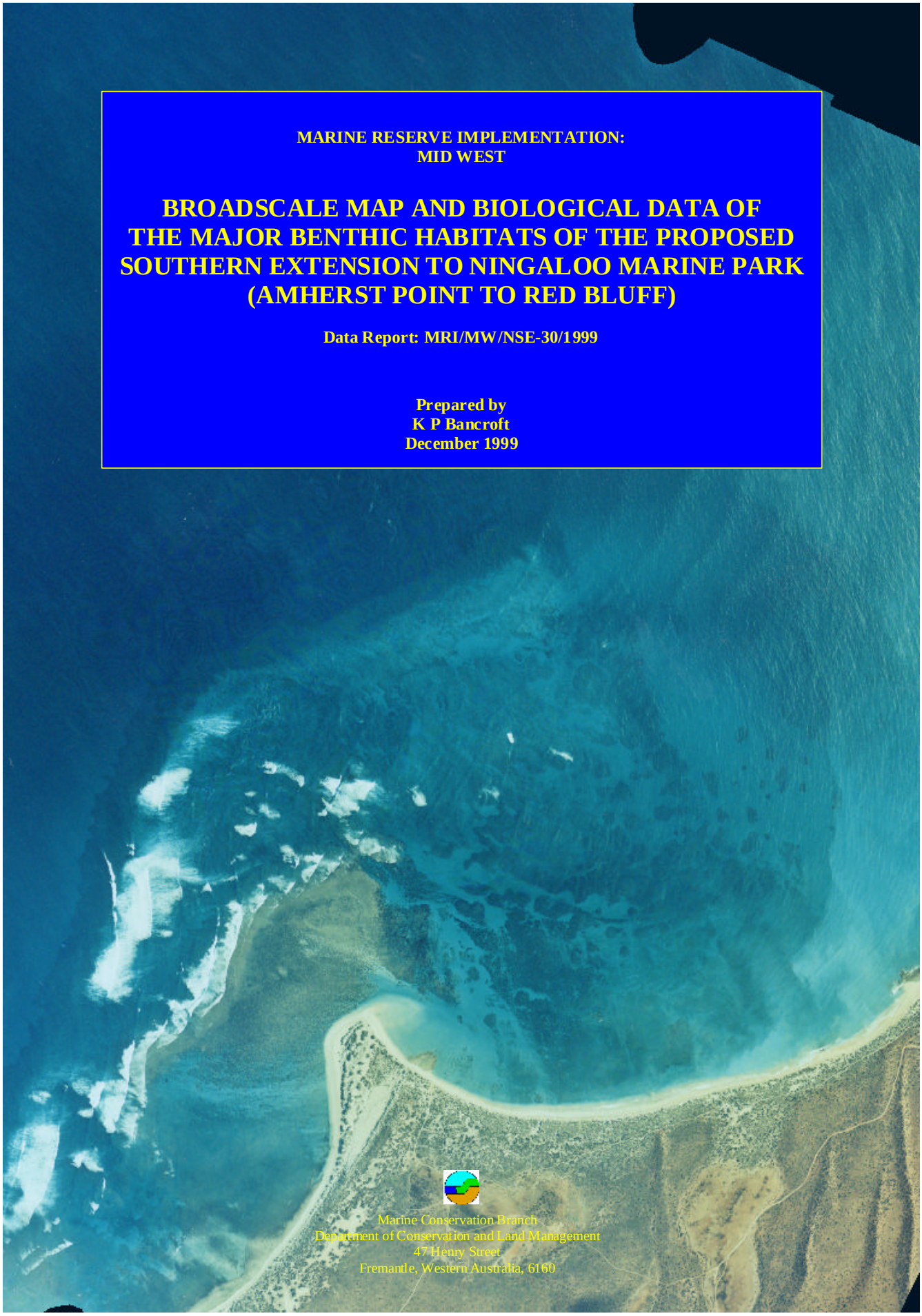
MARINE RESERVE IMPLEMENTATION:
MID WEST

BROADSCALE MAP AND BIOLOGICAL DATA OF THE MAJOR BENTHIC HABITATS OF THE PROPOSED SOUTHERN EXTENSION TO NINGALOO MARINE PARK (AMHERST POINT TO RED BLUFF)

Data Report: MRI/MW/NSE-30/1999

Prepared by
K P Bancroft
December 1999



Marine Conservation Branch
Department of Conservation and Land Management
47 Henry Street
Fremantle, Western Australia, 6160

MARINE RESERVE IMPLEMENTATION:
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BROADSCALE HABITAT MAP AND BIOLOGICAL DATA OF THE MAJOR BENTHIC HABITATS OF THE PROPOSED SOUTHERN EXTENSION TO NINGALOO MARINE PARK (AMHERST POINT TO RED BLUFF)

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A collaborative project between
CALM's Marine Conservation Branch and Midwest Regional Office

A project partially funded through
the Natural Heritage Trust's Coast and Clean Seas Marine Protected Areas Programme
Grant No G024/97

Prepared by
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Direction

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CALM Collaboration

- Kelly Gillen – Regional Manager, Midwest Region
- Kevin Bancroft - Marine Conservation Officer, MCB
- Ray Lawrie - Marine Information Officer, MCB
- Mike Lapwood - Marine Operations Officer, MCB
- Liesl Jonker - Marine Planning Officer, MCB

Funding and Resources

- Partial funding of $22,000 has been provided by the National Heritage Trust, via the Coast and Clean Seas Marine Protected Areas Programme (Grant No G024/97).

- Support in the form of technical, logistical and human resources, has been provided by the Department of Conservation and Land Management ($44,000).

Cover. Gnaraloo Bay (rectified aerial photograph *courtesy* Department of Environmental Protection)

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Copies of this report may be obtained from:

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SUMMARY

This data report presents the results of the first field survey of the major benthic habitats of the southern section of the Ningaloo Reef, from Amherst Point to Red Bluff. This section of coastline includes the proposed southern extension to Ningaloo Marine Park. The survey was conducted during 18-22 October 1999 and coordinated by CALM's Marine Conservation Branch in collaboration with

Partial funding of $22,000 for the project has been obtained through Environment Australia's Natural Heritage Trust, via the Coast and Clean Seas Marine Protected Areas Program. The MCB will contribute resources to the value of approximately $44,000 to the project.

The primary objectives of this survey were:

(a) to ground-truth the major marine habitats of the area, and;

(b) to document the diversity of coral and fish species at representative sites within selected habitats.

The secondary objectives of the survey were:

(a) to establish the location of prominent terrestrial and marine landmarks in order to spatially rectify Landsat satellite images of the area, which was used as a basis for the habitat map, and;

(b) to opportunistically collect photographic stills and digital video footage, which characterise key flora, fauna, habitat type and human usage, for use in the public participation and marine reserve planning processes.

All primary and secondary objectives were achieved.

The data acquired during this survey and the resulting habitat map will be important in the determination of the relative conservation values of the respective major habitats of the proposed southern extension to Ningaloo Marine Park. It will also contribute to the information base required for the marine reserve planning process, during which marine reserve boundaries and zones for multiple-use will be considered for the area. These data will also be of use for ongoing management purposes.

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In view of the high standing that the southern extension to Ningaloo Marine Park has in the MPRA's priority list for new marine conservation reserves, CALM applied to Environment Australia for funding to develop an accurate habitat map of the area. Partial funding of $22,000 for the project has been obtained through Environment Australia's Natural Heritage Trust, via the Coast and Clean Seas Marine Protected Area Programme. CALM has contributed further resources valued at approximately $44,000, to the project.

The data acquired during this survey will be important in the determination of the relative conservation values of the respective major habitats of the proposed Ningaloo Reef southern extension. It will also contribute to the information base required for the marine reserve planning process, during which marine reserve boundaries and zones for multiple-use will be considered for the area.

CALM's preliminary habitat map for the Ningaloo Reef southern extension was derived by auto classification from Landsat Thematic Mapper satellite imagery (30 m pixel) and 1:20,000 aerial photography. This preliminary habitat map needed to be ground-truthed and spatially rectified to obtain a high level of accuracy for the final habitat map. The data acquired during this survey has provided the information to achieve this objective.

This survey was part of the Biological Inventory portfolio of the Marine Reserve Implementation function of CALM's Marine Conservation Branch (MCB). The survey was coordinated by the MCB and conducted in collaboration with CALM's Midwest Regional Office.

The information gathered during this survey has complemented that from other recent studies which have been performed in the Ningaloo Marine Park (D'Adamo, 1997; Cary & Grubba, 1998; Cary, *et al*., 1998; Cary, *et al*., 1999; Cary & Daly, 1999; D'Adamo, 1999).

1.2. OBJECTIVES

The objectives of this field survey were as follows.

Primary objectives were:

- To ground-truth the major marine habitats of the area, and;
- To document the diversity of coral and fish species at representative sites within selected habitats.

Secondary objectives are:

- To establish the location of prominent terrestrial and marine landmarks in order to spatially rectify Landsat satellite images of the area, which will be used as a basis for the habitat map, and;
- To opportunistically collect photographic stills and digital video footage, which characterise key flora, fauna, habitat type and human usage, for use in the public participation and marine reserve planning processes. These data will also be of use for ongoing management purposes.

2. METHODS

2.1. SURVEY AREA

The area for this survey was from Amherst Point (23º S) to Red Bluff (24º S), and extends seaward to the Limit of State Territorial Waters, described as 3 nm from the Territorial Sea Baseline (Figure 1).

