SHARK BAY MARINE RESERVES MONITORING PROGRAMME

Project No. 151/95 - National Ecotourism Programme
Commonwealth Department of Tourism

PRELIMINARY FIELD SURVEY: 15-22 April 1996

Field Programme Report SBMRMP-01/96

A collaborative project between CALM Marine Branch, Geraldton Regional Office and Gascoyne District Office

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CONTENTS

ACKNOWLEDGEMENTS

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CALM Regional/District collaboration

Geraldton Region - Ron Shephard, Program Leader, Nature Conservation

Gascoyne District - Paul Brown, District Manager; Brad Barton, Operations Officer

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Literature Search

Alan Pearce, Commonwealth Scientific and Industrial Research Organisation, Division of Oceanography.

Murray Burling, Dr Charitha Pattiaratchi and Dr Greg Ivey of the Department of Environmental Engineering, University of Western Australia.

Dr Brian Logan, Geology Department, University of Western Australia.

Kathy Little, Librarian, Department of Environmental Protection of Western Australia.

Lisa Wright, Librarian, CALM.

GIS Habitat Maps/Usage database

Rod Properjohn, Land Information Branch, CALM.

Eleanor Bruce, PhD Student, Department of Geography, University of Western Australia.

Satellite imagery

Mike Steber, Department of Land Administration, Remote Sensing Applications Centre.

Alan Pearce, Commonwealth Scientific and Industrial Research Organisation, Division of Oceanography.

1 INTRODUCTION

1.1 General

This field programme report outlines proposed activities for the ***Preliminary Field Survey of Shark Bay 15-22 April 1996*** to be conducted as the first survey of the Department of Conservation and Land Management's ***Shark Bay Marine Reserves Monitoring Programme (SBMRMP).*** Background information, personnel, methods, equipment, timetabling of activities, budget details and issues relating to future work are described. Shark Bay Marine Park, Hamelin Pool Marine Nature Reserve and Shark Bay World Heritage Area and surrounds are shown in Figure 1.

The successful management of the Shark Bay Marine Reserves is contingent upon a comprehensive long-term monitoring program being established that provides information on natural variability and long-term trends in key biological communities, determines the status of important attributes of the reserves at regular intervals and identifies undesirable trends resulting from human activities in time for remedial management action to be effective. Monitoring programmes generally comprise one or more of the following complementary objectives: (i) local scale impact and/or compliance monitoring that examines the effects of human activities in a localised area/s, (ii) temporally constrained broadscale surveillance monitoring to assess the impact of episodic regional physical and biological processes (eg the effect of cyclones/predators) and (iii) spatially constrained long-term monitoring of key biological parameters to determine the extent and cause of natural variation (eg seasonal and inter-annual variability) of key ecosystem attributes.

Although the SBMRMP will provide some information on all three aspects, the primary focus of the SBMRMP is on objective (i) and, to a lesser extent, objective (ii). This emphasis is determined by the perceived nature of current impacts and resource constraints. The third objective, in particular, requires a long-term (> 10 y) committment of resources for useful information to be obtained.

The field survey will be conducted by the Marine Branch of CALM (Principle contact: Dr Chris Simpson, A/Manager, Marine Branch) in collaboration with the Geraldton Regional Office (Contact: Ron Shephard) and the Gascoyne District Office (Contact: Paul Brown). Greg Pobar (Marine Branch) is the Field Team Leader and will coordinate all activities in the field. The field staff will include Jeremy Colman and Nick D'Adamo from the CALM Marine Branch and Kevin Crane from CALM's Swan Region (Marine Operations Group - Swan). Ron Shephard from the CALM Geraldton Regional Office and Paul Brown and Brad Barton, from the Gascoyne District Office will also be part of the field team.

1.2 Background

The SBMRMP is an integration of two projects: (i) ***Baseline Studies and Monitoring of Visitor Sites in the Shark Bay Marine Park*** (Project No. 151/95, granted under the *National Ecotourism Program* by the Commonwealth Department of Tourism in 1995) and (ii) ***Habitat Mapping for Shark Bay Marine Reserves Program*** funded by CALM's World Heritage funds. Although technically separate, there is considerable overlap in these two projects. As such, some of the objectives of the 'Baseline Studies' will directly service the requirements of the 'Habitat Mapping' project.

The SBMRMP will be undertaken in three phases. Phase I includes a review of the current state of knowledge, in relation to monitoring information requirements, and a preliminary exploratory field survey. Phase II will involve designing the monitoring programme and Phase III will establish the long-term monitoring locations and initialise the monitoring programme. Elements of the SBMRMP will be integrated with the MARINE DATABASE project to be funded under OR2000 1996/97. This report describes the field programme for the preliminary exploratory field survey (15-22 April 1996).

The objective of the *Baseline Studies and Monitoring of Visitor Sites in the Shark Bay Marine Park* project is to establish and initialise a monitoring program to ensure that recreation and tourism activities are ecologically sustainable. Quantitative and qualitative biological information will be obtained using video and still photography from replicate fixed transects at relocatable sites throughout the Shark Bay area. Video vision will be archived for future reference. The objective of the *Habitat Mapping for Shark Bay Marine Reserves Program* is to field verify the existing habitat map of the Shark Bay area, particularly in relation to the classification of the major habitat types, and provide better spatial detail in areas where habitat boundaries and marine reserve boundaries approximately coincide.

The SBMRMP is linked to the recommendations of the *Shark Bay Marine Reserve Draft Managment Plan 1994* relating to the research and monitoring required to ensure that activity in the Bay is consistent with its World Heritage, Marine Park and Marine Nature Reserve status (see Figure 1). The *Shark Bay Marine Reserve Draft Managment Plan 1994* is currently being prepared by CALM for the National Parks and Nature Conservation Authority.

1.3 Aims

The aims of the April 1996 field survey are:

(1) Familiarisation of the Shark Bay area and preliminary selection of long-term monitoring sites

(2) Preliminary selection of control sites

(3) Accuracy determination of existing GIS habitat boundaries at representative sites throughout Shark Bay

(4) Trialing and logistic evaluation of proposed monitoring techniques

(5) Accuracy determination of a differential GPS system in a remote location

(6) Evaluation of logistic requirements for the mid-year survey (eg vessel requirements etc.)

(7) Inform the local community of the objectives of the Shark Bay Marine Reserves Monitoring Programme (including local government) via meetings and media contact.

(8) Opportunistically collect still photographs and video footage of major habitat types and visually dominant flora and fauna of the Shark Bay region

2 REVIEW AND PLANNING

2.1 General

A preliminary search of existing literature (published and unpublished) has been conducted with contributions from various government agencies, libraries and individuals (see acknowledgements) and has produced a wide range of scientific literature on the biology, ecology and geology of the Shark Bay area. Considerable local knowledge of the environment of Shark Bay in relation to habitats, visitor usage patterns, contaminant inputs, existing and proposed development activity (eg salt mining, aquaculture), recreational and commercial fishing, recreational diving, navigation and local meteorological and sea conditions has been obtained from CALM officers with professional experience of this area. Appendix I presents available habitat and usage maps for Shark Bay and were used to assist in site selection for the April field trip.

2.2 Reviews

A preliminary review has been conducted of the oceanography of Shark Bay. Murray Burling has provided copies of summer and winter data reports containing three-dimensional salinity-temperature-density structure data and associated preliminary hydrodynamic interpretations for Shark Bay. Mr Burling is a M. Eng. Sc. student at the Department of Environmental Engineering of the University of Western Australia, supervised by Drs Charitha Pattiaratchi and Greg Ivey. Mr Burling is currently carrying out numerical modelling of the circulation of Shark Bay and the results of this will be available in Mr Burling's masters thesis.

Alan Pearce of the CSIRO Division of Oceanography has provided a reference list of oceanographic literature for Shark Bay and has also provided copies of NOAA-AVHRR sea-surface temperature imagery for Shark Bay and adjacent oceanic waters showing what are believed to be characteristic SST structures on a monthly basis. These images were provided to assist in the understanding of broad-scale oceanographic patterns and will be of use in subsequent field and analytical studies of Shark Bay, planned as part of the SBMRMP.

Dr Brian Logan of the Geology Department, University of WA has provided copies of his early work on the salinity regimes and circulation patterns of Shark Bay. This information provides further data on seasonal salinity regimes and inferred broad-scale circulation patterns.

Literature on the ecology of Shark Bay includes the work of the 1970's and 1980's conducted by Dr Brian Logan and colleagues and the more recent work on the seagrasses of Shark Bay by Dr Di Walker. The WA Museum has also conducted many biological surveys of the marine and terrestrial flora and fauna of the region including Bernier and Dorre Islands (Dr P Berry, pers. comm.). Currently the Museum is conducting research on the small clam *Fraygum erugatum* which forms the famous Shell Beach. A comprehensive bibliography has been developed as part of the literature survey for the SBMRMP.

A preliminary review of available remote sensing imagery was conducted with assistance from Mr Alan Pearce (CSIRO, Division of Oceanography) and Mr Rob Shaw (Remote Sensing Applications Centre, Department of Land Administration).

3 SURVEY GRID, METHODS AND EQUIPMENT

3.1 Survey grid

The field survey grid of 30 sites is shown in Figure 2. A listing of the sites, locations, major usage activity, habitat type and existing or perceived impacts are listed in Table 1. Segments at an enlarged scale (1:50000) from the overall habitat map of the Shark Bay region (part of the GIS habitat map set from the Land Information Branch, CALM) and will be used by the field crews to assist in site investigation and GIS habitat map verification. Figure 3 shows the boundaries of the six segments. The complete set of GIS habitat/usage maps are in Appendix I.

3.2 Methods

Apart from the first day, two field crews will be operating independently (see section 4) via two modes:

(i) by 10m chartered catamaran (Explorer Charters, Ph: (099) 481 054. Contact Allan Dyson) for the more remote sites around Shark Bay,

(ii) by the CALM vessel Sirenia for the coastal sites accessible by 4 x WD vehicle.

At each site a description of the major benthic community types (eg seagrass meadows, coral reef etc.), the visually dominant species and the nature and extent of impacts (if present) will be recorded by direct observation from the boat (ie by viewfinder and/or remote video) and/or by divers. Underwater video and still photography will be undertaken at selected sites. A differential GPS will be used at the remote sites and a standard GPS (non-differential) will be used at the coastal sites to determine the site locations. All data will be recorded on a single field data sheet for each site (see Table 2).

Salinity and temperature data will be collected at 1m below the surface, mid-depth and ~1m above the sea bed at selected sites using a Yeokal Salinity-Temperature Bridge (Hamon Model 602). These data will provide some insight into broadscale circulation patterns and determine the degree of stratification of the water column as an aid to interpretations of satellite imagery of sea-surface temperature signals which can be used as a proxy for broadscale surface water circulation patterns. Mike Steber (Remote Sensing Applications Centre, Department of Land Administration) will provide sea surface temperature (SST) images (NOAA-AVHRR) from Monday (14 April 1996) and Wednesday (16 April 1996) via facsimile to the Denham office of CALM. These will be used in conjunction with field measurements of SST to help discern broad-scale circulation features.

The SST data will also be forwarded to Alan Pearce (CSIRO, Division of Oceanography) for ground-truthing of NOAA-AVHRR SST imagery.

The ST data may also be of use to Murray Burling (Department of Environmental Engineering, University of Western Australia) in his work on the numerical modelling of the circulation of Shark Bay.

The ST data will be recorded on a single field data sheet for each site, and example of which is reproduced in Table 3.

3.3 Equipment

10 dive cylinders
7 BCDs
7 Regulators
7 Wt Belts
2 spare dive kits
1 first aid kit
1 oxy viva
1 face mask and oxygen D-cell
1 underwater video
5 Hi8 video tape
1 surface viewing underwater TV
1 Nikonus V (28mm lens)
1 Nikonus V 35mm lens
10 rolls film
1 Ensign GPS
1 Scoutmaster GPS
1 omnistar differential GPS
2 handheld radios
1 salinity - temperature meter
30 salinity bottles
100 whirl packs
1 scientific thermometer
dive slates
bathymetric charts

4 FIELD PROGRAMME

4.1 Team Leader

The Team Leader for the overall field survey is Greg Pobar.

4.2 Diving

During the survey Greg Pobar will be responsible for the coordination of SCUBA and free diving activities. On days when both vessels are operating, diving responsibilities will be delegated by Greg Pobar.

4.3 Onboard data collection

During the survey Nick D'Adamo will be responsible for the coordination of onboard data collection and recording. On days when both vessels are operating onboard data collection responsibilites will be delegated by Nick D'Adamo.

4.4 Field timetable

The timetable in Table 4 lists the activities of the field survey and rostering for the personnel involved for Tuesday-Friday, 16-19 April 1996.

As indicated in Table 4, on the first day of field activities (Tuesday, 16 April 1996) only the charter boat will be used with all field crew onboard. This days field work will be used to not only address the data collection requirements for sites SB5 to SB30 (see Figure 2) but also to ensure familiarisation with the methods to be used and standardisation of the approach amongst all field crew. At each site field crew may be interchanged (re: underwater and onboard activities) as determined by the Team Leader.

4.5 Contingency

All sites (SB5-SB150) are planned to be visited on the first four days (16-19 April 1996). However in the event that additional sites are visited or that bad weather or logistical difficulties retard the proposed programme then additional resources can be employed on Friday 19 April 1996 by using the charter vessel and/or on Saturday 20 April by using the charter vessel and/or the CALM vessel SIRENIA.

5 SAFETY

5.1 Vessels

Charter vessel operation, navigation and associated safety procedures will be the responsibility of the operator. The charter vessel operator has the responsibility to regulate navigation according to sea and weather conditions.

The local CALM vessel will be utilised for inshore shallow coastal sites. The CALM vessel will be towed by four-wheel drive to these sites. All operations on the CALM vessel will be conducted within CALM's safe boating operational guidelines. Boating operations will be the responsibility of an officer nominated by the Team Leader.

5.2 Diving

All diving operations will be conducted within CALM's 'Safe Work in CALM Scientific Guidelines'. The programme Dive Supervisor will be Greg Pobar in liaison with the District Diving Supervisor, Brad Barton.

6 BUDGET

Item	$
Vehicle hire (1 week)	600
Trailer hire	250
Accommodation	850
Vessel charter (3 to 5 days)	2,340-3,900
GPS hire	0
Omni Star (differential GPS hire)	900
Video monitor	0
GIS mapper	0
TM imagery	0
Regional vessel (Sirenia) use	0
Aircraft	500
Charts	300
Photography	400
Diving support	150
Fuel	250
Salinity-temperature Calibrations	250
Allowances (meals etc)	1,750
Staff costs	400
Consumables	500
Contingency	500
Total	**9,040-10,600**

7 FUTURE WORK

7.1 Progress report

A progress report for the SBMRMP will be prepared following this preliminary survey. The report will describe the results of the reviews and preliminary survey. In addition, progress results of the GIS Habitat Maps/Usage Database ground-truthing component of the preliminary survey will be presented. An evaluation will be made of the present status of key sites in terms of impacts due to usage in Shark Bay in the context of the Bay's status as a conservation region. Recommendations as to the selection of long-term baseline monitoring sites will be given in the progress report.

