Critical Marine Habitats Adjacent to Hydrographers Passage, Great Barrier Reef Queensland, Australia

QDPI&F Information Series QI06081
2006 ATLAS

RISK ASSESSMENT

HABITAT MANAGEMENT

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Queensland Government
Department of Primary Industries and Fisheries

MARINE ECOLOGY GROUP

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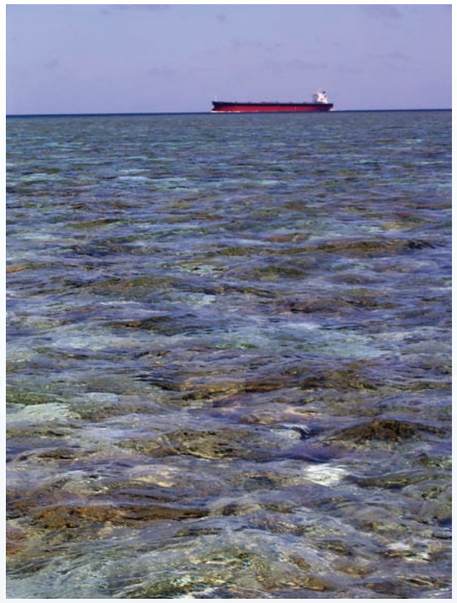

List of Maps

Acknowledgments

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Introduction

The ports and shipping industry is an essential component of Australia's trade and underpins the viability of many of Australia's export and import industries. Designated shipping lanes have been developed in many areas of Queensland to provide a means for large vessels to access ports. Many of these shipping lanes pass through economically and ecologically important natural habitats and are often in areas that contain significant navigation hazards. In these areas there is a heightened risk of shipping accidents including collisions and groundings of vessels that may result in oil, fuel and chemical spills. Many marine habitats such as seagrasses, algae, mangroves and coral reefs are vulnerable to oil and fuel spills, particularly when they occur in intertidal areas. In many instances there are a lack of detailed information on the marine habitats that occur adjacent to these shipping lanes.

Queensland Transport and the Great Barrier Reef Marine Park Authority completed an oil spill and shipping accident risk assessment for coastal waters of Queensland and the Great Barrier Reef Marine Park in 2000 (Queensland Transport and the Great Barrier Reef Marine Park Authority, 2000). The risk assessment identified six Marine Environment High Risk Areas (MEHRA) for Queensland's shipping lanes and ports where there was a heightened risk of accidents as well as heightened consequences. The six MEHRA identified in the risk assessment were:

- Prince of Wales channel (Torres Strait)
- Great North East channel (Torres Strait)
- Inner Shipping Route between Cape Flattery and Torres Strait
- Whitsunday Islands and Passages
- Hydrographers Passage
- Moreton Bay

The Queensland Department of Primary Industries and Fisheries (QDPI&F) Marine Ecology Group with support from the CRC Reef and CRC Torres Strait has developed a program to examine areas of these MEHRA's where there is a lack of detailed information on key marine habitats. The group has published one atlas in this series focusing on a section of the inner shipping route (Rasheed *et al.* 2005a) and is in the process of developing resource atlases for the Prince of Wales and Adolphus Channels in the Torres Strait. The focus of this atlas is on the Hydrographers Passage shipping channel in the Mackay region of the Great Barrier Reef Marine Park. Many ecologically and economically valuable intertidal marine habitats that occur in this area may be vulnerable to oil, fuel or chemical spills from shipping accidents. This atlas provides fine-scale maps of these vulnerable marine habitats.

The detailed information collected on the location and nature of habitat types presented in this atlas will be included in the Geographic Information System (GIS) database for the Oil Spill Response Atlas (OSRA), an important resource which aids decision-making and emergency response to shipping accidents and oil spills. Data presented in this atlas was obtained from surveys conducted in September and October 2003.

Reef habitat adjacent to Hydrographers Passage

Shipping channel beacon at Creal Reef, Hydrographers Passage

Why survey the Hydrographers Passage shipping channel?

Hydrographers Passage was selected for investigation for a number of reasons including:

- It was one of the six identified MEHRA's for Queensland
- It contains a high diversity of intertidal habitats (particularly extensive coral reefs) in close proximity to the shipping channel
- The channel is very complicated to navigate, with extreme tidal streams and currents, and a very narrow channel width (1nm)
- There was a lack of fine-scale information on intertidal habitats in the area.

Satellite image of Hydrographers Passage

The selection process included an examination of existing habitat information and consultation with shipping management agencies in Queensland (Maritime Safety Queensland and Great Barrier Reef Marine Park Authority). The 60 mile long passage was declared as a deepwater shipping channel in 1984 and is bordered by extensive coral reefs. The tight turns that occur at Bugatti and Boulton Reefs, and the close proximity to numerous other reefs and shoals make this channel particularly hazardous for navigation.

The number of vessels utilising Hydrographers Passage has doubled since 1997/1998 making it the busiest of the three shipping entrance channels that pass through the Great Barrier Reef Marine Park. In 2005 / 2006, over 1300 voyages were undertaken through the Passage to the major coal ports of Hay Point and Abbott Point and the sugar port of Mackay (Australian Maritime Safety Authority unpublished information). This increase has been driven by a heightened world demand for Australia's coal.


Coal carrier loading at the Port of Hay Point

The Mackay Capricorn sector of the Great Barrier Reef (GBR) which includes the reefs adjacent to Hydrographers Passage is also a highly visited tourism destination with in excess of 143,000 visitors to the reef per year (Great Barrier Reef Marine Park Authority 2006). Reefs at the inshore entrance of Hydrographers Passage are some of the most popular dive sites in the Mackay Region, with the areas only tourist pontoon located at the entrance to Hydrographers Passage on Credlin Reef.

Shipping accidents in Hydrographers Passage also pose a risk to commercial and recreational fisheries. The East Coast Reef Line Fishery generates in excess of $45 million dollars a year, and has a large fleet based in Mackay (DPI&F 2005). Coral trout accounts for 50% of the total line catch due to its high export value when sold as live animals. The Mackay Capricorn section of the GBR is one of the most productive areas for the fishery and the reefs adjacent to Hydrographers Passage are highly targeted by fisherman due to their proximity to the port of Mackay.

Hydrographers Passage is included within the Great Barrier Reef Marine Park Authority (GBRMPA) Zoning Plan (Map 1). GBRMPA zoning that occurs both within and surrounding the passage includes:

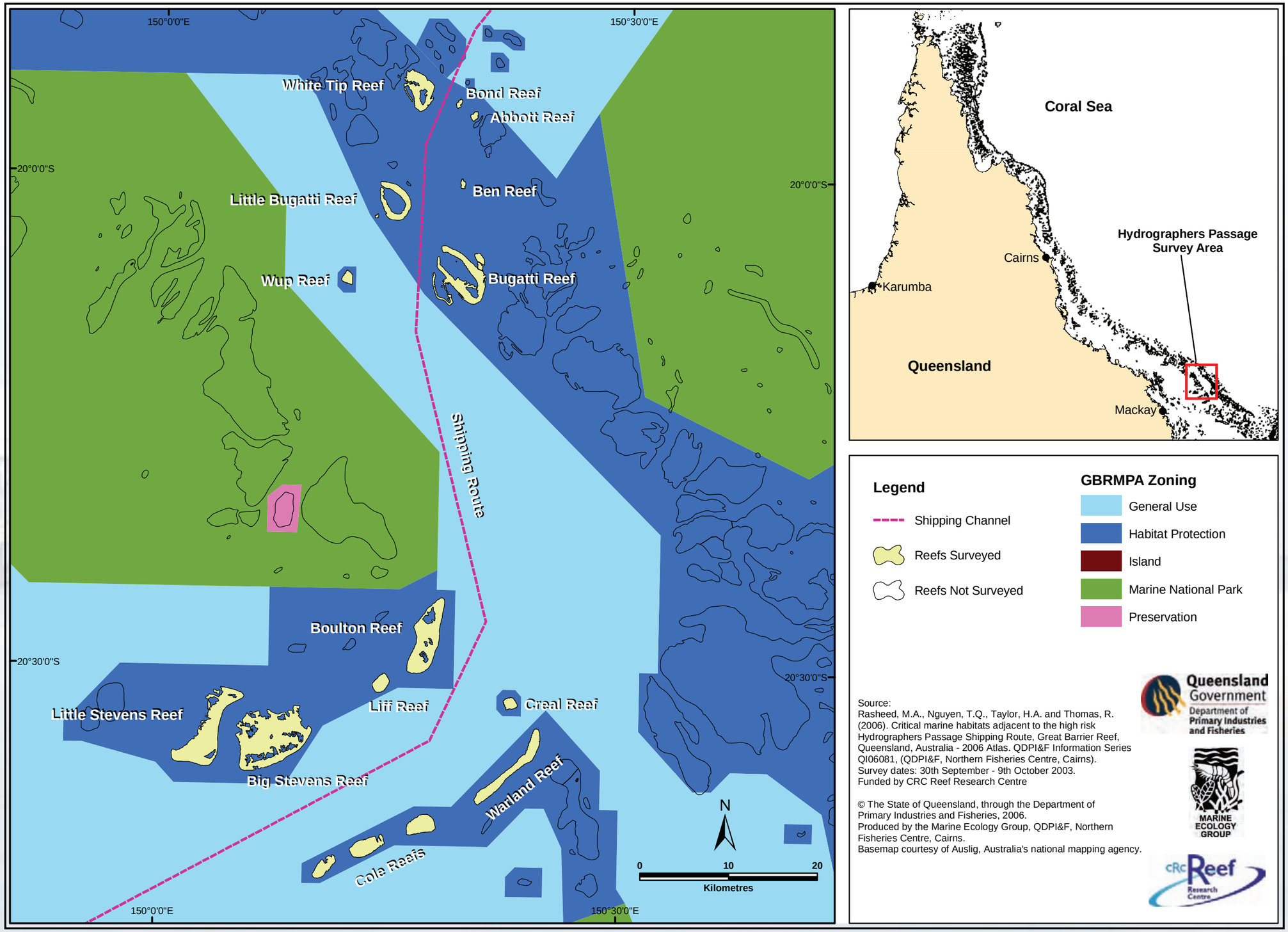
- Preservation Zone (Pink) – The highest level of protection with all activities banned, with the exception of limited impact research if granted with a permit
- Marine National Park Zone (Green) – A high level of protection with many activities excluded except boating, diving, photography, and research, shipping and tourism if granted with a permit
- Habitat Protection Zone (Dark Blue) – Lower level of protection that permits most activities except trawling, with many other activities (including shipping) requiring a permit
- General Use Zone (Light Blue) – Open to most activities but still requires a permit for specific activities including harvest fisheries, research and tourism

The majority of the intertidal habitats closest to the designated shipping lane lie within areas under moderate levels of protection in the Zoning Plan (Habitat Protection Zone). However, a number of reefs adjacent to the passage are classified under very high protection levels (Marine National Park Zone) with Robertson Reefs (no 1.) classified as a Preservation Zone.

High fisheries, social and ecological values of the habitats that surround Hydrographers Passage, combined with the heightened risk of shipping accidents and oil spills, make the area of particular interest.

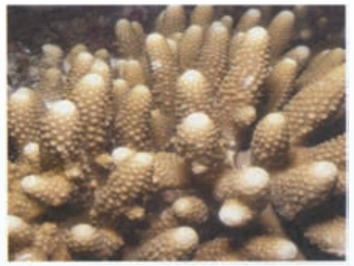

Fishing for coral trout in the Mackay Region

Map 1. Reefs Surveyed, Location of Shipping Route and Great Barrier Reef Marine Park Authority (GBRMPA) Zoning for Hydrographers Passage Area



Source:
Rasheed, M.A., Nguyen, T.Q., Taylor, H.A. and Thomas, R. (2006). Critical marine habitats adjacent to the high risk Hydrographers Passage Shipping Route, Great Barrier Reef, Queensland, Australia - 2006 Atlas. QDPI&F Information Series QI06081, (QDPI&F, Northern Fisheries Centre, Cairns).
Survey dates: 30th September - 9th October 2003.
Funded by CRC Reef Research Centre

Produced by the Marine Ecology Group, QDPI&F, Northern Fisheries Centre, Cairns.
Basemap courtesy of Auslig, Australia's national mapping agency.



Survey Methodology

Boat-based Diver Surveys

This atlas was developed from a survey conducted between 29th September and 11th October 2003. The survey focused on sixteen individual reefs immediately adjacent to the designated Hydrographers Passage shipping route (Map 2). Reef top habitat assessment methodologies used in this survey were adapted from those developed by QDPI&F for intertidal habitat surveys in other Queensland locations (e.g. Rasheed *et al.* 2003; 2005a; 2005b) and visual assessments of coral developed by the Australian Institute of Marine Science (English *et al.* 1997). The surveys focused on the intertidal areas of target reefs as they were considered to be at highest risk from the effects of oil spills and shipping accidents.

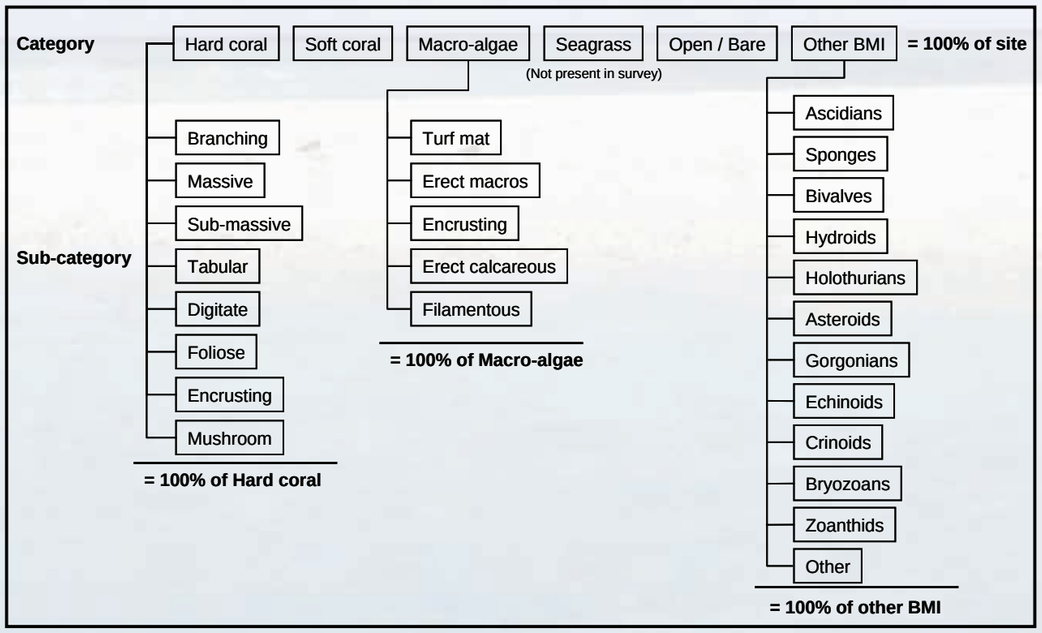
Reef top habitats were described by assessment of survey sites randomly scattered throughout the intertidal areas of the reefs (Map 2). Sampling at these "habitat assessment sites" was stratified to ensure that all major intertidal physical features of the reef were sampled (i.e. reef edge, reef crest, reef flat). Additional sites were added where there was an obvious major change in habitat type once in the field. Each habitat assessment site encompassed an area of 6.25m^2 of the bottom that was defined by deploying a 2.5m long metal rod from the boat. A "free diving" observer then entered the water and described the benthic habitat within the 2.5 x 2.5m "quadrat" (Plate 1). Size of the sampling site was determined by trialing different quadrat sizes in a pilot program conducted on reefs at Green Island prior to the survey. The 2.5m x 2.5m area represented the optimal site size that adequately described the typical benthic diversity at a reef top site that could be reasonably conducted by free divers in a short period of time (approximately 5 minutes).

For each habitat assessment site free-divers collected the following information:

- *Substrate type* – Visually assessed in the field by divers and assigned into reef, rubble, shell, sand and mud or any combination of those based on order of dominance (e.g. mud/sand = more mud than sand)
- *Depth* – Recorded using a depth sounder on the boat and converted to depth below mean sea level
- *Site photograph* – Taken by the diver and used to assist in determination of habitat cover and calibration of estimates between observers.
- *Dead coral* – The percentage of dead coral or dead coral colonised by algae at each site was recorded. Dead coral only included that where an obvious fixed coral structure was evident, rather than coral rubble or weathered corals without obvious structure.
- *Crown of thorns* - Numbers of the crown of thorns starfish *Acanthaster planci* were also noted at each site.
- *Percent cover of benthic habitat groups* (Figure 1) – Divers determined the percent cover that each of 6 main benthic habitat groups comprised of each site. The categories included uncolonised substrates and five broad categories of organisms which together accounted for 100% of the assessment site. The description of the benthic community included sessile and sedentary macro-invertebrates, however motile organisms such as fish and cnidarians were not included. The categories were: Hard coral; Soft coral; Macro-algae; Seagrass; Other Benthic macro-invertebrates; Open/ bare substrate.

