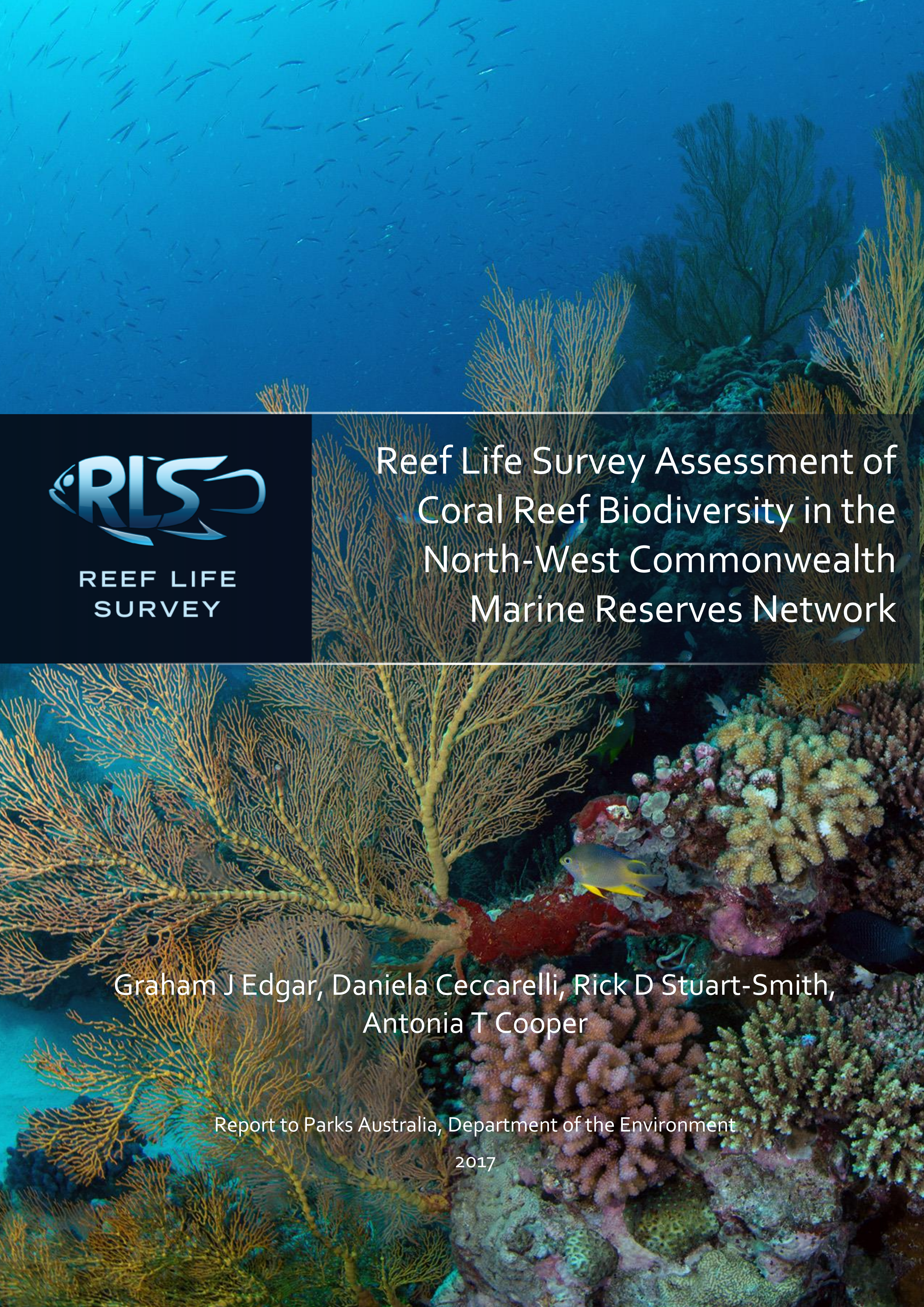

REEF LIFE SURVEY

Reef Life Survey Assessment of Coral Reef Biodiversity in the North-West Commonwealth Marine Reserves Network

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Copyright and disclaimer

Important disclaimer

Images

Graham Edgar and Rick Stuart-Smith

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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

The North-west marine bioregion extends from the Western Australian - Northern Territory border to Kalbarri, south of Shark Bay, in Western Australia (WA). The major coral reefs in the North-west marine bioregion include Ashmore, Cartier, Hibernia, Scott, Seringapatam, and Mermaid Reef in the Rowley Shoals (which consist of Mermaid, Clerke and Imperieuse Reefs), all of which host high coral and fish diversity. Three of these reefs are protected as Commonwealth Marine Reserves (CMRs): Ashmore Reef CMR, Cartier Reef CMR, and Mermaid Reef CMR. Within Ashmore Reef CMR, 550 km^2 is strictly protected within a IUCN Ia Sanctuary Zone, and 33 km^2 is a IUCN IV Recreational Use Zone, where some fishing is permitted; Mermaid Reef is protected as a IUCN II Marine National Park. The other Rowley Shoals are zoned under WA State legislation and are partially protected from fishing. This report presents the findings of the most recent surveys across the North-west CMR Network's reefs, with a focus on comparing coral reef communities on open and protected reefs. Reef Life Survey (RLS) dive teams surveyed 172 transects at 94 sites on reefs within the North-west marine bioregion, including 18 transects at 12 sites within the Ashmore Reef CMR and 37 transects at 18 sites in the Mermaid CMR (Appendix 2). RLS involves recreational divers trained to a scientific level of data-gathering to allow ecological surveys to be conducted across broad geographic areas in a cost-effective manner.

