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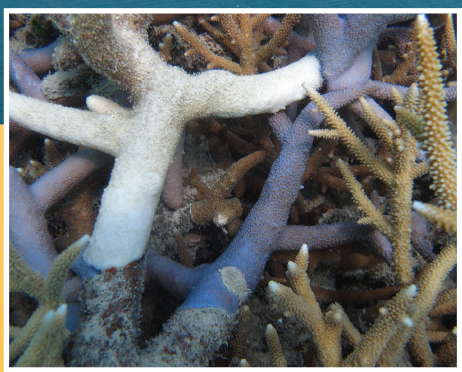
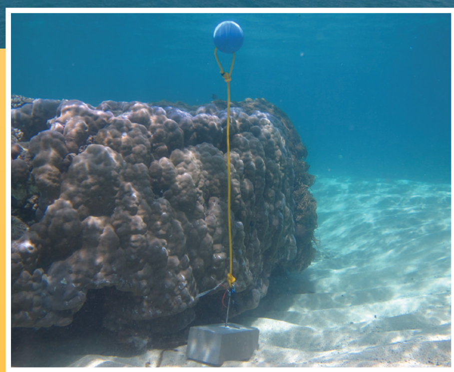
Technical Report

Preliminary report on surveys of biodiversity of fishes and corals in Torres Strait





Kate Osborne, Ian Miller, Kerryn Johns,
Michelle Jonker and Hugh Sweatman

Australian Government
Department of Sustainability, Environment, Water, Population and Communities

Reef & Rainforest Research Centre

Preliminary report on surveys of biodiversity of fishes and corals in Torres Strait

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Australian Institute of Marine Science

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Cover photographs:

This report is available for download from the NERP Tropical Ecosystems Hub website:
http://www.nerptropical.edu.au/research

February 2013

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Acronyms Used In This Report

AIMS .... Australian Institute of Marine Science
CSIRO .... Commonwealth Scientific and Industrial Research Organisation
GBR .... Great Barrier Reef
GBRMPA .... Great Barrier Reef Marine Park Authority
LTMP .... Long-term Monitoring Program
MTQ .... Museum of Tropical Queensland
NERP .... National Environmental Research Program
TSRA .... Torres Strait Regional Authority

Acknowledgements

We thank staff of the Torres Strait Regional Authority Land and Sea Management Unit, particularly Frank Loban and Stan Lui for their advice and assistance in organising the fieldwork. We thank the island communities of Poruma, Masig, Erub and Mer and their traditional owners, the Porumalgal, Masigalgal, Erubam Le and Meriam Le, for allowing us to survey reefs in their seacountry. We thank Marcus Oke and the crew of the MV Floreat for their help. The project was funded through co-investment with the Tropical Ecosystems hub of the National Environmental Research Program.

Summary

The diversity of coral communities and coral reef fish communities was assessed at five locations located along a representative transect that ran from the central to the eastern Torres Strait. In total 279 species of hard corals and 301 species of reef fishes were recorded. For both corals and reef fishes, the communities from central sites differed from those in eastern sites, reflecting a gradient in turbidity and wave exposure. Surveys recorded both coral species and species of fish that had not been observed in the Torres Strait previously. Resurvey of a site on the reef flat at Mer that was described a century ago found many similarities but at least one notable difference in that the abundance of the temperature-sensitive corals in the genus *Seriatopora* appears to have decreased greatly.

Major findings included:

- Ninety-one new coral species for the region have been added to the records of the Museum of Tropical Queensland.
- New observations of fish species including species previously known from New Guinea and the north-western Pacific, as well as species that are rare or absent from the northern Great Barrier Reef.
- Two major types of reef community were distinguished: the Central and Eastern groups.
- Species richness hard coral was comparable between different reef communities, with two thirds of species (68% similarity) shared between the Central and Eastern reef groups.
- Benthic communities of Central group reefs were most similar shallow inshore reefs of the GBR found near Townsville.
- The fish communities on the Central reefs, in particular Poruma Reef, had species composition similar to those of inshore reefs of the GBR.
- While coral reefs in the Torres Strait are less frequently affected by cyclone damage than those of the GBR, other threats such as crown-of-thorns starfish outbreaks, coral bleaching and disease are present.

Introduction

Torres Strait is a shallow, submerged land bridge between PNG and the northern tip of Cape York that includes an extensive area of shallow tropical continental shelf with at least 274 islands and associated reefs, plus many more shoals. With the Coral Sea to the east and the Arafura Sea to the west, and the Fly River to the north, and a tidal range of up to 3 m, strong physical drivers operate throughout the region and the character of the >1,200 coral reef communities of the region reflect these gradients. The great majority of biological datasets from the Torres Strait show a major divide along a line running from ESE to WNW across the region Haywood et al. (2007). This reflects the relative dominance of coral habitats in the clearer water on the eastern shelf edge compared with the relative dominance of seagrass habitats in the more turbid and sediment-laden conditions in the west, closer to the Gulf of Papua. Hard coral cover is greatest on the margins of reefs in the East, and the composition of the coral communities also changes across the Torres Strait region. The reefs of Torres Strait are threatened by a variety of local and global stresses, notably climate change (widespread coral bleaching was recorded for the first time in 2010), the coral-feeding crown-of-thorns starfish and increasing levels of coral diseases.

Information on the biodiversity of reef communities in Torres Strait comes from three main sources. Firstly, some of the earliest records of the scleractinian corals from the Torres Strait come from collections from around Mer Island by Alfred G. Mayer in 1913 and described by T.W. Vaughan (1918). These included a detailed baseline from surveys for a site on the south-eastern reef flat at Mer Island referred to as "Line No. 1." Secondly, the collection held by the Museum of Tropical North Queensland (MTQ) mainly consists of collections made by Veron as part of a major taxonomic study of Eastern Australian corals (Veron and Pichon (1976), Veron and Pichon (1980), Veron and Pichon (1982) Veron and Wallace(1984)) Thirdly there is an extensive body of research from CSIRO. A large body of research in the Torres Strait by CSIRO focussed on the relationship between broad habitat types, fishes, broad categories of benthic organisms and environmental drivers. This research was driven by interest in fisheries and is summarised by Haywood et al. (2007). Also, a catalogue of CSIRO data sets from Torres Strait is published on the **e-Atlas**. Publications from CSIRO contain detailed information about fish species (Haywood et al, 2007), however, the data on corals was focussed on habitat description and corals were not identified to species. The objective of the sampling program in February 2013 was to update knowledge on coral and fish species that are found in the Torres Strait.

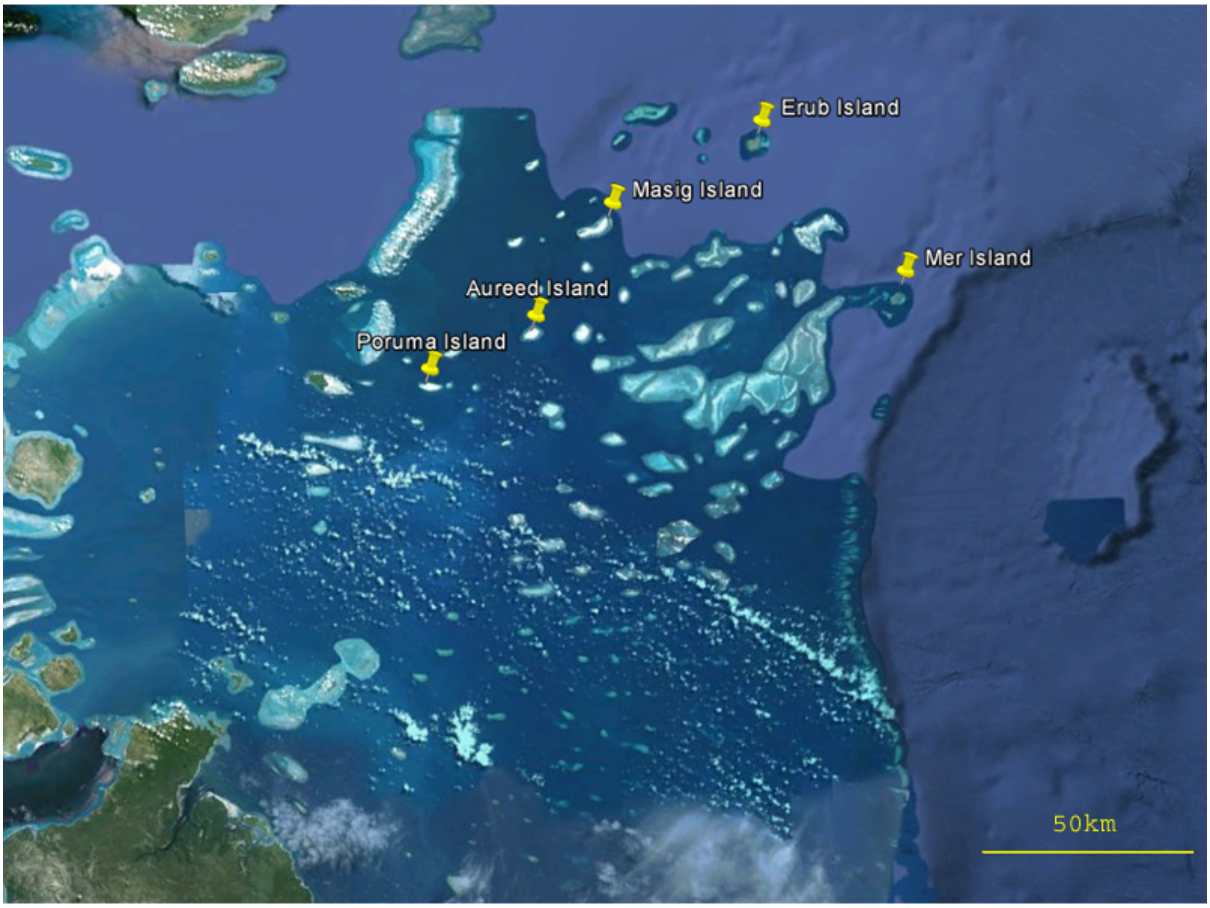

Figure 1 Map of Torres Strait showing the reefs where biodiversity surveys of fish and coral were made in February 2013. For the locations of sites on each island, see Table 1 or visit the e-Atlas reef pages.

Surveys by CSIRO over many years identified environmental gradients that correlated with biological distributions of corals and fish in the Torres Strait and this information influenced selection of survey sites in the present study. Specifically, species lists of corals and reef fishes were recorded for five Torres Strait Island reefs that lay along the environmental gradient from the eastern Torres Strait that is influenced by the Coral Sea to the more sheltered and turbid waters of the central Torres Strait.

