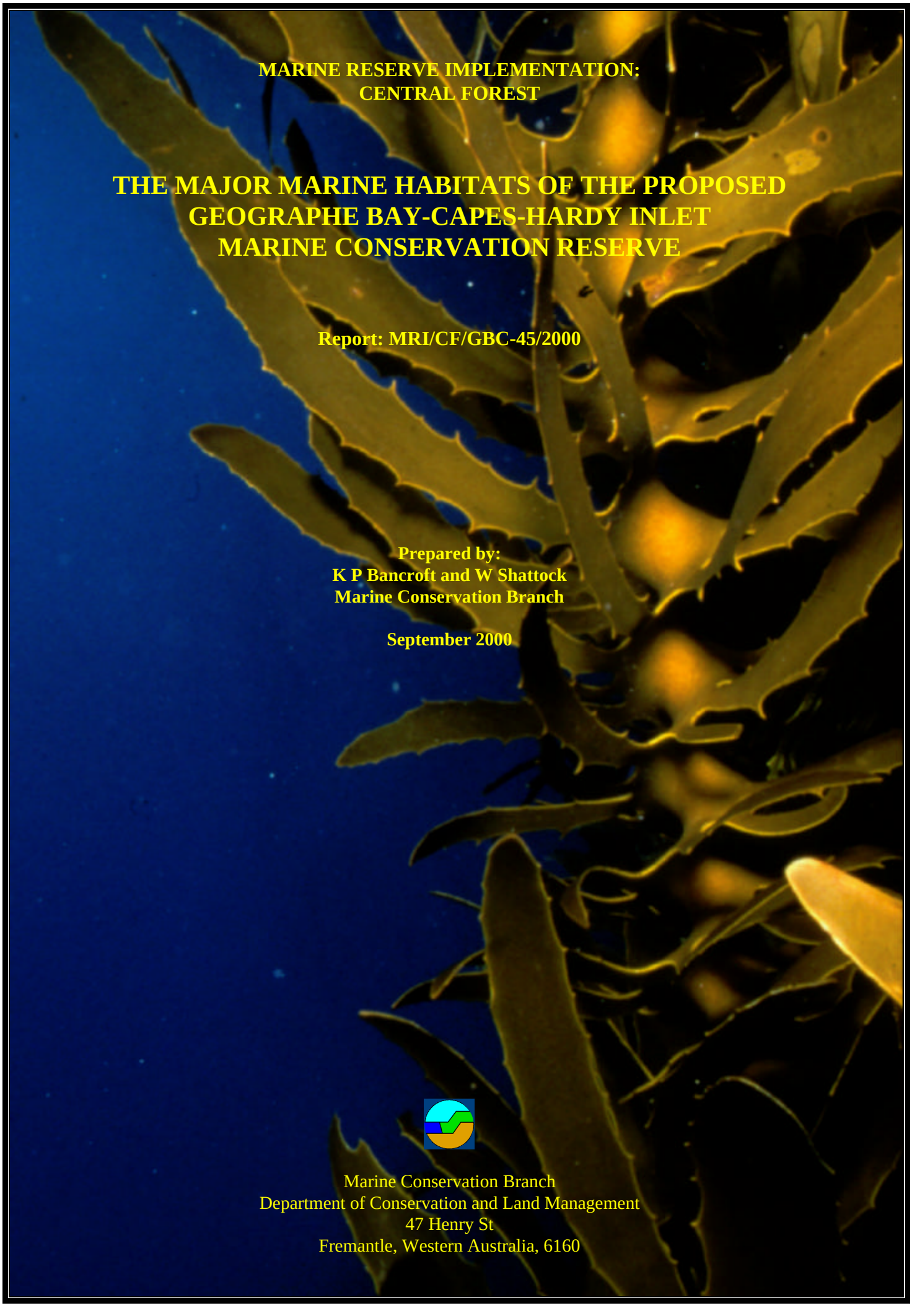

**MARINE RESERVE IMPLEMENTATION:**
**CENTRAL FOREST**

# THE MAJOR MARINE HABITATS OF THE PROPOSED GEOGRAPHE BAY-CAPES-HARDY INLET MARINE CONSERVATION RESERVE

**Report: MRI/CF/GBC-45/2000**

**Prepared by:**
**K P Bancroft and W Shattock**
**Marine Conservation Branch**

**September 2000**

Marine Conservation Branch
Department of Conservation and Land Management
47 Henry St
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Cover: Bull Kelp (*Ecklonia radiata*)

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Copies of this report may be obtained from:

Marine Conservation Branch
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# 1 INTRODUCTION

The Western Australian Government is committed to establishing a statewide representative system of multiple use marine conservation reserves under the *Conservation and Land Management (CALM) Act 1984* to protect the diverse and valuable natural heritage values of our nearshore marine environment. The *CALM Act* provides the framework for sustainable commercial and recreational use of these resources. In 1986, a Marine Parks and Reserves Selection Working Group (MPRSWG) was established to identify marine areas that where thought to be worthy of consideration for marine reserve status. The MPRSWG identified 70 areas around the Western Australian coast (CALM, 1994), which if reserved would provide a system of marine conservation reserves that would be representative of all the major ecosystems of the State.

In December 1997, the Western Australian Government, following advice provided by the Western Australian Marine Parks and Reserves Authority, announced the Geographe Bay-Capes-Hardy Inlet region, MPRSWG recommended areas, as being a priority area for establishment as a marine conservation reserve. Subsequently, the Marine Conservation Branch (MCB) of the Department of CALM has initiated the planning process for implementing a marine conservation reserve.

Under the State Government's marine conservation strategy detailed in *New Horizons - The way ahead in marine conservation and management* released by the Western Australian Government in 1998 (WA Government, undated), there is a requirement for:

> *"Extensive assessment, community consultation and management planning before a new marine conservation reserve is established."*

An essential component of this is that:

> *"A comprehensive assessment of the area's biological and economic resources, and social values is carried out."*

To achieve the biological resource component, a map highlighting the major marine benthic habitats of the Geographe Bay-Capes-Hardy Inlet region was produced. Habitat diversity has been shown to be a 'high level' surrogate of biological diversity (Ward *et al.*, 1998), especially when supplemented with detailed species level biodiversity data (Ward *et al.*, 1999).

The diversity of major marine benthic habitats of the study area will be used as a biodiversity surrogate and, as such will be used in the planning process. The habitat map will also be essential for the future management of the proposed marine conservation reserve once it is established.

# 2 PURPOSE

The purpose of this report is to:

(i) provide information, in the form of a broadscale map, on the major marine benthic habitats on the Geographe Bay-Capes-Hardy Inlet region;

(ii) document the methods used to produce the broadscale habitat map;

(iii) provide a more comprehensive description of habitat types;

(iv) document the metadata for the GIS information layers, and;

(v) document the storage location of the GIS information layers.

# 3 STUDY AREA

The study area for the proposed Geographe Bay-Capes-Hardy Inlet marine conservation reserve (Figure 1) lies about 250 km south of Perth, Western Australia, between 33º30' to 34º30' South and 114º55' to 115º15' East and covers an area of approximately 1096 $km^2$.

The study area is broadly defined as the State Territorial Waters from Geographe Bay to Flinders Bay. This area includes Cape Naturaliste, Cape Leeuwin and Hardy Inlet, the estuarine reaches of the Blackwood River.

# 4 METHODS

## 4.1 HABITAT CLASSIFICATION

The major marine benthic habitats in the Geographe Bay-Capes-Hardy Inlet region were based on the classification outlined in the draft statewide marine benthic habitat classification scheme presented in Appendix I. The classification system is being developed to facilitate a more systematic and standardised approach to this issue and will continue to be refined on an on-going basis. At a regional level, specific sub-categories are being developed to provide the appropriate level of detail required for the marine reserve planning process.

## 4.2 MAPPING METHODS

### 4.2.1. Major marine benthic habitats

The marine benthic habitat map for the proposed Geographe Bay-Capes-Hardy Inlet marine conservation reserve was developed using Geographical Information Systems (GIS) software, ArcView Version 3.2 (ESRI). Habitats are identified at a broadscale only and are suitable for regional analysis and representation at 1:100000. An outline of the method used in the mapping of the marine benthic habitats is as follows:

(a) All available existing marine habitat maps were collated and an assessment was made of their usefulness for the purpose of this project.

(b) A composite map was constructed using the existing marine habitat data.

