

Critical Marine Habitats in the Great North East Shipping Channel, Torres Strait, Kirkcaldie Reef to Bramble Cay

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2009 ATLAS



RISK ASSESSMENT
HABITAT MANAGEMENT
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HABITAT ASSESSMENT



Queensland Government



Australian Government



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Introduction

Coastal marine habitats in the Torres Strait are important to island communities for subsistence as well as having strong cultural and spiritual value. Despite the remote location of the Torres Strait region, increasing pollution particularly associated with shipping activities, threatens the viability of the habitat, wildlife and in turn, the way of life for the local communities.

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 is a lack of detailed information on the marine habitats that occur adjacent to these shipping lanes (Rasheed *et al.* 2005).

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's) for Queensland's shipping lanes and ports where there was a heightened risk of accidents as well as heightened consequences. The six MEHRA's identified in the risk assessment were:

1. Prince of Wales channel (Torres Strait)
2. Great North East channel (Torres Strait)
3. Inner Shipping Route between Cape Flattery and Torres Strait
4. Whitsunday Islands and Passages
5. Hydrographers Passage
6. Moreton Bay

The Queensland Department of Employment, Economic Development and

Innovation (DEEDI; formerly Department of Primary Industries & Fisheries) Marine Ecology Group with support from the Torres Strait Regional Authority 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 already published four atlases in the series, one focusing on the Inner Shipping Route (Rasheed *et al.* 2005), one on the Hydrographers Passage Shipping Channel (Rasheed *et al.* 2006), and the Prince of Whales and Adolphus Shipping Channels (Rasheed and Thomas 2005). The fourth atlas, published in 2008, focused on the central and eastern regions of the Great North East (GNE) shipping channel in the Torres Strait (Taylor *et al.* 2008) and this atlas fills in the remaining gaps to the west and north of the GNE channel.

Many ecologically and economically valuable intertidal marine habitats that occur in this area may be vulnerable to oil, fuel or chemical spills from a shipping accident and concentrated marine debris including ghost nets and derelict fishing gear. 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 aiding decision making and emergency response to shipping accidents and oil spills.

Data presented in the maps in this atlas was obtained from surveys conducted in March and April 2009, whilst figures and tables are from data combined from 2008 and 2009. Therefore, this Atlas is best viewed in conjunction with Taylor *et al.* (2008).

Sea stars commonly observed on *Thalassia* meadows



The tide recedes on Erub Island



Why survey the Torres Strait region?

The Torres Strait lies to the north and north-east of Cape York and separates Australia and Papua New Guinea. It is about 90 nautical miles wide, and 150 miles long. The Torres Strait has biogeographical importance as it represents the meeting of two ocean systems – the Pacific Ocean (Coral Sea) and the Indian Ocean (Arafura Sea). The resulting tidal influence greatly affects the regions biodiversity, and coupled with a large freshwater and sediment input from nearby rivers further influences this unique marine ecosystem (Australian Maritime Safety Authority, 2002).

The Great North East Shipping Channel was selected for investigation for a number of reasons including:

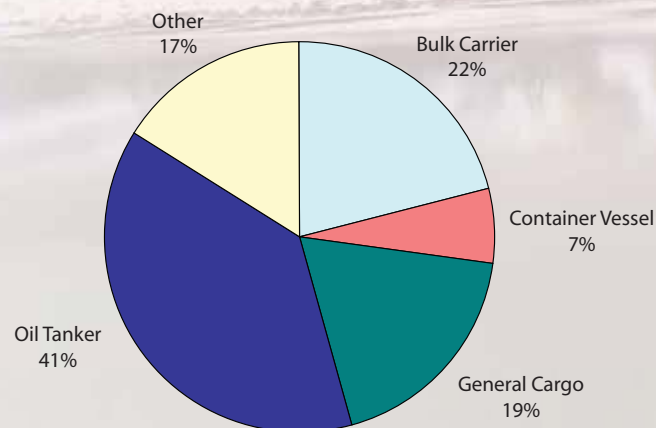
- It is one of the six identified MEHRA's for Queensland
- It contains a high diversity of intertidal habitats (including seagrass and coral reefs) in close proximity to the shipping channel
- The channel is very complicated to navigate, with complex tidal streams and currents, has limited water depth and is in close proximity to islands and reefs
- There was a lack of fine scale information on intertidal habitats in the area
- Torres Strait Islanders have a high reliance on fisheries that depend on these habitats

The selection process included an examination of existing habitat information and consultation with shipping management agencies in Queensland (Maritime Safety Queensland and the Torres Strait Regional Authority). The Torres Strait is a vital economic link, being the only link between the Arafura and Coral Seas. The GNE channel is used primarily by large vessels trading between ports in southern Asia, Australia and New Zealand, South America, Papua New Guinea and Pacific Island nations. It runs in a southwest to northeast direction from Kirkcaldie Reef in the south to Bramble Cay in the north (Map 1). The channel is narrow in a number of sections, being only a few hundred metres wide at its narrowest, and is bordered by important marine habitats including seagrass beds, coral reefs and extensive dugong habitat.

In 2006/2007, nearly 2200 voyages were undertaken by shipping vessels through the GNE channel, making it a high use passage in Queensland waters

(Neil Trainor, Australian Maritime Safety Authority, pers. comm., 2008). Of these ships passing through the Torres Strait, the majority were oil and product tankers, and general cargo ships (Figure 1; Neil Trainor, Australian Maritime Safety Authority, 2008). The Torres Strait region has a high rate of shipping incidents compared to other shipping passages. There are at least 20 separate accidents recorded back to 1970, 18 of which were ship groundings on reefs, with the remaining two being discharge accidents while docked at the Port of Thursday Island (Queensland Transport and the Great Barrier Reef Marine Park Authority, 2000). Of these 20 accidents, four caused large quantities of oil and fuel to be spilt into the sea (John Wright, Maritime Safety Queensland, 2006). The most recent incident occurred in February 2009, where a products tanker grounded on Kirkcaldie Reef. Luckily, there was no damage to the ship and therefore no spill of pollutants, however, there was damage to the reef flat and associated habitats (Australian Maritime Safety Authority, 2009).

Figure 1 The vessel types using the Great North East Channel



Shipping accidents in Torres Strait also pose a serious risk to commercial and Indigenous fishing. Commercial fishing is one of the most economically important activities in the Torres Strait and provides a significant opportunity for financial independence for community fishers. There are a large number of commercial fisheries operating in the region including the Torres Strait prawn, tropical rock lobster, trochus, finfish and beche-de-mer fisheries. The Torres Strait prawn fishery is the most valuable commercial fishery with 907 tonnes of product taken in the 2008 fishing season valued in excess of \$10 million

(Australian Fisheries Management Authority, 2009). The extensive seagrass habitats located around the GNE channel provides vital nursery ground habitats for juvenile prawns associated with the fishery.

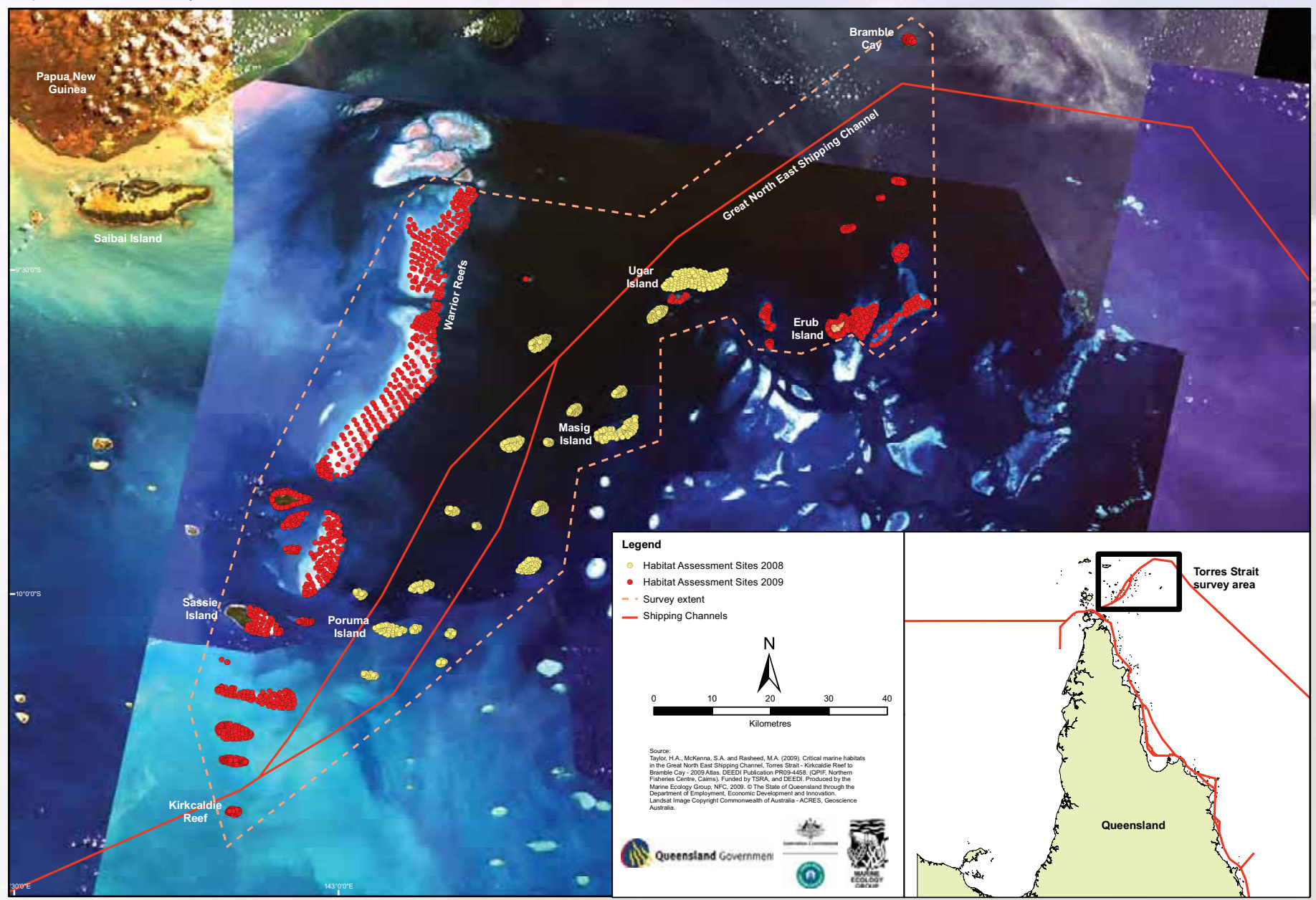
Traditionally, Torres Strait Islanders spiritual and cultural heritage is linked with the land and the sea and many Islanders rely on a wide range of marine species for subsistence and cultural uses. Torres Strait Islanders fish for a large range of species including the well known dugong and turtle. Past surveys have indicated that Torres Strait Islanders mainly target dugong, turtle, fish and crayfish, collecting an average of over 2000 kilograms worth of these species in a typical fishing day (Harris et al. 1995). As traditional inhabitants of the Torres Strait, the people are able to fish for both commercial and non-commercial fish species. The tropical rock lobster fishery is the second most valuable commercial fishery in the Torres Strait and is very important to many islanders. There are 13 licensed primary vessels in the fishery and a further 428 Traditional Inhabitant Boat licences, with 92% of recorded catch by Islanders is sold as commercial catch (Australian Fisheries Management Authority, 2009; Caton & McLoughlin, 2004).

The high fisheries, indigenous and ecological values of the habitats that surround the GNE channel, the high incidence of accidents and increasing shipping use, and threat of marine debris make the Torres Strait region an area of particular interest.





Map 1. Torres Strait survey area and habitat assessment sites around the Great North East Channel, 2008 & 2009



Survey Methodology

Methods used in this survey were based on those developed by Queensland Primary Industries and Fisheries (QPIF) for similar surveys in other Queensland locations (e.g. Rasheed *et al.* 2005; 2004; 2003), and were the same as those used in the 2008 survey. Three spring low tide windows were utilised to survey the GNE channel: 5-11th March 2009; 18-21st March 2009; and 4-6th April 2009. Two main mapping and survey techniques were used to collect marine habitat data for the maps presented in this atlas:

1. Helicopter Aerial Surveys

Intertidal habitat boundaries, characteristics and species composition were determined using a helicopter around spring low tides when habitats were exposed. Observers in a helicopter hovered directly over the habitat at a height of <5m and the position was fixed using a Global Positioning System (GPS), accurate to ± 5 m. Habitat characterisation sites were scattered randomly within the mapped habitat boundaries with a greater intensity of sites in areas with high habitat complexity.

2. Aerial Photography and Satellite Imagery

Existing aerial photography of the survey area (Beach Protection Authority, 1992, 1:50,000), aerial photographs taken during the helicopter surveys and available satellite imagery (LANDSAT 7 ETM+, Commonwealth of Australia; Spot5; Ikonos; Quikbird) were used to aid in mapping and determination of habitat boundaries for intertidal communities.



Helicopter aerial surveys



Aerial photography of Thursday Island in Torres Strait (Beach Protection Authority)

Habitat Characterisation

Habitat characterisation was based on survey sites that encompassed a circular area of the substratum of approximately 10 m². The position of each site was recorded using GPS. The information collected for seagrass, algae and benthic macro-invertebrate (BMI) habitat at each site was consistent:

1. Seagrass

At sites where seagrass was present the seagrass species composition, seagrass above ground biomass, percent cover, sediment type and time were recorded. Seagrass above ground biomass was determined using a modified “visual estimates of biomass” technique described by Mellors (1991). This technique involves an observer ranking seagrass biomass in the field in three random placements of a 0.25 m² quadrat at each site. Ranks were made in reference to a series of quadrat photographs of similar seagrass habitat for which the above ground biomass has previously been measured. Three separate biomass ranges were used: low-biomass, high-biomass and an Enhalus scale. The relative proportion of the above ground biomass (percentage) of each seagrass species within each survey quadrat was also recorded. Field biomass ranks were then converted into above ground biomass estimates in grams dry weight per square metre (g DW m⁻²). At the completion of sampling each observer ranked a series of calibration quadrats that represented the range of seagrass biomass in the survey. After ranking, seagrass in these quadrats was harvested and the actual biomass determined in the laboratory. A separate regression of ranks and biomass from these calibration quadrats was generated for each observer and applied to the field survey data to determine above ground biomass estimates.

The presence or absence of seagrass at each site was defined by the above ground biomass. Where above ground biomass was absent, the presence of rhizome/root and seed bank material was reported. Survey sites with no seagrass can be found within meadows because seagrass cover within meadows is not always uniform and may be patchy and contain bare gaps or scars.



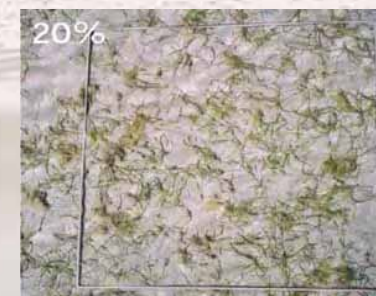
Seagrass quadrat for “visual estimate of above ground biomass”



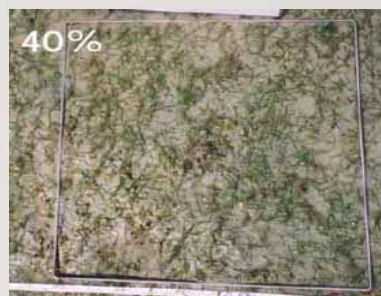
Very Low percent cover
(0 - 10%)

In addition, a visual estimate was made of the overall percent cover of seagrass at each site. All sites within a seagrass region were grouped to provide a mean percent cover of seagrass for that region. This percent cover was presented as a range in five categories:

- Very Low (0-10%)
- Low (10-30%)
- Moderate (30-50%)
- High (50-75%)
- Very High (75-100%)



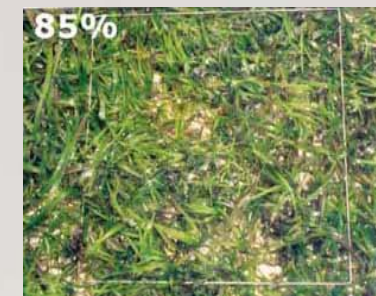
Low percent cover
(10 - 30%)



Moderate percent cover
(30 - 50%)



High percent cover
(50 - 75%)



Very High percent cover
(75 - 100%)

2. Algae

For this atlas, algae habitat occurring in the intertidal zone was mapped. At sites where algae were present, they were identified into the following five functional groups:

- * Erect macrophytes - Macrophytic algae with an erect growth form and high level of cellular differentiation e.g. *Sargassum*, *Caulerpa* and *Galaxaura* species
- * Erect calcareous - Algae with erect growth form and high level of cellular differentiation containing calcified segments e.g. *Halimeda* species
- * Filamentous - Thin thread-like algae with little cellular differentiation
- * Encrusting - Algae growing in sheet like form attached to substrate or benthos e.g. coralline algae
- * Turf Mat - Algae that forms a dense mat or "turf" on the substrate

At each site, a visual estimate was made of the overall percent cover of algae as well as the relative proportion of the total cover made up of each of the five algal functional groups. All sites within an algae region were grouped to provide a mean percent cover of algae for that region. This percent cover was presented as a range in five categories:

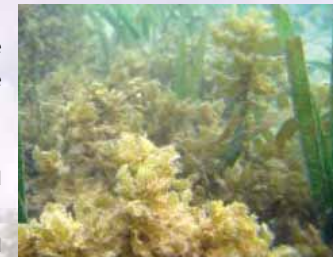
- Very Low (0-10%)
- Low (10-30%)
- Moderate (30-50%)
- High (50-75%)
- Very High (75-100%)

3. Benthic macro-invertebrates (BMI)

For this atlas, benthic macro-invertebrate (BMI) habitat occurring in the intertidal zone was mapped. At sites where BMI were present, they were identified into the following four broad taxonomic groups:

- * Hard corals - All massive, branching, tabular, digitate and mushroom scleractinian corals
- * Soft corals - All alcyonarian corals i.e. corals lacking a hard limestone skeleton
- * Sponges - All sponges were grouped together
- * Other BMI - Any other BMI identified e.g. ascidians, bivalves, gastropods and holothurians

At each site, a visual estimate was made of the overall percent cover of each of the BMI broad taxonomic groups.



Erect Macrophytes with Seagrass



Erect Calcareous Algae



Encrusting and Turf Algae on Coral Rubble



Filamentous Algae



Hard Coral



Soft Coral



Sponges

Geographic Information System (GIS)

All data were entered into a Geographic Information System (GIS) developed for the Torres Strait. Rectified colour aerial and satellite imagery of the region (Beach Protection Authority and Commonwealth of Australia), combined with aerial photography and videotape footage taken from the helicopter during surveys assisted with mapping. Other information including substrate type, the shape of existing geographical features such as reefs and channels, and evidence of strong wave energy or tidal currents was also interpreted and used in determining habitat boundaries.

The precision of determining seagrass, algae and benthic macro-invertebrate (BMI) region boundaries depended on the range of mapping information and methods available for each region. Intertidal region boundaries that were traced with GPS had the highest precision. Large subtidal areas where seagrass meadow boundaries could not be seen from the surface had the lowest mapping precision. For these seagrass meadows, boundaries were based on the mid-point between the last site where seagrass was present and the next non-seagrass site.

Each habitat region was assigned a mapping precision estimate (in metres) based on mapping methodology utilised for that region (Table 1). Mapping precision ranged from $\pm 10\text{m}$ for isolated intertidal seagrass, algae and BMI regions to $\pm 50\text{m}$ (Table 1). The mapping precision estimate was used to calculate a range of area for each region and was expressed as a reliability estimate (R) in hectares. Additional sources of mapping error associated with digitising and rectifying aerial photographs onto base maps and with GPS fixes for survey sites were assumed to be embedded within the reliability estimates.

Seagrass community types were determined according to overall species composition. A standard nomenclature system was used to name each of the seagrass meadows in the survey area. This system was based on the percent composition of biomass contributed by each species within the meadow (Table 2). This nomenclature also included a measure of meadow density that was determined by the mean above ground biomass of the dominant species within the community (Table 3).



Mapping intertidal habitat boundaries by helicopter

Table 1 Mapping precision and methodology for seagrass, algae and benthic macro-invertebrate regions in the Torres Strait survey area, 2009

Mapping precision	Mapping methodology
< 5 m	Seagrass meadow boundaries mapped in detail by GPS from helicopter All regions intertidal and exposed or visible at low tide Relatively high density of mapping and survey sites Recent aerial and satellite imagery aided in mapping
10 m	Region boundaries determined from helicopter surveys Inshore seagrass boundaries mapped from helicopter Offshore seagrass boundaries interpreted from survey sites and aerial photography Algae/BMI regions all intertidal Relatively high density of mapping and survey sites Recent aerial and satellite imagery aided in mapping
20 m	Seagrass meadow boundary interpreted from helicopter surveys Algae/BMI region boundaries based on distance between survey sites All seagrass meadows subtidal Algae/BMI regions all intertidal Relatively high density of survey sites Recent aerial and satellite imagery aided in mapping
50 m	Seagrass meadow boundaries interpreted from helicopter surveys Algae/BMI region boundaries based on distance between survey sites All seagrass meadows subtidal Algae/BMI regions all intertidal Relatively low density of survey sites Recent aerial and satellite imagery aided in mapping
75 m	Seagrass meadow boundaries interpreted from helicopter surveys Applied to subtidal seagrass meadows only Relatively low density of survey sites Recent aerial and satellite imagery aided in mapping

Table 2 Nomenclature for seagrass community types in the Torres Strait survey area, 2009

Community type	Species composition
Species A	Species A is 90-100% of composition
Species A with Species B	Species A is 60-90% of composition
Species A with Species B/Species C	Species A is 50-60% of composition
Species A/Species B	Species A is 40-60% of composition



Confirming species identifications in an intertidal meadow

Table 3 Density (biomass) categories and mean above ground biomass ranges for each species used in determining seagrass community density in the Torres Strait survey area, 2009

Density (biomass) category	Dominant seagrass species in meadow (g DW m ⁻²)					
	<i>Halophila ovalis</i>	<i>Halodule uninervis</i> (thin)	<i>Halodule uninervis</i> (wide)	<i>Cymodocea rotundata</i>	<i>Thalassia hemprichii</i>	<i>Enhalus acoroides</i>
Light	< 0.5	< 1	< 5	< 5	< 5	< 40
Moderate	0.5-5	1-4	5-25	5-25	5-25	40-100
Dense	> 5	> 4	> 25	> 25	> 25	> 100

Critical Marine Habitats of Torres Strait

A total of 2181 habitat assessment sites were surveyed in intertidal regions adjacent to the Great North East (GNE) channel during February 2008 and March/April 2009 (Map 1). The survey assessed the benthic habitat in a total of 45 intertidal island and reef areas. Algae were the dominant habitat type in the survey area (Figure 2), although there were also large areas dominated by benthic macro-invertebrates (BMI), seagrass and open substrate. Seagrass, algae and BMI often occurred together within the same habitat characterisation sites and hence had overlapping distributions. In terms of percent cover of the bottom, algae, BMI and open substrate combined made up an average of more than 91% of the sites surveyed (Figure 2). Seagrass formed a relatively small but important component of the overall benthic habitat within the survey area (Figure 2).

Seagrasses

Extensive intertidal seagrass habitat occurred throughout the Torres Strait survey and covered an area of $34,200 \pm 450$ ha (Table 4; Maps 2-15; and see Taylor et al. 2008). Seagrass was present on nearly every intertidal island/cay region and absent on all small intertidal reef systems. The two major reefs surveyed, Warrior Reef and Dunguness Reef did, however, contain substantial seagrass meadows. Despite the fact that seagrasses covered such a large area of the intertidal regions surveyed, it comprised a relatively small overall cover in proportion to other habitat types (Figure 2).

Percent cover for the majority of intertidal seagrass meadows was generally very low (0-10%). Only four meadows were identified as having a cover of greater than 30% (Table 4; Maps 2 & 3). These moderate cover meadows were all located on the western side of the GNE channel. Eight seagrass species were identified in 13 distinct community types and 30 meadows (Figure 3; Table 4; Maps 6-15).

Over 90% of seagrass communities identified were dominated by large, slow growing species which are highly vulnerable to oil spills and associated dispersants. The majority of these were dominated by *Thalassia hemprichii*, with many of the meadows having a mix of species present (Table 4). *Enhalus acoroides* meadows were more often dominant on islands that were more characteristic of continental islands than sand islands, such as Sassie, Zagai and

Erub Islands (Maps 7, 8, 13). The meadows identified were typically comprised of aggregated patches with some meadows having a continuous cover of seagrass. Seagrass meadows generally occupied the inner intertidal zone adjacent to islands and cays, and in many cases extended to the inside edge of the reef crest.

It is important to note that seagrasses may have a much larger extent than reported here, as subtidal areas were not surveyed.