2.2. SITE SELECTION

A preliminary benthic habitat map was created through auto-classification (using ER Mapper software) of Landsat data based on existing habitat ground-truthing information from Ningaloo Marine Park (Figures 2 & 3). Eighty-five sampling sites were pre-selected (Bancroft & Lapwood, 1999) to lie within distinct habitats as identified in the preliminary habitat map and that they can be accurately located on higher resolution aerial photographs (1:20,000). Of the 85 pre-selected sites, only 13 sites were sampled and another 37 sites were sampled opportunistically (Figures 4, 5, 6 & 7). The latitudes and longitudes for the sites sampled can be found in Appendix I.

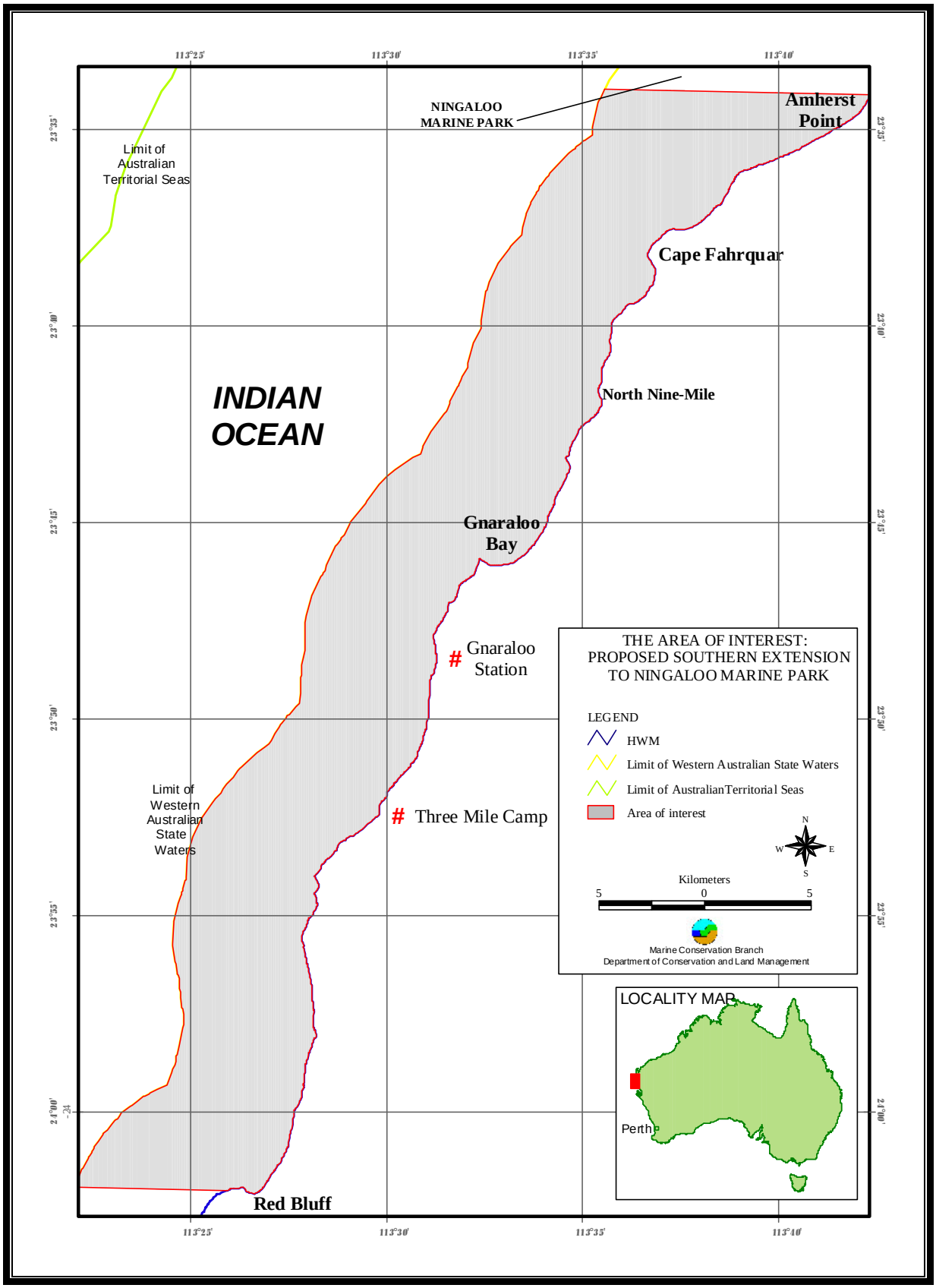

Figure 1. Location map of the proposed southern extension of Ningaloo Marine Park.

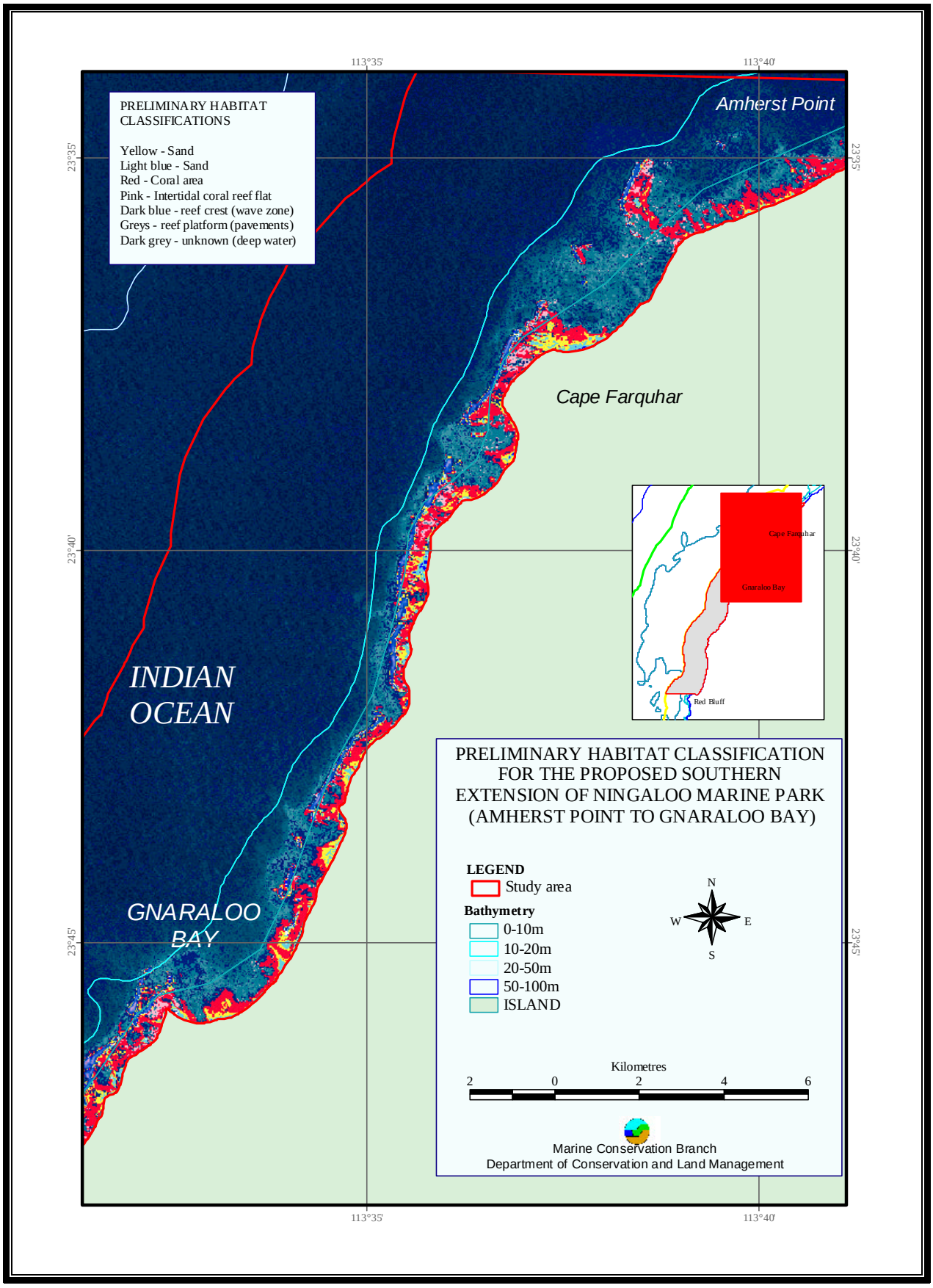

Figure 2. Preliminary habitat map of the proposed southern extension of Ningaloo Marine Park (Amherst Point to Gnaraloo Bay).