Plate 1 Diver conducting habitat assessment

Figure 1 Flow diagram rationale for habitat classification



After assessing the overall proportion of the broad habitat groups, several of the broad categories were divided into a number of sub-categories. The proportion that each of these sub-categories comprised of the broader group was then recorded. The sub-categories were determined using the following rationale (see Figure 1).

Hard Coral Type (after English *et al.* 1997)

- Branching - Has at least secondary branching
- Digitate - No secondary branching
- Massive - Solid boulder or mound
- Sub-massive - Forms small columns, knobs or wedges
- Tabular - Horizontal flattened plates
- Foliose - Attached at several points with leaf-like appearance
- Encrusting - Major portion attached to substrate as a laminar plate
- Mushroom - Solitary free living (unattached) coral

Algae Functional Group

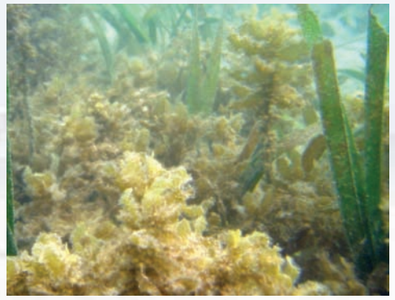
- Turf mat - Sheet like growth form of algae that forms a dense mat on the substrate, generally less than 10mm in height
- Erect Macrophytes - Large structurally complex macro-algae with high degree of cellular differentiation (e.g. *Sargassum* and *Caulerpa*)
- Erect Calcareous - Large structurally complex macro-algae that contain calcified segments (e.g. Halimeda)
- Filamentous - Fine "hair-like" algae with low cellular differentiation greater than 10mm in height
- Encrusting - Sheet-like algae that is firmly attached to hard substrates (e.g. coralline algae)


Branching and Encrusting Coral

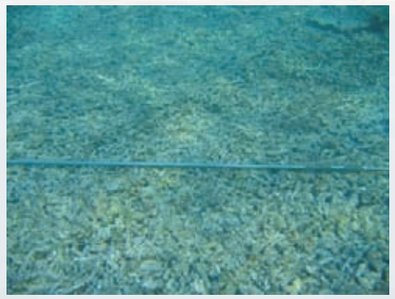

Digitate Coral

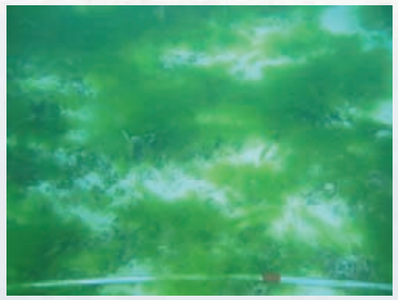

Massive Coral


Tabular Coral


Erect Macrophytes with Seagrass

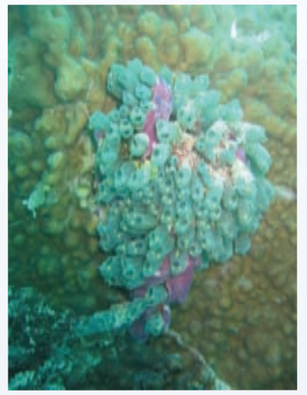

Erect Calcareous Algae


Encrusting and Turf Algae on Coral Rubble

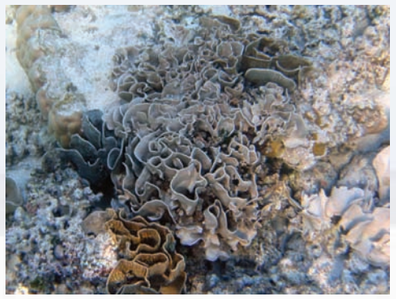

Filamentous Algae

Other benthic macro-invertebrates

The % composition of any habitat forming benthic macro-invertebrate group that formed a significant proportion of a site was also recorded separately. Groups included sponges, hydroids, ascidians, bivalves, asteroids, crinoids, bryozoans, echinoids and holothurians.


Colonial Ascidian

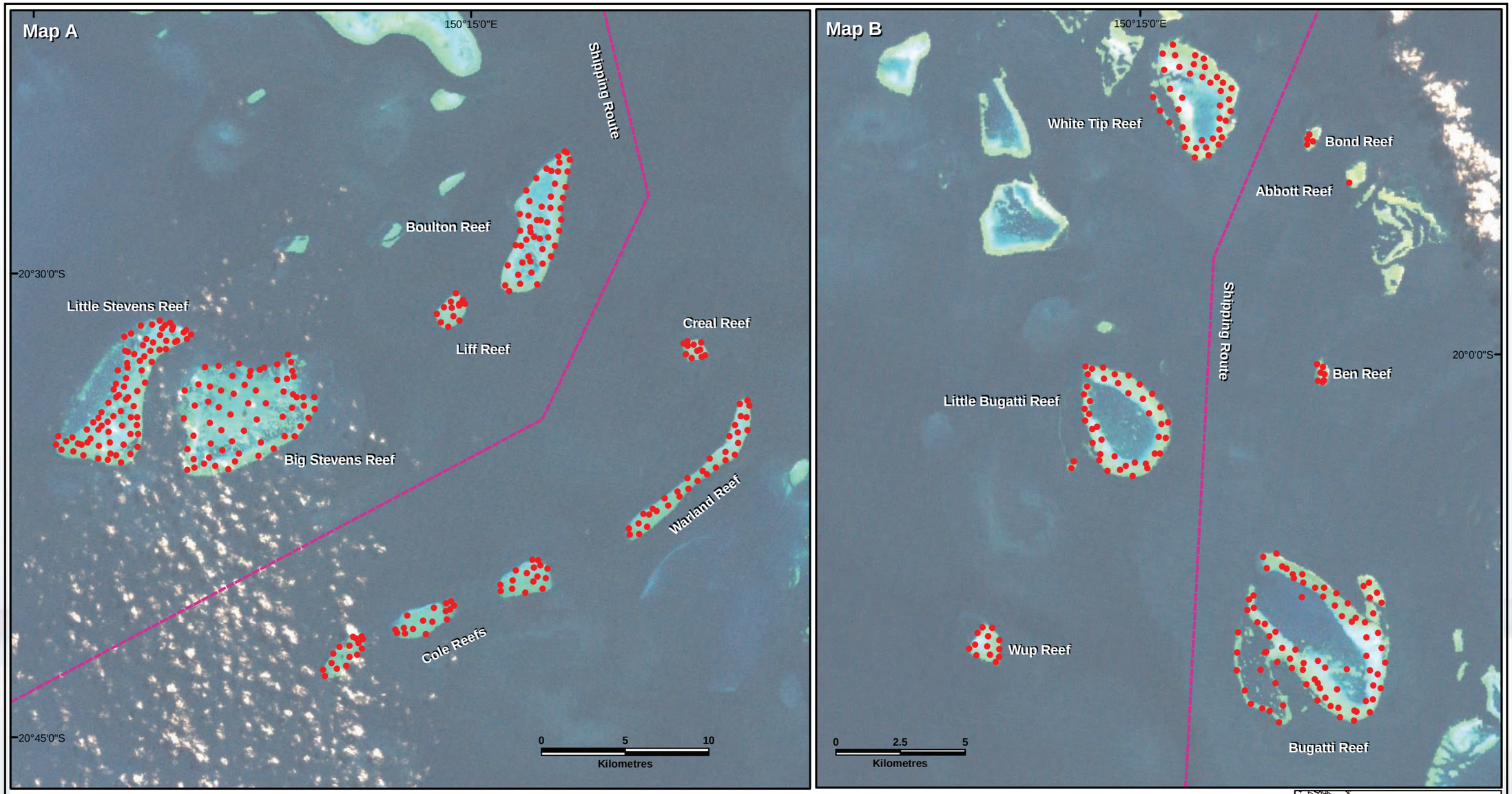

Hydroids


Sponges

Seagrass biomass and species composition

While the biomass of seagrass and species composition was intended to be recorded for each site using standard methodology developed by QDPI&F, no seagrass was found within the survey area.

Map 2. Location of Habitat Sampling Sites and Reefs Surveyed Adjacent to Hydrographers Passage, 2003



Source:
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Geographic Information System (GIS)

All data were entered into a Geographic Information System (GIS) developed for Hydrographers Passage using ArcGIS software. Several GIS layers were developed to describe the habitats of Hydrographers Passage:

1. Site information

This layer contained all data collected at habitat assessment sites. Various subsets of this site data are presented in the maps contained within this atlas including proportions of each algae, coral and other benthic macro-invertebrate sub-category at each site (see Figure 1). Information in the site data layer was used to construct subsequent polygon (area) layers describing coral and algae community types for each reef (see below).

2. Reef boundaries

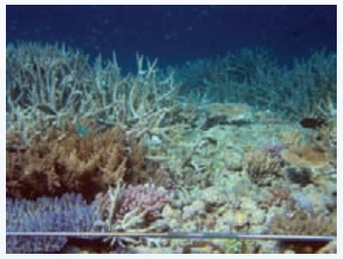
Boundaries of reefs in the survey were interpreted from satellite imagery (LANDSAT 7 ETM+, Commonwealth of Australia). The rectified raster image was used in conjunction with our survey information to determine the reef-top boundaries. Reef boundaries were converted from raster to vector format using ArcGIS software. Satellite imagery also assisted in determining the extent of habitat community regions where features such as high coral cover or open spaces were clearly visible.

3. Coral percent cover

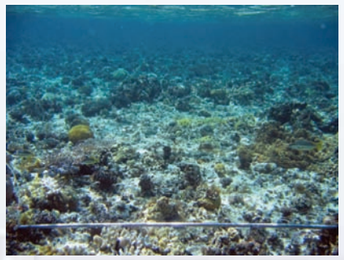
A polygon (area) layer displaying regions of coral percent cover for each of the reefs was developed. Coral percent cover regions were determined using information collected at each habitat assessment site. Thiessen polygons were created at each site in ArcGIS with percent cover of coral represented for each polygon as one of five cover categories:

- Very low (0-5%)
- Low (5-15%)
- Moderate (15-30%)
- High (30-50%)
- Very high (50-100%)

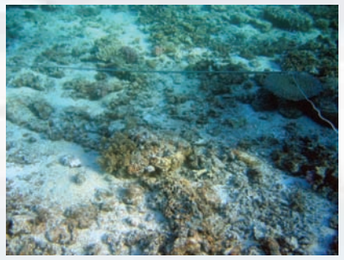
Based on previous surveys in other locations and an initial examination of the data a live coral cover of over 50% was considered to be very high. Subsequent cover categories were assigned so as to produce a good representation of the various density regions that typified the reefs surveyed. Neighbouring thiessen polygons with similar % cover categories were merged to form discrete regions. The boundaries of these regions were also modified taking into account physical features such as reef edges and obvious open substrate or coral areas from the satellite imagery.



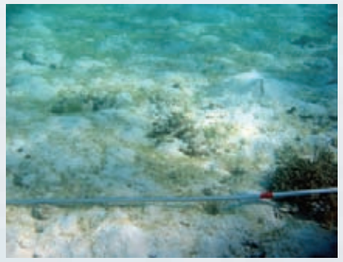
Very High Coral Cover
(>50%)



Moderate Coral Cover
(15-30%)



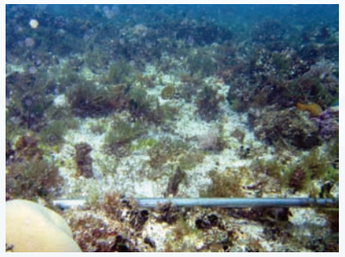
Low Coral Cover
(5-15%)



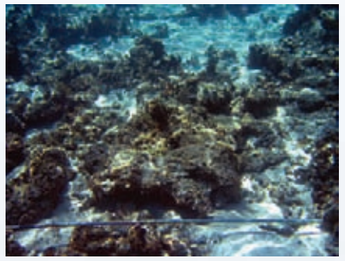
Very Low Coral Cover
(0-5%)

4. Algae percent cover

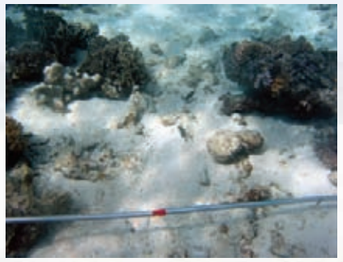
A polygon (area) layer displaying regions of algae percent cover for each of the reefs was also developed. Algae percent cover regions were determined using the same process as for coral percent cover regions. The same five percent cover ranges were also used to describe algae percent cover.



Very High Algae Cover
(>50%)



Moderate Algae Cover
(15-30%)



Low Algae Cover
(5-15%)

5. Other benthic macro-invertebrates

This layer displayed site data as proportional symbols. Benthic macro-invertebrates (excluding coral) were represented in maps using symbols of proportional size to represent percent cover, with pie charts representing the contributions of the various sub-catagories.

Critical Marine Habitats of Hydrographers Passage

A total of 488 habitat assessment sites were surveyed on the reefs adjacent to Hydrographers Passage (Table 1; Map 2). The survey assessed a total of 13,569 ha of intertidal reef area, with individual reefs ranging in size from 44ha (Bond Reef) to 3,452 ha (Big Stevens Reef) (Table 2). In general, macro-algae and coral were the dominant habitat types within the survey area (Table 1; Maps 3 & 4) although some reefs had large areas that were dominated by open substrate and other benthic macro-invertebrate types such as sponges (Table 1). While algae and coral were the dominant habitat types there were differences in the type of coral and algae that were dominant between and within reefs. No seagrass was found on any of the intertidal areas of reefs assessed in this survey.

Coral habitat on reefs adjacent to Hydrographers Passage

Coral

Coral was found on all of the reefs assessed in this survey but was not always the dominant habitat feature with only 21% of the total reef area surveyed having a coral cover (combined hard and soft) greater than 30% (Table 2). The coral cover was not uniform with most reefs containing distinct high and low coral cover zones (Map 3). The highest cover of coral tended to be at the outer edges of reefs and on the edge of reef slopes with the central region of the reef tops tending to have lower coral cover (Map 3).

Table 1 Reefs surveyed, number of survey sites and mean percent cover of major benthic categories for reef survey sites in Hydrographers Passage

Reef	Map	Number of sites	Mean site % cover for benthic categories				
			Macro-algae	Hard Coral	Soft Coral	Open	Other BMI
Little Stevens Reef	5	83	38%	8%	6%	34%	15%
Big Stevens Reef	5	63	53%	5%	1%	35%	6%
Liff Reef	6	13	41%	24%	0	31%	4%
Boulton Reef	6	49	42%	19%	1%	32%	7%
Creal Reef	8	11	29%	29%	7%	34%	1%
Warland Reef	8	30	38%	23%	7%	27%	4%
Cole Reef # 1	7	16	51%	19%	4%	23%	3%
Cole Reef # 2	7	16	42%	22%	10%	23%	3%
Cole Reef # 3	7	19	45%	18%	9%	23%	5%
Wup Reef	9	13	44%	41%	1%	13%	2%
Little Bugatti Reef	9	42	39%	26%	7%	24%	4%
Bugatti Reef	10	82	41%	29%	7%	19%	4%
Ben Reef	10	7	50%	28%	19%	3%	1%
Abbott Reef	11	1	30%	30%	0	38%	2%
Bond Reef	11	4	66%	34%	1%	0	0
White Tip Reef	11	39	50%	20%	12%	11%	6%
Total		**488**	**44%**	**23%**	**6%**	**23%**	**4%**

Table 2 Total intertidal area, area of each coral cover category, mean percent coral cover and proportion of hard and soft coral for reefs surveyed in Hydrographers Passage

Reef	Map	Reef top area (ha)	Area of reef top for each coral cover category (ha) *(Values in brackets are % of total reef area)*					Average coral % cover	Proportion of hard coral (%)	Proportion of soft coral (%)
			Very low (0-5%)	Low (5-15%)	Moderate (15-30%)	High (30-50%)	Very high (50-100%)			
Little Stevens	5	2,324	0	2,301 *(99)*	23 *(1)*	0	0	21	63%	37%
Big Stevens	5	3,452	2,808 *(81)*	382 *(11)*	262 *(8)*	0	0	14	71%	29%
Liff	6	274	218 *(80)*	0	0	56 *(20)*	0	26	99%	1%
Boulton	6	1,732	1,157 *(67)*	0	105 *(6)*	470 *(27)*	0	21	92%	8%
Creal	8	158	0	0	129 *(82)*	0	29 *(18)*	52	92%	8%
Warland	8	1,033	0	0	0	1,033 *(100)*	0	30	74%	26%
Cole 1	7	337	0	258 *(77)*	54 *(16)*	25 *(7)*	0	25	87%	13%
Cole 2	7	579	0	0	502 *(87)*	77 *(13)*	0	35	72%	28%
Cole 3	7	547	0	0	447 *(82)*	32 *(6)*	68 *(12)*	42	84%	16%
Wup	9	134	0	92 *(69)*	0	0	42 *(31)*	33	97%	3%
Little Bugatti	9	660	0	0	521 *(79)*	127 *(19)*	12 *(2)*	40	85%	15%
Bugatti	10	1,501	0	0	833 *(55)*	502 *(33)*	166 *(11)*	41	81%	19%
Ben	10	45	0	0	0	45 *(100)*	0	46	60%	40%
Abbott	11	63	0	0	63 *(100)*	0	0	30	100%	0%
Bond	11	44	0	0	0	44 *(100)*	0	34	99%	1%
White Tip	11	686	0	534 *(78)*	0	0	152 (22)	62	61%	39%
TOTAL		**13,569**	**4,183 (31%)**	**3,567 (26%)**	**2,939 (22%)**	**2,411 (18%)**	**469 (3%)**			

Coral (continued)

The two largest reefs in the survey area, Little Stevens and Big Stevens, had the lowest cover of coral with the majority of their reef top areas containing very low (0-5%) or low (5-10%) cover (Map 5; Figure 2; Table 2). The majority of nearby Boulton and Liff Reefs were also dominated by very low coral cover (67% and 80% of reef area respectively) with only a narrow strip of high cover occurring around the outer edges of the reefs (Map 6; Figure 2; Table 2). Large sections of Cole No 1, Wup and White Tip Reefs were also of low coral cover although these reefs also contained significant areas of very high cover (50-100%) around their outer edges (Maps 7, 9 & 11; Figure 2; Table 2). Cole 2 & 3, Warland, Creal, Little Bugatti, Bugatti, Ben, Bond and Abbott Reefs were dominated by moderate (15-30%) to high (30-50%) coral cover (Maps 7-11; Figure 2; Table 2).