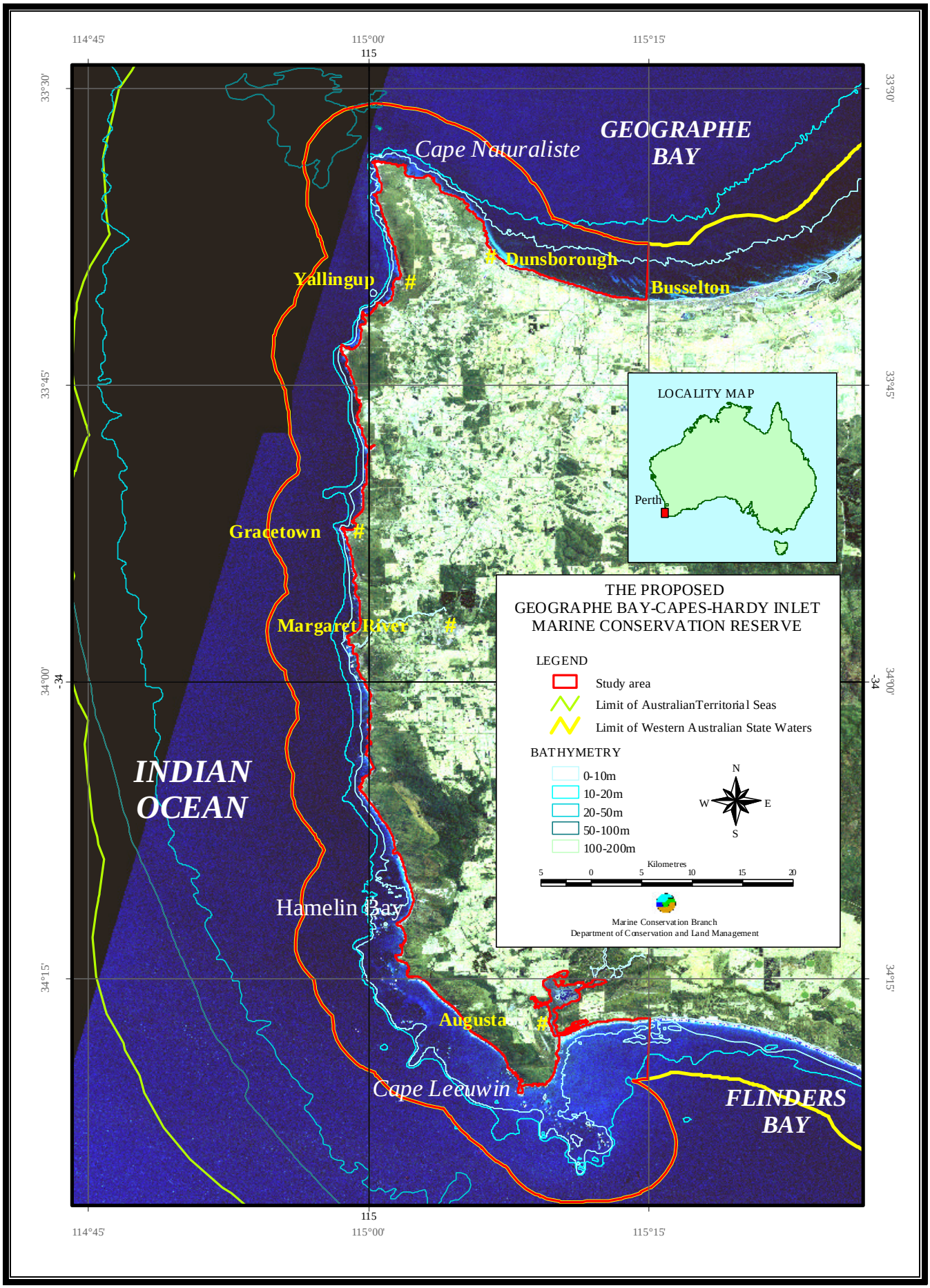


**Figure 1. Study area for the proposed Geographe Bay-Capes-Hardy Inlet marine conservation reserve**

(c) Habitat classifications in existing data were reconciled and standardised to conform with the CALM draft statewide marine benthic habitat classification scheme (Appendix I).

(d) Datasets were assessed for their spatial accuracy and extent, and habitat attribution. The lack of metadata associated with most of the GIS datasets made this task difficult. Where metadata were unavailable, it was assumed that the biological information was correct and the spatial accuracy was not.

(e) Overlaying the habitat data onto Landsat TM and/or aerial photogrammetry to assess the accuracy of habitat shapes (polygons).

(f) In areas where remotely sensed data was unavailable due to excessive depth (generally >10 m depth) and/or turbidity (e.g. nearshore habitats), habitats were classified using a combination of bathymetry, ground-truthing and local knowledge about the likely distribution of habitats in these areas (*see* Section 4.3).

(g) Habitat point data collected in the field (357 sites) by the MCB, was used to ground-truth areas of major uncertainty.

Further detail on the methods and data sources may be found in the metadata, presented in Appendix II (major marine benthic habitats).

### 4.2.2. Major coastline habitats

Major coastline habitats were classified by referring to remote sensing imagery, such as Landsat TM and/or aerial photogrammetry at a scale of 1:20000.

In the major coastline habitat dataset for Geographe Bay-Capes-Hardy Inlet region, a *beach/rocky shore* classification was used to describe intertidal areas where the *rocky shore* was covered with a thin layer of sand or where there was sand above or below the *rocky shore*.

Further detail on the methods and data sources may be found in the metadata, presented in Appendix III (major coastline habitats).

## 4.3 MODELLING

The final phase in the development of habitat data layers for the broadscale habitat map for the Geographe Bay-Capes-Hardy Inlet region was to model unknown or non-attributed areas. This was achieved using field verification data collected during a field survey undertaken in December 1998 (Bancroft & Colman, 1998; Bancroft, 2000), and environmental and local knowledge to develop a simple linear interpolation model where these habitat types may occur.

### 4.3.1. Linear interpolation

The linear interpolation model is where it is assumed that the boundary between two habitats lies midway between two sites of known habitat type.

This model was used mainly in areas where interpretation of benthic habitats from remote sensing and photogrammetry was difficult. Areas that were modelled include the more turbid shallow waters (silt and sand), channels, coral reef communities, lagoonal reef platforms and offshore areas.

### 4.4 HABITAT DESCRIPTIONS

Seventeen habitat types were identified in the broadscale map of the major marine benthic habitats (Figure 2) and the major coastline habitats (Figure 3) of the proposed Geographe Bay-Capes-Hardy Inlet marine conservation reserve:

1. Island;
2. Rocky shore;
3. Beach;
4. Sand shoal;
5. Shoreline reef;
6. Offshore intertidal reef;
7. Macroalgae (limestone reef/high relief);
8. Macroalgae (limestone reef/low relief);
9. Macroalgae (granite reef/high relief);
10. Macroalgae (granite reef/low relief);
11. Seagrass (perennial/dense);
12. Seagrass (perennial/medium);
13. Seagrass (perennial/sparse);
14. Seagrass (ephemeral);
15. Sand;
16. Silt, and;
17. Pelagic.

These 17 habitats are described in broad terms and these descriptions relate to the habitat types on the broadscale map (1:100000) for the marine benthic habitats of the proposed Geographe Bay-Capes-Hardy Inlet marine conservation reserve.

#### 4.4.1. Island

The *island* habitat describes land over 0.05 ha that is surrounded by the sea and permanently above Highest Astronomical Tide (HAT). The substratum of the *island* habitat in the Geographe Bay-Capes-Hardy Inlet region consist of sand, igneous and sedimentary rock (limestone and sandstone). The land may be bare, vegetated or have seasonal vegetation. The larger islands (eg. St Alouarn, Hamelin) in the Geographe Bay-Capes-Hardy Inlet region are typically vegetated by coastal heath which includes spinifex (*Spinifex* sp.), however the smaller islands tend to be bare limestone, gneiss or granite rock. The island habitat of the region is known to be important for haul out, breeding and nesting areas for seabirds (red-tailed tropicbird *Paethon rubricauda*, rock parrot *Neophemea petrophila* fairy penguin *Eudyptula minor*), and marine mammals (Australian sea lion *Neophoca cinerea*, New Zealand fur seal *Arctocephalus fosteri*).