7.2 Field survey to initialise baseline monitoring

The major field survey of the SBMRMP in which long-term baseline monitoring will be initialised, is planned for July/August 1996. That survey will make use of the information collected in the review and preliminary survey phases of the SBMRMP.

7.3 Investigation of methodologies and equipment for future work

7.3.1 ROXANN habitat surveying

The ROXANN habitat surveying technology is essentially a sophisticated single beam echo-sounder transducer that communicates its signal to an onboard PC for hydro-acoustic signal processing. After ground-truthing, the system can be used to quickly scan large areas (along line transects) with the ability to discern different habitat types and spatial variation of density within a particular habitat type. MICROPLOT software is incorporated into the data system and this enables other plotable information to be overlain on the habitat imagery, such as complementary video imagery and Admiralty charts from CD ROM. ROXANN has recently been extensively used by the Victorian Fisheries department for large

scale habitat surveys (contact: John Barry, Ph. 052-580111 (mob.) 019-955292. The approximate cost for a ROXANN package is $30-35000. It is also available for hire. The local agent for ROXANN is:

HB Pacific Pty. Ltd.
(Director: Henrik Jacobsen)
71 Alfred Road
Claremont WA 6010
Ph. 3851771 (mob.) 018 952982 Fax 3833617

7.3.2 Sailing catamaran sleep-aboard field survey vessel

Past field surveys in Shark Bay have made use of a 12 m sailing Catamaran that cruises at about 9 knots and sleeps field crew onboard. The catamaran is fully self-contained and caters for large field crews, providing onboard sleeping and cooking facilities, and is suitable for diving operations and the deployment of scientific equipment.

Table 1 List of sites and main factors used in site selection for the Preliminary Field Survey of Shark Bay 15-22 April 1996

Site	Locality reference name	Chart coordinates (indicative)	Activity or major usage type	Major benthic communities	Actual/potential impacts, or suitability as a control site
SB5	Monkey Rock - Steep Point	26° 08.85' 113° 09.8'	Fishing, diving	Reef	Damage, exploitation
SB10	Surf Point	26° 07.5' 113° 10.9'	Diving	Reef, sanctuary	Damage, expoitation
SB15	Aquaculture (fish cages)	26° 0.3' 113° 13.8'	Aquaculture	Sand, seagrass	Nutrient inputs
SB20	Herrison/Bellfin Flats	25° 58.9' 113° 17.8'	Navigation	Seagrass	Vessel damage
SB25	Useless Inlet	26° 8.5' 113° 21.3	Salt works	Unknown	Adjacent to salt pans
SB30	Useless Jetty	26° 5.5' 113° 25.3'	Ship loading	Seagrass	Vessel damage
SB35	Wilson Island	26° 10.0' 113° 39.5'	Fishing	Seagrass	Anchor damage
SB40	Mary Anne Island	26° 29.07' 113° 41.00'	Fishing	Shelf, sanctuary	Anchor damage
SB45	Three Bays Island	26° 33.5' 113° 39.0'	Fishing	Shelf, seagrass	Anchor damage
SB50	Freycinet Island	26° 23.8' 113° 36.7'	Fishing	Seagrass, depression	Anchor damage
SB55	Kangaroo Island	26° 19.0' 113° 30.0'	Unknown	Unknown, enclosed	Possible control site
SB60	Lefebre Island	26° 13.5' 113° 30.3'	Fishing	Shelf assemblage	Anchor damage
SB65	Homestead Jetty	25° 59.7' 113° 12.0'	Mooring and vessel landing	Shallow reef flat	Substrate damage
SB70	Louisa Bay	25° 46.6' 113° 5.3'	Diving	Reef, coral	Diving impacts
SB75	Sandy Point	25° 43.2' 113° 4.6'	Diving, fishing	Reef, coral, sanctuary	Diving impacts and anchor damage
SB80	Whitnell Point	25° 35.0' 113° 1.4'	Diving	Reef, coral	Diving impacts and anchor damage
SB85	Levillian Shoal	25° 31.4' 113° 2.2'	Diving, fishing	Reef, coral	Diving impacts and anchor damage
SB90	Turtle Bay	25° 29.8' 112° 59.6'	Anchoring, fishing	Sand, seagrass	Anchor damage
SB95	Denham coastal waters	25° 56.7' 113° 30.9'	Aquaculture, vessels	Seagrass	Bed damage, nutrient inputs
SB100	Big Lagoon	25° 46.1' 113° 28.0'	Vessels	Semi-enclosed lagoon	Anchor damage
SB105	Broadhurst Reef	25° 38.1' 113° 22.3'	Fishing	Shoal reef, seagrass	Boating activity
SB110	Gudrun wreck	25° 25.3' 113° 31.31"	Diving	Sanctuary, wreck	Exploitation, anchor damage
SB115	Peron Peninsula	25° 30.0' 113° 31.0'	Diving	Reef shelf	Diver impacts
SB120	80 Acres	25° 34.89' 13° 32.12"	Fishing	Reef flat	Anchor damage
SB125	Cape Rose	25° 44.0' 113° 38.4'	Aquaculture	Seagrass	Debris inputs
SB130	Monkey Mia	25° 47.5' 113° 42.4'	Intense recreation	Sand, seagrass	Intense use
SB135	Green Turtle Flat	25° 41.3' 113° 48.8'	Fishing	Seagrass shelf	Anchor damage
SB140	Faure Sill	26° 0.0' 114° 4.5'	Unknown	Seagrass channel	Possible control site
SB145	Gladstone Jetty	25° 57.5' 114° 14.1'	Boat launching	Seagrass	Vessel impacts
SB150	Wooramel River shelf	25° 53.5' 114° 13.5'	River delta	Shallow, seagrass, mangroves	Sedimentation, transportation

Table 2 Example of field data sheet for habitat observations

SHARK BAY MARINE RESERVES MONITORING PROGRAMME
PRELIMINARY FIELD SURVEY OF SHARK BAY 15-22 APRIL 1996
Marine Branch, Department of Conservation and Land Management

SITE AND HABITAT DATA

SITE: DATE: TIME: VESSEL _____

GPS DETAILS _____

GPS LAT_____**GPS LONG** _____

WEATHER_____**SEA** _____

CREW _____

LANDMARKS/DISCERNING FEATURES OF SITE_____

_____

DIRECT HABITAT OBSERVATION (REMOTE VIDEO)? YES / NO

UNDERWATER VIDEO? YES / NO STILL PHOTO? YES / NO

SCUBA DIVE? YES / NO FREE DIVE? YES / NO ST DATA? YES / NO

SHOULD A TRANSECT BE ESTABLISHED AT THIS SITE? YES / NO

PREFERRED TRANSECT START LAT/LONG _____

PREFERRED TRANSECT: DIRECTION_____**LENGTH**_____

VIDEO FILM I/D (TIME CODE): _____

HABITAT DETAILS _____

_____

_____

_____

VISUALLY DOMINANT SPECIES _____

_____

SIGNS/EVIDENCE OF ACTIVITY/IMPACT _____

_____

_____

_____

OTHER COMMENTS _____

_____

Table 3 Example of salinity-temperature profile data sheet

SHARK BAY MARINE RESERVES MONITORING PROGRAMME
PRELIMINARY FIELD SURVEY OF SHARK BAY 15-22 APRIL 1996
Marine Branch, Department of Conservation and Land Management

SALINITY-TEMPERATURE PROFILE DATA

SITE:_____ **DATE:** _____ **TIME:** _____

WEATHER/SEA:_____

RECORDER: _____

ST METER: _____

BOTTLE NO:_____ **RECORDED SALINITY OF BOTTLE SAMPLE:**_____

DETAILS OF CALIBRATION THERMOMETER:_____

THERMOMETER READING:_____ **METER TEMP. READING:** _____

DEPTH (m)	SALINITY (pss)	TEMPERATURE (^{o}C)	COMMENTS
0			
0.5			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			

Table 4 Timetable of activities and rostering of field personnel for the field survey

SITE	VESSEL	DAY	TIME: ARR/ DEP	DIVING PERSONNEL HABITAT, U/W VIDEO, PHOTOS, IMPACTS	ONBOARD PERSONNEL SITE INFO, REMOTE VIDEO, ST DATA, GIS HABITAT VERIFICATION
DENHAM	CHARTER	16-4-96	DEPART AT 1000	G POBAR K CRANE R SHEPHARD	N DADAMO J COLMAN B BARTON
SB5	CHARTER	16-4-96	1130/ 1230	"	"
SB10	CHARTER	16-4-96	1300/ 1330	"	"
SB15	CHARTER	16-4-96	1400/ 1430	"	"
SB20	CHARTER	16-4-96	1500/ 1530	"	"
SB25	CHARTER	16-4-96	1600/ 1700	"	"
SB30	CHARTER	16-4-96	1730/ 1800	"	"
DENHAM	CHARTER	16-4-96	ARRIVE AT 1900	"	"
DENHAM	CHARTER	17-4-96	DEPART AT 0800	G POBAR N DADAMO K CRANE	
SB35	CHARTER	17-4-96	0830/ 0900	"	
SB40	CHARTER	17-4-96	1000/ 1030	"	
SB45	CHARTER	17-4-96	1100/ 1130	"	
SB50	CHARTER	17-4-96	1230/ 1300	"	
SB55	CHARTER	17-4-96	1400/ 1500	"	
SB60	CHARTER	17-4-96	1530/ 1600	"	
DENHAM	CHARTER	17-4-96	ARRIVE AT 1700	"	
DENHAM	SIRENIA	17-4-96	DEPART AT 0800	R SHEPHARD J COLMAN B BARTON	
SB95	SIRENIA	17-4-96	0830/ 0930	"	
SB100	SIRENIA	17-4-96	1030/ 1200	"	
SB105	SIRENIA	17-4-96	1230/ 1330	"	
SB110	SIRENIA	17-4-96	1430/ 1600	"	
DENHAM	SIRENIA	17-4-96	ARRIVE AT 1800	"	
DENHAM	CHARTER	18-4-96	DEPART AT 0800	G POBAR K CRANE R SHEPHARD	
SB65	CHARTER	18-4-96	0900/ 0930	"	
SB70	CHARTER	18-4-96	1000/ 1100	"	
SB75	CHARTER	18-4-96	1130/ 1230	"	
SB80	CHARTER	18-4-96	1300/ 1400	"	
SB85	CHARTER	18-4-96	1430/ 1530	"	
SB90	CHARTER	18-4-96	1600/ 1700	"	
DENHAM	CHARTER	18-4-96	ARRIVE AT 1700	"	

MONKEY MIA	SIRENIA	18-4-96	DEPART AT 0800	B BARTON N DADAMO J COLMAN
SB130	SIRENIA	18-4-96	0830/ 0930	"
SB125	SIRENIA	18-4-96	1000/ 1030	"
SB120	SIRENIA	18-4-96	1100/ 1200	"
SB115	SIRENIA	18-4-96	1230/ 1400	"
MONKEY MIA	SIRENIA	18-4-96	ARRIVE AT 1530	"
MONKEY MIA	SIRENIA	18-4-96	DEPART AT 0800	G POBAR N DADAMO R SHEPHARD J COLMAN K CRANE
SB130	SIRENIA	19-4-96	0830/ 0900	"
SB125	SIRENIA	19-4-96	1000/ 1030	"
SB120	SIRENIA	19-4-96	1100/ 1200	"
SB115	SIRENIA	19-4-96	1300/ 1400	"
MONKEY MIA	SIRENIA	19-4-96	ARRIVE AT 1600	"

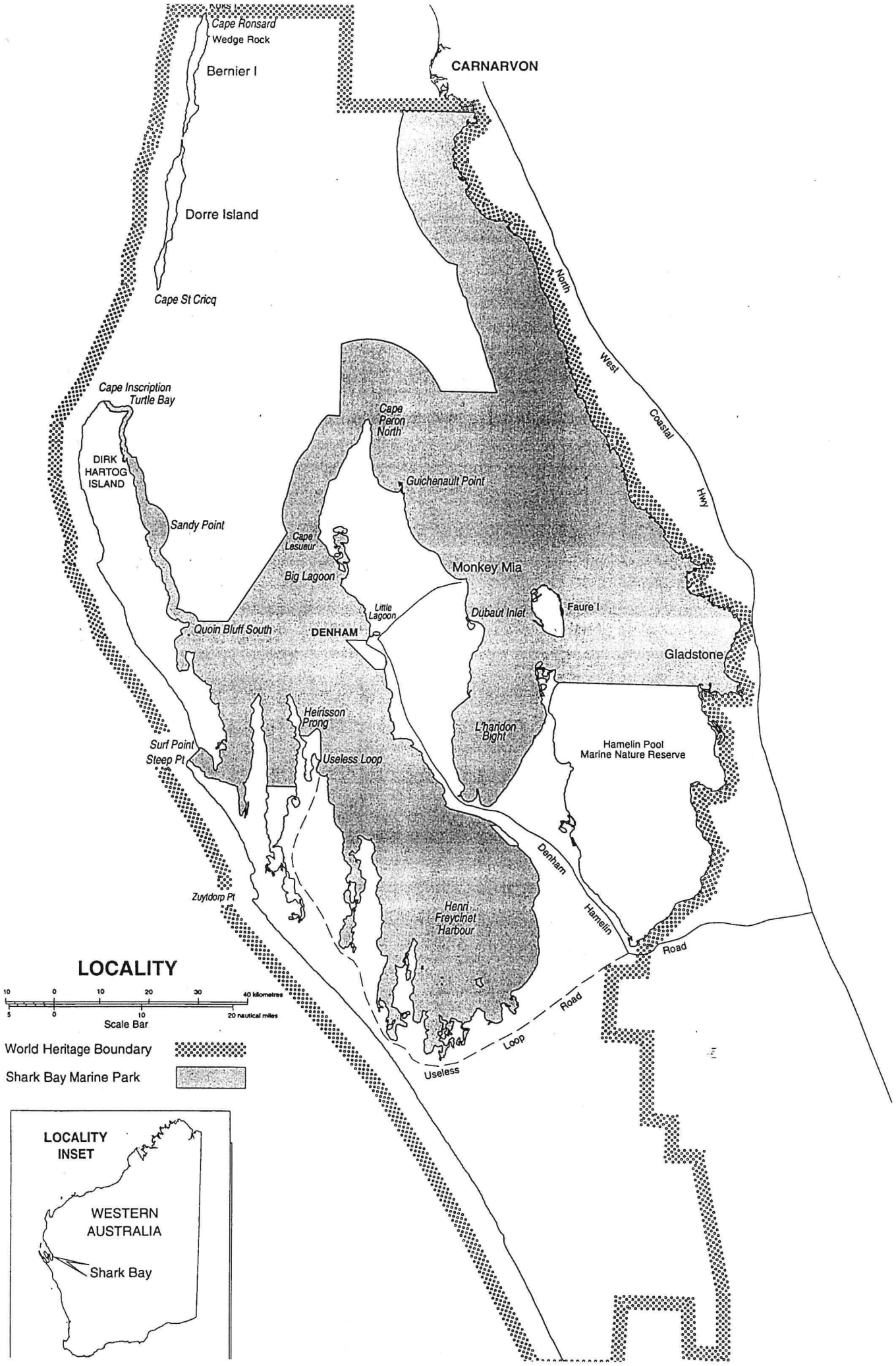

Cape Ronsard
Wedge Rock
Bernier I
CARNARVON
Dorre Island
Cape St Cricq
North West Coastal Hwy
Cape Inscription
Turtle Bay
DIRK HARTOG ISLAND
Sandy Point
Cape Peron North
Guichenault Point
Cape Lesueur
Big Lagoon
Monkey Mia
Little Lagoon
Dubaut Inlet
Faure I
Quoin Bluff South
DENHAM
Gladstone
Heirisson Prong
L'haridon Bight
Hamelin Pool Marine Nature Reserve
Surf Point
Steep Pt
Useless Loop
Denham Hamelin Road
Zuytdorp Pt
Henri Freycinet Harbour
Useless Loop Road
LOCALITY
10 0 10 20 30 40 kilometres
5 0 10 20 nautical miles
Scale Bar
World Heritage Boundary
Shark Bay Marine Park
LOCALITY INSET
WESTERN AUSTRALIA
Shark Bay