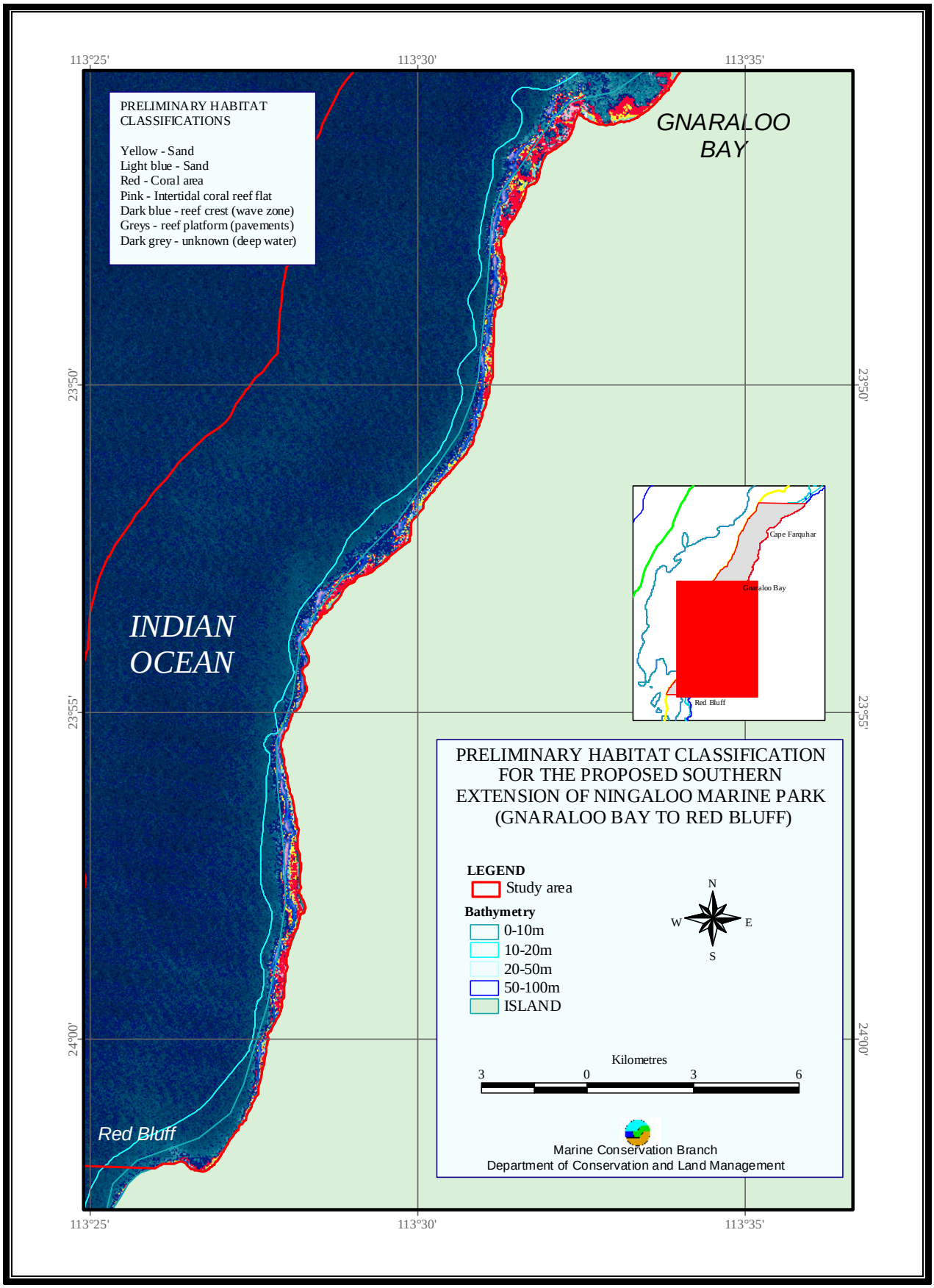

Figure 3. Preliminary habitat map of the proposed southern extension of Ningaloo Marine Park (Gnaraloo Bay to Red Bluff).

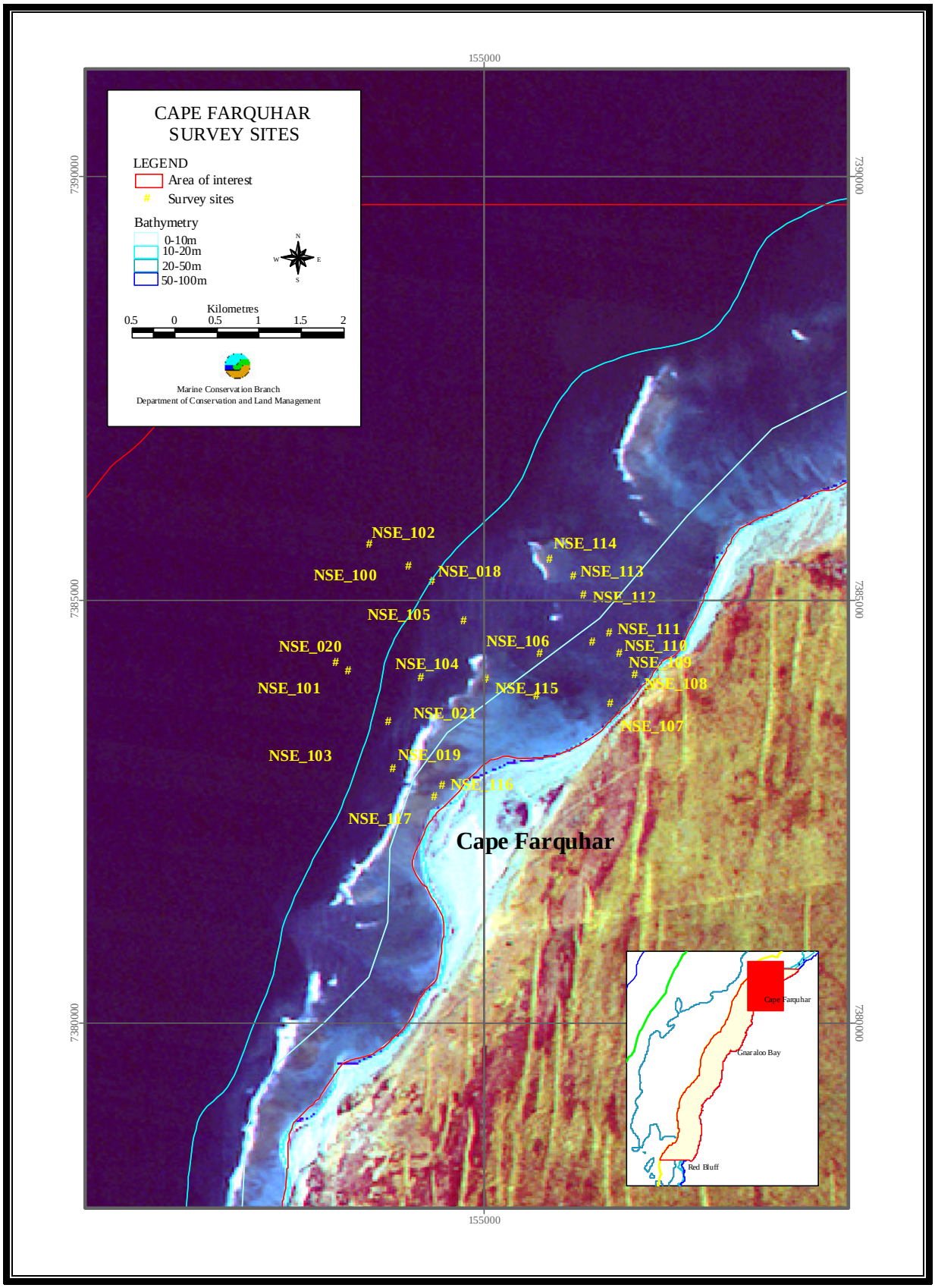

Figure 4. Survey sites at Cape Farquhar in the proposed southern extension of Ningaloo Marine Park