The surveys found clear distinctions in the fish and invertebrate communities of the northern offshore reefs (Ashmore, Scott and Hibernia) and the Rowley Shoals (Mermaid, Clerke and Imperieuse). Also, fish and invertebrate communities were more distinct between Ashmore, Scott and Hibernia Reefs than they were between the Rowley Shoals, reflecting the greater geographic distance between the individual northern reefs. Contrary to expectations, diversity was not higher at Ashmore Reef than at reefs less protected (e.g. Hibernia and Scott) or further south (Rowley Shoals). The Rowley Shoals hosted an overall richer and more diverse fauna, with higher biomass and abundance of sharks, fishes and invertebrates; this like reflects greater exploitation pressure experienced by the northern reefs, including illegal harvesting at Ashmore Reef, rather than the impacts associated with oil spills or climate change. Further research would be needed to tease apart potential relative contributions of exploitation versus climate change and indirect effects of coral bleaching, for example.

Benthic communities were dominated by live hard coral at most surveyed reefs; only Ashmore Reef had comparatively low cover of all morphologies of live hard coral. The Rowley Shoals in particular appear to have maintained historically high cover of branching corals. Fish and invertebrate communities seemed closely aligned to live coral cover, with richer assemblages at reefs with higher coral cover. Ashmore, Scott and Hibernia Reefs appear to host a general Indo-Pacific fauna, due to their proximity to the Indonesian archipelago and the Indonesian Throughflow, while the Rowley Shoals are characterised by a few species typical of the Indian Ocean not found on the Pacific side of the Indo-Australian archipelago.

The success of no-take (IUCN II) zoning (and possibly enhanced compliance through proximity to state MPAs and likely reduced access by international fishers) is clear in the case of the Mermaid Reef CMR; higher biomass, abundance and species richness of fishes and invertebrates, higher numbers of protected species and higher coral cover all indicate a well functioning ecosystem with an intact trophic structure. Assessing the differences between the CMR and reference sites is assisted with an ideal situation of two almost identical reefs in close proximity.

In the case of Ashmore Reef, the effects of management are more difficult to detect. There is a history of disturbance and illegal fishing in this area, and comparison with Scott Reef could imply that impacts are greatest at reefs closest to Indonesia, regardless of protection levels. This could possibly be the result of the footprint of historical exploitation, or contemporary illegal fishing. However, with the Scott and Seringapatam Reef reference sites further away and with different habitat structure to those at Ashmore, time-series data are likely going to be important for detecting the response of previously exploited populations to CMR protection.

RECOMMENDATIONS

- ongoing monitoring of North-west bioregion reefs takes place on a regular basis (5 years or less), using the methods and sites described here;

- data presented in recent RLS surveys be combined with previous surveys to guide efforts to select sites for long-term monitoring;

- research priorities include development of indicators that track changes in reef condition and biodiversity;

- factors contributing to low fish and invertebrate biomass, abundance and species richness at Ashmore Reef are investigated (i.e. investigate potential relative importance of inadequate sampling of the full variety of reef habitats at Ashmore Reef, exploitation and direct versus indirect effects of warming). Further surveys at Ashmore and targeted analyses would be required for this;

- detailed habitat mapping and categorisation of reef types, exposure and aspect is undertaken for inclusion in analyses of ecological patterns;

- detailed spatial and temporal mapping of distribution and impact of natural disturbances is carried out; and

- greater collaboration between agencies collecting data on reefs for the North-west CMR Network is encouraged.

1 Introduction

The North-west marine bioregion extends from the Western Australian - Northern Territory border to Kalbarri, south of Shark Bay, in Western Australia (WA). The marine environment is generally shallow (almost half of the seafloor is less than 200 m deep) and tropical, with a wide continental shelf, a large number of banks and shoals, a highly variable tidal regime, a high incidence of tropical cyclones and a complex system of ocean currents (Baker et al. 2008). The primary oceanographic features in the North-west marine bioregion are the Leeuwin Current and the Indonesian Throughflow, which contribute warm, low-nutrient (oligotrophic) water from the Pacific through the Indonesian island group to areas as far south as the Abrolhos Island group. The large tidal range affects the movements of sediments and turbidity plumes (Commonwealth of Australia 2012). The major offshore coral reefs in the North-west marine bioregion include Ashmore, Hibernia, Scott, Seringapatam, and the Rowley Shoals, all of which host high coral and fish diversity (Commonwealth of Australia 2012).

