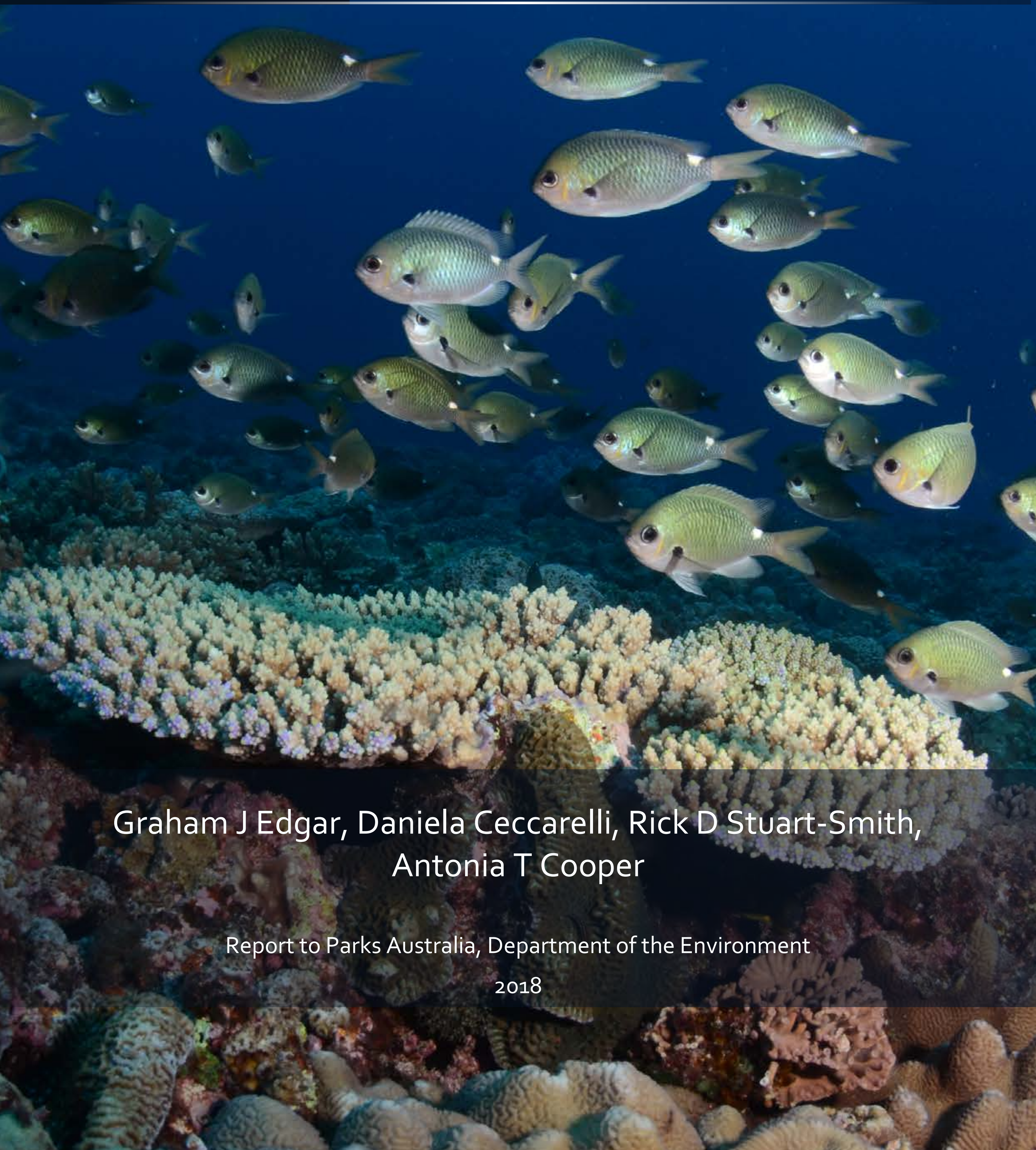
Biodiversity surveys of the Elizabeth and Middleton Reefs Marine National Park Reserve 2013 and 2018



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Images

Cover: *Chromis hypsilepis*, Middleton Reef, Antonia Cooper

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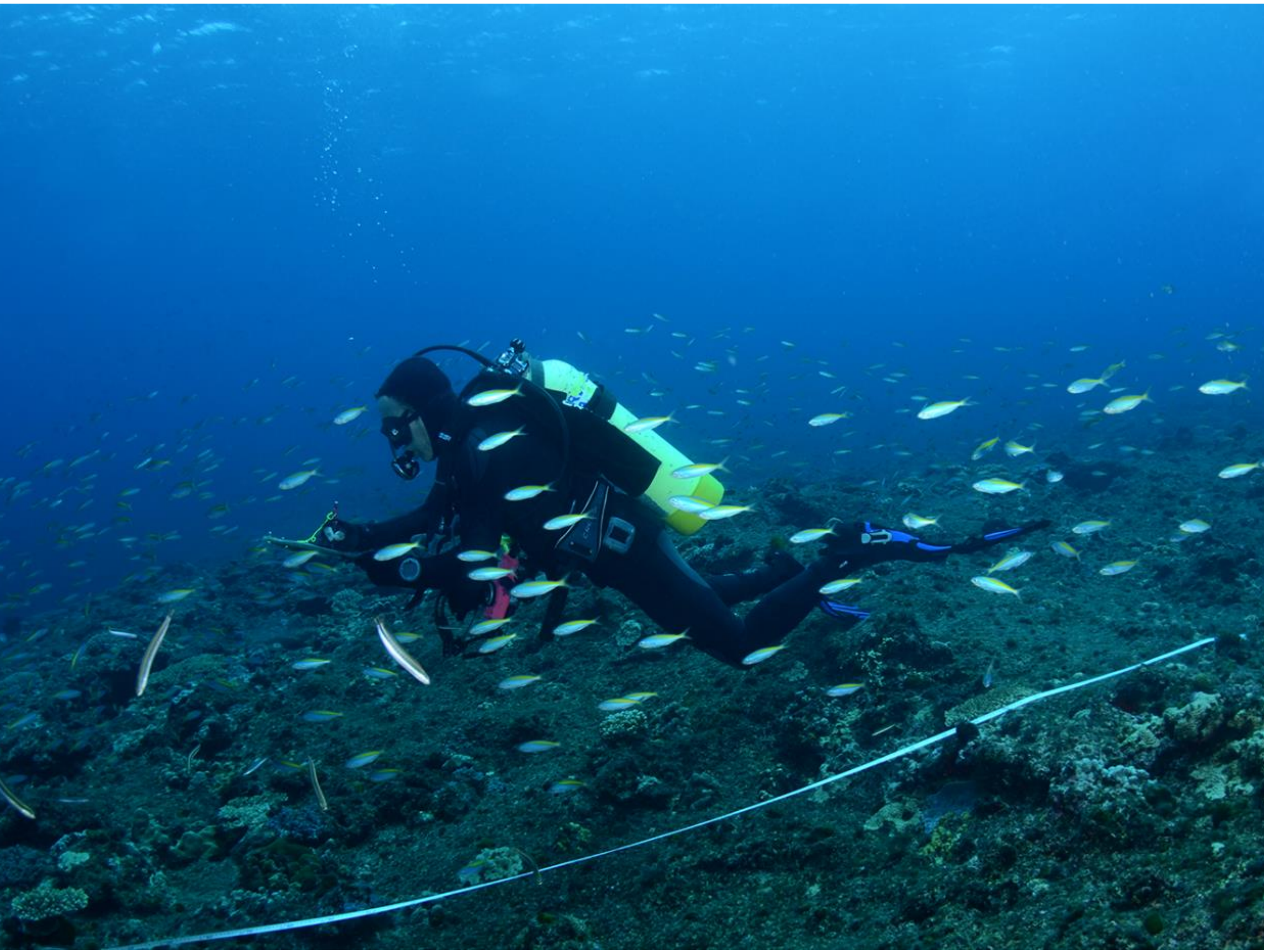

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List of acronyms

ACRONYM	EXPANDED
AMP/CMR	Australian Marine Park/ Commonwealth Marine Reserve
RLSF	The Reef Life Survey Foundation
MPA	Marine Protected Area
IUCN	International Union for Conservation of Nature
RLS	Reef Life Survey
EEZ	Exclusive Economic Zone
CTI	Community Temperature Index

Executive summary

This latest survey of Elizabeth and Middleton Reefs in the Lord Howe Marine Park (referred to here as the EMR) follows on from a decade of surveys conducted approximately every 2-3 years, primarily by James Cook University or Reef Life Survey divers. The primary changes noted in the time between 2013 and 2018 were a sharp increase in the number of species and abundance of cryptic fishes, a decline in turf cover on the reefs, and signs of increasing prevalence and biomass of large tropical herbivores. Functionally important fishes recorded in high densities, compared with other locations, included the regional endemic doubleheader wrasse *Coris bulbifrons*, the black cod *Epinephelus daemelii,* and the Galapagos shark *Carcharhinus galapagensis*, which remained relatively stable between 2013 and 2018. Black cod biomass was similar in 2018 to that recorded in 2013 at Middleton Reef; however, biomass significantly declined at Elizabeth Reef, perhaps due to incidental mortality associated with catch and release by recreational fishers.

Increases in cryptic and herbivorous fishes were also recorded on the southern Great Barrier Reef (GBR) and Coral Sea during the same period (Stuart-Smith et al. 2018), and were hypothesised to be related to warmer seas across the broader region in recent years, and especially the heatwave that caused the 2016 mass coral bleaching event along the GBR and Coral Sea. The consistency in the observations of herbivorous fishes and populations of small cryptic fishes with patterns observed much further north along the GBR and Coral Sea suggest the same large-scale drivers, and strongly point at elevated temperature as most likely responsible.

The cover of living benthos on both reefs was still dominated by low-lying turf growing on a dead coral base in 2018. This appears to be typical of highly exposed reef fronts, but also of reefs that have suffered past disturbances and coral mortality. A decline in turf cover observed at both reefs could be a direct result of the increased abundance of herbivorous fishes. Coral cover was slightly higher at both reefs than that recorded on RLS surveys in 2013, and by other researchers in 2011 and 2014, suggesting that corals have either been recovering from earlier disturbances or at least remained stable over the last decade. Slow recovery is expected on isolated sub-tropical reefs such as the EMR, where connectivity to source reefs and growth rates of corals are naturally low.

The key threats to these reefs are likely to be increasing sea temperatures, physical damage from severe storms, outbreaks of crown-of-thorns seastars, and illegal fishing. A further concern for the EMR in the future will be climate change induced deviations in the East Australian Current, potentially leading to significant changes in larval supply and physical environmental conditions. Recovery from disturbance is likely to be prolonged by the isolation from potential source reefs.

These reefs remain a stronghold for Galapagos sharks and black cod because their isolation potentially protects them from illegal fishing. However, illegal and unreported fishing is still an issue (Edgar et al. 2016), and sharks are sometimes killed because they take fishers' catches. Given the globally crucial role of EMR in protecting these species, enforcement of no-take regulations is critically important.

MANAGEMENT AND RESEARCH RECOMMENDATIONS

- Maintain no-take status of Middleton Reef, consider increasing the level of protection at Elizabeth Reef to reduce potential impacts on black cod associated with recreational fishing, and increase active enforcement of fishing restrictions on both reefs (including enforcing the protected status of black cod when fishing is allowed for other species);
- Compile statistics on visitation rates of fishers, scientists and other users to the Elizabeth and Middleton Reefs. Consider the deployment of acoustic receiver loggers to monitor boat visitation rates;
- Undertake ongoing ecological monitoring at intervals of 1-3 years to continue to build up a temporal dataset to assess changes relative to data provided by this and previous surveys, with results reported using a comprehensive suite of sensitive ecological indicators;
- Undertake regular monitoring of physical characteristics (water quality, nutrients, turbidity, light and other physical parameters) that support ecological processes;
- Support involvement of Lord Howe Island Marine Park staff and rangers in the monitoring of the EMR, as they have the opportunity to coincide surveys with suitable weather conditions in which to undertake surveys;
- Examine levels of gene flow between the EMR and protected areas off the NSW coast, Norfolk Island, New Zealand and Lord Howe Island, to establish possible pathways of stock replenishment;
- Investigate seasonal changes in diversity, abundance and functional groups or productivity of fish and invertebrate communities, to further understand the dynamics of these highly dynamic systems and processes associated with recruitment and stock fluctuations;
- Investigate food webs, including addressing the question of whether large biomasses of sharks were also the norm elsewhere in previous decades, and how a large biomass of sharks influences the reef community.

1 Introduction

Elizabeth and Middleton Reefs (referred to here as the EMR), protected within the Commonwealth managed Lord Howe Marine Park (Figure 1) , are atoll-like structures or platform reefs associated with a seamount chain that extends northward from Lord Howe Island (Woodroffe et al. 2004). They are the two southern-most platform reefs in the world, and host a unique and diverse assemblage of tropical, sub-tropical and temperate organisms. They are also particularly notable as global strongholds for the Galapagos shark, *Carcharhinus galapagensis*, and the black cod, *Epinephelus daemelii* (Hoey et al. 2018).

Middleton Reef has been managed as a no-take area (where fishing is not allowed) and Elizabeth Reef as a limited-take area (where recreational fishing including spearfishing is allowed by permit) since the declaration of the former Elizabeth and Middleton Reef Marine National Nature Reserve on 23 December 1987, other than some minor changes in regulations when the first management plan expired in 2004.

The Region's oceanography and marine ecology are dominated and driven by the East Australian Current, which flows southwards from the Coral Sea to waters east of Tasmania. Its strength varies seasonally, and productivity is affected by its large eddies and associated upwellings. It flows to 500 m depth and 100 km width, conveying up to 30 million cubic meters per second, with associated southward transport of tropical and subtropical species to temperate waters. The East Australian Current meets the Tasman Front at approximately 30 degrees latitude, and this delineates the tropical-temperate transition. This convergence zone is highly productive and geographically dynamic, in that it moves seasonally north or south (Ceccarelli et al. 2013). Elizabeth and Middleton Reefs generally receive warm water from eastward-flowing eddies of the East Australian Current (Brewer et al. 2007). These eddies transport larvae from the Great Barrier Reef (GBR) and Coral Sea. Additionally, the NSW coastal ecosystems to the west, which support subtropical reef ecosystems, are a potential source of propagules of temperate and subtropical species.

Both reefs consist of an extensive lagoon surrounded by a well-defined reef crest with characteristic spur and groove formations, broken only by channels on the northern edges (Choat et al. 2006). The prevailing winds are from east to southwest, resulting in very exposed reef front habitats on the southern face of the reefs. Waves wrapping around the western and northeastern aspects of the reef ensure that these sides are also frequently exposed to heavy seas (Kennedy and Woodroffe 2004).

Early research focusing on individual taxa was conducted in the 1980s, followed by more comprehensive Australian Museum surveys (Australian Museum 1992) and a series of ecological surveys conducted by the Australian Institute of Marine Science, James Cook University and Reef Life Survey (Oxley et al. 2004; Choat et al. 2006; Pratchett et al. 2011; Hoey et al. 2014; Edgar et al. 2016). Surveys by Australian Museum staff indicated that live coral cover has historically been higher at Elizabeth Reef than at Middleton Reef (Australian Museum 1992), but continuing reports of low coral cover indicates frequent disturbances and slow recovery (Pratchett et al. 2011; Hoey et al. 2014). Other differences between the reef communities of Elizabeth and Middleton Reefs hint that small-scale stochasticity in larval input and post-settlement survival are important, and extinction risk is potentially high (Noreen et al. 2009).

Genetically, Elizabeth and Middleton Reefs appear to be similar to each other and reefs further north, but distinct from Lord Howe Island (van Herwerden et al. 2009). Of special interest has been the association between tropical species at the southern edge of their geographic distribution, and extra-tropical species not found on the GBR. The coral communities tend to be dominated by a few abundant species, including *Isopora palifera*, *Acropora glauca*, *Porites spp.* and *Pocillopora damicornis*. Commercially important invertebrates such as holothurians were abundant in 2003, with very high densities of the high-value *Holothuria whitmaei* (133.3 individuals per hectare) recorded during reef surveys (Oxley et al. 2004). Elizabeth and Middleton Reefs also support populations of endemic molluscs (Lee Long 2009). Previous surveys have reported 322 species of reef fishes at Elizabeth and Middleton Reefs, with a high proportion of excavating and scraping parrotfishes and large herbivorous browsing fishes (Choat et al. 2006). Black cod and Galapagos shark populations were most recently recorded as abundant and stable, with the observation that the Elizabeth Reef lagoon may serve as a nursery habitat for Galapagos sharks (Oxley et al. 2004; Choat et al. 2006).

This report summarises data from the latest Reef Life Survey (RLS) investigations (2018) at Elizabeth and Middleton Reefs, and compares them to observations from the previous survey that employed the same standardised RLS methods (2013).