Figure 1

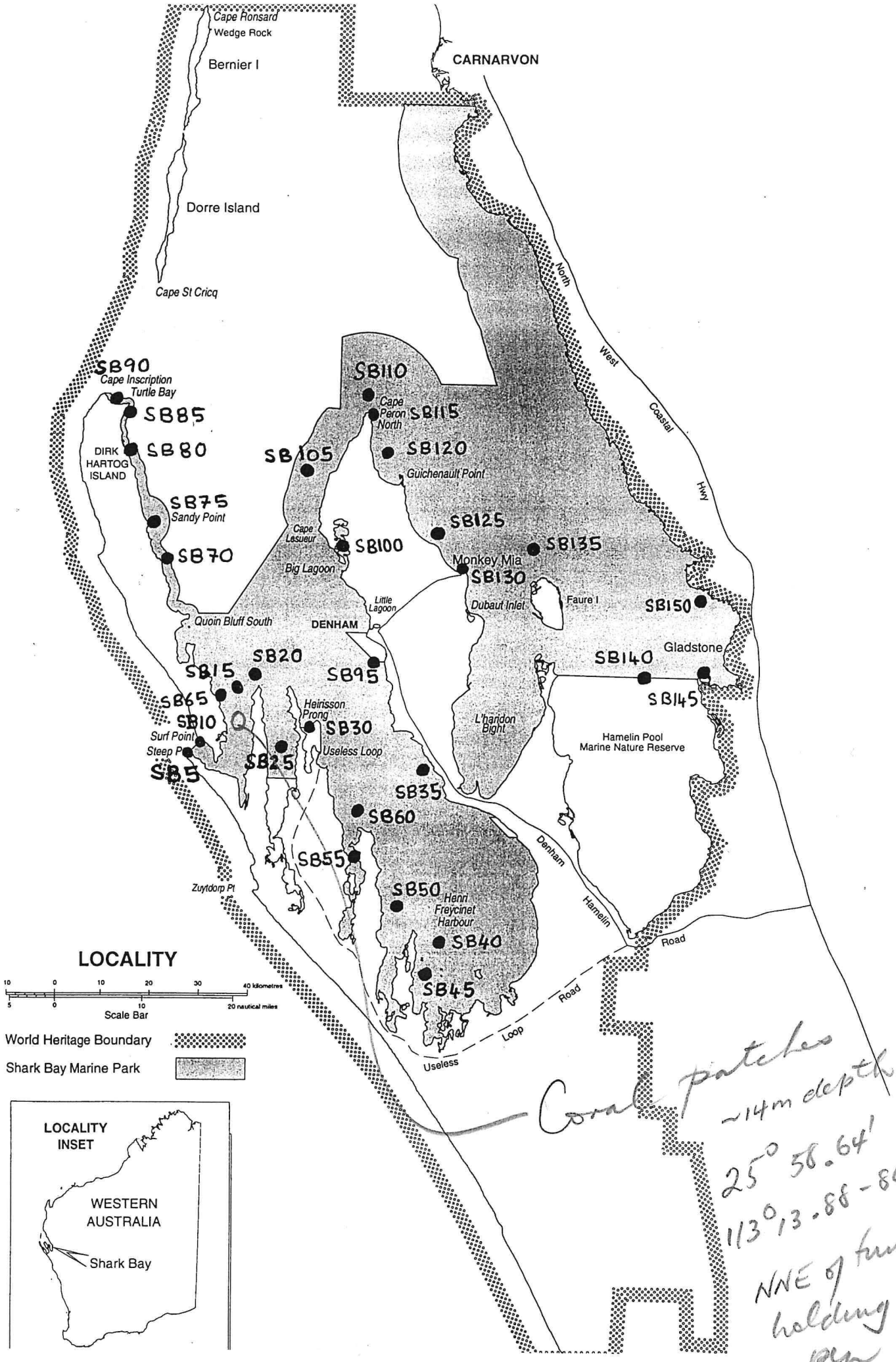

Cape Ronsard
Wedge Rock
Bernier I
CARNARVON
Dorre Island
Cape St Cricq
North West Coastal Hwy
SB90
Cape Inscription
Turtle Bay
SB85
SB80
DIRK HARTOG ISLAND
SB75
Sandy Point
SB70
Quoin Bluff South
SB110
Cape Peron North
SB115
SB120
Guichenault Point
SB105
Cape Lesueur
SB100
Big Lagoon
SB125
SB135
Monkey Mia
SB130
Dubaut Inlet
Faure I
SB150
Little Lagoon
DENHAM
SB20
SB15
SB95
SB65
SB10
Surf Point
Steep P
SB5
Heirisson Prong
SB30
Useless Loop
SB25
SB140
Gladstone
SB145
L'haridon Bight
Hamelin Pool Marine Nature Reserve
SB35
SB60
SB55
Zuytdorp Pt
SB50
Henri Freycinet Harbour
SB40
SB45
Denham Hamelin Road
Useless Loop Road
LOCALITY
10 0 10 20 30 40 kilometres
5 0 10 20 nautical miles
Scale Bar
World Heritage Boundary
Shark Bay Marine Park
LOCALITY INSET
WESTERN AUSTRALIA
Shark Bay
Coral patches
~14m depth
25° 58.64'
113° 13.88-84'
NNE of tuna holding pen

Figure 2

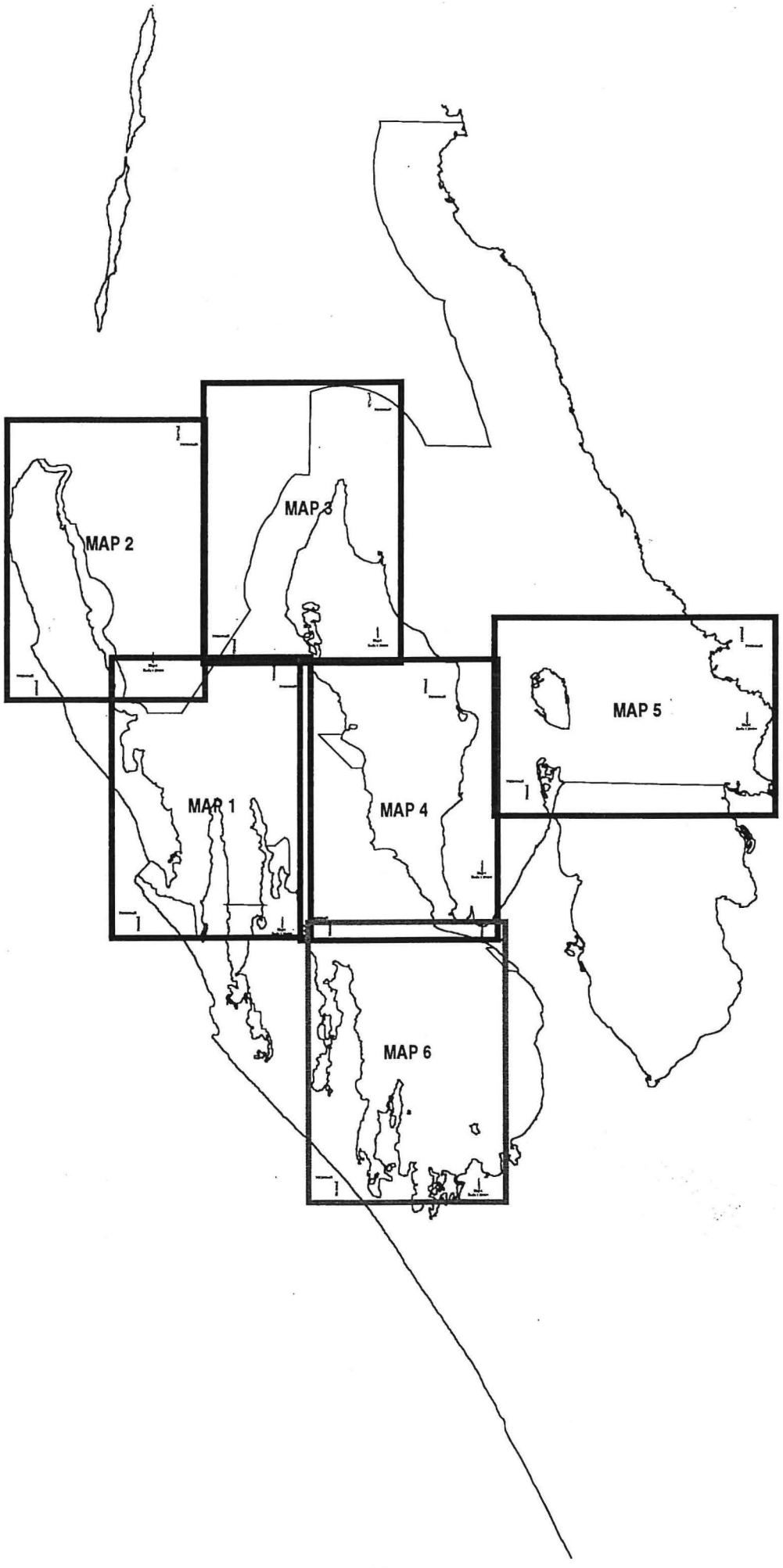
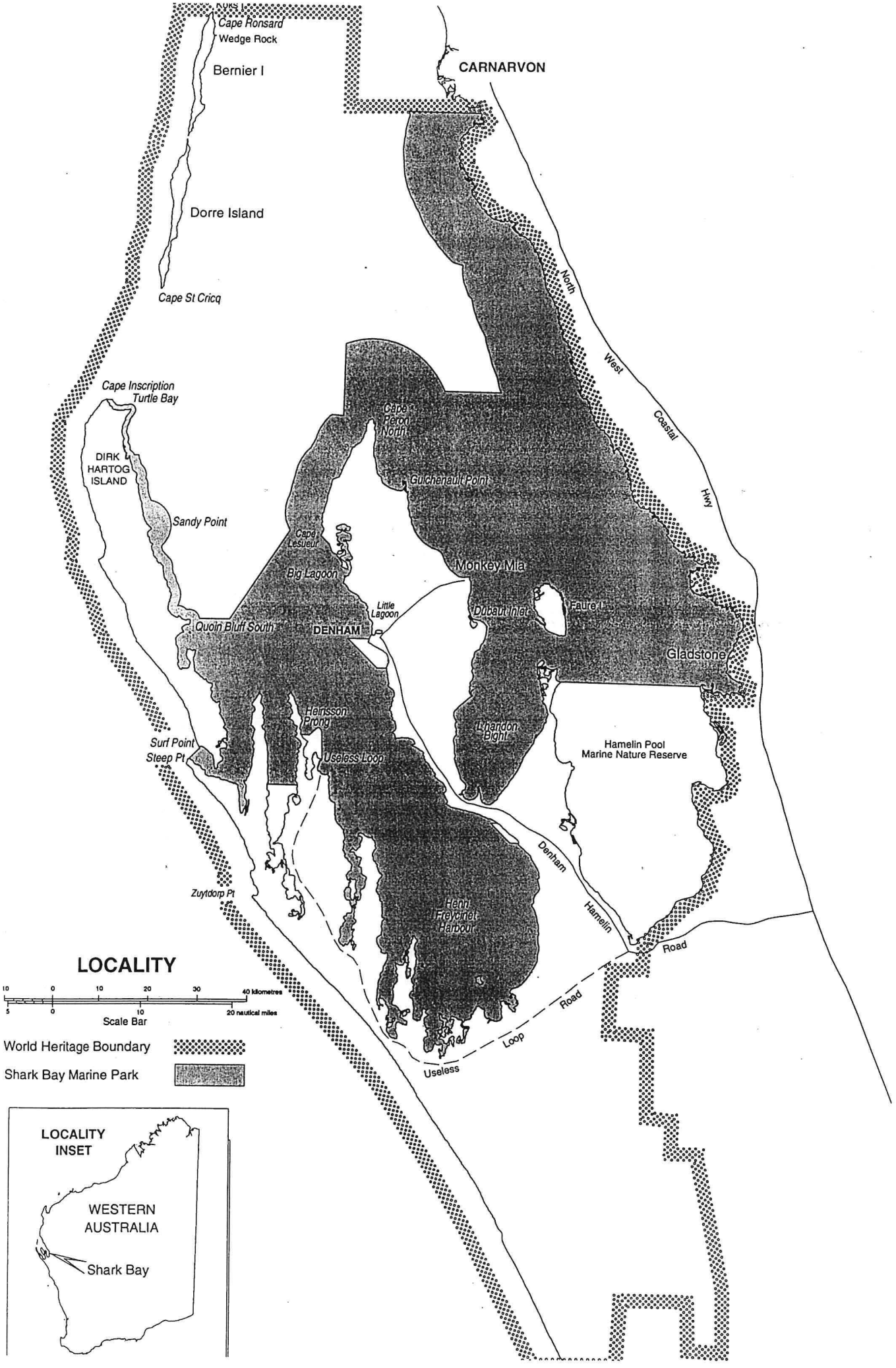
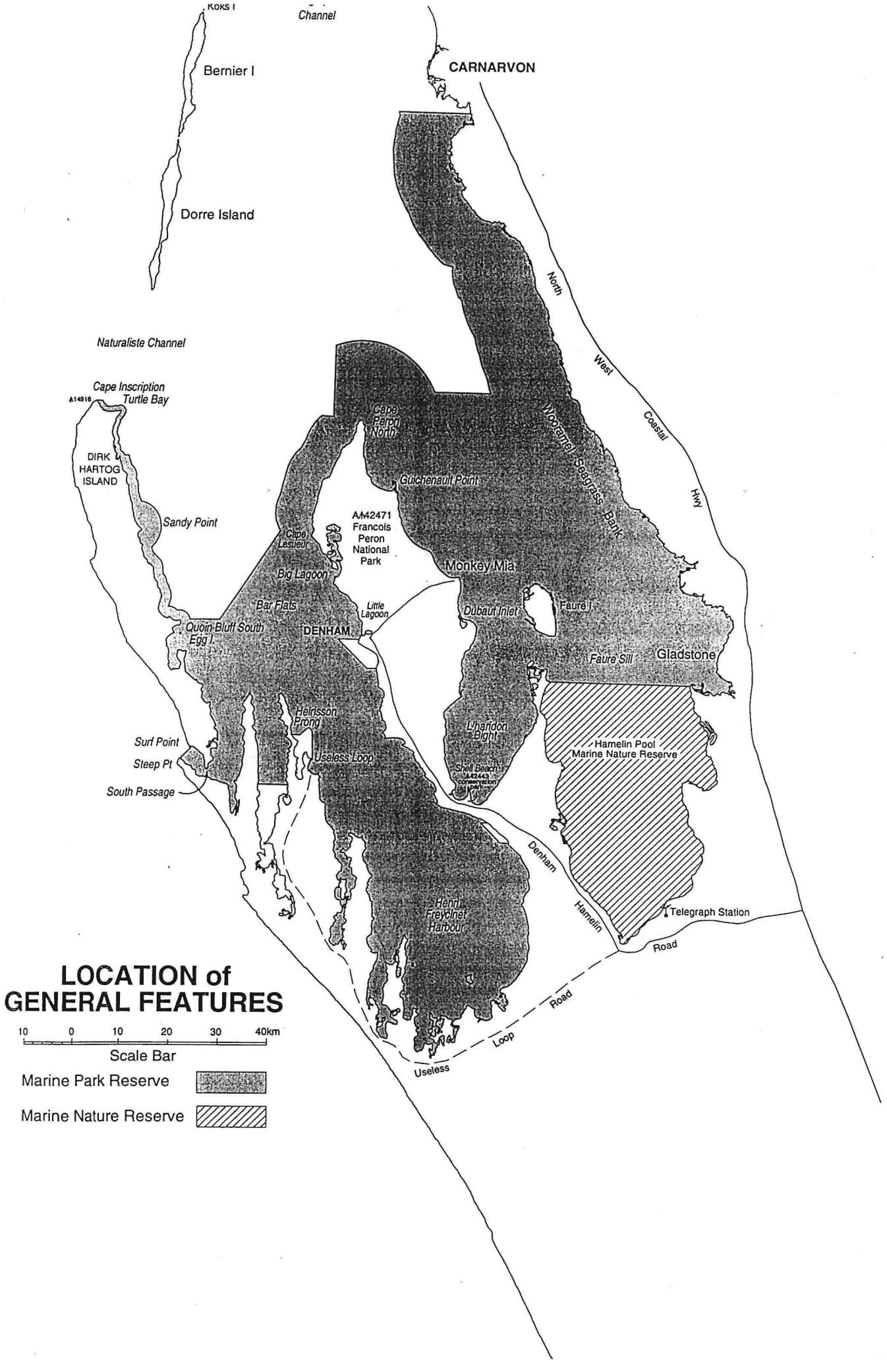