Despite its high species richness, the North-west marine bioregion has relatively low endemicity when compared with other Regions, and shares most species with either the Indian Ocean or the Indo-Pacific. The North-west marine bioregion's high species richness is thought to be a product of the wide variety of available habitats, including hard limestone seafloor, submerged cliffs, sandy and muddy areas, the deep waters of the Cuvier and the Argo Abyssal Plains, and corals reefs along a gradient from the nearshore Kimberley and Ningaloo to the outer edge of the continental shelf (Falkner et al. 2009). The emergent reefs represent patches of high productivity and diversity in the otherwise oligotrophic waters of the North-west marine bioregion, and attract breeding and feeding aggregations of regionally important populations of marine species, such as seabirds and marine mammals. Due to the steep slope of the Rowley Shoals, upwelling of nutrients attracts migratory pelagic species such as dolphins, tuna, billfish and sharks.

Three isolated reefs in the North-west region are currently protected and actively managed Commonwealth Marine Reserves (CMRs; Ashmore Reef CMR, Cartier Reef CMR, and Mermaid Reef CMR). The Ashmore Reef CMR is situated on Australia's north-west shelf in the Timor Sea, covers 583 km^2 and encompasses a coral reef with wide reef flats, gently sloping outer reef slopes, two extensive lagoons, shifting sand flats and cays (including three permanent islands known as East, Middle and West Islands) and seagrass meadows. Within the CMR, 550 km^2 is strictly protected within a IUCN Ia Sanctuary Zone, and 33 km^2 is a IUCN IV Recreational Use Zone, where some fishing is permitted. Ashmore Reef CMR historically provided the highest diversity of sea snakes in the world (Lukoschek et al. 2013), a genetically distinct population of dugongs (Whiting 1999), WA's highest diversity of reef-building corals (Richards et al. 2009) and reef fishes (Allen 1993), and a regionally significant population of marine turtles (Whiting and Guinea 2001). Ashmore's West Island is a recognized seabird breeding and roosting ground of international significance, as well as an annual migratory stop-over for birds on their way between eastern Asia and Australia, resulting in its listing as a Ramsar site (Ferguson 2002). A detailed habitat map exists of the reef, which has guided site selection for ecological surveys (Skewes et al. 1999). Previous monitoring surveys have focused on populations of commercially-important macroinvertebrates, such as holothurians, trochus and tridacnid clams, which have been heavily targeted by Indonesian fishers in the past, and more recently continue to be harvested illegally (Ceccarelli et al. 2011a).

The Mermaid Reef CMR encompasses the northernmost of the three Indian Ocean reefs of Rowley Shoals. The other two reefs (Clerke and Imperieuse) are zoned marine protected areas under WA State legislation and receive partial protection from fishing. The three reefs are similar in size and shape, with enclosed lagoons, small sand cays and steep outer reef edges. Clerke and Imperieuse Reefs are managed within the Western Australian Rowley Shoals Marine Park, but not all reef areas are protected as no-take marine reserves, and some experience some recreational and charter fishing. Mermaid Reef CMR is entirely protected as a IUCN II Marine National Park. Compared to the partially-fished Rowley Shoals reefs, Mermaid was previously found to support higher densities of commercially-valued species of invertebrates and fishes (Meekan et al. 2005). The coral communities at Mermaid Reef were unique even when compared with Clerke and Imperieuse Reefs, with relatively high overall coral cover (34%), and proportionally higher cover of soft (5%), massive (24%), and encrusting (15%) corals (Gilmour et al. 2007). In fact, compared with other reef systems in the region (Scott, Seringapatam, Ashmore, Cartier and Hibernia), the Rowley Shoals, and Mermaid Reef in particular, are thought to represent the most 'pristine' state amongst WA's offshore reefs (Gilmour et al. 2007).

Reefs in the North-west mairne bioregion have experienced a series of disturbances in recent decades. Substantial coral bleaching and subsequent mortality occurred as a result of the abnormally high SST in the summer of 1998 (Skewes et al. 1999). However, while some reefs (Scott and Seringapatam in particular) experienced up to 76% mortality, Ashmore and Cartier Reefs experienced low initial mortality (Skewes et al. 1999), but further bleaching events may have had a greater impact (Rees et al. 2003). Recovery of coral cover was rapid during years of little or no disturbance, suggesting high resilience (Ceccarelli et al. 2011b).

So far, few surveys of coral reefs in the North-west marine bioregion have included all comparable reefs with the same methodology, making it difficult to assess differences between reefs, and between different levels of protection. This report presents the findings of the most recent surveys across the North-west mairne bioregion's reefs, with a focus on comparing coral reef communities on CMR and reference reefs.