Methods

Sites on five reefs in the Torres Strait (Figure 1) were surveyed for reef fish and coral species diversity. The reefs, Poruma, Aureed, Masig, Erub and Mer, were chosen as they all lie within a single bioregion (*sensu* Haywood et al. 2007) between the Warrior Reefs to the west and the Ribbon Reefs to the east. Survey reefs were also chosen for ease of access for future surveys by TSRA rangers and because they were within an area that Haywood et al (2007) identified as having high biodiversity. The islands Poruma, Masig, Erub and Mer have long established communities who have a keen interest in the state of their local resources. Although uninhabited, Aureed is close to communities of the Kukalgal nation of the Central islands and accessible by nearby communities with permission from the traditional owner.

Benthic surveys

With the exception of Poruma, manta tow surveys of the entire reef perimeter were made at each reef (see Miller et. al. 2009). These were used to locate areas of high coral cover and to identify representative habitats for more detailed benthic and biodiversity surveys. They had the added benefit of providing an overview of the condition of each reef in terms of impacts from crown-of-thorns starfish, coral bleaching and disease. Surveys using the Great Barrier Reef Marine Park Authority's (GBRMPA) Reef Health and Impact Survey (RHIS) protocols were also made at haphazardly located points at each reef. These also included estimates of 'damage' (e.g. disease, bleaching and crown-of-thorns starfish). The full results of these surveys will be available on the GBRMPA website in early 2014.

The combined cover of individual benthic organisms (including algae) and the diversity of hard coral communities were surveyed at 2-5 sites at each reef using SCUBA (Table 1). These surveys also recorded the occurrence of coral diseases and coralline algal disease as well as predation from *Drupella* spp. Sites were selected to include representative habitats so as to maximise the accumulation of hard coral species recorded at each survey reef. Habitats included exposed (front reef) and sheltered (back reef) habitats, as well as a range of depths (depending on the time available). Total sampling time at each site was approximately one hour generally determined by the dive time available from one scuba tank. Benthic cover at each site was estimated from photo transects. Three replicate 10 m transects were surveyed by deploying a 50 m transect tape along the substratum parallel to the reef crest and following the depth contour where the coral cover was highest. In practice this meant the benthic cover estimates were generally based on transects at around 5m depth. Photos were taken at half metre intervals, 30 cm from the tape on the down-slope side. Twenty photos were taken per transect with a 5-10m gap between transects. The benthic cover was also estimated at a few reef flat sites to examine the range of variation in benthic cover among depths. This included an opportunistic survey of the reef flat site at Mer Island. This site approximately followed "Line 1" (Mayer 1918), but tidal conditions and the time of day made it impossible to resample with the same techniques or intensity as the original 1918 survey, and only anecdotal observations were possible.

Hard coral diversity surveys began once the benthic cover surveys at each site were complete. Hard coral diversity was determined by searching either side of the transect line, usually in a depth of 2 - 6m along the reef slope, using scuba. These surveys involved following the surveyor's tape back to its beginning and, in many cases continuing beyond the tape to survey as much habitat as possible at a consistent depth (2m to 6m). All hard coral species were recorded. If the observer was uncertain of a species, the coral was photographed to assist with subsequent identification. Where species were of particular interest, small samples of colonies were also collected for further taxonomic analysis. No hard coral diversity surveys were made on reef flats. All taxonomic classification was based on traditional morphologically-based systematic framework of Veron (2000). No attempt was made to classify hard corals in terms of molecular genetic techniques (e.g. Budd et al 2012).

Table 1 Location of each site and types of samples collected during the surveys in February 2013.

Reef	Site	Latitude	Longitude	Habitat	Survey Type
Poruma	1	-10.0517	143.0960	slope	fish & coral, photo transects
Poruma	2	-10.0566	143.1057	slope	fish & coral, photo transects
Poruma	3	-10.0489	143.1247	lower slope	fish & coral, photo transects
Poruma	3	-10.0489	143.1247	slope	fish & coral, photo transects
Poruma	4	-10.0488	143.1247	slope	fish & coral, photo transects
Poruma	5	-10.0496	143.0904	slope	fish & coral, photo transects
Aureed	1	-9.9556	143.2808	slope	fish & coral, photo transects

Aureed	2	-9.9465	143.3054	flat	photo transects
Aureed	2	-9.9465	143.3054	slope	fish & coral, photo transects
Masig	1	-9.7644	143.4023	crest	fish & coral, photo transects
Masig	2	-9.7654	143.4035	slope	fish & coral, photo transects
Masig	3	-9.7592	143.3979	slope	fish & coral, photo transects
Masig	4	-9.7457	143.4074	slope	fish & coral, photo transects
Masig	4	-9.7457	143.4074	flat	photo transects
Masig	4	-9.7457	143.4074	crest	fish & coral, photo transects
Erub	1	-9.5994	143.7805	crest	fish & coral, photo transects
Erub	2	-9.5947	143.7941	crest	fish & coral, photo transects
Erub	2	-9.5947	143.7941	lower slope	fish & coral, photo transects
Erub	3	-9.5974	143.8146	crest	fish & coral, photo transects
Erub	3	-9.5974	143.8146	slope	fish & coral, photo transects
Mer	1	-9.9263	144.0529	crest	fish & coral, photo transects
Mer	2	-9.9273	144.0579	crest	fish & coral, photo transects
Mer	2	-9.9273	144.0579	slope	fish & coral, photo transects
Mer	3	-9.9069	144.0472	slope	fish & coral, photo transects
Mer	4	-9.9014	144.0574	lower slope	fish & coral, photo transects

Upon completion of field surveys and back in the laboratory percent benthic cover was estimated from the transect images by overlaying sample points in a quincunx pattern. For each transect benthic organisms that lay beneath 100 points spread across 20 photos were identified to the finest taxonomic resolution that could be achieved. For hard corals this was genus, while soft corals were identified to family and algae were divided into broad groups such as 'macroalgae' (red, brown and green), 'coralline algae' and 'turf algae' (see Jonker et al. 2008). The benthic cover for each transect was then calculated by taking the proportion of points that fell on individuals of each taxonomic class compared to the total number of points for the transect, to give a value of percentage cover. Percentage cover for each transect was averaged to give the total cover of each taxonomic class at each site.

Surveys of fishes

Fish biodiversity surveys were made using scuba and recorded all visually conspicuous 'bony fish' (Actinopterygii). Reef fishes were surveyed in the same locations as the benthic surveys. Observers ranged haphazardly over the reef slope in a depth range of 1 – 12 m for periods of about one hour. Sightings of all visually obvious species were recorded but species abundances were not estimated. The number of survey sites at each reef varied due to logistical considerations. The following sites on each reef were surveyed (Table 1): Poruma (sites 1,2,3,5), Aureed (sites 1, 2), Masig (sites 1, 4), Erub (sites 1,2,3) and Mer (sites 1,2,4). As in the coral surveys, photos were taken of fishes when the observer was uncertain of the species identity. Where identifications were uncertain, photos were taken in the field and compared with those in Randall et al. 1997 and Allen et al. 2003)

Analyses

Corals

Coral species presence/absence data was pooled across sites for each reef and used to create a similarity matrix based on the Sorensen similarity coefficient for presence/ absence data. A hierarchical cluster analysis grouped reefs with similar combinations of species present. To examine the variation in species assemblages among clusters, variation in the number of species among hard coral families were presented for each cluster group. Species accumulation over sequentially sampled sites for each cluster group was plotted to demonstrate adequacy of sampling. The proportion of coral species at each reef that were present in other survey locations was also calculated.

In order to set the coral community in a regional perspective, based on the percentage cover of families of hard and soft corals from the photo transects at Torres Strait reefs was combined with comparable data from reefs surveyed by the Great Barrier Reef (GBR) Long Term Monitoring Program (LTMP), see Emslie et al. (2010). Multi-dimensional scaling was used to show affinities between coral assemblages of the Torres Strait reefs and coral communities from elsewhere in tropical Queensland (PRIMER v6; Clarke & Gorley 2006)

Fishes

Similarities among fish communities in different locations in Torres Strait were assessed using a simple agglomerative hierarchical cluster analysis on the presence/absence data (SPSS v.20.). This analysis used UPGMA (Unweighted Pair Group Method with Arithmetic Mean) that classified sampling units (reefs) on the basis of their pairwise similarities in species composition. The UPGMA algorithm constructs a dendrogram that reflects the structure present in a pairwise similarity matrix. The similarity measure used was the binary squared euclidean distance.

Results

Benthic communities

We recorded 279 scleractinian coral species from the five island reefs (Figure 2). The 279 species belonged to 60 genera in 14 coral families. The number of species at each island reef varied from 131 at Aureed Reef to 174 at Erub Reef. The lower number of species recorded at Aureed Reef at least in part reflects a lower sampling intensity, since only two sites were surveyed at this location. Sampling intensity was higher at all other locations with three sites sampled at Erub Reef, four sites sampled at Masig Reef and Mer Reef, and five sites sampled at Poruma Reef. Of the 279 species recorded, 186 species were in the Museum of Tropical North Queensland's collection. The museum collection represents the most comprehensive record of corals in Torres Strait and provides a useful baseline by which to put the current survey in to context. Fifty species held at the museum were not recorded during the current survey, while 92 species were recorded that are not currently in the Museum's collections from Torres Strait. Most of these coral species have been recorded on the GBR. However 17 of the species had not been recorded on the GBR by Veron (2000). These were in the following genera: *Acanthastrea, Cantharellus, Favites, Herpolitha, Leptastrea, Montipora, Pavona,* and *Porites*. (Appendix 2). Eight of the 17 species have been recorded on the GBR since 2000 (De Vantier et al, 2006).