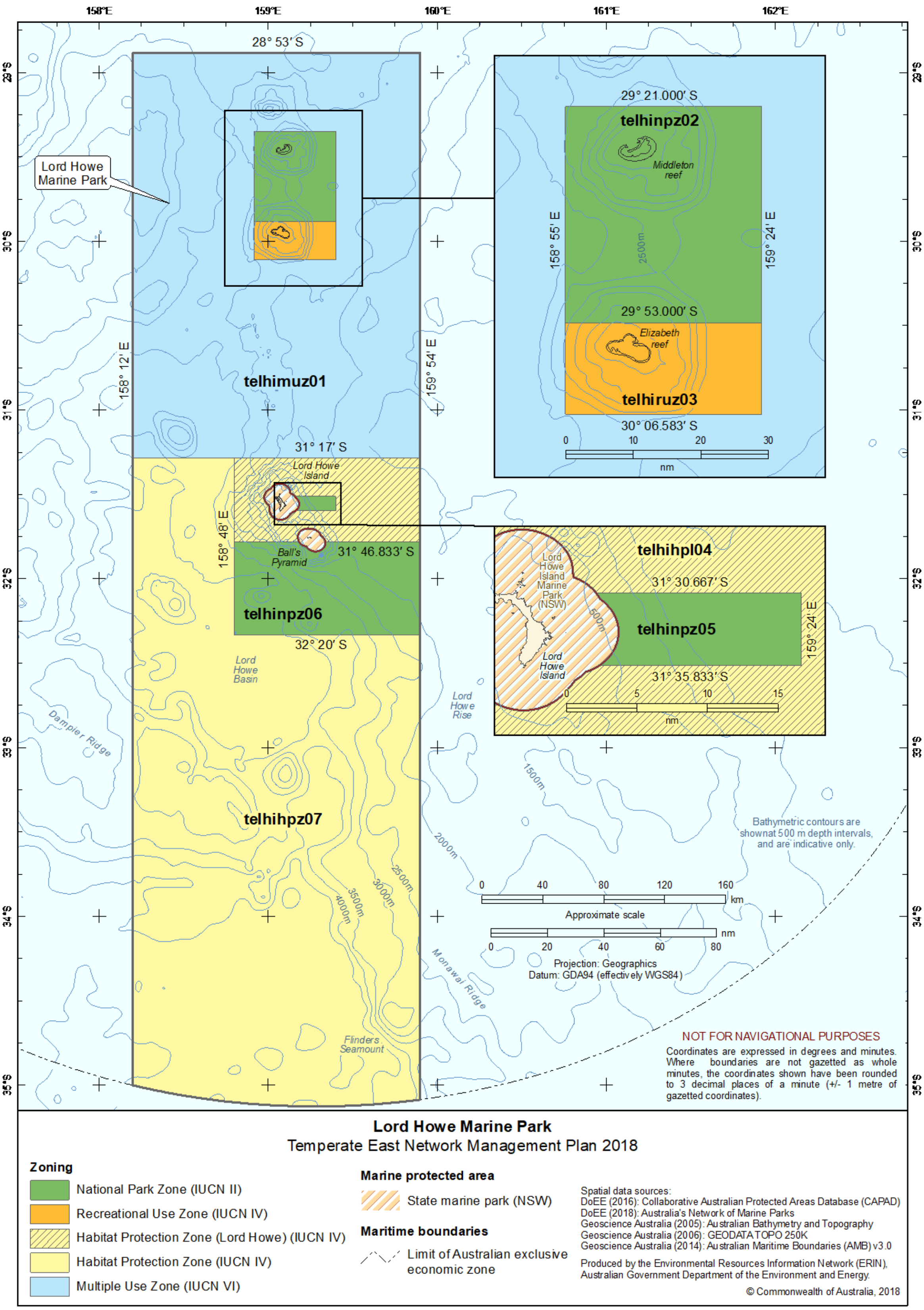

Figure 1. Lord Howe Marine Park, including Elizabeth and Middleton Reefs

2 Methods

Field surveys in the EMR were conducted from 14-17th January 2013 by a team of skilled divers from the Reef Life Survey program (RLS; www.reeflifesurvey.com) and again from 24th February to the 2nd March 2018 by a team from the University of Tasmania using RLS methods. Geographical coordinates of sites (in WGS84) were recorded using handheld Garmin GPS units (Appendix 1). Ecological surveys were conducted at depths ranging from 1 to 16 m, along 66 transects at 33 sites in 2013 and 84 transects at 42 sites in 2018 (Figure 2).

Data collected from each site consisted of abundance and size of fishes, abundance of mobile macroinvertebrates and cryptic fishes, and percentage cover of sessile biota. These are described separately below. Sites were selected to encompass the range of reef types and depths both inside and outside the EMR, but with the depth range limited by dive safety considerations and bottom time restrictions.

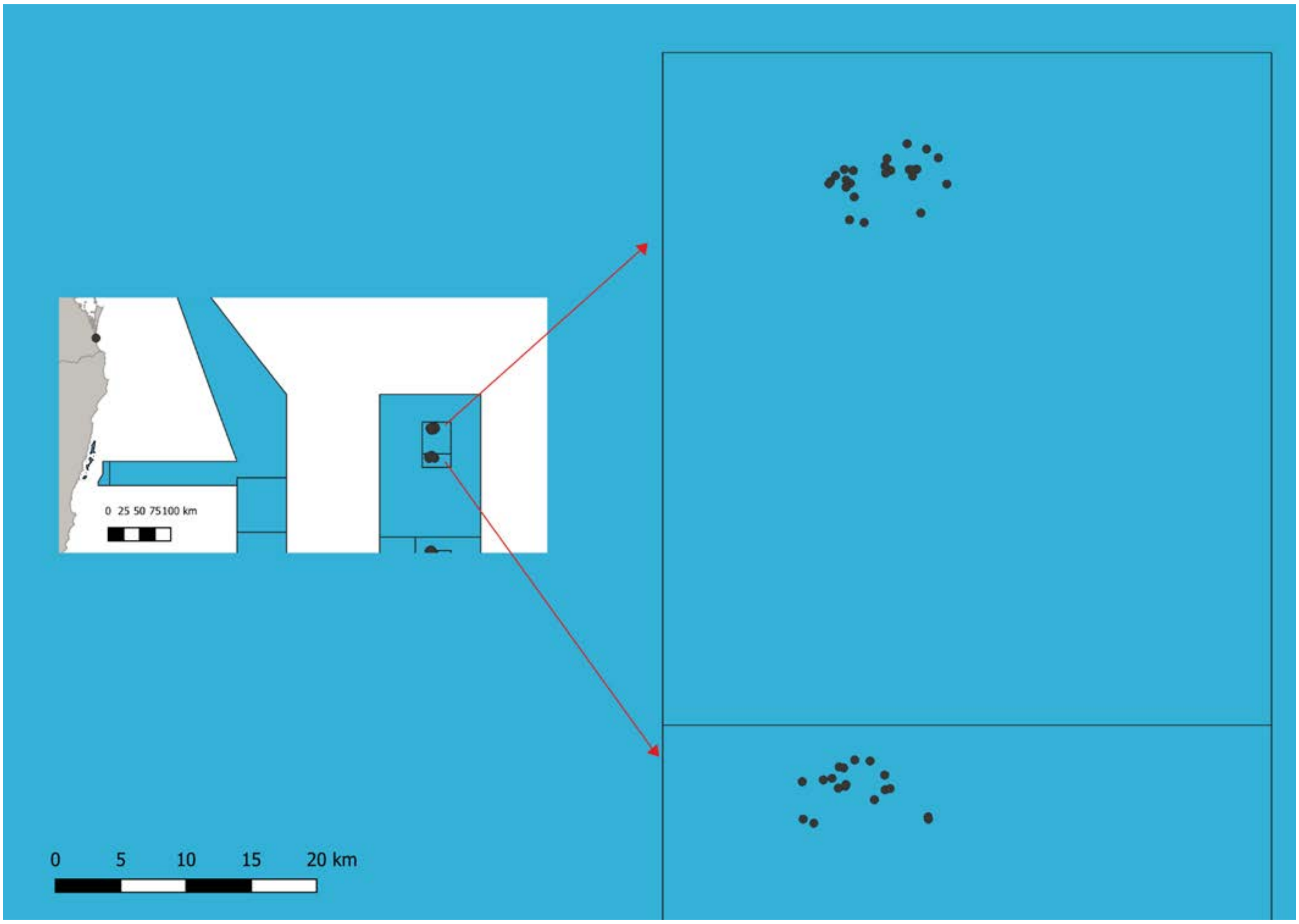

Figure 2.Map of sampling sites in the EMR, 2013 and 2018.

FISH SURVEYS (METHOD 1)

Fish census protocols involved a diver laying out a 50 m transect line along a depth contour on reef. The number and estimated size-category of all fishes sighted within 5 m blocks either side of the transect line were recorded on waterproof paper as the diver swam slowly along up and down each side. Size-classes of total fish length (from snout to tip of tail) used are 25, 50, 75, 100, 125, 150, 200, 250, 300, 350, 400, 500, 625 mm, and above. Lengths of fish larger than 500 mm were estimated to the nearest 12.5 cm and individually recorded.

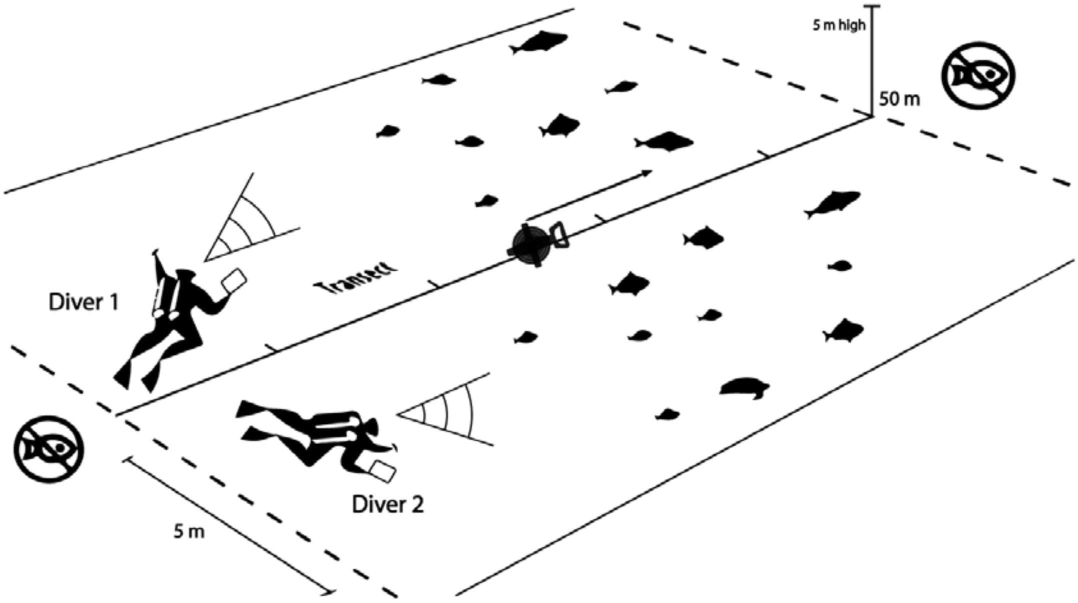

Figure 3. Stylised representation of method 1 survey technique

MACROALGAL AND SESSILE INVERTEBRATE SURVEYS (METHOD 2)

Information on the percentage cover of sessile animals and seaweeds along the transect lines set for fish and invertebrate censuses was recorded using photo-quadrats taken sequentially each 2.5 m (or 5 m, see below) along the 50 m transect. Digital photo-quadrats were taken vertically-downward from a height sufficient to encompass an area of at least 0.3 m x 0.3 m. When a wide-angle lens was used and the photo-quadrats encompassed at least 0.5 m x 0.5 m, only 10 images were taken (one every 5 m). The percentage cover of different macroalgal, coral, sponge and other attached invertebrate species in photo-quadrats was digitally quantified in the laboratory using the Coral Point Count with Excel extensions (CPCe) software (Kohler and Gill, 2006). A grid of 5 points was overlaid on each image and the taxon lying directly below each point recorded. Identification was to the lowest possible taxonomic resolution, with taxa for which identification was uncertain grouped with congeners or other members of the family or order.

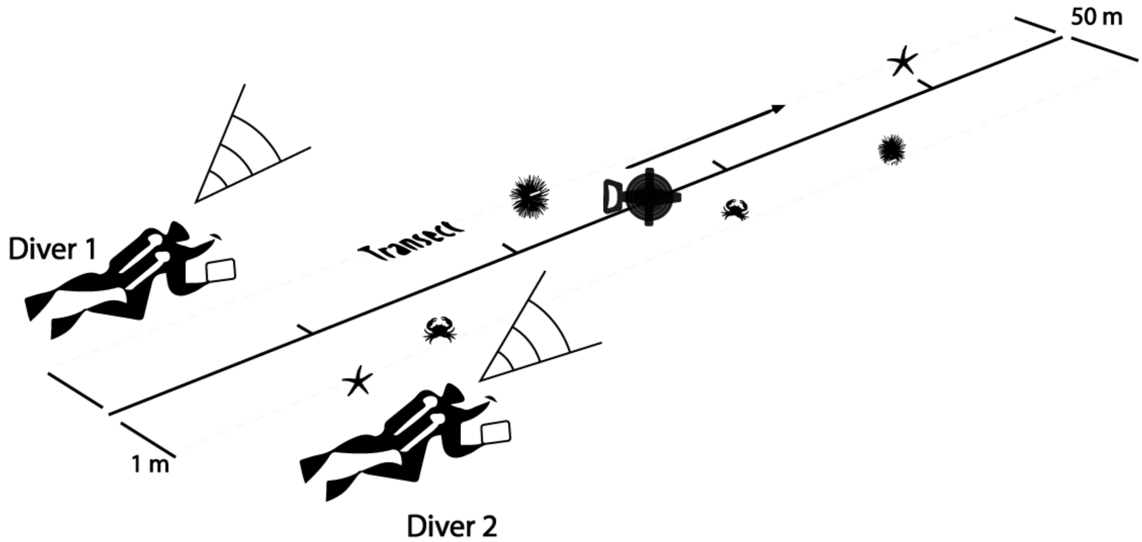

Figure 4. Stylised representation of method 2 survey technique

BENTHIC COVER SURVEYS

Information on the percentage cover of sessile animals and seaweeds along the transect lines set for fish and invertebrate censuses was recorded using photo-quadrats taken sequentially each 2.5 m along the 50 m transect. Digital photo-quadrats were taken vertically-downward from a height sufficient to encompass an area of at least 0.3 m x 0.3 m. The percentage cover of different macroalgal, coral, sponge and other attached invertebrate species in photo-quadrats was digitally quantified in the laboratory using the Coral Point Count with Excel extensions (CPCe) software (Kohler and Gill, 2006) or similar annotation process. A grid of 5 points was overlaid on each image and the benthic cover category lying directly below each point recorded. Benthic cover categories were the same as scored for the 2013 data, and encompass the major growth forms of corals and functional groups of algae.

COMMUNITY TEMPERATURE INDEX

A useful indicator for tracking changes in reef fish community structure in relation to changing sea temperatures is the community temperature index (CTI). This indicator summarises the thermal affinities of the species recorded in fish surveys, and can be sensitive to temperature changes such as those during marine heatwaves (Day et al. 2018), especially in temperate areas. It has not yet been thoroughly tested using time series on coral reefs, but should theoretically detect any directional change in community structure resulting from warmer temperatures (e.g. gains in species with an affinity for warmer seas and losses in those with cooler affinities). It is most useful for time series analyses, although spatial comparison can provide an indication of potential relative vulnerabilities to warming (Stuart-Smith et al. 2015). For its calculation, the midpoint of each species' thermal distribution (similar to the temperature at the centre of its range) is used as a value of thermal affinity. The mean thermal affinity of species recorded on a survey is then taken, weighted by the log of their abundance on the survey.

STATISTICAL ANALYSES

At most sites, two 50-m long transects were surveyed at different depths (see Appendix 1). The unit of replication was total value(s) per pair of adjoining transect blocks (i.e. per 500 m^2 for fishes and per 100 m^2 for mobile macroinvertebrates). Sessile biota percent cover was expressed per transect.

Separate univariate analyses and data exploration techniques were used for fishes, mobile macroinvertebrate communities, sessile communities and the CTI. Univariate metrics that described important community characteristics were calculated for each transect and compared between transects surveyed. Metrics examined for fishes were: relative abundance, estimated total biomass (see below for biomass estimation), biomass of fishes ≥ 20 cm TL, and number of species. Mobile invertebrate metrics were: total relative abundance of mobile invertebrates and number of species. Sessile community/benthic cover metrics were: total cover of live benthos, number of benthic categories (as a proxy for taxonomic richness), and percentage cover of turf, live hard corals, macroalgae and crustose coralline algae.

Dependent variables were tested with linear mixed effects models, using the program R, with Year and Location (Reef) as fixed factors, and Site as a random factor nested within Location, to account for the high variability among sites. All dependent variables were log(x+1) transformed. To explore patterns in fish community trophic structure, the abundance and biomass of fishes in different trophic groups were estimated. Trophic groups used in this analysis were: benthic invertivores (preying almost only on invertebrates), carnivores (preying on both invertebrates and fishes), piscivores (mostly preying on fishes), omnivores (consuming plant and animal matter), planktivores, corallivores, grazers (including algal turf croppers, detritivores, macroalgal browsers, and scraping and excavating parrotfishes) and farmers (territorial damselfishes). Biomass estimates were made for each species on each transect block using fish abundance counts, size estimates, and the length-weight relationships presented for each species (in some cases genus and family) in Fishbase (Froese and Pauly 2016).

Relationships between sites in percent cover of sessile biota, reef fish and invertebrate communities were initially analysed using non-metric Multi-Dimensional Scaling (MDS). These were run using the PRIMER+PERMANOVA program (Anderson et al. 2008). This analysis reduces multidimensional patterns (e.g. with multiple species or functional groups) to two dimensions, showing patterns of biotic similarity between sites. MDS was used to investigate differences in community structure between reefs. Data were converted to a Bray-Curtis distance matrix relating each pair of sites after square root transformation of raw data. The transformation was applied to down-weight the relative importance of the dominant species at a site, therefore allowing less abundant species to also contribute to the plots. MDS was accompanied by ANOSIM to test the significance of community-level differences between reefs.

3 Results

FISH SURVEYS

Surveys across the EMR recorded 295 species of reef fishes along a total of 150 transects over the two survey periods (Appendix 2). Between 2013 and 2018, a number of species increased in abundance and biomass, either at both reefs (*Prionurus maculatus*) or only at Middleton Reef (*Plectropomus laevis*, *Scarus altipinnis*, *S. ghobban*, *S. psittacus*, *Kyphosus sectatrix* and *Chromis* spp.).

There were no clear differences or trends in the community structure of reef fishes between years or between the two reefs (Figure 5). Sites were distinguished by having either a depauperate fish assemblage or a large complement of the suite of fish species generally found in the EMR. Sites with a richer fish community were further separated by either a dominance of grazers and planktivores (e.g. *S. altipinnis*, *K. sectatrix* and *Chromis hypsilepis*), or a greater variety of functional groups including predators, herbivores, omnivores and invertivores (e.g. *Epinephelus daemelii*, *Chlorourus sordidus*, *Neoglyphidodon polyacanthus*, *Apogon norfolcensis*).

Trends of increased reef fish richness, biomass and biomass of large fishes (≥20 cm) in 2018 compared to 2013 existed at Middleton Reef, but these were not statistically significant. Likewise, no significant differences existed between the two reefs and survey periods in reef fish abundance or the biomass of small (<20 cm) fishes (Figure 6, Table 1). Community temperature index (CTI) values were similar between Elizabeth and Middleton Reefs in 2013, but significantly increased at Middleton Reef in 2018, while remaining stable at Elizabeth Reef (Figure 6). The 'warmer' fish community at Middleton Reef in the latest surveys was at least partly a result of the inclusion of more tropical parrotfishes and increased abundances of species with warm preferences that were present in the initial surveys.