2 Methods

Reef Life Survey (RLS) dive teams surveyed 172 transects at 94 sites on reefs across the North-west marine bioregion, including 18 transects at 12 sites within the Ashmore Reef CMR and 37 transects at 18 sites in the Mermaid CMR (APPENDIX 1). All surveys were conducted using the standardised underwater visual census methods applied globally by Reef Life Survey. Reef Life Survey (RLS) involves recreational divers trained to a scientific level of data-gathering to make it possible to conduct ecological surveys across broad geographic areas in a cost-effective manner. RLS divers partner with management agencies and university researchers to undertake detailed assessment of biodiversity on coral and rocky reefs, but all divers and boat crew do so in a voluntary capacity. A summary of these methods is provided here. Full details can be downloaded at: http://reeflifesurvey.com/files/2008/09/NEW-Methods-Manual_15042013.pdf .

Each RLS survey involves three distinct searches undertaken along a 50 m transect line: for fishes, invertebrates and cryptic fishes, and sessile organisms such as corals and macroalgae (described individually below). Two transects were usually surveyed at each site for this study, on predominantly coral reef habitat, and generally parallel at different depths. Depth contours were restricted by depth variations in individual reefs, but where possible were selected to encompass a wide depth range (e.g. 2 – 20 m). Constraints associated with diving bottom time and air consumption generally limited depths to above 22 m. Underwater visibility and depth were recorded at the time of each survey, with visibility measured as the furthest distance at which large objects could be seen along the transect line, and depth as the depth (m) contour followed by the diver when setting the transect line.

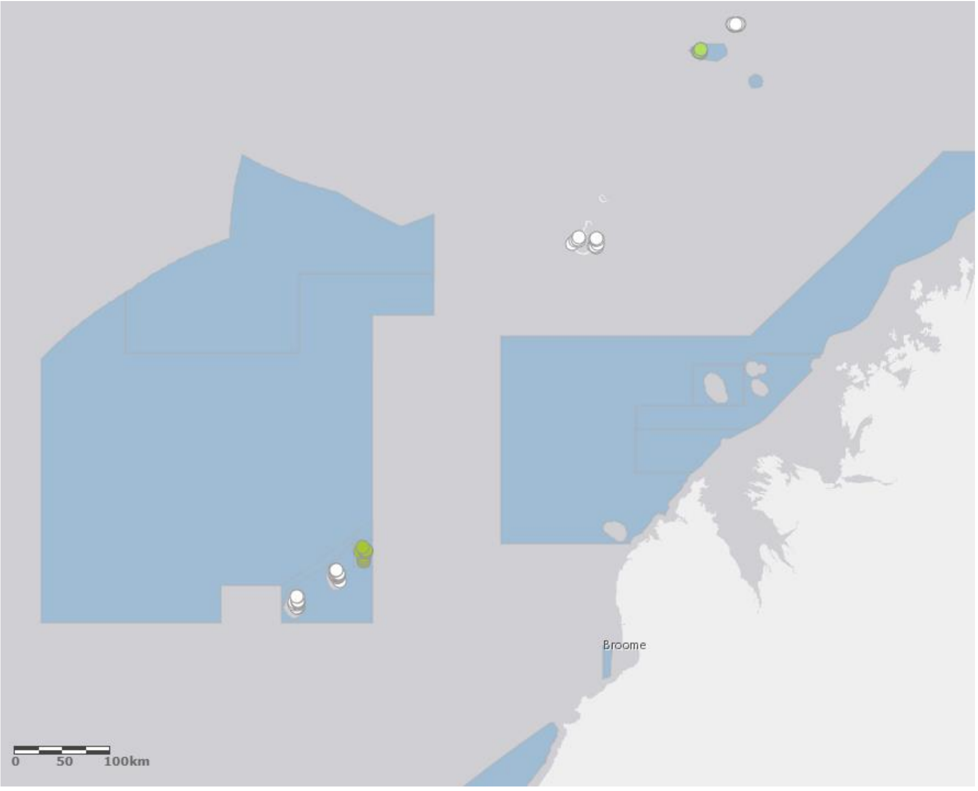

Figure 1. Map of the Northwest sites surveyed from 2009 - 2016.

FISH SURVEYS (METHOD 1)

All fish species sighted within 5 m x 50 m blocks either side of the transect line were recorded on waterproof paper as divers swam slowly along the line. The number and estimated size-category of each species were also recorded. Size categories used were 25, 50, 75, 100, 125, 150, 200, 250, 300, 350, 400, 500, 625 mm, and above, which represent total fish length (from snout to tip of tail). All species sighted within the blocks were recorded, including those with unknown identity. Photographs were used to later confirm identities with appropriate taxonomic experts, as necessary. In occasional circumstances when no photograph was available, taxa were recorded to the highest taxonomic resolution for which there was confidence (e.g. genus or family, if not species). Other large pelagic animals such as mammals, reptiles and cephalopods were also recorded during the Method 1 fish survey, but were excluded for analyses focusing on fishes. Species observed outside the boundaries of the survey blocks or after the fish survey had been completed were recorded as 'Method 0'. Such records are a presence record for the time and location but were not used in quantitative analyses at the site level. 'Method 0' sightings were also made of invertebrates and any other notable taxonomic groups.