#### 4.4.2. Rocky shore

The *rocky shore* habitat is located in the upper intertidal zone (between the Lowest Astronomical Tide (LAT) and HAT), and includes low cliffs (<5 m), boulder or pavement of igneous, metamorphic or

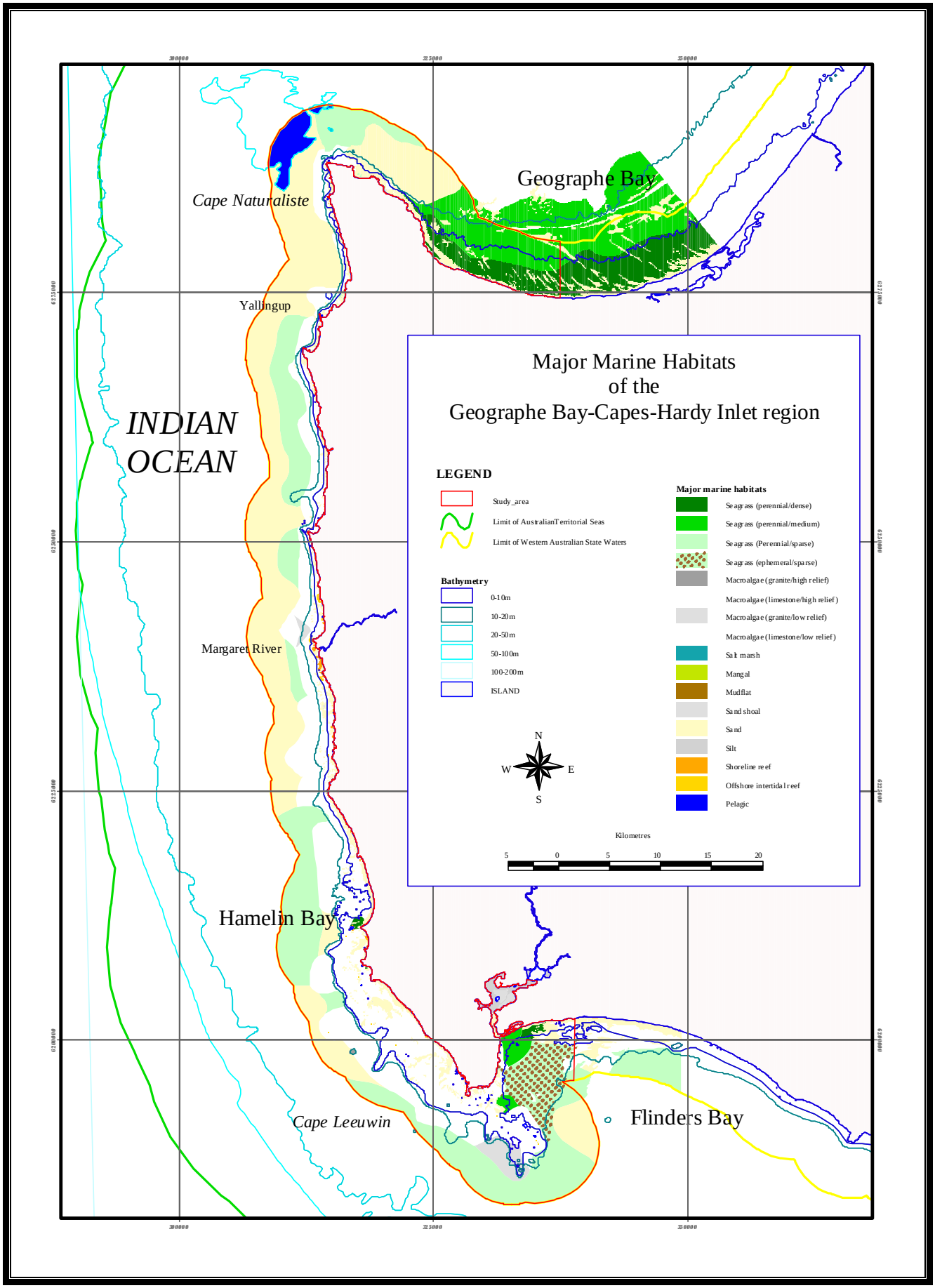


**Figure 2. Revised broadscale map of the major marine habitats in the Geographe Bay-Capes-Hardy Inlet region**

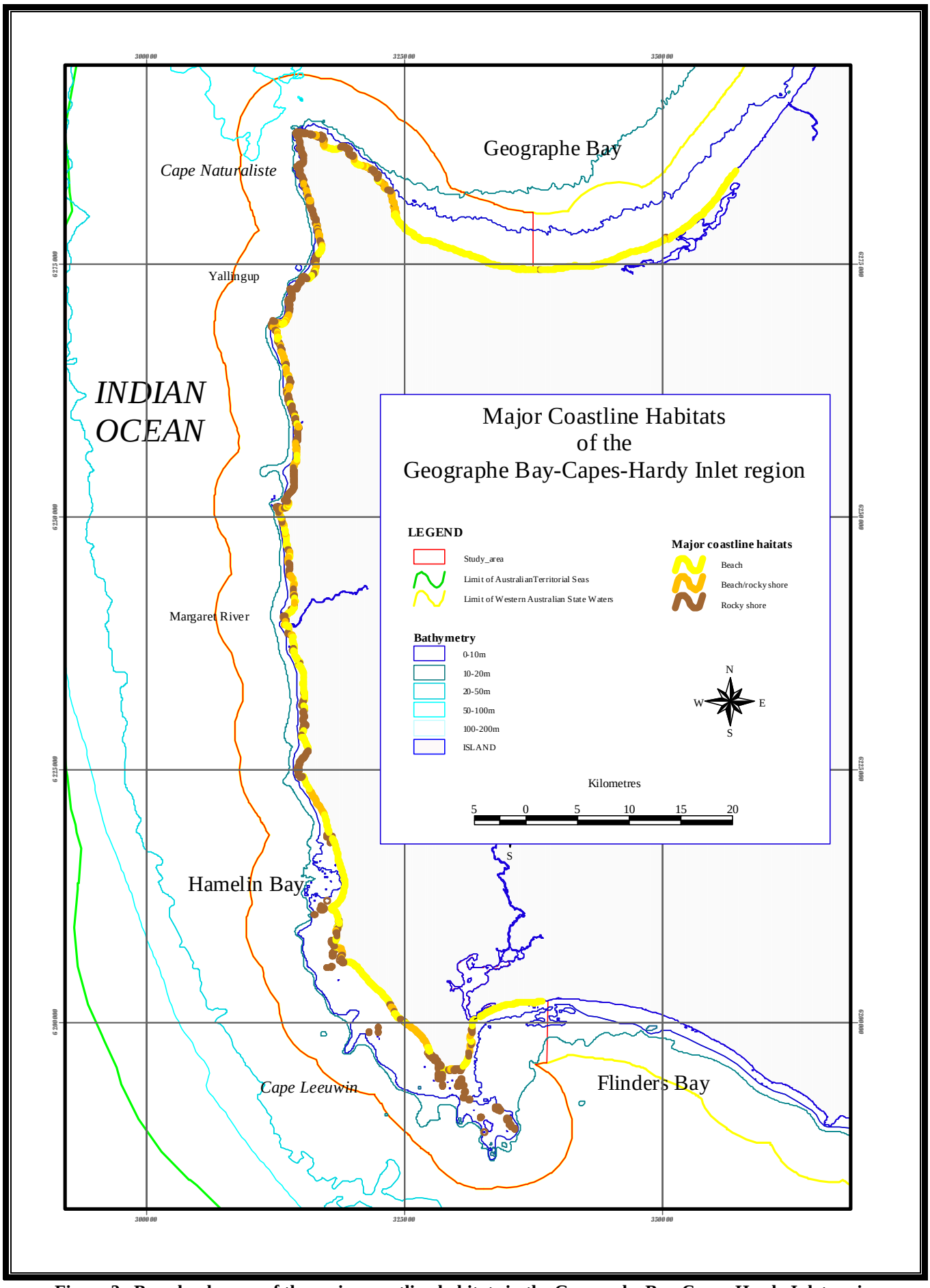


**Figure 3. Broadscale map of the major coastline habitats in the Geographe Bay-Capes-Hardy Inlet region**

sedimentary substratum located along the shoreline. For convenience shoreline high cliffs (>5 m) are included in this category. In the Geographe Bay-Capes-Hardy Inlet region, rocky shores are typically wave-cut or undercut, unvegetated, low limestone cliffs which support a variety of mollusc species including barnacles (e.g. *Austromegabalanus nigrescens*), top shells (*Austrocochlea* spp.) and other invertebrates such as crabs (*Pagurus* sp.).

### 4.4.3. Beach

The *beach* habitat is located in the upper intertidal and supratidal (immediately above HAT) zones and typically consists of unconsolidated carbonate sands. The *beach* habitat is mostly unvegetated however flora such as spinifex (*Spinifex longifolius*) may be present above HAT. The intertidal sands of beach habitats in the Geographe Bay-Capes-Hardy Inlet region typically support a range of invertebrates including bivalve shells and seaurchins.

### 4.4.4. Sand shoal

The *sand shoal* habitat is located in the lower intertidal zone, generally seaward of the coastline habitats and is typically found in macrotidal (>2 m tidal range) areas where strong currents and wave action create offshore banks and shoals. These banks and shoals can also be connected to islands or the mainland. The *sand shoal* habitat consists of mobile, medium to coarse sands, and is typically unvegetated. Sand shoals support bivalves (*Arthritica* sp., *Katelysia sclarina*), gastropods (*Potamopyrgus* sp., *Hydrococcus* sp.) and contains a low diversity of infauna such as polychaetes and nematodes. Sand shoals are important feeding grounds for migratory wading birds such as bar-tailed godwits (*Limosa lapponica*), curlew sandpipers (*Callidris ferruginea*) and white-faced heron (*Egretta novaehollandiae*). In the Geographe Bay-Capes-Hardy Inlet region, sand shoals occur in the Hardy Inlet, which is the estuarine reach of the Blackwood River.