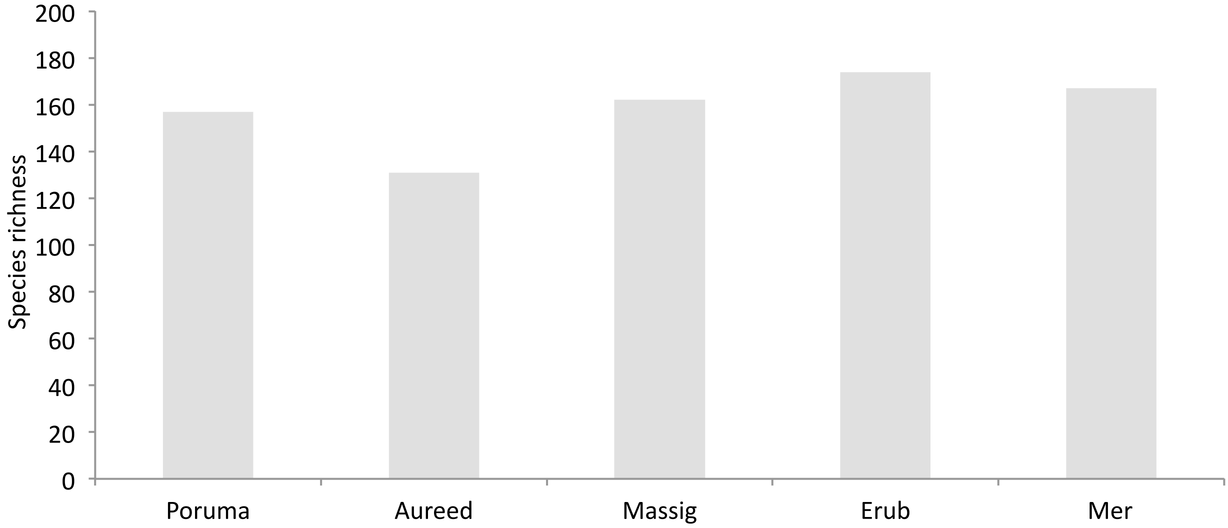

Figure 2 Species richness of scleractinian corals on five reefs in the Torres Strait, arranged from west (Poruma) to east (Mer).

The locations fell into two groups according to a hierarchical cluster analysis (Figure 3) based on a similarity matrix that represented common presence of species (Sorensen coefficient). The reefs of the Central Torres Strait islands of Poruma, Aureed, and Masig form one group (hereafter Central) and those of the north east islands, Erub and Mer, form the second group (hereafter East). The two groups split at the similarity level of 68%. The level of similarity between reefs reflects physical location of reefs along the environmental gradient from the ESE to WNW. With the exception of Aureed Reef, the total number of species is fairly consistent across the gradient, implying that species replacement, rather than species loss or gain, is occurring with the changing environmental gradient. On average 9% of hard coral species were recorded at only one reef and 33% of species were common to all five reefs (Appendix 1, 2). Details of the abundance of coral families and the broader composition of the benthos can be found on the **e-Atlas reef pages**. Differences in species richness between Central and Eastern reefs were observed for five coral families. Species richness in the Acroporidae and Pocilloporidae was higher on the Eastern reefs than the Central reefs. Conversely, richness of Poritidae, Fungiidae and Mussidae species were higher on the Central reefs than on the Eastern Reefs (Figure 4). Species accumulation curves suggest that the level of sampling adequately represents the Eastern reefs, however on the Central reefs the number of species was continuing to rise (Figure 5).

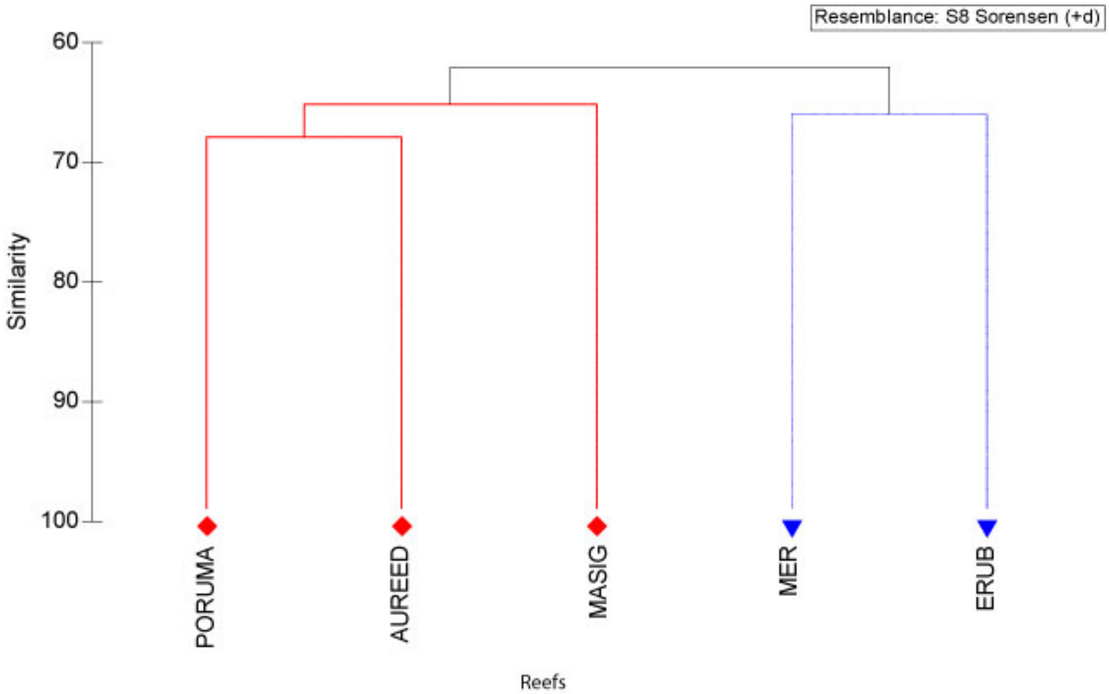

Figure 3 Similarities among coral communities on survey reefs in Torres Strait based on presence/absence of species.

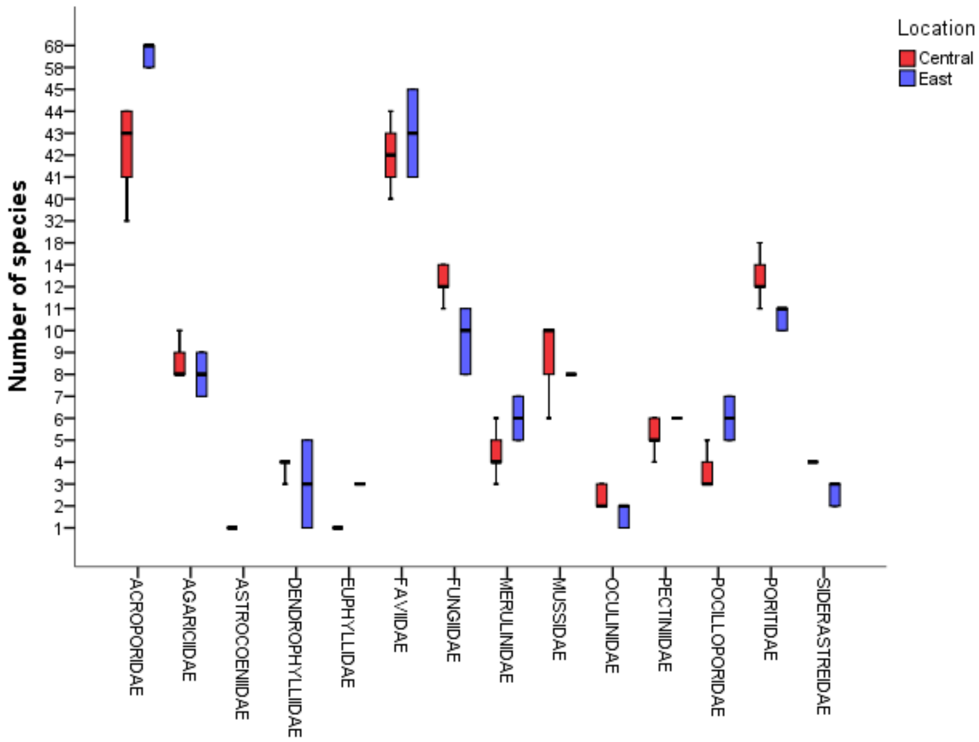

Figure 4 A comparison of the number of species in each scleractinian coral family in the two cluster groups (Central and East).

Preliminary results from the RHIS surveys indicated that with the exception of Mer Island Reef coral diseases and coralline algal disease were generally uncommon. Predation scars from Drupella spp. were also seen at Mer but were rare at other locations. Coral bleaching was observed on the reef flat at Erub Reef and Mer Reef on a small number *Seriatopora* spp. and *Montipora* spp. hard coral colonies. No bleaching was observed on the RHIS sites located on the other reefs surveyed**.**

Regional context

The reefs in Torres Strait occur in a unique regional setting, due to their location between Papua New Guinea and mainland Australia. A comparison with benthic community types of the Great Barrier Reef can help in framing the local context within the larger framework of coral reefs in Australia. When benthos composition data using photo transect surveys was combined with that of LTMP reefs from the GBR the Torres Strait reefs clustered into two of five 'assemblage type' groups. The coral families Poritidae, Acroporidae and Alcyoniidae were the key drivers of dissimilarity between these two clusters (Figure 6). The benthic communities on Central reefs (Poruma,

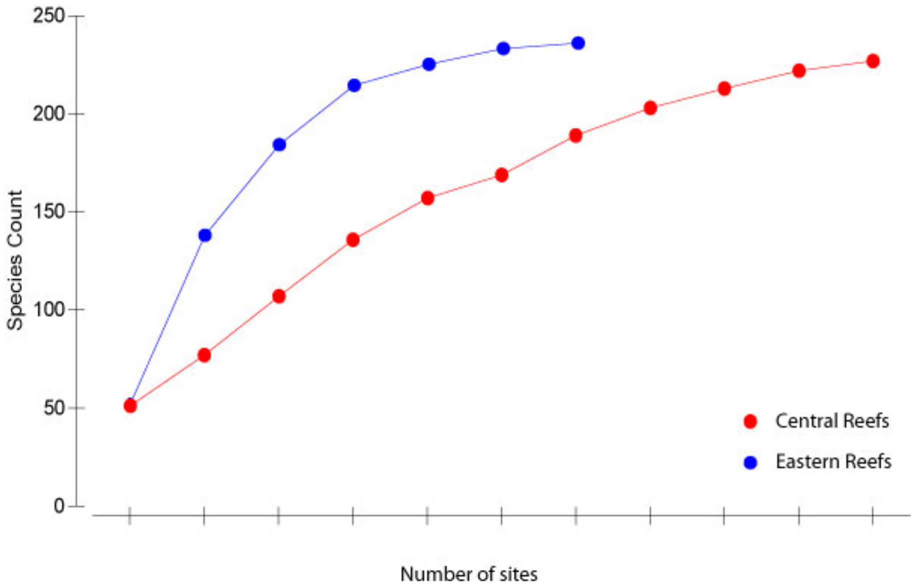

Figure 5 Species accumulation curve for scleractinian coral species on the two groups of reefs.