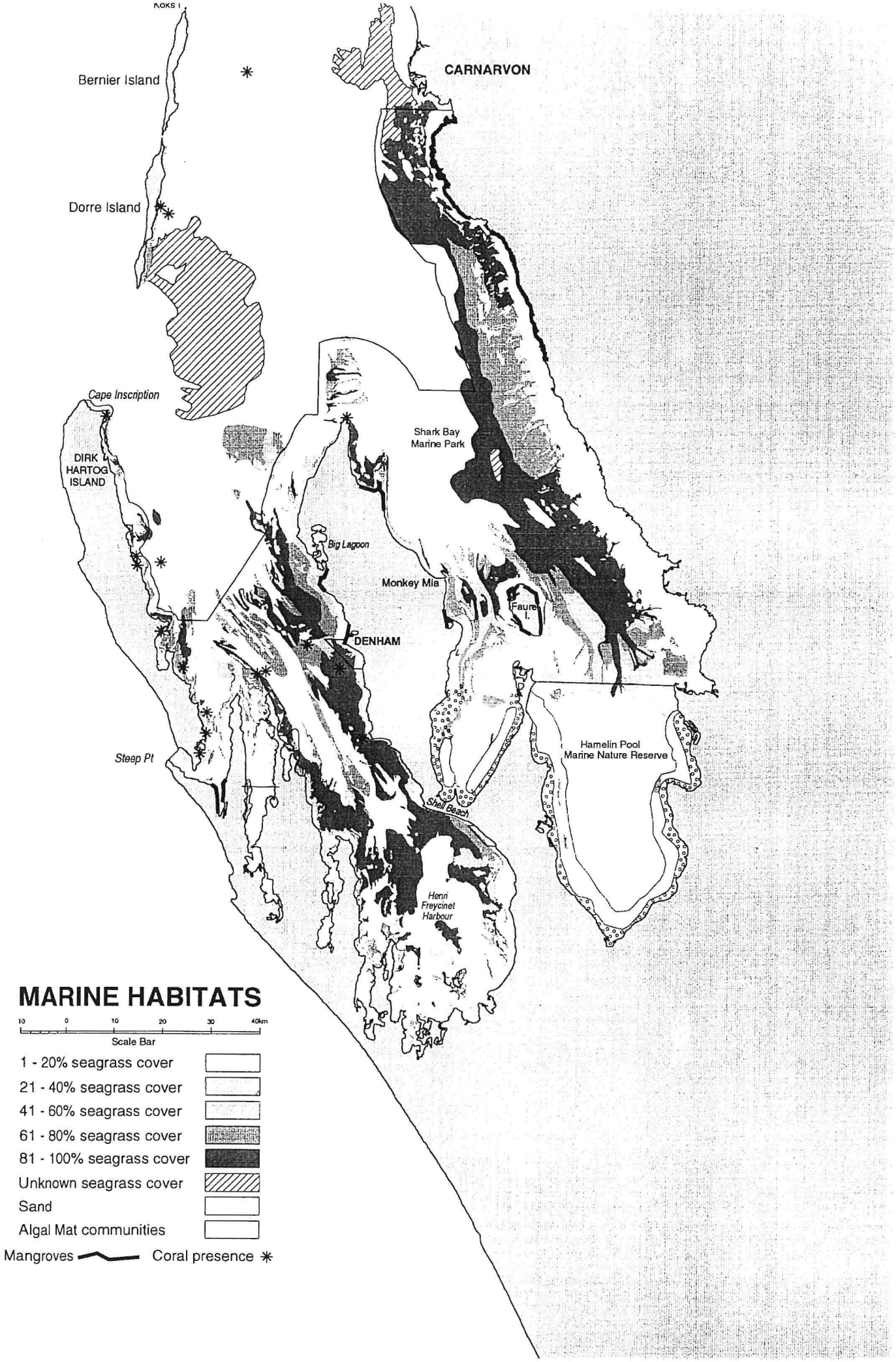
Figure 3

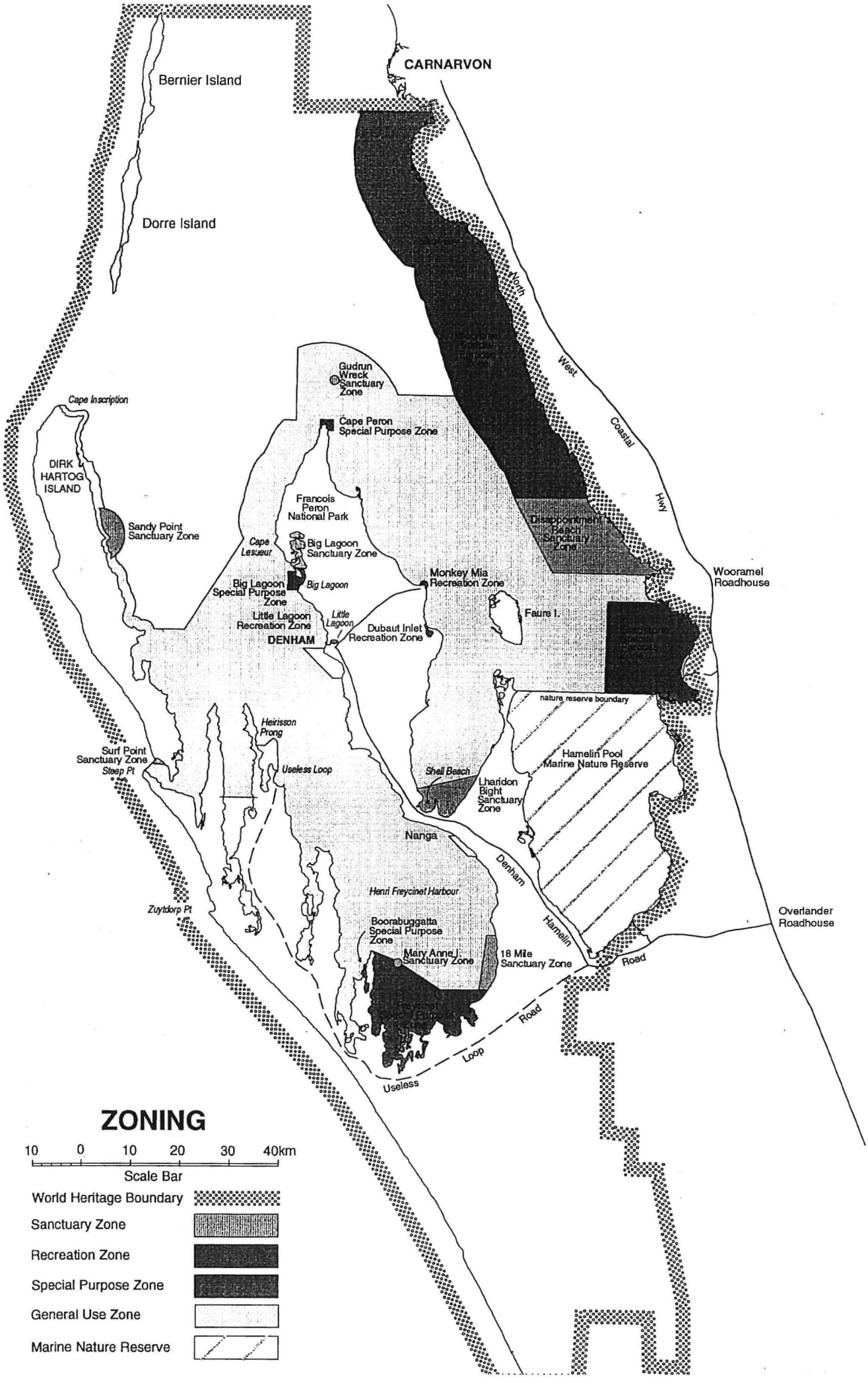
APPENDIX I GIS habitat and usage maps

The following habitat and usage maps were produced by Rod Properjohn (CALM, Land Information Branch) and Eleanor Bruce (University of Western Australia, Department of Geography).


Cape Ronsard
Wedge Rock
Bernier I
CARNARVON
Dorre Island
Cape St Cricq
North West Coastal Hwy
Cape Inscription
Turtle Bay
DIRK HARTOG ISLAND
Cape Peron North
Gulchenault Point
Sandy Point
Cape Lesueur
Big Lagoon
Monkey Mia
Little Lagoon
Dubaut Inlet
Faure I
Quoin Bluff South
DENHAM
Gladstone
Herrisson Prong
L'hardon Bight
Surf Point
Steep Pt
Useless Loop
Hamelin Pool Marine Nature Reserve
Denham Hamelin Road
Zuytdorp Pt
Henri Freycinet Harbour
Useless Loop Road
LOCALITY
10 0 10 20 30 40 kilometres
5 0 10 20 nautical miles
Scale Bar
World Heritage Boundary
Shark Bay Marine Park
LOCALITY INSET
WESTERN AUSTRALIA
Shark Bay


Koks I
Channel
Bernier I
CARNARVON
Dorre Island
North West Coastal Hwy
Naturaliste Channel
Cape Inscription
A14918
Turtle Bay
DIRK HARTOG ISLAND
Sandy Point
Cape Peron North
Guichenault Point
Wooramel Seagrass Bank
AM42471 Francois Peron National Park
Cape Lesueur
Big Lagoon
Bar Flats
Little Lagoon
Monkey Mia
Dubaut Inlet
Faure I
Quoin Bluff South
Egg I
DENHAM
Faure Sill
Gladstone
Herrisson Prong
Surf Point
Steep Pt
Useless Loop
L'haridon Bight
Shell Beach AM42443 conservation label
Hamelin Pool Marine Nature Reserve
South Passage
Denham Hamelin Road
Henri Freycinet Harbour
Telegraph Station
Useless Loop Road
LOCATION of GENERAL FEATURES
10 0 10 20 30 40km
Scale Bar
Marine Park Reserve
Marine Nature Reserve


Bernier Island
Dorre Island
CARNARVON
Cape Inscription
DIRK HARTOG ISLAND
Shark Bay Marine Park
Big Lagoon
Monkey Mia
Faure I.
DENHAM
Steep Pt
Hamelin Pool Marine Nature Reserve
Shell Beach
Henri Freycinet Harbour
MARINE HABITATS
10 0 10 20 30 40km
Scale Bar
1 - 20% seagrass cover
21 - 40% seagrass cover
41 - 60% seagrass cover
61 - 80% seagrass cover
81 - 100% seagrass cover
Unknown seagrass cover
Sand
Algal Mat communities
Mangroves
Coral presence

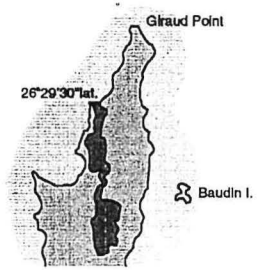

CARNARVON
Bernier Island
Dorre Island
North West Coastal Hwy
Gudrun Wreck Sanctuary Zone
Cape Inscription
Cape Peron Special Purpose Zone
DIRK HARTOG ISLAND
Francois Peron National Park
Sandy Point Sanctuary Zone
Disappointment Bluff Sanctuary Zone
Cape Lesueur
Big Lagoon Sanctuary Zone
Big Lagoon Special Purpose Zone
Big Lagoon
Monkey Mia Recreation Zone
Wooramel Roadhouse
Little Lagoon Recreation Zone
Little Lagoon
DENHAM
Dubaut Inlet Recreation Zone
Faure I.
nature reserve boundary
Heirisson Prong
Surf Point Sanctuary Zone
Steep Pt
Useless Loop
Shell Beach
Hamelin Pool Marine Nature Reserve
Lharidon Bight Sanctuary Zone
Nanga
Denham Hamelin Road
Henri Freycinet Harbour
Zuytdorp Pt
Boorabuggatta Special Purpose Zone
Overlander Roadhouse
Mary Anne I. Sanctuary Zone
18 Mile Sanctuary Zone
Useless Loop Road
ZONING
10 0 10 20 30 40km
Scale Bar
World Heritage Boundary
Sanctuary Zone
Recreation Zone
Special Purpose Zone
General Use Zone
Marine Nature Reserve