Figure 2 Mean percent cover of the major benthos types in the Torres Strait survey area

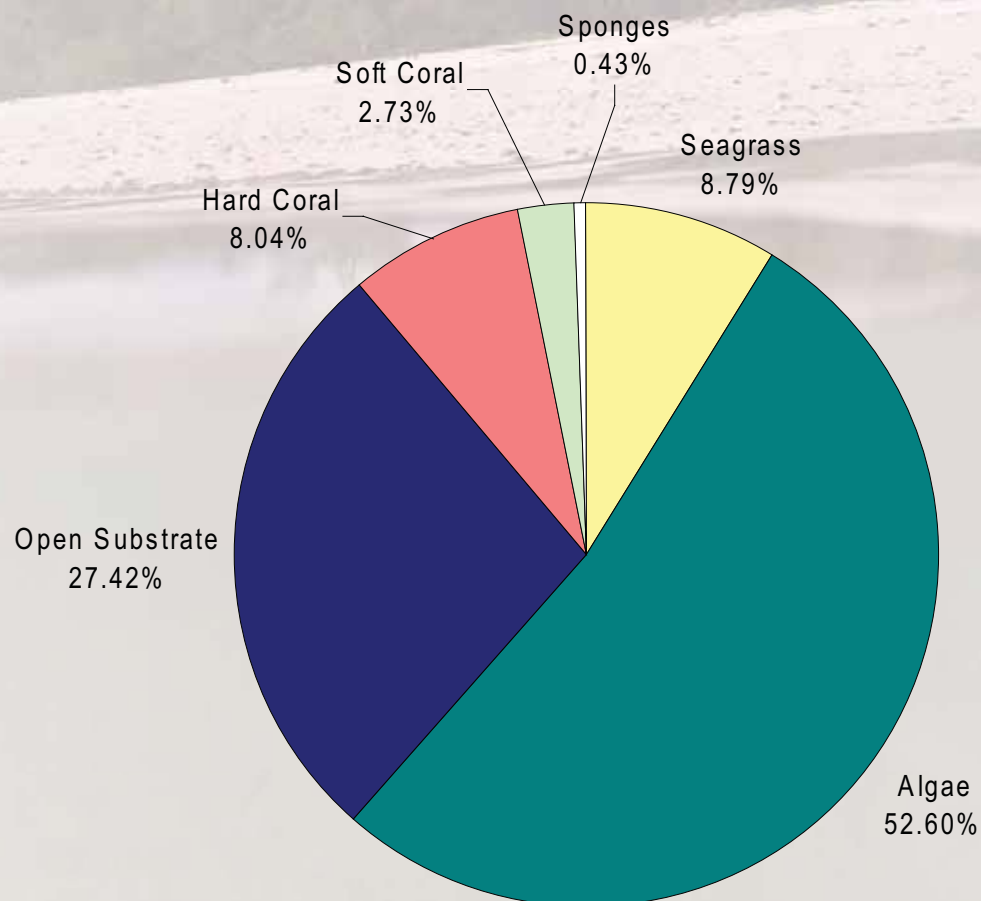


Table 4 Seagrass community type, biomass, and area (ha) around the Torres Strait survey area, 2008 and 2009

Meadow ID	Location	Community Type	Cover	Species Present	Mean Biomass (g dw m ⁻²)	Area ± R (ha)
1	Richardson Reef	Light <i>Thalassia hemprichii</i>	Aggregated Patches	<i>Thalassia hemprichii</i> , <i>Halodule uninervis</i> (narrow)	0.78 ± 0.70	75.16 ± 3.56
2	Poruma Island	Light <i>Thalassia hemprichii</i> with mixed species	Continuous Cover	<i>Thalassia hemprichii</i> , <i>Cymodocea rotundata</i> , <i>Halodule uninervis</i> (wide), <i>Halophila ovalis</i>	9.73 ± 2.53	364.71 ± 14.99
3	Uhu Islet	Light <i>Thalassia hemprichii</i>	Aggregated Patches	<i>Thalassia hemprichii</i>	4.32 ± 2.43	63.59 ± 3.74
4	Roberts Island	Light <i>Thalassia hemprichii</i>	Aggregated Patches	<i>Thalassia hemprichii</i>	2.28 ± 0.99	192.69 ± 6.82
5	Aureed Island	Light <i>Thalassia hemprichii</i> with <i>Halophila ovalis</i> / <i>Halodule uninervis</i> (narrow)	Aggregated Patches	<i>Thalassia hemprichii</i> , <i>Halophila ovalis</i> , <i>Halodule uninervis</i> (narrow)	0.71 ± 0.26	268.34 ± 8.28
6	Garboy Island	Light <i>Thalassia hemprichii</i>	Aggregated Patches	<i>Thalassia hemprichii</i>	0.1 ± 0.03	64.43 ± 3.15
7	Layoak Island	Light <i>Thalassia hemprichii</i>	Aggregated Patches	<i>Thalassia hemprichii</i> , <i>Halophila ovalis</i>	0.12 ± 0.03	106.14 ± 4.27
8	Mauar Island	Light <i>Thalassia hemprichii</i>	Aggregated Patches	<i>Thalassia hemprichii</i> , <i>Halodule uninervis</i> (wide), <i>Halophila ovalis</i>	3.0 ± 0.90	238.39 ± 10.45
9	Masig Island	Light <i>Thalassia hemprichii</i> with mixed species	Aggregated Patches	<i>Thalassia hemprichii</i> , <i>Halodule uninervis</i> (wide & narrow), <i>Halophila ovalis</i> , <i>Cymodocea rotundata</i>	4.26 ± 0.97	770.29 ± 27.58
10	Eegarbu Island	Light <i>Thalassia hemprichii</i> / <i>Halophila ovalis</i>	Aggregated Patches	<i>Thalassia hemprichii</i> , <i>Halophila ovalis</i>	0.89 ± 0.48	61.95 ± 5.61
11	Homogar Island	Light <i>Thalassia hemprichii</i>	Aggregated Patches	<i>Thalassia hemprichii</i>	0.20 ± 0.06	56.10 ± 3.60
12	Damuth Island	Light <i>Thalassia hemprichii</i>	Aggregated Patches	<i>Thalassia hemprichii</i>	4.11 ± 1.04	255.03 ± 9.88
13	Tappoea Island	Light <i>Thalassia hemprichii</i> with <i>Halophila ovalis</i>	Aggregated Patches	<i>Thalassia hemprichii</i> , <i>Halophila ovalis</i>	1.48 ± 0.58	147.81 ± 6.80
14	Ugar Island	Light <i>Thalassia hemprichii</i> with mixed species	Aggregated Patches	<i>Thalassia hemprichii</i> , <i>E. acoroides</i> , <i>Halophila ovalis</i> , <i>Cymodocea rotundata</i> , <i>Halodule uninervis</i> (wide & narrow)	5.25 ± 0.97	1,514.63 ± 35.16
15	Bramble Cay	Light <i>Halodule uninervis</i> (narrow)	Aggregated Patches	<i>Halodule uninervis</i> (narrow)	0.7 ± 0.7	4.85 ± 0.91
16	Erub Island	Light <i>Thalassia hemprichii</i>	Aggregated Patches	<i>Thalassia hemprichii</i>	0.5 ± 0.27	45.28 ± 2.80

Table 4 Seagrass community type, biomass, and area (ha) around the Torres Strait survey area, 2008 and 2009

Meadow ID	Location	Community Type	Cover	Species Present	Mean Biomass (g dw m ⁻²)	Area ± R (ha)
17	Erub Island	Light <i>Enhalus acoroides</i> / <i>Thalassia hemprichii</i>	Continuous Cover	<i>Enhalus acoroides</i> , <i>Thalassia hemprichii</i> , <i>Cymodocea rotundata</i> , <i>Halophila ovalis</i> , <i>Halodule uninervis</i> (narrow), <i>Halodule uninervis</i> (wide), <i>Cymodocea serrulata</i>	7.19 ± 1.71	218.80 ± 13.18
18	Nepean Islet	Light <i>Thalassia hemprichii</i> with <i>Halophila ovalis</i>	Aggregated Patches	<i>Thalassia hemprichii</i> , <i>Halophila ovalis</i>	0.2 ± 0.09	23.88 ± 3.20
19	Kirkcaldie Reef	Light <i>Halophila ovalis</i>	Aggregated Patches	<i>Halophila ovalis</i>	0.11 ± 0.0.09	12.07 ± 2.07
20	Poll Islet	Light <i>Thalassia hemprichii</i> with <i>Halophila ovalis</i>	Aggregated Patches	<i>Thalassia hemprichii</i> , <i>Halophila ovalis</i>	0.14 ± 0.07	162 ± 8.47
21	Warraber Island	Light <i>Cymodocea serrulata</i> with <i>Halodule uninervis</i> (narrow)	Continuous Cover	<i>Cymodocea serrulata</i> , <i>Halodule uninervis</i> (narrow), <i>Halophila ovalis</i>	0.4 ± 0.18	457.48 ± 21
22	Bet Islet	Light <i>Thalassia hemprichii</i>	Aggregated Patches	<i>Thalassia hemprichii</i> , <i>Halophila ovalis</i>	3.08 ± 0.67	1,095.94 ± 27.03
23	Sassie Island	Moderate <i>Thalassia hemprichii</i> with mixed species	Continuous Cover	<i>Thalassia hemprichii</i> , <i>Cymodocea rotundata</i> , <i>Cymodocea serrulata</i> , <i>Enhalus acoroides</i>	9.32 ± 2.77	1,344.44 ± 16.43
24	Dungeness Reef	Light <i>Thalassia hemprichii</i> with <i>Enhalus acoroides</i>	Continuous Cover	<i>Thalassia hemprichii</i> , <i>Enhalus acoroides</i> , <i>Cymodocea rotundata</i>	3.84 ± 0.65	3,677.57 ± 32.80
25	Dungeness Reef	Light <i>Thalassia hemprichii</i>	Aggregated Patches	<i>Thalassia hemprichii</i>	0.99 ± 0.59	173.64 ± 5.95
26	Zagai Island	Light <i>Enhalus acoroides</i> with mixed species	Continuous Cover	<i>Enhalus acoroides</i> , <i>Thalassia hemprichii</i> , <i>Cymodocea rotundata</i> , <i>Halophila ovalis</i>	3.06 ± 0.79	268.40 ± 28.50
27	Tudu Island	Light <i>Enhalus acoroides</i> with mixed species	Aggregated Patches	<i>Enhalus acoroides</i> , <i>Thalassia hemprichii</i> , <i>Cymodocea rotundata</i> , <i>Halophila ovalis</i>	1.35 ± 0.61	163.34 ± 8.51
28	Warrior Reef South	Moderate <i>Thalassia hemprichii</i> mixed species	Continuous Cover	<i>Thalassia hemprichii</i> , <i>Enhalus acoroides</i> , <i>Thalassodendron ciliatum</i> , <i>Cymodocea rotundata</i> , <i>Halophila ovalis</i>	13.2 ± 1.27	13,785.78 ± 72.44
29	Moon Passage Reef	Light <i>Thalassodendron ciliatum</i> with mixed species	Aggregated Patches	<i>Thalassodendron ciliatum</i> , <i>Cymodocea serrulata</i> , <i>Thalassia hemprichii</i>	24.93 ± 20.75	67.27 ± 3.17
30	Warrior Reef North	Light <i>Enhalus acoroides</i> with mixed species	Continuous Cover	<i>Enhalus acoroides</i> , <i>Thalassodendron ciliatum</i> , <i>Thalassia hemprichii</i> , <i>Cymodocea rotundata</i> , <i>Cymodocea serrulata</i> , <i>Halophila ovalis</i> , <i>Syringodium isoetifolium</i>	20.97 ± 1.83	8,520 ± 59.86

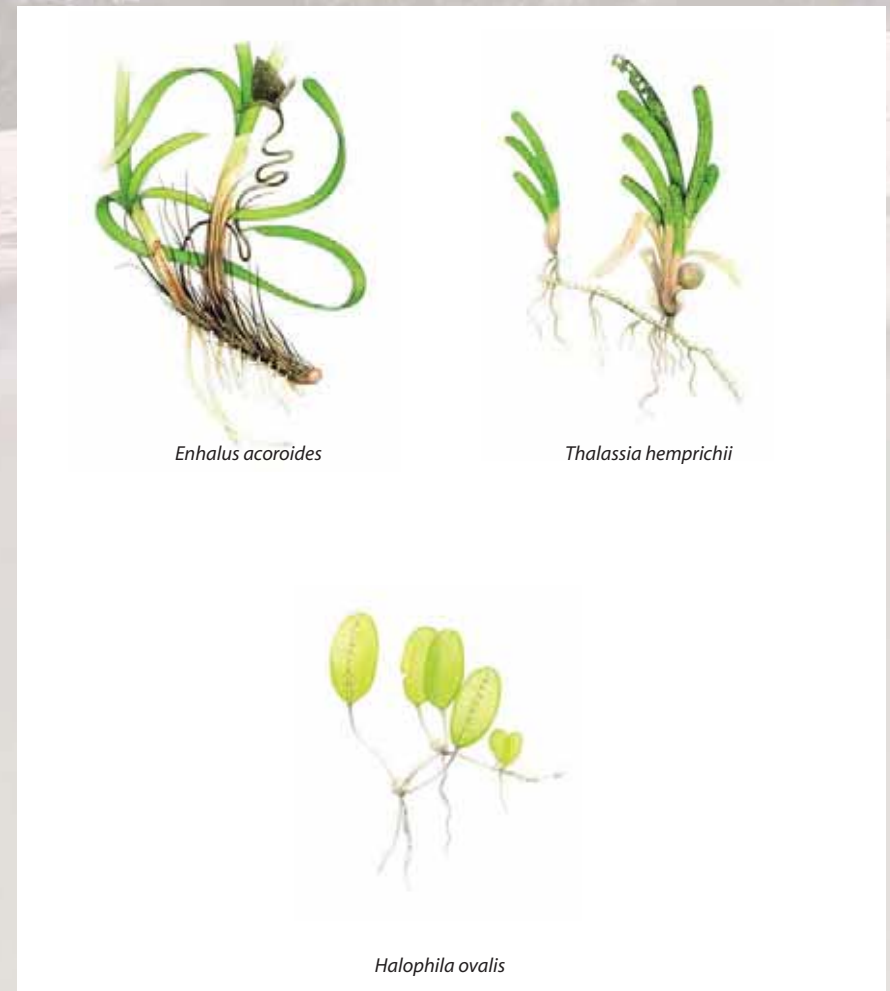
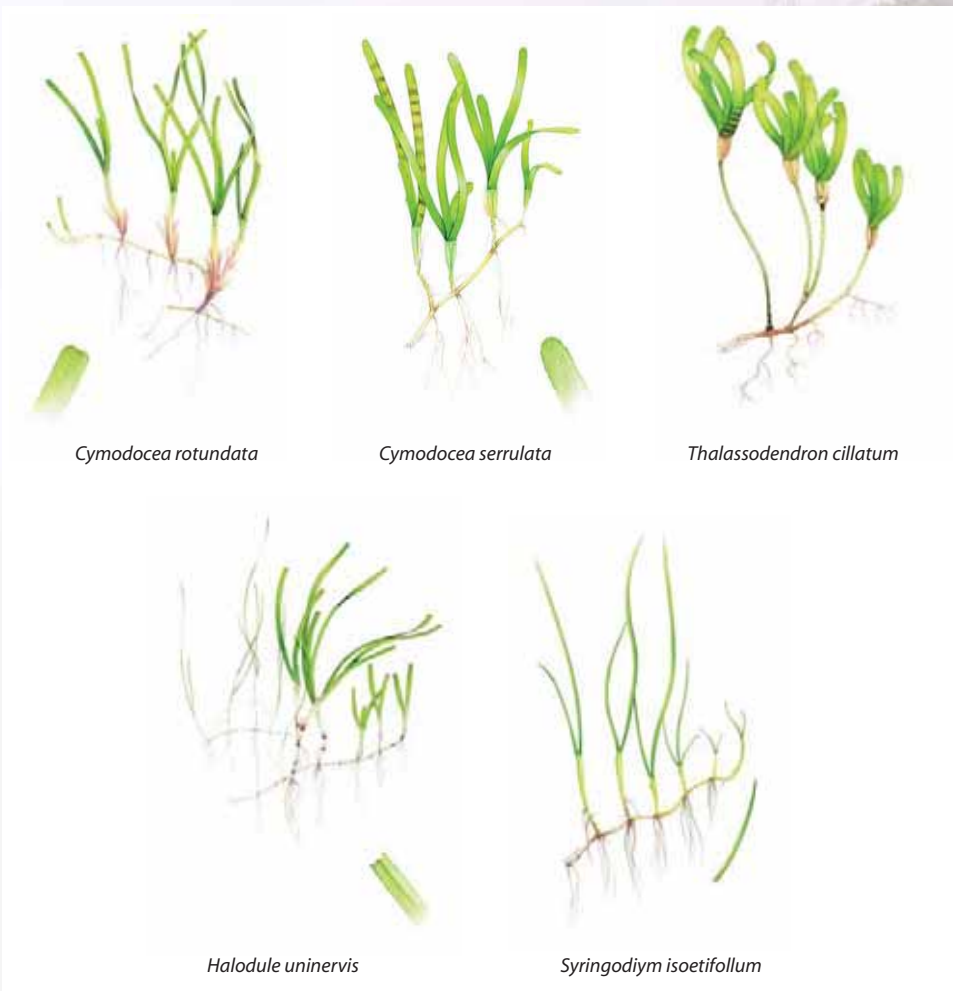
Figure 3 Eight seagrass species (from two families) identified around the Torres Strait survey area, 2008 & 2009

Family CYMODOCEACEAE Taylor:

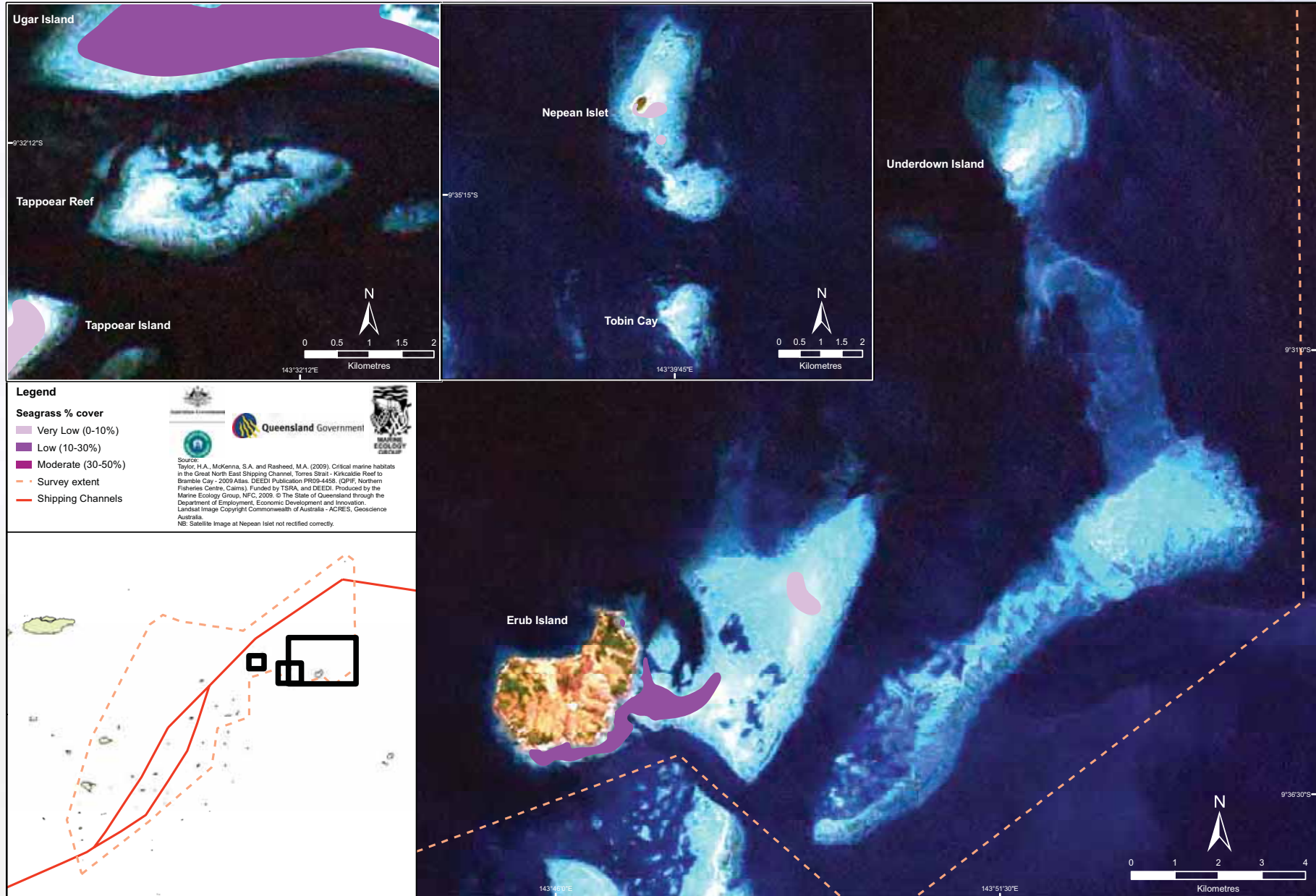
Cymodocea rotundata Ehrenb. et. Hempr. ex Aschers
Cymodocea serrulata (R.Br.) Aschers and Magnus
Halodule uninervis (wide and narrow leaf morphology) (Forsk.) Aschers in Boissier
Thalassodendron ciliatum (Forsk.) den Hartog
Syringodium isoetifolium (Aschers.) Dandy

Family HYDROCHARITACEAE Jussieu:

Enhalus acoroides (L.F.) Royle
Halophila ovalis (R. Br.) Hook. F.
Thalassia hemprichii (Ehrenb.) Aschers. in Petermann



Map 4. Seagrass distribution and percent cover in the north eastern section of the Torres Strait survey area, March/April 2009

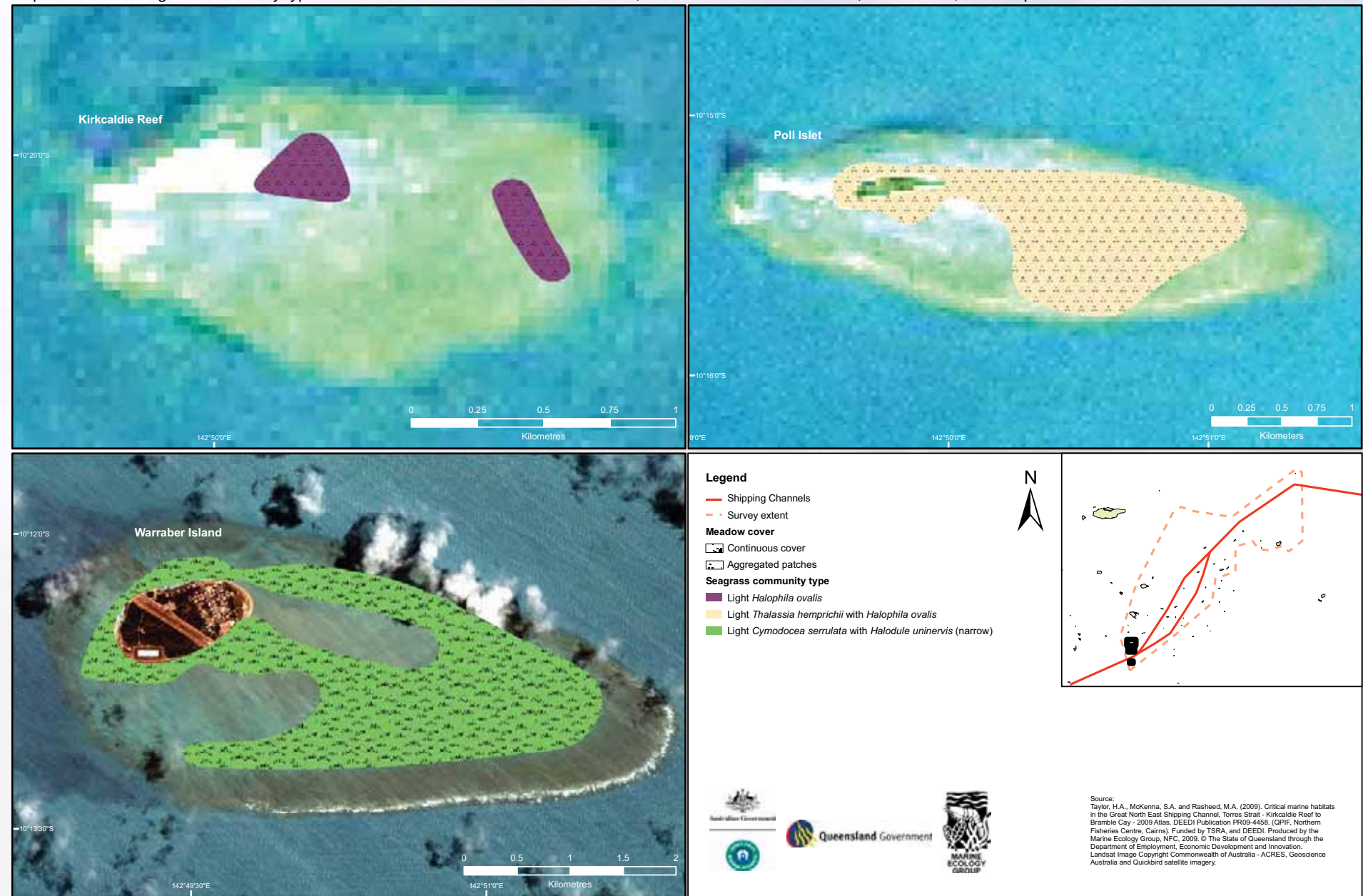


Map 5. Seagrass distribution and percent cover in the northern-most section of the Torres Strait survey area, March/April 2009