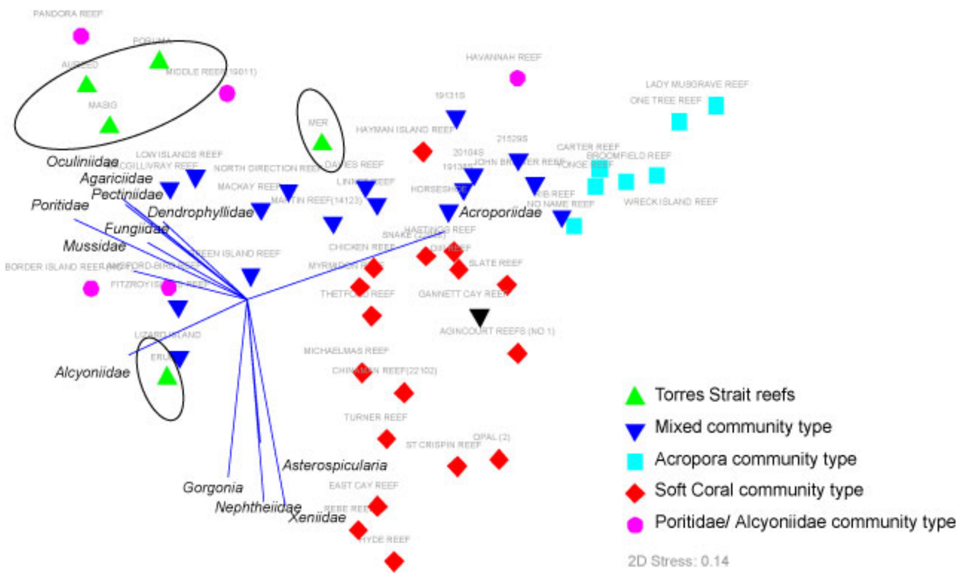

Figure 6 The coral communities from the reef slope of each survey reef in Torres Strait in context of communities on survey reefs on the GBR based on similar data. Per cent cover of families of hard and soft corals was estimated from photo transects. The community types follow those described in Emslie et al (2010). Locations of coral communities on Torres Strait reefs in multivariate space are indicated by green triangle symbols; the 3 reefs in the hull at the top right are the Central group of reefs, the reef at the top centre is Mer; the reef mid-way down on the left is Erub.

Aureed and Masig Islands) were most similar to shallow inshore reefs near Townsville on the Central GBR. That is, they were characterised by relatively high abundance of Poritidae and other coral families that are typically found in turbid protected waters, particularly Agariciidae. Alcyoniidae (soft corals) was the most abundant family on the Eastern reefs (Erub and Mer Islands). Erub Reef was most similar to the near-shore reefs in the Cairns and Whitsunday sectors with a mixed community of typically inshore hard coral families and Acroporidae, along with the relatively high abundance of Alcyoniidae. The communities at Mer Reef were most similar to those on mid-shelf reefs near Cairns, having a relatively high abundance of both Acroporidae and soft coral. The higher Acroporidae cover at Mer Reef drove the separation between Mer Reef and Erub Reef.

Fish communities

The combined records of fish species observed in the region by AIMS and CSIRO indicate that the five reefs surveyed by AIMS in the Torres Strait support a diverse reef fish community (Appendices 3 and 4). A total of 301 fish species were recorded from the region between the two studies. The surveys extended the CSIRO fish species list for the region, for example, five new surgeonfishes were added *Acanthurus auranticavus*, *A. pyroferus*, *A. triostegus*, *A. grammoptilus* and *Naso tuberosus*, with *A. grammoptilus* being common at the majority of sites. The AIMS surveys showed a gradient in richness of fish species, with diversity increasing from west to east (Figure 7). The reef fish community on Mer had the highest total species richness (Figure 7) and the highest species richness of each of the major fish families (Figure 8). A similar pattern has been reported in recent studies on the GBR showing that there are more species of Chaetodontidae, Acanthuridae, Scaridae and Pomacentridae on mid and outer-shelf reefs than on inshore reefs (Emslie at al. 2010, Cheal et al. 2012, Emslie et al. 2012). These types of distribution appear to reflect broad environmental gradients and have been observed historically on the GBR (Williams 1982, Hoey and Bellwood 2008). The fish communities on the survey reefs in Torres Strait conform to this pattern. Haywood et al. (2007) showed turbidity and wave exposure were likely factors driving

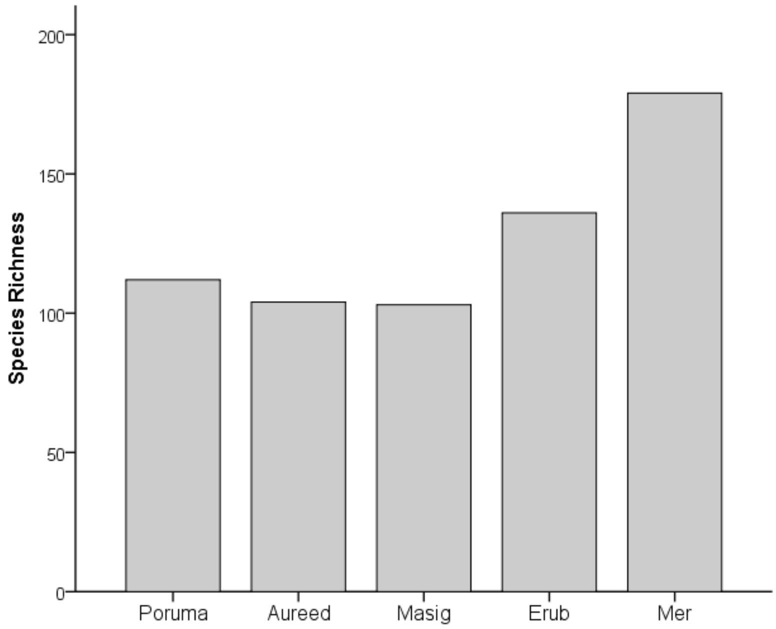

Figure 7 Species richness of conspicuous reef fish species on five survey locations in the Torres Strait, arranged from west (Poruma) to east (Mer).

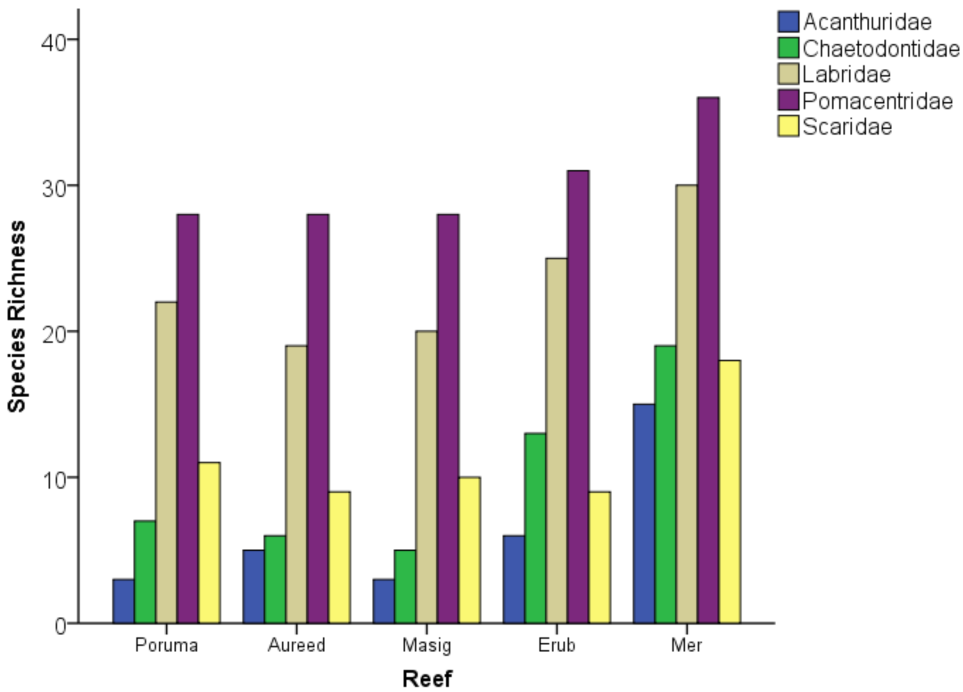

Figure 8 Species richness of major fish families on five survey locations in the Torres Strait, arranged from west (Poruma) to east (Mer).

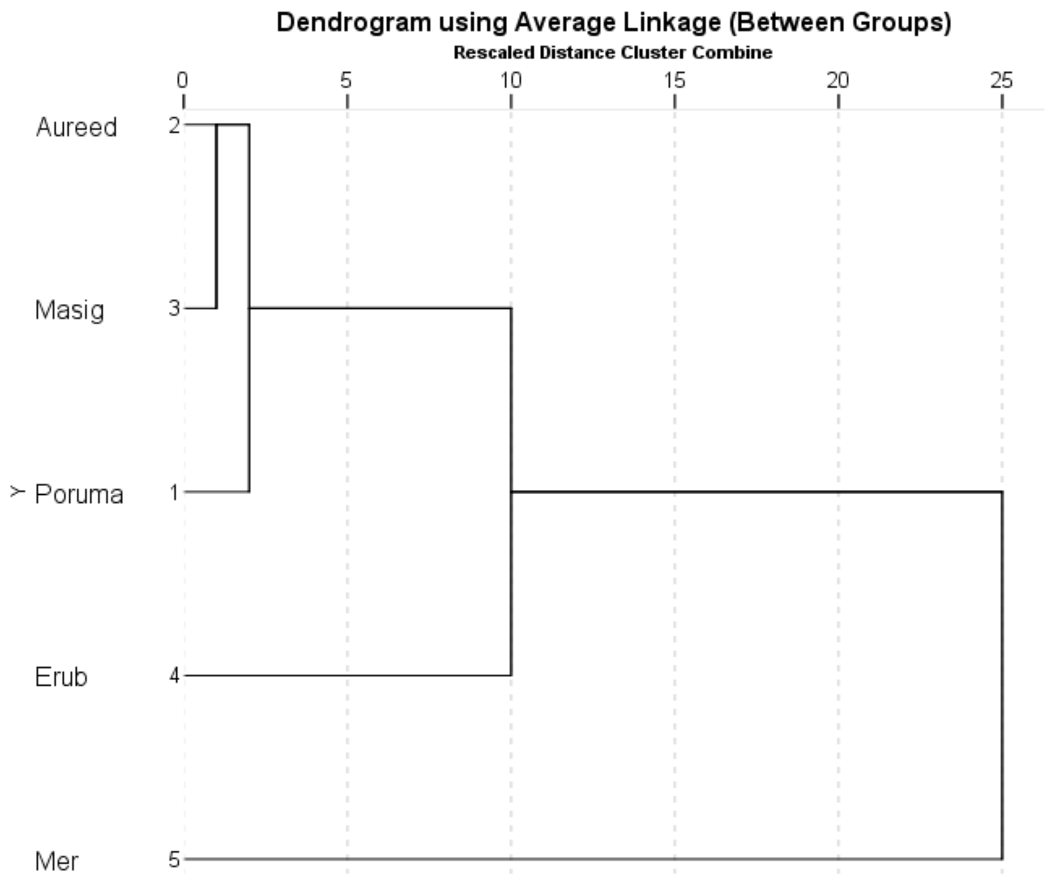

Figure 9. **The similarities among the fish communities in the five survey locations in Torres Strait.**

the distribution of fish species in the Torres Strait, with coral reefs to the west being more turbid and exposed to less wave action than reefs further east. This conforms to anecdotal observations made in the course of the AIMS survey.