RECREATION and SPECIAL PURPOSE ZONES

Recreation
Special Purpose
Sanctuary
General Use

Monkey Mia Recreation Zone

0 6km
0 3nm



Boorabuggatta Special Purpose Zone

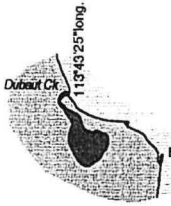
0 10km
0 5nm

Big Lagoon Special Purpose Zone

10 0 10km
5 0 5nm

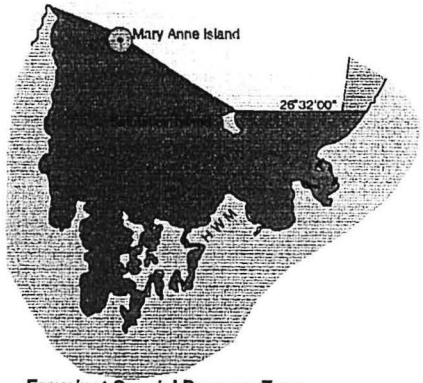
Little Lagoon Recreation Zone

0 10km
0 5nm



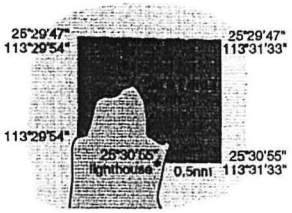
Dubaut Inlet Recreation Zone

0 10km
0 5nm



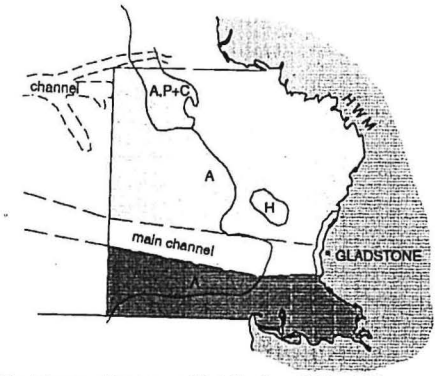
Freycinet Special Purpose Zone

10 0 10km
5 0 5nm



Cape Peron Special Purpose Zone

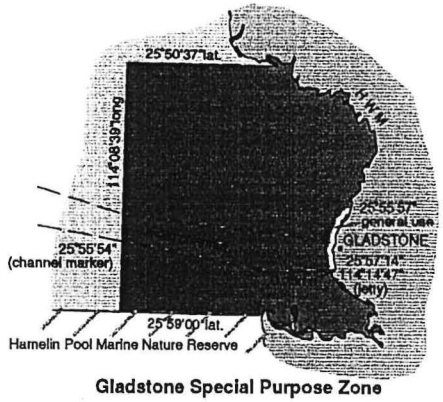
0 6km
0 3nm



Gladstone - Seagrass Distribution & Boat Closures

H = Halodule uninervis seagrass bed
A,P+C = Amphibolis antarctica, Posidonia australis + Cymodocea sp.
A = Amphibolis antarctica

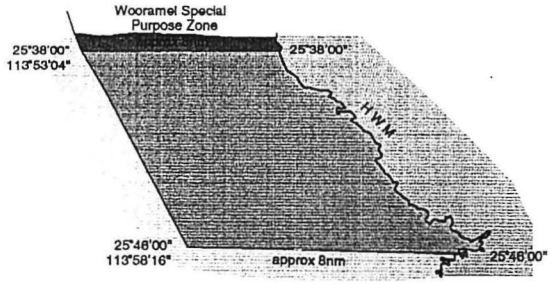
Waters closed to boating 1 Sept - 15 Jan
Waters closed to boating 1 Dec - 31 Mar