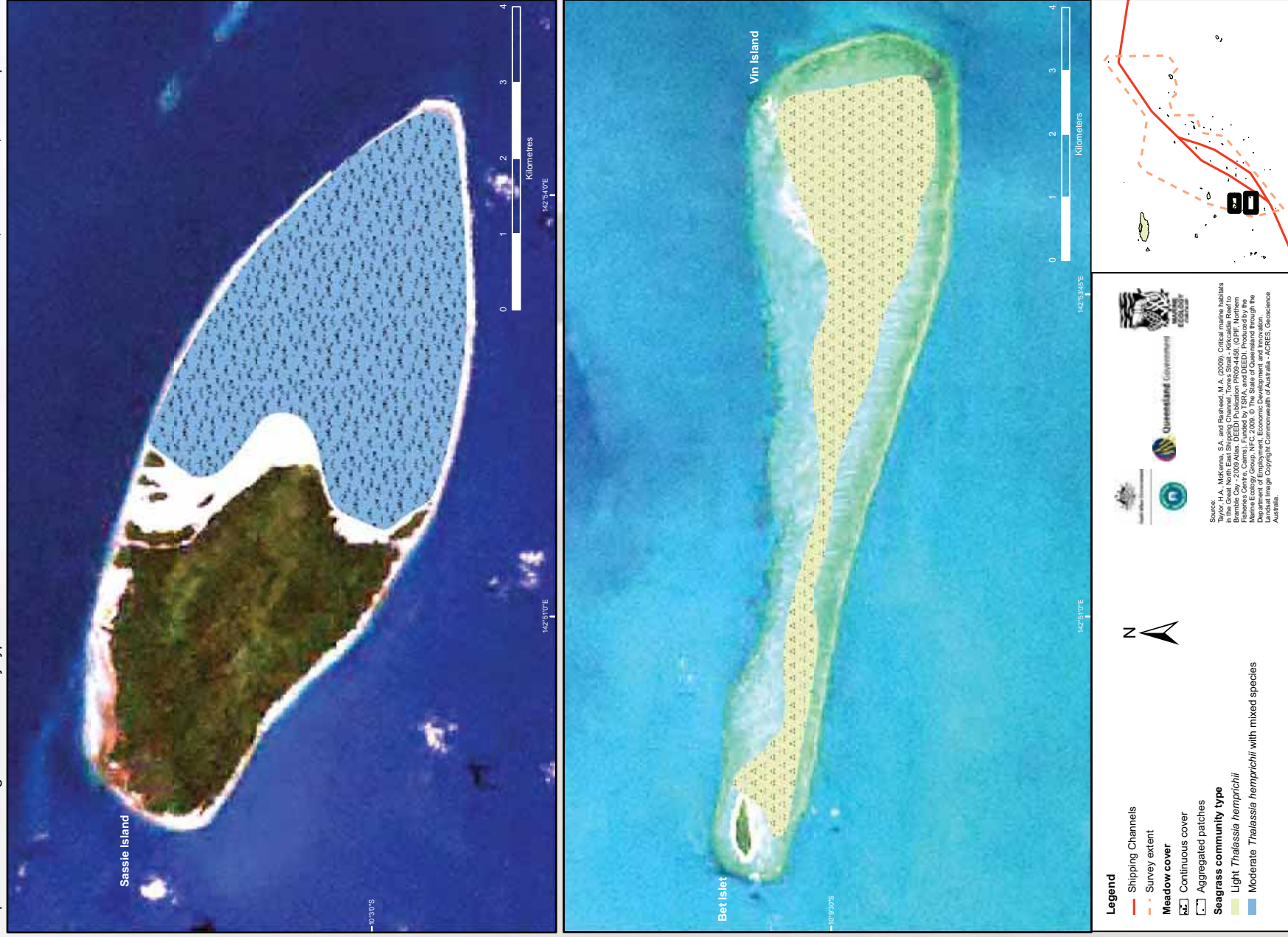


Map 6. Intertidal seagrass community types and meadow cover around Kirkcaldie Reef, Poll Islet and Warraber Island, Torres Strait, March/April 2009

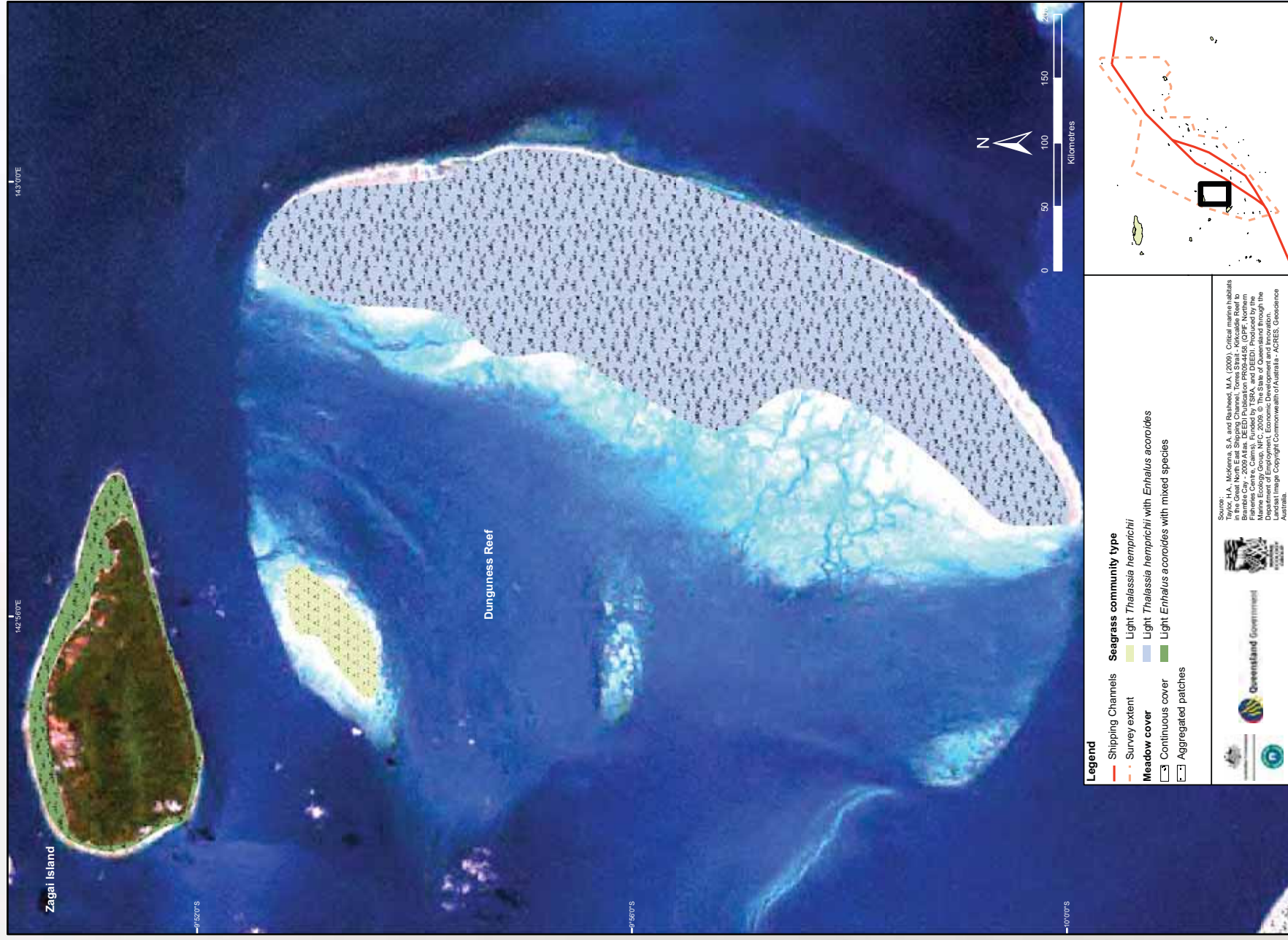




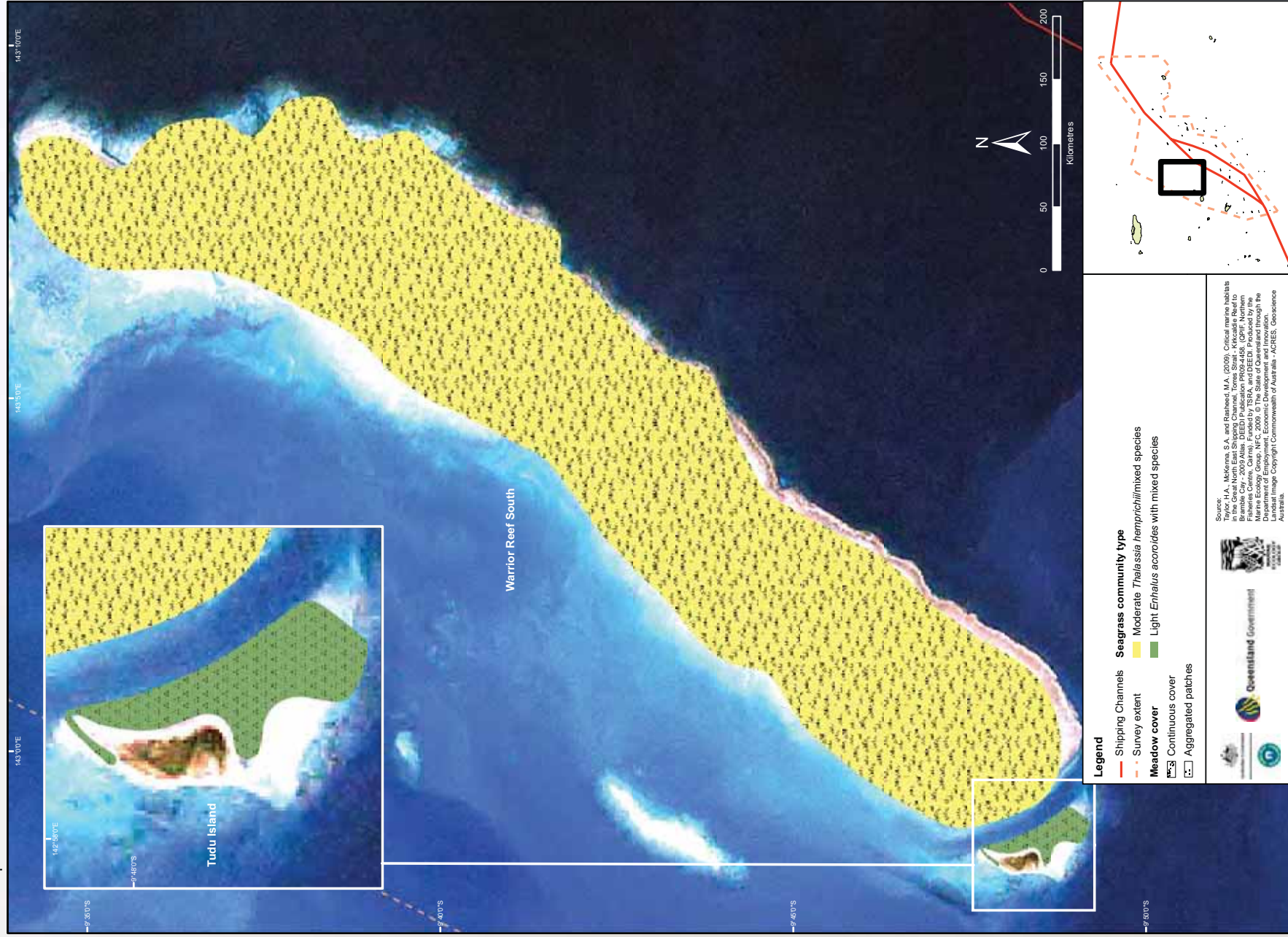
Map 7. Intertidal seagrass community types and meadow cover around Bet Islet and Sassie Island, Torres Strait, March/April 2009



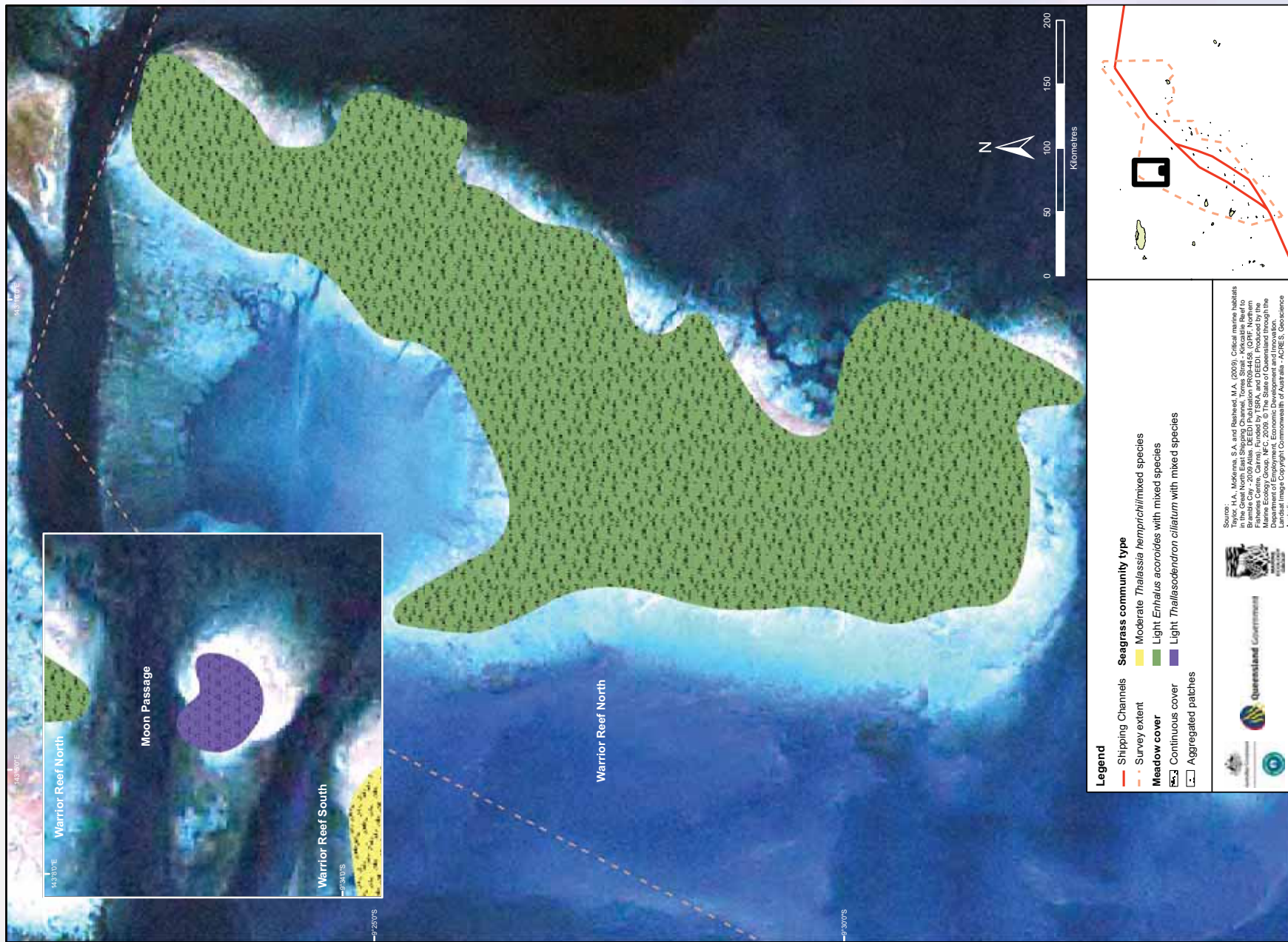
Map 8. Intertidal seagrass community types and meadow cover around Dungunness Reef and Zagai Island, Torres Strait, March/April 2009



Map 9. Intertidal seagrass community types and meadow cover on Tuđu Island and Warrior Reef South, Torres Strait, March/April 2009

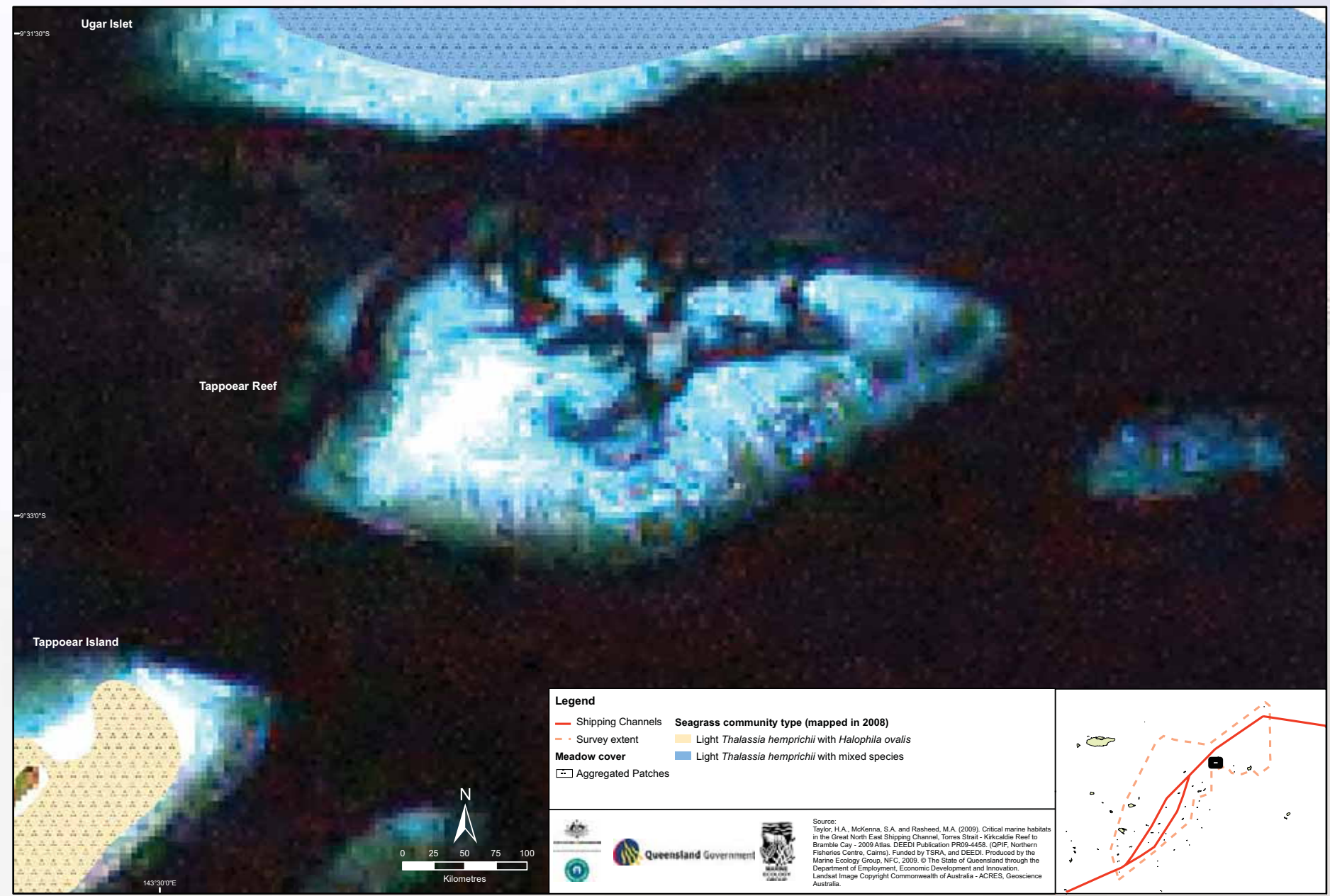


Map 10. Intertidal seagrass community types and meadow cover on Moon Passage Reef and Warrior Reef North, Torres Strait, March/April 2009



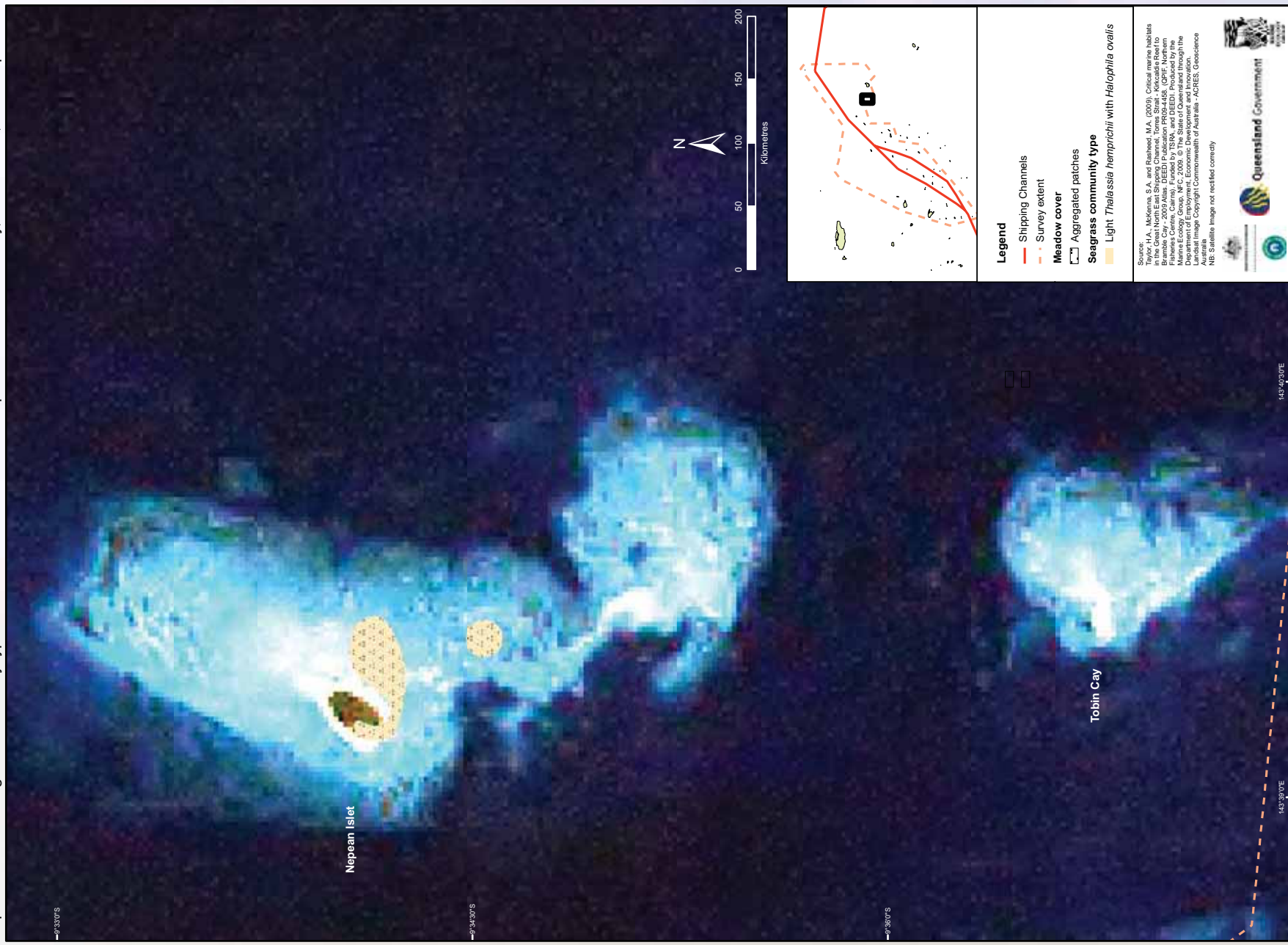


Map 11. Intertidal seagrass community types and meadow cover around Tappoeare Island reef, Torres Strait, March/April 2009



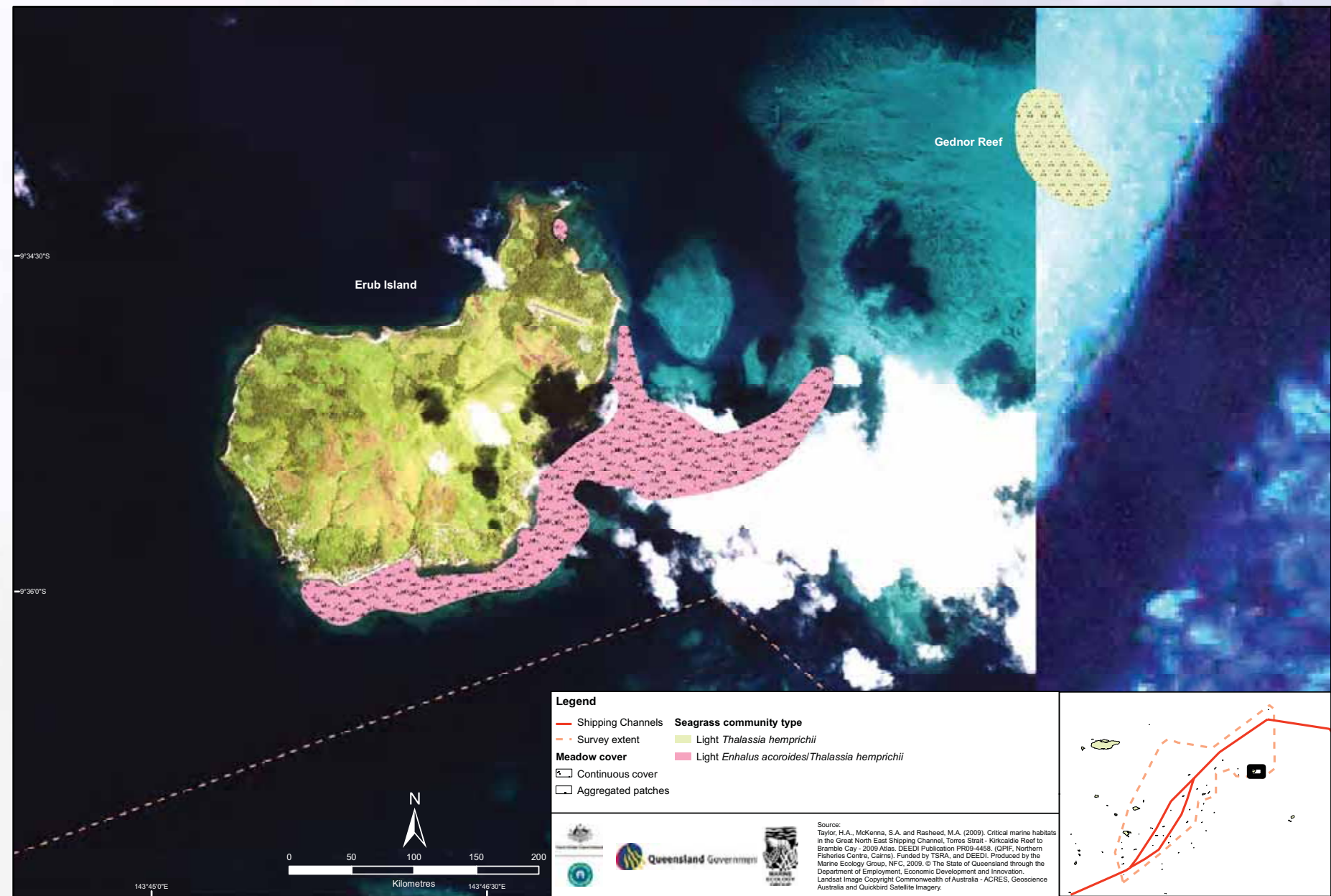


Map 12. Intertidal seagrass community types and meadow cover around Nepean Islet and Tobin Cay, Torres Strait, March/April 2009