### 4.4.5. Shoreline reef

The *shoreline reef* habitat is typically located in the lower intertidal or nearshore subtidal zones (<1 m below LAT) and occurs as low relief reef platforms of sedimentary (limestone or sandstone) substratum that are contiguous with the shoreline. In the Geographe Bay-Capes-Hardy Inlet region, *shoreline reef* habitat typically supports turf algae (*Galeolaria* sp., *Scytosiphon* sp.) and invertebrates such as gastropods (turban shells *Turbo* spp., dogwhelks *Thais orbita*, abalone *Haliotis* spp.), seaurchins (*Heliocidaris erythrogramma*), anemones (*Actinia tenebrosa*), seastars (*Patiriella* spp.) and sponges (*Haliclona* sp.).

### 4.4.6. Offshore intertidal reef

The *offshore intertidal reef* habitat is typically in the intertidal or shallow waters and occurs as offshore low relief (<1 m high) reef platforms of sedimentary (limestone) or high relief (>1 m high) igneous (granites) or metamorphic (gneiss) substratum. In the Geographe Bay-Capes-Hardy Inlet region this habitat is obvious in high swell conditions, and typically supports turf algae (*Galeolaria* sp., *Scytosiphon* sp.) and invertebrates such as gastropods (turban shells *Turbo* spp., dogwhelks *Thais orbita*, abalone *Haliotis* spp.), and arthropods (barnacles *Austrobalanus* sp.)

### 4.4.7. Macroalgae (limestone reef/low relief)

The *macroalgae (limestone reef/low relief)* habitat is typically subtidal limestone substratum of low relief (<1 m high). In the Geographe Bay-Capes-Hardy Inlet region this habitat also may incorporate mobile sand patches or patches of seagrass. This habitat generally is covered in large fleshy macroalgae (e.g. bull kelp *Ecklonia radiata, Cystophora* spp.) and macroalgal turf (red, green and

brown algae). In sheltered areas, *Sargassum* spp. is the dominant macroalgae. This habitat is associated with a wide range of invertebrate life such as ascidians (*Pyura* spp.), calcareous sponges and gastropods are associated with this habitat.

### 4.4.8. Macroalgae (limestone reef/high relief)

The *macroalgae (limestone reef/high relief)* habitat is typically subtidal limestone substratum of high relief (>1 m high). In the Geographe Bay-Capes-Hardy Inlet region, this habitat also may incorporate sand patches or patches of seagrass. This habitat generally is covered in a wide range of fleshy macroalgae (e.g. bull kelp *Ecklonia radiata*, *Scytothalia* sp., *Platythalia* sp., *Cystophora* spp.) and macroalgal turf (red, green and brown algae). This habitat is characterised by caves and overhangs, which support a diverse range of sessile invertebrate life such as colonial ascidians (*Aplidium* spp., *Clavelina* spp., *Herdmania* spp., *Didemnum* spp.), sponges (*Echinoclathria* spp., *Thorecta* spp., *Mycale* spp.), octocorals (*Mopsella* sp.) and soft corals (*Capnella* spp., *Sinularia* sp.). Mobile invertebrates such as seastars (*Nectria* spp., *Echinaster* spp.), seaurchins (*Heliocidaris erythrogramma*, *Holopneustes* sp.), crustaceans (*Panulirus cygnus*) and many gastropods are associated with this habitat.

### 4.4.9. Macroalgae (granite reef/low relief)

The *macroalgae (granite reef/low relief)* habitat is typically subtidal granite or gneiss substratum of low relief (<1 m high). In the Geographe Bay-Capes-Hardy Inlet region this habitat is typically either the surface of large buried boulders or fields of small boulders, which may also incorporate sand patches. This habitat generally is covered in large fleshy macroalgae (e.g. bull kelp *Ecklonia radiata*, *Cystophora* spp.) and macroalgal turf (red, green and brown algae). A wide range of invertebrate life such as ascidians (*Pyura* spp.), calcareous sponges, ascidians and gastropods are associated with this habitat.

### 4.4.10. Macroalgae (granite reef/high relief)

The *macroalgae (granite reef/low relief)* habitat is typically subtidal granite or gneiss substratum of high relief (<1 m high). In the Geographe Bay-Capes-Hardy Inlet region this habitat is typically either the surface of large buried boulders or fields of small boulders, which may also incorporate sand patches. This habitat generally is covered in large fleshy macroalgae (such as *Ecklonia radiata*, *Scytothalia* sp., *Platythalia* sp and *Cystophora* spp.), macroalgal turf (red, green and brown algae) and crustose coralline algae. This habitat is characterised by caves and crevices, which support a diverse range of sessile invertebrate life such as colonial ascidians (*Aplidium* spp., *Clavelina* spp., *Didemnum* spp.), sponges (*Echinoclathria* spp., *Thorecta* spp., *Mycale* spp.), octocorals (*Mopsella* sp.), soft corals (*Capnella* spp., *Sinularia* sp.). Mobile invertebrates such as seastars (*Fromia* sp.), seaurchins (*Phyllacanthus irregularis*) and gastropods (*Turbo jordani*, *Haliotis laevigata*) are also present. Many recreationally targetted large demersal fish such as the Western Australian jewfish (*Glaucosoma hebraicum*), western blue groper (*Achoerodus viridis*) and harlequin fish (*Othos dentex*) are associated with this habitat.

### 4.4.11. Seagrass (perennial)

The seagrass (perennial) habitat is typically an area of seagrass meadow, which consists of species that are present throughout the year. This habitat typically is present upon sand substratum, however seagrasses (e.g. *Thalassodendron pachyrhizum*) commonly occur in sand patches on reef pavement. The perennial seagrass species found in the Geographe Bay-Capes-hardy Inlet region include *Amphibolis antarctica*, *A. griffithii*, *Posidonia coriacea*, *P. australis*, *P. ostenfeldii*, *P. augustifolia* *P. robertsoni* and *T. pachyrhizum*. Macroalgae (particularly *Scaberia agardii*), sessile invertebrates such as ascidians (e.g. *Pyura* spp., *Botrylloides* spp.) and sponges (e.g. *Oceanapia* sp.), and mobile

invertebrates such as seastars (*Fromia* sp.), seaurchins (*Amblypneustes* sp.) and crustaceans (*Portunus pelagicus*), are associated with this habitat. Seagrass meadows are also known as important nursery grounds for many fish species.

The differences in seagrass cover have significant influence on the diversity and abundance of the associated flora and fauna. Therefore this habitat category has been divided into three sub-categories:

1. dense - where the seagrass coverage is greater than the area of exposed substrate;
2. medium - where the seagrass cover approximates the area of exposed substrate, and;
3. sparse - where the seagrass cover is less than the area of exposed substrate.

### 4.4.12. Seagrass (ephemeral)

The seagrass (ephemeral) habitat is typically an area of seagrass meadow, which consists of species that are short-lived or has high seasonal variation in coverage. This habitat typically is present upon sand substratum however seagrasses commonly occur in sand patches on reef pavement. The ephemeral seagrass species found in the Geographe Bay-Capes-Hardy Inlet region include *Heterozostera tasmanica, Halophila ovalis and H. australis.* Few fauna and flora species are associated with this habitat.

### 4.4.13. Sand

The *sand* habitat is defined as subtidal habitats that have predominately white carbonate sands as a substrate, however the sand may overlay reef platform or have patches of other habitats present. In the Geographe Bay-Capes-Hardy Inlet, *sand* habitats typically are bare, and may have seasonal vegetation or permanent patches of seagrass or macroalgae. Invertebrate infauna may also be present.

### 4.4.14. Silt

The *silt* habitat is located in subtidal areas with mud or silt substratum, with a significant terrigenous fraction. In the Geographe Bay-Capes-Hardy Inlet region, *silt* habitats occur in the sheltered areas in the Hardy Inlet (the estuarine reach of the Blackwood River) and are usually unvegetated. *Silt* habitats support a rich variety of infauna such as polychaete and nematode worms, molluscs (*Nassarius* spp.) and crustaceans (estuarine shrimp *Palaemonetes australis*).

### 4.4.15. Pelagic

This category is specific to those areas that are greater that 50 m in depth. The focus in this classification is not on substrates but rather on the macrobiology of the water column, hence pelagic environments may have various substrates. Pelagic fish and invertebrates, and larval stages of various phyla dominate the macrobiology of this habitat.