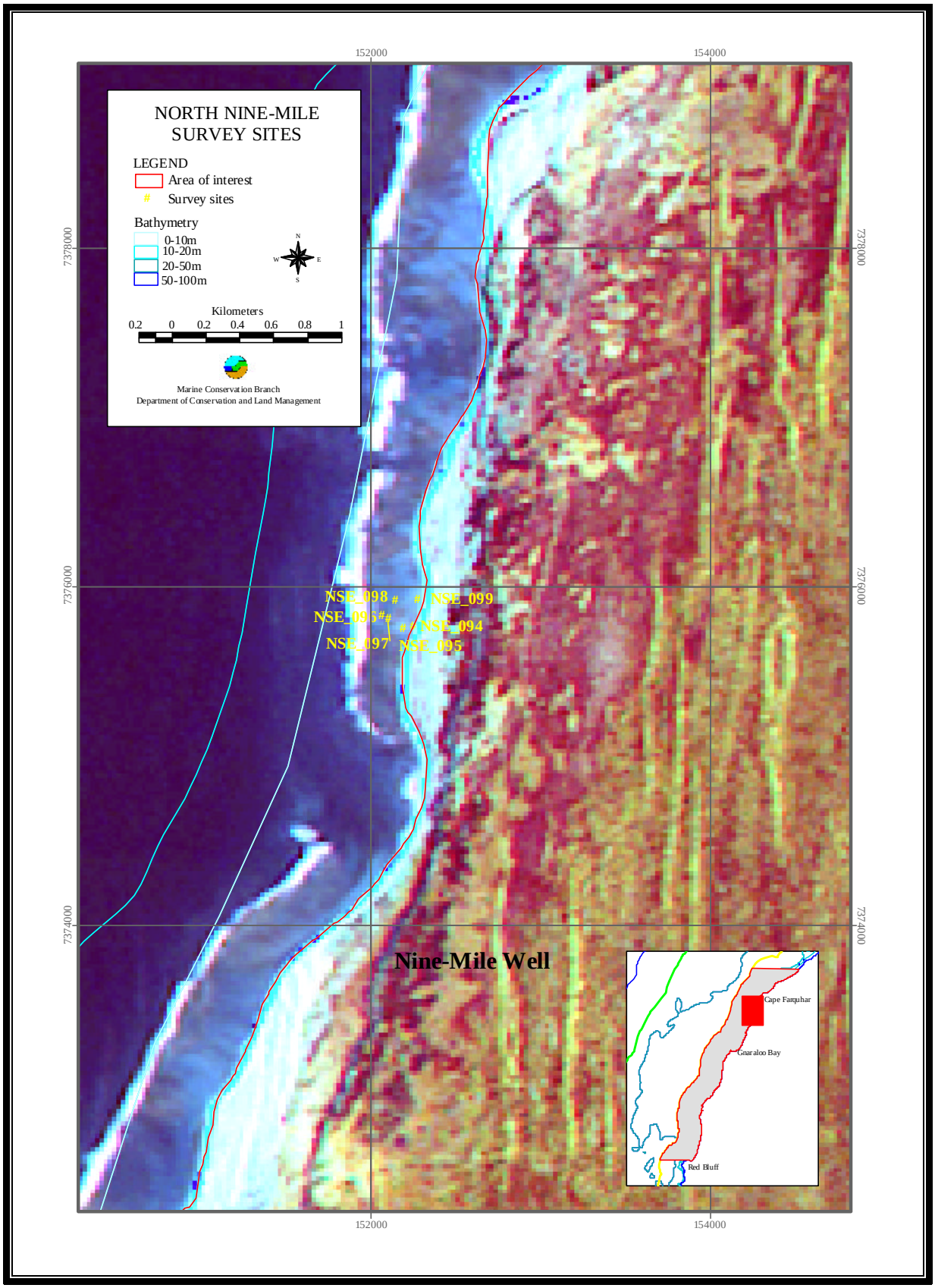

Figure 5. Survey sites north of Nine-Mile Well in the proposed southern extension of Ningaloo Marine Park

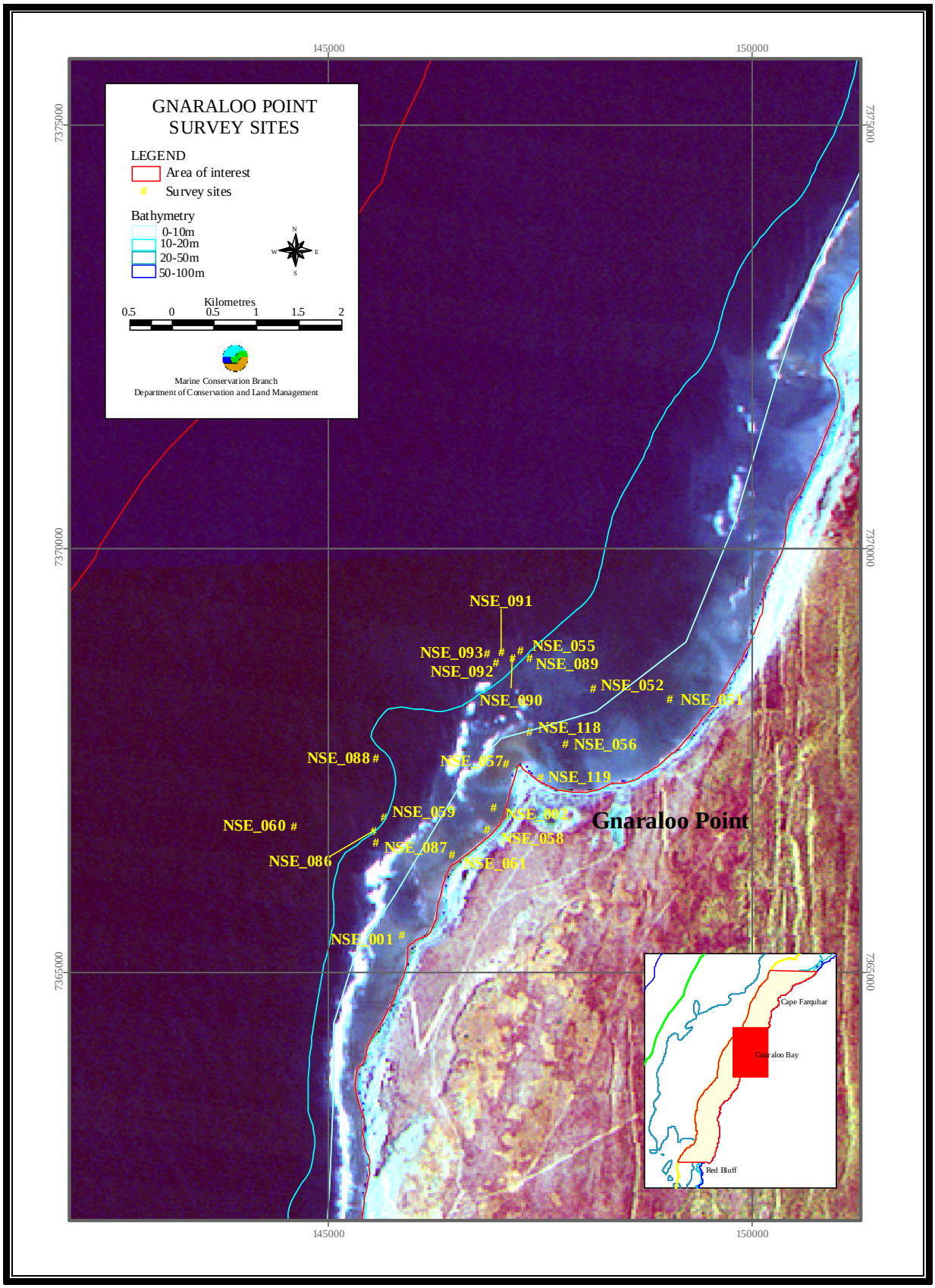

Figure 6. Survey sites at Gnaraloo Point in the proposed southern extension of Ningaloo Marine Park

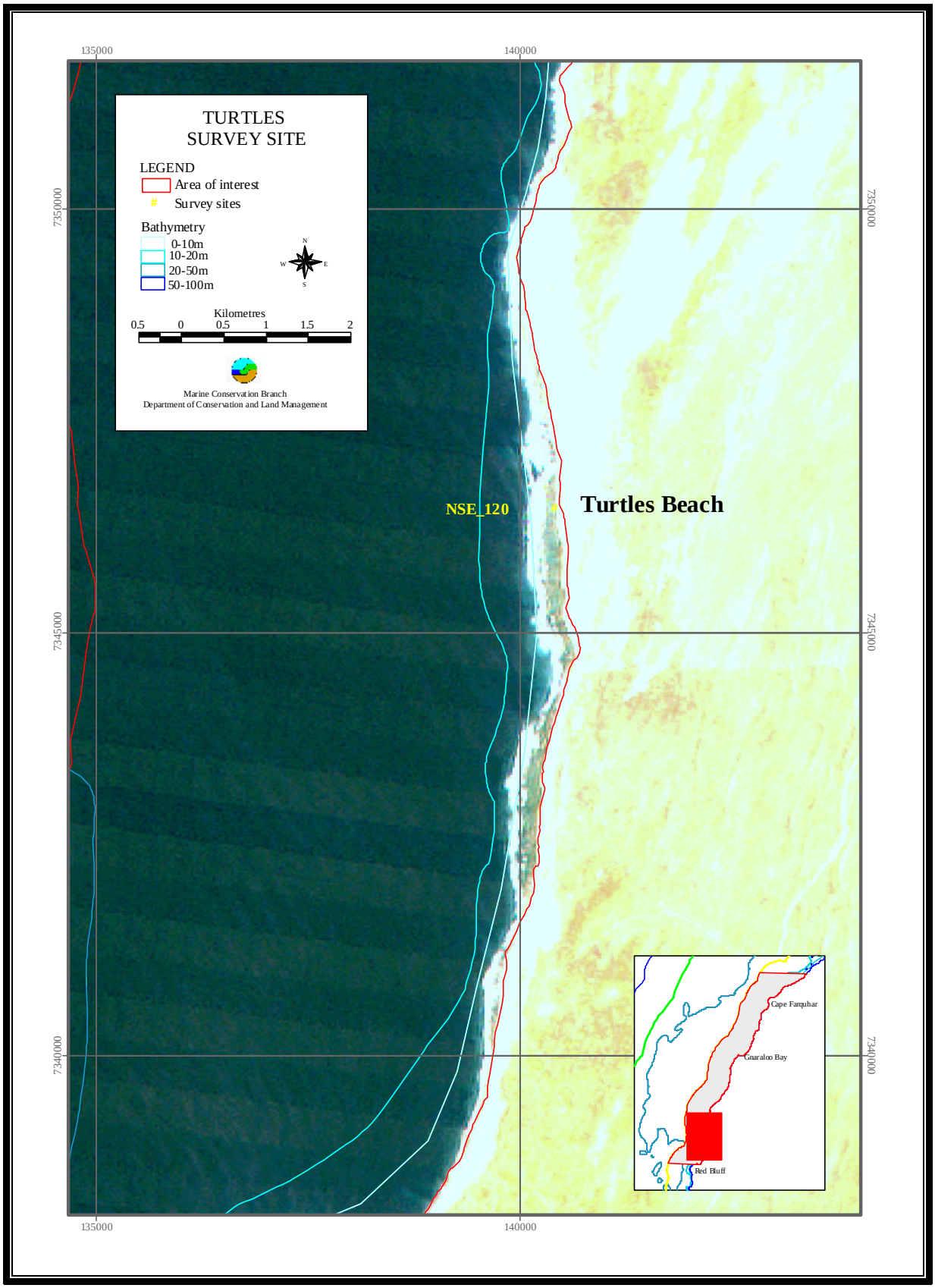

Figure 7. Survey sites at Turtles beach in the proposed southern extension of Ningaloo Marine Park

2.3. FIELD METHODS

Video footage of the major benthic community types (eg. coral communities, limestone platform etc.) were filmed to facilitate the biological verification of the preliminary benthic habitat map. Visually dominant flora and fauna were recorded:

(a) at deep sites (>5 m) using a manually deployed, underwater digital drop-down video camera system, and;

(b) at shallow lagoonal sites (<5 m) using the hand held digital video camera.