Reefs contained a mix of both hard and soft corals although hard corals were the dominant form of coral present for all of the surveyed reefs (Maps 5-11; Table 2). Massive, branching and encrusting corals were the dominant hard coral types making up 26%, 23% and 21% of the total hard coral cover in the survey area respectively (Table 3). Composition of hard coral types varied considerably between and within reefs (Table 3 Maps 5-11). Massive corals were the dominant hard coral type for reefs that had a low overall coral cover such as Little Stevens and Big Stevens Reefs and massive and sub-massive corals also dominated the low density regions of the other reefs in the survey area (Table 3; Maps 5-11). Reefs with higher cover of coral tended to have a higher diversity of coral types (Table 3). Branching, digitate and tabular corals were most common near the edges of reefs and on reefs located farthest offshore (Maps 5-11). Foliose and mushroom corals contributed only a minor proportion of the hard coral cover for reefs in the survey area (Table 3; Maps 5-11).

Bugatti Reef edge, Hydrographers Passage

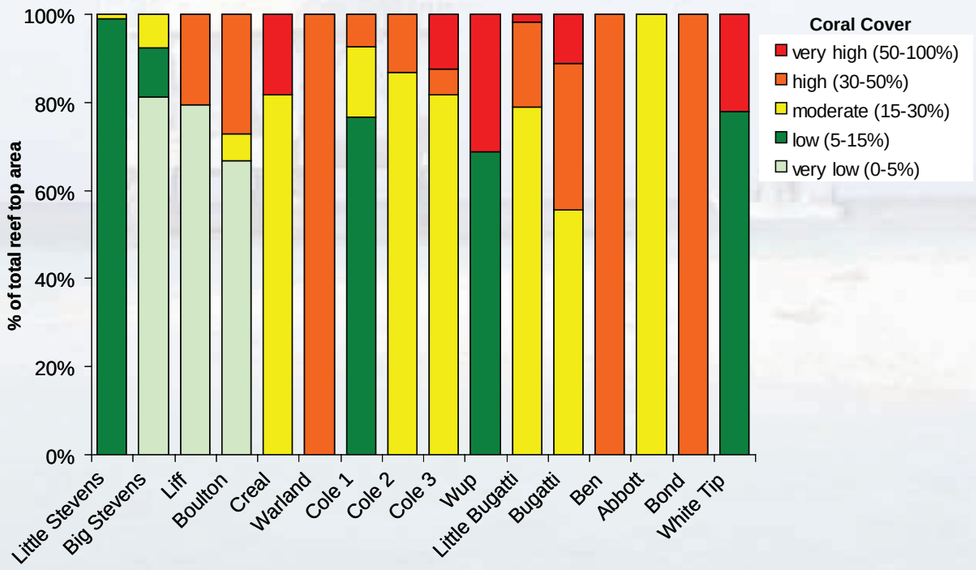
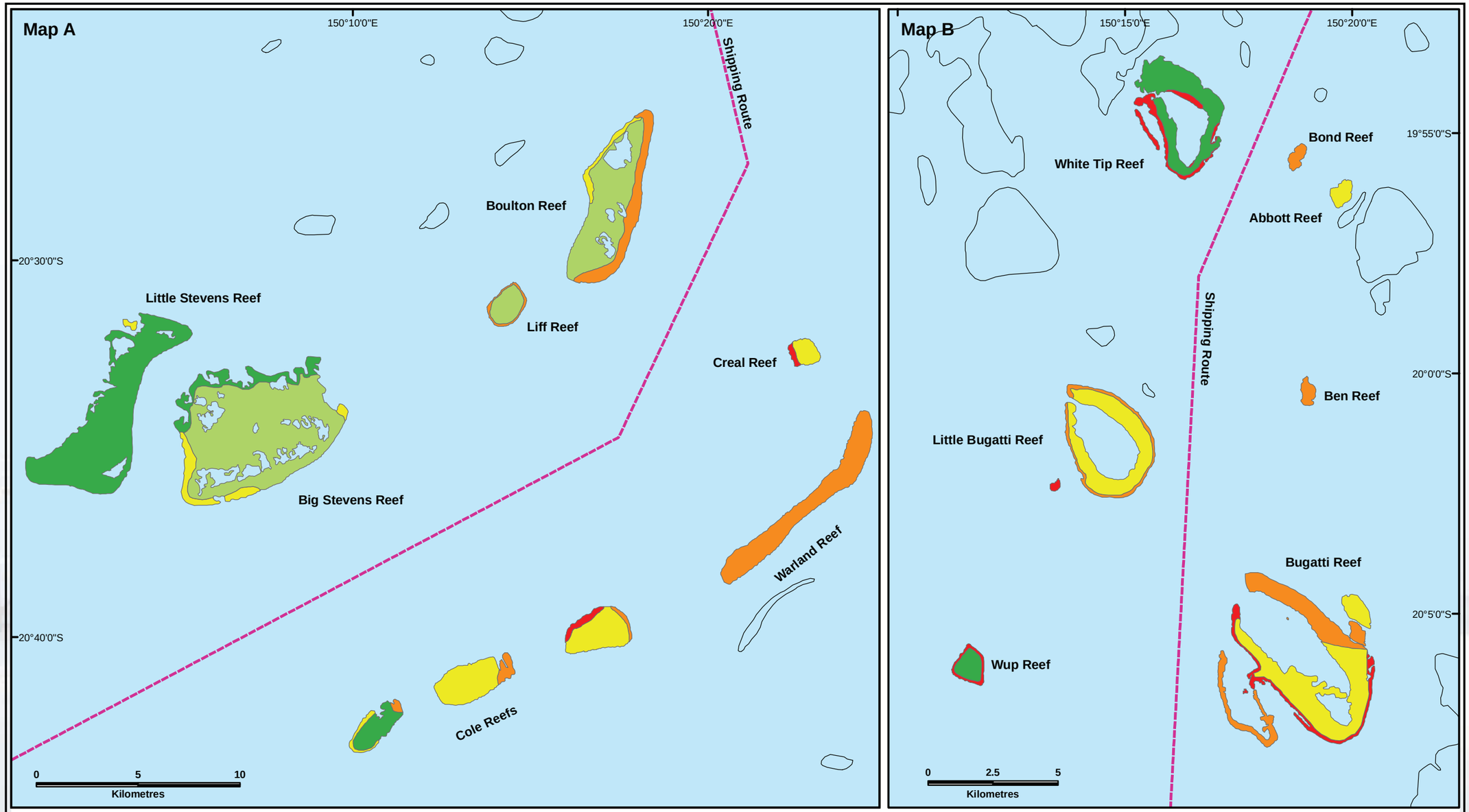


Figure 2 Percent of total reef top area for each coral cover category, Hydrographers Passage 2003

Table 3 Percent cover of hard coral with the proportion of each hard coral type surveyed in Hydrographers Passage 2003

Reef	Map	% cover of hard coral	Proportion of each hard coral type (% of total hard coral cover)							
			Branching	Massive	Sub-massive	Tabular	Digitate	Foliose	Encrusting	Mushroom
Little Stevens	5	13	13.6	70.1	3.5	1.6	6.5	0.0	4.6	0.0
Big Stevens	5	10	19.5	50.8	5.9	0.2	2.8	0.1	16.5	4.2
Liff	6	26	35.4	31.7	0.4	5.4	11.3	0.0	15.8	0.0
Boulton	6	19	27.4	26.0	8.5	0.3	17.9	0.1	19.6	0.0
Creal	8	48	22.0	25.5	40.5	1.0	6.0	0.8	4.0	0.2
Warland	8	22	19.5	32.1	22.9	2.1	17.9	0.2	5.0	0.3
Cole 1	7	22	18.4	30.0	2.5	0.0	9.1	0.0	40.0	0.0
Cole 2	7	25	26.3	26.8	3.1	2.5	5.6	0.0	34.6	1.1
Cole 3	7	35	16.7	48.3	8.1	2.8	16.4	0.0	7.8	0.0
Wup	9	32	35.3	6.7	5.8	3.8	21.1	0.0	27.3	0.0
Little Bugatti	9	34	35.3	17.0	20.4	2.2	18.8	0.0	6.4	0.0
Bugatti	10	33	36.5	15.1	12.9	5.0	15.6	0.1	14.5	0.3
Ben	10	28	21.4	11.4	19.3	2.9	10.7	0.0	34.3	0.0
Abbott	11	30	0.0	0.0	0.0	0.0	50.0	0.0	50.0	0.0
Bond	11	34	30.0	2.0	2.5	6.3	30.0	0.0	29.3	0.0
White Tip	11	38	17.5	15.9	19.1	1.7	18.1	0.0	27.5	0.0
TOTAL			**23.4**	**25.6**	**11.0**	**2.4**	**16.1**	**0.1**	**21.1**	**0.4**

Map 3. Coral Percent Cover for Reefs Adjacent to Hydrographers Passage, October 2003



Source:
Rasheed, M.A., Nguyen, T.Q., Taylor, H.A. and Thomas, R. (2006). Critical marine habitats adjacent to the high risk Hydrographers Passage Shipping Route, Great Barrier Reef, Queensland, Australia - 2006 Atlas. QDPI&F Information Series QI06081, (QDPI&F, Northern Fisheries Centre, Cairns).
Survey dates: 30th September - 9th October 2003.
Funded by CRC Reef Research Centre

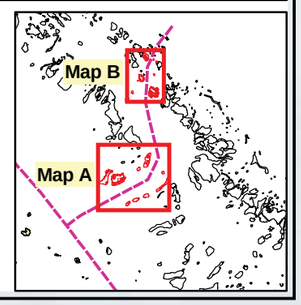
Produced by the Marine Ecology Group, QDPI&F, Northern Fisheries Centre, Cairns.

Legend

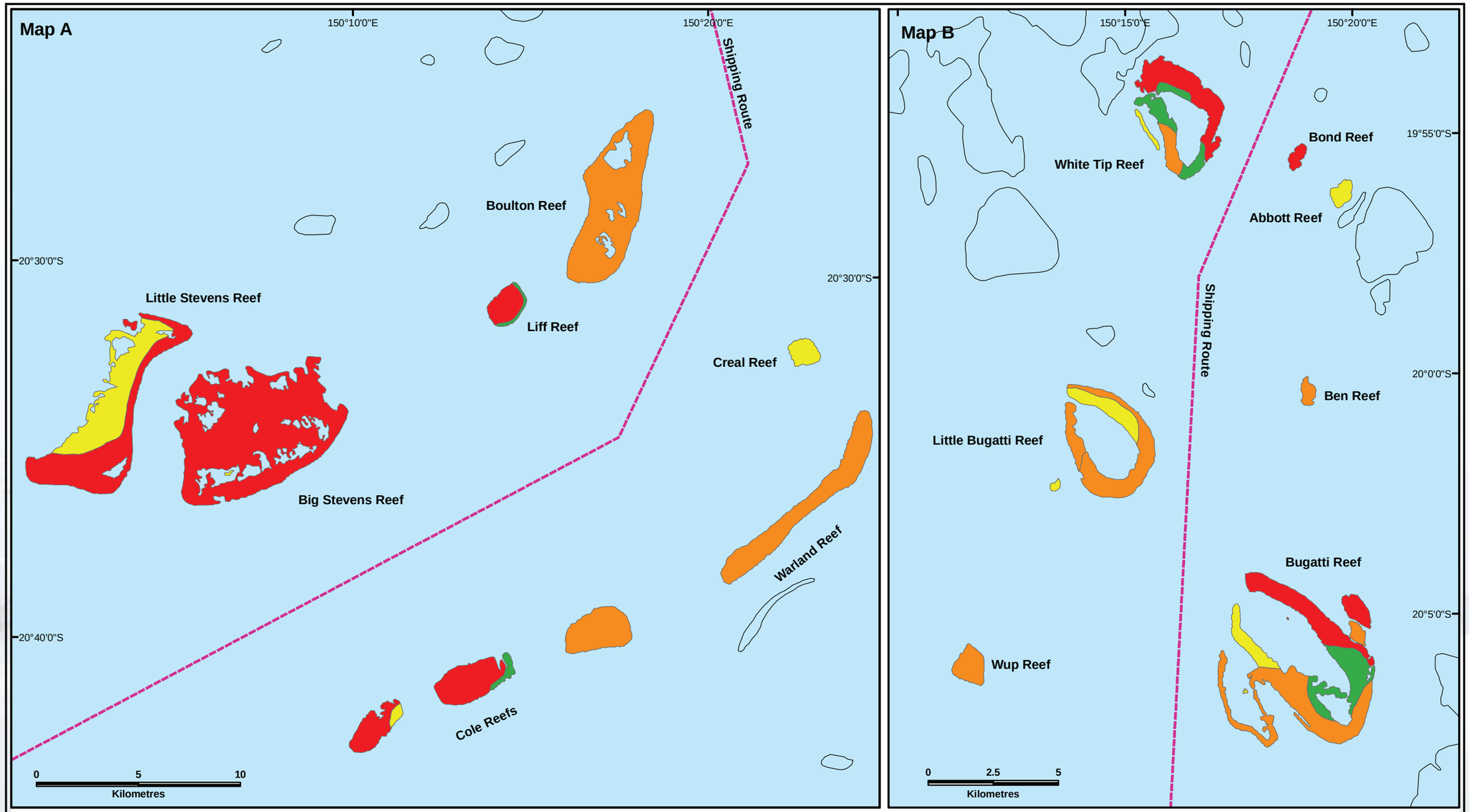
Coral % Cover
- very low (0-5%)
- low (5 - 15%)
- moderate (15 - 30%)
- high (30 - 50%)
- very high (50 - 100%)

N

- Shipping Channel
- Reefs Not Surveyed



Map 4. Algae Percent Cover for Reefs Adjacent to Hydrographers Passage, October 2003



Source:
Rasheed, M.A., Nguyen, T.Q., Taylor, H.A. and Thomas, R. (2006). Critical marine habitats adjacent to the high risk Hydrographers Passage Shipping Route, Great Barrier Reef, Queensland, Australia - 2006 Atlas. QDPI&F Information Series QI06081, (QDPI&F, Northern Fisheries Centre, Cairns).
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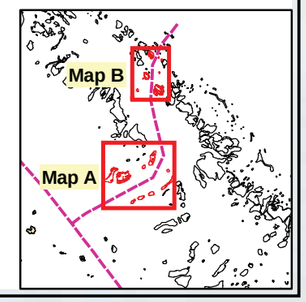
Legend