The biomass of all functional groups was relatively uniform between reefs and years, with no significant spatial or temporal differences (Figure 7, Table 2). Generally, the dominant functional groups were the grazers (including turf croppers, macroalgae browsers, detritivores, scraping and excavating parrotfishes), followed by piscivores, benthic invertivores and planktivores. For many groups, there was a trend, albeit not statistically significant, of increased biomass in 2018 compared with 2013. This was especially the case for planktivores and grazers on Middleton Reef, and for farmers at Elizabeth Reef, for which the increase was significant (Figure 7, Table 2).

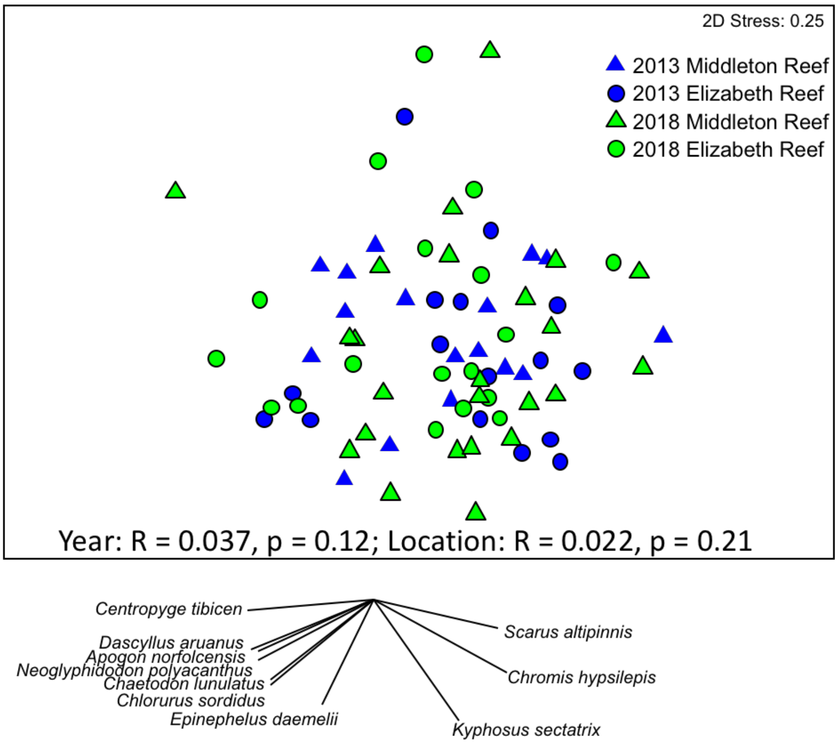

Figure 5. Multidimensional Scaling (MDS) plot of reef fish biomass in the EMR in 2013 and 2018, performed on the Bray-Curtis similarity matrix of the log(x+1) transformed data. Species vectors are shown if they had a correlation value of at least 0.5. ANOSIM (Year x Location) results are presented below the plot.

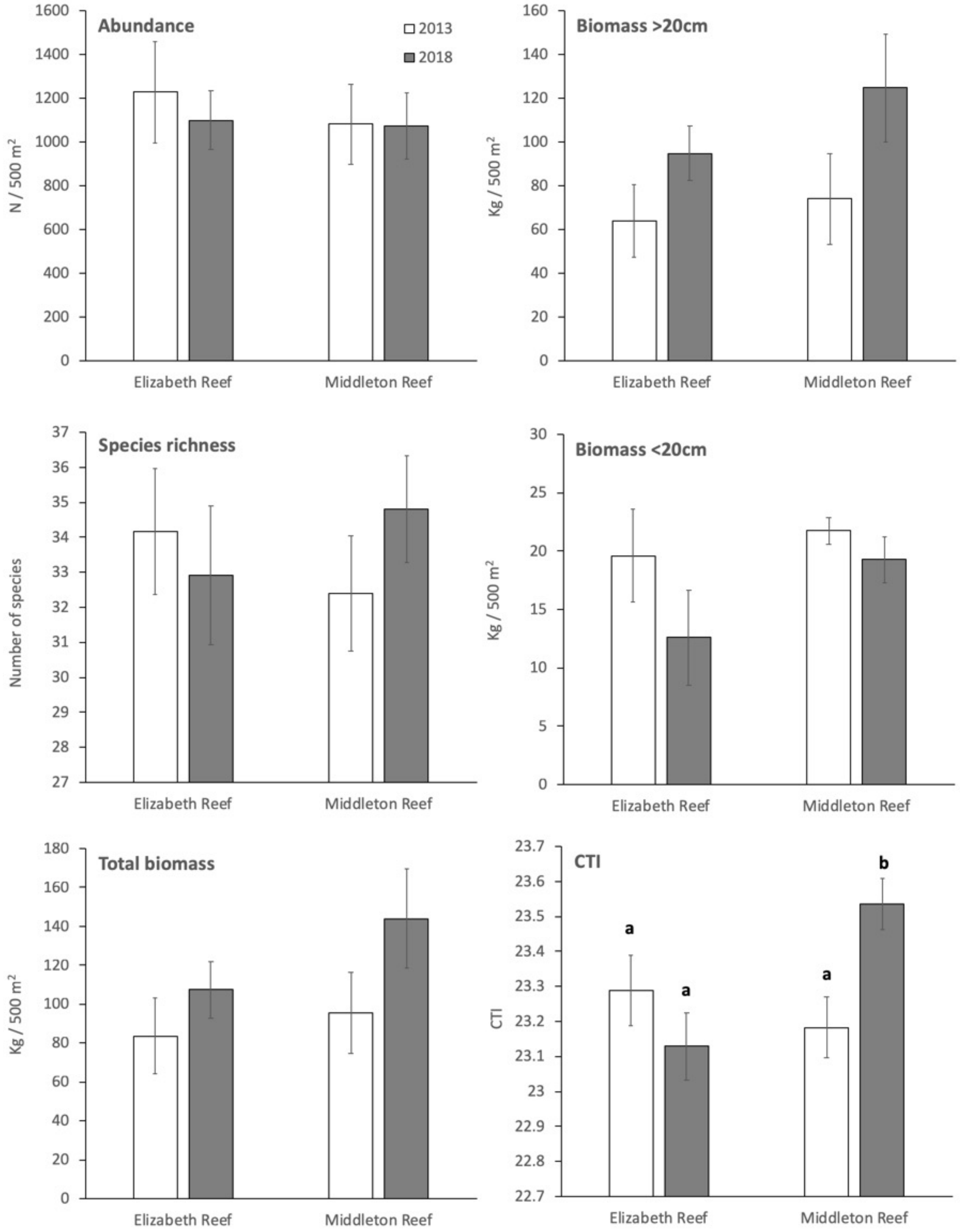

Figure 6. Reef fishes surveyed with Method 1. Abundance, species richness, total biomass, biomass of large (>=20cm), biomass of small (<20cm) reef fishes at in the EMR in 2013 and 2018 (per 500m^2) and Community Temperature Index (CTI). Error Bars = 1 SE. Where differences were statistically significant, this is indicated with lower-case letters above the bars. Bars with the same letters are statistically similar; bars with different letters are statistically different.

Table 1. Linear model results on key metrics of the fish community in the EMR. Data were log (x+1) – transformed. Significant results are highlighted in bold.

Metric	Factor	F	df	p
Abundance	Location	0.07	1,40	0.79
	Year	0.54	1,106	0.46
	Location x Year	0.29	1,106	0.59
Biomass	Location	1.11	1,40	0.30
	Year	0.80	1,106	0.37
	Location x Year	0.36	1,106	0.55
Biomass >20	Location	0.48	1,40	0.49
	Year	1.08	1,106	0.30
	Location x Year	0.90	1,106	0.34
Biomass <20	Location	0.01	1,40	0.92
	Year	0.79	1,106	0.38
	Location x Year	0.72	1,106	0.39
Species richness	Location	0.31	1,40	0.58
	Year	0.39	1,106	0.54
	Location x Year	2.00	1,106	0.16
CTI	Location	0.5	1,40	0.49
	Year	**8.3**	**1,106**	**<0.01**
	Location x Year	**33.3**	**1,106**	**<0.001**

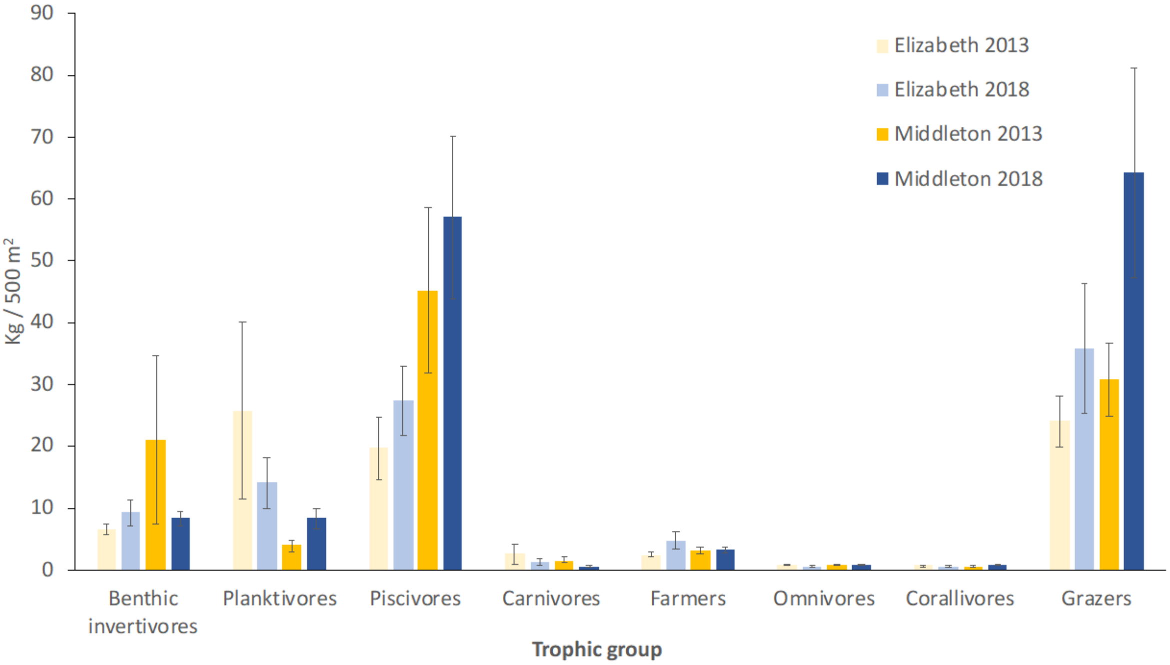

Figure 7. Biomass in kg / 500m^2 of key functional groups of reef fishes in the EMR in 2013 and 2018. Error Bars = 1 SE.

Table 2. Linear model results on fish functional groups in the EMR. Data were log (x+1) – transformed.

Functional group	Factor	F	df	p
Benthic invertivores	Location	0.35	1,40	0.56
	Year	0.06	1,106	0.81
	Location x Year	0.52	1,106	0.47
Planktivores	Location	0.51	1,40	0.48
	Year	0.71	1,106	0.19
	Location x Year	0.20	1,106	0.66
Piscivores	Location	0.73	1,40	0.40
	Year	0.09	1,106	0.76
	Location x Year	0.14	1,106	0.71
Carnivores	Location	0.04	1,40	0.84
	Year	2.26	1,106	0.14
	Location x Year	0.60	1,106	0.44
Farmers	Location	0.08	1,40	0.78
	Year	1.03	1,106	0.31
	Location x Year	**4.71**	**1,106**	**0.03**
Omnivores	Location	0.24	1,40	0.63
	Year	1.53	1,106	0.22
	Location x Year	0.42	1,106	0.52
Corallivores	Location	0.003	1,40	0.96
	Year	0.02	1,106	0.90
	Location x Year	1.63	1,106	0.20
Grazers	Location	1.09	1,40	0.30
	Year	1.60	1,106	0.21
	Location x Year	0.05	1,106	0.82

MOBILE MACROINVERTEBRATE SURVEYS

Across all transects, 74 species of macroinvertebrates were identified in the EMR (Appendix 3). The macroinvertebrate community was dominated by sea urchins, especially *Echinostrephus* spp., *Echinometra mathaei* and *Diadema savignyi*. The combined abundance of these three species exceeded that of all other invertebrate species by an order of magnitude. Among the three species, *Echinostrephus* spp. was also ten times more abundant than the next species, *E. mathaei*. Apart from the sea hare *Stylocheilus longicauda*, the ten most abundant species were all echinoderms. Noteworthy changes occurred in the frequency and abundance of *Actinopyga palauensis* (increase at Middleton Reef and decline at Elizabeth Reef), *Diadema savignyi*, *E. mathaei, Holothuria atra* and *H. edulis* (declined 4x at Elizabeth, increased by 3x at Middleton), *Ophidiaster confertus* (more than doubled at both reefs) and *Tridacna crocea* (almost disappeared from both reefs).

The two reefs were dominated by different species, but species composition remained consistent between years (Figure **8**). The abundance of commercially important invertebrates, such as the holothurian *Holothuria whitmaei*, remained stable between 2013 and 2018. Middleton Reef had a greater dominance of *E. mathaei*, *D. savignyi* and *H. atra*, whilst Elizabeth Reef had greater numbers of sea stars such as *Ophidiaster confertus*. At a more localised scale, sites were either dominated by *H. edulis*, or by a group of other echinoderms (Figure 8).

Macroinvertebrates were significantly more abundant and species rich at Middleton Reef than Elizabeth Reef, and remained stable between 2013 and 2018 (Figure 9, Table 4). This pattern was driven by echinoderms, which dominated the benthic community both in abundance and species richness, especially at Middleton Reef (Figure 10, Table 4). Echinoderms were more abundant and species rich at Middleton Reef, and there was a non-significant trend of declining species richness at both reefs from 2013 to 2018. Molluscs, on the other hand, increased in species richness at both reefs (Figure 10, Table 3).The EMR surveys identified 57 species of cryptic fishes along the transects when searching the reef substrate closely using Method 2 (Appendix 4). Gobies and blennies were the most abundant families, with three species represented by over 1,000 individuals during the surveys: *Ecsenius fourmanoiri*, *Eviota hoesei* and *Stanulus talboti*. Among the ten most abundant species were also two cardinalfishes: *Apogon norfolcensis* and *Apogon doederleini*. The former has a restricted range and is known only from Lord Howe Island, Norfolk Island, New Caledonia and the EMR, while the latter is a more widely distributed subtropical and tropical species. The abundance and species richness of cryptic fishes was similar between the two reefs, but increased significantly between 2013 and 2018 (Figure 11, Table 4). Some species experienced dramatic changes in abundance, including *Apogon norfolcensis* (increased by a factor of 1.5 at Elizabeth Reef and declined by half at Middleton Reef), *Atrosalarias holomelas* (increased at Middleton Reef), *Ecsenius fourmanoiri* (declined by 80% at Elizabeth Reef and 20% at Middleton Reef), *Helcogramma chica* (fell by a factor of ~4 at Elizabeth Reef and ~5 at Middleton Reef), and *Stanulus talboti* (declined by a factor of 4 at Elizabeth Reef and increased by a factor of 3 at Middleton Reef). These trends are those detected with the M2 method (Appendix 4). Although different trends were apparent for some of these species when they were recorded with the M1, their abundance is more reliably estimated using the close in searching of the reef surface done for M2 (Appendix 2).

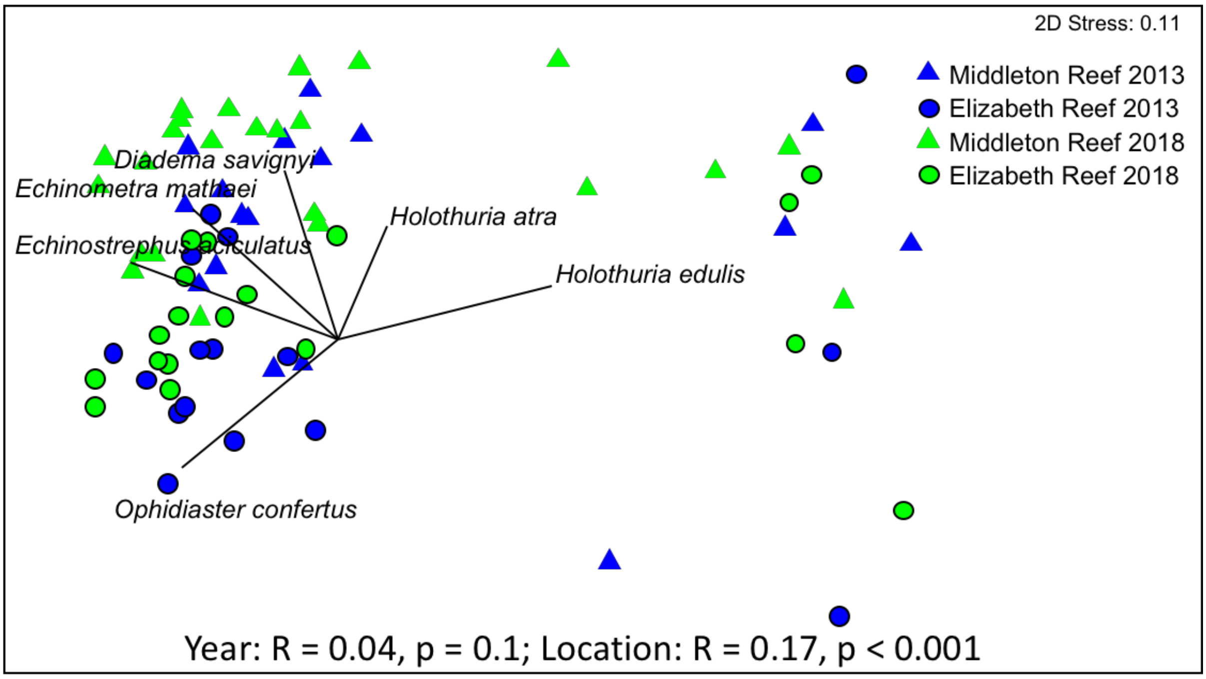

Figure 8. Multidimensional Scaling (MDS) plot of macroinvertebrate abundance in the EMR in 2013 and 2018, performed on the Bray-Curtis similarity matrix of the log(x+1) transformed data. Species vectors are shown if they had a correlation value of at least 0.4. ANOSIM (Year x Location) results are presented below the plot.

Table 3. Linear model results on key metrics and taxonomic groups of the invertebrate community, and abundance and species richness of cryptic fishes in the EMR. Data were log (x+1) – transformed.