This provided broadscale representation of the visually dominant flora and fauna of the proposed southern extension of the Ningaloo Marine Park.

The video camera was lowered over the side of the field survey vessel and 30 seconds of video footage of the seabed was recorded at each of these sites. Site number, date, time, water depth, GPS coordinates and habitat description was recorded for each section of video footage (Appendix II).

Two sites, a coral area and an intertidal coral reef flat, were selected for a qualitative diversity survey. At these sites a species list was compiled and representative organisms were videoed.

2.4. HABITAT CLASSIFICATION

Habitats were classified as per the draft classification scheme presented in Table 1. However the habitat classification "coral reef", was split into 2 sub categories:

1. ***Coral area***, is typically subtidal and has high cover of live coral (>10% live coral). This sub-category would include fore reef, back reef lagoons and isolated coral patch reefs (bommies). The 20 m contour was used as the seaward cutoff for this category. This was modelled from the ground-truthing data, which highlighted the transition around 15-20 m.

2. ***Intertidal coral reef flats***, is typically the intertidal or shallow coral community, which is periodically exposed (ie. out of the water). This sub-category has reasonable coral cover however is mostly dead (<5% live coral).

Two combination categories were also used:

1. ***Sand + reef platform***, was used to highlight the nature of the reef pavement. Generally limestone pavement covered with sand patches or a thin veneer of sand. The sand in some instances may be mobile. There can be algal turf or macroalgae present. Temporal changes in sand cover does occur.

2. ***Beach + rocky shore***, is typically rocky shore, cliff, boulders of pavement around the high water mark with a sandy beach further onshore.

Table 1. Draft habitat classification scheme

HABITAT CLASSIFICATION	TIDAL RANGE	SUBSTRATE TYPE	TROPICAL	TEMPERATE	RELIEF	MACROBIOLOGY	COMMENTS
1. Rocky shore	Intertidal	igneous metamorphic sedimentary	✓	✓	high & low	bare	• continuous rocky shore • cliff, boulders, pavement • around HWM
2. Beach	Intertidal	sand	✓	✓	low	bare	• continuous intertidal sand
3. Shoreline reef platform	Intertidal	igneous metamorphic sedimentary	✓	✓	low	bare algal turf	• continuous reef platform along the shoreline
4. Intertidal reef	Intertidal	igneous metamorphic sedimentary	✓	✓	low	coralline algae, macroalgae	• offshore
5. Mangal	Intertidal	n/a	✓	✓	n/a	mangroves	• continuous mangrove cover (<1 ha)
6. Mudflat	Intertidal	mud silts	✓	✓	n/a	bare algal mats	• continuous intertidal mudflat • includes flats behind mangals
7. Salt marsh	Intertidal	mud silt	✓	✓	n/a	samphire	• continuous salt marsh cover (>1 ha) • on protected or low energy coastline
8. Coral reef	Intertidal & Subtidal	n/a	✓		high & low	hard & soft corals	• typical coral reef community • seaward reef slope, reef crest, back reef, reef flat and individual bommies
9. Rubble	Subtidal	dead coral	✓		low	sparse live coral sparse vegetation	• lagoonal areas • mainly unconsolidated coral rubble

HABITAT CLASSIFICATION	TIDAL RANGE	SUBSTRATE TYPE	TROPICAL	TEMPERATE	RELIEF	MACROBIOLOGY	COMMENTS
10. Reef platform	Subtidal	igneous metamorphic sedimentary	✓	✓	low	diverse algae sessile invertebrates (including sponges, sea-whips, sea-pens)	• includes limestone pavement or low relief reef
11. Macroalgae dominated limestone reef	Subtidal	sedimentary		✓	high & low	macroalgae	• typically covered in macroalgae (>10%) with diverse invertebrate life in overhangs & caves
12. Macroalgae dominated granite reef	Subtidal	igneous metamorphic	✓	✓	high & low	macroalgae	• typically covered in macroalgae (>10%) with diverse invertebrate life in overhangs & caves
13. Macroalgal beds	Subtidal	sand pavement	✓	✓	low	macroalgae	• continuous macroalgal cover (>1 ha) • seasonal macroalgae % coverage allowance (min 10%)
14. Seagrass meadows	Subtidal	sand pavement	✓	✓	low	seagrasses	• continuous (>10%) seagrass coverage (>1 ha) • perennials/ephemerals
15. Sand	Subtidal	Sand (generally white)	✓	✓	low	bare	• little or no vegetation
16. Silt	Subtidal	muds silts	✓	✓	low	bare	• marine and/or terrigenous muds & silts • little or no vegetation

3. RESULTS

3.1. SITE AND HABITAT DATA

3.1.1. Habitat verification

A total of 50 sites were verified in the field (Figures 4,5,6 & 7). Site information, location, habitat classification and biological assemblage data was collected (Appendix II). This data was used in conjunction with aerial photographs and a preliminary digital map of marine benthic habitats based on auto-classified shapes, to produce a revised broad-scale map of major marine habitat types for the study area (Figures 8 & 9).

There were nine habitat classifications used:

1. Rocky shore;
2. Beach;
3. Beach + rocky shore;
4. Shoreline reef platform;
5. Reef platform;
6. Coral area;
7. Intertidal coral reef flat;
8. Sand and;
9. Sand + reef platform.

These categories are defined in Table 2 and Section 2.4.

3.1.2. Biodiversity

Fish and coral species lists were compiled for sites NSE_002 and NSE_057.

At site NSE_002, a coral area, 24 species of hard corals (Appendix III) and 23 fish species (Appendix IV) were recorded.

At site NSE_057, an intertidal coral reef flat, 20 species of hard coral (Appendix V) and 16 fish species (Appendix VI) were recorded.

3.1.3. Spatial rectification

Two locations were used for spatial rectification purposes:

- Site NSE_116. This site is the intertidal reef platform near the boat ramp at Gnaraloo Point (23º 46.010’ S 113º 32.525’ E Datum: AGD84)

- The old Gnaraloo homestead (23º 49.438’ S 113º 31.396’ E Datum: AGD84).

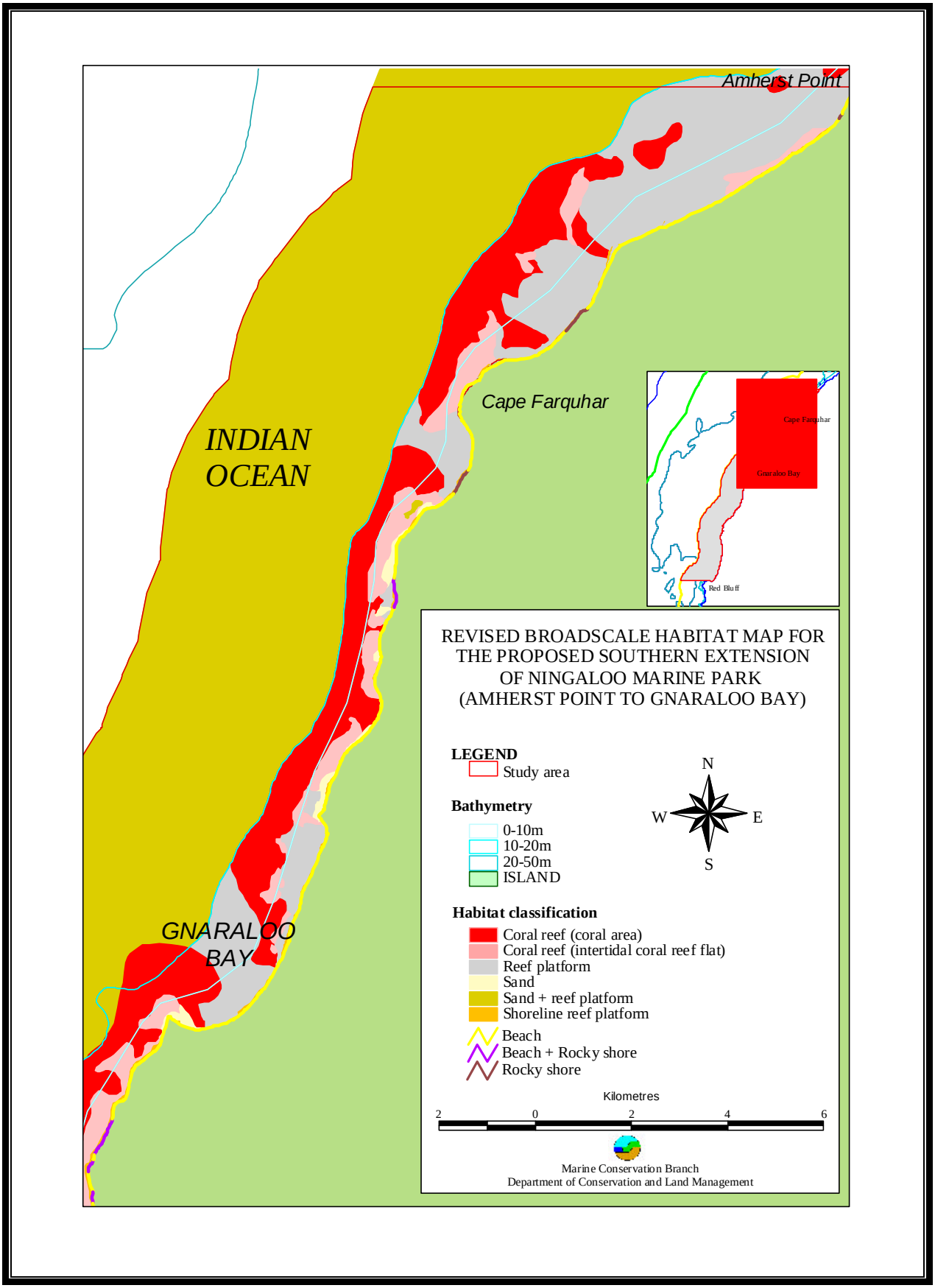

Figure 8. Revised broad-scale habitat map for the proposed southern extension to Ningaloo Marine Park (Amherst Point to Gnaraloo Bay)