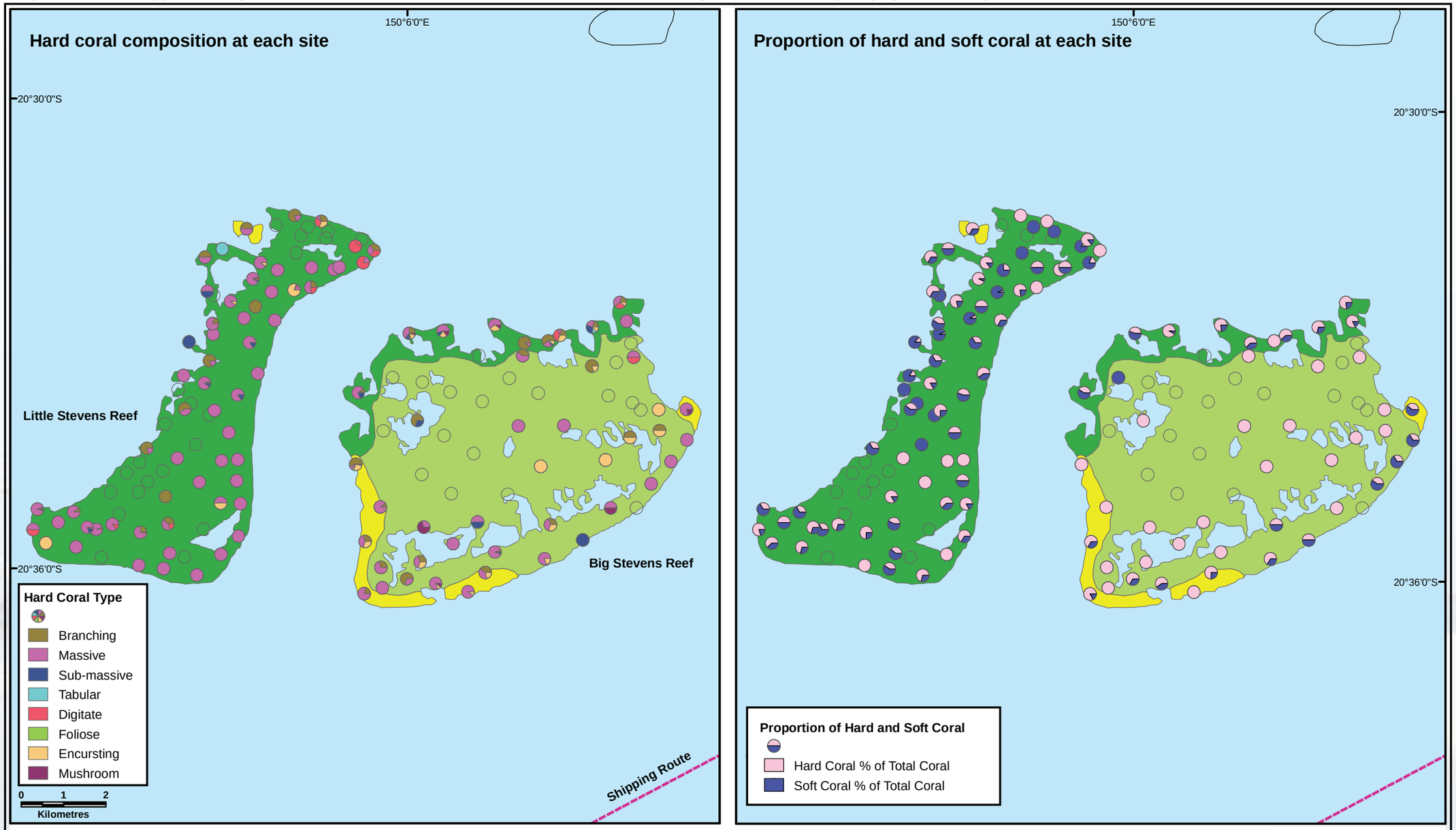
Algae % Cover
- very low (0 - 5%)
- low (5 - 15%)
- moderate (15 - 30%)
- high (30 - 50%)
- very high (50 -100%)

N

- Shipping Channel
- Reefs Not Surveyed



Map 5. Hard Coral Type and Proportion of Hard and Soft Coral for Sites on Little Stevens and Big Stevens Reefs, Hydrographers Passage, October 2003



Source:
Rasheed, M.A., Nguyen, T.Q., Taylor, H.A. and Thomas, R. (2006). Critical marine habitats adjacent to the high risk Hydrographers Passage Shipping Route, Great Barrier Reef, Queensland, Australia - 2006 Atlas. QDPI&F Information Series QI06081, (QDPI&F, Northern Fisheries Centre, Cairns).
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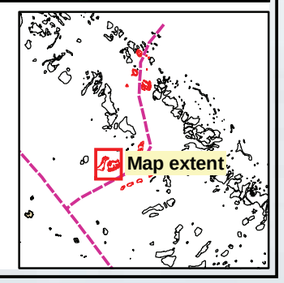
Legend

Coral % Cover
- very low (0 - 5%)
- low (5 - 15%)
- moderate (15 - 30%)
- high (30 - 50%)
- very high (50 - 100%)

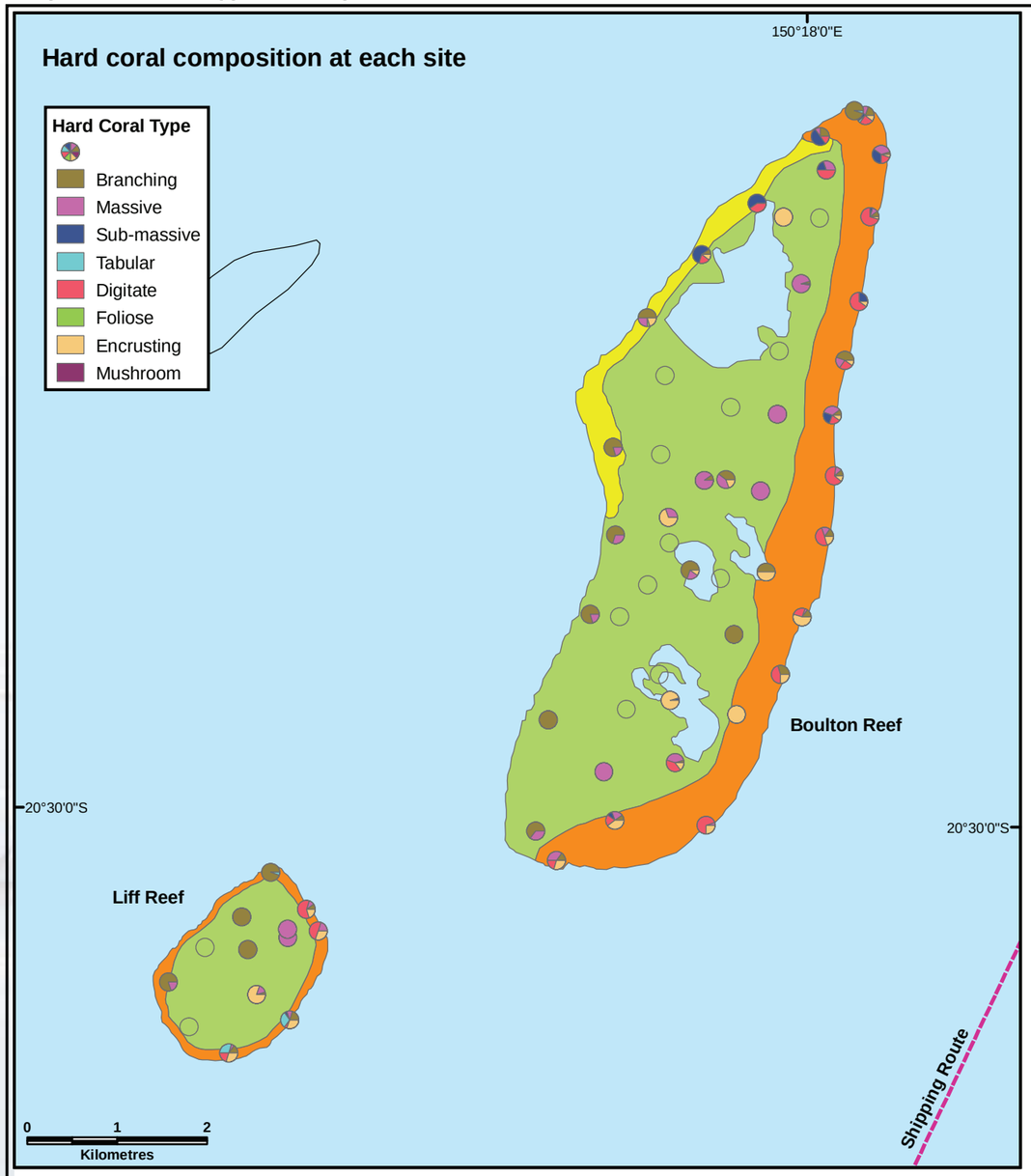
N

- Shipping Channel
- Reefs Not Surveyed



Map 6. Hard Coral Type and Proportion of Hard and Soft Coral for Sites on Liff and Boulton Reefs, Hydrographers Passage, October 2003

Hard coral composition at each site



Proportion of hard and soft coral at each site

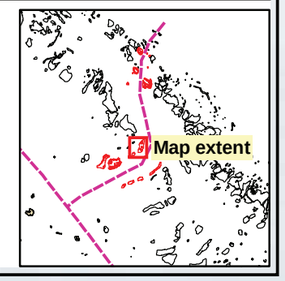
Source:
Rasheed, M.A., Nguyen, T.Q., Taylor, H.A. and Thomas, R. (2006). Critical marine habitats adjacent to the high risk Hydrographers Passage Shipping Route, Great Barrier Reef, Queensland, Australia - 2006 Atlas. QDPI&F Information Series QI06081, (QDPI&F, Northern Fisheries Centre, Cairns).
Survey dates: 30th September - 9th October 2003.
Funded by CRC Reef Research Centre

Legend

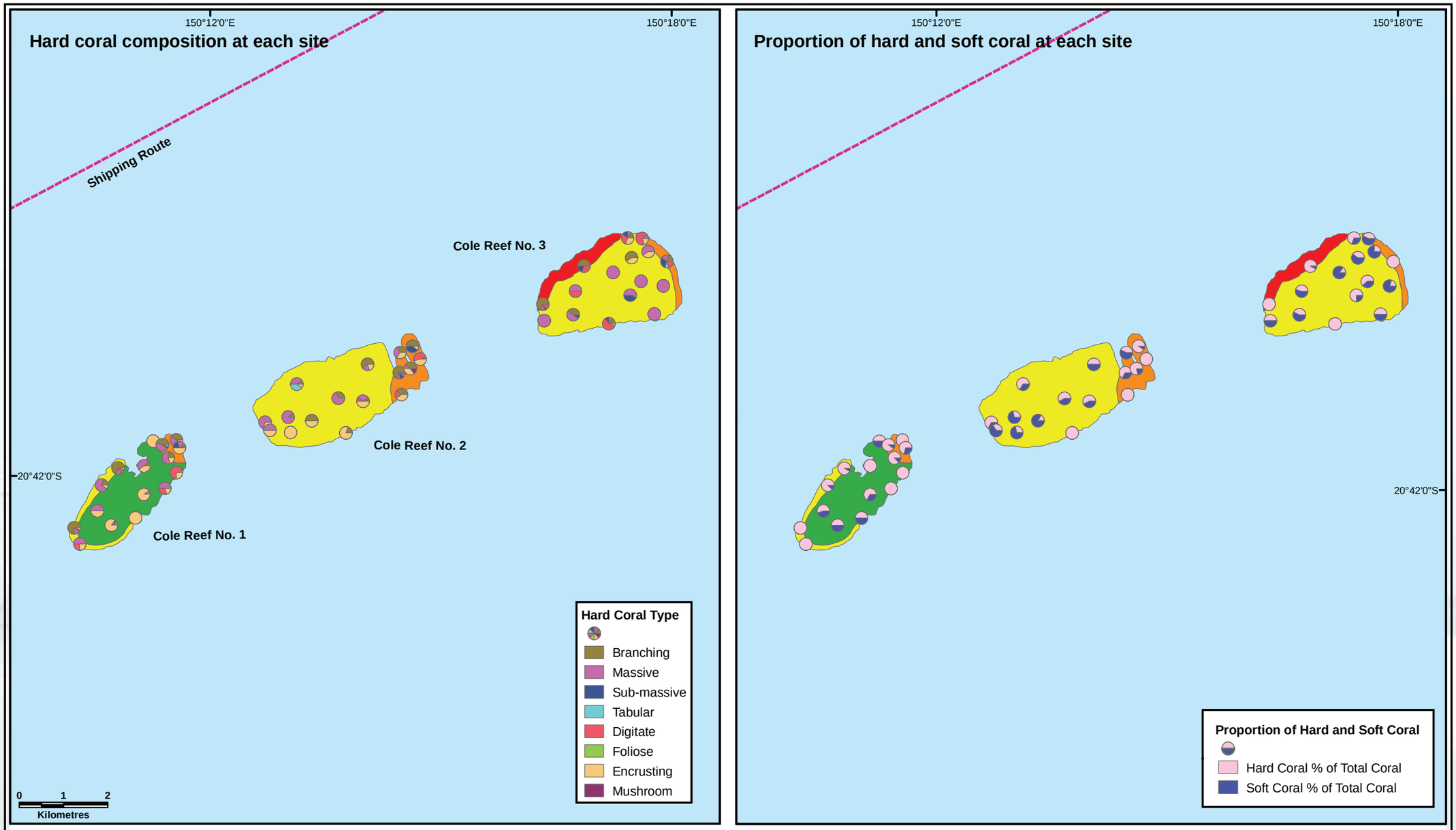
Coral % Cover
- very low (0 - 5%)
- low (5 - 15%)
- moderate (15 - 30%)
- high (30 - 50%)
- very high (50 - 100%)

N

- Shipping Channel
- Reefs Not Surveyed



Map 7. Hard Coral Type and Proportion of Hard and Soft Coral for Sites on Cole Reefs, Hydrographers Passage, October 2003



Source:
Rasheed, M.A., Nguyen, T.Q., Taylor, H.A. and Thomas, R. (2006). Critical marine habitats adjacent to the high risk Hydrographers Passage Shipping Route, Great Barrier Reef, Queensland, Australia - 2006 Atlas. QDPI&F Information Series QI06081, (QDPI&F, Northern Fisheries Centre, Cairns).
Survey dates: 30th September - 9th October 2003.
Funded by CRC Reef Research Centre

Produced by the Marine Ecology Group, QDPI&F, Northern Fisheries Centre, Cairns.

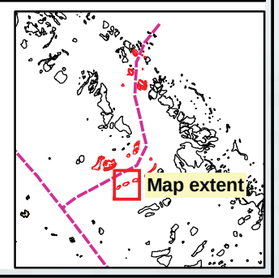
Legend

Coral % Cover
- very low (0 - 5%)
- low (5 - 15%)
- moderate (15 - 30%)
- high (30 - 50%)
- very high (50 - 100%)

N

Shipping Channel

Reefs Not Surveyed



Map 8. Hard Coral Type and Proportion of Hard and Soft Coral for Sites on Creal and Warland Reefs, Hydrographers Passage, October 2003

Hard coral composition at each site

150°24'0"E

Hard Coral Type
- Branching
- Massive
- Sub-massive
- Tabular
- Digitate
- Foliose
- Encrusting
- Mushroom

Creal Reef

Warland Reef

20°36'0"S

0 1 2
Kilometres

Proportion of hard and soft coral at each site

150°24'0"E

20°36'0"S

Proportion of Hard and Soft Coral
- Hard Coral % of Total Coral
- Soft Coral % of Total Coral

Legend

Coral % Cover
- very low (0 - 5%)
- low (5 - 15%)
- moderate (15 - 30%)
- high (30 - 50%)
- very high (50 - 100%)