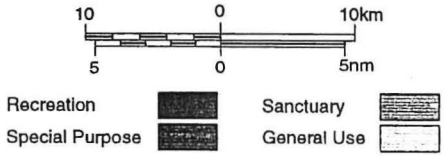
Gladstone Special Purpose Zone

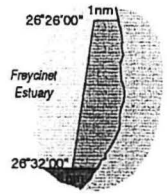
10 0 10km
5 0 5nm

SANCTUARY ZONES



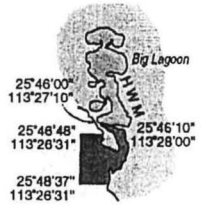
Disappointment Reach Sanctuary Zone



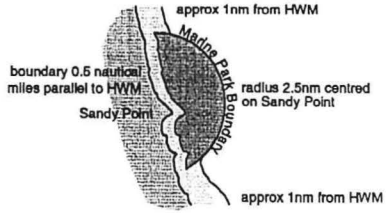


18 Mile Sanctuary Zone

Lharidon Bight Sanctuary Zone



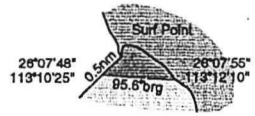
Big Lagoon Sanctuary Zone



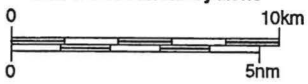
Sandy Point Sanctuary Zone

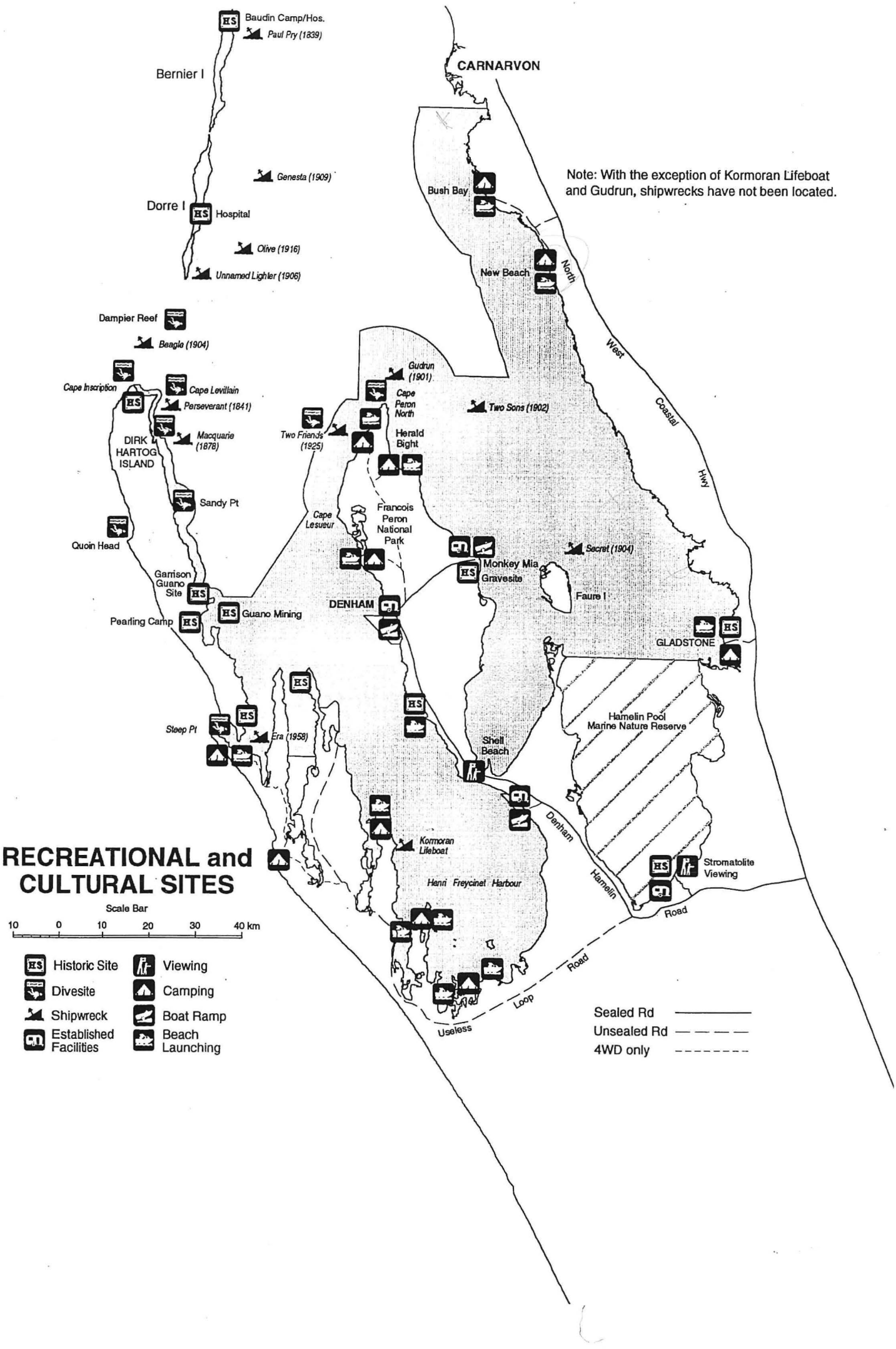
Gudrun Wreck Sanctuary Zone

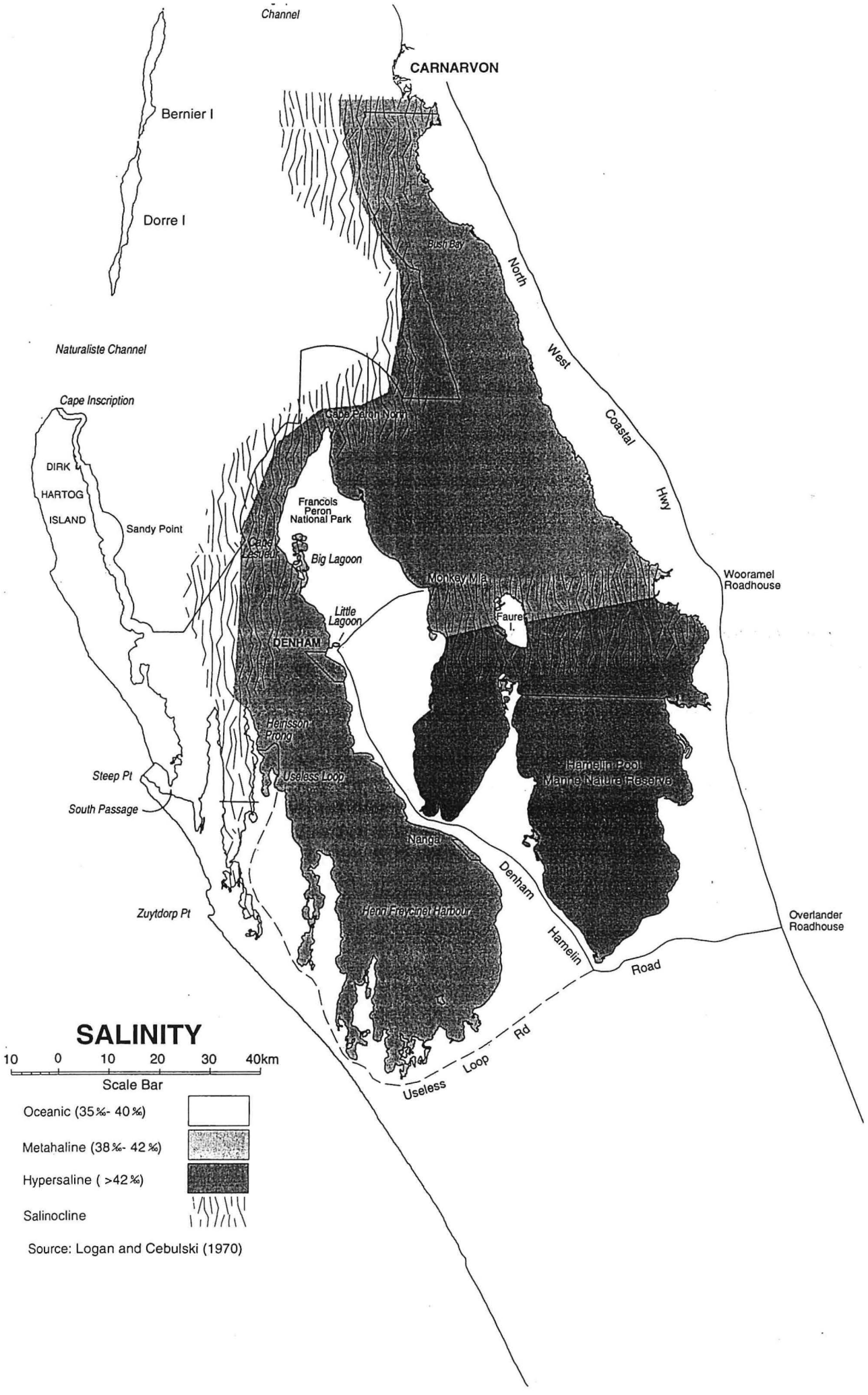
Mary Anne Island Sanctuary Zone



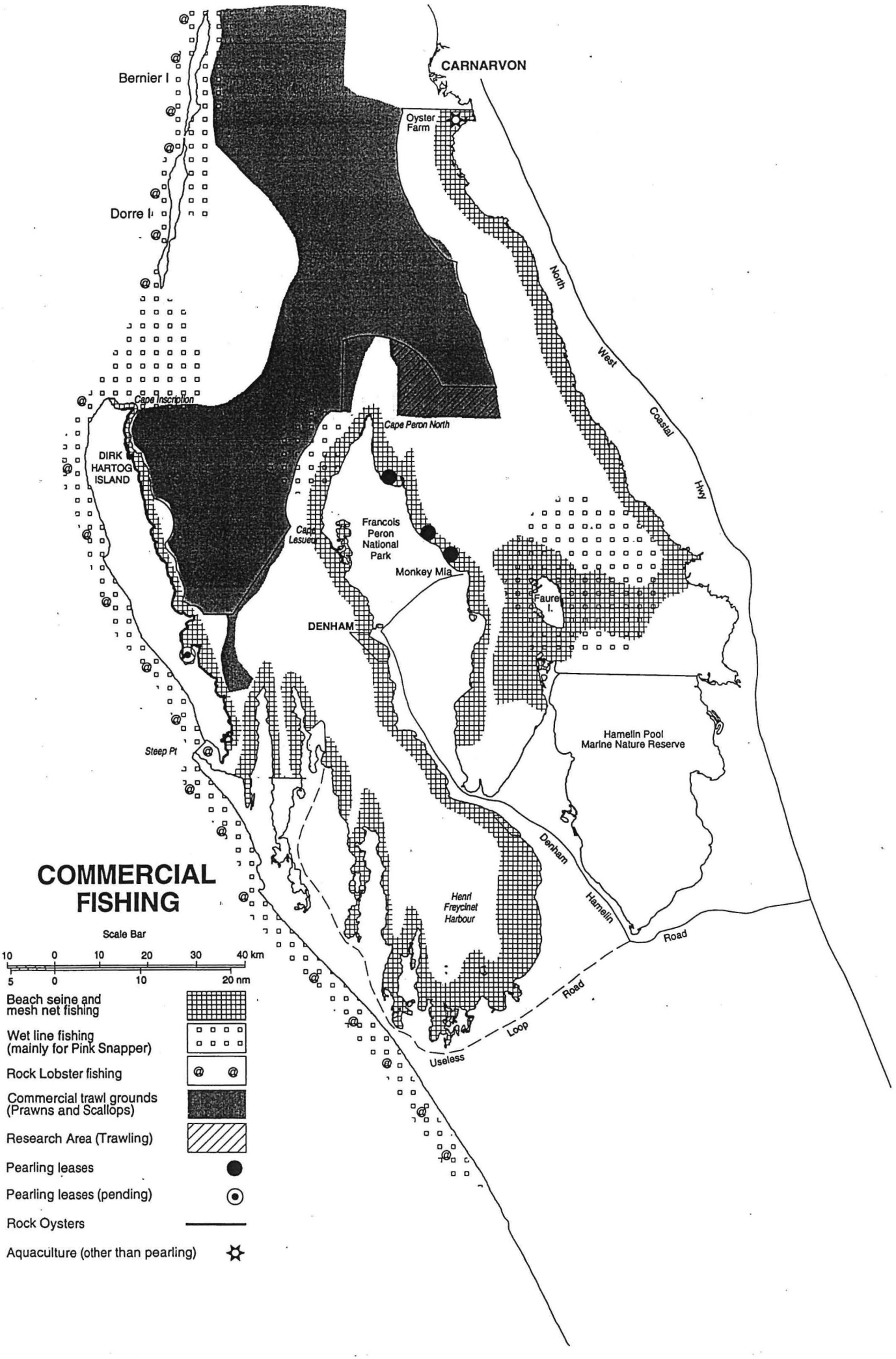
Surf Point Sanctuary Zone

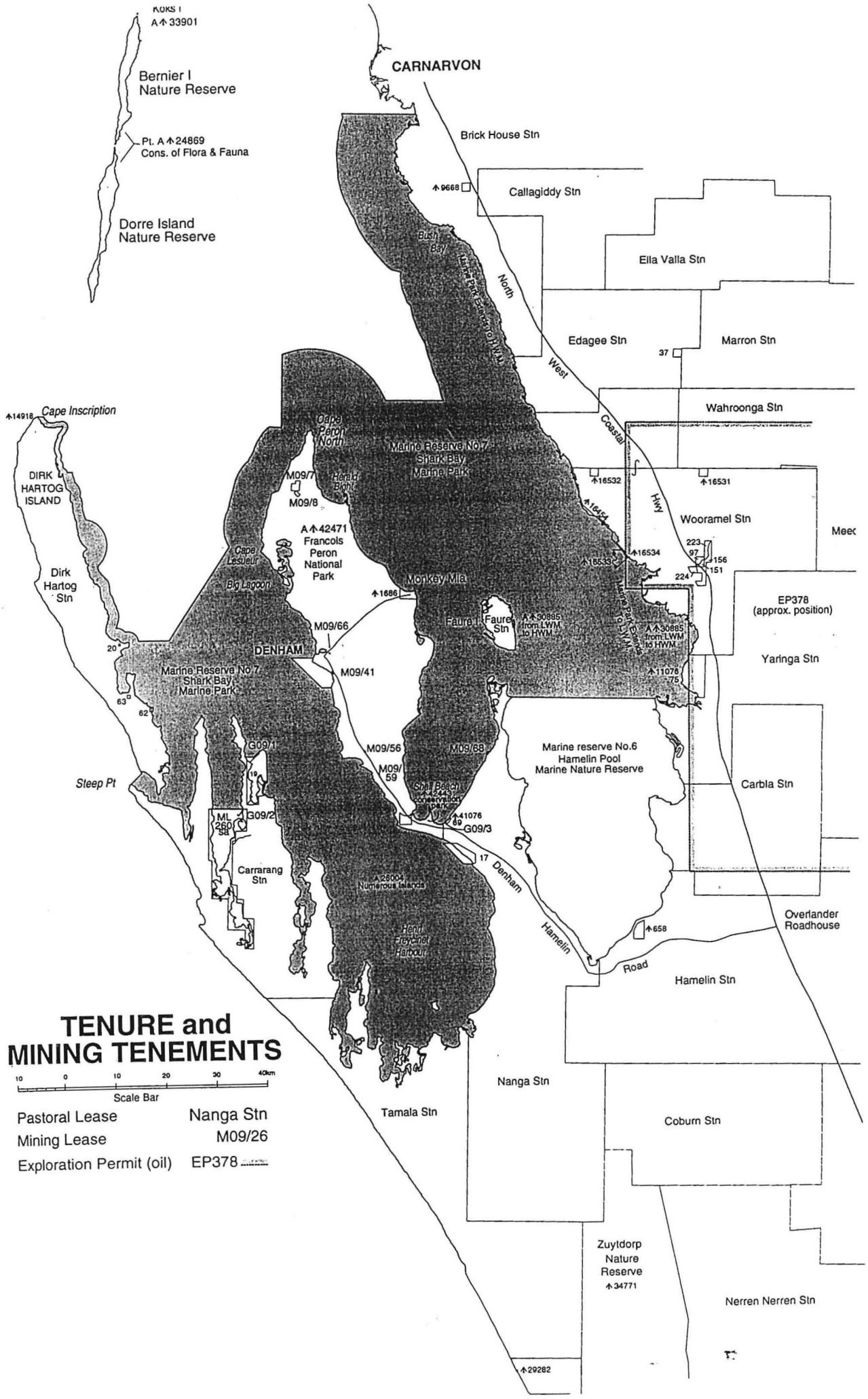


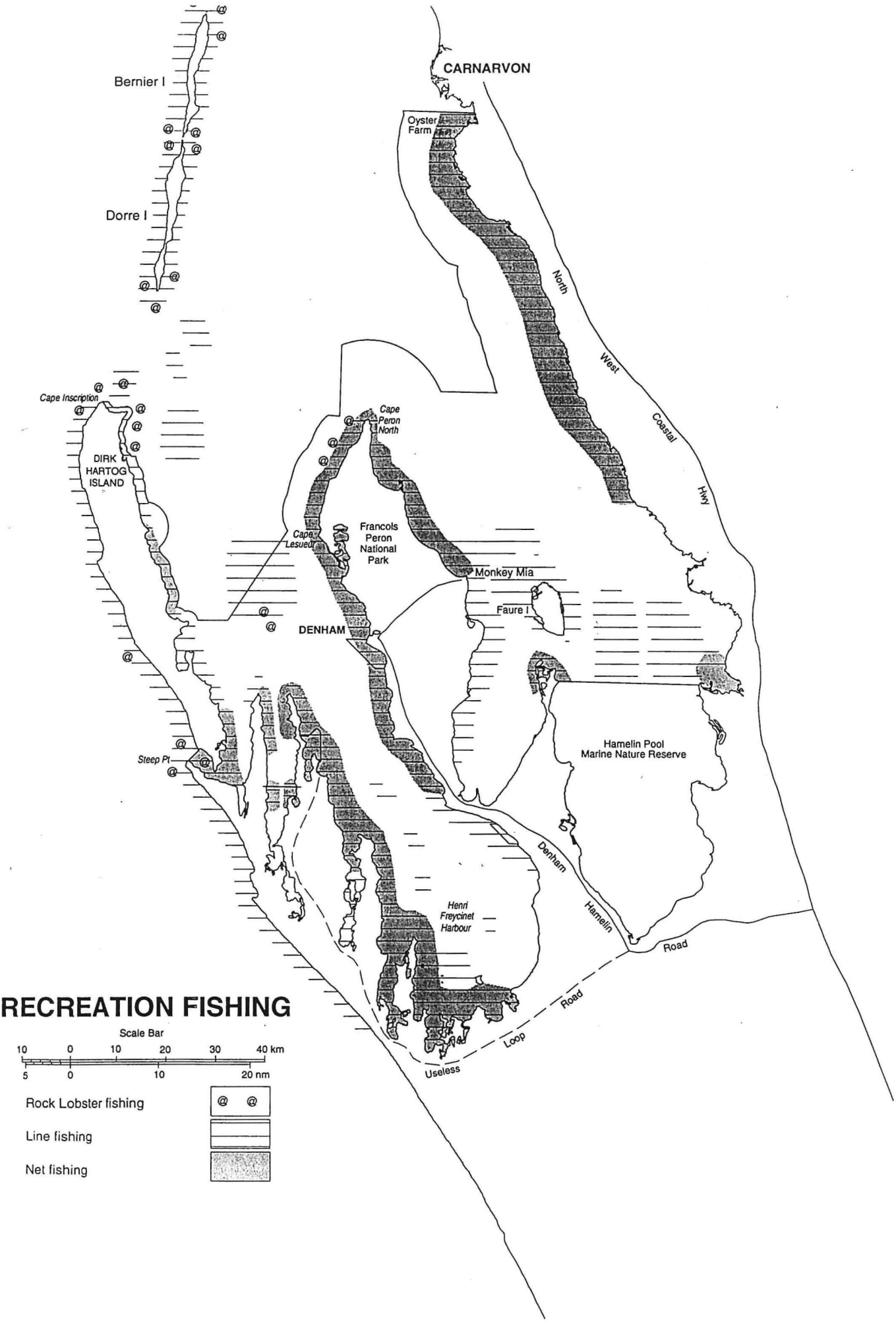

Baudin Camp/Hos.
Paul Pry (1839)
Bernier I
Genesta (1909)
Dorre I
Hospital
Olive (1916)
Unnamed Lighter (1906)
Dampier Reef
Beagle (1904)
Cape Inscription
Cape Levillain
Perseverant (1841)
DIRK HARTOG ISLAND
Macquarie (1878)
Sandy Pt
Quoin Head
Garrison Guano Site
Pearling Camp
Guano Mining
Steep Pt
Era (1958)
CARNARVON
Bush Bay
New Beach
North West Coastal Hwy
Gudrun (1901)
Cape Peron North
Two Sons (1902)
Two Friends (1925)
Herald Bight
Cape Lesueur
Francois Peron National Park
Monkey Mia Gravesite
Secret (1904)
Faure I
DENHAM
GLADSTONE
Hamelin Pool Marine Nature Reserve
Shell Beach
Kormoran Lifeboat
Henri Freycinet Harbour
Denham Hamelin Road
Stromatolite Viewing
Useless Loop Road
Note: With the exception of Kormoran Lifeboat and Gudrun, shipwrecks have not been located.
RECREATIONAL and CULTURAL SITES
Scale Bar
10 0 10 20 30 40 km
Historic Site
Divesite
Shipwreck
Established Facilities
Viewing
Camping
Boat Ramp
Beach Launching
Sealed Rd
Unsealed Rd
4WD only