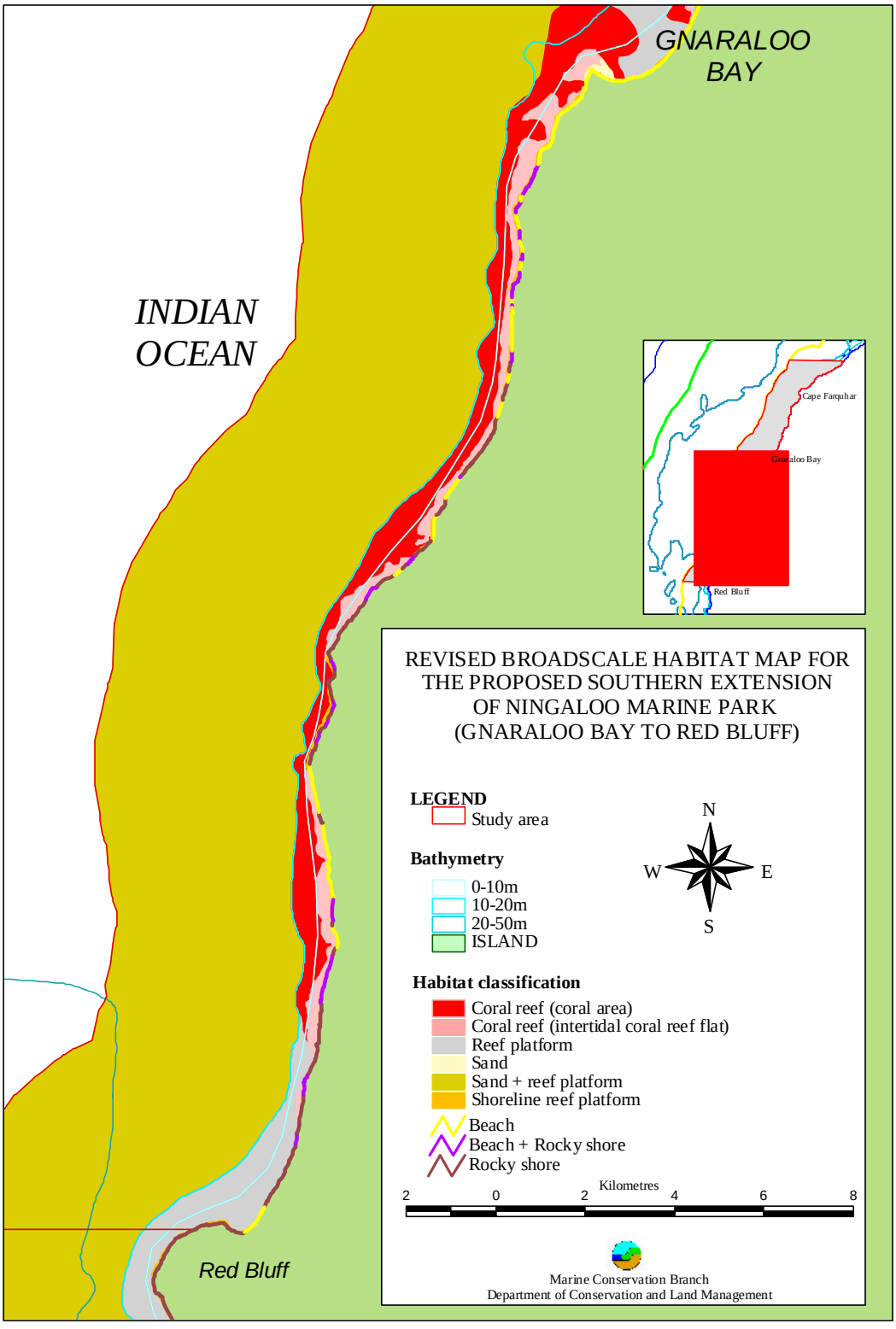

Figure 9. Revised broad-scale habitat map for the proposed southern extension to Ningaloo Marine Park (Gnaraloo Bay to Red Bluff)

3.2. STILL PHOTOGRAPHY AND DIGITAL VIDEO FOOTAGE

Underwater video footage was recorded at most of the ground-truthing sites. This footage is coded by site and referred to in the habitat data. This footage provides examples of all habitat types encountered.

Underwater and above water still photography, and video footage was taken whenever possible to record icon marine fauna and flora, prominent local landmarks and features.

This information has been archived in CALM's Marine Conservation Branch's video and slide libraries.

4. DATA MANAGEMENT

4.1. DATA REPORT

Hard copies of the Data 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 the Data Report at three locations:

1. The Marine Conservation Branch Server:
   mcb on StreetTalk\User Data@CALM.FREM@CALM [T:/Reports/MRI/MRI_3099

2. MCB Server full backup DAT tape [T:/Reports/MRI/MRI_3099]

3. CD-ROM [MRI_3099]

4.2. GIS DATA

Data presented in the form of GIS layers will be stored digitally at three locations:

1. The Marine Conservation Branch Server:
   GIS Data@FREM.SHARED@CALM on StreetTalk [L:/GIS/MCB/MW/NSE/]

2. MCB Server full backup DAT tape [L:/GIS/MCB/MW/NSE/]
3. On GIS Information Coordinator's Computer. [H:/MCB/MW/NSE/]

4.3. VIDEO RECORDS

Five (5) mini digital tapes were used to record habitat data. Tape numbers are:

1. MRI/MW/NSE/DD#1-10/1999
2. MRI/MW/NSE/DD#2-10/1999
3. MRI/MW/NSE/HH#1-10/1999
4. MRI/MW/NSE/HH#2-10/1999
5. MRI/MW/NSE/HH#2-10/1999

Video footage will be held at two locations:

1. Digital masters to be archived at the CALM's Information Management Branch, Como.
2. VHS copies to be stored at CALM's Marine Conservation Branch, Fremantle.

4.4. STILL PHOTOGRAPHY

All slide photographs are held at CALM's Marine Conservation Branch (MCB), Fremantle.

Digital images of selected slides are available on the MCB slide library.

5. REFERENCES

Bancroft K.P. & Lapwood M. (1999). Biological verification of the major benthic habitats of the proposed southern extension to the Ningaloo Marine Park (Amherst Point to Red Bluff): 18-24 October 1999. Field Programme Report: MRI/MW/NSE-24/1999. October 1999. Marine Conservation Branch, Department of Conservation and Land Management, Perth, Western Australia. (Unpublished report).