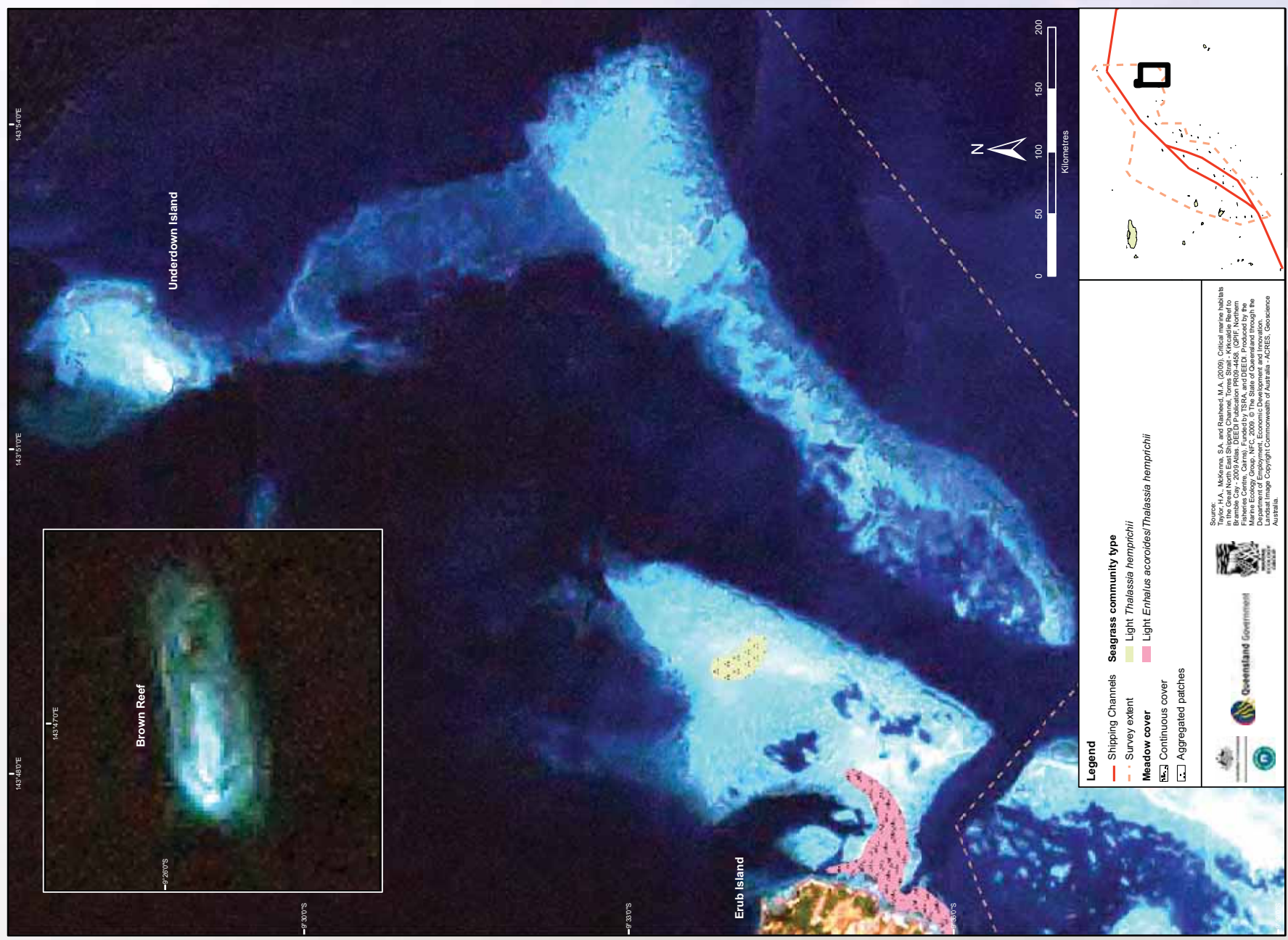


Map 13. Intertidal seagrass community types and meadow cover around Erub Island, Torres Strait, March/April 2009



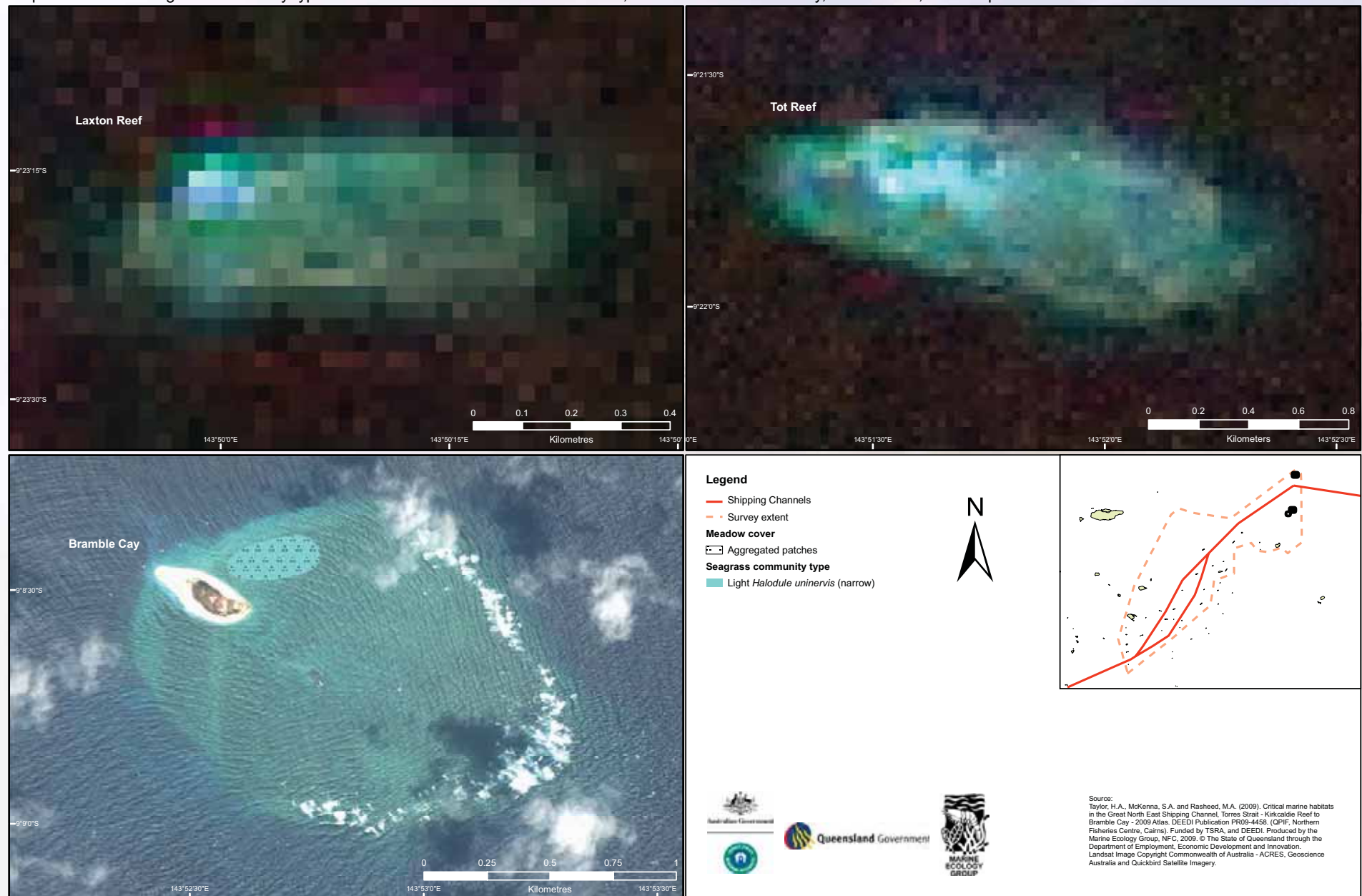


Map 14. Intertidal seagrass community types and meadow cover around Underdown Island and reef, Torres Strait, March/April 2009





Map 15. Intertidal seagrass community types and meadow cover around Laxton Reef, Tot Reef and Bramble Cay, Torres Strait, March/April 2009



Algae

Extensive areas of intertidal algae habitat were identified throughout the survey region with a total of $49,020 \pm 637$ ha mapped. Algae was the dominant benthic habitat type identified, accounting for over 50% of the benthos (Figure 2). There were five dominant algal groups recorded, however most communities were comprised of a mixture of groups (Figure 4; Maps 16-25).

The majority of algae habitat had high (50-75%) cover and were dominated by either erect macrophyte or algal turf mat species. Erect macrophyte species were more commonly found in shallow pools on the reef flat or in partially subtidal reef crest and slope areas (Maps 16-25). Algal turf mats formed extensive communities on many of the exposed reef flats and often occurred in conjunction with both seagrass meadows and reef communities. Erect macrophyte communities included genera such as *Sargassum* and *Caulerpa*.

Erect calcareous, encrusting and filamentous algal functional groups made up a small proportion of the algal community in the survey area.

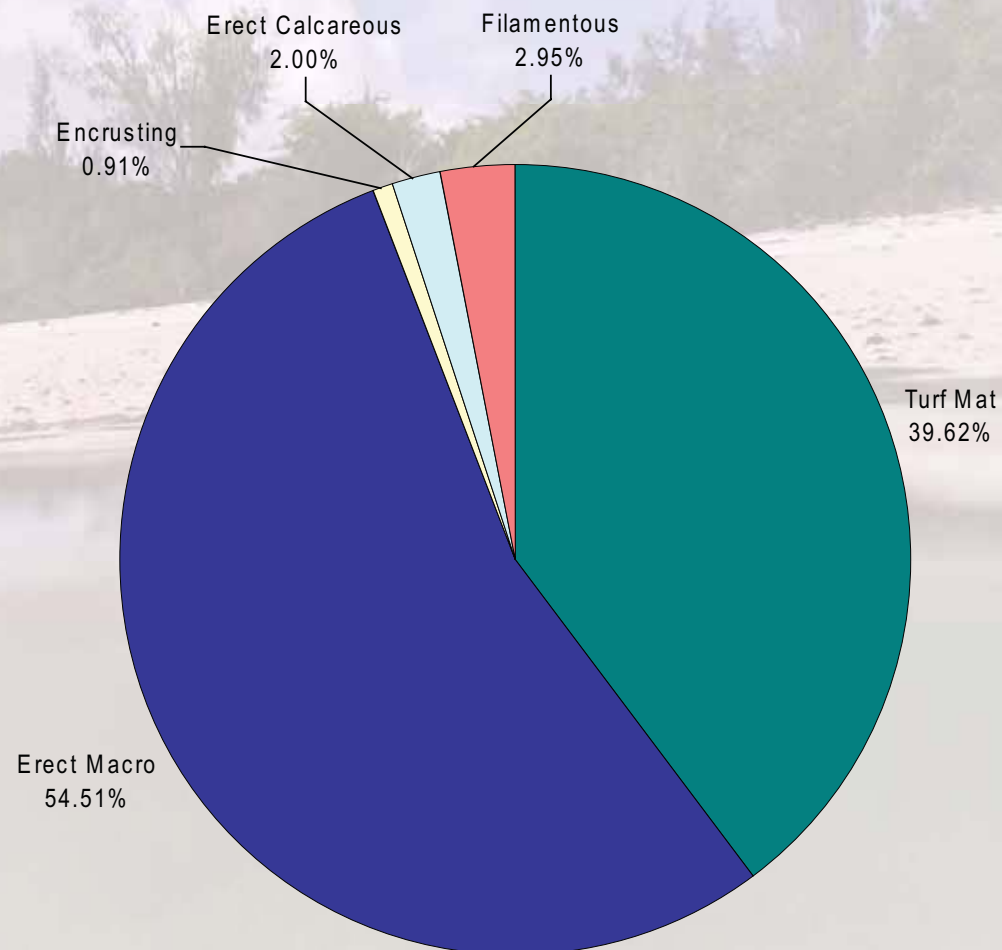
Typical erect macrophyte community with encrusting and turf algae on coral rubble



Filamentous algae on open substrate

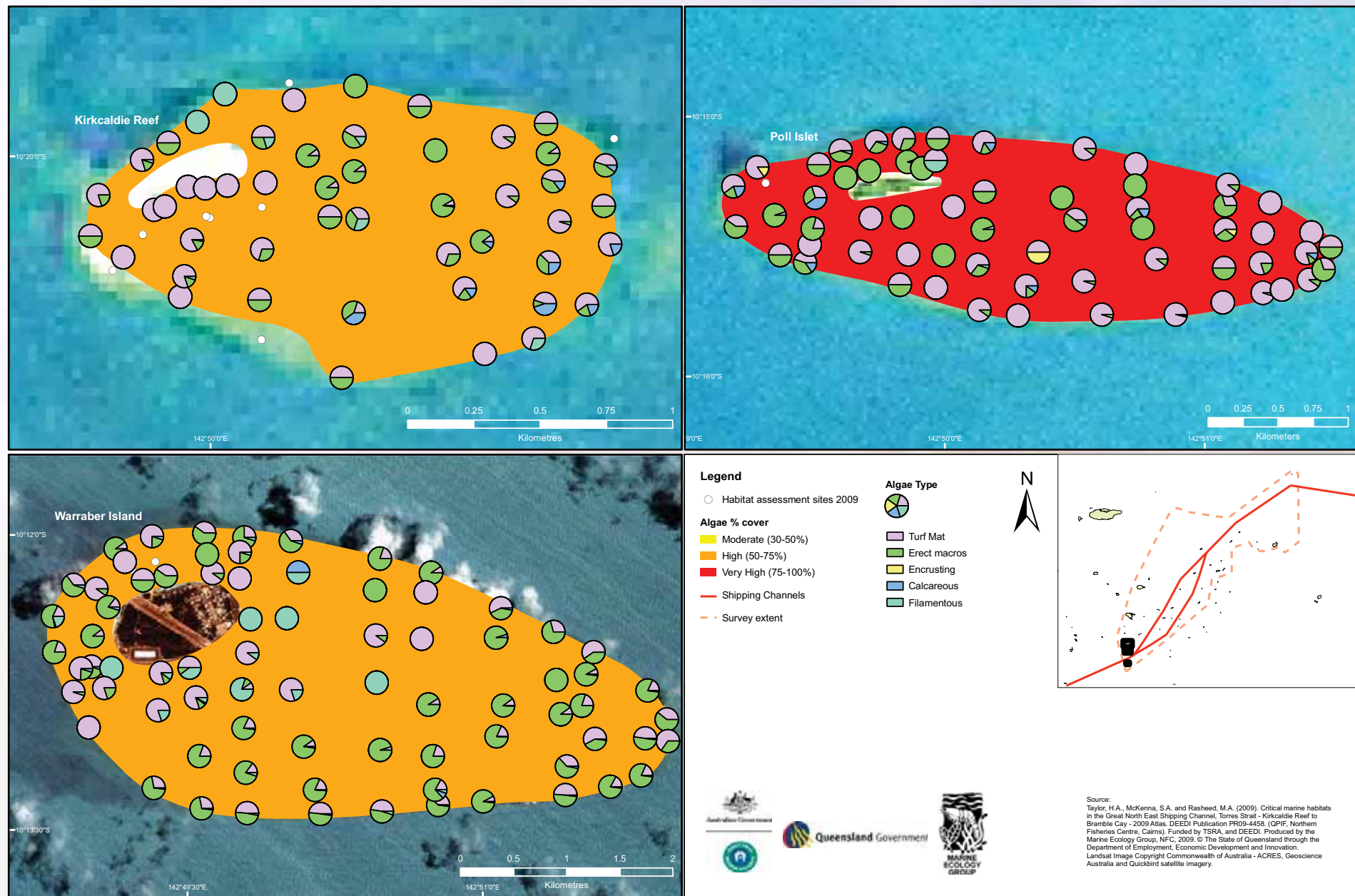


Figure 4 Mean percent cover of algal types in the Torres Strait survey area, 2008 & 2009

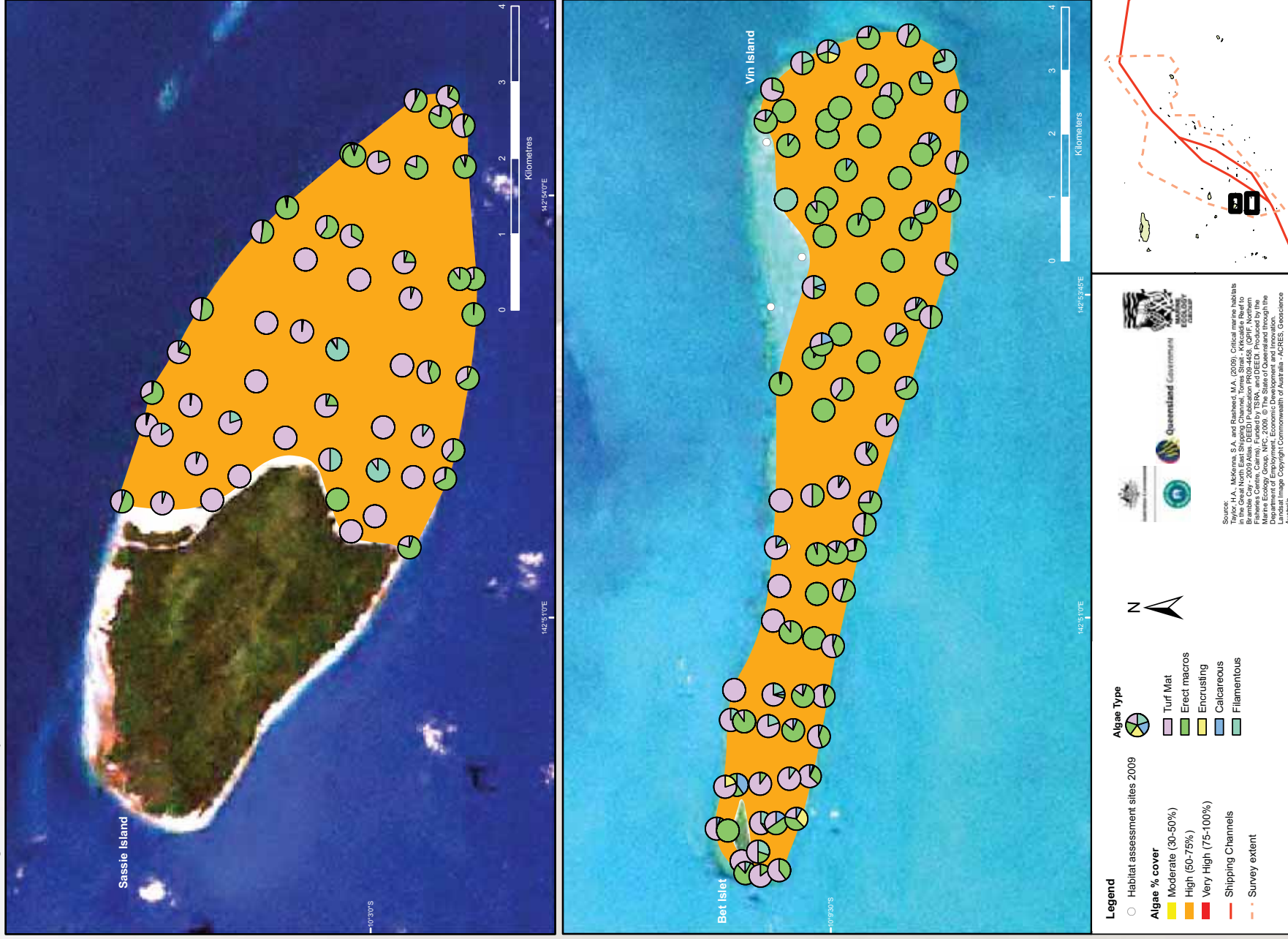




Map 16. Algae cover and types for sites around Kirkcaldie Reef, Poll Islet and Warraber Island, Torres Strait, March/April 2009

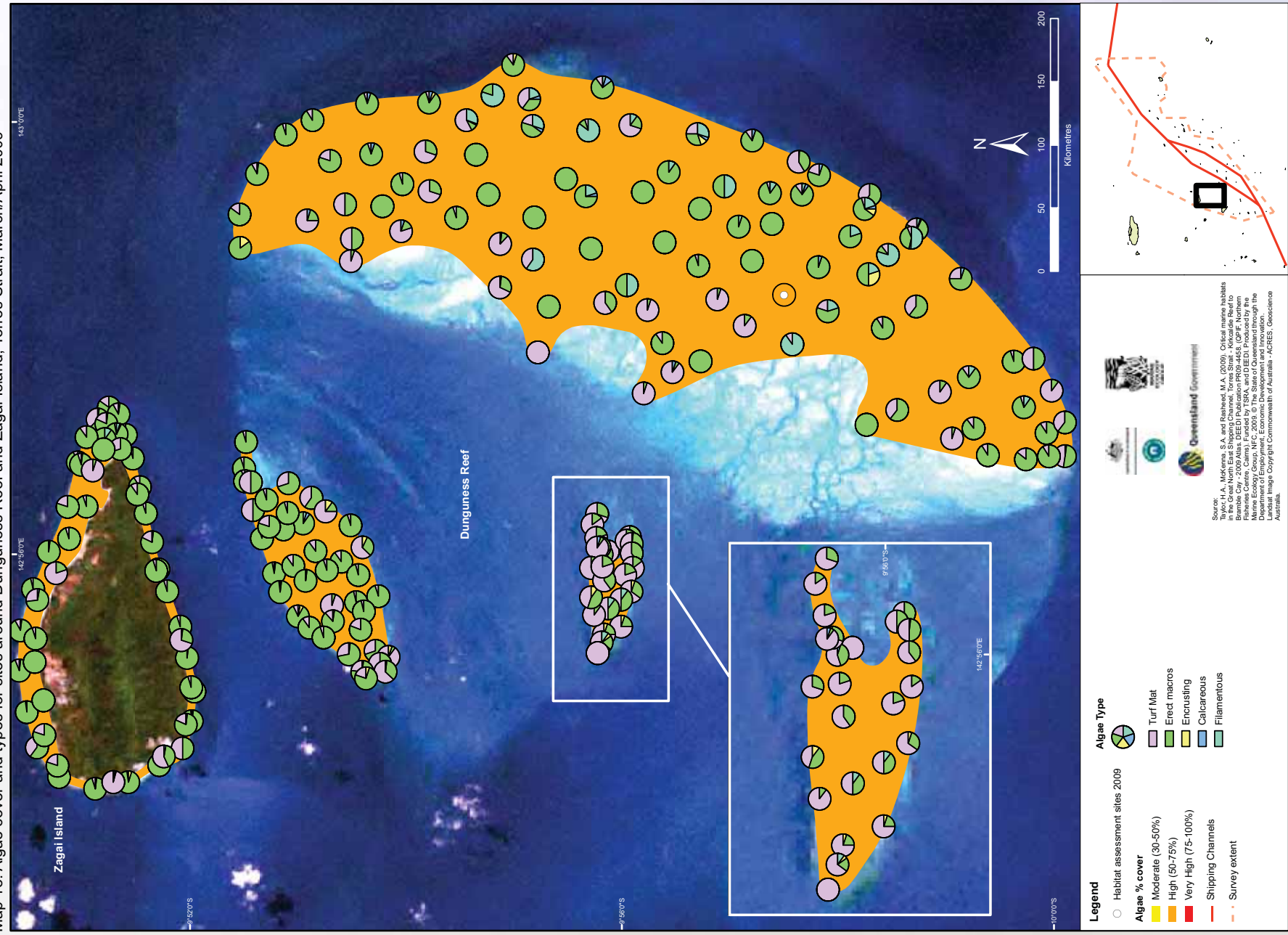


Map 17. Algae cover and types for sites around Bet Islet and Sassie Island, Torres Strait, March/April 2009



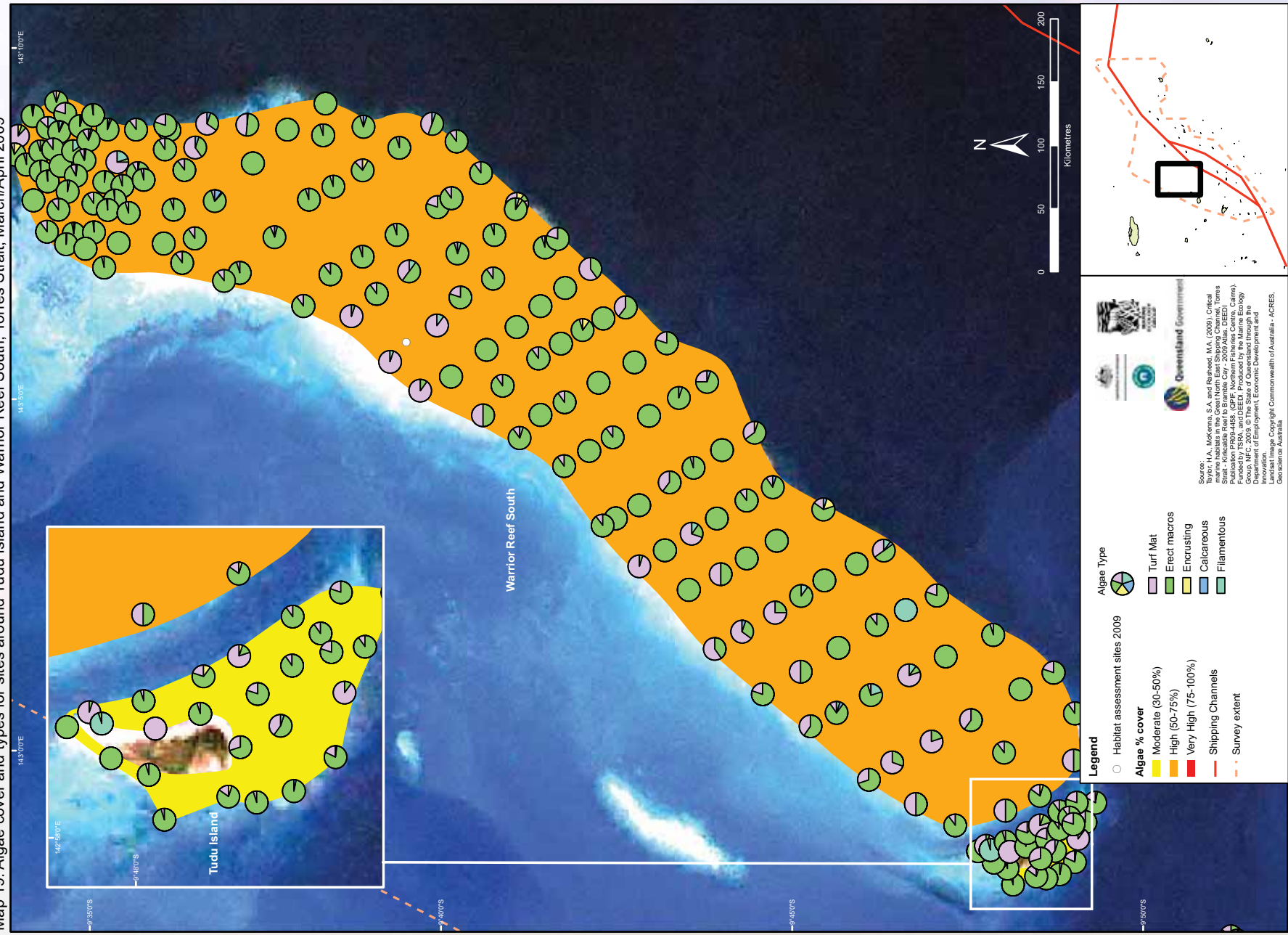


Map 18. Algae cover and types for sites around Dungunness Reef and Zagai Island, Torres Strait, March/April 2009