Shipping Channel

Reefs Not Surveyed

N

Map extent

Source:
Rasheed, M.A., Nguyen, T.Q., Taylor, H.A. and Thomas, R. (2006). Critical marine habitats adjacent to the high risk Hydrographers Passage Shipping Route, Great Barrier Reef, Queensland, Australia - 2006 Atlas. QDPI&F Information Series QI06081, (QDPI&F, Northern Fisheries Centre, Cairns).
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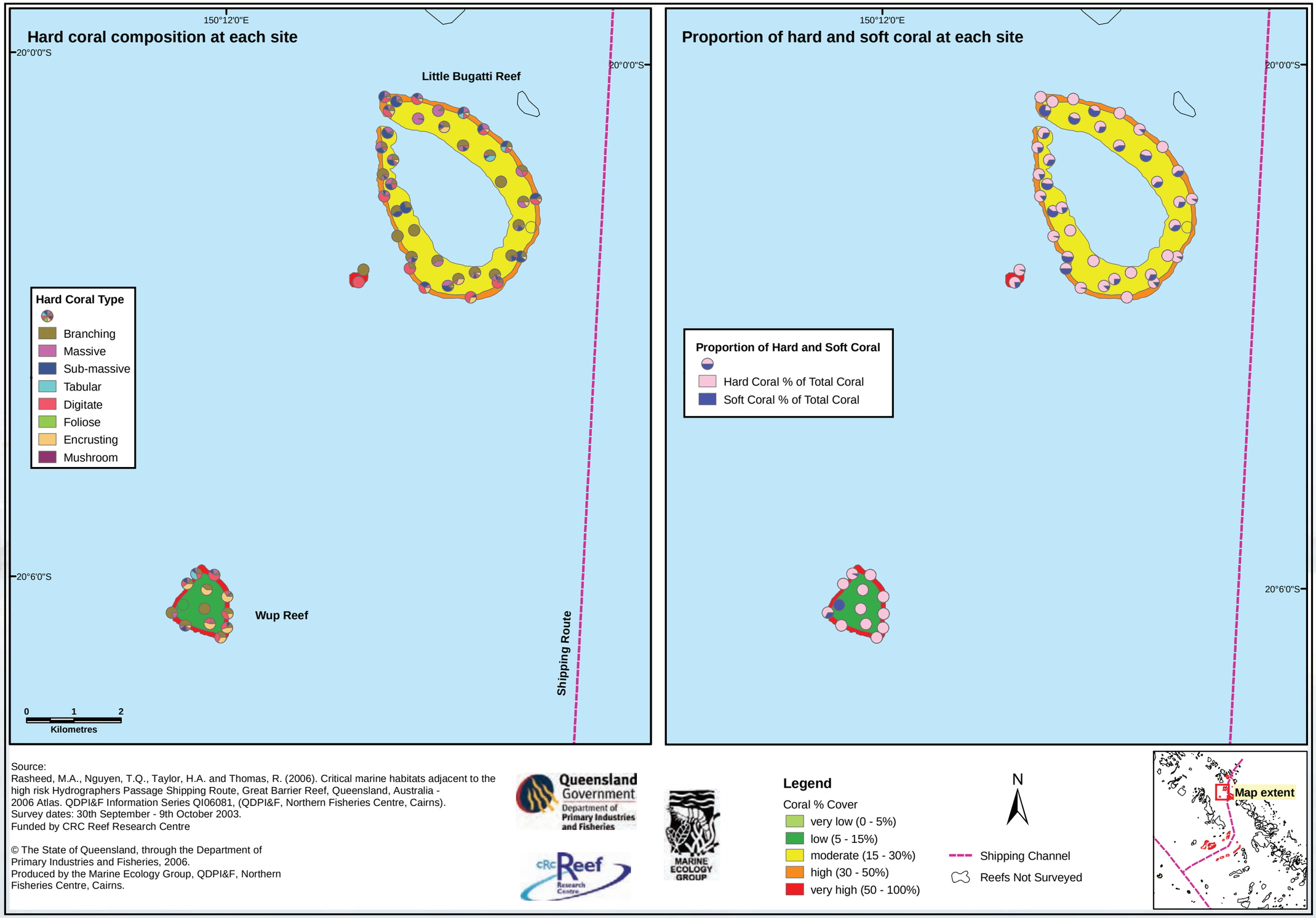
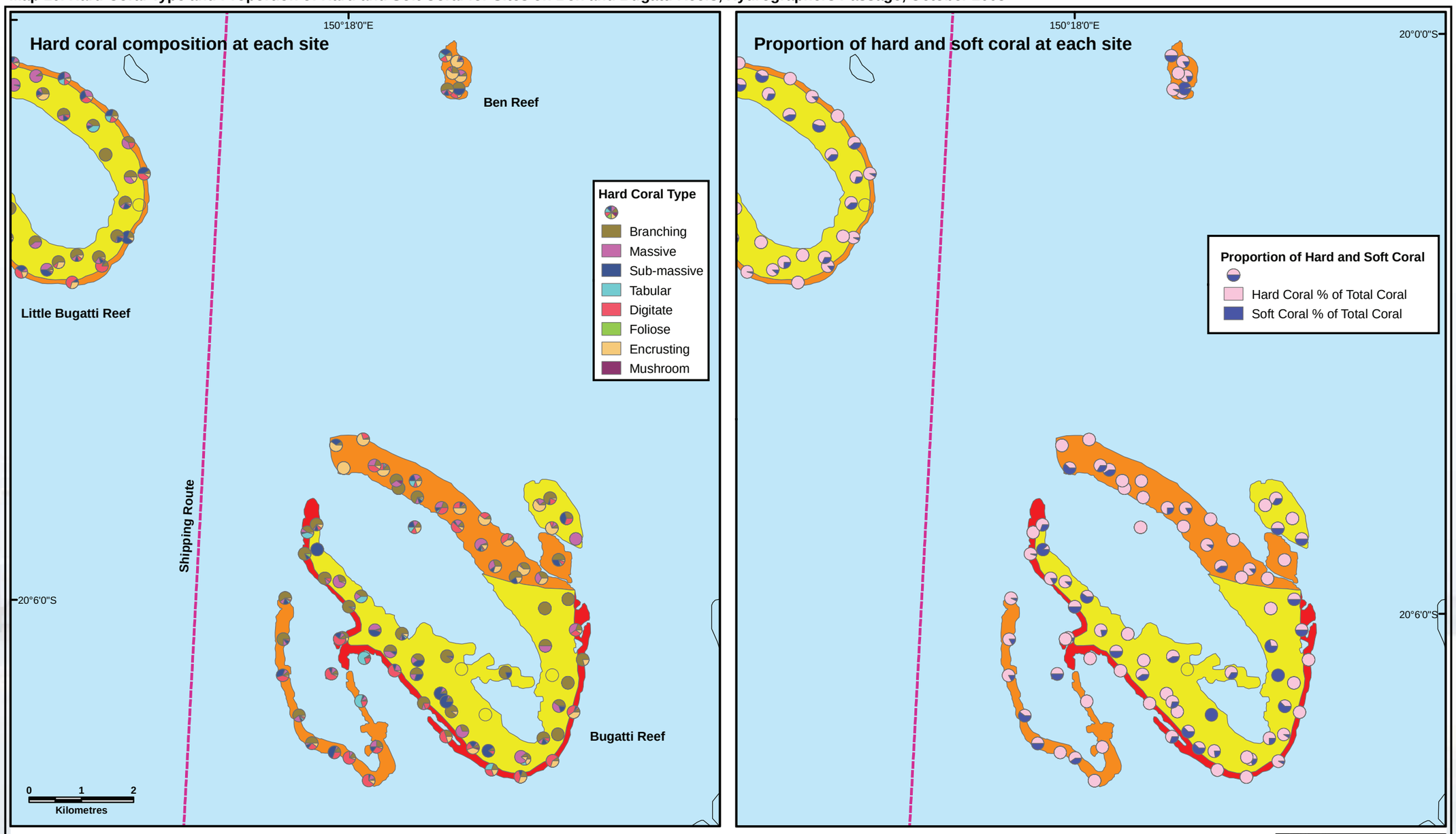
Map 9. Hard Coral Type and Proportion of Hard and Soft Coral for Sites on Wup and Little Bugatti Reefs, Hydrographers Passage, October 2003



Source:
Rasheed, M.A., Nguyen, T.Q., Taylor, H.A. and Thomas, R. (2006). Critical marine habitats adjacent to the high risk Hydrographers Passage Shipping Route, Great Barrier Reef, Queensland, Australia - 2006 Atlas. QDPI&F Information Series QI06081, (QDPI&F, Northern Fisheries Centre, Cairns).
Survey dates: 30th September - 9th October 2003.
Funded by CRC Reef Research Centre

Produced by the Marine Ecology Group, QDPI&F, Northern Fisheries Centre, Cairns.

Map 10. Hard Coral Type and Proportion of Hard and Soft Coral for Sites on Ben and Bugatti Reefs, Hydrographers Passage, October 2003



Source:
Rasheed, M.A., Nguyen, T.Q., Thomas, R. and Taylor, H.A. (2006). Critical marine habitats adjacent to the high risk Hydrographers Passage Shipping Route, Great Barrier Reef, Queensland, Australia - 2006 Atlas. QDPI&F Information Series QI06081, (QDPI&F, Northern Fisheries Centre, Cairns).
Survey dates: 30th September - 9th October 2003.
Funded by CRC Reef Research Centre

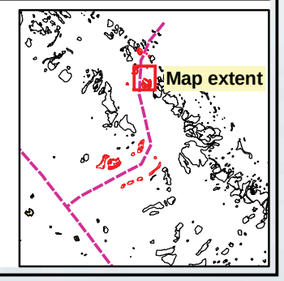
Produced by the Marine Ecology Group, QDPI&F, Northern Fisheries Centre, Cairns.

Legend

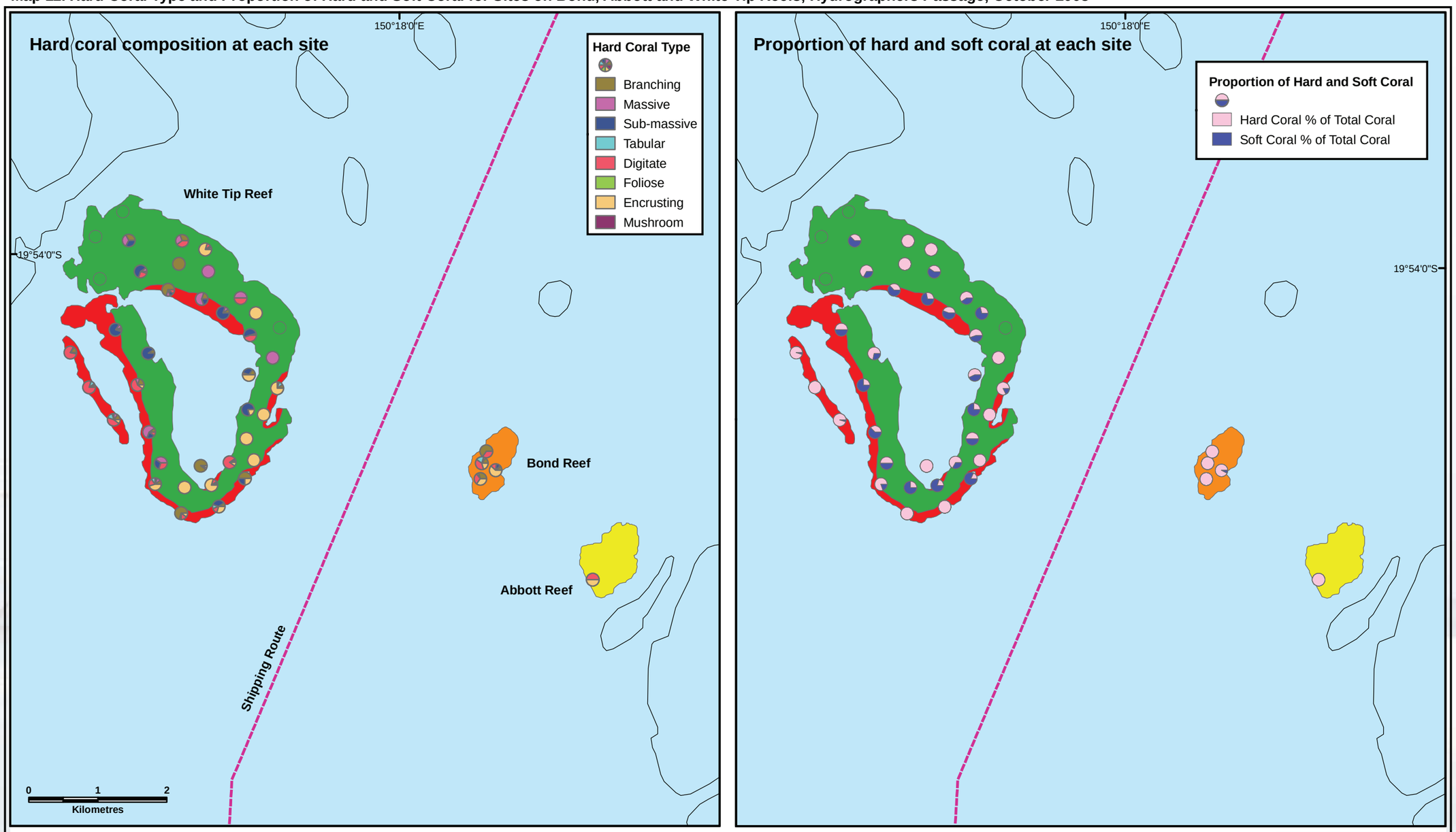
Coral % Cover
- very low (0 - 5%)
- low (5 - 15%)
- moderate (15 - 30%)
- high (30 - 50%)
- very high (50 - 100%)

N

- Shipping Channel
- Reefs Not Surveyed



Map 11. Hard Coral Type and Proportion of Hard and Soft Coral for Sites on Bond, Abbott and White Tip Reefs, Hydrographers Passage, October 2003



Source:
Rasheed, M.A., Nguyen, T.Q., Thomas, R. and Taylor, H.A. (2006). Critical marine habitats adjacent to the high risk Hydrographers Passage Shipping Route, Great Barrier Reef, Queensland, Australia - 2006 Atlas. QDPI&F Information Series QI06081, (QDPI&F, Northern Fisheries Centre, Cairns).
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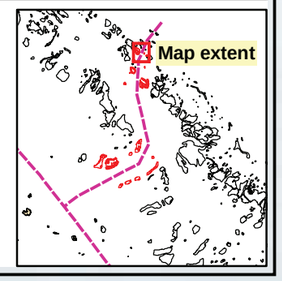
Legend

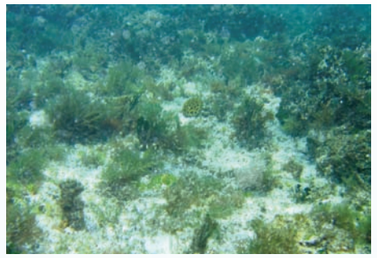
Coral % Cover
- very low (0 - 5%)
- low (5 - 15%)
- moderate (15 - 30%)
- high (30 - 50%)
- very high (50 - 100%)

N

Shipping Channel

Reefs Not Surveyed





Macro-algae

Macro-algae were found on all of the reefs surveyed and were often the dominant habitat feature with 84% of the total reef area surveyed having at least a moderate macro-algae cover (>30%) (Table 4). Unlike, coral cover algae cover was more uniform for most reefs. Several reefs contained only one density category of algae (Figure 3; Table 4; Map 4). High (30-50%) and very high (>50%) algae cover regions dominated the majority of reefs with only White Tip and Bugatti Reefs containing significant areas of low algae cover (Figure 3; Table 4; Maps 12-15). There were no algae regions mapped with less than 5% cover of algae (Figure 3; Table 4; Maps 12-15).

The macro-algae communities of Hydrographers Passage reef tops were dominated by fast growing and structurally basic growth forms. Turf mat and encrusting algae were the dominant forms of algae on the surveyed reefs making up 55% and 25% of the area surveyed respectively (Table 5). Turf mat was the dominant functional group of algae for all of the larger reefs surveyed and generally occurred on sediments between coral colonies and on the large, mostly open areas of the reef tops (Table 5; Maps 12-15). Encrusting algae was more common on the smaller reefs that had a high coral cover (Bond, Abbott, Ben and Wup) and occurred as part of the reef matrix or on hard substrates such as dead coral colonies and "coral rock" (Table 5; Maps 12-15). The larger growing, more structurally complex, erect macrophytes and erect calcareous algae formed only a minor component of the macro-algae communities (Table 5; Maps 12-15).