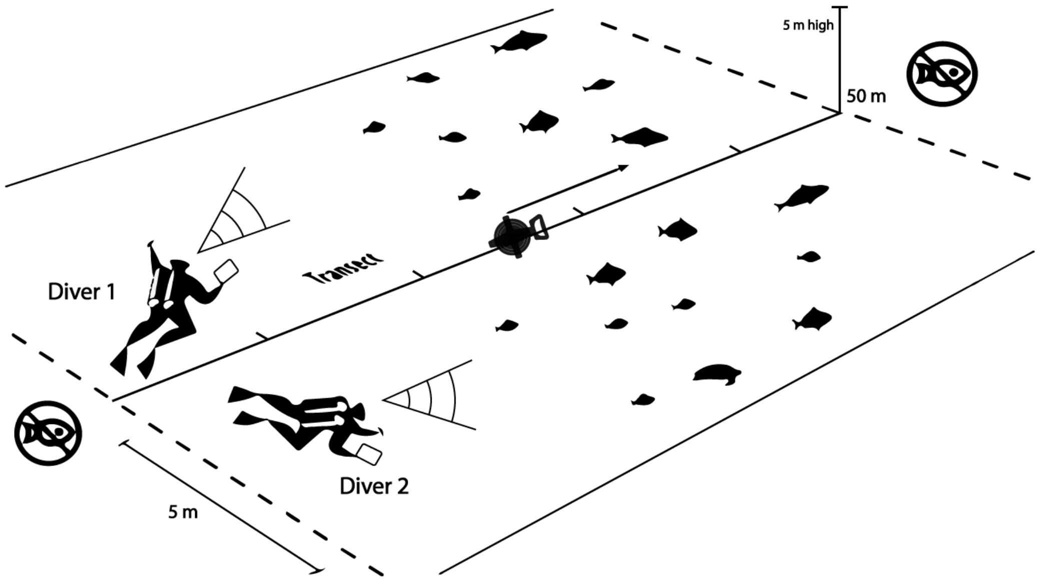

Figure 2. Stylised representation of method 1 survey technique

MACROINVERTEBRATE AND CRYPTIC FISH SURVEYS (METHOD 2)

Large macroinvertebrates (echinoderms, and molluscs and crustaceans > 2.5 cm) and cryptic fishes were surveyed along the same transect lines set for fish surveys. Divers swam near the seabed, up each side of the transect line, recording all mobile macroinvertebrates and cryptic fishes on the reef surface within 1 m of the line. This required searching along crevices and undercuts, but without moving rocks or disturbing corals. Cryptic fishes include those from particular, pre-defined families that are inconspicuous and closely associated with the seabed (and are thus disproportionately overlooked during general Method 1 fish surveys). The global list of families defined as cryptic for the purpose of RLS surveys can be found in the online methods manual. As data from Method 2 were collected in blocks of a different width to that used for Method 1 and were analysed separately from those data, individuals of cryptic fishes known to already be recorded on Method 1 were still recorded as part of Method 2. Sizes were estimated for cryptic fishes using the same size classes as for Method 1.

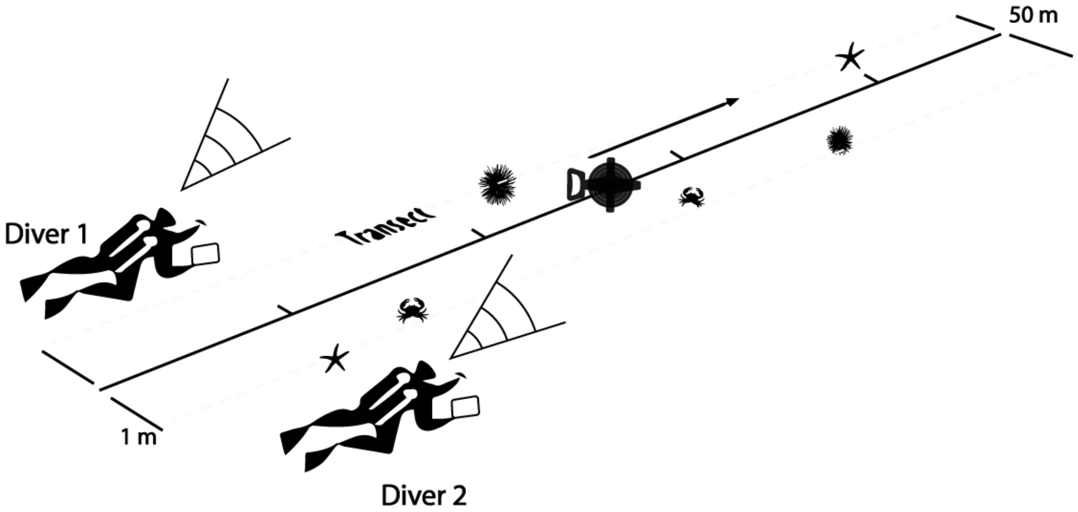

Figure 3. Stylised representation of method 2 survey technique

PHOTO-QUADRATS OF BENTHIC COVER

Information on the percentage cover of sessile animals and macroalgae along the transect lines set for fish and invertebrate surveys were recorded using photo-quadrats taken every 2.5 m along the 50 m transect. Digital photo-quadrats were taken vertically-downward from a height sufficient to encompass an area of approximately 0.3 m x 0.3 m. In total, images were available and processed for 158 transects.