Metric	Taxa	Factor	F	df	p
Abundance	**Total**	**Location**	**10.06**	**1,40**	**0.003**
		Year	0.90	1,106	0.34
		Location x Year	0.57	1,106	0.45
	Crustaceans	Location	1.47	1,40	0.23
		Year	0.06	1,106	0.80
		Location x Year	3.91	1,106	0.05
	Echinoderms	**Location**	**10.16**	**1,40**	**0.003**
		Year	1.16	1,106	0.28
		Location x Year	0.69	1,106	0.41
	Molluscs	Location	0.04	1,40	0.84
		Year	2.60	1,106	0.11
		Location x Year	0.82	1,106	0.37
	Cryptic fishes	Location	1.35	1,40	0.25
		Year	**98.15**	**1,106**	**<0.001**
		Location x Year	0.63	1,106	0.43
Species richness	**Total**	**Location**	**5.18**	**1,40**	**0.03**
		Year	0.19	1,106	0.66
		Location x Year	1.16	1,106	0.28
	Crustaceans	Location	1.49	1,40	0.23
		Year	0.00	1,106	0.98
		Location x Year	1.53	1,106	0.22
	Echinoderms	**Location**	**5.84**	**1,40**	**0.02**
		Year	3.76	1,106	0.06
		Location x Year	1.06	1,106	0.30
	Molluscs	Location	0.45	1,40	0.51
		Year	**7.35**	**1,106**	**0.008**
		Location x Year	0.03	1,106	0.87
	Cryptic fishes	Location	2.04	1,40	0.16
		Year	**46.33**	**1,106**	**<0.001**
		Location x Year	1.06	1,106	0.31

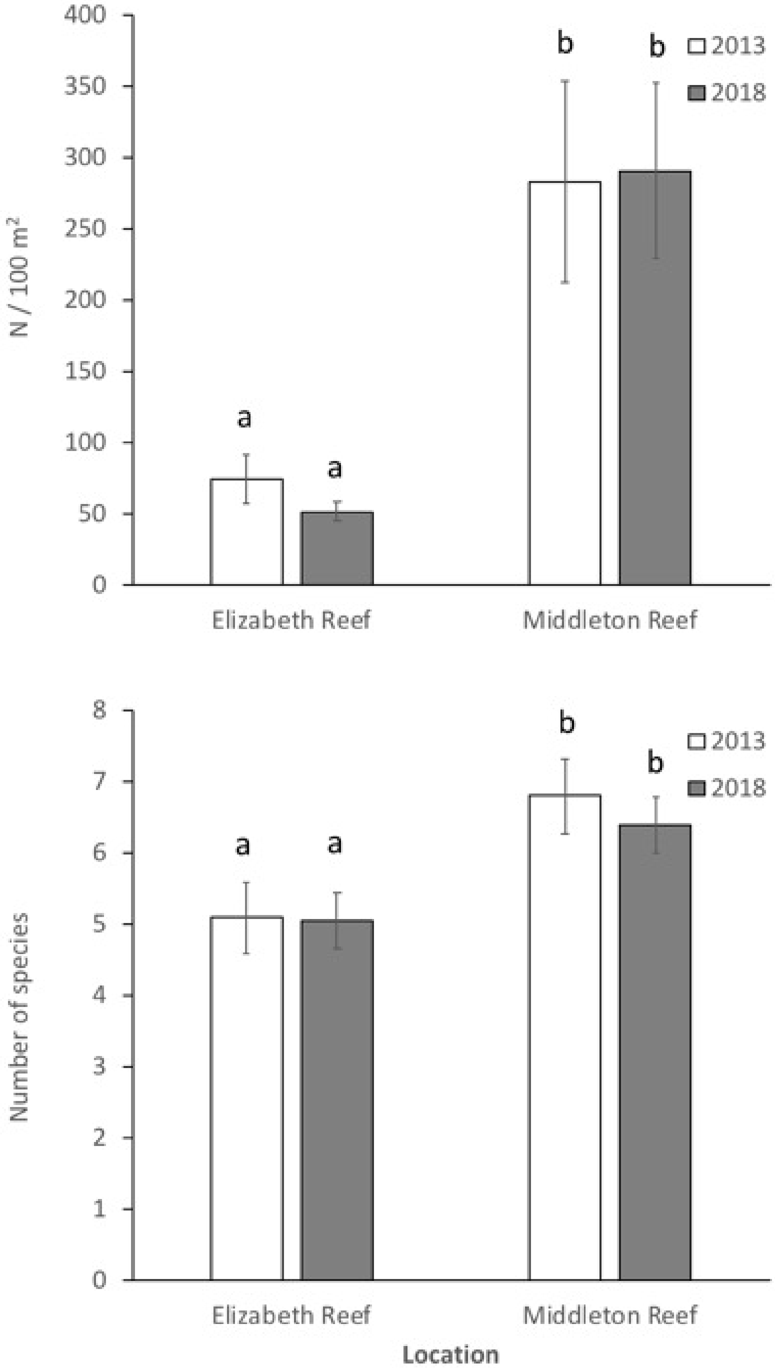

Figure 9. Abundance and species richness of macroinvertebrates in the EMR in 2013 and 2018 (per 100m²). Error Bars = 1 SE. Where differences were statistically significant, this is indicated with lower-case letters above the bars. Bars with the same letters are statistically similar; bars with different letters are statistically different.

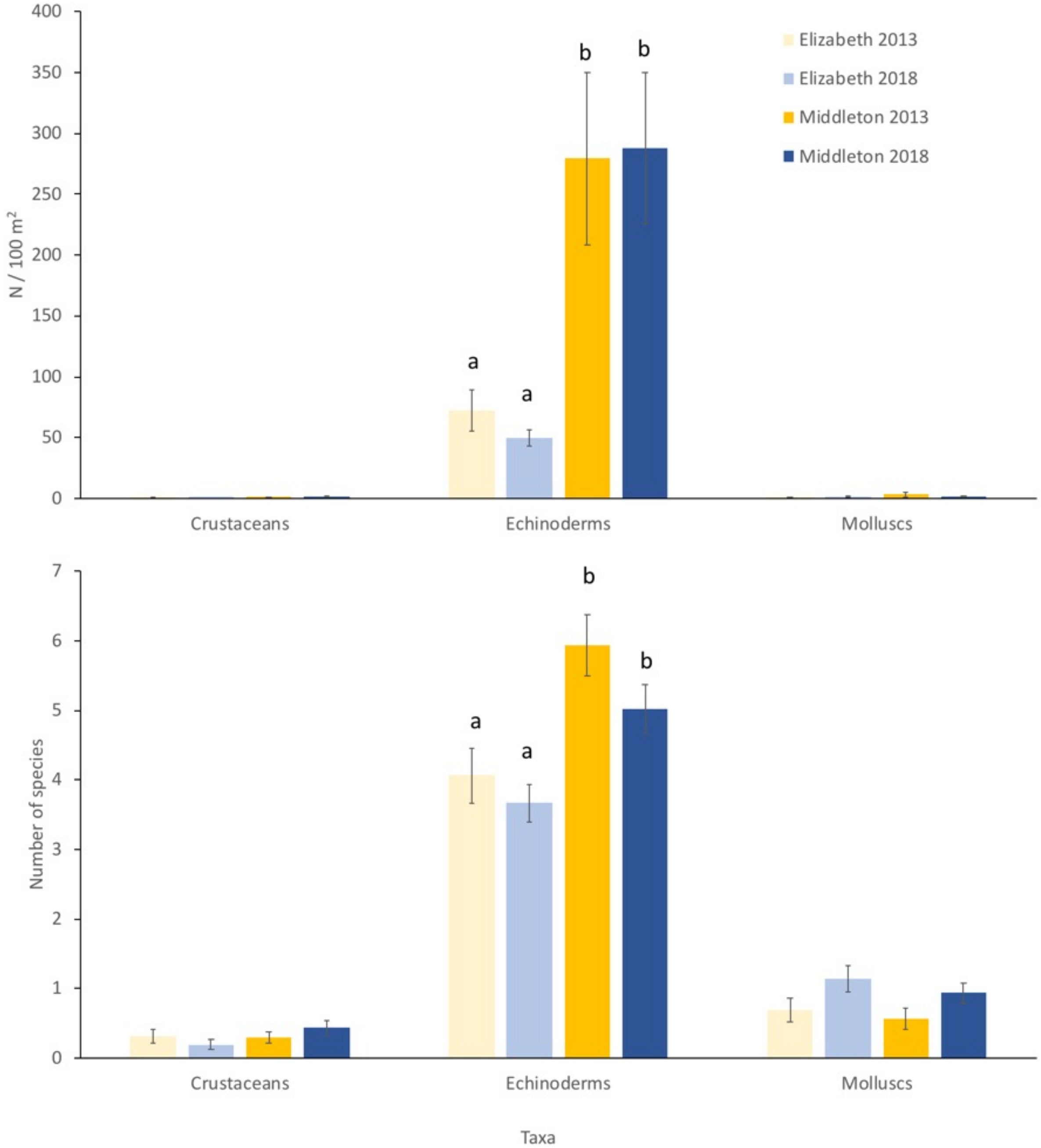

Figure 10. Abundance and species richness (per 100m^2) of key macroinvertebrates taxa in the EMR in 2013 and 2018. Error Bars = 1 SE. Where differences were statistically significant, this is indicated with lower-case letters above the bars. Bars with the same letters are statistically similar; bars with different letters are statistically different.

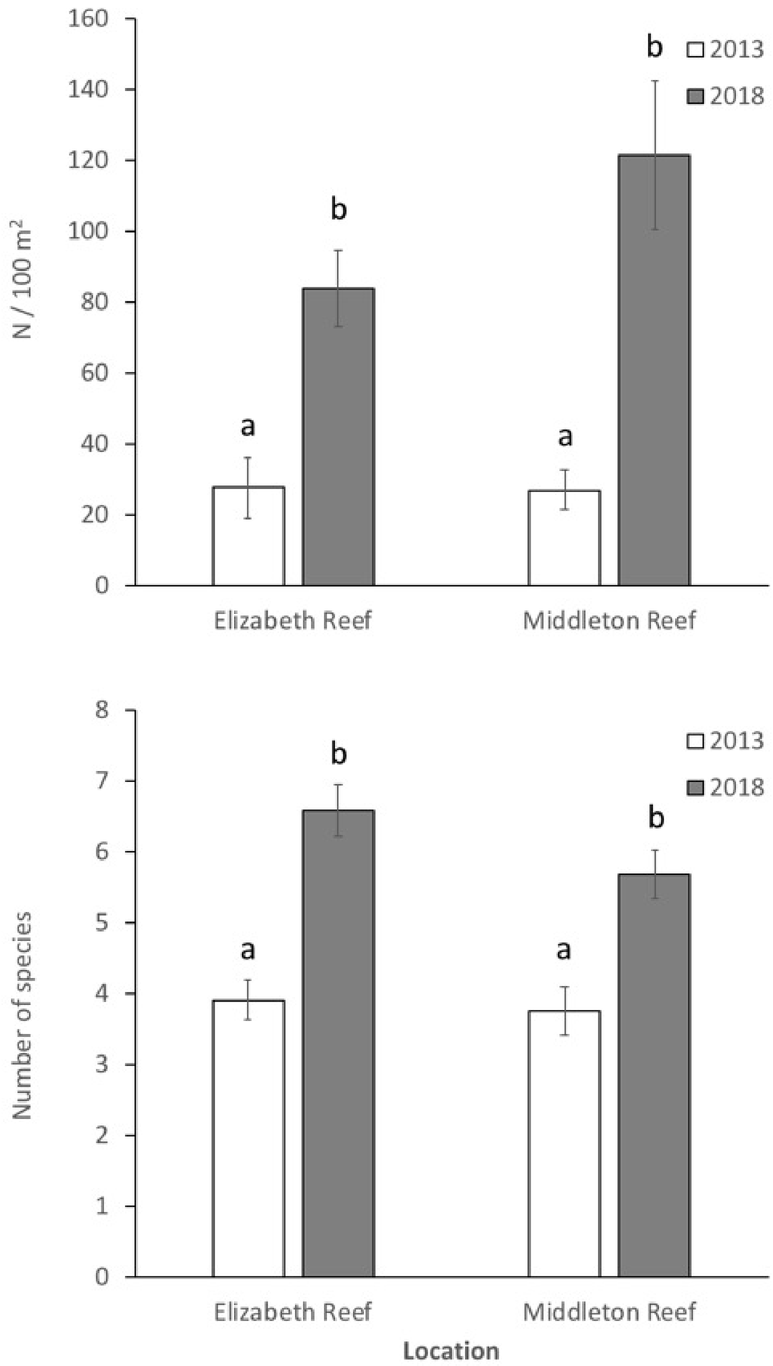

Figure 11. Abundance and species richness of cryptic fishes in the EMR in 2013 and 2018 (per 100m^2). Error Bars = 1 SE. Where differences were statistically significant, this is indicated with lower-case letters above the bars. Bars with the same letters are statistically similar; bars with different letters are statistically different.

BENTHIC COMMUNITY

Benthic community composition was scored from images taken on a total of 136 transects; 66 in 2013 and 69 in 2018. Across all transects, the highest average cover was for low-lying algal turf. The two reefs did not differ significantly in their benthic composition, and the benthos did not change significantly between years (Figure 12). Sites tended to be dominated either by branching *Acropora* corals with abiotic components and red algae, or by a variety of coral morphologies with turf and crustose coralline algae.

The total cover of live sessile biota ranged from 85 to 95%, and was not significantly different between the two reefs (although slightly lower at Middleton Reef); a small but statistically significant decline was recorded at Elizabeth Reef (Figure 13a). General benthic diversity, measured as the number of benthic categories, was significantly lower at Middleton Reef. Benthic category diversity increased between 2013 and 2018 at Elizabeth Reef and dropped at Middleton Reef (Figure 13b, Table 4), but the change between years was only significant at Middleton Reef. The dominant benthic category, algal turf, was significantly higher at Middleton Reef and declined significantly between 2013 and 2018 at both reefs (Figure 13c, Table 4). In contrast, live hard coral was higher at Elizabeth Reef, but increased significantly at Middleton Reef between 2013 and 2018 (Figure 13d, Table 4). Patterns in the cover of macroalgae and crustose coralline algae were highly variable and not significant; both remained stable between survey periods at Elizabeth Reef but increased at Middleton Reef (Figure 13e, f).

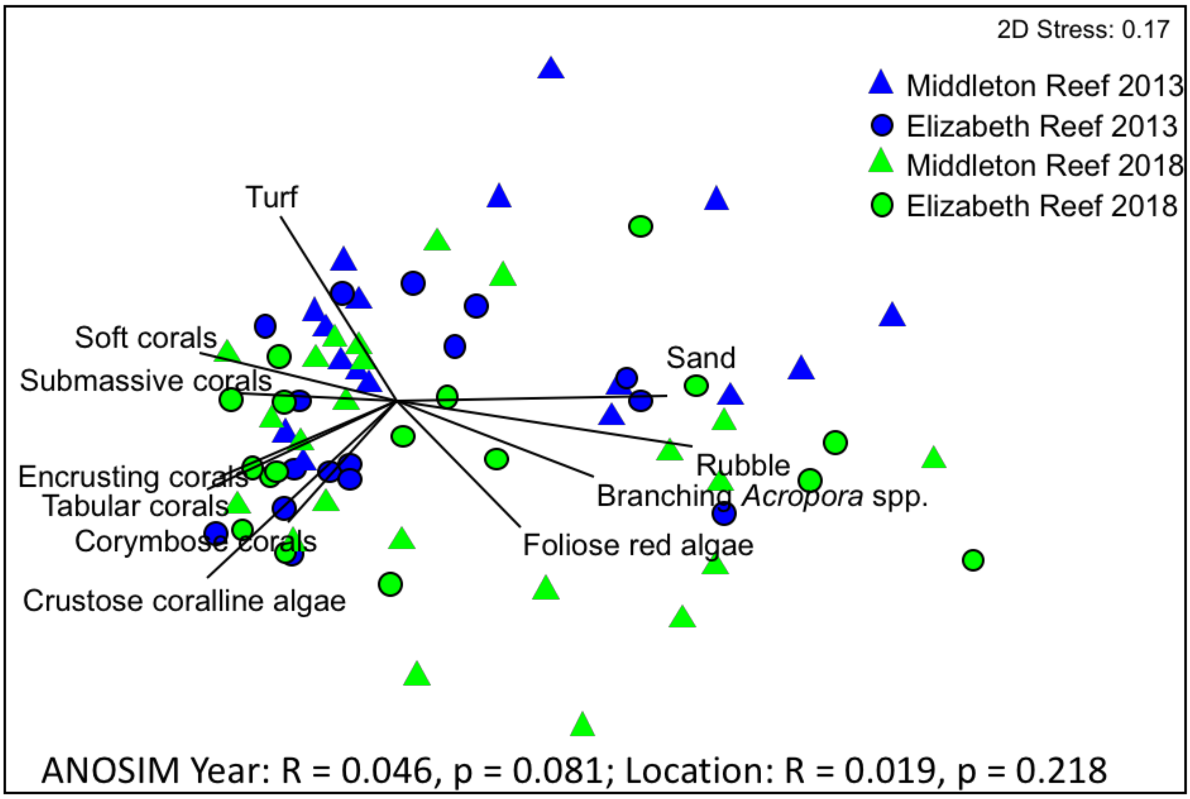

Figure 12. Multidimensional Scaling (MDS) plot of benthic percent cover in the EMR in 2013 and 2018, performed on the Bray-Curtis similarity matrix of the log(x+1) transformed data. Benthic category vectors are shown if they had a correlation value of at least 0.5.