A hierarchical cluster analysis provides a more detailed overview of the relationship between the communities on reefs in terms of species presence (Figure 9). This analysis looked at the relationship between fish communities on reefs in terms of the species that co-occurred. The analysis included between group linkages for binary (presence, absence) data. The fish communities at Aureed and Masig were most alike in terms of their species composition and these communities were quite similar to that at Poruma. This group of reefs may be termed the central group. Further separation occurred travelling east with Erub forming a larger cluster with the previous three reefs and finally Mer had the highest diversity was the most dissimilar to the other reefs but closest to Erub.

Regional context

As with the corals, the fish communities on the survey reefs in Torres Strait can be compared with communities on reefs of the GBR. In that context, the fish communities on reefs in the Central cluster, in particular Poruma Is Reef, included a number of fish species that are commonly found on inshore reefs on the GBR. These included *Neopomacentrus cyanomus, N. bankieri, Chaetodon rainfordi,* and *Plectropomus maculatus.* The community at the most eastern reef (Mer) included a number of fish species that are associated with offshore reefs on the GBR, such as *Chromis xanthura, Acanthurus lineatus, Chaetodon kleinii, Plectropomus laevis* and *Pomacentrus bankanensis.* Some species such as *Acanthurus nigricauda, Chaetodon aureofasciatus, Epibulus insidiator, Lutjanus carponotatus, Pomacentrus mollucensis,* and *Scarus* *globiceps* were common to all reefs. The fish communities on the survey reefs in Torres Strait include elements from the northern GBR (e.g. *Chelmon marginalis, Lethrinus laticaudus, Apogon properupta)* and to a lesser extent species normally associated with reefs further north in New Guinea (e.g. *Plectorhinchus unicolor, Choerodon monostigma, Halichoeres richmondi*). Sighting *H. richmondi* (Richmond's wrasse) at Erub Reef may represent a range extension as this species was previously known from New Guinea and the north-western Pacific. The fish community on Poruma Reef was particularly interesting because included a number of species the southern GBR but are rare or absent from the northern GBR (e.g. *Chromis nitida*, *Chilomycterus reticulates, Macropharyngodon choati*). The record of *M. choati* in Torres Strait may be a range extension.

Discussion

Biodiversity surveys of five reefs in Torres Strait increased the number of fish and coral species recorded from the region. Surveys extended the CSIRO fish species list for the region to a new total of 323 fish species. New species records include fish species known from New Guinea and the north-western Pacific, the northern GBR and species rare or absent from the northern GBR that are normally associated with the southern GBR. Surveys of scleratinian corals extended the records held by the MTQ (238 species). Of 279 coral species recorded in this survey, 91 species were not in the previous collection, bringing total number of species to 329 for the Torres Strait. New records were predominantly of coral species also found the GBR. Nine coral species had no known records for the GBR and had previously been recorded from the coral triangle or were more widespread through the Indo-Pacific. The most recent survey of coral biodiversity on inshore reefs of the GBR reported 362 coral species from 599 sites (De Vantier et al. 2006). Given the small number of locations sampled in our survey we would expect more extensive sampling would reveal at least the 396 species reported for the Great Barrier Reef (Veron, 1995, 2000).

The diversity of coral reef habitats within the Torres Strait is dependent on the geomorphic setting and environmental gradients of turbidity, depth and exposure (Haywood et al. 2007, Leona and Woodroffe, 2013). The geomorphology of reefs within the Torres Strait is diverse and the five reefs sampled represent only two of at least six geomorphic settings (Leon and Woodroffe, 2013). Similarly the range in values of environmental drivers of habitat diversity across Torres Strait is large and our sample locations were located within only a portion of that gradient. Research by CSIRO in Torres Strait found fishes and habitat-forming species shared a species composition gradient from ESE to WNW and that there was a correlation between species composition and a gradient from warm, clear water with long wave period to cool, turbid water, short wave period and soft sediment (Haywood et al. 2007). The groupings they identified from the environmental and habitat variables were the same groupings as generated in this study from the coral species diversity, fish species diversity and benthic cover. In each case Poruma, Aureed and Masig grouped together (central cluster) and Erub and Mer grouped to form an eastern cluster. The correspondence between data types is an indication of the homogeneity of the geomorphic setting within groups, the strength of the environmental gradients and its controlling role in the formation of fish and benthic communities.

Overall the coral species richness was quite similar on reefs in the two groups; there was 68% similarity between the Central and Eastern reef groups. Species mostly occurred on two or more reefs; on average 9% of coral species were found at only one of the reefs. Shallow water habitats with an abundance of *Porites* colonies were common throughout the sites that were surveyed. The reefs at Erub and Mer islands had distinct reef crests and more heterogeneous reef structure within each island's fringing reef. This reef crest habitat supported species of Acroporidae and Pocilloporidae that were not recorded on the central reefs. Conversely coral genera that were more diverse on reefs in the central group (Figure 4) were typically associated with more turbid conditions or low energy environments (Done, 1982). Rapid biodiversity assessments of coral communities on inshore reefs in the northern GBR recorded 362 coral species, but the species accumulation curves did not reached a plateau and a high proportion of coral species were found in only a small proportion of sites (De Vantier et al, 2006). Species curves on the central reefs of Torres Strait were also continuing to rise (Figure 5). However, deep water habitats with sufficient light to support coral growth were rare on these reefs which could limit species diversity. It is also possible that these habitats were under-sampled because we were unable to find them in the turbid conditions that prevailed at the time of the surveys, due to neap tides.

The benthic communities of the reef slope were most similar to inshore reefs of the GBR, this being indicative of the low wave energy environment with the groups being distinguished by differences in water clarity (Figure 6.). Within the fish communities, species composition of communities of the central reefs, in particular Poruma Reef, resembled those on inshore reefs of the GBR, being characterised by *Neopomacentrus cyanomus, N. bankieri, Chaetodon rainfordi, Plectropomus maculatus.* Finding fish species that are typical of the southern GBR at Poruma Reef echoes the situation for corals in the northern GBR: De Vantier et al. (2006) recorded subtropical hard coral species on the far northern GBR and, with further sampling, a suite of subtropical coral species may well be found in Torres Strait. While there was some differentiation between the reefs at Erub and Mer Islands in coral species, this was more pronounced in the fish community, with Erub Reef having some New Guinea species (e.g. *Ecsenius stictus* and *Halichoeres richmondi)* and Mer Reef having species in common with exposed reefs of the northern GBR (e.g. *Chromis xanthura, Acanthurus lineatus, Chaetodon kleinii, Plectropomus laevis,* and *Pomacentrus bankanensis).*

An important component in this project was to build upon existing baselines in order to establish reliable reference points for future change. In addition to the collections held at MTQ and references from CSIRO, a historical baseline from surveys by Alfred G. Mayer in 1913 exists for a site on the south-eastern reef flat at Mer Island referred to as "Line No. 1." Mayer mapped coral community composition from the beach to the outer edge of the reef and included quite detailed information on the composition and density and counts of coral colonies across the reef flat. While it was not possible to resample Line No. 1 with the same techniques or intensity, Mayer's transect was relocated as closely as possible using his sketch map, and the transition in coral species between the beach and the reef crest was found to be generally as described in Mayer (1918). One significant point of difference concerned the '*Seriatopora* zone'; Mayer described an area 1,000 feet (310 m) from the high tide mark:

> "Seriatopora *here is at its acme and covers about a third of this area. It forms masses 4 to 7 feet in diameter, the upper surface being flat and killed at the level of low tide."*

This is interesting in the context of climate change; *Seriatopora* spp. are notably sensitive to thermal bleaching (Marshall and Baird, 2000). Our brief examination of Line No. 1 found no evidence of *Seriatopora* "microatolls" such as Mayer described, and the few colonies of *Seriatopora* spp. seen along Line No. 1 in February 2013 were bleached or diseased. One hundred years have passed since Mayer's survey, in which time there may well have been significant reef accretion which would affect habitat for corals in terms of the depth and location of pools and the drainage patterns on the reef flat. A more quantitative reassessment of Line No. 1 as a baseline would require careful determination of how the depth profile of the reef has changed since 1913.

Mer Island reef was the only location where coral diseases and coralline algal disease were common. Scars from *Drupella* spp. predation were also seen at Mer but were rare at other locations. Coral bleaching was observed on the reef flat at Erub Reef and Mer Reef, but only in a few colonies of sensitive species such as *Seriatopora* spp. and *Montipora* spp. There were no records of coral bleaching from Torres Strait during the anomalously warm years on the GBR (1998, 2002 and 2006), but a major bleaching episode occurred around Thursday Island in 2010. Turbidity and the strong currents that occur across a large area of Torres Strait would be expected to confer some bleaching resistance (West and Salm, 2003), although some runoff comes from the Fly River and high levels of nutrients can increase susceptibility to bleaching (Wooldridge 2009, Wiedenmann et al. 2013). The shallow depths in Torres Strait mean that the coral communities are necessarily concentrated within a relatively small depth range, which would make the reef communities vulnerable to bleaching mortality if a widespread thermal anomaly occurred. It will be important to identify reef areas in Torres Strait that might be resistant, for instance reefs in areas with strong currents that flow from deep (cooler) water, and protect those reefs from as many other environmental stresses as possible.