## 4.5 HABITAT DISTRIBUTIONS

Marine benthic habitat percentages (Table 1) and coastal habitat percentages (Table 2) were calculated to highlight the dominant habitats in the Geographe Bay-Capes-Hardy Inlet region.

**Table 1. Percentages of the major marine habitats in the study area**

| Habitat type | Percentage (%) |
|---|---|
| Sand shoal | 0.2 |
| Shoreline reef platform | 0.4 |
| Offshore intertidal reef | 0.1 |
| Macroalgae (limestone reef/low relief) | 10.9 |
| Macroalgae (limestone reef/high relief) | 0.4 |
| Macroalgae (granite reef/low relief) | 10.6 |
| Macroalgae (granite reef/high relief) | 6.5 |
| Perennial seagrass (dense) | 6.1 |
| Perennial seagrass (medium) | 10.9 |
| Perennial seagrass (sparse) | 18.7 |
| Ephemeral seagrass | 2.9 |
| Sand | 30.4 |
| Silt | 0.6 |
| Pelagic | 1.3 |

**Table 2. Percentages of coastal habitats in the study area**

| Habitat classification | Percentage (%) |
|---|---|
| Beach | 36.0 |
| Beach/rocky shore | 14.3 |
| Rocky shore | 40.2 |
| Inlet closure | 9.1 |
| Unclassified | 0.4 |

### 4.6 GROUND-TRUTHED DATA

There was a total of 357 habitat ground-truthing survey sites collected by the MCB during a survey conducted in December 1998 (Bancroft & Colman, 1998). This habitat data has been documented in

a MCB data report (Bancroft, 2000). For further information on this habitat data, refer to the data report.

### 4.7 METADATA

The simplest definition of metadata is 'data about data'. It describes the content, quality, currency and availability of data. Metadata is required for a range of purposes and often includes detailed information such as, data collection methods, processing history and details of content, quality, accuracy, geographic extent and contact information of data sets. This information is important as it allows potential users to assess the suitability of existing data for other purposes.

The metadata for the Geographe Bay-Capes-Hardy Inlet marine habitat data layers are presented in Appendix II (major marine benthic habitats) and Appendix III (major coastline habitats).

## 5 CAVEAT

The marine benthic habitat map should not be used for navigational purposes.

This marine benthic habitat map has its origin in the dataset developed by CSIRO. A subsequent marine benthic habitat survey undertaken by the Marine Conservation Branch, Department of Conservation and Land Management has provided additional information.

The delineation between habitats on the map is shown by abrupt changes in habitat classification. In reality changes are more often a gradual transition from one habitat to another. As a result, the location of some habitat boundaries should be considered as approximate only.

In addition, relatively limited ground-truthing data has been used in determining these habitats due to their extensive area.

## 6 DATA MANAGEMENT

### 6.1 REPORT

Hard copies of this report will be held at three locations:

1. Marine Conservation Branch, Department of Conservation and Land Management, 47 Henry St., Fremantle Western Australia, 6160. Ph. (08) 9432 5100 Fax. (08) 9430 5408.

2. Woodvale Library, Science and Information Division, Ocean Reef Rd., Woodvale, Western Australia, 6026. Ph. (08) 9405 5100 Fax. (08) 9306 1641.

3. Archives, Woodvale Library, Science and Information Division, Ocean Reef Rd., Woodvale, Western Australia, 6026. Ph. (08) 9405 5100 Fax. (08) 9306 1641.

The Marine Conservation Branch will hold digital copies of this report at the following locations:

1. Marine Conservation Branch on-site: CD-ROM [mri_4500]

2. Marine Conservation Branch off-site: CD-ROM [mri_4500]

3. MCB homepage on the Department of Conservation and Land Management Intranet CALMweb: http://calmweb.calm.wa.gov.au/drb/ncd/mcb/rep_pdf/mri_reps/mri_2000/mrirep00.htm#mri_4500

### 6.2 GIS DATA

Data presented in the form of GIS layers will be stored digitally at the following directory pathways:

1. The Marine Conservation Branch Server:
   GIS Data@FREM.SHARED@CALM on 'StreetTalk'
   [L:\Marine_Information\Data\Production\Marine_Biology\Benthic_habitats\CALM\]

2. MCB Server full backup DAT tape:
   [L:\Marine_Information\Data\Production\Marine_Biology\Benthic_habitats\CALM\]

3. On GIS Information server:
   [H:\Marine_Information\Data\Production\Marine_Biology\Benthic_habitats\CALM\]

## 7 REFERENCES

Bancroft, K.P. & Colman, J.G. (1998). Biological verification of the major benthic habitats of the Geographe Bay-Capes-Hardy Inlet region (Geographe Bay to Flinders Bay): 29 November-6 December 1998. Field Programme Report: MRI/CF/GBC-16/1998. November 1998. Marine Conservation Branch, Department of Conservation and Land Management, Fremantle, Western Australia. (Unpublished report)

CALM (1994). A Representative Marine Reserve System for Western Australia. Report of the Marine Parks and Reserves Selection Working Group. Department of Conservation and Land Management, Perth.

WA Government (undated). New Horizons, the way ahead in marine conservation and management. Prepared for the Western Australian Government by the Department of Conservation and Land Management, Perth, Western Australia.

Ward T.J., Kenchington, R.A., Faith, D.P. and Margules, C.R. (1998). Marine BioRap guidelines: Rapid assessment of marine biological diversity. CSIRO, Perth. 52p.

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# 8 APPENDICES

## APPENDIX I. DRAFT BROADSCALE HABITAT CLASSIFICATION SCHEME (AS AT DEC 1999)

| HABITAT CLASSIFICATION | TIDAL RANGE | SUBSTRATE TYPE | TROPICAL | TEMPERATE | RELIEF | MACROBIOLOGY | SUB-CATEGORIES | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| **1. Island** | Supratidal | Sand<br>igneous<br>metamorphic<br>sedimentary | ✓ | ✓ | high & low | Can be vegetated or bare | | • Permanent land above HWM<br>• May have seasonal vegetation<br>• Seabirds, terrestrial mammals & reptiles<br>• Important for marine mammals as haul out or breeding areas |
| **2. Rocky shore** | Intertidal<br>Supratidal | igneous<br>metamorphic<br>sedimentary | ✓ | ✓ | high & low | bare | | • continuous rocky shore<br>• cliff, boulders, pavement<br>• around HWM<br>• "*uncomfortable to walk on*" |
| **3. Beach** | Intertidal<br>Supratidal | sand | ✓ | ✓ | low | bare | | • continuous intertidal sand<br>• unvegetated<br>• mobile sands<br>• "*comfortable to walk on*" |
| **4. Salt marsh** | Intertidal<br>Supratidal | mud<br>silt | ✓ | ✓ | n/a | samphire<br>saltmarsh<br>blue-green algal mats<br>can be bare | | • continuous salt marsh cover (>1 ha)<br>• on protected or low energy coastline<br>• often landward of mangals and estuaries<br>• includes unvegetated coastal saline flats |

| HABITAT CLASSIFICATION | TIDAL RANGE | SUBSTRATE TYPE | TROPICAL | TEMPERATE | RELIEF | MACROBIOLOGY | SUB-CATEGORIES | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| **5. Mangal** | Intertidal | Muds<br>silts | ✓ | ✓ | n/a | mangroves | | • continuous mangrove cover (>1 ha)<br>• mud/sand/intertidal reef/shoreline reef may be present<br>• intertidal gastropods and other invertebrates may be present |
| **6. Mudflat** | Intertidal | mud<br>silts | ✓ | ✓ | low | bare<br>blue-green algal mats | | • continuous mudflat, intertidal or very shallow, <1m lowest astronomical tide (LAT)<br>• includes mudflats behind mangals<br>• intertidal gastropods and other invertebrates may be present |
| **7. Sand shoal** | Intertidal | sand | ✓ | ✓ | low | bare<br>little macroalgae | | • Often in offshore macrotidal areas<br>• medium to coarse sand<br>• highly mobile sand<br>• Intertidal or very shallow, <1m lowest astronomical tide (LAT) |
| **8. Shoreline reef** | Intertidal | igneous<br>metamorphic<br>sedimentary | ✓ | ✓ | low | bare,<br>algal turf | | • continuous reef platform along the shoreline<br>• may be bare or have macroalgal turf or sand patches<br>• intertidal gastropods and other invertebrates may be present |
| **9. Offshore intertidal reef** | Intertidal | igneous<br>metamorphic<br>sedimentary | ✓ | ✓ | low | coralline algae,<br>macroalgal turf,<br>macroalgae | | • Offshore reef<br>• Intertidal or very shallow, <1m lowest astronomical tide (LAT)<br>• intertidal gastropods and other invertebrates may be present |