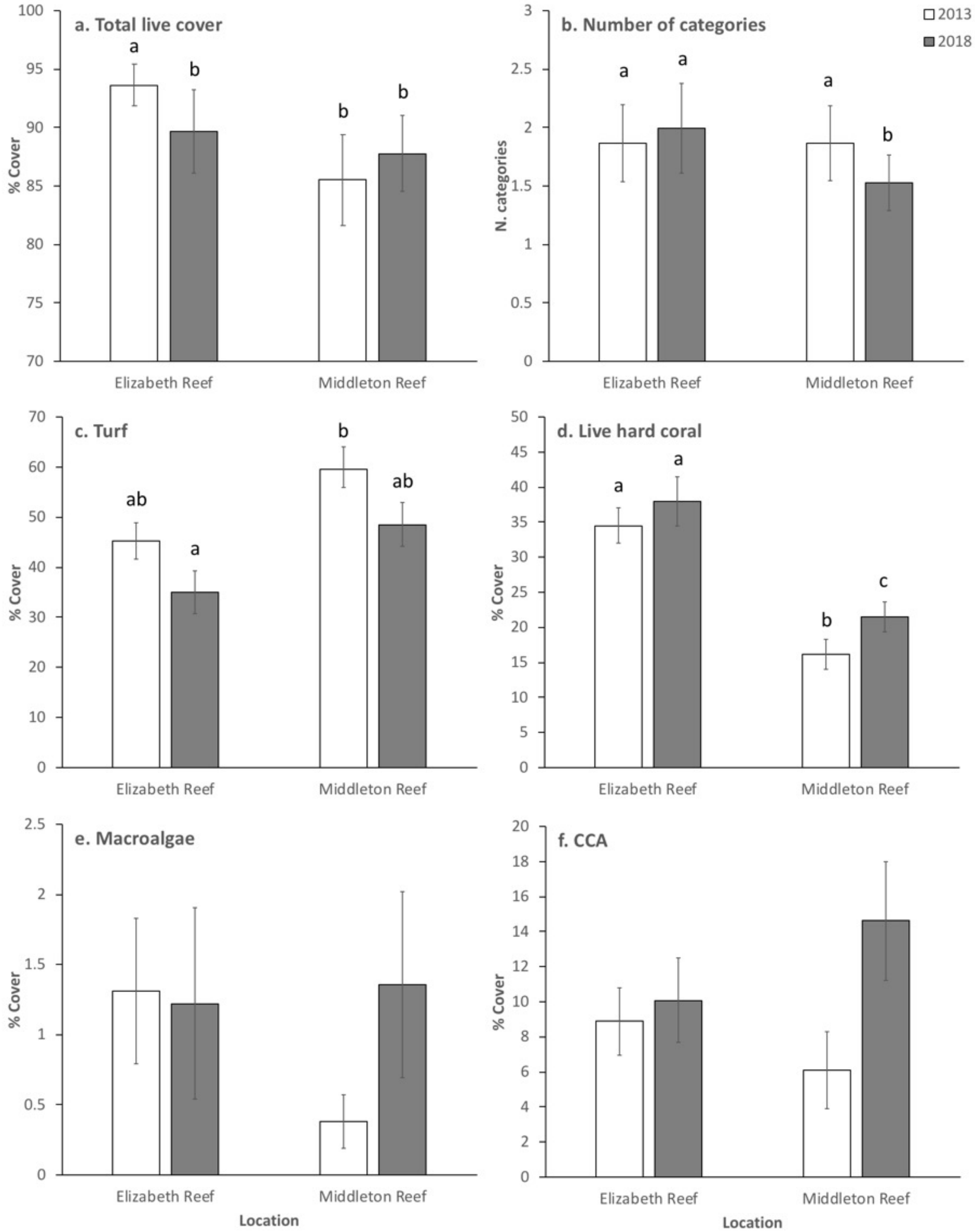

Figure 13. Percentage cover of a) total cover of live biota, b) number of benthic categories, c) turf, d) live hard coral, e) macroalgae and f) crustose coralline algae recorded on transects inside the EMR in 2013 and 2018. Y-axes represent mean values (+SE) per transect (100 random points). Where differences were statistically significant, this is indicated with lower-case letters above the bars. Bars with the same letters are statistically similar; bars with different letters are statistically different.

Table 4. Linear model results on key categories of the benthic community in the EMR. Data were log (x+1) – transformed.

Benthic category	Factor	F	df	p
Total live cover	Location	0.47	1,40	0.50
	Year	**4.24**	**1,91**	**0.04**
	Location x Year	0.03	1,91	0.87
Number of benthic categories	**Location**	**16.31**	**1,40**	**<0.001**
	Year	0.47	1,91	0.50
	Location x Year	**6.77**	**1,91**	**0.01**
Turf	Location	1.08	1,40	0.30
	Year	**8.04**	**1,91**	**0.006**
	Location x Year	0.07	1,91	0.80
Live hard coral	**Location**	**11.72**	**1,40**	**0.001**
	Year	**6.95**	**1,91**	**0.01**
	Location x Year	3.39	1,91	0.07
Macroalgae	Location	0.23	1,40	0.63
	Year	0.01	1,91	0.92
	Location x Year	1.24	1,91	0.27
Crustose coralline algae	Location	0.20	1,40	0.66
	Year	2.71	1,91	0.10
	Location x Year	1.52	1,91	0.22

THREATENED AND PROTECTED SPECIES

The biomass of the Galapagos shark, *Carcharhinus galapagensis*, was significantly higher at Middleton Reef compared to Elizabeth Reef. Despite an increasing trend between survey years at both reefs, the differences between years were not statistically significant (Figure 14a).

The biomass of the black cod *Epinephelus daemelii* was substantially lower than that of *C. galapagensis*, probably owing to its lower abundance (overall mean of 0.41 vs. 2.04 individuals per 500m^2, respectively). The biomass of black cod significantly declined between 2013 and 2018 at Elizabeth Reef, and an apparent increase at Middleton Reef was not statistically significant (Figure 14b). Across both reefs, the black cod were recorded on 35% of transects in 2013, but only on 18% of transects in 2018. The decline in frequency was slightly more pronounced at Elizabeth Reef, where sightings fell from 47% of transects to 19% between 2013 and 2018, but also occurred at Middleton Reef, where sightings fell from 24% of transects to 17% of transects.

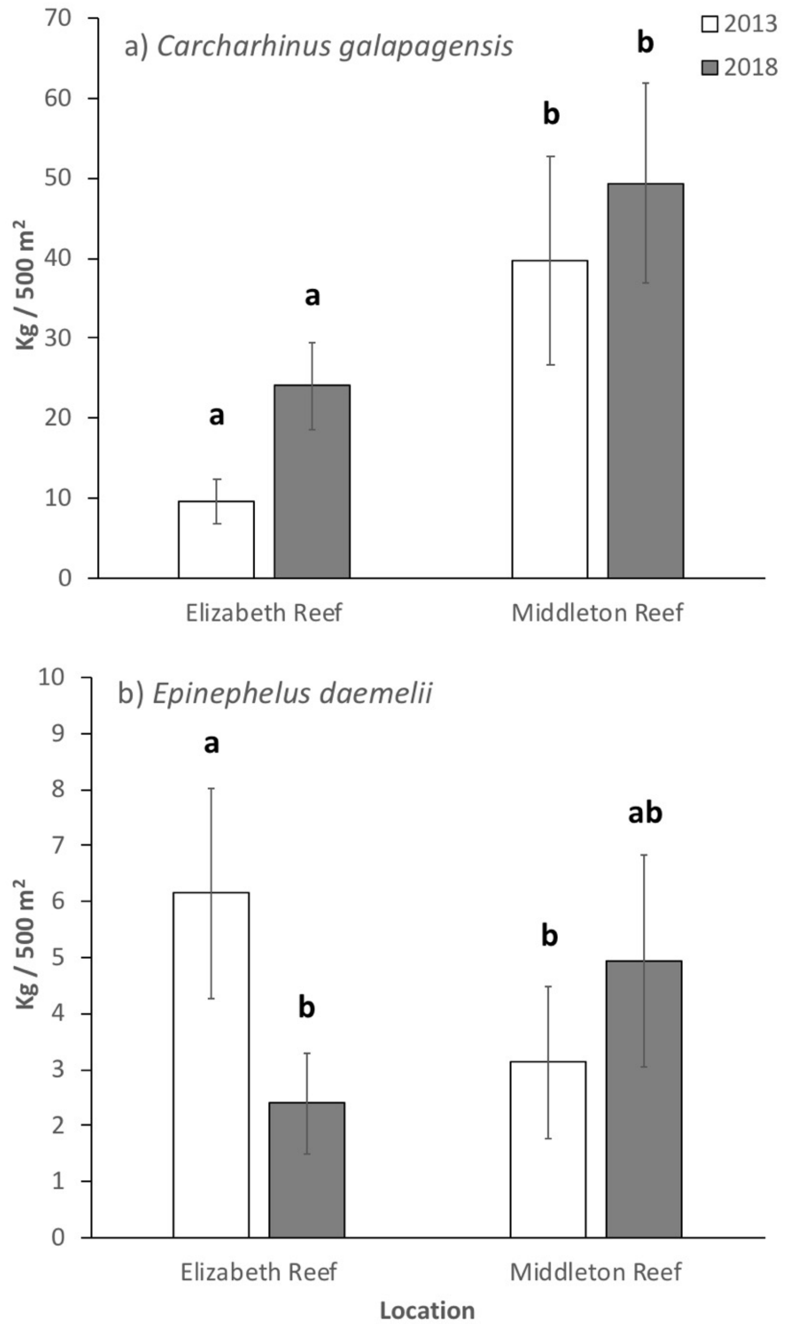

Figure 14. Biomass of a) *Carcharhinus galapagensis* (Location effect: $F_{1,40} = 4.37$, $p = 0.04$) and b) *Epinephelus daemelii* (Location x Year: Location $F_{1,106} = 5.76$, $p = 0.02$) across the EMR in 2013 and 2018 (per 500m^2). Error Bars = 1 SE. Where differences were statistically significant, this is indicated with lower-case letters above the bars. Bars with the same letters are statistically similar; bars with different letters are statistically different.

4 Discussion

The EMR has developed on the latitudinal boundary of coral reef formation, between tropical, subtropical and temperate influences (Choat et al. 2006). The East Australian Current and its eddies bring warmer water and tropical larvae into the region (Choat et al. 2006; Stuart-Smith et al. 2015). This is reflected in the fish, macroinvertebrate and benthic assemblages recorded during the two Reef Life Survey surveys, conducted five years apart. Elizabeth and Middleton Reefs retained broadly similar ecological communities, with some noteworthy changes to individual taxa and groups, and slightly richer assemblages and a higher biomass of predators at the more highly protected Middleton Reef.

In the last decade, surveys of the EMR have occurred approximately every 2-3 years, primarily by Reef Life Survey divers or by James Cook University (e.g. Pratchett et al. 2011; Hoey et al. 2014; Edgar et al. 2016). These surveys have found these reefs host a range of tropical species commonly found on the Great Barrier Reef (GBR) and a smaller number of subtropical and temperate species. Despite the abundance of some tropical reef fishes, some key factors distinguish the EMR from lower latitude reefs: the lower incidence of high-intensity pulse disturbances typical in the tropics (e.g. cyclones and bleaching events); the high abundance of scraping and excavating fishes, whose effects on coral are both beneficial (by removing algal biomass) and possibly sometimes detrimental (by removing live coral and coral recruits); and an historically low cover of live hard corals (Choat et al. 2006).

Functionally important fishes recorded in high densities included the regional endemic doubleheader wrasse *Coris bulbifrons* (Randall and Kuiter 1982), black cod *Epinephelus daemelii* and Galapagos sharks *Carcharhinus galapagensis*, which remained relatively stable between 2013 and 2018. In contrast, herbivorous fishes, including excavating and scraping parrotfishes and large browsing fishes (Hoey et al. 2014), showed signs of increasing biomass and frequency between 2013 and 2018, albeit not statistically significant. An increase in herbivorous fishes was also documented on the southern GBR over the same period (Stuart-Smith et al. 2018), and was hypothesised to be related to warmer seas across the broader region in recent years (especially the heatwave that caused the 2016 mass coral bleaching event along the GBR and Coral Sea). It is unclear whether warmer seas directly benefited the herbivores (e.g. though increased feeding rates, metabolism, reproductive success) or influenced food availability (e.g. through increased algal production; (Pratchett et al. 2008; Koch et al. 2012).

The stark increase in cryptic fish populations monitored using the RLS methods at EMR were also consistent with the changes observed in the southern GBR and Coral Sea over this period (Hughes et al. 2017; Hughes et al. 2018; Stuart-Smith et al. 2018). Regardless of the specific mechanisms responsible, the consistency in the observations of herbivorous fishes and populations of small cryptic fishes with patterns observed much further north along the GBR and Coral Sea suggest the same large-scale drivers, and point strongly at elevated temperature as most likely responsible. While cryptic fish densities are notoriously hard to estimate accurately, and this group is routinely omitted from other survey methodologies, the patterns reported here are extremely unlikely to be related to differences in observers or stochastic noise associated with inaccurate surveys. There was an element of consistency in divers (considerable data were collected in both years by GE), and consistency with broad regional patterns from the GBR both add support to the reliability of the trends observed in cryptic fishes. The increased numbers of cryptic fishes recorded could also be a function of altered hiding behaviour due to temperature changes, making them more visible to observers. Assuming elevated temperature to be the primary driver of these patterns, elevated herbivory by fishes and small cryptic fish richness and densities appear to be signs of what a warmer future at EMR may look like.

The dominance of the macroinvertebrate community by echinoderms, especially sea urchins such as *Echinostrephus* spp., *Echinometra mathaei* and *Diadema savignyi*, is typical of sub-tropical Australian reefs (Edgar et al. 2016). In fact, sea urchin herbivory is a key factor in maintaining space for coral growth on sub-tropical and temperate reefs (Ling et al. 2018). Fluctuations in the abundance of a number of species could be linked to natural population dynamics, which can be pronounced on isolated reefs (Ayre and Hughes 2004), no-take protection of Middleton Reef, as most of the increases in abundance occurred there, and more complex interactions such as competition and predation. The high densities (~133 individuals per hectare) of the commercially valuable holothurian *Holothuria whitmaei* recorded in 2003 (Oxley et al. 2004) were approached at Middleton Reef in 2018 (~104 individuals per hectare), but were much lower at Elizabeth Reef in both years (22 and 28 individuals per hectare in 2013 and 2018, respectively). However, extrapolating these densities from two very different survey methods is subject to error and any interpretations from such a comparison should be made with caution.

The cover of living benthos on both reefs remained high in 2018, but was still dominated by low-lying turf growing on rock or dead coral. This appears to be typical of highly exposed reef fronts, but also of reefs that have suffered past disturbances and coral mortality. Of few significant changes in benthic cover since the 2013 RLS surveys, turf cover has decreased at both reefs. It is quite possible that this is a direct result of increased herbivory from fishes. Coral cover was lower at both reefs than at comparable reefs of Lord Howe Island and the southern GBR (Hoey et al. 2014; Edgar et al. 2016). Habitat structure appears to have been generally stable between 2013 and 2018, which may have contributed to general stability in many elements of the fish and invertebrate communities (as indicated by few significant effects of year or location in the analyses above). Coral cover was slightly higher than that reported by other researchers in 2011 and 2014 at both reefs, which, although based on different methods at different individual sites, suggests that corals have either been recovering from earlier disturbances or at least remained stable over the 7-year period to 2018. Slow recovery is expected on isolated sub-tropical habitats such as the EMR, where connectivity to source reefs and growth rates of corals are naturally low (Harriott 1992; Gilmour et al. 2013).

Biogeographically, these reefs appear to have some connectivity to Lord Howe Island, but less than would be expected given their geographic proximity. In their regional analysis of *Acanthaster planci* genetics, Benzie and Stoddart (1992) found that, unlike Lord Howe Island, which appeared as an outlier, EMR formed a subgroup with the reefs of the GBR. Furthermore, larval recruitment from external sources, including long-range migrants from the GBR, rather than from Lord Howe Island, apparently serve to replenish Elizabeth and Middleton's coral populations (Noreen et al. 2009). Even in the case of large species such as Galapagos sharks and black cod, which could be expected to move between reefs, the Elizabeth and Middleton Reef populations were suggested to show signs of reduced connectivity with Lord Howe Island (Appleyard and Ward 2007; van Herwerden et al. 2009).

A more important reason for the difference between Lord Howe Island and EMR, however, is the position of the thermal gradient and the resulting shift from temperate to tropical fauna. Lord Howe Island is at the northern limit for many species with temperate affinities, and these species are mostly absent from Elizabeth and Middleton Reefs. For a few species for which EMR represents their northern limit, declines appear to have occurred during the warmer intervening years between surveys. Notably, *Seriola lalandi* dropped sharply in abundance and frequency of transects where sighted. This large, mobile species may have readily emigrated during heatwaves and has not found its way back yet in moderate numbers.

Human uses of these reefs include recreational fishing (at Elizabeth, but not Middleton Reef), scientific research activities and recreational boating, snorkeling and diving (Ceccarelli 2010). Surrounding areas support commercial demersal and pelagic longline fisheries (Commonwealth of Australia 2006); there is also potential for illegal fishing, which may be the reason for the decline in black cod numbers recorded in previous surveys (Choat et al. 2006; Hoey et al. 2018). During this most recent survey, black cod biomass at Middleton Reef was similar to biomass recorded in 2013. At Elizabeth Reef, black cod biomass significantly declined between surveys, perhaps because of mortality associated with recreational fishing. While black cod are fully protected, the extent of incidental mortality associated with catch and release is unknown. The key threats to the stability and condition of these reefs are likely to be increasing sea temperatures, physical damage from severe storms, outbreaks of crown-of-thorns starfish, illegal fishing, and range expansion of marine pests (Lawrence et al. 2007; Hoey et al. 2014).

Recovery from disturbance is likely to be prolonged by the isolation from potential source reefs (Ayre and Hughes 2004). A further concern for the EMR in the future will be climate change induced changes to the East Australian Current, potentially leading to significant changes in larval supply and physical environmental conditions (Lawrence et al. 2007). These reefs remain a stronghold for Galapagos sharks and black cod because their isolation potentially protects them from illegal fishing. However, illegal and unreported fishing is still an issue, and sharks are often killed because they take fishers' catch. Given the globally crucial role of the EMR in protecting these populations, enforcement of no-take regulations is critically important here.

5 Recommendations

- Maintain no-take status of Middleton Reef, consider increasing the level of protection at Elizabeth Reef to reduce potential impacts on black cod associated with recreational fishing, and increase active enforcement of fishing restrictions on both reefs (including enforcing the protected status of black cod when fishing is allowed for other species);

- Compile statistics on visitation rates of fishers, scientists and other users to the Elizabeth and Middleton Reefs. Consider the deployment of acoustic receiver loggers to monitor boat visitation rates;

- Undertake ongoing ecological monitoring at intervals of 1-3 years to continue to build up a temporal dataset to assess changes relative to data provided by this and previous surveys, with results reported using a comprehensive suite of sensitive ecological indicators;

- Undertake regular monitoring of physical characteristics (water quality, nutrients, turbidity, light and other physical parameters) that support ecological processes;

- Support involvement of Lord Howe Island Marine Park staff and rangers in the monitoring of the EMR, as they have the opportunity to coincide surveys with suitable weather conditions in which to undertake surveys;

- Examine levels of gene flow between the EMR and protected areas off the NSW coast, Norfolk Island, New Zealand and Lord Howe Island, to establish possible pathways of stock replenishment;

- Investigate seasonal changes in diversity, abundance and functional groups or productivity of fish and invertebrate communities, to further understand the dynamics of these highly dynamic systems and processes associated with recruitment and stock fluctuations;

- Investigate food webs, including addressing the question of whether large biomasses of sharks were also the norm elsewhere in previous decades, and how a large biomass of sharks influences the reef community.