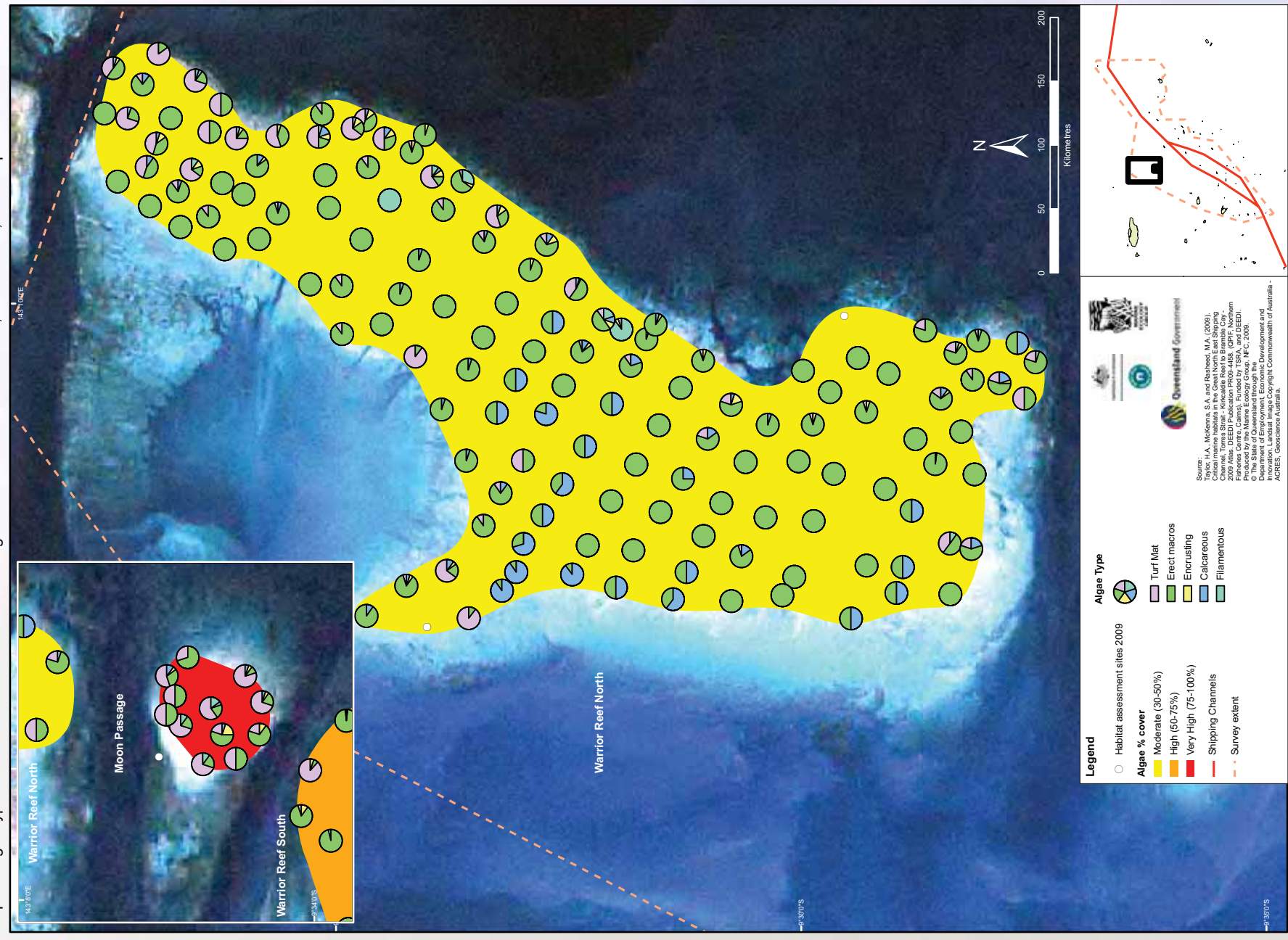


Map 19. Algae cover and types for sites around Tudu Island and Warrior Reef South, Torres Strait, March/April 2009

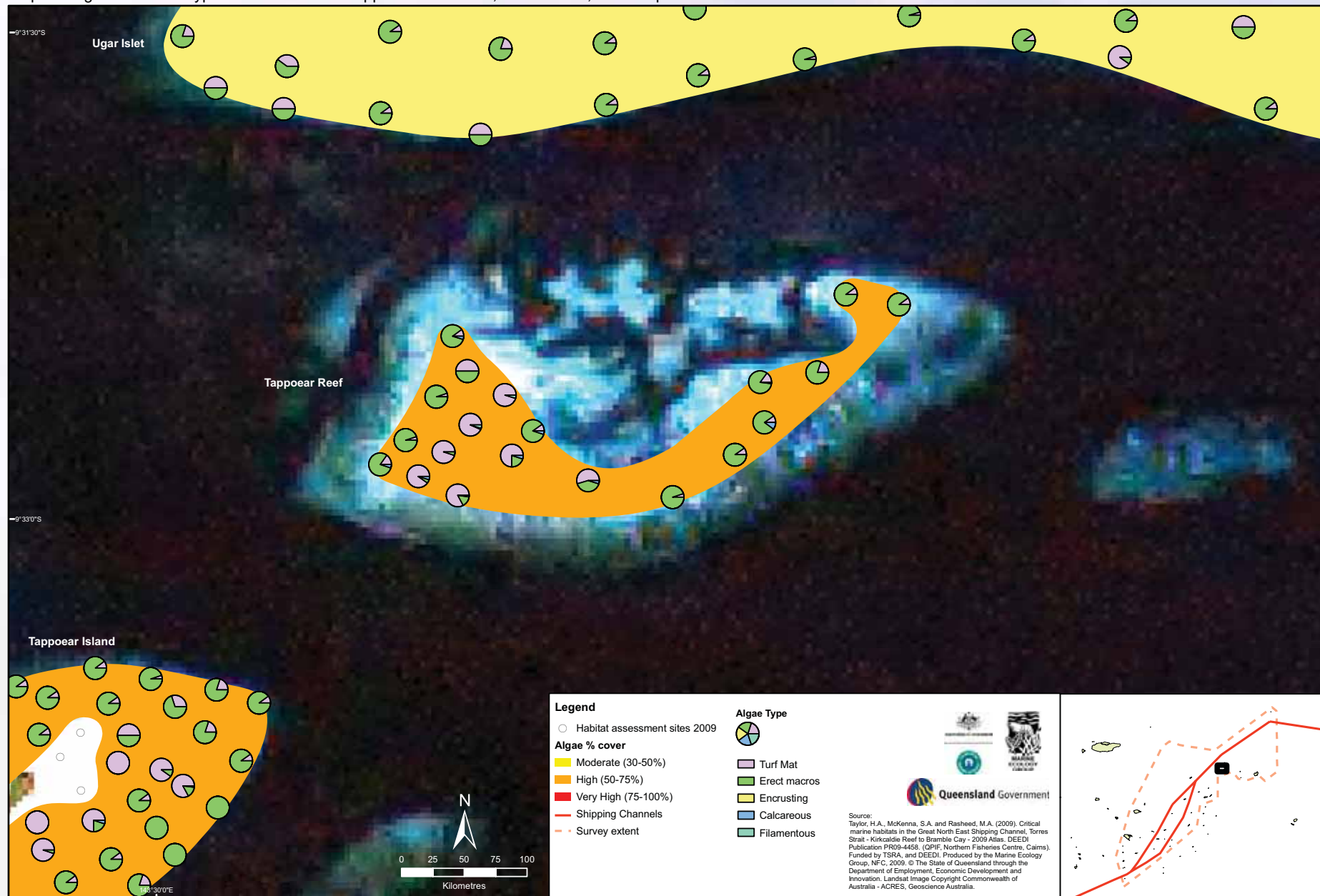




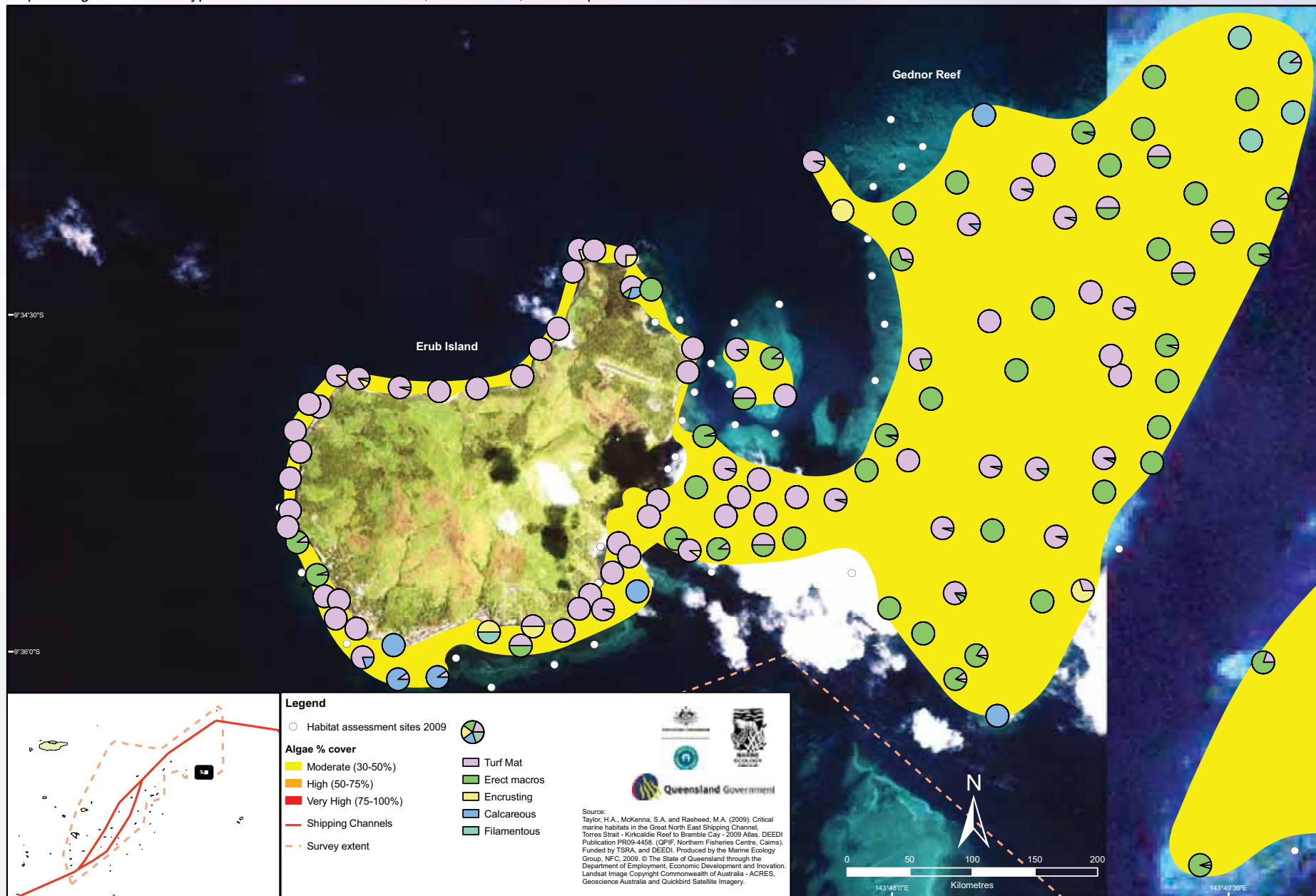
Map 20. Algae type and cover for sites on Moon Passage Reef and Warrior Reef North, Torres Strait, March/April 2009



Map 21. Algae cover and types for sites around Tappoear Island reef, Torres Strait, March/April 2009

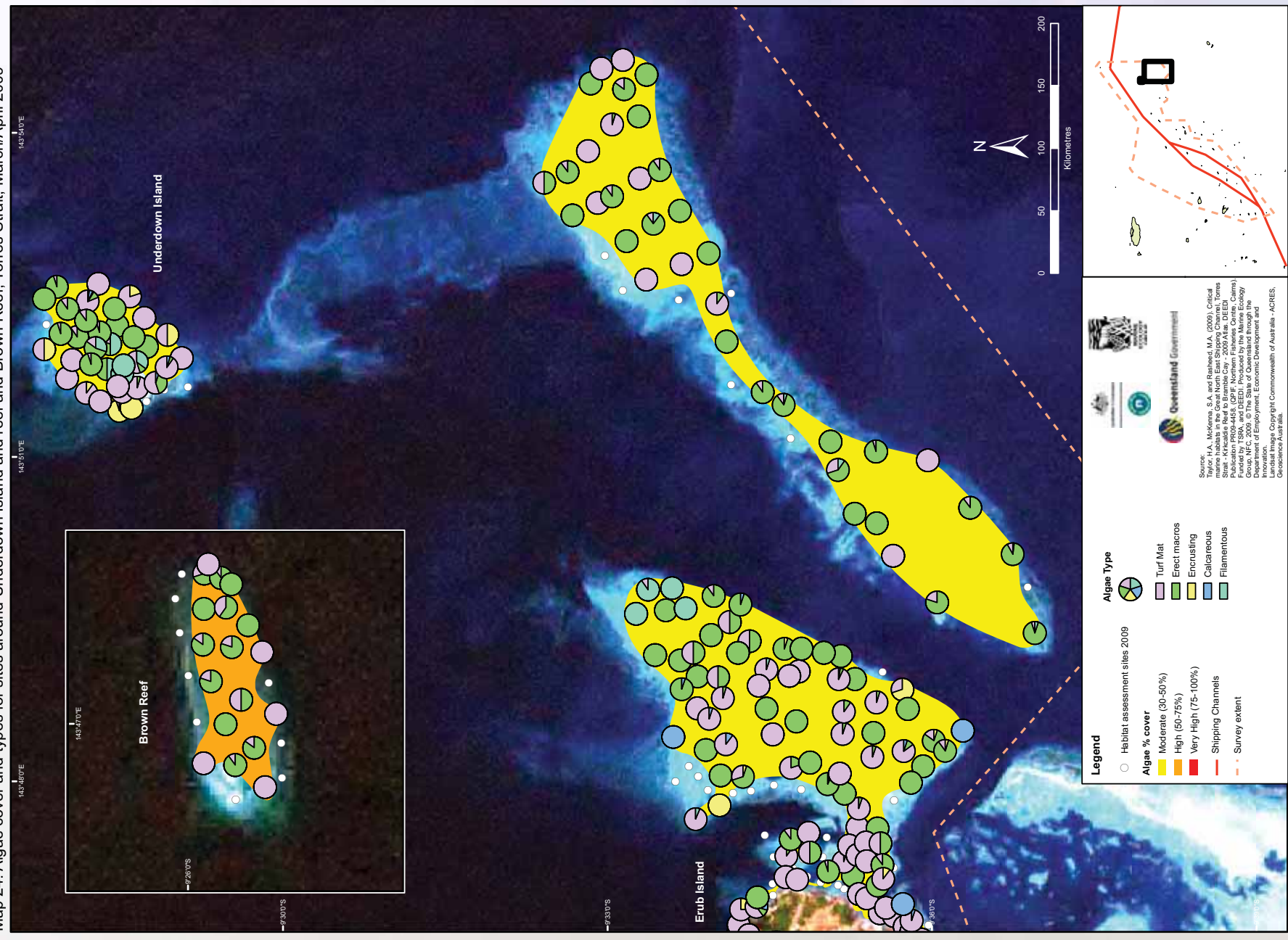


Map 23. Algae cover and types for sites around Erub Island, Torres Strait, March/April 2009

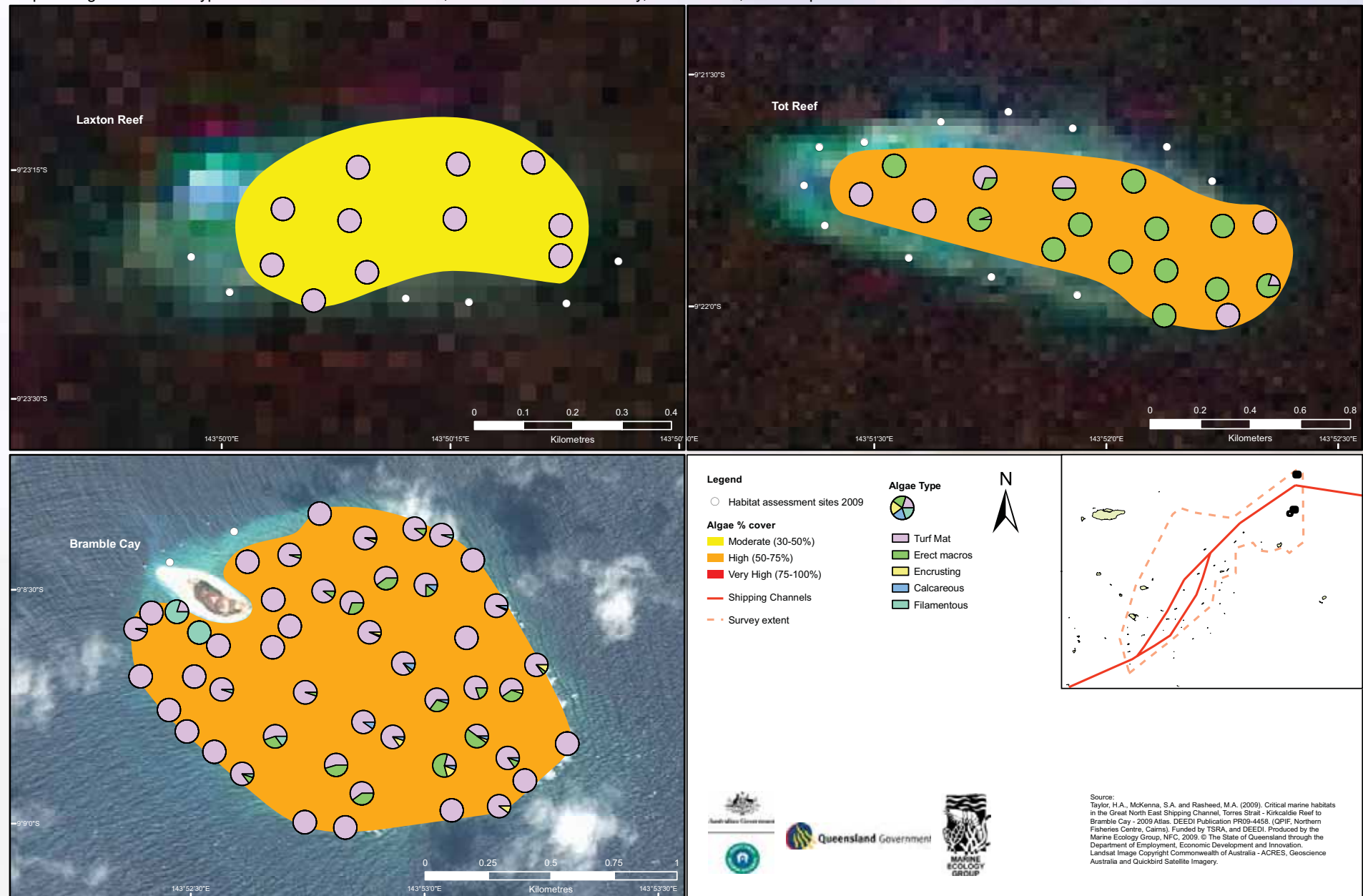




Map 24. Algae cover and types around Underdown Island and reef and Brown Reef, Torres Strait, March/April 2009



Map 25. Algae cover and types for sites around Laxton Reef, Tot Reef and Bramble Cay, Torres Strait, March/April 2009



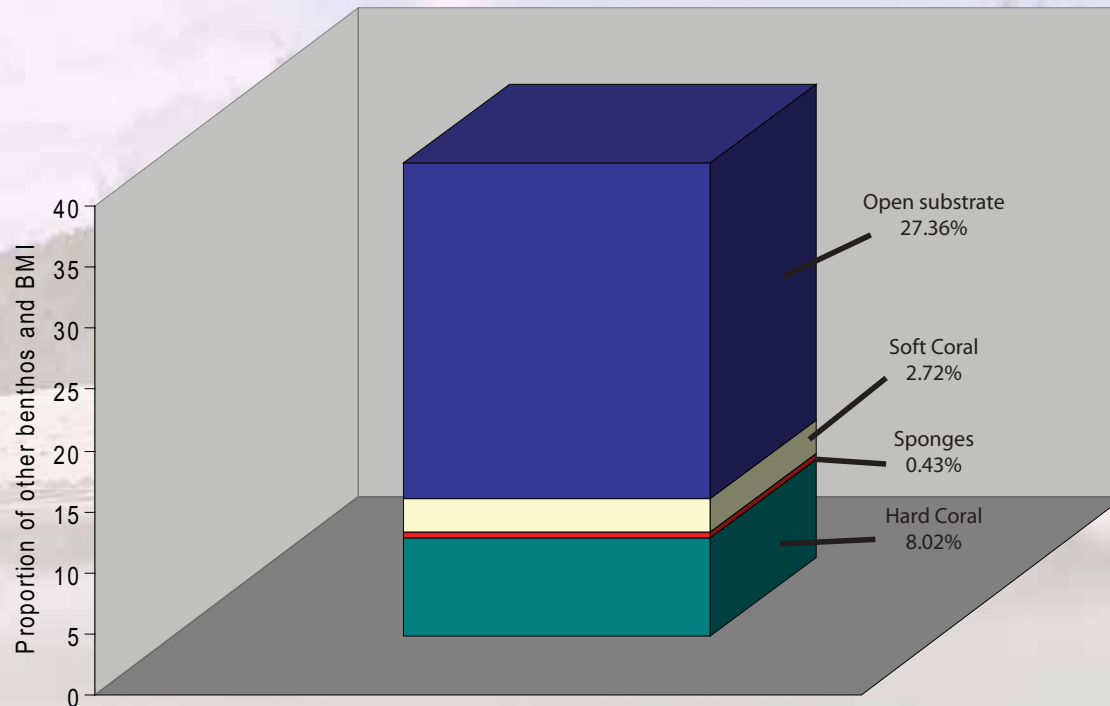
Other benthos and benthic macro-invertebrates (BMI)

Other benthos (excluding seagrass and algae) made up a significant component of the benthic habitat cover in the survey (Figure 1), within which open substrate comprised the largest fraction of benthic type. Open substrate was typically found in conjunction with seagrass, algae and BMI communities. BMI within reef habitat communities were dominated by hard and soft corals, with increasing occurrence to the north-east of the GNE channel (Maps 26-35).

Generally, hard and soft coral communities formed a ring around the outside of the intertidal areas surveyed, dominating the reef crest and extending into the subtidal region. This pattern was clearly evident on Layoak Island (see Taylor *et al.* 2008), Erub Island (Map 33), and the four north-eastern most reefs; Brown, Laxton and Tot reefs, and Bramble Cay (Maps 34 & 35). Where present, hard and soft coral cover was typically very high (>75%). Sponges had a low presence across the GNE channel. The intertidal areas that are more exposed on low tide were more typically dominated by open substrate.

Other benthic taxa including ascidians, anenomes, bivalves and holothurians formed obvious components of the benthic habitat at only a few sites in the survey area.