The low latitude of Torres Strait means that cyclones, a major cause of coral mortality on the GBR (Osborne et al., 2011), are rare compared with the central GBR (Puotinen 2004), and therefore are not a major driver of change in coral communities. Crown-of-thorns starfish have often been observed in Torres Strait and there is evidence that numbers have been increasing recently (Murphy et al., 2011). Two incipient outbreaks were recorded during surveys in February 2013 (e-Atlas). However there are no records of large-scale outbreaks such as occur on the GBR where they have caused substantial coral loss (Osborne et al., 2011). It seems probable that the average disturbance interval for reefs in Torres Strait has historically been much lower than on the GBR. Habitat stability is known to be a factor in explaining species richness in North Queensland rainforests, particularly in endemic species with low dispersal ability (Graham et al. 2006). More detailed coral collections and studies of historical climate in relation to species diversity patterns could be a focus of future research.

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Appendices

Appendix 1. Percentage of coral species shared between reefs.

	Percentage of coral species shared between reefs				
	Species on one reef only	2 reefs	3 reefs	4 reefs	All reefs
Poruma n=157	6.4	15.3	19.1	26.1	33.1
Aureed n=131	3.8	5.3	22.9	28.2	39.7
Masig n=162	13	11.7	19.1	24.1	32.1
Erub n=174	8.6	14.9	22.4	24.1	29.9
Mer n=167	13.8	18	17.4	19.8	31.1

Appendix 2. List of scleractinian coral species recorded at each location. *** indicates no previous records are known for Eastern Australia. ** indicates new record since Veron (2000). Shaded cells indicate that the species was only recorded at one location.

Scleractinian species	Poruma	Aureed	Masig	Erub	Mer
Acanthastrea bowerbankii				✓	
*Acanthastrea brevis****					✓
Acanthastrea echinata	✓			✓	
Acanthastrea faviaformis	✓	✓	✓	✓	
Acanthastrea hemprichii	✓				✓
Acanthastrea regularis	✓		✓	✓	✓
Acropora abrotanoides					✓
Acropora aculeus	✓	✓	✓	✓	
Acropora acuminata			✓		
Acropora anthocercis	✓		✓		✓
Acropora aspera					✓
Acropora austera	✓	✓	✓	✓	✓
Acropora cerealis	✓		✓	✓	✓
Acropora chesterfieldensis	✓				✓
Acropora clathrata	✓				✓
Acropora cytherea	✓		✓	✓	✓
Acropora digitifera	✓			✓	✓
Acropora divaricata	✓	✓	✓	✓	✓
Acropora donei			✓	✓	✓
Acropora elseyi					✓
Acropora florida	✓	✓	✓	✓	✓
Acropora gemmifera	✓			✓	✓
Acropora grandis	✓	✓	✓	✓	✓
Acropora granulosa		✓	✓		✓
Acropora horrida	✓	✓		✓	
Acropora humilis	✓		✓	✓	✓
Acropora hyacinthus	✓			✓	✓
Acropora intermedia	✓	✓	✓	✓	✓
Acropora latistella	✓	✓	✓	✓	✓
Acropora listeri					✓
Acropora longicyathus	✓	✓	✓	✓	✓
Acropora loripes			✓		✓
Acropora lutkeni		✓		✓	✓
Acropora microclados					✓
Acropora microphthalma	✓	✓	✓	✓	✓
Acropora millepora	✓	✓	✓	✓	✓
Acropora monticulosa					✓
Acropora muricata	✓	✓	✓	✓	✓
Acropora nana					✓
Acropora nasuta	✓	✓	✓	✓	✓

Scleractinian species	Poruma	Aureed	Masig	Erub	Mer
Acropora palmerae					✓
Acropora paniculata			✓		✓
Acropora polystoma					✓
Acropora prostrata	✓	✓	✓	✓	✓
Acropora pulchra					✓
Acropora robusta					✓
Acropora rosaria	✓	✓	✓	✓	✓
Acropora samoensis	✓	✓	✓	✓	✓
Acropora sarmentosa	✓	✓	✓	✓	✓
Acropora secale	✓	✓	✓	✓	✓
Acropora selago	✓	✓	✓		✓
Acropora spathulata					✓
Acropora subulata	✓		✓	✓	
Acropora tenuis	✓	✓	✓	✓	✓
Acropora tortuosa				✓	
Acropora valenciennesi			✓		✓
Acropora valida	✓	✓		✓	✓
Acropora vaughani	✓	✓	✓	✓	✓
Acropora willisae			✓		
Acropora yongei				✓	✓
Alveopora catalai				✓	
Alveopora spongiosa				✓	✓
Alveopora tizardi					✓
Astreopora gracilis			✓		
Astreopora listeri	✓				
Astreopora moretonensis			✓		
Astreopora myriophthalma		✓	✓	✓	✓
Astreopora ocellata				✓	
Astreopora randalli	✓		✓	✓	✓
Australogyra zelli	✓				
Barabattoia amicorum	✓	✓	✓	✓	✓
*Cantharellus jebbi****			✓	✓	
Caulastrea furcata	✓	✓	✓	✓	
Coeloseris mayeri	✓	✓		✓	
Coscinaraea columna		✓	✓	✓	
Coscinaraea exesa	✓	✓			
Ctenactis albitentaculata				✓	
Ctenactis crassa		✓	✓		
Ctenactis echinata	✓	✓	✓		✓
Cyphastrea chalcidicum	✓			✓	✓
Cyphastrea decadia	✓	✓	✓		
Cyphastrea microphthalma	✓	✓	✓	✓	
Cyphastrea serailia	✓		✓		
Diploastrea heliopora	✓	✓	✓	✓	✓

Scleractinian species	Poruma	Aureed	Masig	Erub	Mer
Echinophyllia aspera				✓	✓
Echinophyllia echinoporoides	✓		✓		
Echinophyllia orpheensis	✓				✓
Echinopora gemmacea	✓	✓	✓	✓	✓
Echinopora horrida	✓	✓	✓		✓
Echinopora lamellosa	✓	✓	✓	✓	✓
Echinopora mammiformis	✓	✓	✓	✓	✓
Echinopora pacificus	✓	✓	✓	✓	✓
Euphyllia ancora				✓	
Euphyllia cristata				✓	✓
Favia danae		✓	✓	✓	
Favia favus		✓			✓
Favia helianthoides	✓				
Favia laxa			✓		
Favia lizardensis	✓	✓	✓	✓	✓
Favia maritima		✓	✓	✓	✓
Favia matthaii		✓	✓	✓	✓
Favia pallida	✓	✓	✓	✓	✓
Favia rosaria	✓	✓	✓	✓	
Favia rotumana	✓				✓
Favia rotundata	✓		✓		
Favia speciosa	✓	✓	✓		✓
Favia stelligera	✓	✓		✓	✓
Favia truncatus	✓			✓	✓
Favia veroni	✓		✓	✓	
Favites abdita	✓	✓		✓	✓
Favites chinensis					✓
Favites complanata	✓	✓			✓
Favites flexuosa	✓	✓	✓		
Favites halicora	✓		✓	✓	✓
Favites pentagona				✓	✓
Favites russelli	✓			✓	
*Favites vasta****	✓		✓	✓	✓
Fungia concinna	✓			✓	
Fungia corona	✓				
Fungia danai	✓	✓	✓	✓	
Fungia fungites	✓	✓		✓	✓
Fungia granulosa				✓	✓
Fungia horrida			✓		
Fungia moluccensis					✓
Fungia paumotensis	✓				
Fungia repanda	✓	✓			✓
Fungia scabra	✓	✓			✓

Scleractinian species	Poruma	Aureed	Masig	Erub	Mer
Fungia scruposa	✓				
Fungia scutaria					✓
Galaxea acrhelia	✓	✓	✓	✓	
Galaxea astreata			✓		
Galaxea fascicularis	✓	✓	✓	✓	✓
Gardineroseris planulata	✓	✓	✓	✓	
Goniastrea aspera	✓	✓	✓	✓	✓
Goniastrea australensis		✓	✓	✓	
Goniastrea edwardsi	✓	✓	✓	✓	✓
Goniastrea favulus	✓		✓	✓	✓
Goniastrea palauensis				✓	
Goniastrea pectinata	✓	✓	✓		✓
Goniastrea retiformis	✓				✓
Goniopora djiboutiensis		✓	✓	✓	
Goniopora fruticosa	✓	✓	✓	✓	
Goniopora minor				✓	✓
Goniopora palmensis			✓		
Goniopora somaliensis	✓		✓		
Goniopora tenuidens			✓		
Halomitra pileus					✓
Heliofungia actiniformis	✓	✓		✓	
Herpolitha limax	✓	✓	✓		
*Herpolitha weberi****		✓			
Hydnophora exesa	✓		✓	✓	
Hydnophora grandis		✓		✓	✓
Hydnophora microconos	✓			✓	✓
Hydnophora pilosa	✓		✓		
Hydnophora rigida	✓	✓		✓	✓
Isopora palifera			✓	✓	✓
Leptastrea bewickensis			✓		
*Leptastrea bottae****			✓		
Leptastrea inaequalis					✓
Leptastrea pruinosa		✓		✓	✓
Leptastrea purpurea	✓	✓	✓	✓	
Leptastrea transversa		✓	✓	✓	
Leptoria phrygia	✓	✓	✓	✓	✓
Leptoseris explanata					✓
Leptoseris mycetoseroides	✓				
Leptoseris yabei		✓	✓	✓	✓
Lithophyllon mokai			✓	✓	
Lobophyllia corymbosa	✓	✓	✓	✓	
Lobophyllia flabelliformis			✓		
Lobophyllia hataii			✓		
Lobophyllia hemprichii	✓	✓	✓	✓	✓