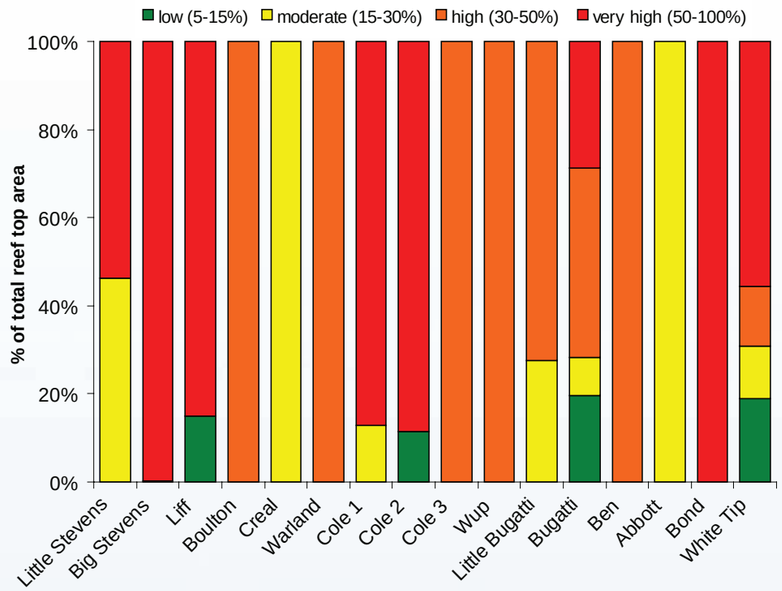


Figure 3 Percent of total reef top area for each algal cover category in Hydrographers Passage

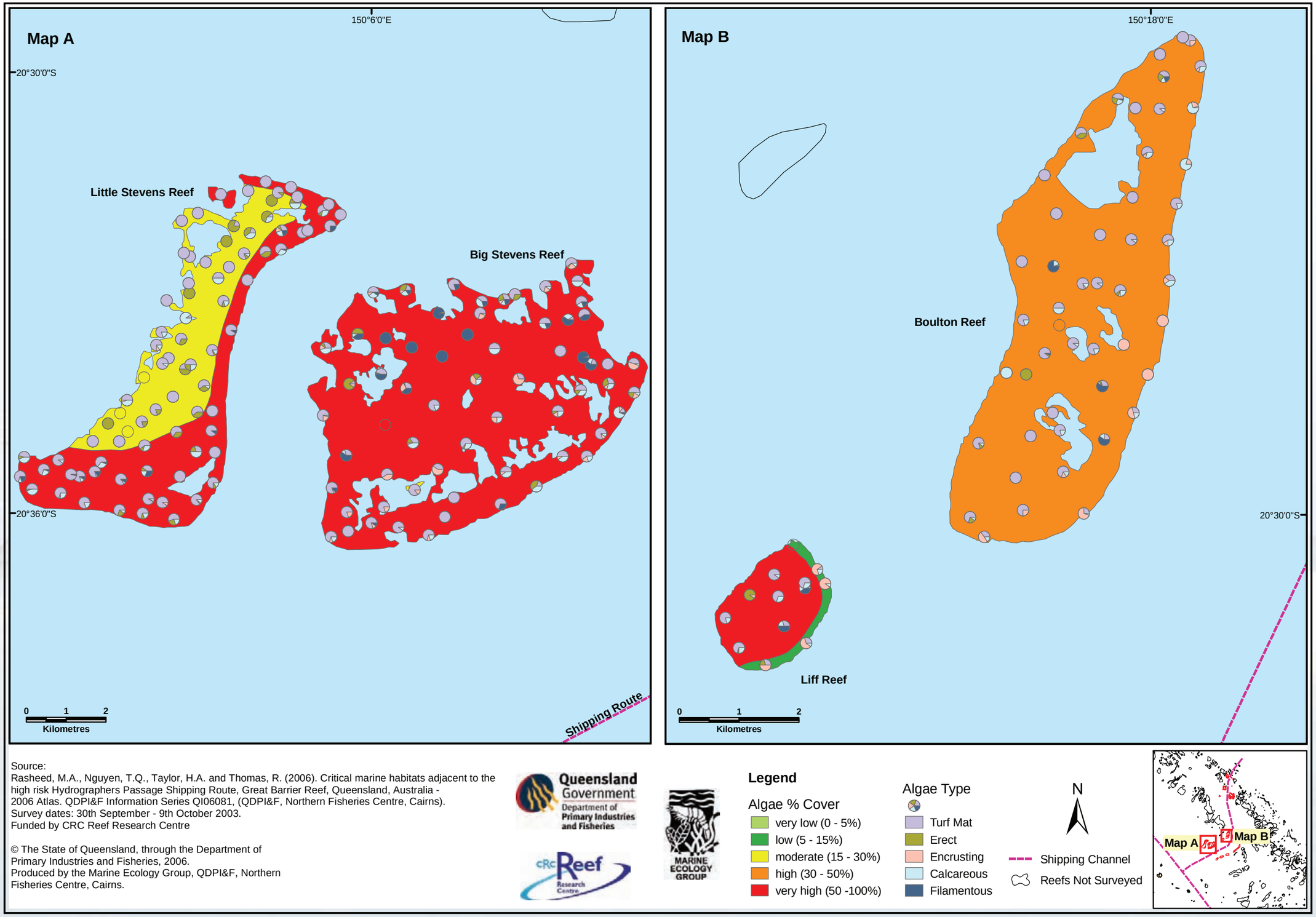
Table 4 Total intertidal area, area of each macro-algae cover category and mean percent algae cover for reefs surveyed in Hydrographers Passage

Reef	Map	Reef top area (ha)	Area of reef top for each algae cover category (ha) *(Values in brackets are % of total reef area)*					Average algae % cover
			Very low (0-5%)	Low (5-15%)	Moderate (15-30%)	High (30-50%)	Very high (50-100%)	
Little Stevens	5	2,324	0	0	1,076 *(46)*	0	1,248 *(54)*	38
Big Stevens	5	3,459	0	0	5 *(0.2)*	0	3,453 *(99.8)*	53
Liff	6	274	0	41 *(15)*	0	0	233 *(85)*	41
Boulton	6	1,740	0	0	0	1,740 *(100)*	0	42
Creal	8	157	0	0	157 *(100)*	0	0	29
Warland	8	1,033	0	0	0	1,033 *(100)*	0	38
Cole 1	7	337	0	0	43*(13)*	0	294 *(87)*	51
Cole 2	7	580	0	66 *(11)*	0	0	513 *(89)*	42
Cole 3	7	546	0	0	0	546 *(100)*	0	45
Wup	9	134	0	0	0	134 *(100)*	0	44
Little Bugatti	9	660	0	0	182 *(28)*	477 *(72)*	0	39
Bugatti	10	1,500	0	294 *(20)*	129 *(9)*	645 *(43)*	432 *(29)*	41
Ben	10	45	0	0	0	45 *(100)*	0	49
Abbott	11	63	0	0	63 *(100)*	0	0	30
Bond	11	44	0	0	0	0	44 *(100)*	66
White Tip	11	686	0	130 *(19)*	83 *(12)*	93 *(14)*	382 *(56)*	50
TOTAL		**13,581**	**0**	**531 (4%)**	**1,738 (13%)**	**4,713 (35%)**	**6,599 (49%)**	

Table 5 Percent cover of macro-algae with the proportion of each algal functional group for reefs surveyed in Hydrographers Passage

Reef	Map	% cover of macro-algae	Proportion of each algae functional group (% of total macro-algae cover)				
			Turfmat	Erect macrophytes	Encrusting	Erect calcareous	Filamentous
Little Stevens	5	38	72	14	1	12	2
Big Stevens	5	53	50	6	11	15	18
Liff	6	41	43	10	23	17	8
Boulton	6	42	61	5	13	15	5
Creal	8	29	64	0	18	15	3
Warland	8	38	70	2	11	16	1
Cole 1	7	51	79	16	1	4	0
Cole 2	7	42	68	7	13	12	0
Cole 3	7	45	61	8	13	16	2
Wup	9	44	45	2	46	7	0
Little Bugatti	9	39	50	11	23	14	2
Bugatti	10	41	58	7	23	11	1
Ben	10	49	44	4	46	6	0
Abbott	11	30	10	0	90	0	0
Bond	11	66	51	0	49	0	0
White Tip	11	50	57	4	16	23	0
TOTAL			**55**	**6**	**25**	**12**	**3**

Map 12. Algae Type (Functional Group) for Sites on Stevens, Little Stevens (Map A), Boulton and Liff Reefs (Map B), Hydrographers Passage, October 2003



Source:
Rasheed, M.A., Nguyen, T.Q., Taylor, H.A. and Thomas, R. (2006). Critical marine habitats adjacent to the high risk Hydrographers Passage Shipping Route, Great Barrier Reef, Queensland, Australia - 2006 Atlas. QDPI&F Information Series QI06081, (QDPI&F, Northern Fisheries Centre, Cairns).
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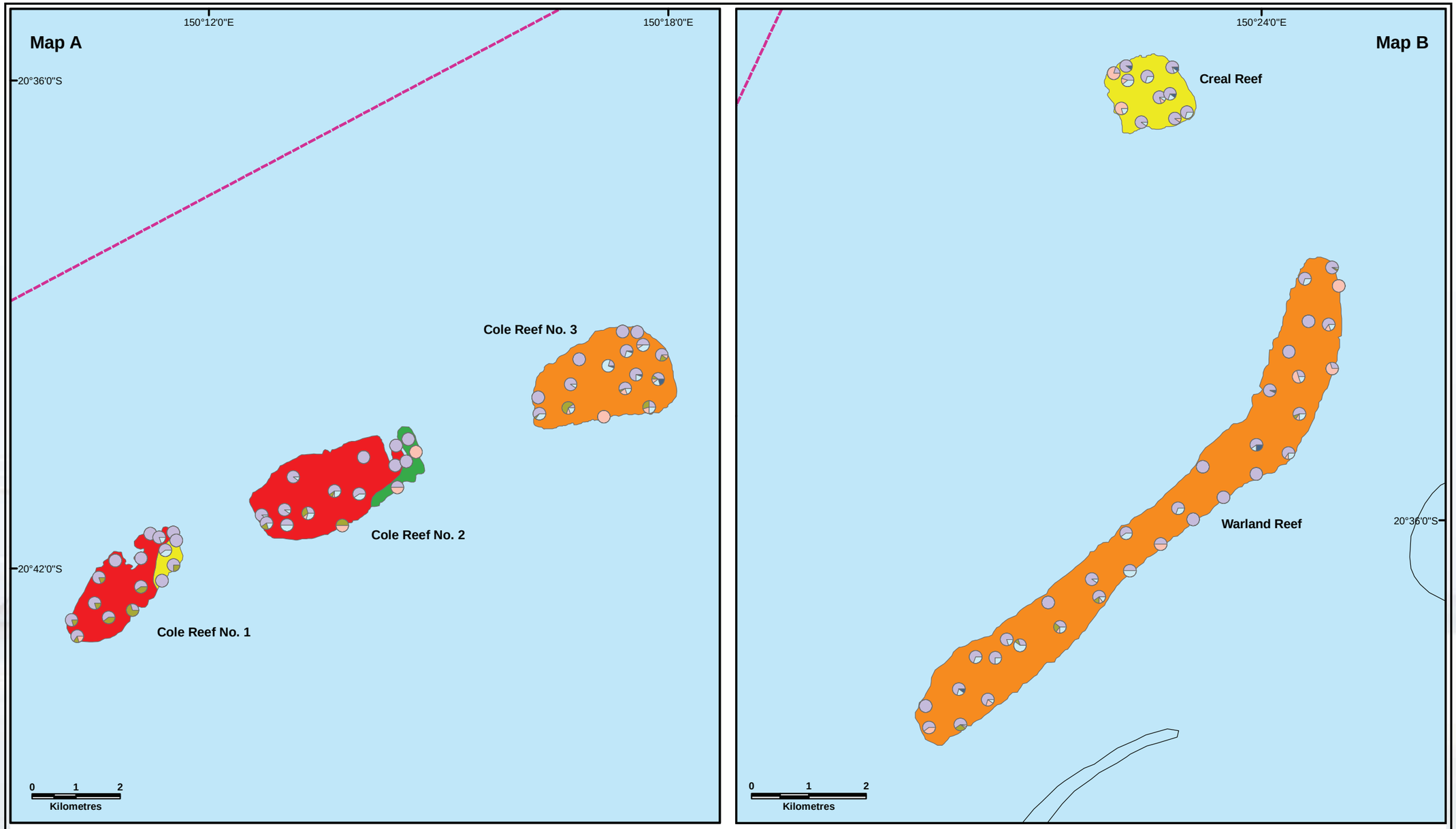
Map 13. Algae Type (Functional Group) for Sites on Cole (Map A), Warland and Creal Reefs (Map B), Hydrographers Passage, October 2003



Source:
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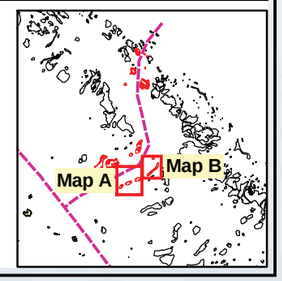
Legend

Algae % Cover
- very low (0 - 5%)
- low (5 - 15%)
- moderate (15 - 30%)
- high (30 - 50%)
- very high (50 -100%)

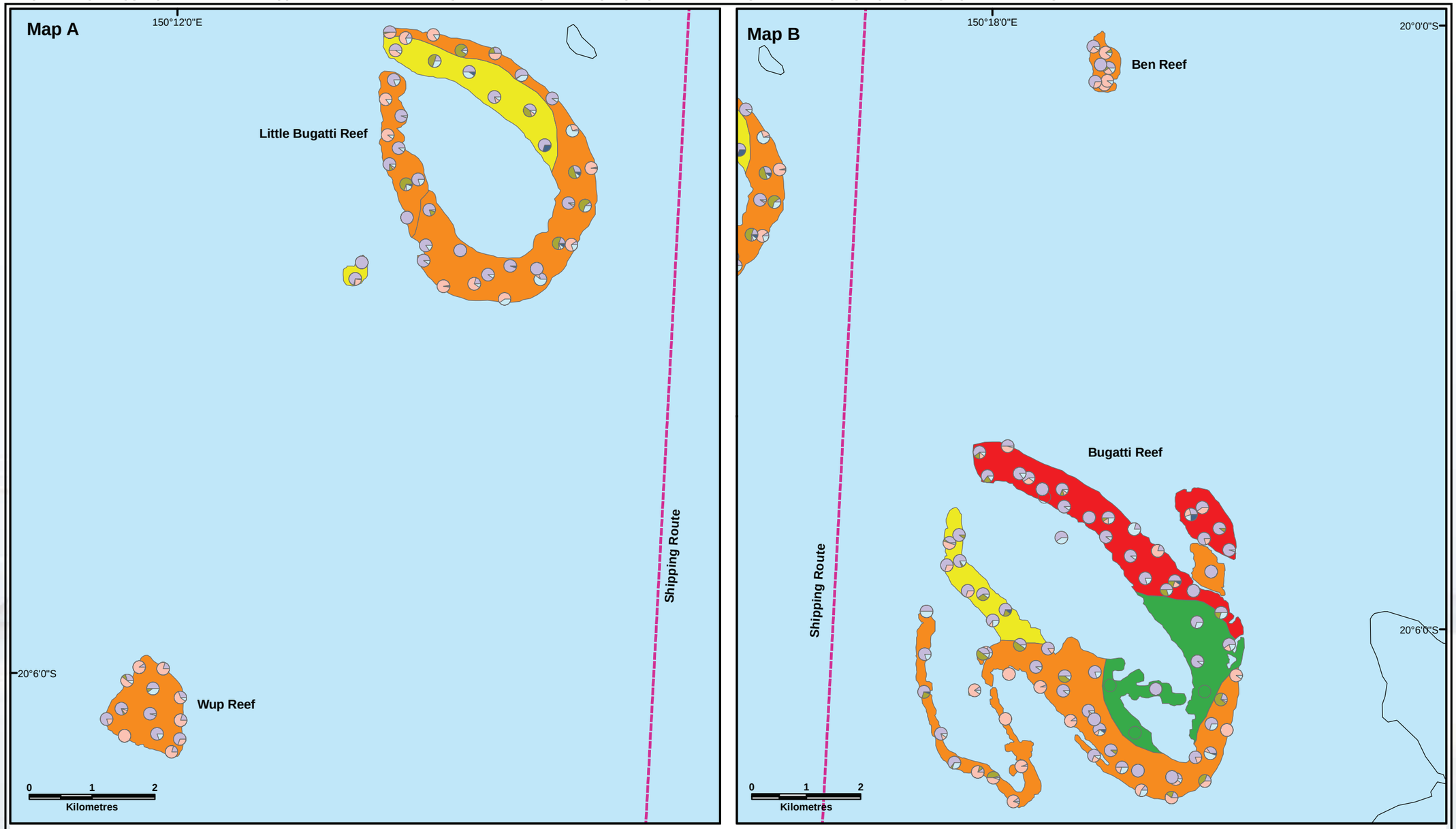
Algae Type
- Turf Mat
- Erect
- Encrusting
- Calcareous
- Filamentous