Figure 3 Mean percent cover (at each site) of benthic macro-invertebrate type around the Torres Strait survey area, 2008 & 2009



Mixed seagrass, algae and open substrate community



Soft coral dominated reef community



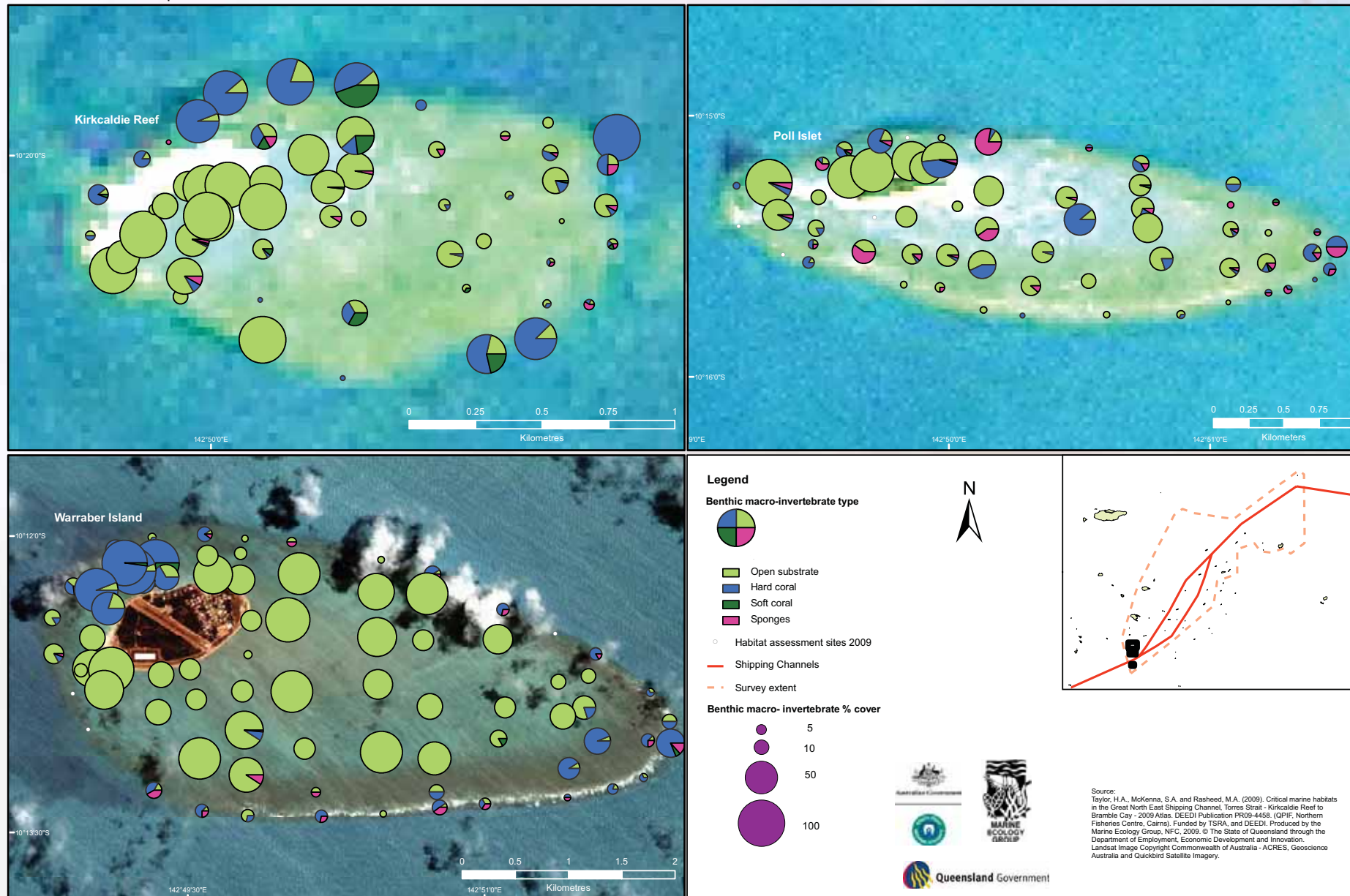
Mixed Hard coral, algae and other community



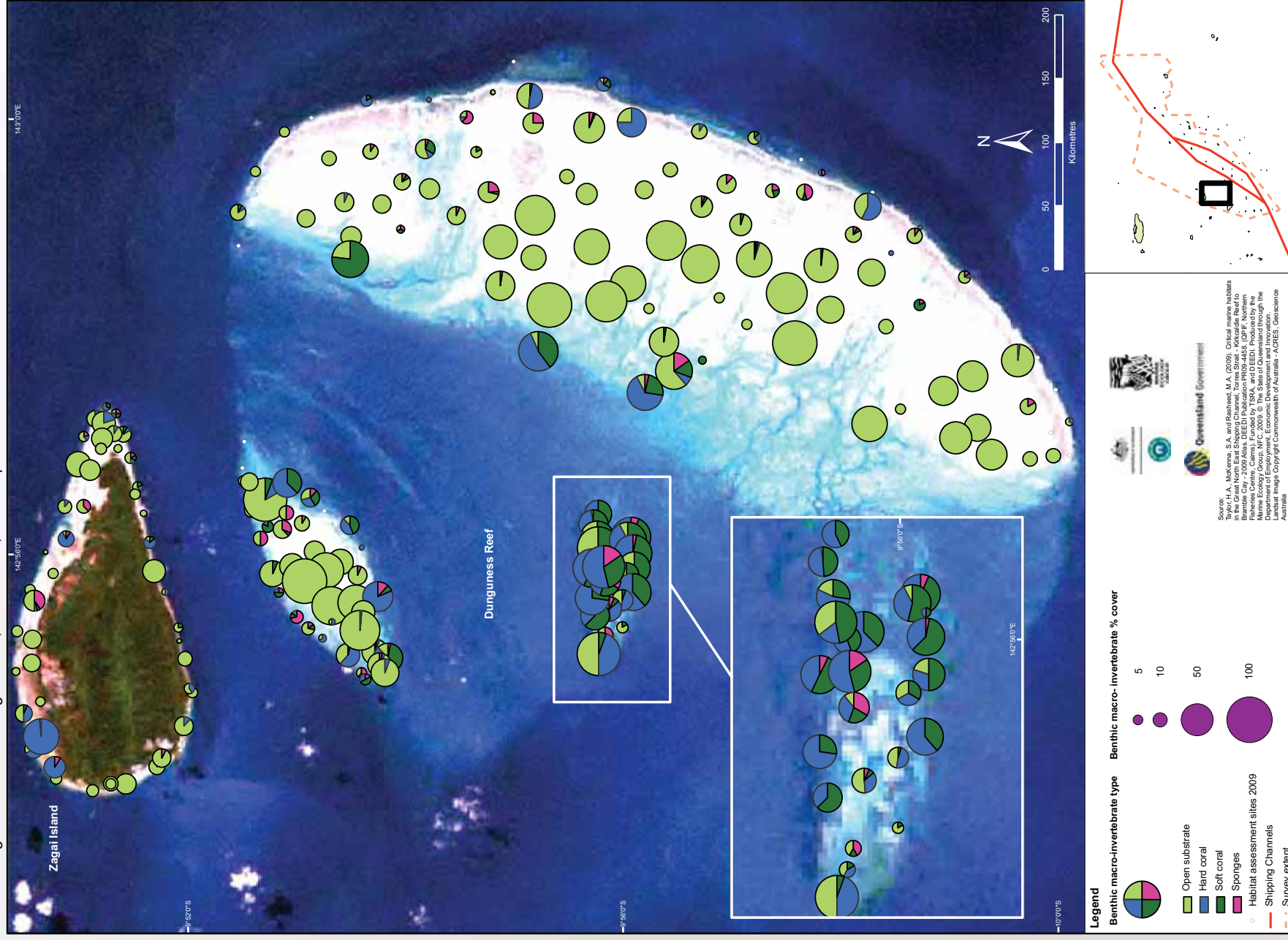
Mixed Hard coral dominated reef community



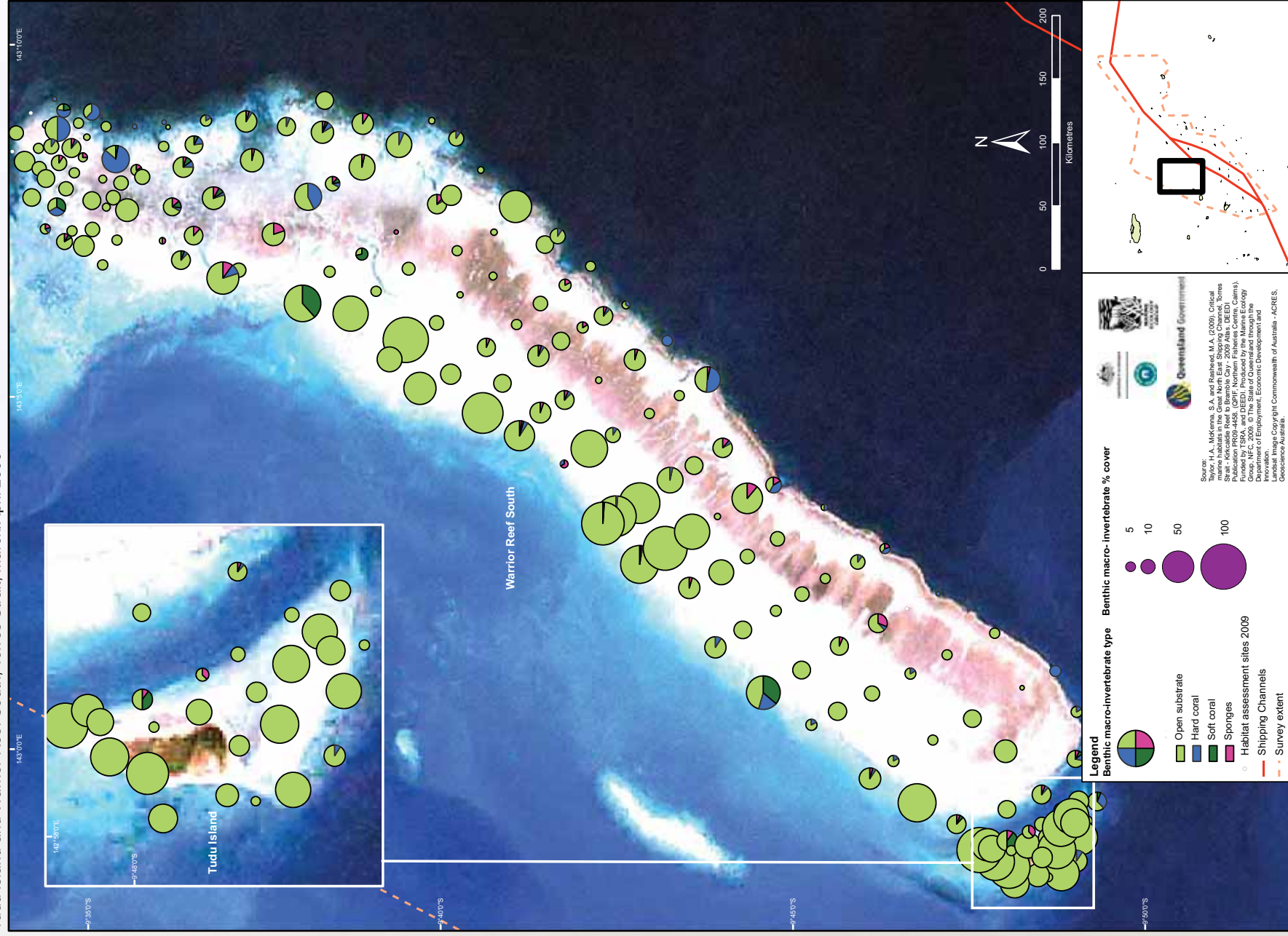
Map 26. Other benthos (excluding seagrass and algae) and benthic macro-invertebrate distribution and abundance for sites around Kirkcaldie Reef, Poll Islet and Warraber Island, Torres Strait, March/April 2009



Map 28. Other benthos (excluding seagrass and algae) and benthic macro-invertebrate distribution and abundance for sites around Dunguness Reef and Zagai Island, Torres Strait, March/April 2009

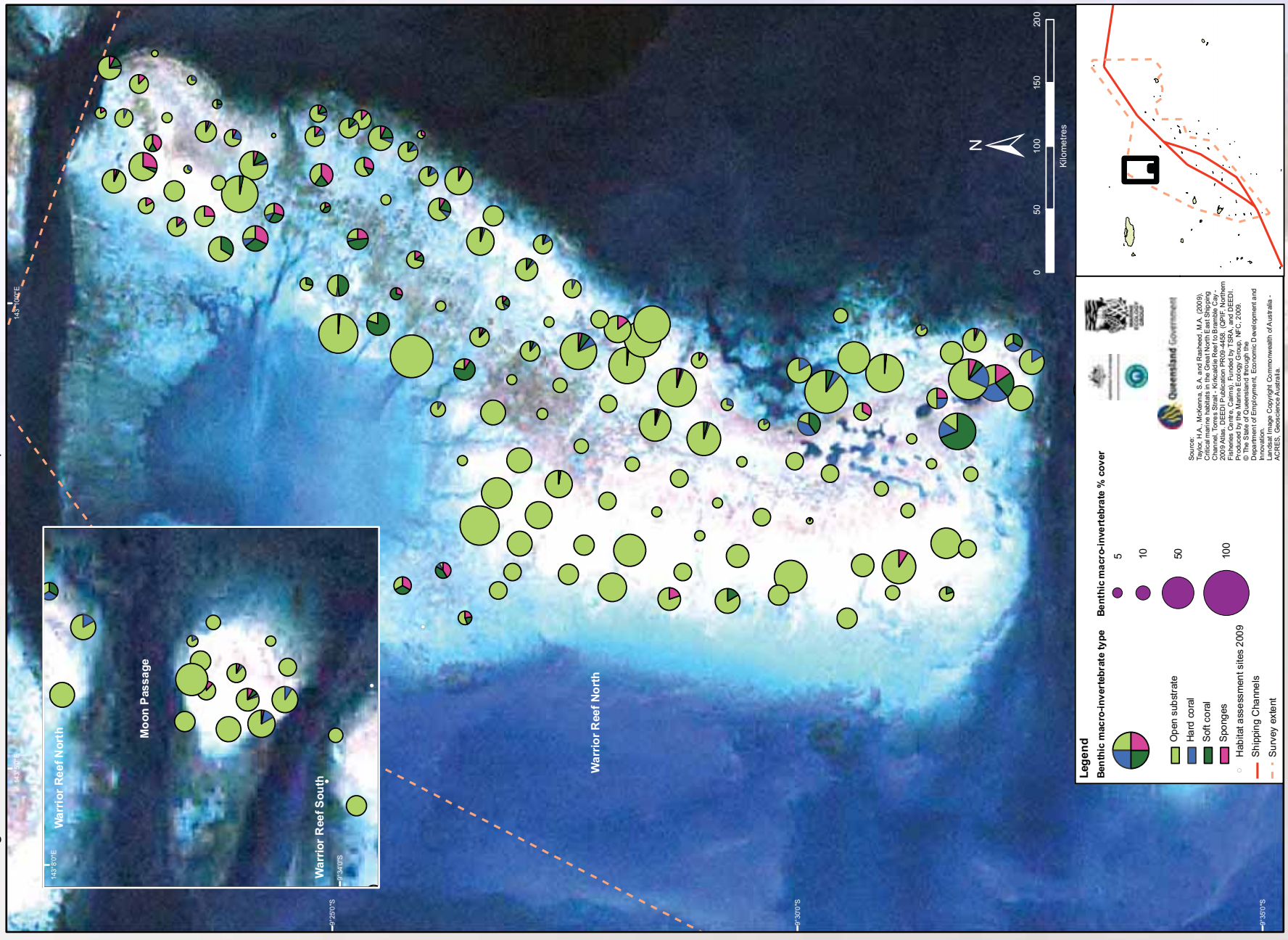


Map 29. Other benthos (excluding seagrass and algae) and benthic macro-invertebrate distribution and abundance for sites around Tudu Island and Warrior Reef South, Torres Strait, March/April 2009



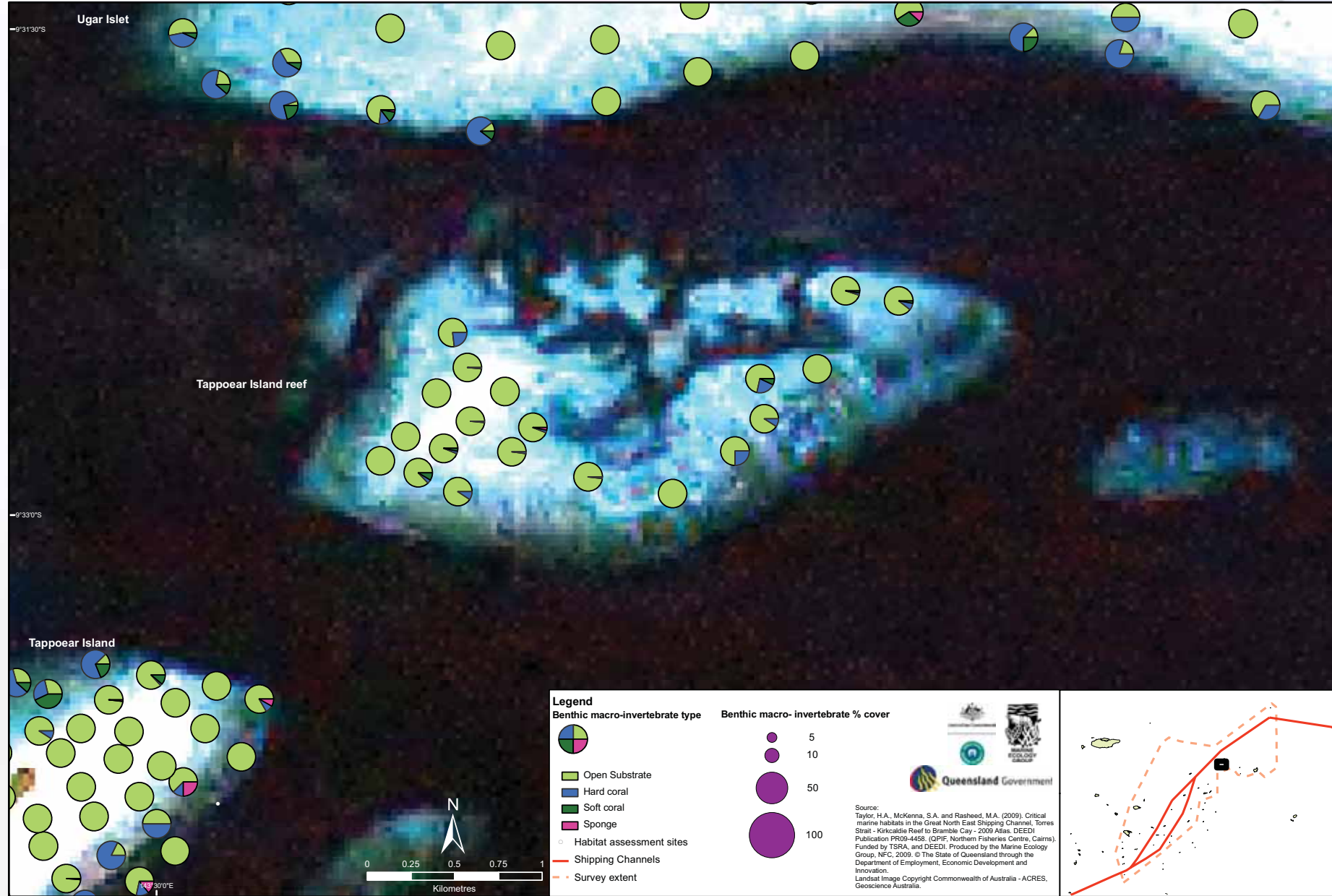


Map 30. Other benthos (excluding seagrass and algae) and benthic macro-invertebrate distribution and abundance for sites on Moon Passage Reef and Warrior Reef North, Torres Strait, March/April 2009

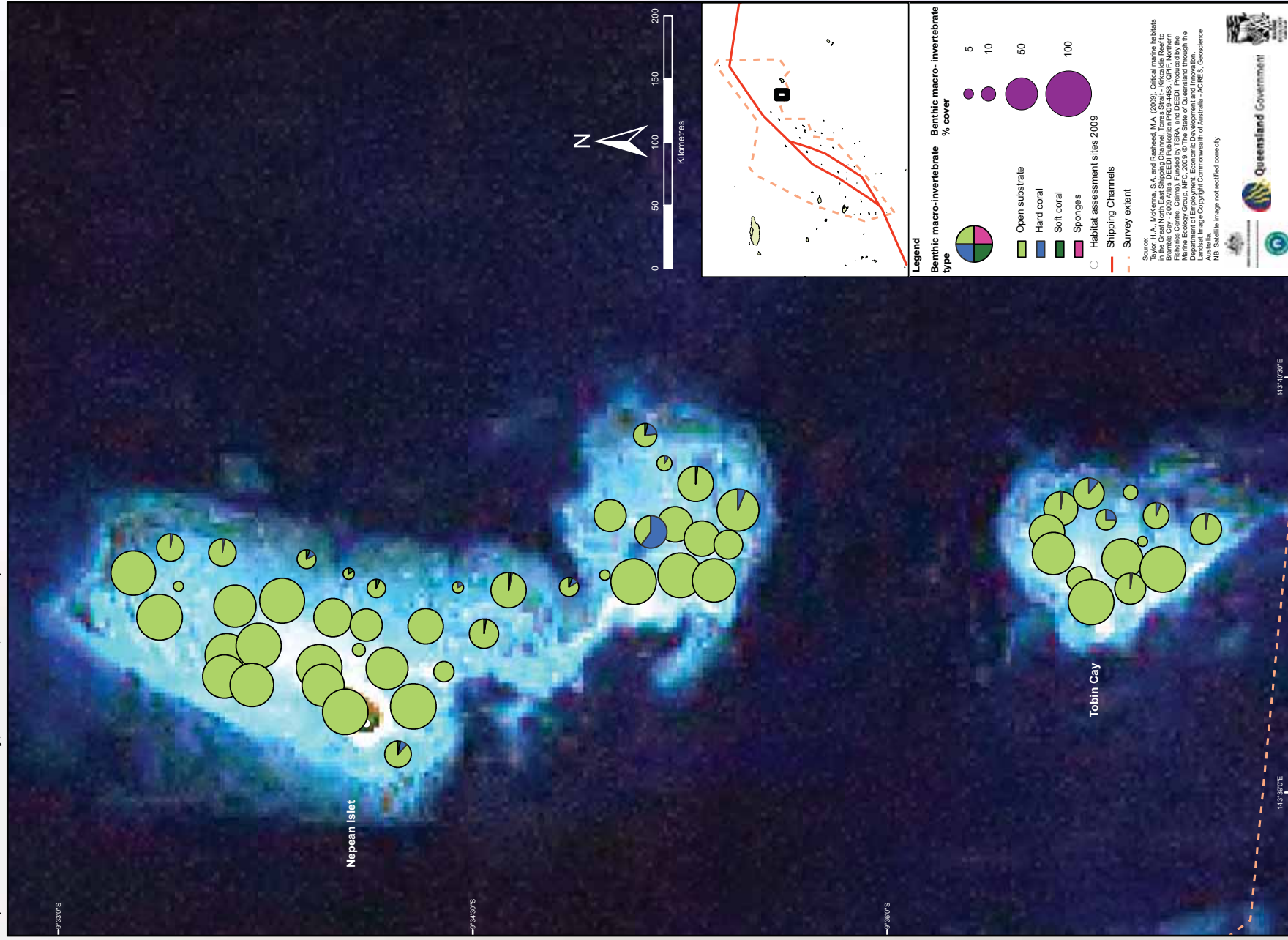




Map 31. Other benthos (excluding seagrass and algae) and benthic macro-invertebrate distribution and abundance for sites around Tappoear Island reef, Torres Strait, March/April 2009

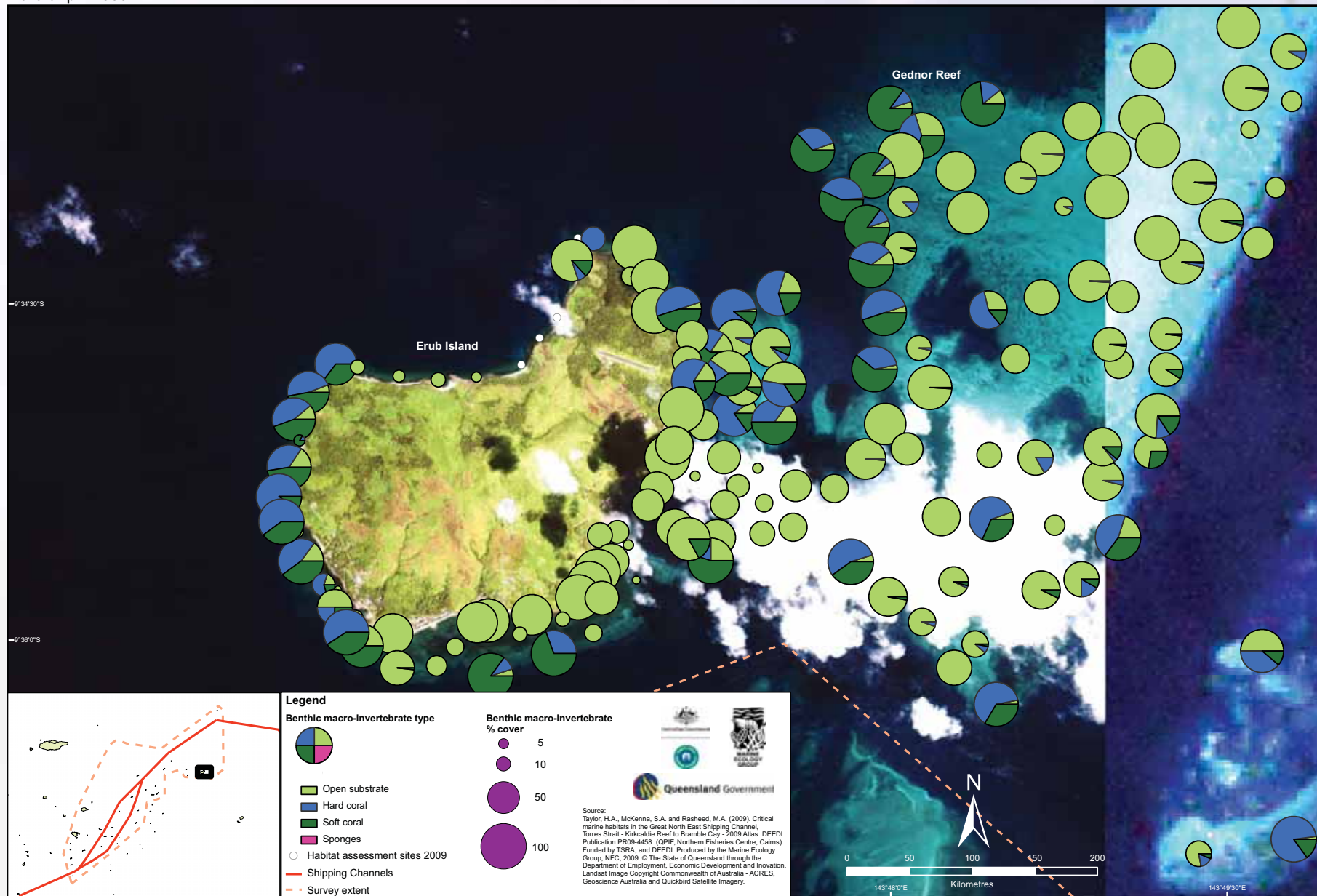


Map 32. Other benthos (excluding seagrass and algae) and benthic macro-invertebrate distribution and abundance for sites around Nepean Islet and Tobin Cay, Torres Strait, March/April 2009