6 Acknowledgements

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Appendices

APPENDIX 1 – LIST OF SITES AND SITE DETAILS SURVEYED ACROSS EMR NETWORK.

Site Code	Site Name	Latitude	Longitude	Depth / Transects
EMR1	Lagoon Inner Wreck Middleton Reef	-29.45103	159.06227	2
				3
				3.5
EMR2	Lagoon 2 Middleton Reef	-29.45683	159.0622	2
				2.5
EMR3	SW Lagoon Middleton Reef	-29.46451	159.06873	2
				2.5
				2.6
EMR4	Wreck 1	-29.44751	159.05391	9
				14
EMR5	Wreck 2	-29.44269	159.06088	5
				6.5
				11
EMR6	North West Horn	-29.44366	159.06796	5
				8
				12
EMR7	Back reef bommie Middleton Reef	-29.44	159.09315	5
				6
				6.1
EMR8	Back Reef 1	-29.44563	159.09369	4.5
				5
EMR9	Blue Holes W	-29.44278	159.11231	5
				6
				8
EMR10	Blue Holes N	-29.44246	159.11843	3
				4
EMR11	Blue Holes 3	-29.44803	159.11499	5
				7
				8
EMR12	NW outer reef1 Middleton Reef	-29.42234	159.11073	8
				9
				10
				13
EMR13	NW outer reef2 Middleton Reef	-29.42655	159.12611	9
				10
				13
EMR14	NW outer reef3 Middleton Reef	-29.43351	159.13542	8

Site Code	Site Name	Latitude	Longitude	Depth / Transects
				9
				10
				12
EMR15	NW inner bommie Middleton Reef	-29.4341	159.09479	7
				8
				10
EMR16	Wreck 3	-29.45407	159.04857	7
				9
				13
EMR17	Wreck outer reef4 Middleton Reef	-29.45221	159.04988	8
				9
				11
EMR18	North Cay Elizabeth Reef	-29.92554	159.0511	5
				6
				7
				8
EMR19	Lagoon blue hole Elizabeth Reef	-29.93329	159.0561	5
				6
EMR20	Cay Bommie Elizabeth Reef	-29.93192	159.06155	4
				5
				7
EMR21	Elizabeth SW	-29.95787	159.02814	9
				11
EMR22	Elizabeth SW2	-29.96119	159.03659	9
				11
EMR23	Wreck Flank	-29.92823	159.02745	5
				8
				10
				11
EMR24	North Point Elizabeth Reef	-29.911	159.0691	5
				6
				10
EMR25	Northern Tip	-29.91181	159.08131	8
				9
				11
				12
EMR26	Elizabeth Anchorage South	-29.92682	159.04417	6
				7
				10
EMR27	Elizabeth Anchorage East	-29.91731	159.06029	5
				8
EMR28	Elizabeth Hole	-29.9305	159.06213	4
				5
				6
				8

Site Code	Site Name	Latitude	Longitude	Depth / Transects
EMR29	NW anchorage Elizabeth Reef	-29.91656	159.05681	15
				16
EMR30	NE Wreck Elizabeth Reef	-29.92296	159.09285	8
				14
EMR31	NE Inlet Elizabeth Reef	-29.93369	159.09714	4
				5
				13
EMR32	East Elizabeth North	-29.95612	159.12732	7
				10
EMR33	South Elizabeth Reef	-29.95796	159.12759	7
				12
EMR34	Middleton 8 South West	-29.48476	159.076616	2
				10
EMR35	Middleton 6 South	-29.477283	159.1216	2
				10
EMR36	Middleton 9 South East	-29.45436	159.1422	2
				10
EMR37	Middleton South Outside	-29.48267	159.06495	9
				10
EMR38	Middleton 3 Lagoon	-29.453716	159.065667	1
				3
EMR39	Middleton 4	-29.4429	159.11502	2
				10
EMR40	Middleton 1	-29.4435	159.09767	2
				10
EMR41	Elizabeth 6D	-29.93465	159.09327	6
				6.1
EMR42	Lagoon Hole west	-29.94249	159.0847	4.2
				6

APPENDIX 2 – LIST OF SITES AND SITE DETAILS SURVEYED ACROSS TEMPERATE EAST NETWORK.

	% of transects				Mean abundance				Mean biomass			
	Elizabeth		Middleton		Elizabeth		Middleton		Elizabeth		Middleton	
Year	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018
N. transects	32	36	34	48	32	36	34	48	32	36	34	48
Abudefduf sexfasciatus	0.00	2.78	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Abudefduf vaigiensis	0.00	0.00	0.00	4.17	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.01
Acanthurus albipectoralis	6.25	5.56	2.94	10.42	0.81	0.42	0.18	1.15	0.21	0.15	0.01	0.53
Acanthurus blochii	0.00	2.78	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00
Acanthurus dussumieri	28.13	36.11	50.00	41.67	2.19	2.25	3.62	2.06	1.53	1.38	2.00	1.27
Acanthurus nigrofuscus	12.50	19.44	17.65	33.33	0.53	3.83	0.44	3.77	0.02	0.23	0.03	0.33
Acanthurus nigroris	0.00	0.00	2.94	6.25	0.00	0.00	1.35	0.13	0.00	0.00	0.10	0.01
Acanthurus olivaceus	0.00	5.56	5.88	8.33	0.00	0.06	0.12	0.58	0.00	0.00	0.04	0.01
Acanthurus pyroferus	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Acanthurus thompsoni	0.00	0.00	2.94	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.01	0.00
Amblyglyphidodon curacao	3.13	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Amblygobius phalaena	3.13	13.89	0.00	4.17	0.06	0.36	0.00	0.08	0.00	0.00	0.00	0.00
Amphiprion mccullochi	15.63	8.33	11.76	12.50	0.69	0.22	0.56	0.98	0.01	0.01	0.00	0.03
Anampses caeruleopunctatus	3.13	8.33	5.88	4.17	0.03	0.14	0.12	0.04	0.00	0.00	0.01	0.01
Anampses elegans	40.63	11.11	26.47	20.83	1.50	0.92	4.12	0.71	0.03	0.04	0.12	0.04
Anampses femininus	37.50	30.56	44.12	33.33	2.34	3.25	3.15	1.81	0.02	0.05	0.03	0.03
Anampses geographicus	3.13	5.56	5.88	4.17	0.03	0.08	0.06	0.08	0.00	0.00	0.00	0.00
Anampses neoguinaicus	53.13	52.78	26.47	29.17	3.47	3.33	1.44	1.08	0.04	0.08	0.02	0.02
Apogon capricornis	0.00	0.00	2.94	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.01	0.00
Apogon doederleini	3.13	25.00	8.82	6.25	0.03	1.92	147.50	0.54	0.00	0.52	0.05	0.00

	% of transects				Mean abundance				Mean biomass			
	Elizabeth		Middleton		Elizabeth		Middleton		Elizabeth		Middleton	
Year	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018
N. transects	32	36	34	48	32	36	34	48	32	36	34	48
Apogon flavus	0.00	2.78	0.00	0.00	0.00	3.53	0.00	0.00	0.00	0.04	0.00	0.00
Apogon norfolcensis	25.00	22.22	14.71	12.50	12.34	17.42	0.47	2.48	0.27	0.26	0.02	0.16
Aprion virescens	9.38	2.78	5.88	6.25	0.09	0.03	0.06	0.06	0.06	0.06	0.12	0.04
Asterropteryx semipunctata	3.13	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Atrosalarias holomelas	0.00	11.11	0.00	4.17	0.00	0.17	0.00	0.35	0.00	0.01	0.00	0.01
Aulostomus chinensis	25.00	11.11	8.82	22.92	0.34	0.22	0.21	0.42	0.08	0.03	0.04	0.07
Bodianus axillaris	9.38	2.78	5.88	2.08	0.13	0.06	0.15	0.02	0.01	0.00	0.01	0.00
Bodianus perditio	3.13	8.33	11.76	20.83	0.03	0.08	0.15	0.31	0.02	0.09	0.07	0.16
Bothus mancus	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01
Cantherhines dumerilii	9.38	2.78	0.00	6.25	0.09	0.03	0.00	0.06	0.05	0.01	0.00	0.02
Cantherhines pardalis	12.50	0.00	2.94	0.00	0.19	0.00	0.03	0.00	0.01	0.00	0.00	0.00
Canthigaster axiologus	6.25	2.78	5.88	4.17	0.16	0.03	0.06	0.13	0.00	0.00	0.00	0.00
Canthigaster callisterna	6.25	2.78	0.00	0.00	0.22	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Canthigaster janthinoptera	6.25	2.78	2.94	4.17	0.06	0.03	0.03	0.04	0.00	0.00	0.00	0.00
Canthigaster valentini	34.38	30.56	35.29	33.33	0.94	1.17	0.71	1.19	0.01	0.07	0.01	0.03
Carangoides chrysophrys	0.00	0.00	0.00	2.08	0.00	0.00	0.00	1.04	0.00	0.00	0.00	0.08
Carangoides orthogrammus	0.00	5.56	2.94	2.08	0.00	0.06	0.06	0.02	0.00	0.15	0.03	0.03
Caranx lugubris	0.00	2.78	8.82	4.17	0.00	0.06	0.12	0.46	0.00	0.06	0.14	0.80
Caranx melampygus	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.03
Caranx sexfasciatus	0.00	0.00	2.94	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.05	0.00
Carcharhinus galapagensis	46.88	52.78	58.82	50.00	0.91	1.56	2.47	2.88	9.52	24.06	39.67	49.39
Centropyge bispinosa	6.25	2.78	8.82	10.42	0.13	0.03	0.26	0.15	0.00	0.00	0.00	0.00
Centropyge flavissima	3.13	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropyge tibicen	43.75	33.33	26.47	33.33	2.31	1.36	2.09	1.25	0.05	0.04	0.04	0.05
Centropyge vrolikii	3.13	0.00	0.00	4.17	0.03	0.00	0.00	0.06	0.00	0.00	0.00	0.00
Cephalopholis argus	21.88	19.44	23.53	18.75	0.28	0.28	0.32	0.23	0.14	0.19	0.17	0.13
Cephalopholis miniata	0.00	2.78	5.88	2.08	0.00	0.03	0.15	0.02	0.00	0.02	0.08	0.01

	% of transects				Mean abundance				Mean biomass			
	Elizabeth		Middleton		Elizabeth		Middleton		Elizabeth		Middleton	
Year	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018
N. transects	32	36	34	48	32	36	34	48	32	36	34	48
Chaetodon auriga	46.88	33.33	55.88	35.42	1.38	1.00	1.97	1.23	0.13	0.11	0.21	0.13
Chaetodon baronessa	3.13	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chaetodon citrinellus	28.13	16.67	26.47	37.50	0.72	0.53	0.91	1.13	0.02	0.04	0.04	0.07
Chaetodon ephippium	0.00	0.00	2.94	10.42	0.00	0.00	0.12	0.25	0.00	0.00	0.01	0.05
Chaetodon flavirostris	40.63	25.00	44.12	43.75	0.97	0.89	1.09	2.08	0.18	0.14	0.20	0.19
Chaetodon guentheri	3.13	8.33	2.94	2.08	0.06	0.28	0.03	0.02	0.00	0.01	0.00	0.00
Chaetodon kleinii	9.38	8.33	2.94	4.17	0.13	0.11	0.06	0.13	0.00	0.01	0.00	0.00
Chaetodon lineolatus	12.50	2.78	2.94	18.75	0.22	0.03	0.24	0.71	0.03	0.00	0.06	0.06
Chaetodon lunula	3.13	0.00	0.00	2.08	0.06	0.00	0.00	0.04	0.01	0.00	0.00	0.02
Chaetodon lunulatus	18.75	27.78	17.65	29.17	1.78	0.97	1.09	1.23	0.09	0.05	0.06	0.09
Chaetodon melannotus	15.63	13.89	5.88	16.67	0.22	0.14	0.09	0.23	0.01	0.01	0.01	0.02
Chaetodon mertensii	37.50	36.11	52.94	43.75	1.09	1.00	1.79	1.15	0.07	0.05	0.14	0.07
Chaetodon ornatissimus	3.13	0.00	0.00	2.08	0.09	0.00	0.00	0.04	0.01	0.00	0.00	0.01
Chaetodon pelewensis	50.00	33.33	26.47	35.42	1.41	0.81	0.88	1.71	0.06	0.04	0.05	0.10
Chaetodon plebeius	40.63	27.78	41.18	31.25	1.19	0.58	1.12	0.81	0.05	0.03	0.05	0.04
Chaetodon speculum	3.13	2.78	2.94	2.08	0.03	0.06	0.06	0.02	0.00	0.01	0.00	0.00
Chaetodon tricinctus	65.63	52.78	50.00	39.58	2.88	2.47	1.88	1.77	0.31	0.30	0.29	0.22
Chaetodon trifascialis	43.75	44.44	17.65	35.42	1.63	1.19	0.71	1.35	0.09	0.09	0.04	0.11
Chaetodon ulietensis	6.25	5.56	8.82	6.25	0.09	0.11	0.15	0.13	0.01	0.01	0.02	0.01
Chaetodon unimaculatus	3.13	11.11	5.88	6.25	0.03	0.22	0.12	0.10	0.00	0.02	0.01	0.01
Chaetodon vagabundus	0.00	2.78	5.88	12.50	0.00	0.06	0.09	0.21	0.00	0.01	0.01	0.01
Chaetodontoplus conspicillatus	12.50	19.44	11.76	4.17	0.16	0.25	0.18	0.08	0.03	0.06	0.06	0.02
Cheilinus chlorourus	3.13	2.78	0.00	2.08	0.03	0.03	0.00	0.02	0.01	0.00	0.00	0.00
Cheilinus fasciatus	9.38	0.00	0.00	6.25	0.09	0.00	0.00	0.10	0.02	0.00	0.00	0.04
Cheilinus trilobatus	6.25	16.67	2.94	10.42	0.06	0.19	0.03	0.13	0.01	0.10	0.01	0.05
Cheilodactylus ephippium	6.25	5.56	5.88	4.17	0.13	0.58	0.12	0.08	0.07	0.34	0.07	0.04
Cheilodactylus francisi	28.13	25.00	47.06	41.67	0.72	1.14	1.62	1.04	0.25	0.50	0.57	0.39

	% of transects				Mean abundance				Mean biomass			
	Elizabeth		Middleton		Elizabeth		Middleton		Elizabeth		Middleton	
Year	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018
N. transects	32	36	34	48	32	36	34	48	32	36	34	48
Cheilodipterus macrodon	9.38	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Cheilodipterus quinquelineatus	6.25	8.33	0.00	4.17	0.09	0.31	0.00	0.13	0.00	0.00	0.00	0.00
Chironemus marmoratus	0.00	2.78	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00
Chlorurus microrhinos	40.63	8.33	17.65	20.83	1.31	0.33	1.38	0.94	1.41	0.48	1.16	1.12
Chlorurus sordidus	68.75	80.56	58.82	79.17	25.66	24.83	42.94	49.65	1.43	2.93	2.41	6.15
Chromis agilis	6.25	0.00	2.94	4.17	0.06	0.00	0.03	0.21	0.00	0.00	0.00	0.00
Chromis atripectoralis	6.25	2.78	11.76	2.08	0.06	2.36	2.88	0.04	0.00	0.00	0.01	0.00
Chromis atripes	0.00	0.00	2.94	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00
Chromis chrysura	0.00	0.00	14.71	8.33	0.00	0.00	2.15	0.52	0.00	0.00	0.02	0.01
Chromis cyanea	0.00	5.56	0.00	0.00	0.00	3.19	0.00	0.00	0.00	0.04	0.00	0.00
Chromis flavomaculata	31.25	30.56	35.29	39.58	53.81	16.11	24.03	116.90	0.45	0.36	0.27	0.83
Chromis hypsilepis	62.50	61.11	61.76	50.00	443.13	428.75	257.71	341.40	3.65	9.95	2.08	3.37
Chromis iomelas	0.00	5.56	0.00	4.17	0.00	0.17	0.00	0.04	0.00	0.00	0.00	0.00
Chromis margaritifer	12.50	19.44	17.65	18.75	0.25	1.28	0.50	30.48	0.00	0.01	0.00	0.08
Chromis vanderbilti	25.00	36.11	11.76	22.92	6.38	24.00	0.41	14.50	0.02	0.04	0.00	0.07
Chromis viridis	0.00	0.00	2.94	2.08	0.00	0.00	0.12	2.71	0.00	0.00	0.00	0.05
Chrysiptera notialis	75.00	77.78	76.47	62.50	170.72	120.50	168.18	38.35	0.81	0.83	0.60	0.19
Cirrhilabrus laboutei	3.13	0.00	8.82	8.33	0.41	0.00	0.21	0.33	0.01	0.00	0.00	0.00
Cirrhilabrus punctatus	15.63	13.89	11.76	6.25	0.78	1.58	2.82	0.17	0.01	0.00	0.01	0.01
Cirrhitichthys falco	15.63	2.78	17.65	14.58	0.22	0.03	0.24	0.31	0.00	0.00	0.00	0.00
Cirripectes alboapicalis	0.00	8.33	0.00	2.08	0.00	0.11	0.00	0.10	0.00	0.00	0.00	0.00
Cirripectes castaneus	3.13	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coris aygula	9.38	2.78	8.82	6.25	0.13	0.03	0.71	0.06	0.02	0.02	0.15	0.03
Coris bulbifrons	62.50	77.78	67.65	64.58	2.66	3.44	4.97	2.48	0.91	2.82	1.42	0.77
Coris dorsomacula	3.13	0.00	8.82	0.00	0.03	0.00	0.44	0.00	0.00	0.00	0.01	0.00
Coris gaimard	0.00	0.00	0.00	4.17	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Coris picta	9.38	5.56	17.65	2.08	0.41	0.22	2.41	0.02	0.00	0.00	0.01	0.00