The percentage cover of different macroalgal, coral, sponge and other attached invertebrate species was obtained from photo-quadrats by recording the functional group observed under each of five points overlaid on each image, such that 100 points were usually counted for each transect (thus percentage cover was calculated as the number of points each group was scored under).

Functional groups for photo-quadrat processing comprised the standard 50 categories applied in broad-scale analysis of RLS data (APPENDIX 2), which are aligned with the CATAMI classification system (Althaus et al. 2015). With greater time investment by a specialist operator than was achievable for this report, higher taxonomic resolution analyses are possible using the photo-quadrat set for groups such as corals and algae. Images have been archived and are available for processing at any resolution through the future.

Mean and maximum rugosity values were also estimated for each transect from photo-quadrats, on a scale of 1 to 4, as follows: 1) flat smoothly-curved seabed, occasional projecting rocks when present, not rising more than 5 cm; 2) smoothly-curved seabed with cracks and ridges (with rounded edges) rising vertically 5-20 cm but not undercut; 3) dissected reef surface with cracks and ridges (with some angular edges) rising vertically 20-50 cm and with small undercuts; and 4) highly-dissected reef with extensive (>0.5 m) undercuts.

INDICATORS

Three indicators of reef condition were calculated for each survey: the biomass of large reef fishes (B20), the community temperature index (CTI), and an IUCN threatened species index. The biomass of large fishes (B20) is an indicator of fishing impacts, with previous analyses revealing lower values found in regions of higher impact around Australia. It is calculated as the sum of biomass for all individuals on any survey that are in the 20 cm size class or larger, regardless of identity. CTI is an indicator of the thermal affinities of the species, and is a sensitive indicator of temperature changes. It is thus most useful for time series analyses, although spatial comparison can provide an indication of potential relative vulnerabilities to warming (e.g., Stuart-Smith et al. 2015). For its calculation, the midpoint of each species' thermal distribution (i.e. 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. The IUCN threatened species index is calculated using the species list from the combined Method 1 and Method 2 data for a given survey, as the proportion of those species which are listed on the IUCN red list under the categories Vulnerable, Endangered, or Critically Endangered.

STATISTICAL ANALYSES

Collection of detailed data on fishes, including species-level identities, length classes and abundance information, allow the calculation of species-specific biomass estimates. The RLS database includes coefficients for length–weight relationships obtained for each species from Fishbase (www.fishbase.org) (in cases of missing length-weight coefficients, these are taken from similar-shaped species). When length–weight relationships were described in Fishbase in terms of standard length or fork length rather than total length, additional length-length relationships provided in Fishbase allowed conversion to total length, as estimated by divers. For improved accuracy in biomass estimates, the bias in divers' perception of fish size underwater was additionally corrected using the mean relationship provided in Edgar et al. (2004), where a consistent bias was found amongst divers that led to underestimation of small fish sizes and overestimation of large fish sizes. Note that estimates of fish abundance made by divers can be greatly affected by fish behaviour for many species (Edgar et al. 2004); consequently, biomass determinations, like abundance estimates, can reliably be compared only in a relative sense (i.e. for comparisons with data collected using the same methods) rather than providing an accurate absolute estimate of fish biomass for a patch of reef.

Univariate analyses

A range of univariate metrics were calculated from survey data: total fish abundance, fish species richness, abundance of fish functional groups, total fish biomass, abundance and biomass of large fishes (> 25cm), and percent cover of corals and other key benthic organisms. All metrics represent mean values per 500 m^2 transect area for Method 1 fishes, per 100 m^2 transect area for Method 2 fishes and invertebrates, and percent cover of benthic organisms from photo-quadrats. Analysis of Variance (ANOVA) with appropriate transformations was conducted on the above metrics, with Reef as a fixed factor. While Reef would normally be considered a random factor in biogeographical studies with a subset of reefs sampled, we considered it fixed for this application because we surveyed almost the full set of shallow reefs present in the North-west CMR network, and each reef is of specific interest in its own right.

Multivariate analyses

Relationships between North-west bioregion 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 similarity between sites. MDS was used to investigate differences in community structure between reefs.

Data (biomass for fishes, abundance for invertebrates) were converted to a Bray-Curtis distance matrix relating each pair of sites after square root transformation of raw data. This transformation was applied to downweight the relative importance of the dominant species at a site, and so allow less abundant species to also contribute to the plots. MDS was followed up with ANOSIM to test the significance of differences between reefs.