N

- Shipping Channel
- Reefs Not Surveyed



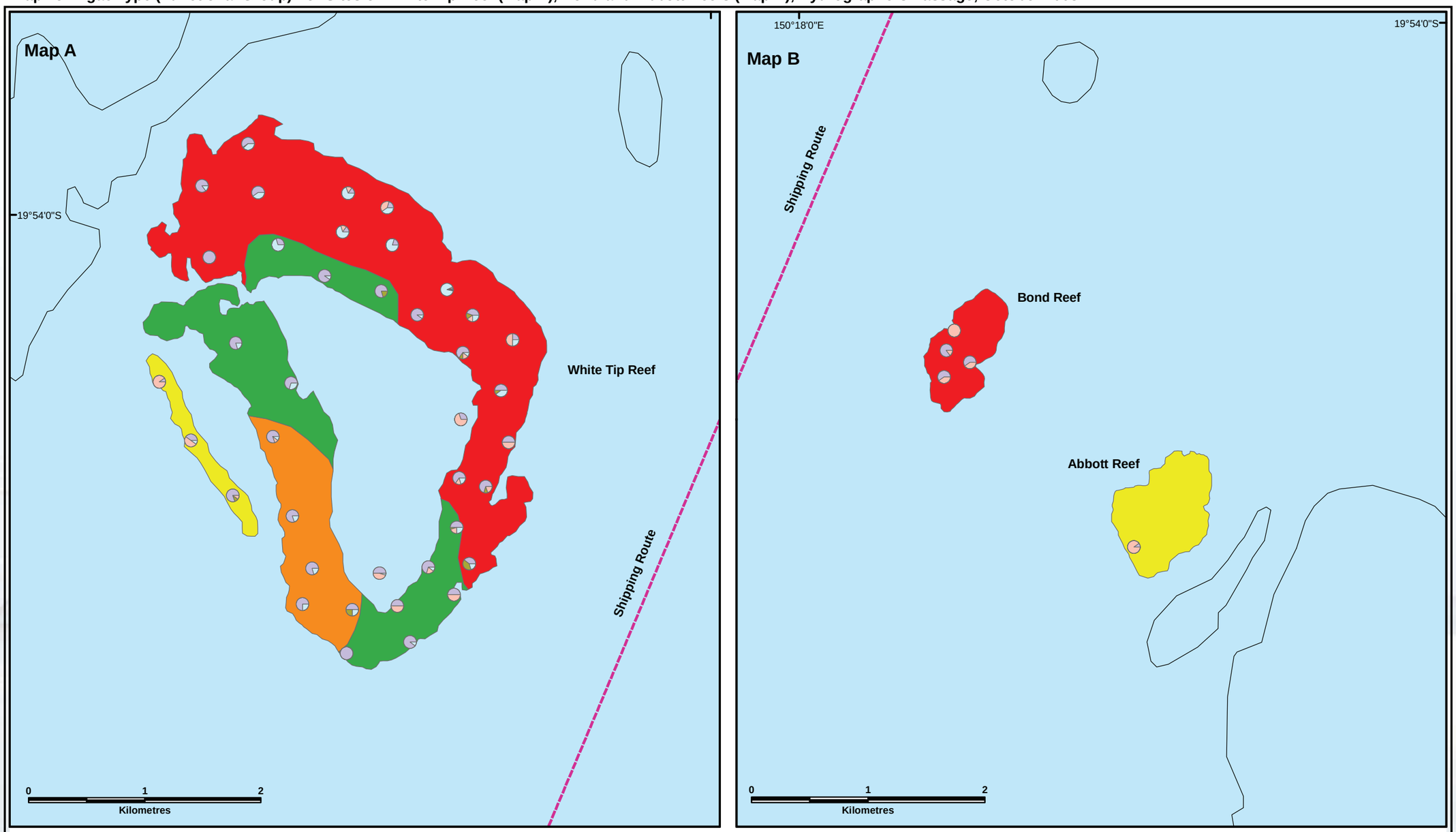
Map 14. Algae Type (Functional Group) for Sites on Little Bugatti and Wup Reefs (Map A), Ben and Bugatti Reefs (Map B), Hydrographers Passage, October 2003



Source:
Rasheed, M.A., Nguyen, T.Q., Taylor, H.A. and Thomas, R. (2006). Critical marine habitats adjacent to the high risk Hydrographers Passage Shipping Route, Great Barrier Reef, Queensland, Australia - 2006 Atlas. QDPI&F Information Series QI06081, (QDPI&F, Northern Fisheries Centre, Cairns).
Survey dates: 30th September - 9th October 2003.
Funded by CRC Reef Research Centre

Produced by the Marine Ecology Group, QDPI&F, Northern Fisheries Centre, Cairns.

Map 15. Algae Type (Functional Group) for Sites on White Tip Reef (Map A), Bond and Abbott Reefs (Map B), Hydrographers Passage, October 2003



Source:
Rasheed, M.A., Nguyen, T.Q., Taylor, H.A. and Thomas, R. (2006). Critical marine habitats adjacent to the high risk Hydrographers Passage Shipping Route, Great Barrier Reef, Queensland, Australia - 2006 Atlas. QDPI&F Information Series QI06081, (QDPI&F, Northern Fisheries Centre, Cairns).
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Other benthic macro-invertebrates

Habitat forming benthic macro-invertebrates other than coral (other BMI) comprised only a minor component of most reefs surveyed (Table 6). The only reef where other BMI were a major component was Little Stevens Reef where they formed 15% of the sites surveyed (Table 6).

There were a range of different macro-invertebrates that formed the other BMI component of reef tops, but sponges (Porifera) were the most common (Table 6). Sponges were recorded on all reefs apart from Abbott and Bond (Maps 16-19) and were the dominant benthic component of a large section of Little Stevens reef top (Map 16). Bivalves (clams) were commonly found at sites on the edges of most reef tops although they formed only a minor component of the benthic habitat at these sites (Maps 16-19). Ascidians and hydroids were less common but were also found on many of the reef tops in low abundances (Maps 16-19). Other benthic taxa including holothurians, gorgonians, echinoids, crinoids, bryozoans, asteroids and zoanthids formed obvious components of the benthic habitat at only a few sites in the survey area (Table 6; Maps 16-19).

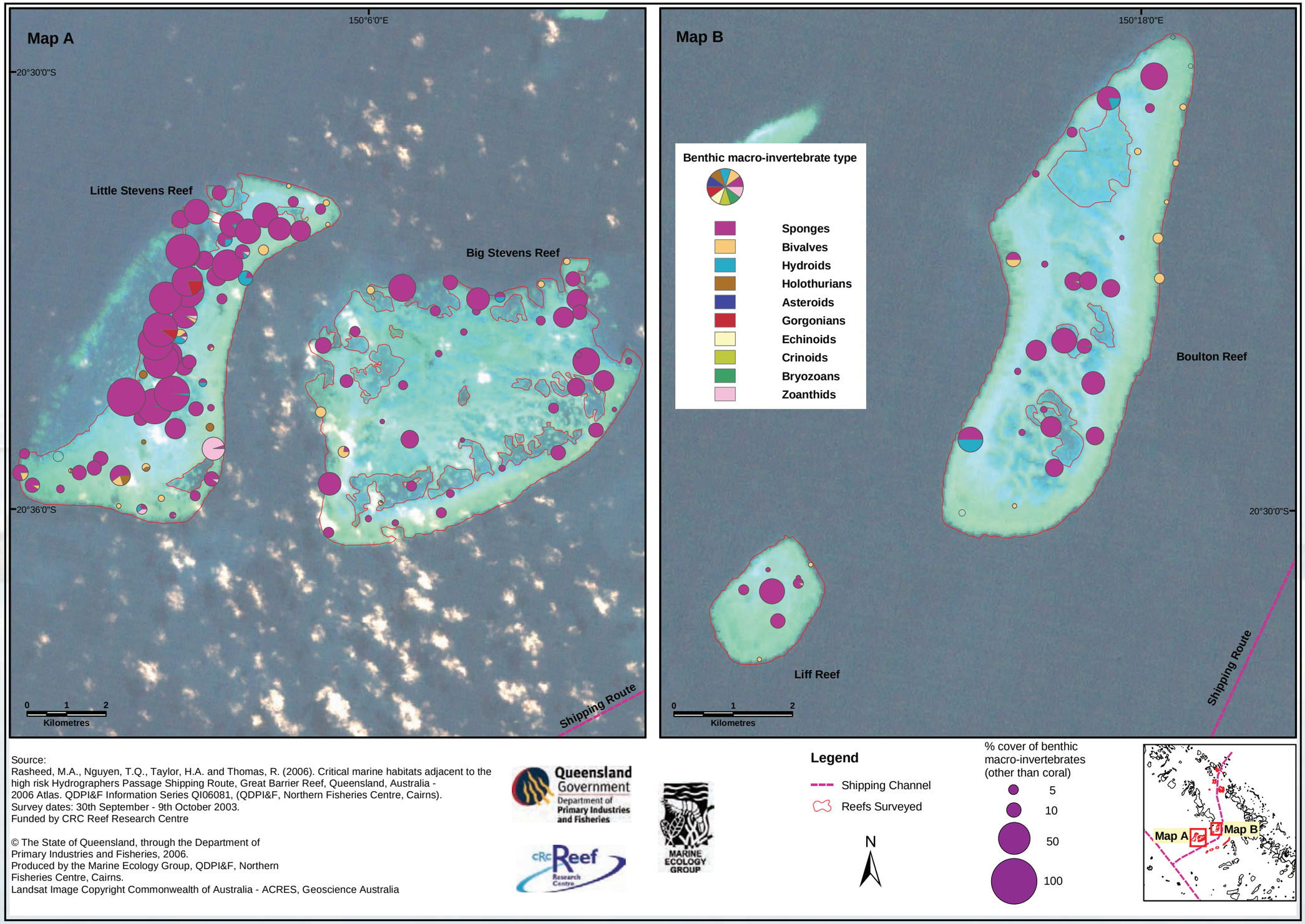
Bivalve (clam)

Table 6 Percent cover of other benthic macro-invertebrates and mean percent cover of sites for each benthic macro-invertebrate type for reefs surveyed in Hydrographers Passage

Reef	Total % Other BMI	Mean % cover of sites for each benthic macro-invertebrate type (other than coral) for each reef											
		Sponges	Bivalves	Hydroids	Ascidians	Holothurians	Gorgonians	Gastropods	Echinoids	Zoanthids	Bryozoans	Asteroids	Crinoids
Little Stevens	**15**	13.1	0.3	0.3	0.2	0.2	0.2	-	-	0.4	-	-	-
Big Stevens	**6**	5.5	0.2	<0.01	<0.01	-	<0.01	-	-	-	-	-	-
Liff	**4**	3.9	0.2	-	<0.01	-	-	0.1	-	-	-	-	-
Boulton	**7**	5.5	0.5	0.4	0.2	-	-	-	-	-	-	-	-
Creal	**1**	0.3	0.4	-	0.1	-	-	-	-	0.5	-	-	-
Warland	**4**	2.1	1.3	0.5	0.4	0.1	-	-	-	-	-	-	-
Cole # 1	**3**	2.1	0.9	-	0.1	-	-	-	-	-	-	-	-
Cole # 2	**3**	1.8	0.8	0.3	0.3	-	-	-	-	-	-	-	-
Cole # 3	**5**	3.5	0.5	0.2	0.8	-	-	-	-	<0.01	-	-	-
Wup	**2**	0.8	0.8	-	-	-	-	-	-	-	-	-	-
Little Bugatti	**4**	2.5	0.9	-	-	0.1	-	-	0.1	-	-	-	-
Bugatti	**4**	3.2	0.5	0.1	0.3	0.1	-	-	-	-	-	<0.01	<0.01
Ben	**1**	0.9	0.3	-	-	-	-	-	-	-	-	-	-
Abbott	**2**	-	2.0	-	-	-	-	-	-	-	-	-	-
Bond	**0**	-	-	-	-	-	-	-	-	-	-	-	-
White Tip	**6**	4.8	0.1	-	0.1	0.1	-	-	-	-	0.2	-	-
TOTAL	**4.1**	**3.1**	**0.6**	**0.1**	**0.2**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**0.1**	**<0.01**	**<0.01**	**<0.01**

Sponge dominated habitat, Little Stevens Reef

Map 16. Benthic Macro-invertebrate (other than coral) Distribution and Abundance for Sites on Stevens, Little Stevens (Map A), Boulton and Liff Reefs (Map B), Hydrographers Passage, October 2003



Source:
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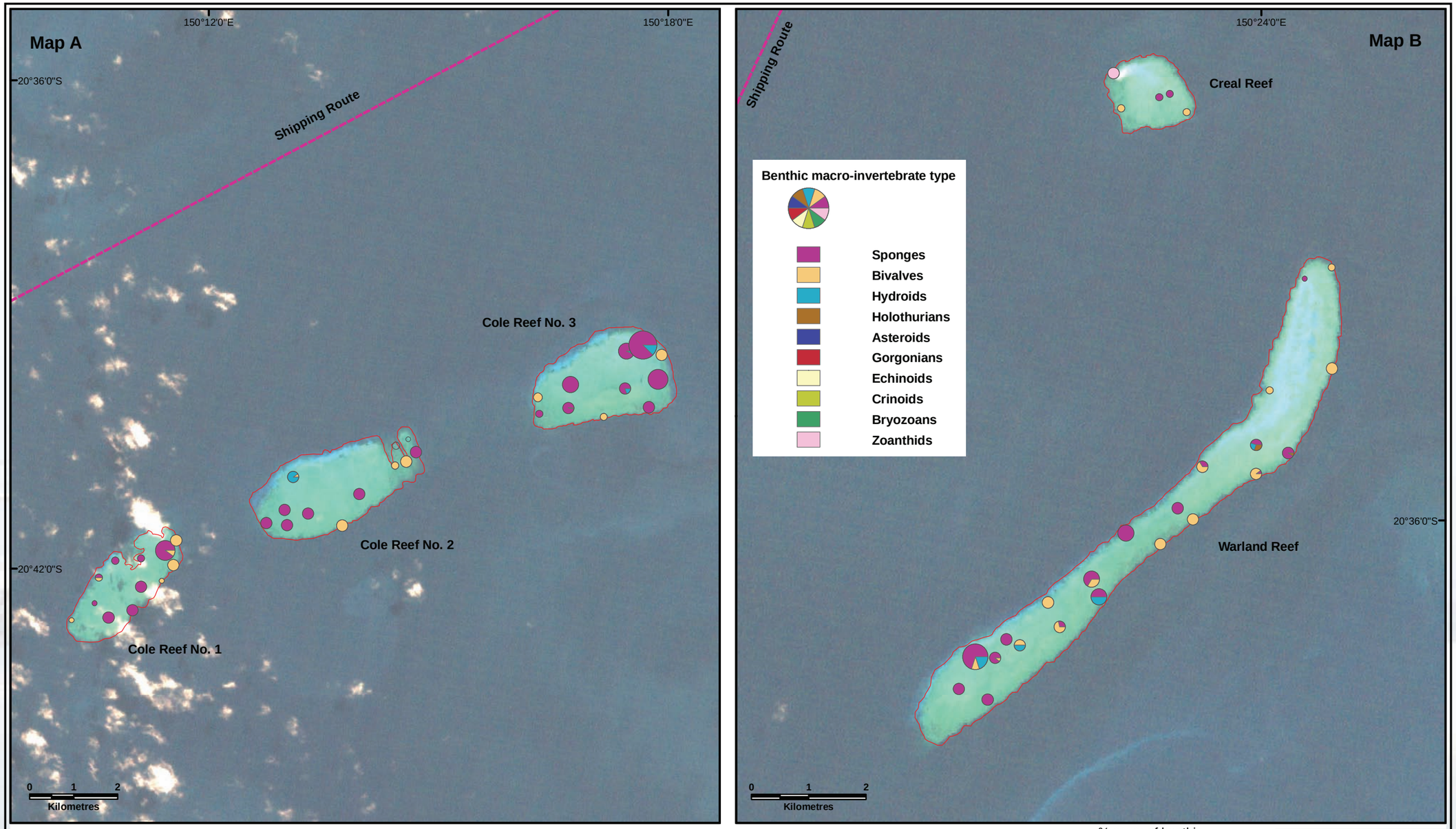
Legend
- Shipping Channel
- Reefs Surveyed

N

% cover of benthic macro-invertebrates (other than coral)
5
10
50
100

Map 17. Benthic Macro-invertebrate (other than coral) Distribution and Abundance for Sites on Cole (Map A), Warland and Creal Reefs (Map B), Hydrographers Passage, October 2003