Scleractinian species	Poruma	Aureed	Masig	Erub	Mer
Lobophyllia pachysepta			✓		
Lobophyllia robusta	✓	✓	✓	✓	✓
Madracis kirbyii				✓	
Merulina ampliata	✓	✓		✓	
Merulina scabricula	✓	✓	✓	✓	✓
Montastrea annuligera			✓		
Montastrea colemani				✓	✓
Montastrea curta		✓		✓	✓
Montastrea magnistellata				✓	
Montastrea salebrosa	✓				✓
Montipora aequituberculata			✓	✓	✓
Montipora confusa		✓	✓	✓	
Montipora crassituberculata			✓	✓	✓
Montipora danae	✓	✓		✓	✓
Montipora efflorescens	✓		✓	✓	✓
Montipora effusa	✓				✓
Montipora floweri				✓	
Montipora foliosa	✓				✓
Montipora foveolata				✓	✓
Montipora grisea			✓	✓	
Montipora hispida	✓	✓	✓	✓	✓
Montipora hoffmeisteri				✓	
Montipora incrassata				✓	
Montipora informis				✓	✓
Montipora mollis				✓	
Montipora monasteriata	✓	✓		✓	✓
Montipora nodosa				✓	
*Montipora palawanensis****				✓	✓
Montipora peltiformis				✓	✓
Montipora stellata	✓	✓			
Montipora tuberculosa	✓			✓	✓
Montipora turgescens		✓		✓	✓
Montipora undata		✓	✓	✓	✓
Montipora venosa				✓	✓
Montipora verrucosa				✓	✓
Mycedium elephantotus		✓	✓	✓	✓
Oulophyllia bennettae	✓	✓	✓	✓	✓
Oulophyllia crispa	✓	✓	✓	✓	✓
Oxypora glabra			✓	✓	✓
Oxypora lacera	✓	✓	✓	✓	✓
Pachyseris rugosa	✓	✓	✓	✓	✓
Pachyseris speciosa	✓	✓	✓	✓	✓
Palauastrea ramosa				✓	
Paraclavarina triangularis				✓	

Scleractinian species	Poruma	Aureed	Masig	Erub	Mer
*Pavona bipartita****		✓			
Pavona cactus	✓	✓	✓		
Pavona clavus					✓
Pavona decussata	✓	✓	✓	✓	✓
Pavona explanulata	✓	✓	✓	✓	✓
Pavona varians			✓	✓	
Pavona venosa		✓		✓	✓
Pectinia alcicornis		✓	✓	✓	
Pectinia lactuca	✓				
Pectinia paeonia	✓	✓	✓	✓	✓
Physogyra lichtensteini	✓	✓	✓	✓	✓
*Platygyra acuta****	✓	✓		✓	
*Platygyra contorta****		✓			
Platygyra daedalea	✓	✓		✓	✓
Platygyra lamellina		✓		✓	
Platygyra pini	✓	✓	✓	✓	✓
Platygyra ryukyuensis	✓	✓	✓	✓	✓
Platygyra sinensis	✓		✓		✓
Platygyra verweyi		✓	✓	✓	✓
Plerogyra sinuosa					✓
Plesiastrea versipora			✓	✓	
Pocillopora damicornis	✓	✓	✓	✓	✓
Pocillopora eydouxi				✓	✓
Pocillopora meandrina			✓	✓	✓
Pocillopora verrucosa					✓
Podabacia crustacea	✓	✓	✓	✓	
Podabacia motuporensis			✓		
Polyphyllia talpina			✓	✓	
Porites annae	✓		✓		✓
*Porites attenuata****			✓		
*Porites cumulatus****	✓		✓		
Porites cylindrica	✓	✓	✓	✓	✓
Porites deformis		✓			
Porites evermanni	✓		✓		
Porites heronensis			✓		
*Porites horizontalata****			✓		✓
Porites lichen	✓		✓	✓	✓
Porites lobata	✓	✓	✓	✓	✓
Porites mayeri	✓	✓	✓	✓	
Porites monticulosa		✓	✓		
*Porites negrosensis****	✓	✓			
Porites nigrescens	✓	✓	✓	✓	✓
Porites rus	✓	✓	✓	✓	✓
Psammocora contigua	✓	✓	✓		

Scleractinian species	Poruma	Aureed	Masig	Erub	Mer
Psammocora digitata	✓		✓	✓	
Psammocora obtusangula	✓				✓
Psammocora profundacella			✓	✓	✓
Psammocora superficialis		✓			
Sandalolitha robusta	✓	✓	✓	✓	
Scapophyllia cylindrica					✓
Scolymia vitiensis			✓		
Seriatopora caliendrum			✓		✓
Seriatopora hystrix	✓	✓	✓	✓	✓
Stylocoeniella armata	✓				
Stylocoeniella guentheri			✓		
Stylophora pistillata	✓	✓	✓		✓
Symphyllia agaricia	✓	✓			✓
Symphyllia radians	✓	✓		✓	✓
Symphyllia recta	✓		✓	✓	✓
Turbinaria frondens	✓		✓	✓	
Turbinaria mesenterina	✓	✓	✓	✓	✓
Turbinaria peltata		✓	✓	✓	
Turbinaria reniformis	✓			✓	
Turbinaria stellulata	✓	✓	✓	✓	

Appendix 3. List of fish species observed as part of current surveys and not recorded previously during surveys by Haywood et al. 2007 (see Appendix 4).

Family	Genus	Species
Acanthuridae	*Acanthurus*	*auranticavus*
Acanthuridae	*Acanthurus*	*grammoptilus*
Apogonidae	*Apogon*	*compressus*
Apogonidae	*Apogon*	*properuptus*
Apogonidae	*Cheilodipterus*	*macrodon*
Apogonidae	*Cheilodipterus*	*quinquelineatus*
Apogonidae	*Sphaeramia*	*nematoptera*
Aulostomidae	*Aulostomus*	*chinensis*
Balistidae	*Balistapus*	*undulatus*
Balistidae	*Balistoides*	*conspicillum*
Balistidae	*Balistoides*	*viridescens*
Balistidae	*Pseudobalistes*	*flavimarginatus*
Balistidae	*Rhinecanthus*	*rectangulus*
Balistidae	*Sufflamen*	*chrysopterus*
Blenniidae	*Aspidontus*	*dussumieri*
Blenniidae	*Crossosalarias*	*macrospilus*
Blenniidae	*Ecsenius*	*stictus*
Blenniidae	*Meiacanthus*	*atrodorsalis*
Blenniidae	*Meiacanthus*	*grammistes*
Blenniidae	*Plagiotremus*	*laudandus*
Blenniidae	*Plagiotremus*	*laudandus*
Blenniidae	*Plagiotremus*	*rhinorhynchos*
Carangidae	*Carangoides*	*fulvoguttatus*
Carangidae	*Carangoides*	*gymnostethus*
Carangidae	*Carangoides*	*orthogrammus*
Carangidae	*Caranx*	*lugubricus*
Carangidae	*Caranx*	*melampygus*
Carangidae	*Gnathanodon*	*speciosus*
Carangidae	*Gnathanodon*	*speciosus*
Chaetodontidae	*Coradion*	*chrysozonus*
Chaetodontidae	*Heniochus*	*varius*
Cirrhitidae	*Paracirrhites*	*arcatus*
Cirrhitidae	*Paracirrhites*	*forsteri*
Echeneidae	*Echeneis*	*naucrates*
Ephippidae	*Platax*	*pinnatus*
Ephippidae	*Platax*	*teira*
Gobiidae	*Amblygobius*	*decussatus*
Gobiidae	*Amblygobius*	*rainfordi*
Gobiidae	*Exyrias*	*belissimus*

Appendix 3 continued.

Family	Genus	Species
Gobiidae	*Istigobius*	*rigilius*
Gobiidae	*Valenciennea*	*puellaris*
Haemulidae	*Diagramma*	*pictum*
Haemulidae	*Plectorhinchus*	*chaetodonoides*
Haemulidae	*Plectorhinchus*	*flavomaculatus*
Haemulidae	*Plectorhinchus*	*lessonii*
Haemulidae	*Plectorhinchus*	*lineatus*
Haemulidae	*Plectorhinchus*	*macrolepis*
Haemulidae	*Plectorhinchus*	*multivittatum*
Haemulidae	*Plectorhinchus*	*unicolor*
Holocentridae	*Neoniphon*	*sammara*
Holocentridae	*Sargocentron*	*rubrum*
Kyphosidae	*Kyphosus*	*bigibbus*
Labridae	*Anampses*	*caeruleopunctatus*
Labridae	*Anampses*	*meleagrides*
Labridae	*Anampses*	*neoguinaicus*
Labridae	*Bodianus*	*mesothorax*
Labridae	*Cheilinus*	*fasciatus*
Labridae	*Cheilinus*	*trilobatus*
Labridae	*Choerodon*	*anchorago*
Labridae	*Choerodon*	*cyanodus*
Labridae	*Choerodon*	*monostigma*
Labridae	*Choerodon*	*schoenleinii*
Labridae	*Choerodon*	*vitta*
Labridae	*Cirrhilabrus*	*exquisitus*
Labridae	*Cirrhilabrus*	*punctatus*
Labridae	*Coris*	*ballieui*
Labridae	*Coris*	*batuensis*
Labridae	*Halichoeres*	*chloropterus*
Labridae	*Halichoeres*	*maculipinna*
Labridae	*Halichoeres*	*margaritaceus*
Labridae	*Halichoeres*	*marginatus*
Labridae	*Halichoeres*	*Melanurus*
Labridae	*Halichoeres*	*nebulosus*
Labridae	*Halichoeres*	*prosopeion*
Labridae	*Halichoeres*	*richmondi*
Labridae	*Labrichthys*	*unilineatus*
Labridae	*Labroides*	*dimidiatus*
Labridae	*Leptojulis*	*cyanopleura*
Labridae	*Macropharyngodon*	*choati*
Labridae	*Oxycheilinus*	*digrammus*
Labridae	*Oxycheilinus*	*orientalis*
Labridae	*Oxycheilinus*	*unifasciatus*
Labridae	*Pseudocoris*	*yamashiroi*

Appendix 3 continued.