3 Results

FISH COMMUNITY

The surveys of offshore reefs of the North-west bioregion yielded a total of 401 species of reef fish recorded along the 500 m^2 transects at Ashmore (Zone Ia and IV), Hibernia, Scott, Imperieuse, Mermaid and Clerke Reefs. Fish species richness varied between reefs, with totals of 164, 148, 214, 243, 210, 230 and 225 species recorded, respectively. The most commonly recorded species also varied between reefs; in the Ashmore CMR (Zone IV) there was an even representation of common Indo-Pacific reef fish species, including *Amblyglyphidodon curacao*, *Chaetodon lunulatus,* the grazers *Chlorurus sordidus*, *Ctenochaetus striatus* and the wrasse *Halichoeres melanurus*. In the Sanctuary Zone, the two grazers were followed by the three wrasses *Labroides dimidiatus*, *Thalassoma lunare* and *Pseudocheilinus hexataenia*. Hibernia and Scott Reefs had a higher frequency of wrasses and damselfishes, and the Rowley Shoals had similar combinations of wrasse and damselfish species.

There was a clear distinction between fish communities of Ashmore Reef CMR and its reference sites (Hibernia and Scott Reefs), and those of the Rowley Shoals, including Mermaid Reef CMR (ANOSIM Global R = 0.38, p = 0.001, Figure 4). Key species that characterised the northern reefs were the scaly damsel *Pomacentrus lepidogenys*, the pearlscale angelfish *Centropyge vrolikii*, and the moon wrasse *Thalassoma lunare*; these are common and widespread species of coral reef fishes. There was no distinction between the two different protection levels of Ashmore Reef CMR. Ashmore Reef CMR was distinct from Scott Reef, but Hibernia Reef overlapped with both. Even more overlap occurred among the three reefs of the Rowley Shoals; the group of species that distinguished these reefs from the northern reefs was larger and more diverse. The greatest dissimilarity (SIMPER 84.24%) occurred between the Ashmore Reef CMR's Sanctuary Zone and Mermaid Reef CMR, with higher biomass of a number of herbivorous species and the checkered snapper *Lutjanus decussatus* at Mermaid Reef CMR driving the difference.

The biomass of reef fishes was lower in the Ashmore Reef CMR (both IUCN zones) than in all other locations (ANOVA $F_{4,159}$ = 3.047, p = 0.02; Figure 5). Given the relatively high variability in fish biomass, the main difference was between Ashmore Reef CMR's IUCN Ia Zone and the Mermaid Reef CMR. Species richness of reef fishes was highest in Ashmore Reef's IUCN IV zone, and lowest at the Mermaid reference sites (Clerke and Imperieuse Reefs), but these differences were relatively minor (ANOVA $F_{4,159}$ = 3.073, p = 0.02; Figure 5).

The biomass of benthic carnivores and planktivores was similar across CMRs and reference sites, but there were significant differences in the biomass of the other functional groups (Figure 6). The biomass of piscivores, grazers and omnivores was generally higher at the three Rowley Shoals reefs than at the Ashmore CMR and reference sites. Mermaid, Hibernia and Scott Reefs had lower biomass of farming damselfishes than other reefs. Hibernia and Ashmore Reefs had significantly lower biomass of corallivores than other surveyed reefs (Table 1).

Mermaid Reef CMR, Scott Reef and Clerke Reef had the highest biomass of large reef fishes (>20cm), an indicator of reef state in relation to fishing pressure. Ashmore and Hibernia Reefs, and Ashmore Reef CMR in particular, had significantly lower biomass of large fishes than Scott Reef and the Rowley Shoals (ANOVA $F_{5,158} = 5.653$, $p < 0.001$; Figure 7). Community temperature index (CTI) scores were significantly higher at Ashmore reference sites, Ashmore CMR's Zone IV and Mermaid Reef CMR than in Ashmore CMR's Sanctuary Zone and Mermaid reference sites (ANOVA $F_{4,159} = 6.62$, $p < 0.001$). In contrast, the northern reefs (Ashmore Reef CMR and reference sites) had less than half the proportion of IUCN-listed species than the Rowley Shoals (ANOVA $F_{4,159} = 12.32$, $p < 0.001$). Within the Rowley Shoals, Mermaid Reef CMR had a lower proportion of IUCN listed species than the reference reefs (Figure 8).