| HABITAT CLASSIFICATION | TIDAL RANGE | SUBSTRATE TYPE | TROPICAL | TEMPERATE | RELIEF | MACROBIOLOGY | SUB-CATEGORIES | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| **10. Coral reef communities** | Intertidal & subtidal | n/a | ✓ | | high & low | hard & soft corals other sessile invertebrates | • **Coral reef communities (subtidal)** - subtidal, often high live coral cover , coral colonies with sand patches in lagoons<br>➢ *Seaward reef slope*<br>➢ *Deep lagoon*<br>• **Coral reef communities** (i**ntertidal or shallow)** - intertidal or shallow, <1m lowest astronomical tide (LAT), often live coral cover is low,<br>➢ *Reef crest*<br>➢ *Back reef*<br>➢ *Reef flat*<br>➢ *Shallow lagoon* | • typical coral reef community-hard coral, soft coral, sponges, bryozoans, ascidians, etc.<br>• seaward reef slope, reef crest, back reef, reef flat and individual bommies<br>• some sand, pavement, macroalgae or seagrass interspersed |
| **11. Rubble** | Subtidal | dead coral | ✓ | | low | sparse live coral sparse vegetation | | • lagoonal areas<br>• mainly unconsolidated coral rubble |
| **12. Subtidal reef platform** | Subtidal | igneous metamorphic sedimentary | ✓ | ✓ | low | diverse algae sessile invertebrates (including sponges, sea-whips, sea-pens) | • **Subtidal reef platform (high relief)** - >1 m high<br>• **Subtidal reef platform (low relief)** - <1 m high | • includes limestone pavement or low relief reef<br>• may be covered with macroalgae or seagrass, patchy mobile sands<br>• may incorporate sand patches, rubble and scattered isolated corals |
| **13. Macroalgae (limestone reef)** | Subtidal | sedimentary | ✓ | ✓ | high & low | large fleshy macroalgae invertebrates | • **Macroalgae (limestone reef/high relief)** - >1 m high<br>• **Macroalgae (limestone reef/low relief)** - <1 m high | • typically covered in macroalgae with diverse invertebrate life in overhangs & caves<br>• may incorporate sand patches, rubble and scattered isolated corals |

| HABITAT CLASSIFICATION | TIDAL RANGE | SUBSTRATE TYPE | TROPICAL | TEMPERATE | RELIEF | MACROBIOLOGY | SUB-CATEGORIES | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| **14. Macroalgae (granite reef)** | Subtidal | igneous metamorphic | ✓ | ✓ | high & low | Large fleshy macroalgae invertebrates | • **Macroalgae (granite reef/high relief)** - >1 m high<br>• **Macroalgae (granite reef/low relief)** - <1 m high | • typically covered in macroalgae with diverse invertebrate life in overhangs & caves |
| **15. Seagrass meadows** | Subtidal | sand pavement | ✓ | ✓ | low | seagrasses | • **Seagrass (perennial)** -<br>➢ Seagrass (perennial/dense) substrate cover < seagrass cover<br>➢ Seagrass (perennial/medium) substrate cover = seagrass cover<br>➢ Seagrass (perennial/sparse) substrate cover > seagrass cover<br>• **Seagrass (ephemeral)** -<br>➢ Seagrass (ephemeral/dense) substrate cover < seagrass cover<br>➢ Seagrass (ephemeral/medium) substrate cover = seagrass cover<br>➢ Seagrass (ephemeral/sparse) substrate cover > seagrass cover | • continuous seagrass coverage (>1 ha)<br>• ephemeral seagrass species<br>*Halophila*<br>*Halodule*<br>• perennial seagrass species<br>*Amphibolis*,<br>*Cymodocea*,<br>*Enhalus*,<br>*Heterozostera*,<br>*Posidonia*,<br>*Syringodium*,<br>*Thalassia*<br>*Thalassodendron*,<br>*Zostera* |
| **16. Sand** | Subtidal | Sand (generally white) | ✓ | ✓ | low | Bare may have seagrass or macroalgal patches | | • little or no vegetation<br>• may have patches of other habitat<br>• may overlay reef platform<br>• may have patches of seagrass or macroalgae<br>• may have seasonal vegetation |

| HABITAT CLASSIFICATION | TIDAL RANGE | SUBSTRATE TYPE | TROPICAL | TEMPERATE | RELIEF | MACROBIOLOGY | SUB-CATEGORIES | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| **17. Silt** | Subtidal | muds<br>silts | ✓ | ✓ | low | bare | | • marine and/or terrigenous muds & silts<br>• little or no vegetation<br>• may have seasonal vegetation |
| **18. Pelagic** | In waters >50m | various | ✓ | ✓ | N/a | Mainly pelagic fish and invertebrates | | • This category is specific to those areas that are greater than 50 metres in depth.<br>• May have various substrates however the water column is dominant |

## APPENDIX II. METADATA FOR THE MAJOR MARINE HABITATS OF THE PROPOSED GEOGRAPHE BAY-CAPES-HARDY INLET MARINE CONSERVATION RESERVE

| | |
|---|---|
| **DATASET** | |
| **Title** | **hab_gbc24092000_amg50_agd84** - Regional Marine Benthic Habitat Mapping of the Geographe Bay/Capes Area |
| **Custodian** | Department of Conservation and Land Management (CALM) |
| **Jurisdiction** | Western Australia |
| **DESCRIPTION** | |
| **Abstract** | This dataset consists of polygons detailing the regional benthic marine habitats of WA's WA's Busselton -Augusta area and covers approximately 200 kilometers of coastline from Geographe Bay around to Augusta. Broad scale habitats extend from the shoreline to the Limit of Western Australian State Waters (3 nautical miles offshore). The dataset is complemented by a linework dataset detailing onshore coastline habitats of the Geographe Bay/Capes area (hab_gbc_onshore_24032000_amg50_agd84).<br><br>Habitats are identified at a broad scale only and are suitable for regional analysis and representation at 1:100 000. Habitats were delineated on a rectified Landsat 5 TM base using hard copy aerial photographs as a guide, and identified using a combination of ortho-rectified aerial photography, expert knowledge, and ground-truthing from several field trips.<br><br>The dataset was compiled by Wing Shattock under direction from Ray Lawrie. Habitat determination was largely undertaken by Kevin Bancroft. The project was undertaken in February - March 2000. |
| **Search Word(s)** | |
| **Geographic Extent Name(s)** | hab_gbc_onshore_24032000_amg50_agd84 |
| **DATA CURRENCY** | |
| **Begin Date** | September 1994 |
| **End Date** | October 96 |
| **DATASET STATUS** | |
| **Progress** | In Progress |
| **Maintenance & Update Frequency** | As required |

| | |
|---|---|
| **ACCESS** | |
| **Stored Data Format** | DIGITAL ArcView shapefile, projected to Australian Map Grid Zone 50 from Australian Geodetic Datum 1984 (AGD84). |
| **Available Format Type** | DIGITAL ArcView 3.2 shapefile |
| **Access Constraint** | Data available for external use subject to transfer fee and license conditions.<br><br>Data is not to be distributed without authorisation from CALM.<br><br>Contact CALM's database administrator for further details. |
| **DATA QUALITY** | |
| **Lineage** | **1.** A standard broad scale marine habitat classification system was developed by CALM Marine Conservation Branch (see attached documentation **hab_classification.doc**).<br><br>NOTE: The classification system is being refined on an on-going basis.<br><br>**2.** Hard copy base maps were compiled from a projected and rectified Landsat 5 TM image (Geography_ Bay_AGD_Dual.bil) covering the full extent of the habitat mapping project. These maps were produced at 1:20 000 scale and provided a spatially rectified base for the habitat mapping.<br><br>**3.** Aerial photographs at equivalent scale to the base maps were then used as a reference to delineate habitat boundaries on the base maps. The aerial photographs were from Department of Land Administration job numbers 940590 (Cape Leeuwin-Kalbarri 1:20000, 1994), 960114 (Leeuwin 1:100000 map sheet, 1:25 000, Dec1996), 960007 Busselton 1930 sht & ext, 1:25000, Oct1996). Habitat boundaries were delineated according to CALM's standardised habitat classification system. Habitat identification was determined by expert knowledge of marine biologists who have many years experience in the area. Identification was aided by known ground-truth information collected on several CALM field trips to the area.<br><br>**4.** Habitat boundaries were digitised on-screen using the ortho-rectified photography and Landsat image as a backdrop, and overlaid with ground-truth locations and their accompanying data. The current DOLA coastline was used to define the land water interface and hence the landward extent of the habitat mapping. This coastline was modified in only a few small areas where there was large conflict with the image data The Limit of Western Australian State Waters boundary was used to define the seaward extent of the habitat mapping.<br><br>**5.** The linework was reviewed, then cleaned and built in ArcView 3.2. The resultant polygons were then attributed with the point data set (label). A dissolve in ArcView was run on the dataset based on interpreted habitat type. This was done to merge adjoining polygons of the same interpreted habitat type. Some of these dissolved polygons may need further ground-truthing. |
| **Positional Accuracy** | The rectified Landsat image used as a base to digitise the habitat boundaries is generally considered accurate to within 4 pixels or better. This equates to a positional accuracy of linework of +- 100 metres.<br><br>Linework was digitised at scale 1:20 000 or better. |