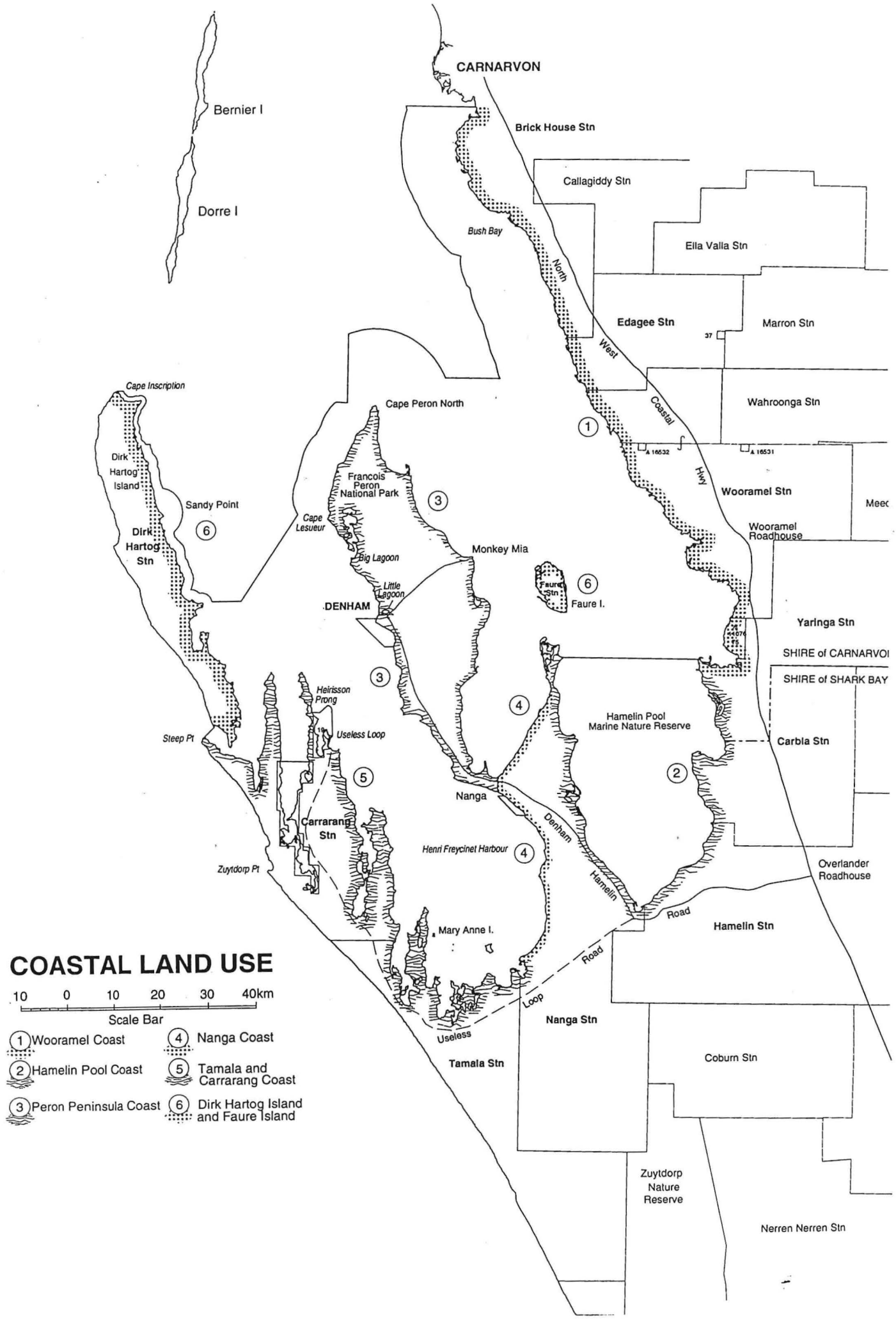


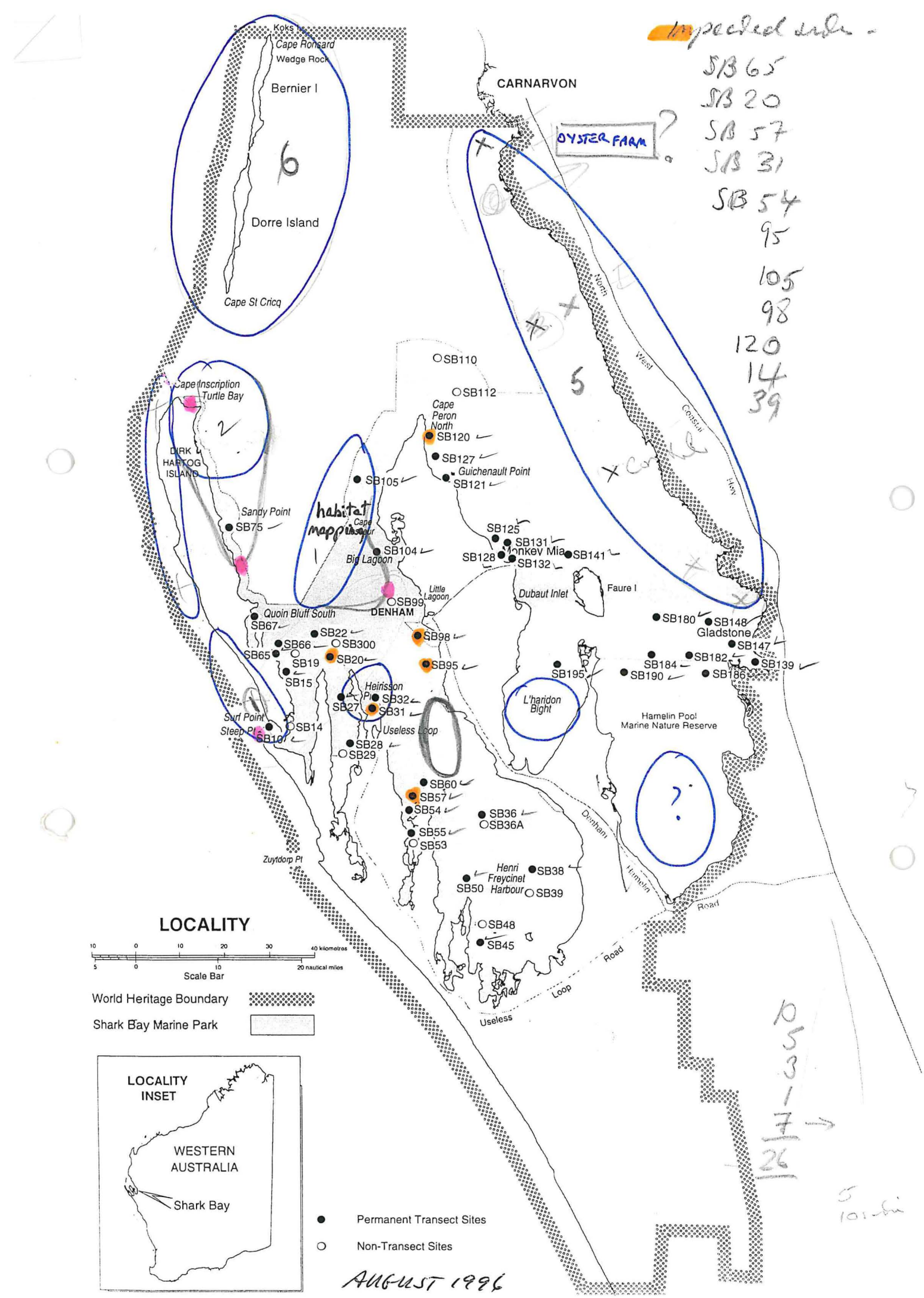
Source: Logan and Cebulski (1970)


CARNARVON
Bernier I
Dorre I
Oyster Farm
North West Coastal Hwy
Cape Inscription
Cape Peron North
DIRK HARTOG ISLAND
Cape Lesueur
Francois Peron National Park
Monkey Mia
Faure I.
DENHAM
Steep Pt
Hamelin Pool Marine Nature Reserve
Denham Hamelin Road
Henri Freycinet Harbour
Useless Loop Road
COMMERCIAL FISHING
Scale Bar
10 0 10 20 30 40 km
5 0 10 20 nm
Beach seine and mesh net fishing
Wet line fishing (mainly for Pink Snapper)
Rock Lobster fishing
Commercial trawl grounds (Prawns and Scallops)
Research Area (Trawling)
Pearling leases
Pearling leases (pending)
Rock Oysters
Aquaculture (other than pearling)

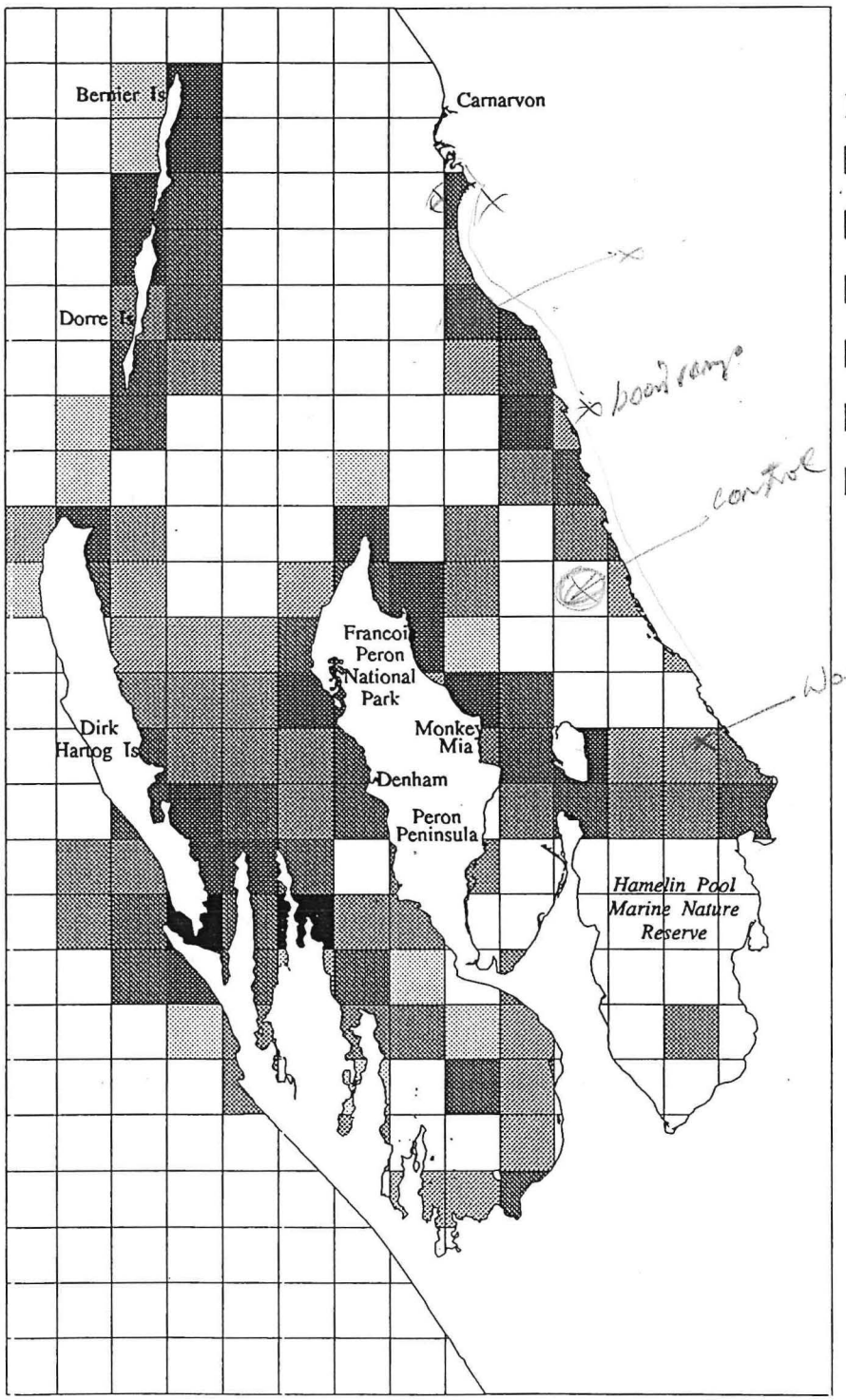

A 33901
Bernier I
Nature Reserve
Pt. A 24869
Cons. of Flora & Fauna
Dorre Island
Nature Reserve
CARNARVON
Brick House Stn
9668
Callagiddy Stn
Bush Bay
Marine Park Extends to HWM
North West Coastal Hwy
Ella Valla Stn
Edagee Stn
Marron Stn
37
Wahroonga Stn
14918
Cape Inscription
DIRK HARTOG ISLAND
Cape Peron North
Marine Reserve No 7
Shark Bay
Marine Park
M09/7
Herald Bight
M09/8
16532
16531
16454
Wooramel Stn
A 42471
Francois Peron National Park
Cape Lesueur
Big Lagoon
16534
16535
223
97
156
151
224
Dirk Hartog Stn
Monkey Mia
1686
EP378
(approx. position)
Faure I
Faure Stn
A 30885 from LWM to HWM
Marine Park Extends to LWM
M09/66
DENHAM
20
Yaringa Stn
Marine Reserve No 7
Shark Bay
Marine Park
M09/41
11076
75
63
62
G09/1
M09/56
M09/68
Marine reserve No.6
Hamelin Pool
Marine Nature Reserve
M09/59
Steep Pt
19
Shell Beach Conservation Park
11076
69
G09/3
ML 260 SA
G09/2
Carbla Stn
17
Denham
Carrarang Stn
A 26004 Numerous Islands
Henri Freycinet Harbour
Hamelin
658
Overlander Roadhouse
Road
Hamelin Stn
Nanga Stn
Tamala Stn
Coburn Stn
Zuytdorp Nature Reserve
34771
Nerren Nerren Stn
29282
TENURE and
MINING TENEMENTS
10 0 10 20 30 40km
Scale Bar
Pastoral Lease Nanga Stn
Mining Lease M09/26
Exploration Permit (oil) EP378


Bernier I
Dorre I
CARNARVON
Oyster Farm
North West Coastal Hwy
Cape Inscription
DIRK HARTOG ISLAND
Cape Peron North
Cape Lesueur
Francois Peron National Park
Monkey Mia
Faure I
DENHAM
Steep Pt
Hamelin Pool Marine Nature Reserve
Denham Hamelin Road
Henri Freycinet Harbour
Useless Loop Road
RECREATION FISHING
Scale Bar
10 0 10 20 30 40 km
5 0 10 20 nm
Rock Lobster fishing
Line fishing
Net fishing


CARNARVON
Bernier I
Dorre I
Brick House Stn
Callagiddy Stn
Bush Bay
Ella Valla Stn
North West Coastal Hwy
Edagee Stn
Marron Stn
Wahroonga Stn
Wooramel Stn
Wooramel Roadhouse
Cape Inscription
Cape Peron North
Dirk Hartog Island
Francois Peron National Park
Sandy Point
Dirk Hartog Stn
Cape Lesueur
Big Lagoon
Little Lagoon
Monkey Mia
DENHAM
Faure Stn
Faure I.
Yarlinga Stn
SHIRE of CARNARVON
SHIRE of SHARK BAY
Heirisson Prong
Useless Loop
Steep Pt
Hamelin Pool Marine Nature Reserve
Carbla Stn
Nanga
Carrarang Stn
Denham Hamelin Road
Henri Freycinet Harbour
Zuytdorp Pt
Overlander Roadhouse
Mary Anne I.
Hamelin Stn
Useless Loop Road
Nanga Stn
Coburn Stn
Tamala Stn
Zuytdorp Nature Reserve
Nerren Nerren Stn
COASTAL LAND USE
10 0 10 20 30 40km
Scale Bar
1 Wooramel Coast
2 Hamelin Pool Coast
3 Peron Peninsula Coast
4 Nanga Coast
5 Tamala and Carrarang Coast
6 Dirk Hartog Island and Faure Island


Koks Is
Cape Ronsard
Wedge Rock
Bernier I
6
Dorre Island
Cape St Cricq
CARNARVON
OYSTER FARM
5
North West Coastal Hwy
SB110
SB112
Cape Peron North
SB120
SB127
Guichenault Point
SB121
SB105
Cape Inscription
Turtle Bay
2
DIRK HARTOG ISLAND
Sandy Point
SB75
habitat mapping
Cape Laveur
SB104
Big Lagoon
1
SB125
SB131
Monkey Mia
SB128
SB132
SB141
Little Lagoon
SB99
DENHAM
Dubaut Inlet
Faure I
Quoin Bluff South
SB67
SB22
SB66
SB300
SB65
SB19
SB20
SB15
SB98
SB95
SB180
SB148
Gladstone
SB147
SB184
SB182
SB139
SB190
SB186
SB195
Heirisson Pt
SB32
SB27
SB31
L'haridon Bight
Hamelin Pool Marine Nature Reserve
Surf Point
Steep Pt
SB14
SB10
Useless Loop
SB28
SB29
SB60
SB57
SB54
SB36
SB36A
SB55
SB53
Denham
Hamelin
Road
Zuytdorp Pt
Henri Freycinet Harbour
SB50
SB38
SB39
SB48
SB45
Loop
Road
Useless
LOCALITY
10 0 10 20 30 40 kilometres
5 0 10 20 nautical miles
Scale Bar
World Heritage Boundary
Shark Bay Marine Park
LOCALITY INSET
WESTERN AUSTRALIA
Shark Bay
Permanent Transect Sites
Non-Transect Sites
AUGUST 1996