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APPENDICES

APPENDIX I. LATITUDE AND LONGITUDES OF SITES SAMPLED IN THE PROPOSED SOUTHERN EXTENSION OF NINGALOO MARINE PARK

Site No	Location	Lat deg	Long deg	GPS type	Datum
NSE_001	Gnaraloo Point	-23.7832	113.5256	GPS	ADG84
NSE_002	Gnaraloo Point	-23.7699	113.5366	GPS	ADG84
NSE_018	Cape Farquhar	-23.6066	113.6137	GPS	ADG84
NSE_019	Cape Farquhar	-23.6264	113.6086	GPS	ADG84
NSE_020	Cape Farquhar	-23.6149	113.6024	GPS	ADG84
NSE_021	Cape Farquhar	-23.619	113.6255	GPS	ADG84
NSE_051	Gnaraloo Point	-23.7587	113.5572	GPS	ADG84
NSE_052	Gnaraloo Point	-23.7575	113.5485	GPS	ADG84
NSE_055	Gnaraloo Point	-23.7532	113.5401	GPS	ADG84
NSE_056	Gnaraloo Point	-23.7632	113.5451	GPS	ADG84
NSE_057	Gnaraloo Point	-23.7652	113.5381	GPS	ADG84
NSE_058	Gnaraloo Point	-23.7722	113.5358	GPS	ADG84
NSE_059	Gnaraloo Point	-23.7706	113.5238	DGPS	ADG84
NSE_060	Gnaraloo Point	-23.7714	113.5134	GPS	ADG84
NSE_061	Gnaraloo Point	-23.7748	113.5316	GPS	ADG84
NSE_086	Gnaraloo Point	-23.772	113.5226	DGPS	ADG84
NSE_087	Gnaraloo Point	-23.7732	113.5229	GPS	ADG84
NSE_088	Gnaraloo Point	-23.7643	113.5231	GPS	ADG84
NSE_089	Gnaraloo Point	-23.7541	113.5411	GPS	ADG84
NSE_090	Gnaraloo Point	-23.754	113.5392	GPS	ADG84
NSE_091	Gnaraloo Point	-23.7533	113.5379	GPS	ADG84
NSE_092	Gnaraloo Point	-23.7545	113.5372	GPS	ADG84
NSE_093	Gnaraloo Point	-23.7535	113.5363	GPS	ADG84
NSE_094	North Nine Mile	-23.6914	113.5905	GPS	ADG84
NSE_095	North Nine Mile	-23.6915	113.5899	GPS	ADG84
NSE_096	North Nine Mile	-23.6908	113.5887	GPS	ADG84
NSE_097	North Nine Mile	-23.691	113.5891	GPS	ADG84
NSE_098	North Nine Mile	-23.69	113.5895	GPS	ADG84
NSE_099	North Nine Mile	-23.69	113.5908	GPS	ADG84
NSE_100	Cape Farquhar	-23.6049	113.611	GPS	ADG84
NSE_101	Cape Farquhar	-23.6159	113.6037	GPS	ADG84
NSE_102	Cape Farquhar	-23.6025	113.6065	GPS	ADG84
NSE_103	Cape Farquhar	-23.6214	113.6082	GPS	ADG84
NSE_104	Cape Farquhar	-23.6168	113.6121	GPS	ADG84
NSE_105	Cape Farquhar	-23.6109	113.6172	GPS	ADG84
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NSE_107	Cape Farquhar	-23.62	113.634	GPS	ADG84
NSE_108	Cape Farquhar	-23.617	113.6369	GPS	ADG84
NSE_109	Cape Farquhar	-23.6147	113.6351	GPS	ADG84
NSE_110	Cape Farquhar	-23.6135	113.6321	GPS	ADG84
NSE_111	Cape Farquhar	-23.6125	113.634	GPS	ADG84
NSE_112	Cape Farquhar	-23.6084	113.6311	GPS	ADG84
NSE_113	Cape Farquhar	-23.6064	113.6301	GPS	ADG84
NSE_114	Cape Farquhar	-23.6045	113.6274	GPS	ADG84
NSE_115	Cape Farquhar	-23.6171	113.6196	GPS	ADG84
NSE_116	Cape Farquhar	-23.6283	113.6143	GPS	ADG84
NSE_117	Cape Farquhar	-23.6295	113.6134	GPS	ADG84
NSE_118	Gnaraloo Point	-23.7618	113.541	GPS	ADG84
NSE_119	Gnaraloo Point	-23.7668	113.5421	GPS	ADG84
NSE_120	Turtles	-23.9529	113.4674	GPS	ADG84

APPENDIX II. HABITAT DATA FOR THE PROPOSED EXTENSION TO NINGALOO MARINE PARK

Site No	Location	Substrate	Depth	Habitat type	Biological assemblage	Latitude (deg)	Longitude (deg)	GPS type	Datum	Observation method	Video tape number
NSE_001	Gnaraloo Point	Limestone	-1	Intertidal coral reef flat	conslolidated coral reef; coralline algae dominated (bushy); sparse macroalgae, corals; thin vaneer of sand; <10% live coral cover; no litter observed.	-23.7832	113.5256	GPS	ADG84	handheld digital video	MRI/MW/NSE /HH#1_10/99
NSE_002	Gnaraloo Point	Limestone	-1.5	Coral area	soft corals common; 10-50% live coral cover (~30%); Acropora very common (generally <30cm dia); very healthy; no feeding scars or Drupella observed; no rubbish	-23.7699	113.5366	GPS	ADG84	handheld digital video	MRI/MW/NSE /HH#1_10/99
NSE_018	Cape Farquhar	Limestone	-12	Reef platform	reef platform; some isolated corals; some soft corals (Sinularia); covered with algal turf; some macroalgae; low relief; seastars, digitate sponges.	-23.6066	113.6137	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#2_10/99
NSE_019	Cape Farquhar	Limestone	-8.5	Reef platform	reef pavement; <10% macroalgae cover; some isolated corals <10%; some soft corals (Sinularia); c seastars; Tridacna clams; seaurchins	-23.6264	113.6086	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#2_10/99
NSE_020	Cape Farquhar	Sand	-28	Sand	bare sand	-23.6149	113.6024	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#2_10/99
NSE_021	Cape Farquhar	Limestone	-3	Reef platform	rppled sand veneer on limestone pavement; isolated coral bommies/hard corals.	-23.619	113.6255	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#2_10/99
NSE_051	Gnaraloo Point	Limestone	-4.5	Reef platform	limestone pavement; some turf algae; <5% live coral cover; soft corals; coral is in patches	-23.7587	113.5572	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#1_10/99
NSE_052	Gnaraloo Point	Limestone	-4.5	Reef platform	limestone pavement; some turf algae; <5% live coral cover; soft corals	-23.7575	113.5485	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#1_10/99
NSE_055	Gnaraloo Point	Sand	-29.2	Sand	bare sand	-23.7532	113.5401	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#1_10/99
NSE_056	Gnaraloo Point	Limestone	-2.9	Coral area	coral community; >60% live coral cover; up to 100%; some sand patches; acropora tabular and arborescent forms.	-23.7632	113.5451	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#1_10/99
NSE_057	Gnaraloo Point	Limestone	-1	Intertidal coral reef flat	coral community; reef lats: ~30% live coral cover; dead corals covered in turf algae; tabular and arborescent forms.	-23.7652	113.5381	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#1_10/99

Site No	Location	Substrate	Depth	Habitat type	Biological assemblage	Latitude (deg)	Longitude (deg)	GPS type	Datum	Observation method	Video tape number
NSE_058	Gnaraloo Point	Limestone	-1	Intertidal coral reef flat	coralline algae; scattered small macroalgae; Halimeda common; <10% live coral cover; no rubbish observed	-23.7722	113.5358	GPS	ADG84	handheld digital video	MRI/MW/NSE /HH#1_10/99
NSE_059	Gnaraloo Point	Sand	-25	Sand	bare sand	-23.7706	113.5238	DGPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#1_10/99
NSE_060	Gnaraloo Point	Sand	-29.2	Sand	bare sand	-23.7714	113.5134	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#1_10/99
NSE_061	Gnaraloo Point	Limestone	-1.5	Intertidal coral reef flat	conslolidated coral reef; coralline algae dominated (bushy); Halimeda common; darker areas on aerial photos indicate more relief; thin veneer of sand in places; <10% live coral cover; large sponges present; no litter observed.	-23.7748	113.5316	GPS	ADG84	handheld digital video	MRI/MW/NSE /HH#1_10/99
NSE_086	Gnaraloo Point	Sand	-19.2	Sand	bare sand	-23.772	113.5226	DGPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#1_10/99
NSE_087	Gnaraloo Point	Limestone		Reef platform	limestone pavement; some turf algae (mainly blue/green?); sea urchins	-23.7732	113.5229	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#1_10/99
NSE_088	Gnaraloo Point	Sand	-24.2	Sand	bare sand	-23.7643	113.5231	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#1_10/99
NSE_089	Gnaraloo Point	Limestone	-6	Reef platform	limestone pavement; some turf algae some sand veneer; sponges; Halimeda; sea urchins	-23.7541	113.5411	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#1_10/99
NSE_090	Gnaraloo Point	Limestone	-13.2	Reef platform	limestone pavement; some turf algae some sand veneer; sea urchins	-23.754	113.5392	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#1_10/99
NSE_091	Gnaraloo Point	Sand	-24	Sand	bare sand	-23.7533	113.5379	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#1_10/99
NSE_092	Gnaraloo Point	Limestone	-13	Reef platform	limestone pavement; some turf algae some sand veneer; sea urchins	-23.7545	113.5372	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#1_10/99
NSE_093	Gnaraloo Point	Sand	-24	Sand	bare sand	-23.7535	113.5363	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#1_10/99
NSE_094	North Nine Mile	Limestone	-1	Shoreline reef platform	intertidal reef; littoral gastropods; some filamentous green algae; Crassostrea oysters.	-23.6914	113.5905	GPS	ADG84	handheld digital video	MRI/MW/NSE /HH#2_10/99
NSE_095	North Nine Mile	Limestone	-2	Intertidal coral reef flat	reef platform; <5% live coral cover; increases into outer reef; plenty of Tridacna clams	-23.6915	113.5899	GPS	ADG84	handheld digital video	MRI/MW/NSE /HH#2_10/99
NSE_096	North Nine Mile	Limestone	-1	Intertidal reef	algal turf; some Halimeda	-23.6908	113.5887	GPS	ADG84	handheld digital video	MRI/MW/NSE /HH#2_10/99
NSE_097	North Nine Mile	Limestone	-3	Coral area	coral bommies; plate Acropora: Drupella snails observed on Acropora; lots of fish.	-23.691	113.5891	GPS	ADG84	handheld digital video	MRI/MW/NSE /HH#2_10/99