| | |
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| | While every effort was made to digitise the datasets accurately, the large pixel size (25 m) of the Landsat image, and the resultant spectral response, sometimes made it difficult to interpret corresponding locations on aerial photography and Landsat image. Some positional in-accuracies may have resulted, however these are estimated to be infrequent. |
| **Attribute Accuracy** | The classification system used for this project is broad scale only, and designed for interpretation at regional scales of 1:100 000. The development of the standard broad scale habitat classification system on a statewide basis is a large and ongoing task. This system is close to a robust system, but will be refined and improved as anomalies arise that warrant modification to the system.<br><br>Some polygons were difficult to attribute using only the aerial photography, and the current knowledge and ground-truthing of the area. An educated interpretation of the marine habitat has been made on these polygons. This interpretation will remain until further fieldwork verifies otherwise. |
| **Logical Consistency** | The digitised linework was cleaned and built in ArcView 3.2. It was then attributed using the point data set as labels. |
| **Completeness** | The dataset will be upgraded as priorities, time and resources permit. Further work needs to be undertaken on ground-truthing. |
| **CONTACT INFORMATION** | |
| **Contact Organisation** | Department of Conservation and Land Management, Marine Conservation Branch |
| **Contact Position** | Marine GIS Co-ordinator |
| **Mail Address 1** | 47 Henry Street |
| **Mail Address 2** | |
| **Suburb or Place or Locality** | Fremantle |
| **State or Locality 2** | WA |
| **Country** | Australia |
| **Postcode** | 6160 |
| **Telephone** | 08 9432 5100 |
| **Facsimile** | 08 9430 5408 |
| **Electronic Mail Address** | rayl@calm.wa.gov.au |

| **METADATA DATE** | |
|---|---|
| **Metadata Date** | 27 January 2000 |
| **ADDITIONAL METADATA** | |
| **Additional Metadata** | -See accompanying habitat classification documentation (**hab_classification.doc**) further describing the classification system.<br><br>NOTE: This system is still in development. Any feedback would be appreciated.<br><br>See report:<br><br>Bancroft KP. and Shattock, W. (2000). The major marine habitats of the proposed Geographe Bay-Hardy Inlet marine conservation reserve. Report: MRI/CF/GBC-45/2000. September 2000. Marine Conservation Branch, Department of Conservation and Land Management, 47 Henry St., Fremantle, Western Australia, 6160. (unpublished report). |

## APPENDIX III. METADATA FOR THE MAJOR COASTLINE HABITATS OF THE PROPOSED GEOGRAPHE BAY-CAPES-HARDY INLET MARINE CONSERVATION RESERVE

| | |
|---|---|
| **DATASET** | |
| **Title** | **GBC_COASTLINE_AMG50_AGD84** - Onshore Coastal Mapping of the Geographe Bay/Capes Area |
| **Custodian** | Department of Conservation and Land Management (CALM) |
| **Jurisdiction** | Western Australia |
| **DESCRIPTION** | |
| **Abstract** | This dataset consists of linework detailing the onshore coastline habitats of WA's Busselton -Augusta area and covers approximately 200 kilometers of coastline extending from Geographe Bay around to Augusta. The dataset was produced to complement the polygon dataset of marine benthic habitats of the Geographe Bay/Capes area (gbc_habmap_amg50_agd84).<br><br>The coastline is delineated into areas of **Beach**, **Rocky shore**, **Beach + Rocky shore** or **Inlet Closure** and attributed accordingly. Lines are further attributed with habitat length, beach width (average and maximum), and direction the beach is facing. The base coastline linework was provided by DOLA. A source attribute has been added to each line based on DOLA's coastline source and/or method used to derive the coastline in any area.<br><br>Habitats were identified from aerial and ortho-rectified photography. Beach widths were measured from the ortho-rectified photography using a scale rule, and a scaled adjustable magnifying glass where necessary. Habitat facing directions were determined using a transparency of a compass rose (360 degree circle).<br><br>The dataset was compiled by Wing Shattock in February - March 2000. |
| **Search Word(s)** | |
| **Geographic Extent Name(s)** | Leeuwin/Naturaliste (LNE) IMCRA Region |
| **DATA CURRENCY** | |
| **Begin Date** | September 1994 |
| **End Date** | October 1996 |

| | |
|---|---|
| **DATASET STATUS** | |
| **Progress** | In Progress |
| **Maintenance & Update Frequency** | As required |
| **ACCESS** | |
| **Stored Data Format** | DIGITAL ArcView shapefile, projected to Australian Map Grid Zone 50 from Australian Geodetic Datum 1984 (AGD84). |
| **Available Format Type** | DIGITAL ArcView 3.2 shapefile |
| **Access Constraint** | Data available for external use subject to transfer fee and license conditions.<br><br>Data is not to be distributed without authorisation from CALM.<br><br>Contact CALM's database administrator for further details. |
| **DATA QUALITY** | |
| **Lineage** | **1.** A standard broad scale marine habitat classification system was developed by CALM Marine Conservation Branch (see attached documentation **hab_classification.doc**).<br><br>NOTE: The classification system is being refined on an on-going basis.<br><br>**2.** A rectified Landsat 5 TM image covering the full extent of the habitat mapping project was used to provide a spatially rectified reference base for the habitat mapping, and facilitate accurate location of coastline features.<br><br>**3.** The current DOLA coastline was used as the base linework for the coastline habitats to be 'split' and attributed as necessary. This coastline was modified in only a few small areas where there was large conflict with the image data . A source attribute was been added to each line based on DOLA's coastline source and/or method used to derive the coastline in any area.<br><br>**4.** Ortho-rectified aerial photographs were then used as a reference to delineate habitat boundaries on the base coastline. The aerial photographs were from Department of Land Administration job numbers 940590 (Cape Leeuwin-Kalbarri 1:20000, 1994), 960114 (Leeuwin 1:100000 map sheet, 1:25 000, Dec1996), 960007 Busselton 1930 sht & ext, 1:25000, Oct1996). Habitat boundaries were delineated (according to CALM's standardised habitat classification system) into areas of **Beach**, **Rocky shore**, or **Beach / Rocky shore** and attributed accordingly. Delineation was done using the 'split line' functionality of ArcView 3.2 and was generally done to co-incide with the offshore polygons contained in the complementary dataset of marine benthic habitats.<br><br>Lines containing beach habitats were then attributed with beach width (average and maximum). Width was measured in metres from the ortho-rectified photography using the distance measuring capability within ArcView.<br><br>Habitats were further attributed with direction the beach is facing. This was determined using a transparency of a compass rose (360 degree circle). See 'Attribute Accuracy' below for further details. |

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| | Habitat length was calculated using the CALM added functionality extension (Calc length). |
| **Positional Accuracy** | Habitats extents were delineated as accurately as is possible to determine from ortho-rectified photography zoomed to 1:5000. Accuracy of geodetic control is unknown at this stage but is assumed to be at least equivalent to 1:25000 topo mapping giving horizontal positional accuracy of within 12 metre of true position. Ground-truthing needs to be undertaken to determine them with greater accuracy.<br><br>Accuracy of DOLA's coastline linework is not stated. DOLA has compiled this dataset from a number of sources of best available information including 1:2 000, 1:50 000 and 1:100 000 scale datasets. These source datasets were collected at various levels of positional accuracy, and as such each individual line is as accurate as its source data. The SOURCE attribute in the shapefile identifies these sources.<br><br>The DOLA coastline was modified in only a few small areas where there was large conflict with the Landsat image data and the aerial photography. |
| **Attribute Accuracy** | - Habitat classifications were determined visually from aerial photography, and while every effort has been made to assign these correctly, there may be some errors. The habitats are accurate as best determined at the time of aerial photography. Coastlines by their very nature are subject to change due to natural and man-made forces. This is particularly the case with the movement of sand up and down the coast, and as such beaches may form and disappear with the passing of time. Ground-truthing needs to be undertaken to determine habitats with greater accuracy.<br><br>- Beach width was measured in metres from the ortho-rectified photography at a zoom of 1:5000 using the distance measuring capability within ArcView and are accurate to at least 5 metres.<br><br>Beach directions were determined using a transparency of a compass rose (360 degree circle) and the digital linework. Directions were assigned based on the seaward direction the habitat was facing. The following domain was used based on the seaward perpendicular of the bearing of the habitat.<br><br>west = $337.5^{o}$- $22.5^{o}$<br><br>south-west = $22.5^{o}$ - $67.5^{o}$<br><br>south = $67.5^{o}$ - $112.5^{o}$<br><br>south-east = $112.5^{o}$ - $157.5^{o}$<br><br>east = $157.5^{o}$ - $202.5^{o}$<br><br>north-west = $202.5^{o}$ - $247.5^{o}$<br><br>north = $247.5^{o}$- $292.5^{o}$<br><br>north-east = $292.5^{o}$ - $337.5^{o}$<br><br>Where there were obvious conflicts in the digital coastline and the aerial photography, the aerial photography direction was used to override that of the digital coastline. This was very in-frequent. |