	% of transects				Mean abundance				Mean biomass			
	Elizabeth		Middleton		Elizabeth		Middleton		Elizabeth		Middleton	
Year	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018
N. transects	32	36	34	48	32	36	34	48	32	36	34	48
Crossosalarias macrospilus	3.13	5.56	5.88	2.08	0.03	0.08	0.06	0.02	0.00	0.00	0.00	0.00
Ctenochaetus striatus	3.13	2.78	8.82	8.33	0.03	0.03	0.18	0.19	0.00	0.01	0.01	0.03
Cypho purpurascens	3.13	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dascyllus aruanus	18.75	22.22	26.47	20.83	22.50	51.53	7.65	10.23	0.16	0.17	0.06	0.15
Dascyllus reticulatus	15.63	16.67	2.94	22.92	0.69	0.50	0.09	2.38	0.01	0.01	0.00	0.02
Dascyllus trimaculatus	3.13	11.11	11.76	16.67	0.06	0.83	0.65	1.48	0.00	0.02	0.01	0.04
Diodon hystrix	3.13	0.00	2.94	4.17	0.03	0.00	0.03	0.04	0.06	0.00	0.04	0.07
Echeneis naucrates	6.25	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Echidna nebulosa	0.00	0.00	2.94	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
Ecsenius fourmanoiri	15.63	30.56	14.71	37.50	0.28	1.64	0.62	6.56	0.00	0.00	0.00	0.02
Enneapterygius rufopileus	6.25	2.78	5.88	2.08	0.13	0.14	0.15	0.13	0.00	0.00	0.00	0.00
Epibulus insidiator	6.25	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Epinephelus cyanopodus	3.13	5.56	0.00	2.08	0.03	0.11	0.00	0.02	0.05	0.06	0.00	0.03
Epinephelus daemelii	46.88	19.44	23.53	16.67	0.78	0.28	0.35	0.29	6.15	2.40	3.13	4.94
Epinephelus fasciatus	15.63	8.33	23.53	12.50	0.25	0.08	0.47	0.33	0.08	0.03	0.16	0.10
Epinephelus maculatus	3.13	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Epinephelus merra	0.00	0.00	2.94	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.01	0.00
Epinephelus polyphekadion	3.13	0.00	0.00	4.17	0.03	0.00	0.00	0.04	0.02	0.00	0.00	0.08
Eviota hoesei	12.50	13.89	38.24	10.42	1.38	0.83	5.26	0.67	0.00	0.00	0.00	0.00
Eviota readerae	0.00	8.33	0.00	2.08	0.00	0.28	0.00	0.04	0.00	0.00	0.00	0.00
Exallias brevis	3.13	13.89	0.00	0.00	0.03	0.14	0.00	0.00	0.00	0.00	0.00	0.00
Fistularia commersonii	6.25	2.78	5.88	8.33	0.06	0.06	0.12	0.10	0.02	0.00	0.03	0.04
Forcipiger flavissimus	9.38	5.56	14.71	12.50	0.16	0.25	0.44	0.44	0.00	0.01	0.02	0.01
Genicanthus semicinctus	0.00	2.78	0.00	2.08	0.00	0.06	0.00	0.13	0.00	0.01	0.00	0.06
Girella cyanea	9.38	5.56	8.82	10.42	1.94	1.44	0.53	0.23	0.00	0.00	0.00	0.00
Gnatholepis cauerensis	3.13	5.56	17.65	0.00	0.09	0.11	0.38	0.00	0.00	0.00	0.00	0.00
Gomphosus varius	56.25	44.44	38.24	33.33	1.41	1.94	1.44	1.04	0.02	0.02	0.01	0.01

	% of transects				Mean abundance				Mean biomass			
	Elizabeth		Middleton		Elizabeth		Middleton		Elizabeth		Middleton	
Year	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018
N. transects	32	36	34	48	32	36	34	48	32	36	34	48
Grammistes sexlineatus	3.13	0.00	5.88	0.00	0.03	0.00	0.06	0.00	0.00	0.00	0.00	0.00
Gymnocranius euanus	9.38	19.44	11.76	10.42	0.16	0.58	0.18	0.79	0.12	0.63	0.14	0.58
Gymnothorax annasona	6.25	2.78	2.94	0.00	0.06	0.03	0.03	0.00	0.00	0.00	0.00	0.00
Gymnothorax eurostus	12.50	13.89	0.00	8.33	0.13	0.14	0.00	0.08	0.00	0.00	0.00	0.00
Gymnothorax meleagris	0.00	2.78	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Gymnothorax thrysoideus	3.13	0.00	0.00	2.08	0.03	0.00	0.00	0.02	0.00	0.00	0.00	0.01
Halichoeres margaritaceus	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00
Halichoeres nebulosus	0.00	0.00	2.94	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
Halichoeres trimaculatus	3.13	11.11	17.65	12.50	0.13	1.28	1.85	1.67	0.00	0.05	0.02	0.06
Helcogramma chica	0.00	8.33	2.94	4.17	0.00	0.17	0.03	0.06	0.00	0.00	0.00	0.00
Hemigymnus fasciatus	9.38	2.78	5.88	4.17	0.09	0.03	0.09	0.04	0.01	0.01	0.01	0.00
Hemigymnus melapterus	21.88	19.44	8.82	8.33	1.25	0.36	0.21	0.19	0.55	0.19	0.03	0.09
Heniochus chrysostomus	0.00	0.00	2.94	6.25	0.00	0.00	0.03	0.10	0.00	0.00	0.01	0.04
Hologymnosus annulatus	0.00	2.78	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00
Hologymnosus doliatus	0.00	2.78	5.88	0.00	0.00	0.03	0.06	0.00	0.00	0.00	0.00	0.00
Kyphosus bigibbus	0.00	5.56	2.94	8.33	0.00	0.19	0.06	0.19	0.00	0.17	0.03	0.15
Kyphosus cinerascens	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.02
Kyphosus sectatrix	59.38	33.33	64.71	56.25	19.13	9.11	23.00	68.38	11.82	5.92	15.36	29.09
Labracoglossa nitida	12.50	19.44	20.59	14.58	115.41	21.08	6.50	35.38	20.07	1.43	0.85	2.00
Labrichthys unilineatus	12.50	2.78	2.94	2.08	0.25	0.03	0.03	0.02	0.00	0.00	0.00	0.00
Labroides bicolor	28.13	2.78	14.71	6.25	0.44	0.03	0.24	0.10	0.00	0.00	0.00	0.00
Labroides dimidiatus	65.63	52.78	64.71	60.42	2.47	2.03	3.15	2.31	0.01	0.01	0.01	0.02
Labropsis australis	12.50	16.67	5.88	2.08	0.78	0.28	0.15	0.02	0.01	0.01	0.00	0.00
Lethrinus nebulosus	0.00	0.00	0.00	8.33	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.13
Lutjanus bohar	18.75	16.67	8.82	20.83	1.44	0.47	0.18	1.46	0.83	0.62	0.08	0.75
Lutjanus kasmira	6.25	5.56	0.00	0.00	8.09	3.28	0.00	0.00	1.81	0.66	0.00	0.00
Macropharyngodon meleagris	3.13	13.89	5.88	2.08	0.03	0.44	0.09	0.02	0.00	0.01	0.00	0.00

	% of transects				Mean abundance				Mean biomass			
	Elizabeth		Middleton		Elizabeth		Middleton		Elizabeth		Middleton	
Year	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018
N. transects	32	36	34	48	32	36	34	48	32	36	34	48
Macropharyngodon negrosensis	0.00	0.00	2.94	2.08	0.00	0.00	0.03	0.02	0.00	0.00	0.00	0.00
Malacanthus brevirostris	3.13	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Meiacanthus phaeus	25.00	55.56	14.71	31.25	0.44	1.42	0.38	1.10	0.00	0.01	0.00	0.01
Monotaxis grandoculis	3.13	8.33	8.82	4.17	0.06	0.31	0.09	0.06	0.01	0.30	0.01	0.01
Monotaxis heterodon	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.06
Mulloidichthys vanicolensis	0.00	2.78	0.00	4.17	0.00	0.14	0.00	3.23	0.00	0.02	0.00	1.14
Myrichthys maculosus	3.13	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Myripristis kuntee	6.25	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.15	0.00	0.00	0.00
Myripristis murdjan	3.13	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Naso annulatus	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.04
Naso brevirostris	3.13	2.78	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.02	0.00	0.00
Naso caesius	0.00	2.78	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.02	0.00	0.00
Naso hexacanthus	3.13	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Naso lituratus	6.25	0.00	2.94	2.08	0.06	0.00	0.24	0.06	0.01	0.00	0.09	0.02
Naso thynnoides	0.00	0.00	0.00	4.17	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.09
Naso tonganus	6.25	0.00	8.82	2.08	0.19	0.00	0.18	0.02	0.09	0.00	0.16	0.01
Naso unicornis	53.13	30.56	47.06	41.67	1.38	0.61	3.26	1.10	0.56	0.41	0.93	0.59
Nemateleotris magnifica	0.00	2.78	2.94	6.25	0.00	0.06	0.06	0.08	0.00	0.00	0.00	0.00
Neoglyphidodon polyacanthus	28.13	30.56	32.35	35.42	8.84	5.78	7.47	6.15	0.22	0.15	0.08	0.22
Neoniphon sammara	0.00	0.00	8.82	6.25	0.00	0.00	0.29	0.23	0.00	0.00	0.09	0.01
Notocirrhitus splendens	3.13	0.00	0.00	4.17	0.03	0.00	0.00	0.08	0.01	0.00	0.00	0.00
Novaculichthys taeniourus	0.00	2.78	0.00	2.08	0.00	0.06	0.00	0.08	0.00	0.00	0.00	0.01
Ostorhinchus angustatus	0.00	0.00	2.94	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
Ostracion cubicus	6.25	8.33	5.88	16.67	0.06	0.08	0.06	0.27	0.03	0.02	0.03	0.10
Oxycheilinus bimaculatus	0.00	0.00	5.88	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00
Oxycheilinus digrammus	9.38	2.78	2.94	6.25	0.13	0.06	0.03	0.08	0.01	0.00	0.00	0.01
Oxycheilinus orientalis	3.13	0.00	2.94	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00

	% of transects				Mean abundance				Mean biomass			
	Elizabeth		Middleton		Elizabeth		Middleton		Elizabeth		Middleton	
Year	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018
N. transects	32	36	34	48	32	36	34	48	32	36	34	48
Oxycheilinus unifasciatus	3.13	2.78	2.94	0.00	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.00
Oxymonacanthus longirostris	3.13	2.78	2.94	0.00	0.06	0.11	0.06	0.00	0.00	0.00	0.00	0.00
Paracaesio xanthura	15.63	16.67	5.88	31.25	2.50	9.53	9.62	25.96	0.24	0.75	0.02	0.84
Paracanthurus hepatus	0.00	0.00	2.94	8.33	0.00	0.00	0.06	0.13	0.00	0.00	0.01	0.00
Paracirrhites arcatus	15.63	5.56	0.00	4.17	0.19	0.06	0.00	0.04	0.00	0.00	0.00	0.00
Paracirrhites forsteri	12.50	11.11	0.00	4.17	0.16	0.14	0.00	0.04	0.01	0.00	0.00	0.00
Parapercis australis	0.00	5.56	8.82	10.42	0.00	0.17	0.26	0.15	0.00	0.00	0.01	0.00
Parapercis queenslandica	6.25	0.00	0.00	6.25	0.06	0.00	0.00	0.06	0.00	0.00	0.00	0.00
Parma polylepis	31.25	22.22	32.35	50.00	0.44	0.64	1.29	1.88	0.12	0.19	0.53	0.48
Parupeneus ciliatus	0.00	0.00	2.94	2.08	0.00	0.00	0.03	0.04	0.00	0.00	0.02	0.01
Parupeneus cyclostomus	3.13	0.00	8.82	0.00	0.06	0.00	0.12	0.00	0.01	0.00	0.03	0.00
Parupeneus multifasciatus	21.88	22.22	26.47	35.42	0.44	0.67	0.82	0.94	0.04	0.18	0.06	0.10
Parupeneus pleurostigma	9.38	11.11	11.76	14.58	0.41	0.31	0.35	0.27	0.07	0.08	0.08	0.04
Parupeneus spilurus	18.75	27.78	23.53	47.92	0.88	0.97	2.09	2.00	0.28	0.30	0.49	0.60
Pempheris analis	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Pervagor alternans	3.13	8.33	0.00	4.17	0.03	0.08	0.00	0.04	0.00	0.00	0.00	0.00
Pervagor janthinosoma	6.25	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plagiotremus rhinorhynchos	0.00	0.00	5.88	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00
Plagiotremus tapeinosoma	25.00	44.44	38.24	41.67	0.94	3.83	2.09	7.42	0.00	0.01	0.00	0.01
Plectorhinchus picus	28.13	16.67	20.59	35.42	0.50	0.25	1.15	0.67	0.24	0.25	0.49	0.66
Plectroglyphidodon dickii	21.88	41.67	2.94	10.42	0.72	2.03	0.06	0.19	0.00	0.05	0.00	0.00
Plectroglyphidodon johnstonianus	56.25	47.22	29.41	14.58	5.38	2.47	2.21	0.31	0.04	0.07	0.03	0.01
Plectroglyphidodon lacrymatus	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00
Plectropomus laevis	0.00	0.00	0.00	4.17	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.78
Plotosus lineatus	0.00	0.00	2.94	0.00	0.00	0.00	3.24	0.00	0.00	0.00	0.01	0.00
Pomacanthus semicirculatus	0.00	0.00	0.00	4.17	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.05
Pomacentrus australis	0.00	2.78	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00

	% of transects				Mean abundance				Mean biomass			
	Elizabeth		Middleton		Elizabeth		Middleton		Elizabeth		Middleton	
Year	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018
N. transects	32	36	34	48	32	36	34	48	32	36	34	48
Pomacentrus coelestis	3.13	5.56	2.94	8.33	0.03	0.14	0.03	0.21	0.00	0.00	0.00	0.00
Pomacentrus vaiuli	0.00	0.00	2.94	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00
Prionurus maculatus	28.13	47.22	29.41	41.67	5.16	22.97	6.68	12.38	3.95	20.07	4.08	13.40
Prionurus microlepidotus	0.00	5.56	0.00	6.25	0.00	0.17	0.00	0.58	0.00	0.35	0.00	0.86
Pseudanthias pictilis	0.00	0.00	5.88	6.25	0.00	0.00	2.21	0.27	0.00	0.00	0.01	0.00
Pseudanthias squamipinnis	0.00	0.00	5.88	0.00	0.00	0.00	1.59	0.00	0.00	0.00	0.00	0.00
Pseudocaranx sp.	15.63	16.67	29.41	14.58	7.25	3.53	7.35	18.85	2.88	0.00	1.87	0.00
Pseudocheilinus hexataenia	9.38	5.56	11.76	4.17	0.09	0.06	0.18	0.04	0.00	0.00	0.00	0.00
Pseudochromis fuscus	18.75	0.00	2.94	0.00	0.28	0.00	0.03	0.00	0.00	0.00	0.00	0.00
Pseudocoris yamashiroi	0.00	2.78	2.94	0.00	0.00	0.03	3.68	0.00	0.00	0.00	0.01	0.00
Pseudojuloides elongatus	0.00	2.78	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.03	0.00	0.00
Pseudolabrus luculentus	96.88	100.00	97.06	93.75	59.22	54.33	89.97	35.58	1.19	0.82	1.10	0.81
Pteragogus cryptus	3.13	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ptereleotris evides	3.13	0.00	2.94	12.50	0.03	0.00	0.12	6.06	0.00	0.00	0.00	0.02
Ptereleotris heteroptera	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Pterois volitans	0.00	2.78	8.82	6.25	0.00	0.03	0.09	0.10	0.00	0.01	0.04	0.03
Salarias fasciatus	9.38	0.00	5.88	4.17	0.09	0.00	0.12	0.04	0.00	0.00	0.00	0.00
Sargocentron diadema	3.13	2.78	0.00	2.08	0.03	0.03	0.00	0.02	0.00	0.01	0.00	0.01
Saurida nebulosa	0.00	0.00	0.00	6.25	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00
Scarus altipinnis	50.00	47.22	55.88	66.67	2.22	2.03	2.91	4.90	1.68	1.40	2.49	3.19
Scarus chameleon	18.75	19.44	35.29	31.25	0.56	1.72	4.15	4.46	0.07	0.05	0.51	0.40
Scarus dimidiatus	3.13	2.78	0.00	4.17	0.03	0.11	0.00	0.31	0.01	0.15	0.00	0.09
Scarus flavipectoralis	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.01
Scarus frenatus	37.50	19.44	20.59	31.25	0.91	0.67	0.44	1.08	0.47	0.72	0.27	0.87
Scarus ghobban	18.75	36.11	26.47	31.25	0.53	1.44	0.53	6.33	0.07	0.48	0.20	0.82
Scarus globiceps	9.38	0.00	17.65	6.25	0.13	0.00	0.32	0.15	0.02	0.00	0.09	0.05
Scarus longipinnis	3.13	5.56	0.00	0.00	0.13	0.06	0.00	0.00	0.02	0.02	0.00	0.00