Source:
Rasheed, M.A., Nguyen, T.Q., Taylor, H.A. and Thomas, R. (2006). Critical marine habitats adjacent to the high risk Hydrographers Passage Shipping Route, Great Barrier Reef, Queensland, Australia - 2006 Atlas. QDPI&F Information Series QI06081, (QDPI&F, Northern Fisheries Centre, Cairns).
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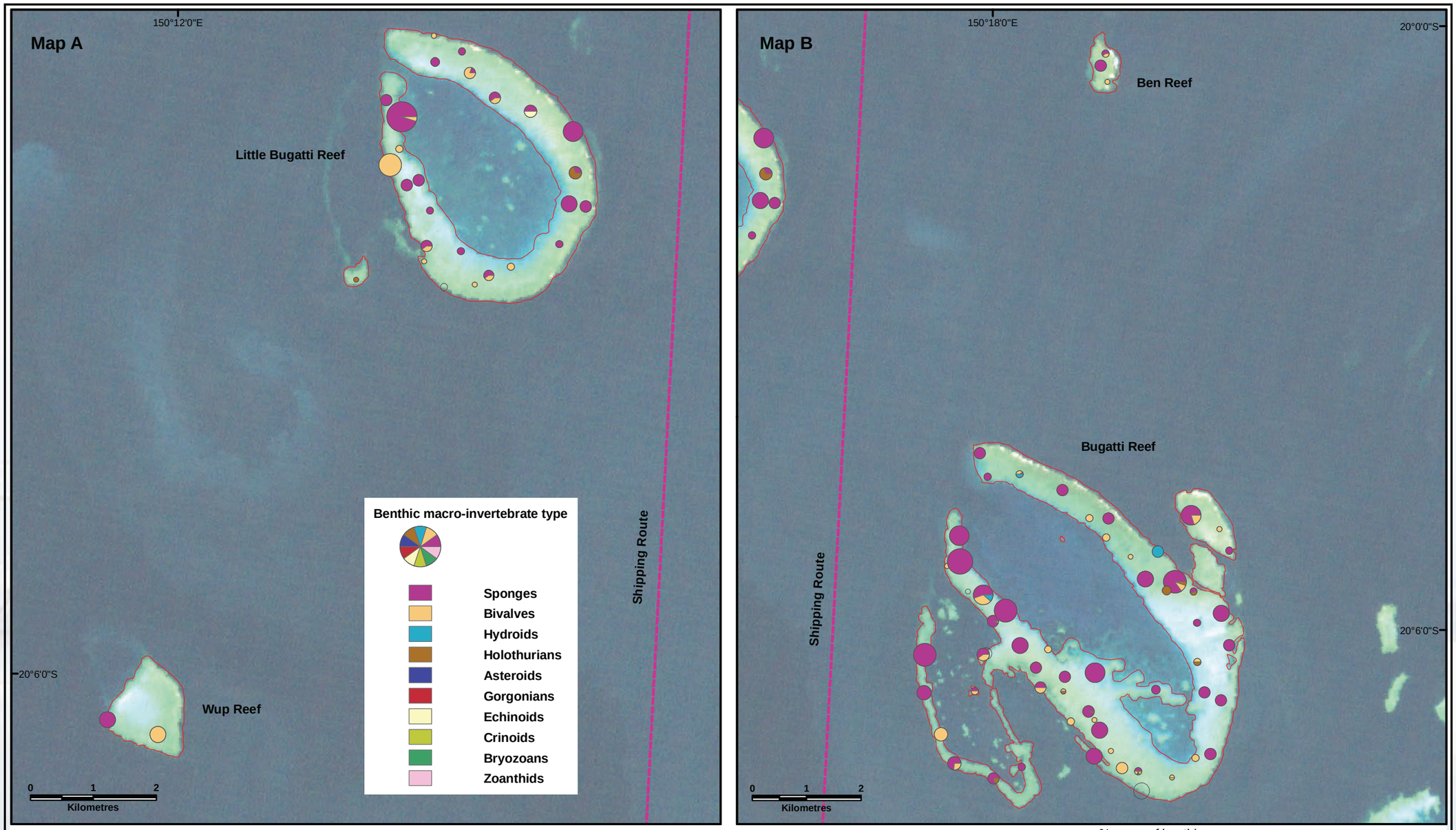
Map 18. Benthic Macro-invertebrate (other than coral) Distribution and Abundance for Sites on Little Bugatti, Wup (Map A), Bugatti and Ben Reefs (Map B), Hydrographers Passage, October 2003



Source:
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Survey dates: 30th September - 9th October 2003.
Funded by CRC Reef Research Centre

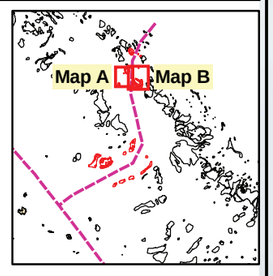
Legend

- Shipping Channel
- Reefs Surveyed

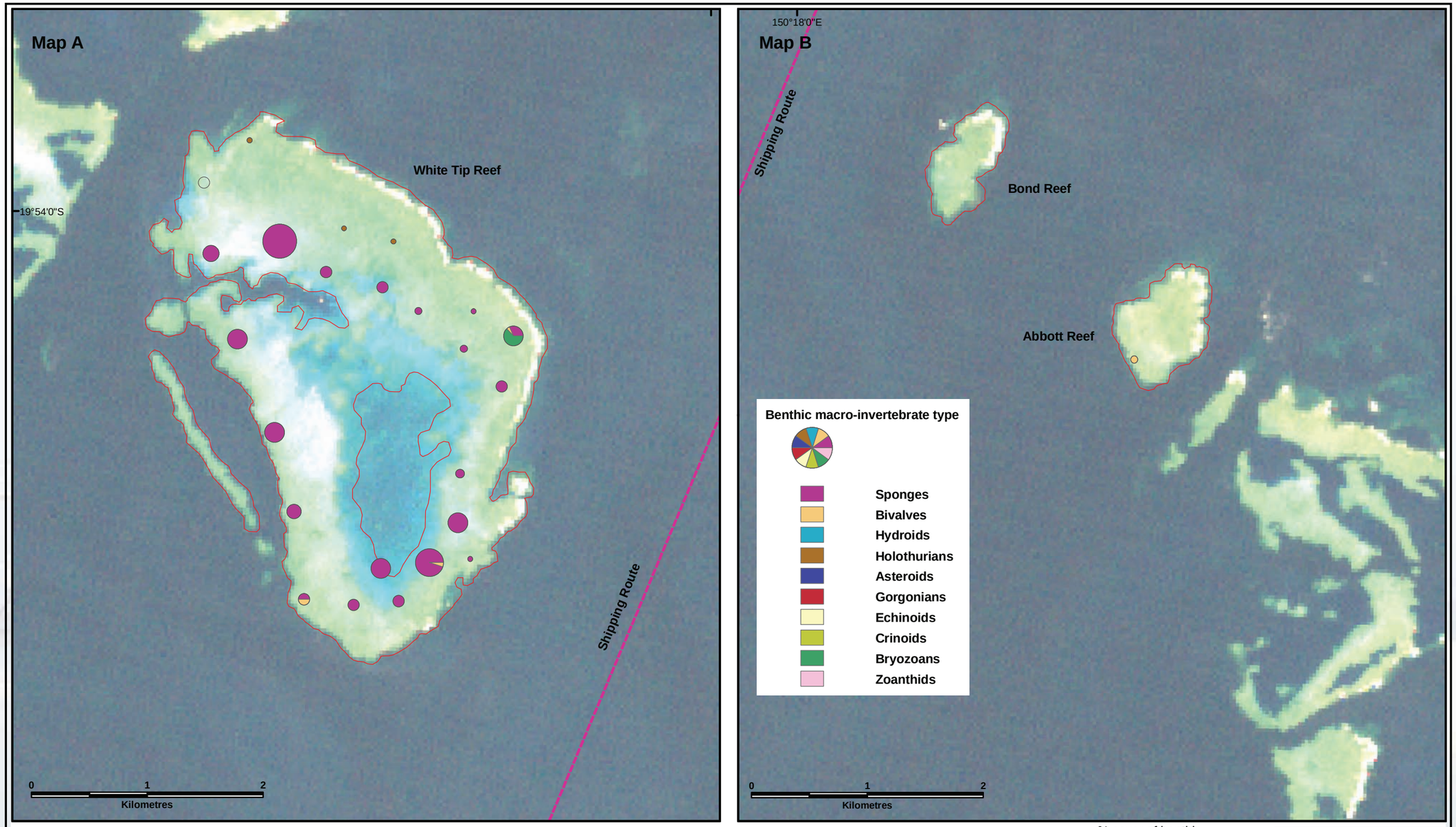
N

% cover of benthic macro-invertebrates (other than coral)

- 5
- 10
- 50
- 100



Map 19. Benthic Macro-invertebrate (other than coral) Distribution and Abundance for Sites on White Tip (Map A), Bond and Abbott Reefs (Map B), Hydrographers Passage, October 2003



Source:
Rasheed, M.A., Nguyen, T.Q., Taylor, H.A. and Thomas, R. (2006). Critical marine habitats adjacent to the high risk Hydrographers Passage Shipping Route, Great Barrier Reef, Queensland, Australia - 2006 Atlas. QDPI&F Information Series QI06081, (QDPI&F, Northern Fisheries Centre, Cairns).
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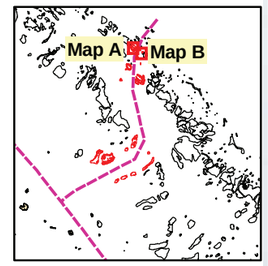
Legend

- Shipping Channel
- Reefs Surveyed

N

% cover of benthic macro-invertebrates (other than coral)

- 5
- 10
- 50
- 100



Conclusions and Habitat Risk

This Atlas documents ecologically and economically valuable marine habitats occurring on the reefs adjacent to Hydrographers Passage that may be at risk from a shipping accident or oil spill. The atlas focused on the reef tops and intertidal areas of reefs as these areas were the most likely to be impacted from oil spills and shipping accidents. Habitats identified included extensive areas of coral reef but much of the area was dominated by macro-algae communities and open substrate. The diversity of habitats and their near pristine condition makes this area particularly valuable with the habitats described important for commercial fisheries, regional biodiversity and tourism. The area is also recognised as having a particularly high risk of shipping accidents (Queensland Transport, 2000). The number of vessels utilising Hydrographers Passage to access central Queensland's coal ports has doubled since 1998 further heightening the risk of accidents occurring. The accident risk combined with the high habitat sensitivity makes the area particularly vulnerable to oil spills and associated marine pollution.

In order to assist in priority setting for accident response we have combined the habitats mapped in this survey into three distinct categories of impact risk from shipping accidents. The categories were based on the habitats biological susceptibility to oil spills and habitat quality (Table 7; Map 20). While all of the intertidal areas surveyed could be considered at risk, some ability to discriminate between areas was considered important when there may be limited resources available to deal with an oil spill or shipping accident.

Although all coral and macro-algae types found within the survey area are susceptible to damage from oil (e.g. Knap *et al.* 1983; O'Brien & Dixon 1976) they vary substantially in their growth rates and ability to recover from damage. The growth and recovery rate for massive and sub-massive corals is substantially slower than for the other forms of coral (Hall 1997). Therefore, it could be expected that reefs dominated by massive and sub-massive corals would take longer to recover from damage. Similarly different macro-algae types vary in their growth rates and ability to recolonise. Filamentous and turf algae are rapid colonisers and are quick to recover from damage compared to the more structurally complex erect macrophyte and erect calcareous growth forms (e.g. Diaz-Pulido & McCook 2002; McClanahan 1997; Littler & Littler 1980).

Benthic habitats were assigned into five separate groups for determination of risk by applying the known information on recovery rates and susceptibility to oil damage (see Table 7). Habitat risk assessment categories for reef regions were then assigned by applying a risk matrix that accounted for the density of various habitat types, their relative susceptibility to damage from oil and their ability to recover from damage (Table 7). The application of the risk matrix resulted in the majority of reefs being at moderate or high risk although several reefs including Little Stevens, Big Stevens, Boulton, Wup and White Tip contained large lower risk areas (Map 20). An additional moderate risk region was added to the western side of Little Stevens Reef due to the high density of sponges found in the area (Map 20).

Care should be taken when using the maps in this atlas for shipping accident response. Despite some sections of reefs being deemed at "low-risk" it should be remembered that this is a relative category and that these areas still contained benthic habitats that would be susceptible to damage from oil spills and shipping accidents. Many of the habitats described may also vary in distribution and density, seasonally and between years. Attempts at ground truthing the extent of these habitats as part of any response to an accident/oil spill is recommended.

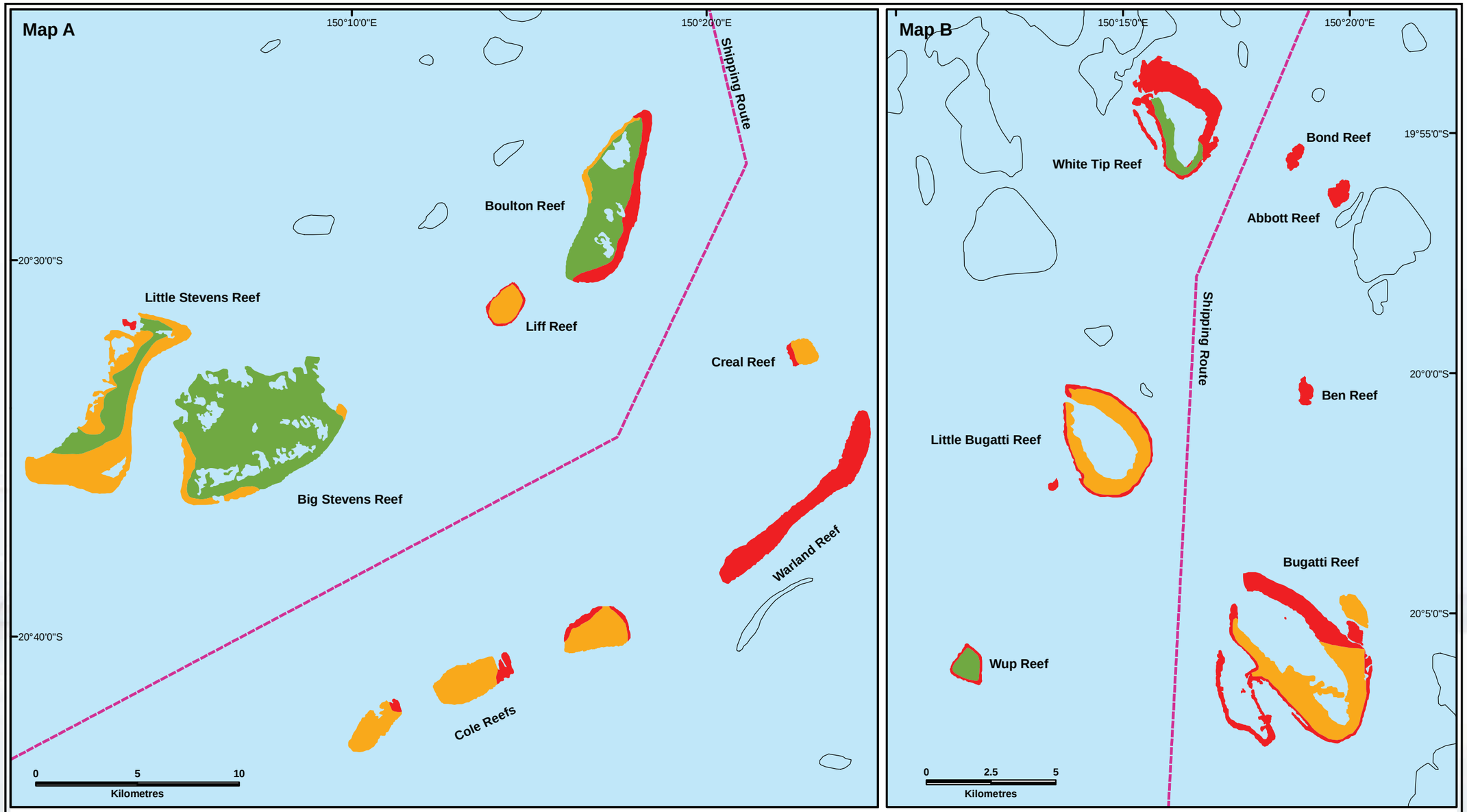
The Hydrographers Passage area is a small section of the overall Great Barrier Reef and was selected for closer investigation due to the complex nature of navigation, frequency of shipping traffic and the presence of highly diverse marine habitats with only limited previously available information. Information in this atlas will be incorporated into the National Oil Spill Response Atlas (OSRA) to assist in the planning and management of shipping accidents within the Great Barrier Reef World Heritage Area.

Table 7 Risk matrix for major habitat types in Hyrdographers Passage
(L = low risk; M = moderate risk; H = high risk

Habitat type		% cover of habitat				
		Very low (0-5%)	Low (5-15%)	Moderate (15-30%)	High (30-50%)	Very high (50-100%)
Corals	Branching/ Digitate/ Foliose/ Tabular/ Soft	L	L	M	H	H
	Massive/ Sub-massive	L	M	H	H	H
Macro-algae	Turf / Filamentous	L	L	L	L	L
	Encrusting	L	L	L	M	H
	Erect macrophytes/ Erect calcareous	L	M	M	H	H

Navigation beacon Creal Reef

Map 20. Habitat risk assessment categories for oil spills and other shipping accidents for reefs adjacent to Hydrographers Passage, October 2003



Source:
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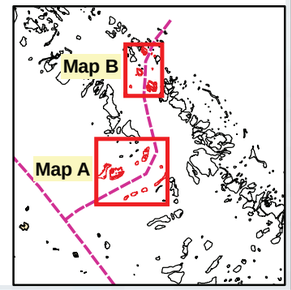
Legend

Habitat Risk Category
- high
- moderate
- low
- Shipping Channel
- Reefs Not Surveyed

N



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White Tip Reef

DPI&F Research Vessel *Gwendoline May*