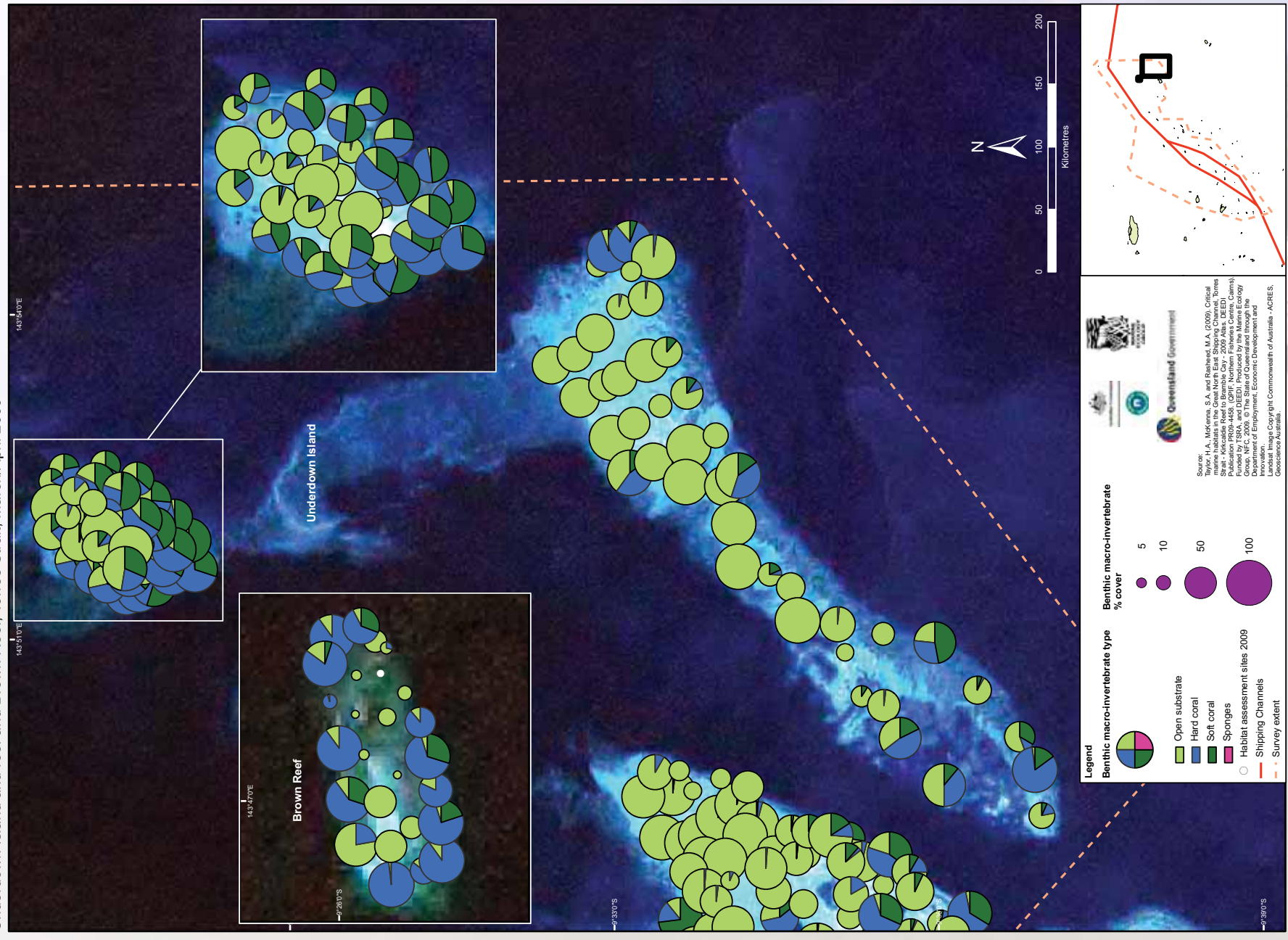


Map 33. Other benthos (excluding seagrass and algae) and benthic macro-invertebrate distribution and abundance for sites around Erub Island and on Gednor reef, Torres Strait, March/April 2009



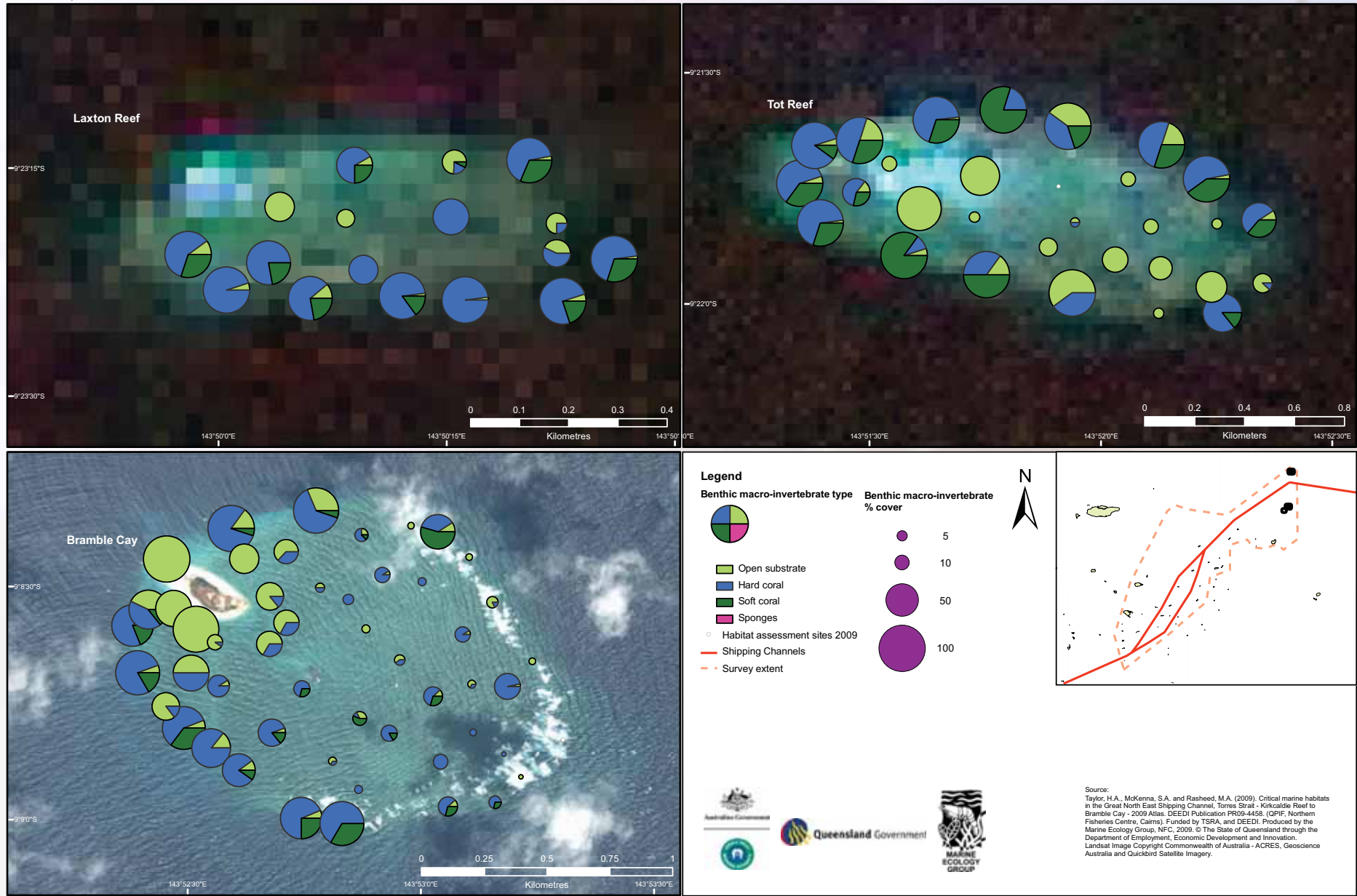


Map 34. Other benthos (excluding seagrass and algae) and benthic macro-invertebrate distribution and abundance for sites around Underdown Island and reef and Brown Reef, Torres Strait, March/April 2009





Map 35. Other benthos (excluding seagrass and algae) and benthic macro-invertebrate distribution and abundance for sites around Laxton Reef, Tot Reef and Bramble Cay, Torres Strait, March/April 2009



Conclusions and Habitat Vulnerability

This atlas documents the incidence of ecologically and economically valuable intertidal marine habitats occurring adjacent to a section of the Great North East (GNE) Shipping Channel and in the Torres Strait. During the surveys, extensive areas of seagrass, algae and benthic macro-invertebrate (BMI) habitats were identified in close proximity to the shipping channel. The diversity of habitats and their near pristine condition makes this area particularly valuable with the habitats described important for commercial fisheries and regional biodiversity. The area is also recognised as having a particularly high risk of shipping accidents as reef areas are very close to the channel. The accident risk combined with the high habitat sensitivity means the area is likely to be highly sensitive to shipping accidents and oil spills.

In order to assist in priority setting for accident response we have combined the habitats mapped in these surveys into three distinct categories of habitat vulnerability from shipping accidents. The categories were based on habitats biological susceptibility to oils and habitat quality (Table 5; Map 36-45). While all of the intertidal area could be considered vulnerable, 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 seagrass, coral and algae types found within the survey area are susceptible to damage from oil and also to some of the dispersants commonly used in oil spill management (e.g. Baca *et al.* 1996; Knap *et al.* 1983; O'Brien & Dixon 1976) they can vary substantially in their growth rates and ability to recover from damage. Small, fast growing seagrass species such as *Halophila* have the capacity for rapid recolonisation and recovery from disturbance when compared with larger slower growing species (eg. Rasheed 1999; 2004). Similarly, different algae types vary in their growth rates and ability to recolonise. Filamentous 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; Littler & Littler 1980; McClanahan 1997).

Benthic habitats were assigned into seven different groups for determination of vulnerability by applying the known information on recovery rates and susceptibility to oil damage (Table 5). From this, a habitat vulnerability matrix

that also accounted for density of habitat types was applied and regions were assigned into habitat vulnerability categories: low, moderate and high (Table 5). This information was overlaid onto the habitat vulnerability maps. Almost all

intertidal areas were mapped into these categories, however areas that contained purely open substrate were occasionally omitted as their vulnerability to shipping accidents and oil spills is very low.

Table 5 Risk matrix for major habitat types for the Great North East Shipping Channel, 2008 & 2009.

Habitat Type		Percent cover of habitat				
		Very Low (0 – 10)	Low (10 – 30)	Moderate (30 – 50)	High (50 – 75)	Very High (75 – 100)
Seagrass	Slow growing, long recovery time (EA, TH, CR, CS, TC)*	M	H	H	H	H
	Fast growing, short recovery time (HO, HUN, SI)*	M	M	M	M	H
Algae	Turf / Filamentous	L	L	L	L	L
	Encrusting	L	L	L	M	H
	Erect macrophytes / Erect calcareous	L	L	M	H	H
BMI	Hard & Soft Coral	L	M	M	H	H
	Sponges	L	M	M	H	H

* EA - *Enhalus acoroides*; TH - *Thalassia hemprichii*; CR - *Cymodocea rotundata*; CS - *Cymodocea serrulata*; TC - *Thalassodendron ciliatum*
HO - *Halophila ovalis*; HUN - *Halodule uninervis* (thin); SI - *Syringodium isoetifolium*

A *Baler* mollusc feeding



Papua New Guineans fishing on Warrior Reef



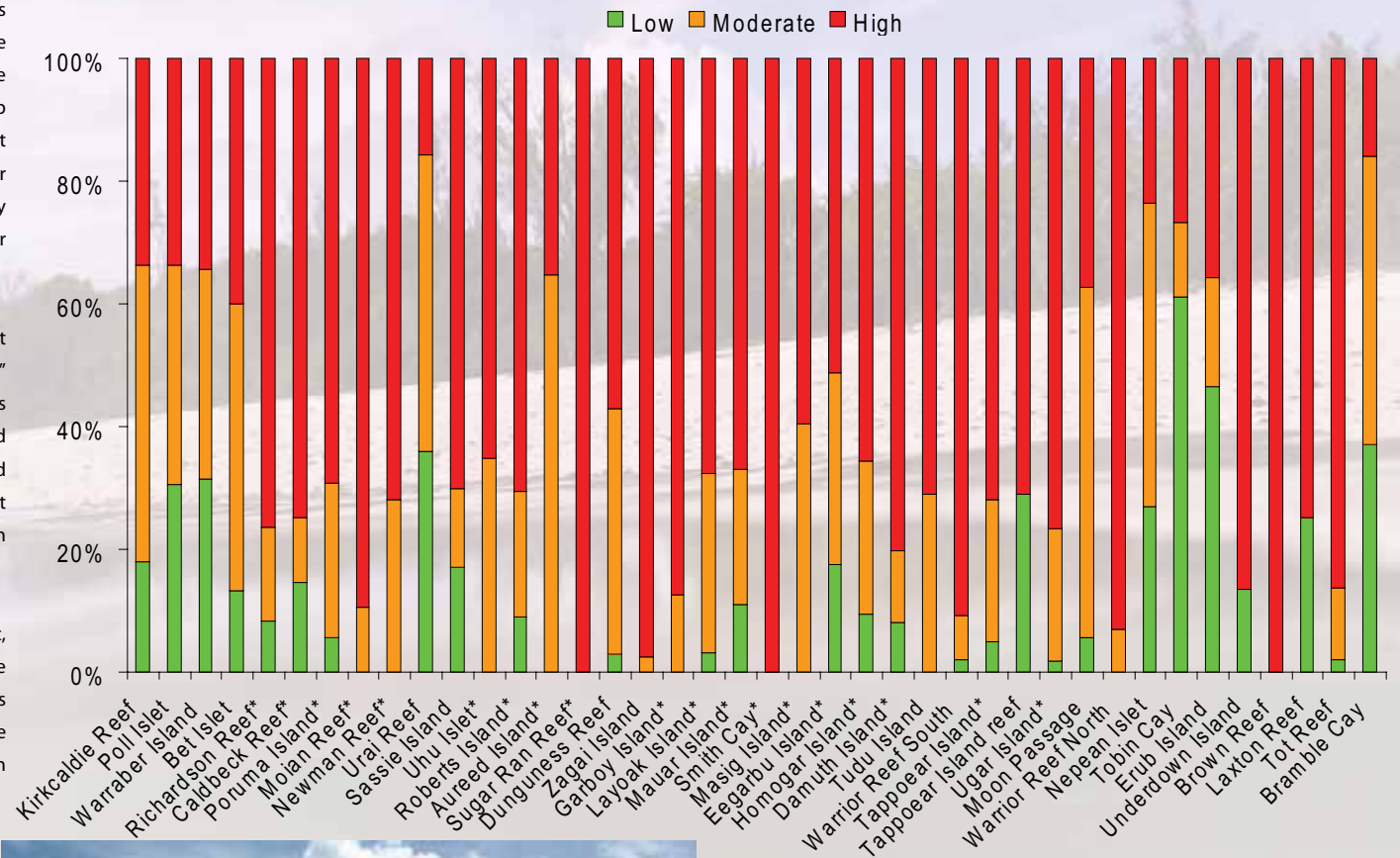


The application of the habitat vulnerability matrix resulted in 78% of the intertidal areas in the survey area being highly vulnerable to shipping accidents and oil spills (Figure 6; Maps 36-45). Most reefs and islands surveyed contained areas of all three vulnerability categories, however Brown and Sugar Ran reefs and Smith Cay were 100% highly vulnerable (Map 44; see Taylor *et al.* 2008) while Tobin Cay and Erub Island consisted of large areas of lower vulnerability areas (Maps 42 & 43). In most cases, highly vulnerable areas were those that retained shallow pools of water during low tide events with higher algal cover, seagrass and BMI, whereas fully exposed areas were typically at moderate or low vulnerability due to lower concentrations of structurally complex habitats forming there.

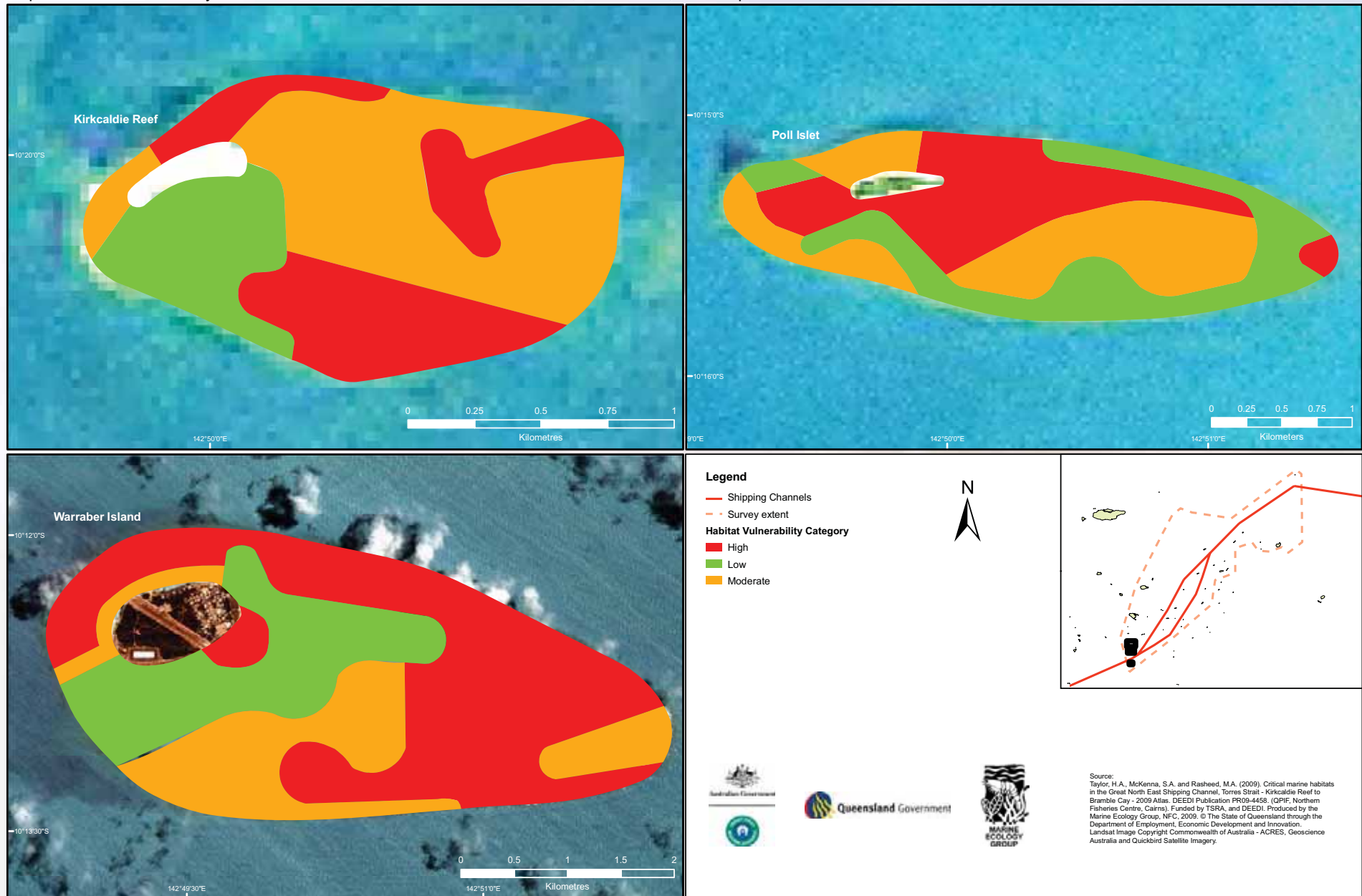
Care should be taken when using the maps in this atlas for shipping accident response. Despite some sections of the region being deemed at "low vulnerability" it should be remembered that this is a relative category and that these areas contained habitats that would be susceptible to damage from oil spills and shipping accidents. Many of the habitats described may also show intra- and inter-annual variability in distribution and density of habitat structure. Attempts at ground truthing the extent of these habitats as part of any response to an accident/oil spill is recommended.

The Great North East Shipping Channel has a high frequency of shipping traffic, complex navigation through reef and island habitat and has highly diverse marine habitat with only limited information previously available. The information in this atlas will be made available to be incorporated into the National Oil Spill Response Atlas (OSRA) to assist in the planning and management of shipping accidents in the Torres Strait.

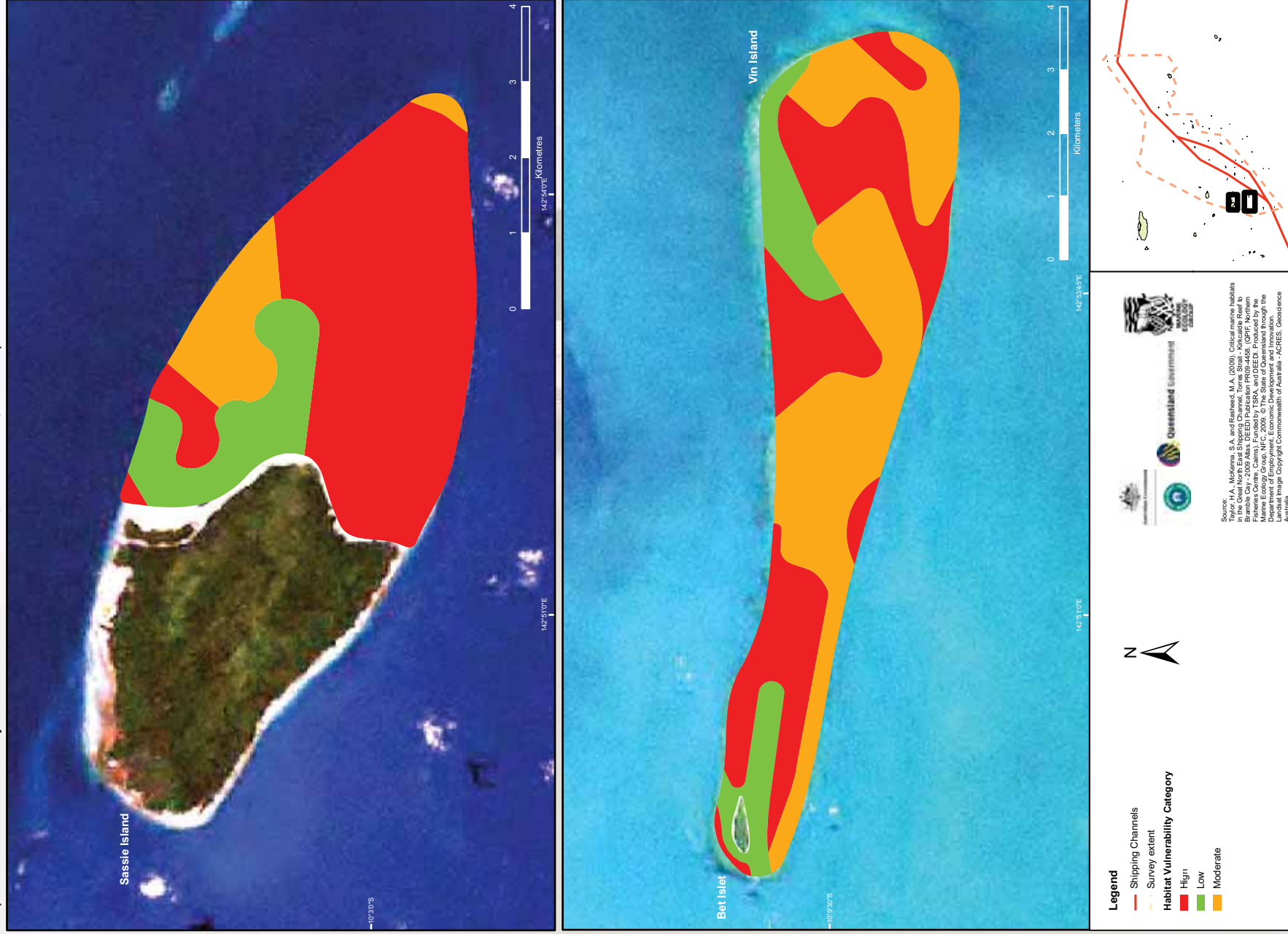
Figure 6 Habitat vulnerability (per cent) for intertidal islands and reefs in the Torres Strait survey area, 2008 & 2009



Map 36. Habitat Vulnerability on Kirkcaldie Reef, Poll Islet and Warraber Island, Torres Strait, March/April 2009