| | |
|---|---|
| | The classification **Beach + Rocky shore** included both the following areas:<br><br>1) where there was a beach that had a rocky shore abutting it from the landward side, and may also have had the rocky shore extending into the beach,<br><br>2) where a beach was divided along its extent by the emergence of a rock platform through the beach.<br><br>These classifications have not been discerned in the dataset. To determine which category a particular **Beach + Rocky shore** classification falls into, the relevant aerial photograph would need to be viewed. |
| **Logical Consistency** | The digitised linework was converted to an ArcInfo coverage using double precision to remove inconsistencies in the data. The data was not cleaned as this was done on the coastline by DOLA.<br><br>It was then converted back to a shapefile. |
| **Completeness** | The dataset will be completed in gap areas as data becomes available and upgraded as priorities, time and resources permit.<br><br>Further work needs to be undertaken on ground-truthing. |
| **CONTACT INFORMATION** | |
| **Contact Organisation** | Department of Conservation and Land Management, Marine Conservation Branch |
| **Contact Position** | Marine GIS Co-ordinator |
| **Mail Address 1** | 47 Henry Street |
| **Mail Address 2** | |
| **Suburb or Place or Locality** | Fremantle |
| **State or Locality 2** | WA |
| **Country** | Australia |
| **Postcode** | 6160 |
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| **Electronic Mail Address** | rayl@calm.wa.gov.au |

| **METADATA DATE** | |
|---|---|
| **Metadata Date** | 17 Oct 2000 |
| **ADDITIONAL METADATA** | |
| **Additional Metadata** | See accompanying habitat classification documentation further describing the classification system. NOTE: This system is still in development. Any feedback would be appreciated.<br><br>See report:<br><br>Bancroft K.P. and Shattock, W. (2000). The major marine habitats of the proposed Geographe Bay-Hardy Inlet marine conservation reserve. Report: MRI/CF/GBC-45/2000. September 2000. Marine Conservation Branch, Department of Conservation and Land Management, 47 Henry St., Fremantle, Western Australia, 6160. (unpublished report).<br><br>See DOLA coastline Metadata report for further details on the coastline. |

The marine benthic habitat map should not be used for navigational purposes.

This marine benthic habitat map has its origin in the dataset developed by CSIRO. A subsequent marine benthic habitat survey undertaken by the Marine Conservation Branch, Department of Conservation and Land Management has provided additional information.

The delineation between habitats on the map is shown by abrupt changes in habitat classification. In reality changes are more often a gradual transition from one habitat to another. As a result, the location of some habitat boundaries should be considered as approximate only.

In addition, relatively limited ground-truthing data has been used in determining these habitats due to their extensive area.

For further information on data sources and methods, refer to:
Bancroft KP. and Shattock, W. (2000). The major marine habitats of the proposed Geographe Bay-Hardy Inlet marine conservation reserve. Report: MRI/CF/GBC-45/2000. September 2000. Marine Conservation Branch, Department of Conservation and Land Management, 47 Henry St., Fremantle, Western Australia, 6160. (unpublished report).

300000 325000 350000

6275000 6250000 6225000 6200000

Geographe Bay

*Cape Naturaliste*

Yallingup

*INDIAN OCEAN*

Margaret River

Hamelin Bay

*Cape Leeuwin*

Flinders Bay

# Major Marine Habitats of the Geographe Bay-Capes-Hardy Inlet region

**LEGEND**

- Study_area
- Limit of AustralianTerritorial Seas
- Limit of Western Australian State Waters

**Bathymetry**

- 0-10m
- 10-20m
- 20-50m
- 50-100m
- 100-200m
- ISLAND

**Major marine habitats**

- Sand shoal
- Shoreline reef
- Offshore intertidal reef
- Macroalgae (limestone/high relief)
- Macroalgae (limestone/low relief)
- Macroalgae (granite/high relief)
- Macroalgae (granite/low relief)
- Seagrass (perennial/dense)
- Seagrass (perennial/medium)
- Seagrass (Perennial/sparse)
- Seagrass (ephemeral/sparse)
- Sand
- Silt
- Pelagic

N W E S

Kilometres

5 0 5 10 15 20

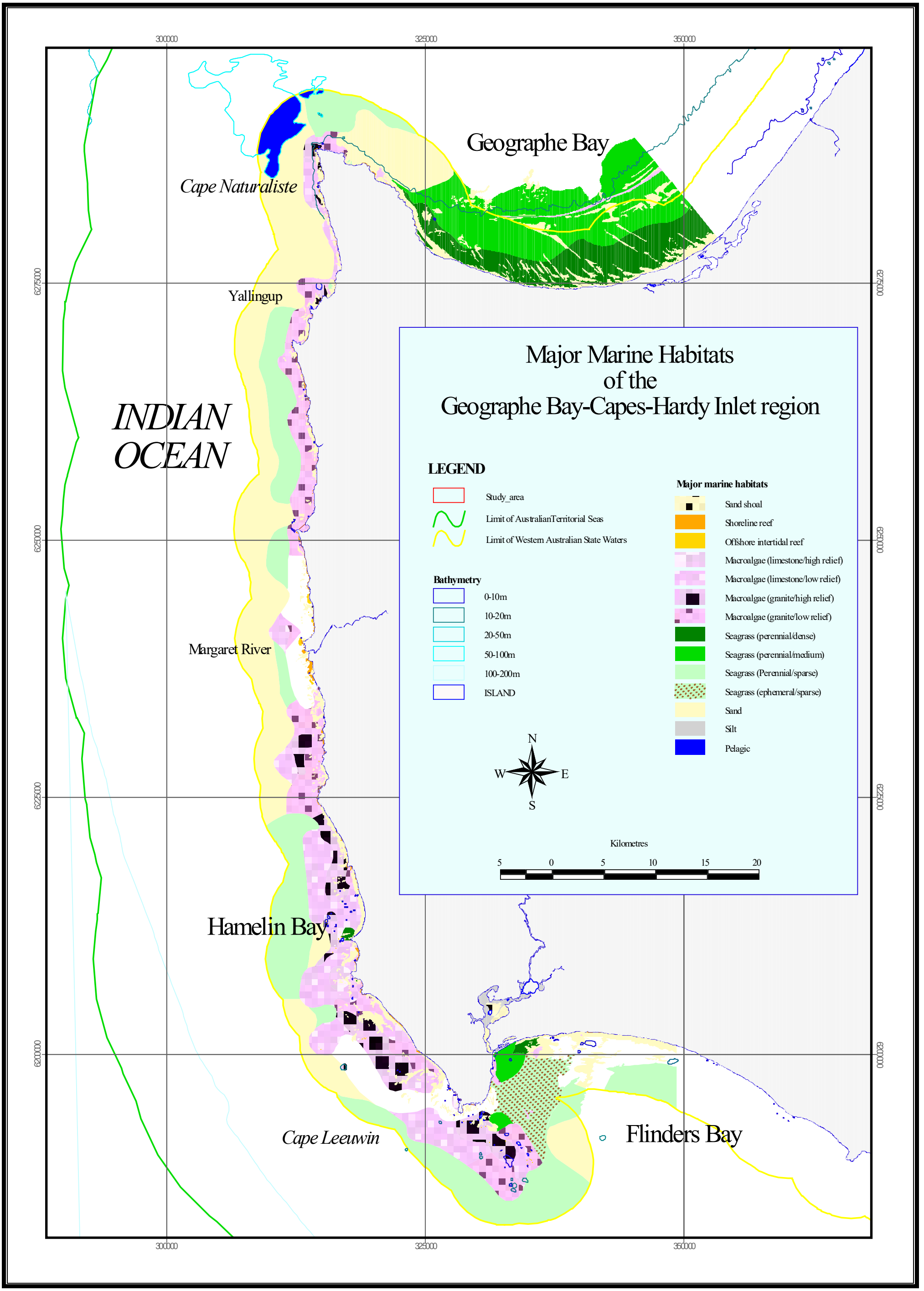


**Figure 2. Revised broadscale map of the major marine habitats in the Geographe Bay-Capes-Hardy Inlet region**