Family	Genus	Species
Scombridae	*Scomberomorus*	*commerson*
Serranidae	*Anyperodon*	*leucogrammicus*
Serranidae	*Cephalopholis*	*argus*
Serranidae	*Cephalopholis*	*boenak*
Serranidae	*Cephalopholis*	*cyanostigma*
Serranidae	*Cephalopholis*	*microprion*
Serranidae	*Diploprion*	*bifasciatum*
Serranidae	*Epinephelus*	*cyanopodus*
Serranidae	*Epinephelus*	*fasciatus*
Serranidae	*Epinephelus*	*merra*
Serranidae	*Epinephelus*	*octofasciatus*
Serranidae	*Epinephelus*	*ongus*
Siganidae	*Siganus*	*punctatissimus*
Synodontidae	*Synodus*	*jaculum*
Synodontidae	*Synodus*	*variegatus*
Synodontidae	*Synodus*	*variegatus*
Tetraodontidae	*Arothron*	*caeruleopunctatus*
Tetraodontidae	*Arothron*	*nigropunctatus*
Tetraodontidae	*Canthigaster*	*papua*

Appendix 4. List of CSIRO target species (from Haywood et al. 2007)

Family	Genus	Species
Acanthuridae	*Acanthurus*	*blochii*
Acanthuridae	*Acanthurus*	*dussumieri*
Acanthuridae	*Acanthurus*	*lineatus*
Acanthuridae	*Acanthurus*	*mata*
Acanthuridae	*Acanthurus*	*nigricans*
Acanthuridae	*Acanthurus*	*nigricauda*
Acanthuridae	*Acanthurus*	*nigrofuscus*
Acanthuridae	*Acanthurus*	*olivaceus*
Acanthuridae	*Acanthurus*	*pyroferus*
Acanthuridae	*Acanthurus*	*thompsoni*
Acanthuridae	*Acanthurus*	*triostegus*
Acanthuridae	*Acanthurus*	*xanthopterus*
Acanthuridae	*Ctenochaetus*	*binotatus*
Acanthuridae	*Ctenochaetus*	*striatus*
Acanthuridae	*Naso*	*annulatus*
Acanthuridae	*Naso*	*brevirostris*
Acanthuridae	*Naso*	*lituratus*
Acanthuridae	*Naso*	*tuberosus*
Acanthuridae	*Naso*	*unicornis*
Acanthuridae	*Naso*	*vlamingii*
Acanthuridae	*Paracanthurus*	*hepatus*
Acanthuridae	*Zebrasoma*	*scopas*
Acanthuridae	*Zebrasoma*	*veliferum*
Siganidae	*Siganus*	*argenteus*
Siganidae	*Siganus*	*corallinus*
Siganidae	*Siganus*	*doliatus*
Siganidae	*Siganus*	*javus*
Siganidae	*Siganus*	*lineatus*
Siganidae	*Siganus*	*puellus*
Siganidae	*Siganus*	*punctatus*
Siganidae	*Siganus*	*spinus*
Siganidae	*Siganus*	*vulpinus*
Zanclidae	*Zanclus*	*cornutus*
Labridae	*Cheilinus*	*undulatus*
Labridae	*Cheilinus*	*fasciatus*
Labridae	*Coris*	*aygula*
Labridae	*Coris*	*gaimard*
Labridae	*Epibulus*	*insidiator*
Labridae	*Gomphosus*	*varius*
Labridae	*Halichoeres*	*hortulanus*
Labridae	*Halichoeres*	*trimaculatus*
Labridae	*Hemigymnus*	*fasciatus*

Appendix 4 continued.

Family	Genus	Species
Labridae	*Hemigymnus*	*melapterus*
Labridae	*Thalassoma*	*jansenii*
Labridae	*Thalassoma*	*lunare*
Labridae	*Thalassoma*	*lutescens*
Pomacentridae	*Abudefduf*	*bengalensis*
Pomacentridae	*Abudefduf*	*sexfasciatus*
Pomacentridae	*Abudefduf*	*vaigiensis*
Pomacentridae	*Abudefduf*	*whitleyi*
Pomacentridae	*Acanthachromis*	*polyacanthus*
Pomacentridae	*Amblyglyphidodon*	*leucogaster*
Pomacentridae	*Chromis*	*acares*
Pomacentridae	*Chromis*	*amboinensis*
Pomacentridae	*Chromis*	*atripectoralis*
Pomacentridae	*Chromis*	*atripes*
Pomacentridae	*Chromis*	*chrysura*
Pomacentridae	*Chromis*	*iomelas*
Pomacentridae	*Chromis*	*lepidolepis*
Pomacentridae	*Chromis*	*margaritifer*
Pomacentridae	*Chromis*	*nitida*
Pomacentridae	*Chromis*	*retrofasciata*
Pomacentridae	*Chromis*	*ternatensis*
Pomacentridae	*Chromis*	*vanderbilti*
Pomacentridae	*Chromis*	*viridis*
Pomacentridae	*Chromis*	*weberi*
Pomacentridae	*Chromis*	*xanthura*
Pomacentridae	*Chrysiptera*	*cyanea*
Pomacentridae	*Chrysiptera*	*flavipinnis*
Pomacentridae	*Chrysiptera*	*rex*
Pomacentridae	*Chrysiptera*	*rollandi*
Pomacentridae	*Chrysiptera*	*talboti*
Pomacentridae	*Dascyllus*	*reticulatus*
Pomacentridae	*Dascyllus*	*trimaculatus*
Pomacentridae	*Neopomacentrus*	*azysron*
Pomacentridae	*Neopomacentrus*	*bankieri*
Pomacentridae	*Neopomacentrus*	*cyanomos*
Pomacentridae	*Plectroglyphidodon*	*dickii*
Pomacentridae	*Plectroglyphidodon*	*johnstonianus*
Pomacentridae	*Plectroglyphidodon*	*lacrymatus*
Pomacentridae	*Pomacentrus*	*amboinensis*
Pomacentridae	*Pomacentrus*	*bankanensis*
Pomacentridae	*Pomacentrus*	*brachialis*
Pomacentridae	*Pomacentrus*	*chrysurus*
Pomacentridae	*Pomacentrus*	*coelestis*
Pomacentridae	*Pomacentrus*	*grammorhynchus*

Appendix 4 continued.

Family	Genus	Species
Pomacentridae	*Pomacentrus*	*lepidogenys*
Pomacentridae	*Pomacentrus*	*moluccensis*
Pomacentridae	*Pomacentrus*	*nagasakiensis*
Pomacentridae	*Pomacentrus*	*pavo*
Pomacentridae	*Pomacentrus*	*phillipinus*
Pomacentridae	*Pomacentrus*	*taeniometapon*
Pomacentridae	*Pomacentrus*	*vaiuli*
Pomacentridae	*Pomacentrus*	*wardi*
Pomacentridae	*Stegastes*	*apicalis*
Pomacentridae	*Stegastes*	*fasciolatus*
Pomacentridae	*Stegastes*	*nigricans*
Scaridae	*Cetoscarus*	*bicolour*
Scaridae	*Chlorurus*	*bleekeri*
Scaridae	*Chlorurus*	*japanensis*
Scaridae	*Chlorurus*	*microrhinos*
Scaridae	*Chlorurus*	*sordidus*
Scaridae	*Hipposcarus*	*longiceps*
Scaridae	*Scarus*	*altipinnis*
Scaridae	*Scarus*	*chameleon*
Scaridae	*Scarus*	*dimidiatus*
Scaridae	*Scarus*	*flavipectoralis*
Scaridae	*Scarus*	*forsteni*
Scaridae	*Scarus*	*frenatus*
Scaridae	*Scarus*	*ghobban*
Scaridae	*Scarus*	*globiceps*
Scaridae	*Scarus*	*niger*
Scaridae	*Scarus*	*oviceps*
Scaridae	*Scarus*	*psittacus*
Scaridae	*Scarus*	*rivulatus*
Scaridae	*Scarus*	*rubroviolaceus*
Scaridae	*Scarus*	*schlegeli*
Scaridae	*Scarus*	*spinus*
Caesionidae	*Caesio*	*caerulaurea*
Caesionidae	*Caesio*	*cuning*
Caesionidae	*Caesio*	*teres*
Caesionidae	*Pterocaesio*	*marri*
Caesionidae	*Pterocaesio*	*tile*
Caesionidae	*Pterocaesio*	*trilineata*
Chaetodontidae	*Chaetodon*	*aureofasciatus*
Chaetodontidae	*Chaetodon*	*auriga*
Chaetodontidae	*Chaetodon*	*baronessa*
Chaetodontidae	*Chaetodon*	*bennetti*
Chaetodontidae	*Chaetodon*	*citrinellus*

Appendix 4 continued.

Family	Genus	Species
Chaetodontidae	*Chaetodon*	*ephippium*
Chaetodontidae	*Chaetodon*	*kleinii*
Chaetodontidae	*Chaetodon*	*lineolatus*
Chaetodontidae	*Chaetodon*	*lunula*
Chaetodontidae	*Chaetodon*	*melannotus*
Chaetodontidae	*Chaetodon*	*ornatissimus*
Chaetodontidae	*Chaetodon*	*pelewensis*
Chaetodontidae	*Chaetodon*	*plebeius*
Chaetodontidae	*Chaetodon*	*rafflesii*
Chaetodontidae	*Chaetodon*	*rainfordi*
Chaetodontidae	*Chaetodon*	*speculum*
Chaetodontidae	*Chaetodon*	*trifascialis*
Chaetodontidae	*Chaetodon*	*ulietensis*
Chaetodontidae	*Chaetodon*	*unimaculatus*
Chaetodontidae	*Chaetodon*	*vagabundus*
Chaetodontidae	*Chelmon*	*marginalis*
Chaetodontidae	*Chelmon*	*muelleri*
Chaetodontidae	*Chelmon*	*rostratus*
Chaetodontidae	*Coradion*	*chrysozonus*
Chaetodontidae	*Forcipiger*	*flavissimus*
Chaetodontidae	*Forcipiger*	*longirostris*
Chaetodontidae	*Parachaetodon*	*ocellatus*
Lethrinidae	*Lethrinus*	*atkinsoni*
Lethrinidae	*Lethrinus*	*erythropterus*
Lethrinidae	*Lethrinus*	*harak*
Lethrinidae	*Lethrinus*	*laticaudis*
Lethrinidae	*Lethrinus*	*lentjan*
Lethrinidae	*Lethrinus*	*obsoletus*
Lethrinidae	*Lethrinus*	*olivaceus*
Lethrinidae	*Lethrinus*	*ornatus*
Lethrinidae	*Lethrinus*	*rubrioperculatus*
Lethrinidae	*Lethrinus*	*xanthochilus*
Lutjanidae	*Lutjanus*	*biguttatus*
Lutjanidae	*Lutjanus*	*bohar*
Lutjanidae	*Lutjanus*	*carponotatus*
Lutjanidae	*Lutjanus*	*fulviflamma*
Lutjanidae	*Lutjanus*	*fulvus*
Lutjanidae	*Lutjanus*	*gibbus*
Lutjanidae	*Lutjanus*	*kasmira*
Lutjanidae	*Lutjanus*	*monostigma*
Lutjanidae	*Lutjanus*	*quinquelineatus*
Lutjanidae	*Lutjanus*	*rivulatus*
Lutjanidae	*Lutjanus*	*sebae*

Appendix 4 continued.

Family	Genus	Species
Lutjanidae	*Lutjanus*	*vitta*
Lutjanidae	*Symphorus*	*nematophorus*
Serranidae	*Chromileptes*	*altivelis*
Serranidae	*Plectropomus*	*areolatus*
Serranidae	*Plectropomus*	*laevis*
Serranidae	*Plectropomus*	*leopardus*
Serranidae	*Plectropomus*	*maculatus*
Serranidae	*Variola*	*louti*