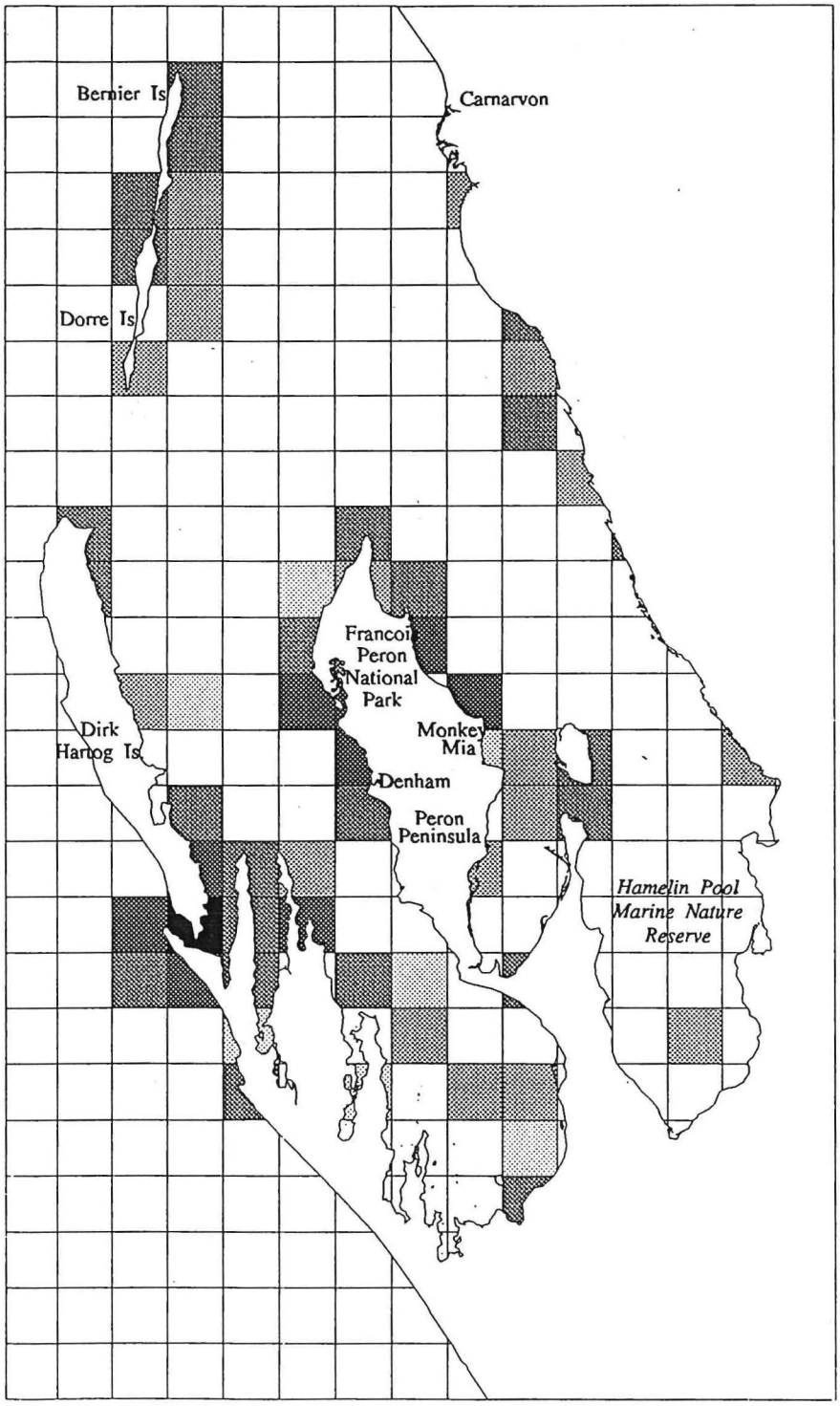
Total Activities* in the Shark Bay World Heritage Area



Data Source: CALM Shark Bay Visitor Survey, 1993

* Includes line fishing, spearfishing, diving and sightseeing.

Sightseeing in the Shark Bay World Heritage Area



Number of Visits

- 1
- 1 - 5
- 5 - 15
- 15 - 40
- 40 - 91

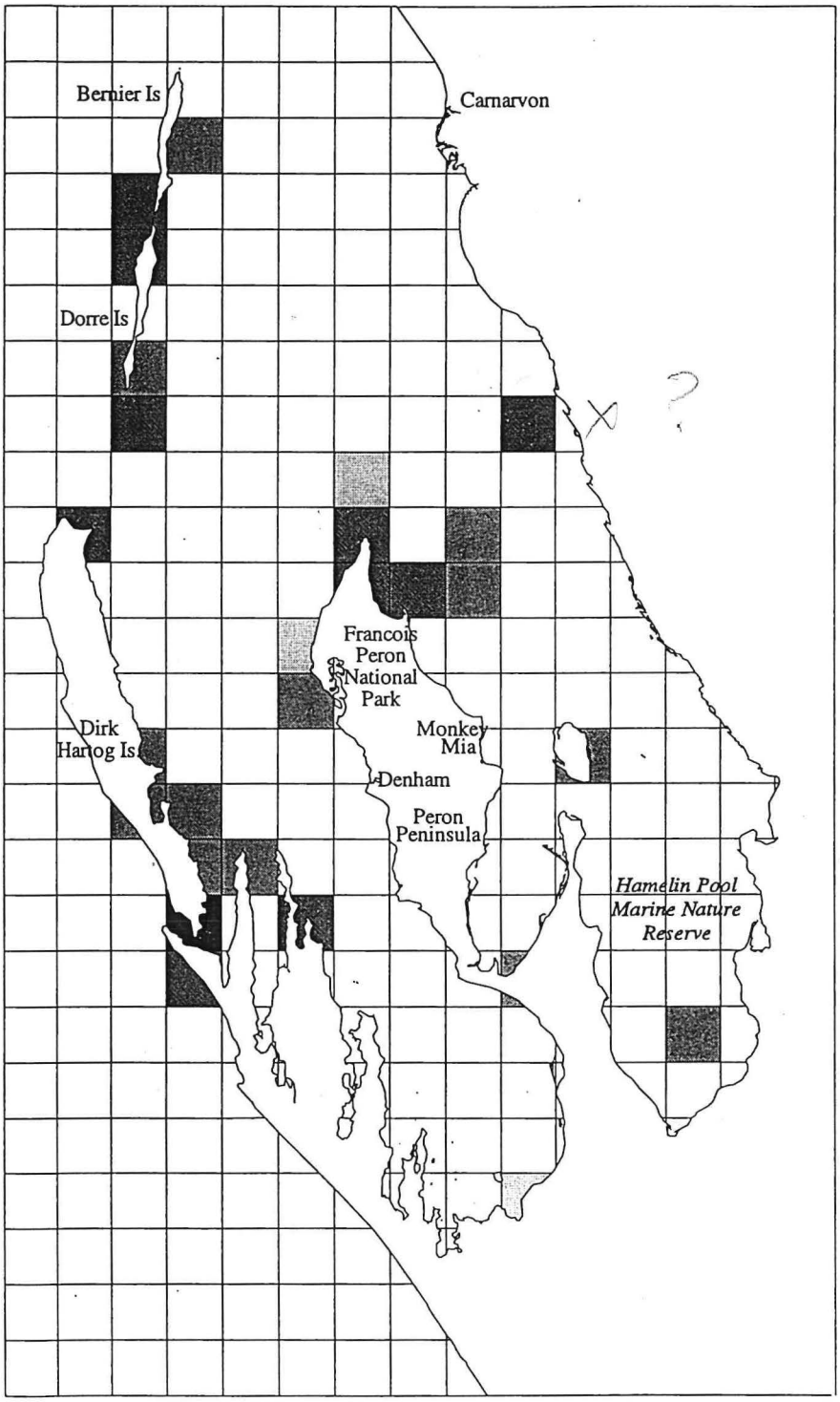
Scale

0 10 20 30 Km

1: 1300000

Data Source: CALM Shark Bay Visitor Survey, 1993

Diving in the Shark Bay World Heritage Area



Number of Visits

- 1
- 1 –5
- 5 –15
- 15 –40
- 40 –91

N

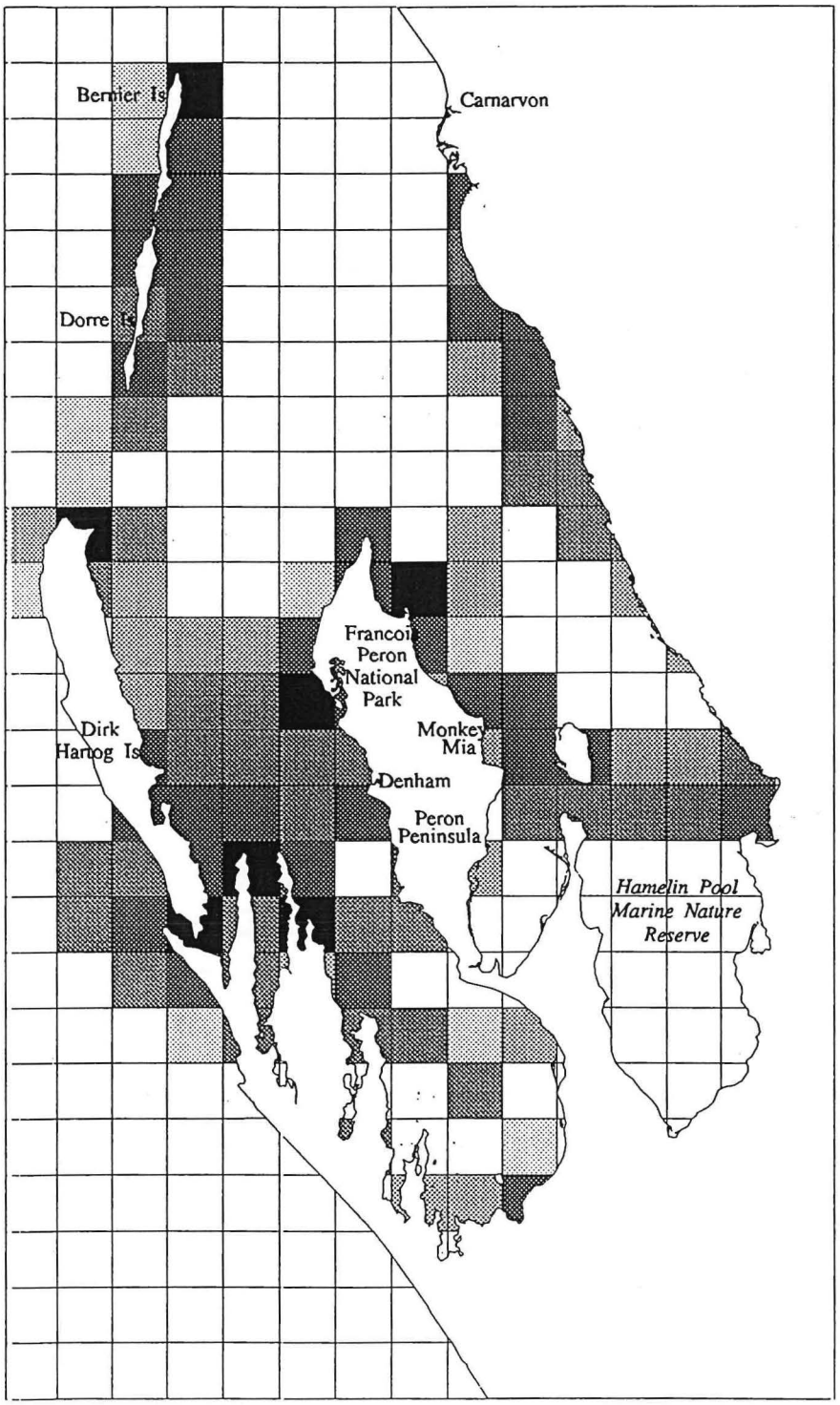
Scale

0 10 20 30 Km

1: 1300000

Data Source: CALM Shark Bay Visitor Survey, 1993

Line Fishing in the Shark Bay World Heritage Area



Number of Visits

- 1
- 1 - 5
- 5 - 15
- 15 - 40
- 40 - 91

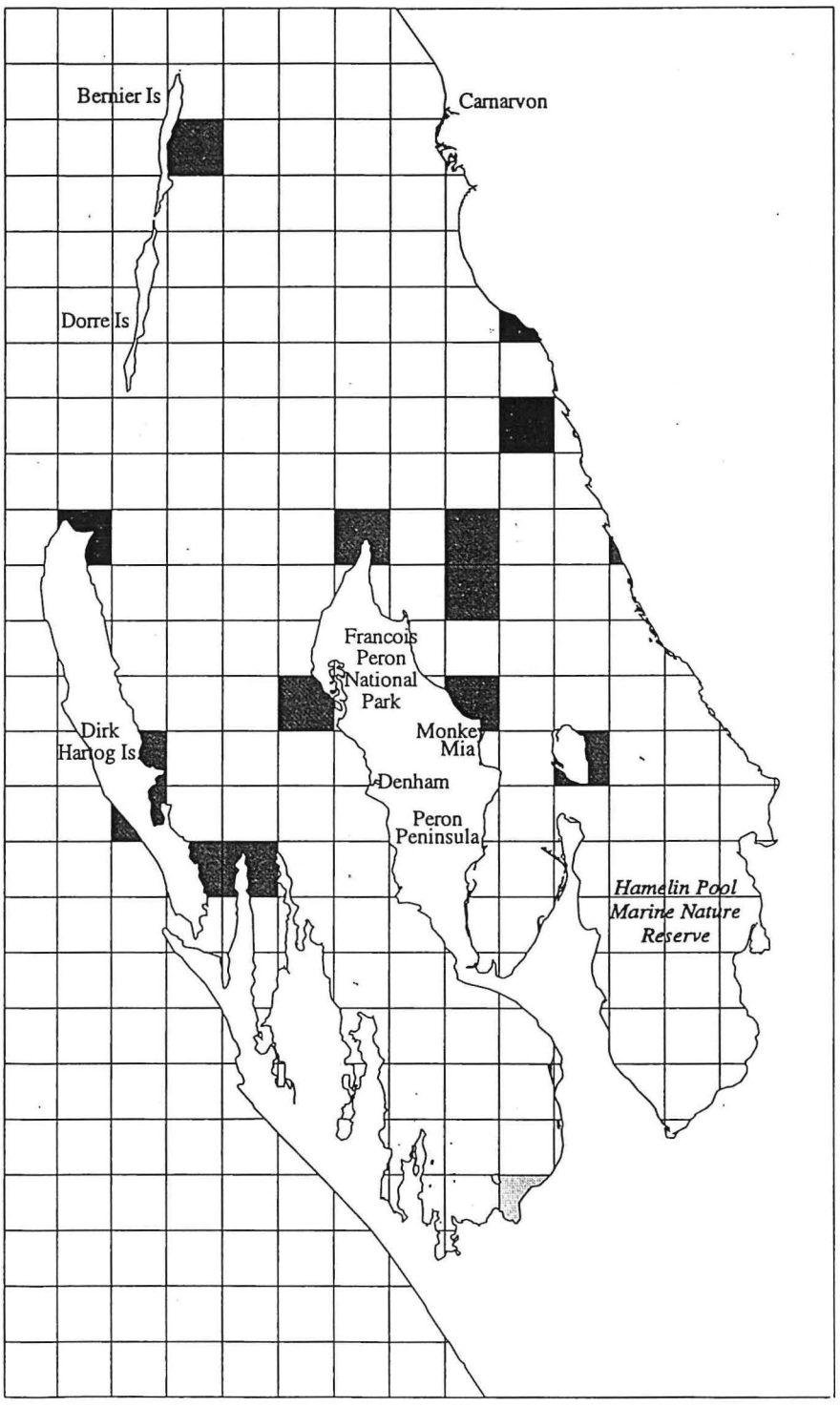
Scale

0 10 20 30 Km

1: 1300000

Data Source: CALM Shark Bay Visitor Survey, 1993

Spearfishing in the Shark Bay World Heritage Area



Number of Visits

- 1
- 1 –5
- 5 –15

N

Scale

0 10 20 30 Km

1: 1300000

Data Source: CALM Shark Bay Visitor Survey, 1993