Site No	Location	Substrate	Depth	Habitat type	Biological assemblage	Latitude (deg)	Longitude (deg)	GPS type	Datum	Observation method	Video tape number
NSE_098	North Nine Mile	Limestone	-1	Intertidal reef	reef platform; quite bare; some algal turf; some green calcareous and red calcareous (srticulated) algae; isolated corals	-23.69	113.5895	GPS	ADG84	handheld digital video	MRI/MW/NSE /HH#2_10/99
NSE_099	North Nine Mile	Limestone	-1	Shoreline reef platform	bare platform; sand patches; some algal turf in places.	-23.69	113.5908	GPS	ADG84	handheld digital video	MRI/MW/NSE /HH#2_10/99
NSE_100	Cape Farquhar	Sand	-23	Sand	bare sand	-23.6049	113.611	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#2_10/99
NSE_101	Cape Farquhar	Sand	-23	Sand	bare sand	-23.6159	113.6037	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#2_10/99
NSE_102	Cape Farquhar	Sand	-20	Sand	bare sand	-23.6025	113.6065	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#2_10/99
NSE_103	Cape Farquhar	Limestone	-12	Reef platform	reef pavement; <10% macroalgae cover; some isolated corals; some soft corals; could be some digitate sponge; seastars; Montipora; turf algae; seaurchins	-23.6214	113.6082	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#2_10/99
NSE_104	Cape Farquhar	Limestone	-8	Reef platform	reef pavement; low relief; <10% macroalgae; isolated soft corals and hard corals; Tridacna clams; sea urchins.	-23.6168	113.6121	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#2_10/99
NSE_105	Cape Farquhar	Limestone	-7	Reef platform	reef pavement; low relief; <10% macroalgae; isolated soft corals and hard corals (tabular Acropora); Tridacna clams; sea urchins; some digitate sponges.	-23.6109	113.6172	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#2_10/99
NSE_106	Cape Farquhar	Limestone	-3.4	Coral area	>60% live coral cover; Acropora species; lots of fish life; Tridacna clams; soft corals; no rubbish; no Drupella snails.	-23.6145	113.6259	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#2_10/99
NSE_107	Cape Farquhar	Limestone	-1.5	Reef platform	low reliefreef platform; scattered macroalgae; spikey coralline algae and bushy coralline algae; soft corals (Sinularia); Tridacna clams; scattered corals; macroalgae common.	-23.62	113.634	GPS	ADG84	direct	none
NSE_108	Cape Farquhar	Limestone	-1.5	Reef platform	low reliefreef platform; scattered macroalgae; spikey coralline algae acommon; soft corals (Sinularia); Tridacna clams;	-23.617	113.6369	GPS	ADG84	direct	none
NSE_109	Cape Farquhar	Limestone	-3	Reef platform	low to medium relief; scattered hard and soft corals; Sinularia and Acropora; some macroalgae.	-23.6147	113.6351	GPS	ADG84	direct	none
NSE_110	Cape Farquhar	Limestone	-5	Reef platform	reef platform; <10% live corals; some turf algae; mainly Acropora species; soft corals; low relief.	-23.6135	113.6321	GPS	ADG84	drop-down digital video	MRI/MW/NSE /DD#2_10/99

Site No	Location	Substrate	Depth	Habitat type	Biological assemblage	Latitude (deg)	Longitude (deg)	GPS type	Datum	Observation method	Video tape number
NSE_111	Cape Farquhar	Limestone		Coral area	>10% live coral cover; isolated and sparse; some Tridacna clams; no macroalgae; some soft corals; like NSE-109 but more sparse; low relief	-23.6125	113.634	GPS	ADG84	direct	none
NSE_112	Cape Farquhar	Limestone	-4.5	Reef platform	macroalgae common; low relief: isolated corals and soft corals; some Tridacna clams; more macroalgae than other sites.	-23.6084	113.6311	GPS	ADG84	direct	none
NSE_113	Cape Farquhar	Limestone	-5	Macroalgal bed	macroalgal bed; 50-100% cover. (Zonaria)	-23.6064	113.6301	GPS	ADG84	direct	none
NSE_114	Cape Farquhar	Limestone	-1	Coral area	shallow coral reef; 20% live coral cover; Tridacna clams; corals common	-23.6045	113.6274	GPS	ADG84	direct	none
NSE_115	Cape Farquhar	Limestone	-1.5	Coral area	>50% live coral cover; aborescent Acropora; coral reef	-23.6171	113.6196	GPS	ADG84	direct	none
NSE_116	Cape Farquhar	Limestone	-1	Coral area	>50% live coral cover; aborescent Acropora; Acropora formosa; Acropora hyacinthus; coral reef	-23.6283	113.6143	GPS	ADG84	direct	none
NSE_117	Cape Farquhar	Limestone	-1	Intertidal coral reef flat	coral reef; 75% dead coral cover; few live colonies; northerly drift 50-70cm/s	-23.6295	113.6134	GPS	ADG84	direct	none
NSE_118	Gnaraloo Point	Limestone	-5	Coral area	Acropora coral bombies; 10-50%coral cover; 75% live cover;	-23.7618	113.541	GPS	ADG84	handheld digital video	MRI/MW/NSE /HH#3_10/99
NSE_119	Gnaraloo Point	Limestone	-1	Shoreline reef platform	some Crassostrea oysters; periwinkle gastropods; soft corals; algal turf.	-23.7668	113.5421	GPS	ADG84	direct	none
NSE_120	Turtles	Limestone	-1	Intertidal coral reef flat	soft coral garden; 10-50% soft coral cover (~30%); some isolated corals; some intertidal platform; seaurchins; seastars; egg cowries; no rubbish	-23.9529	113.4674	GPS	ADG84	direct	MRI/MW/NSE /HH#3_10/99

APPENDIX III. HARD CORAL SPECIES LIST FOR SITE NSE_002.

Family	Species	Comments
ACROPORIDAE	*Acropora cyntherea*	
	A. digitifera	
	A. florida	
	A. formosa	
	A. grandis	
	A. hyacinthus	
	A. millipora	
	A. nobilis	blue
	A. robusta (?)	
	A. valenciennesi	
	A. valida	
	Cyphastrea microphthalma	
	Montipora mollis (?)	
	Montipora sp 2	blue encrusting
	Montipora sp 3	digitate
	Montipora sp 4	brown encrusting
	Montipora sp 5	brown plates & whorls
FAVIIDAE	*Favia speciosa*	
	Favites abdita	
	Leptoria phygria	
	Platygyra daedalea	
	P. sinensis	
MERULINIDAE	*Hydnophora verracusa*	
OCULINIDAE	*Galaxea fascicularis*	

APPENDIX IV. FISH SPECIES LIST FOR SITE NSE_002.

Family	Species	Common name
ACANTHURIDAE	*Acanthurus grammoptilus*	Ring-tailed surgeonfish
APOGONIDAE	*Apogon* sp.	Cardinalfish
BLENNIDAE	Blennidae sp.	Blenny
CHAETODONTIDAE	*Chaetodon bennetti*	Bennett's butterflyfish
	C. plebeius	Blue spot butterflyfish
	C. trifascialis	Cheveroned butterflyfish
HAEMULIDAE	*Plectorhinchus flavomaculatus*	Gold-spotted sweetlip
LABRIDAE	Labridae sp 2	
	Labridae sp 3	
	Labridae sp 4	
	Labridae sp 5	
	Thalassoma lunare	Moon wrasse
OSTRACIIDAE	*Ostracion meleagris*	Spotted boxfish
POMACENTRIDAE	*Chromis* sp.	
	Dascyllus aruanus	Humbug dascyllus
	D. melanurus	Black-tailed dascyllus
	Neoglyphidodon melas	Black damsel
	Pomocentrus coelestris	Neon damsel
	P. molluccensis	Lemon damsel
	Pomacentridae sp.	
SCARIDAE	*Chlorurus sordidus*	Green-finned parrotfish
POMOCANTHIDAE	*Pomocanthus* sp.	Angelfish
Unidentified	*Unidentified fish*	

APPENDIX V. HARD CORAL SPECIES LIST FOR SITE NSE_057

Family	Species	Comments
ACROPORIDAE	*Acropora digitifera*	
	A. florida	
	A. formosa	
	A. millipora	
	A. nobilis	blue
	A. valida	
	Cyphastrea microphthalma	
	Montipora sp 2	blue encrusting
	Montipora sp 4	brown encrusting
FAVIIDAE	*Favia speciosa*	
	Favites abdita	
	Favites sp 2	
	Favites sp 3	
	Leptoria phygria	
	Platygyra daedalea	
	P. sinensis	
MUSSIDAE	*Lobophyllia corymbosa (?)*	
	L. hemprichii	
POCILLOPORIDAE	*Pocillopora damicornis*	
PORITIDAE	*Porites lutea (?)*	

APPENDIX VI. FISH SPECIES LIST FOR SITE NSE_057.

Family	Species	Common name
ACANTHURIDAE	*Acanthurus nigrofuscus*	Dusky surgeonfish
CHAETODONTIDAE	*Chaetodon bennetti*	Bennett's butterflyfish
	C. plebeius	Blue spot butterflyfish
	C. trifascialis	Cheveroned butterflyfish
LABRIDAE	Labridae sp 2	
	Labridae sp 3	
	Labroides dimidiatus	Cleanerfish
	Thalassoma lunare	Moon wrasse
POMACENTRIDAE	*Dascyllus aruanus*	Humbug dascyllus
	D. melanurus	Black-tailed dascyllus
	Neoglyphidodon melas	Black damsel
	Pomocentrus coelestris	Neon damsel
	P. molluccensis	Lemon damsel
SERRANIDAE	Serranidae sp.	
SCARIDAE	*Chlorurus sordidus*	Green-finned parrotfish
Unidentified	*Unidentified fish*	• Possibly a labrid • Long mouth • Green with stripes of black dots