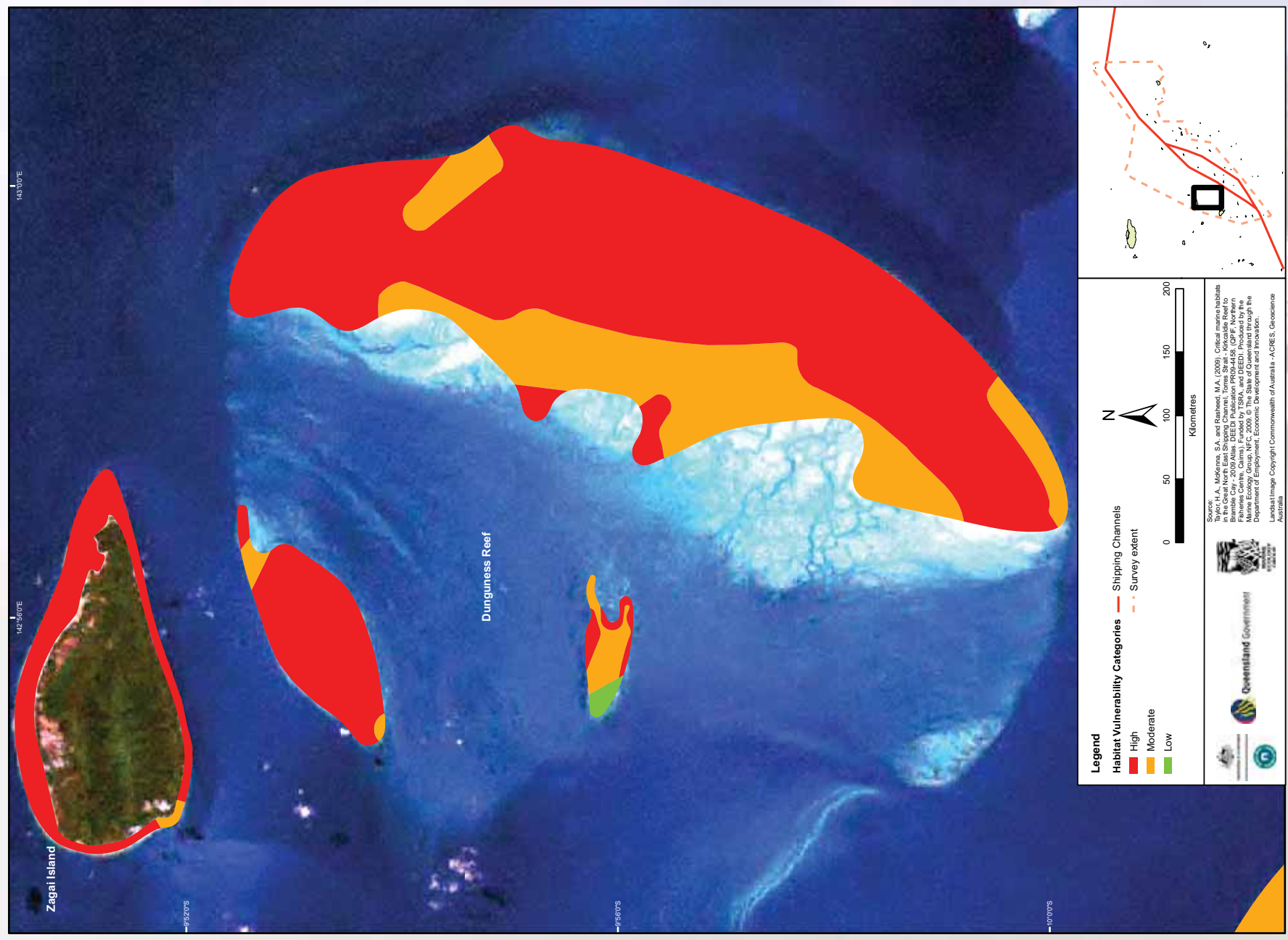


Map 37. Habitat Vulnerability on Bet Islet and Sassie Island, Torres Strait, March/April 2009



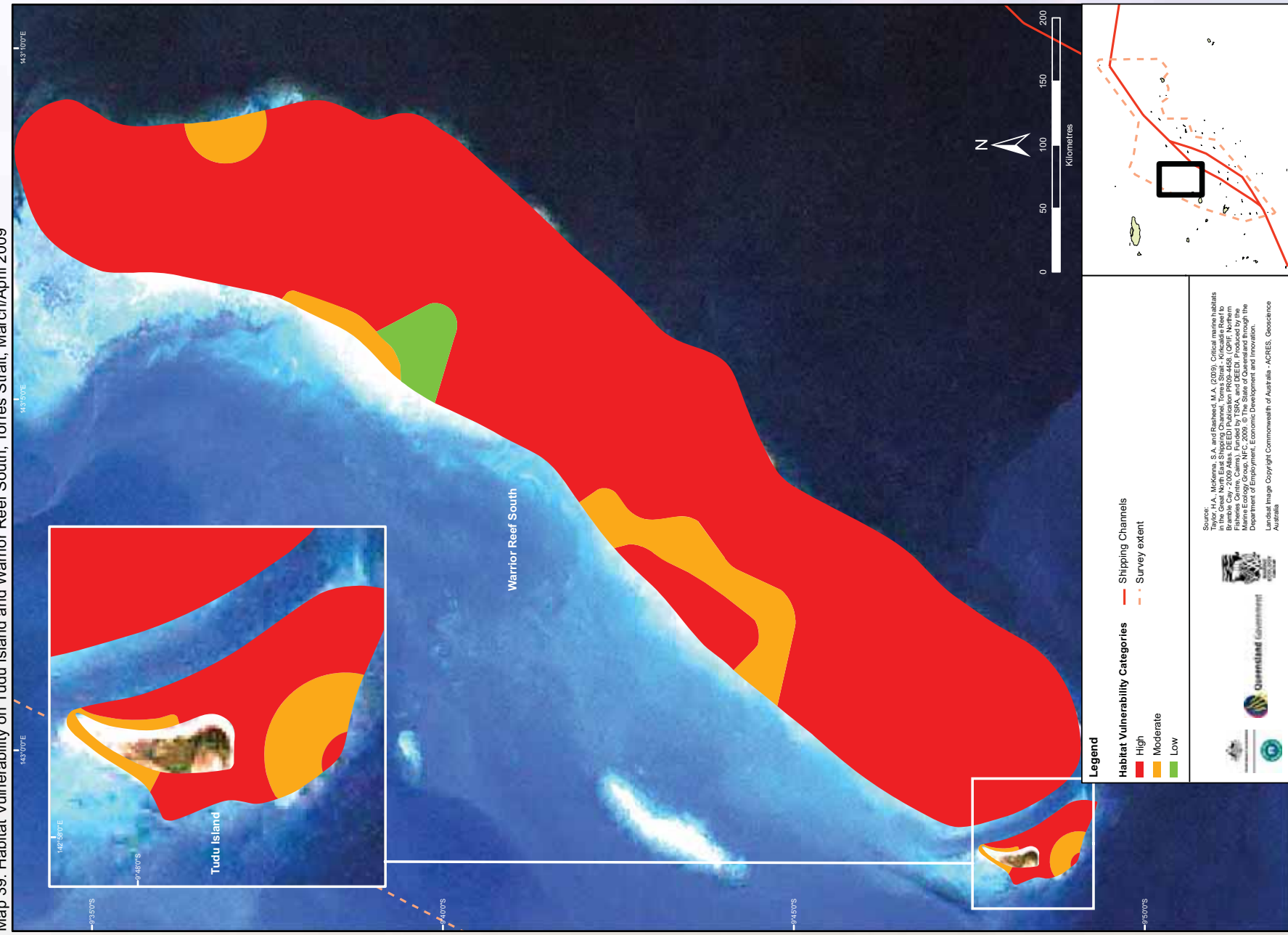


Map 38. Habitat Vulnerability on Dungunness Reef and Zagai Island, Torres Strait, March/April 2009

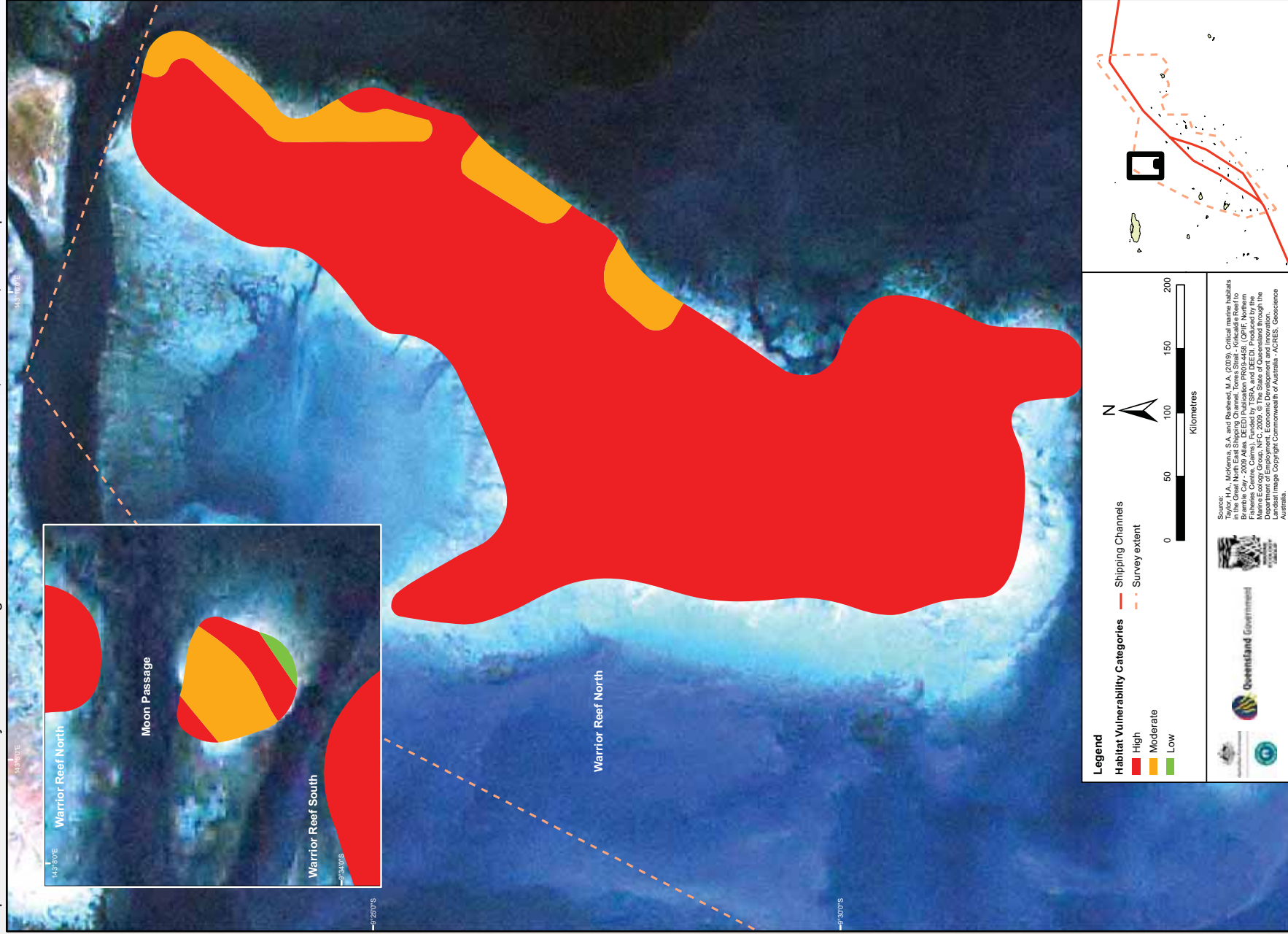




Map 39. Habitat Vulnerability on Tudu Island and Warrior Reef South, Torres Strait, March/April 2009

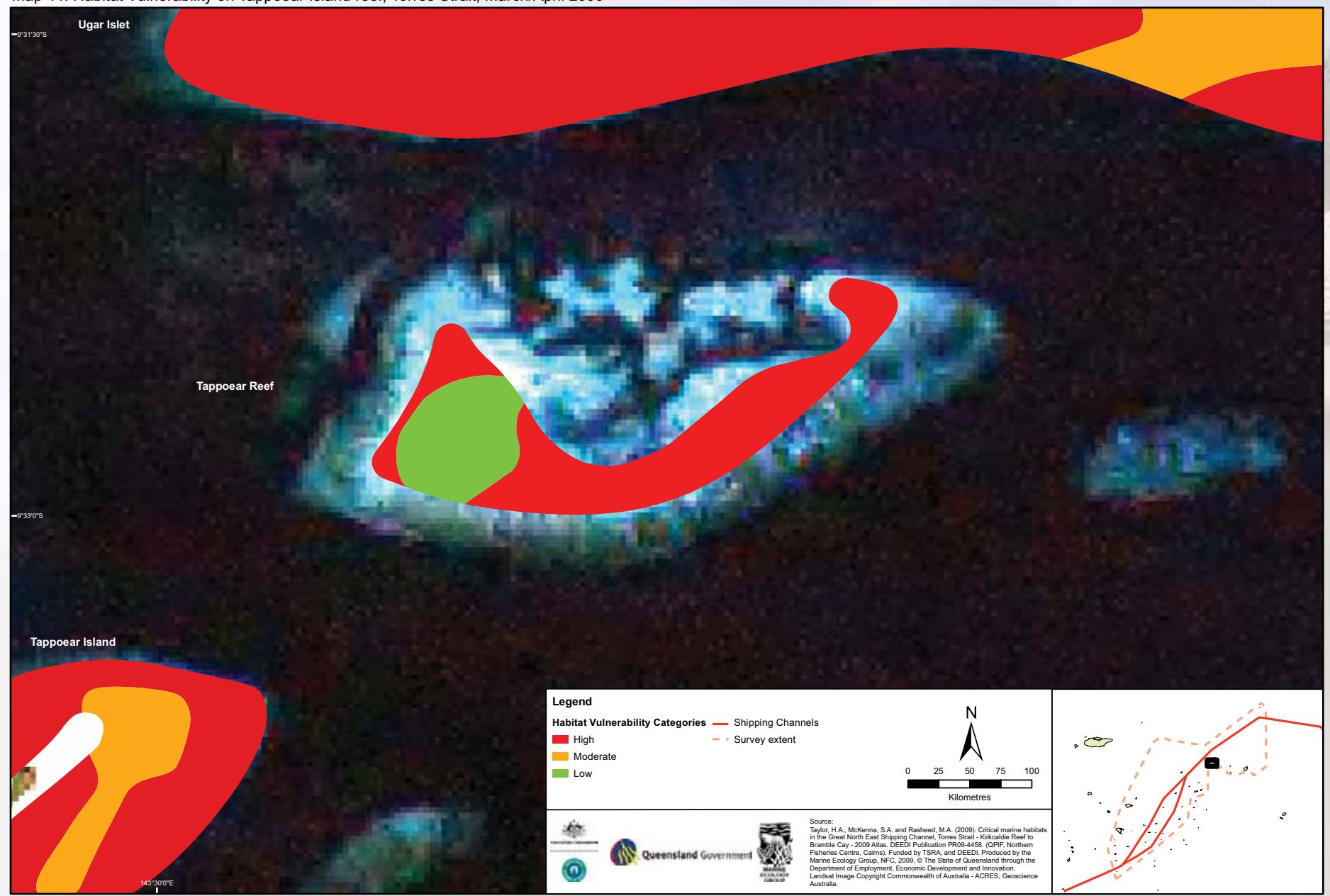


Map 40. Habitat Vulnerability on Moon Passage Reef and Warrior Reef North, Torres Strait, March/April 2009



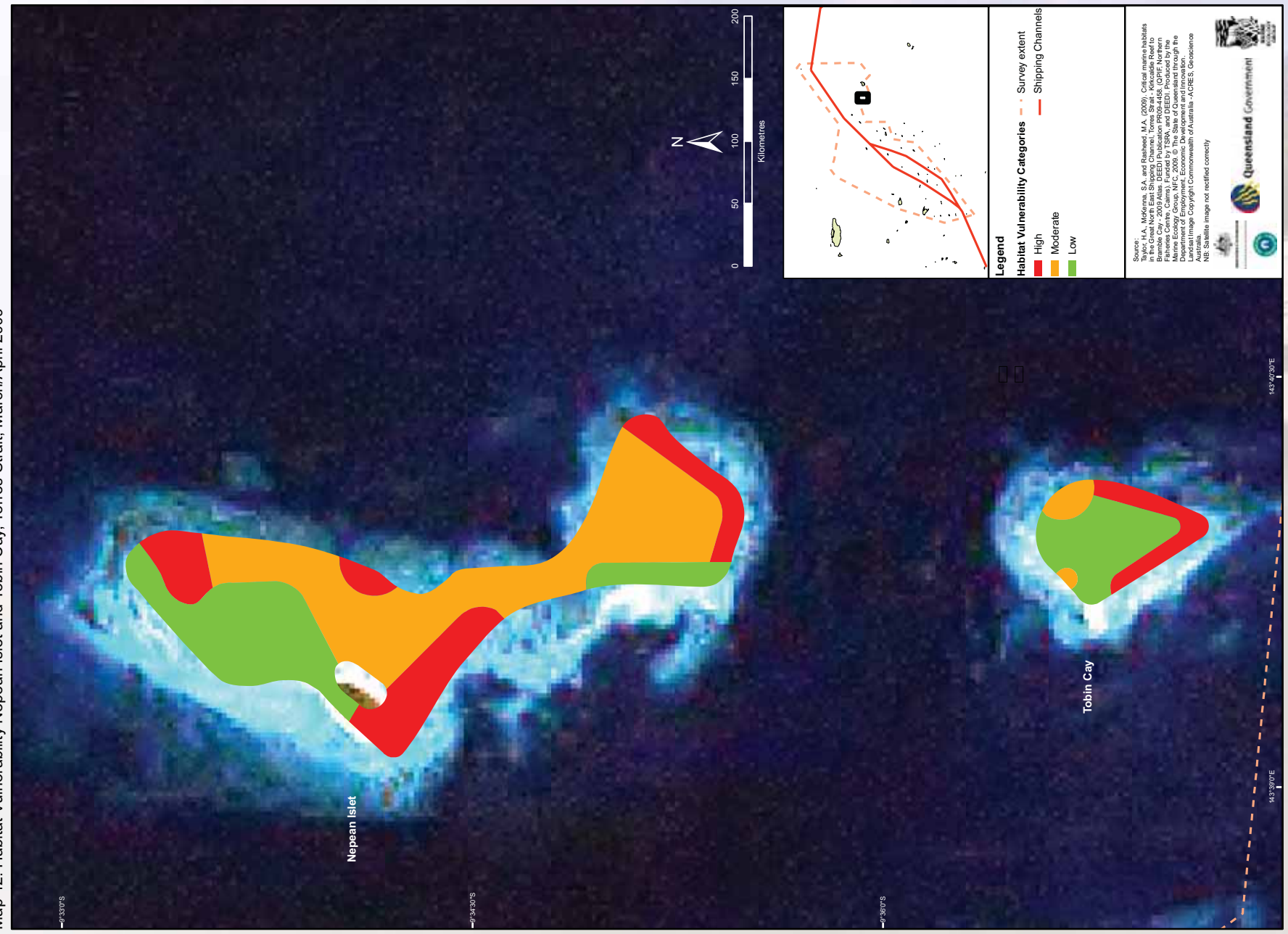


Map 41. Habitat Vulnerability on Tappoeear Island reef, Torres Strait, March/April 2009

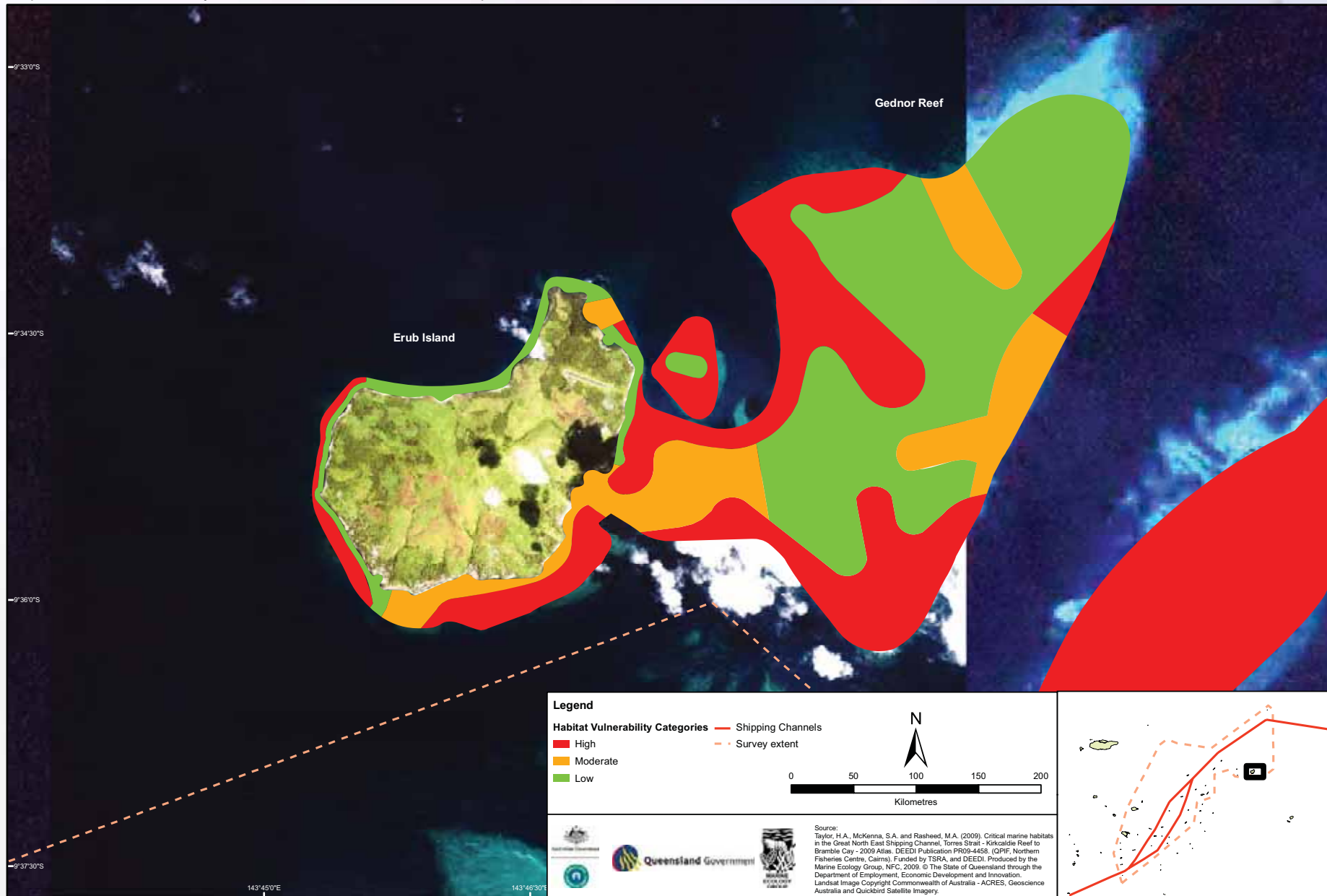




Map 42. Habitat Vulnerability Nepean Islet and Tobin Cay, Torres Strait, March/April 2009

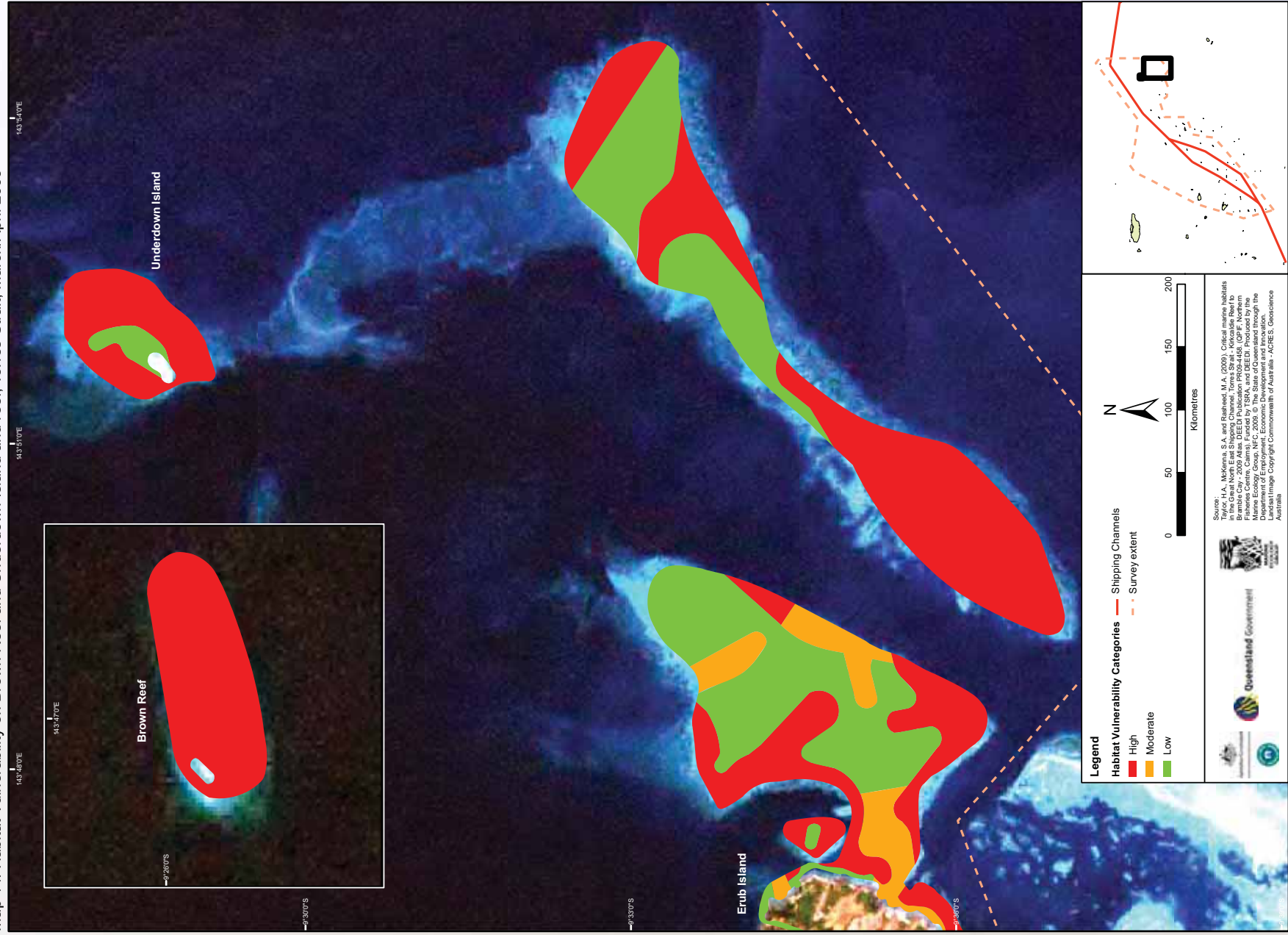


Map 43. Habitat Vulnerability on Erub Island, Torres Strait, March/April 2009





Map 44. Habitat Vulnerability on Brown Reef and Underdown Island and reef, Torres Strait, March/April 2009





Map 45. Habitat Vulnerability on Laxton Reef, Tot Reef and Bramble Cay, Torres Strait, March/April 2009



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