	% of transects				Mean abundance				Mean biomass			
	Elizabeth		Middleton		Elizabeth		Middleton		Elizabeth		Middleton	
Year	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018
N. transects	32	36	34	48	32	36	34	48	32	36	34	48
Scarus niger	12.50	2.78	8.82	10.42	0.25	0.03	0.18	0.13	0.02	0.00	0.03	0.03
Scarus oviceps	3.13	5.56	0.00	0.00	0.03	0.06	0.00	0.00	0.02	0.02	0.00	0.00
Scarus psittacus	31.25	13.89	23.53	18.75	0.91	0.33	0.94	1.94	0.16	0.08	0.19	0.48
Scarus rivulatus	0.00	2.78	0.00	2.08	0.00	0.03	0.00	0.04	0.00	0.06	0.00	0.43
Scarus schlegeli	25.00	36.11	35.29	31.25	2.03	1.67	2.15	1.88	0.33	0.75	0.50	0.68
Scolopsis bilineata	3.13	0.00	0.00	4.17	0.03	0.00	0.00	0.06	0.00	0.00	0.00	0.01
Scorpaena cardinalis	0.00	2.78	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.03	0.00	0.00
Scorpaena cookii	3.13	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Seriola lalandi	18.75	2.78	23.53	10.42	0.47	0.03	0.47	0.10	0.46	0.09	1.15	0.16
Seriola rivoliana	3.13	11.11	2.94	2.08	0.03	0.11	0.03	0.02	0.05	0.24	0.03	0.07
Siganus argenteus	3.13	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Stanulus talboti	0.00	11.11	0.00	6.25	0.00	1.14	0.00	2.58	0.00	0.23	0.00	0.00
Stegastes apicalis	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Stegastes fasciolatus	34.38	30.56	8.82	31.25	9.41	7.75	0.15	11.67	0.31	0.48	0.00	0.78
Stegastes gascoynei	93.75	91.67	88.24	93.75	94.03	89.47	106.94	66.58	2.02	4.05	2.51	2.00
Stethojulis bandanensis	71.88	72.22	58.82	58.33	3.03	4.14	2.88	2.92	0.03	0.05	0.03	0.03
Stethojulis interrupta	0.00	5.56	11.76	8.33	0.00	0.33	0.44	0.17	0.00	0.00	0.00	0.01
Stethojulis strigiventer	0.00	2.78	0.00	10.42	0.00	0.22	0.00	0.15	0.00	0.01	0.00	0.00
Suezichthys arquatus	0.00	0.00	5.88	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00
Sufflamen bursa	0.00	0.00	2.94	2.08	0.00	0.00	0.03	0.02	0.00	0.00	0.00	0.00
Sufflamen chrysopterum	12.50	30.56	35.29	33.33	0.31	0.39	1.06	0.96	0.07	0.16	0.21	0.25
Sufflamen fraenatum	40.63	19.44	47.06	31.25	0.97	0.19	1.09	0.77	0.35	0.07	0.40	0.23
Synodus dermatogenys	9.38	5.56	11.76	2.08	0.09	0.08	0.21	0.02	0.00	0.00	0.01	0.00
Synodus doaki	0.00	0.00	0.00	4.17	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00
Synodus variegatus	9.38	19.44	2.94	16.67	0.09	0.36	0.03	0.27	0.00	0.01	0.00	0.01
Taeniura meyeni	0.00	0.00	2.94	0.00	0.00	0.00	0.03	0.00	0.00	0.00	13.64	0.00
Thalassoma amblycephalum	40.63	27.78	38.24	35.42	12.78	2.50	15.12	12.08	0.32	0.03	0.19	0.18

	% of transects				Mean abundance				Mean biomass			
	Elizabeth		Middleton		Elizabeth		Middleton		Elizabeth		Middleton	
Year	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018	2013	2018
N. transects	32	36	34	48	32	36	34	48	32	36	34	48
Thalassoma hardwicke	15.63	8.33	17.65	25.00	0.75	0.17	1.06	1.08	0.01	0.01	0.01	0.02
Thalassoma jansenii	21.88	0.00	23.53	0.00	0.75	0.00	0.62	0.00	0.02	0.00	0.01	0.00
Thalassoma lunare	37.50	75.00	50.00	68.75	9.75	6.50	10.59	8.40	0.21	0.07	0.20	0.30
Thalassoma lutescens	87.50	88.89	97.06	93.75	47.53	43.92	43.03	28.46	1.00	1.08	0.78	0.59
Thalassoma nigrofasciatum	0.00	13.89	0.00	41.67	0.00	0.58	0.00	1.46	0.00	0.02	0.00	0.03
Thalassoma purpureum	0.00	2.78	2.94	6.25	0.00	0.03	0.03	0.15	0.00	0.00	0.01	0.02
Thalassoma quinquevittatum	3.13	0.00	2.94	10.42	0.03	0.00	0.03	0.25	0.00	0.00	0.00	0.01
Valenciennea strigata	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Variola louti	9.38	8.33	8.82	6.25	0.09	0.11	0.09	0.06	0.19	0.13	0.09	0.06
Zanclus cornutus	6.25	11.11	14.71	29.17	0.09	0.19	0.35	0.60	0.06	0.10	0.15	0.29
Zebrasoma scopas	9.38	13.89	17.65	12.50	3.19	0.69	0.88	0.33	0.20	0.08	0.06	0.02
Zebrasoma velifer	9.38	13.89	8.82	12.50	0.97	0.28	0.18	9.50	0.06	0.09	0.06	4.21

APPENDIX 3: Frequency and total abundance of invertebrate species recorded at all sites (per 100 m^2), excluding unidentified genera and families.

	% of transects				Mean abundance			
	Elizabeth		Middleton		Elizabeth		Middleton	
Years	**2013**	**2018**	**2013**	**2018**	**2013**	**2018**	**2013**	**2018**
N. transects	**32**	**36**	**34**	**48**	**32**	**36**	**34**	**48**
Acanthaster planci	0.00	2.78	2.94	0.00	0.00	0.08	0.03	0.00
Actinopyga palauensis	9.38	8.33	41.18	14.58	0.16	0.19	1.15	0.83
Aniculus maximus	3.13	0.00	0.00	0.00	0.03	0.00	0.00	0.00
Aplysia argus	0.00	5.56	0.00	2.08	0.00	0.06	0.00	0.02
Aplysia dactylomela	0.00	0.00	5.88	0.00	0.00	0.00	0.15	0.00
Astralium lapillus	0.00	2.78	0.00	0.00	0.00	0.03	0.00	0.00
Bohadschia argus	0.00	0.00	8.82	8.33	0.00	0.00	0.41	0.19
Bursa verrucosa	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.02
Calcinus imperialis	0.00	0.00	2.94	4.17	0.00	0.00	0.03	0.08
Caloria indica	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.02
Centrostephanus rodgersii	3.13	2.78	8.82	12.50	0.06	0.03	0.18	0.23
Chelidonura inornata	0.00	5.56	0.00	0.00	0.00	0.06	0.00	0.00
Chromodoris elisabethina	0.00	2.78	0.00	0.00	0.00	0.03	0.00	0.00
Colobometra perspinosa	0.00	0.00	2.94	0.00	0.00	0.00	0.03	0.00
Comanthus mirabilis	0.00	2.78	0.00	0.00	0.00	0.03	0.00	0.00
Comanthus parvicirrus	0.00	2.78	0.00	0.00	0.00	0.03	0.00	0.00
Comaster nobilis	0.00	5.56	0.00	4.17	0.00	0.06	0.00	0.06
Conus capitaneus	0.00	0.00	2.94	0.00	0.00	0.00	0.03	0.00
Conus flavidus	0.00	2.78	0.00	8.33	0.00	0.03	0.00	0.13
Conus litteratus	0.00	2.78	0.00	0.00	0.00	0.03	0.00	0.00
Conus miles	3.13	0.00	0.00	0.00	0.06	0.00	0.00	0.00
Conus rattus	0.00	0.00	2.94	0.00	0.00	0.00	0.03	0.00
Coriocella nigra	12.50	5.56	0.00	2.08	0.16	0.08	0.00	0.02
Culcita novaeguineae	6.25	2.78	2.94	2.08	0.06	0.03	0.03	0.02
Cypraea tigris	0.00	0.00	2.94	0.00	0.00	0.00	0.03	0.00
Dardanus lagopodes	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.10
Dardanus pedunculatus	0.00	2.78	0.00	0.00	0.00	0.03	0.00	0.00
Diadema savignyi	28.13	25.00	61.76	58.33	3.63	2.33	18.41	17.65
Doriprismatica atromarginata	0.00	0.00	2.94	0.00	0.00	0.00	0.03	0.00
Drupella rugosa	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.04
Echinometra mathaei	68.75	58.33	64.71	85.42	6.34	6.25	19.26	32.38
Echinostrephus aciculatus	78.13	75.00	76.47	79.17	44.53	28.78	216.79	223.08
Echinothrix calamaris	3.13	0.00	2.94	10.42	0.06	0.00	0.03	0.19
Gastropteron bicornutum	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.02
Heterocentrotus mamillatus	0.00	0.00	0.00	4.17	0.00	0.00	0.00	0.04
Hexabranchus sanguineus	6.25	0.00	0.00	0.00	0.06	0.00	0.00	0.00
Holothuria atra	25.00	27.78	55.88	37.50	0.38	1.19	3.59	4.75
Holothuria edulis	15.63	16.67	20.59	18.75	0.53	1.39	3.53	2.67
Holothuria fuscocinerea	6.25	2.78	11.76	0.00	0.06	0.17	0.38	0.00
Holothuria fuscorubra	0.00	2.78	0.00	0.00	0.00	0.08	0.00	0.00

	% of transects				Mean abundance			
	Elizabeth		Middleton		Elizabeth		Middleton	
Years	**2013**	**2018**	**2013**	**2018**	**2013**	**2018**	**2013**	**2018**
N. transects	**32**	**36**	**34**	**48**	**32**	**36**	**34**	**48**
Holothuria hilla	0.00	0.00	11.76	12.50	0.00	0.00	0.26	0.40
Holothuria impatiens	3.13	0.00	8.82	2.08	0.03	0.00	0.15	0.02
Holothuria leucospilota	6.25	0.00	5.88	2.08	0.06	0.00	0.09	0.06
Holothuria pervicax	0.00	11.11	0.00	2.08	0.00	0.39	0.00	0.04
Holothuria scabra	0.00	2.78	0.00	0.00	0.00	0.03	0.00	0.00
Holothuria whitmaei	18.75	16.67	38.24	29.17	0.22	0.28	0.82	1.04
Hypselodoris jacksoni	0.00	8.33	0.00	0.00	0.00	0.08	0.00	0.00
Hypselodoris tryoni	0.00	5.56	0.00	0.00	0.00	0.11	0.00	0.00
Hypselodoris whitei	0.00	11.11	0.00	2.08	0.00	0.25	0.00	0.02
Linckia guildingi	3.13	2.78	17.65	20.83	0.03	0.03	0.21	0.38
Linckia laevigata	3.13	0.00	8.82	12.50	0.03	0.00	1.09	0.17
Linckia multifora	3.13	0.00	47.06	33.33	0.03	0.00	3.85	1.79
Mancinella alouina	0.00	0.00	0.00	4.17	0.00	0.00	0.00	0.04
Mithrodia clavigera	0.00	0.00	2.94	2.08	0.00	0.00	0.03	0.04
Octopus cyanea	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.02
Octopus tetricus	6.25	0.00	0.00	0.00	0.06	0.00	0.00	0.00
Ophidiaster confertus	81.25	75.00	55.88	31.25	15.41	8.06	8.41	1.65
Panulirus longipes	6.25	0.00	0.00	4.17	0.22	0.00	0.00	0.04
Phyllidiella pustulosa	0.00	5.56	0.00	2.08	0.00	0.08	0.00	0.02
Prionocidaris callista	3.13	0.00	0.00	0.00	0.03	0.00	0.00	0.00
Pseudobiceros bedfordi	0.00	2.78	0.00	0.00	0.00	0.03	0.00	0.00
Pseudobiceros stellae	0.00	2.78	0.00	0.00	0.00	0.06	0.00	0.00
Stenopus hispidus	0.00	2.78	2.94	0.00	0.00	0.03	0.06	0.00
Stichopus hermanni	3.13	0.00	0.00	8.33	0.03	0.00	0.00	0.13
Stichopus horrens	3.13	0.00	0.00	2.08	0.03	0.00	0.00	0.02
Thelenota ananas	0.00	0.00	0.00	4.17	0.00	0.00	0.00	0.04
Trapezia rufopunctata	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.06
Tridacna crocea	0.00	19.44	0.00	12.50	0.00	0.42	0.00	0.17
Tridacna derasa	9.38	0.00	0.00	0.00	0.16	0.00	0.00	0.00
Tridacna maxima	6.25	13.89	11.76	20.83	0.09	0.17	0.15	0.44
Tropiometra afra	0.00	2.78	0.00	2.08	0.00	0.03	0.00	0.02
Turbo cepoides	9.38	11.11	5.88	6.25	0.16	0.11	0.06	0.10

APPENDIX 4: Frequency and total abundance of identified cryptic fish species recorded at all sites (per 100 m^2), excluding unidentified families.

	% of transects				Mean abundance			
	Elizabeth		Middleton		Elizabeth		Middleton	
Years	2013	2018	2013	2018	2013	2018	2013	2018
N. of transects	32	36	34	48	32	36	34	48
Amblygobius phalaena	3.13	13.89	0.00	4.17	0.06	0.36	0.00	0.19
Apogon capricornis	3.13	0.00	0.00	0.00	0.03	0.00	0.00	0.00
Apogon doederleini	9.38	22.22	14.71	8.33	0.63	2.42	1.56	0.54
Apogon flavus	0.00	5.56	0.00	0.00	0.00	1.31	0.00	0.00
Apogon norfolcensis	25.00	16.67	8.82	10.42	8.81	5.81	0.09	1.10
Atrosalarias holomelas	3.13	8.33	0.00	12.50	0.19	0.11	0.00	2.52
Caracanthus maculatus	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.04
Cephalopholis argus	0.00	0.00	2.94	0.00	0.00	0.00	0.00	0.02
Cheilodipterus macrodon	3.13	0.00	0.00	0.00	0.31	0.00	0.00	0.00
Cheilodipterus quinquelineatus	6.25	11.11	2.94	2.08	0.63	0.42	0.03	0.04
Cirrhitichthys falco	18.75	19.44	35.29	31.25	0.38	0.39	0.97	1.02
Cirripectes alboapicalis	0.00	0.00	0.00	4.17	0.00	0.00	0.00	0.21
Cirripectes castaneus	3.13	2.78	0.00	0.00	0.03	0.06	0.00	0.00
Cirripectes chelomatus	3.13	0.00	0.00	2.08	0.03	0.00	0.00	0.02
Crossosalarias macrospilus	6.25	19.44	5.88	12.50	0.09	0.31	0.06	0.69
Cypho purpurascens	0.00	2.78	5.88	4.17	0.00	0.03	0.06	0.04
Echidna nebulosa	0.00	2.78	0.00	0.00	0.03	0.00	0.00	0.00
Ecsenius fourmanoiri	50.00	80.56	55.88	87.50	1.28	20.69	2.50	31.54
Enneapterygius howensis	0.00	8.33	0.00	12.50	0.00	0.44	0.00	1.40
Enneapterygius rufopileus	18.75	36.11	5.88	41.67	0.38	9.47	0.24	12.15
Epinephelus fasciatus	0.00	0.00	2.94	0.00	0.00	0.03	0.00	0.00
Epinephelus polyphekadion	0.00	0.00	0.00	6.25	0.00	0.00	0.06	0.02
Eviota hoesei	75.00	61.11	64.71	60.42	10.47	12.08	15.00	23.17
Eviota readerae	0.00	55.56	0.00	29.17	0.00	6.11	0.00	3.71
Exallias brevis	9.38	16.67	0.00	2.08	0.09	0.25	0.00	0.04
Fusigobius neophytus	12.50	2.78	8.82	8.33	0.59	0.06	0.26	0.23
Gnatholepis cauerensis	15.63	19.44	23.53	4.17	0.50	1.00	0.76	0.06
Gobiodon quinquestrigatus	3.13	0.00	0.00	2.08	0.28	0.00	0.00	0.08
Grammistes sexlineatus	0.00	0.00	0.00	2.08	0.03	0.00	0.00	0.00
Gymnomuraena zebra	6.25	11.11	2.94	0.00	0.00	0.00	0.00	0.02
Gymnothorax annasona	0.00	0.00	0.00	2.08	0.06	0.11	0.03	0.00
Gymnothorax chilospilus	12.50	11.11	11.76	12.50	0.00	0.00	0.00	0.02
Gymnothorax eurostus	0.00	11.11	0.00	2.08	0.16	0.14	0.12	0.15
Gymnothorax meleagris	0.00	0.00	2.94	4.17	0.00	0.11	0.00	0.02
Gymnothorax thrysoideus	12.50	61.11	0.00	41.67	0.00	0.00	0.03	0.04
Helcogramma chica	0.00	11.11	0.00	4.17	0.44	9.28	0.00	9.29
Macrodontogobius wilburi	0.00	2.78	0.00	2.08	0.00	0.44	0.00	0.04
Meiacanthus phaeus	3.13	0.00	0.00	0.00	0.00	0.03	0.00	0.02
Myripristis kuntee	0.00	0.00	0.00	2.08	0.28	0.00	0.00	0.00

	% of transects				Mean abundance			
	Elizabeth		Middleton		Elizabeth		Middleton	
Years	2013	2018	2013	2018	2013	2018	2013	2018
N. of transects	32	36	34	48	32	36	34	48
Norfolkia squamiceps	3.13	0.00	0.00	2.08	0.00	0.00	0.00	0.04
Notocirrhitus splendens	0.00	0.00	2.94	0.00	0.03	0.00	0.00	0.02
Ostorhinchus angustatus	3.13	0.00	0.00	4.17	0.00	0.00	0.03	0.00
Paracirrhites arcatus	3.13	8.33	0.00	2.08	0.03	0.00	0.00	0.06
Paracirrhites forsteri	3.13	0.00	2.94	0.00	0.03	0.08	0.00	0.02
Paragobiodon echinocephalus	0.00	8.33	0.00	8.33	0.16	0.00	0.09	0.00
Parapercis australis	0.00	0.00	0.00	2.08	0.00	0.14	0.00	0.25
Parapercis queenslandica	0.00	2.78	0.00	0.00	0.00	0.00	0.00	0.02
Parascorpaena aurita	0.00	0.00	8.82	2.08	0.00	0.03	0.00	0.00
Plagiotremus rhinorhynchos	0.00	5.56	2.94	0.00	0.00	0.00	0.09	0.02
Plagiotremus tapeinosoma	3.13	2.78	2.94	0.00	0.00	0.19	0.03	0.00
Pseudochromis fuscus	0.00	11.11	0.00	4.17	0.03	0.03	0.03	0.00
Pterois volitans	3.13	2.78	0.00	2.08	0.03	0.03	0.00	0.02
Salarias fasciatus	6.25	0.00	2.94	6.25	0.16	0.00	0.15	0.06
Saurida nebulosa	0.00	0.00	11.76	4.17	0.00	0.00	0.00	0.02
Stanulus talboti	6.25	30.56	2.94	27.08	0.06	9.11	0.38	22.48
Synanceia verrucosa	0.00	0.00	1.00	0.00	0.00	0.03	0.00	0.00
Synodus binotatus	0.00	5.56	0.00	6.25	0.00	0.14	0.00	0.10
Synodus dermatogenys	6.25	8.33	17.65	12.50	0.06	0.08	0.29	0.27
Synodus doaki	0.00	8.33	0.00	12.50	0.00	0.11	0.00	0.13
Synodus variegatus	12.50	13.89	11.76	14.58	0.13	0.17	0.15	0.19
Trachypoma macracanthus	3.13	0.00	0.00	2.08	0.03	0.00	0.00	0.04