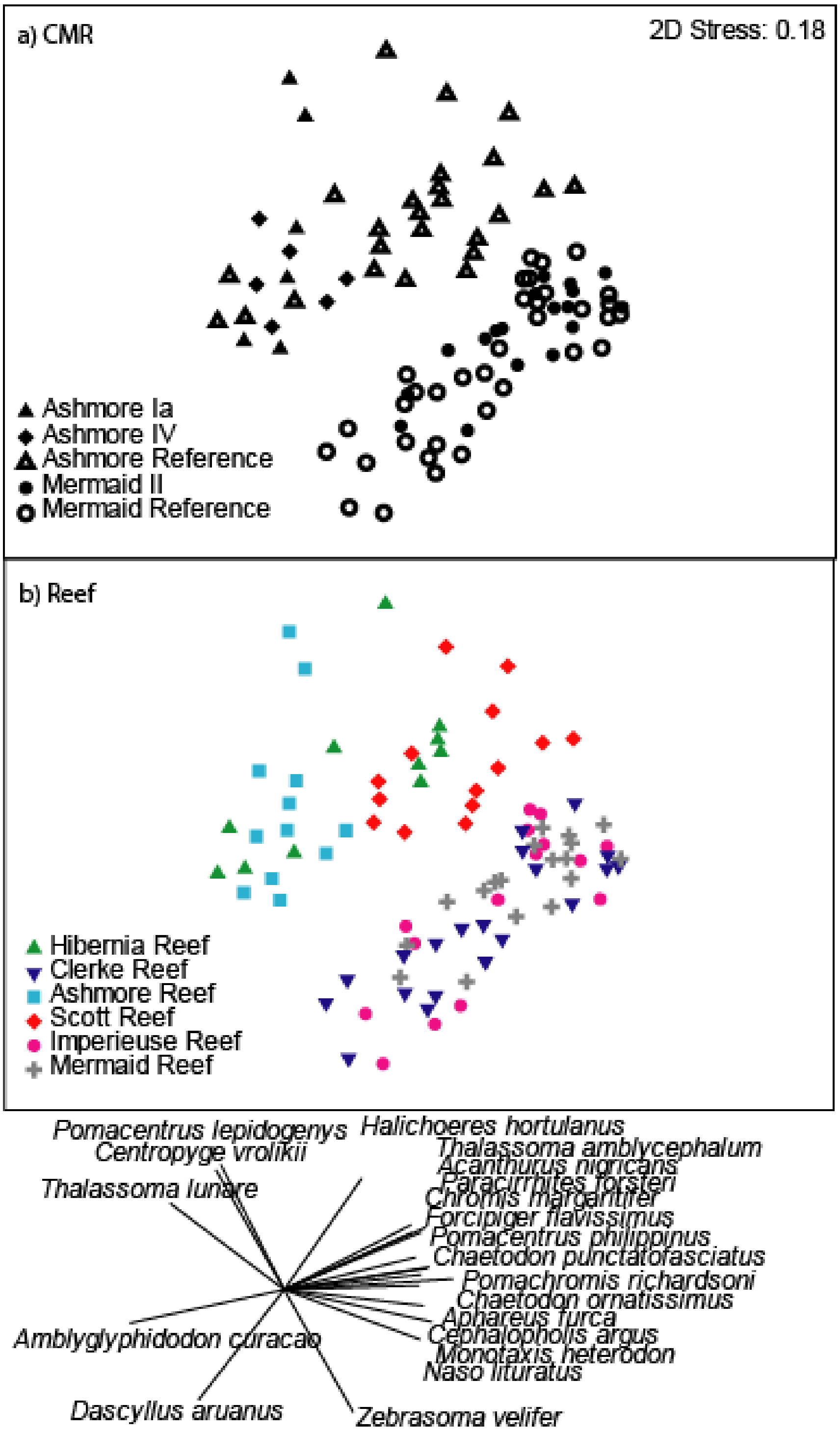

Figure 4. Multidimensional Scaling (MDS) plot of reef fish biomass across Ashmore and Mermaid Reef CMRs and their reference sites, performed on the Bray-Curtis similarity matrix of the square-root transformed data. Sites are shown by a) CMR categories and b) individual reefs. Species vectors are shown if they had a correlation value of at least 0.6.

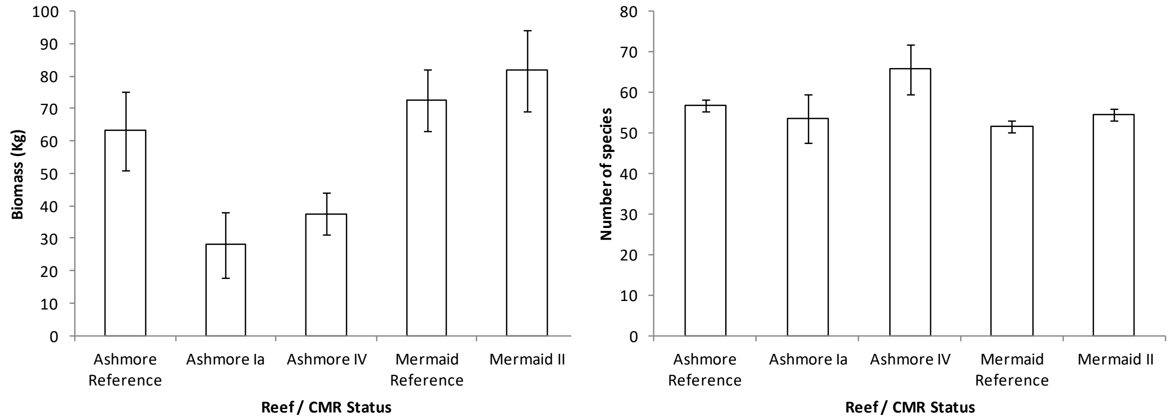

Figure 5. Biomass in kg and species richness of reef fishes per 500 m^2 transect at Ashmore Reef CMR, Mermaid Reef CMR and reference sites in the North-west bioregion. Error Bars = 1 SE.

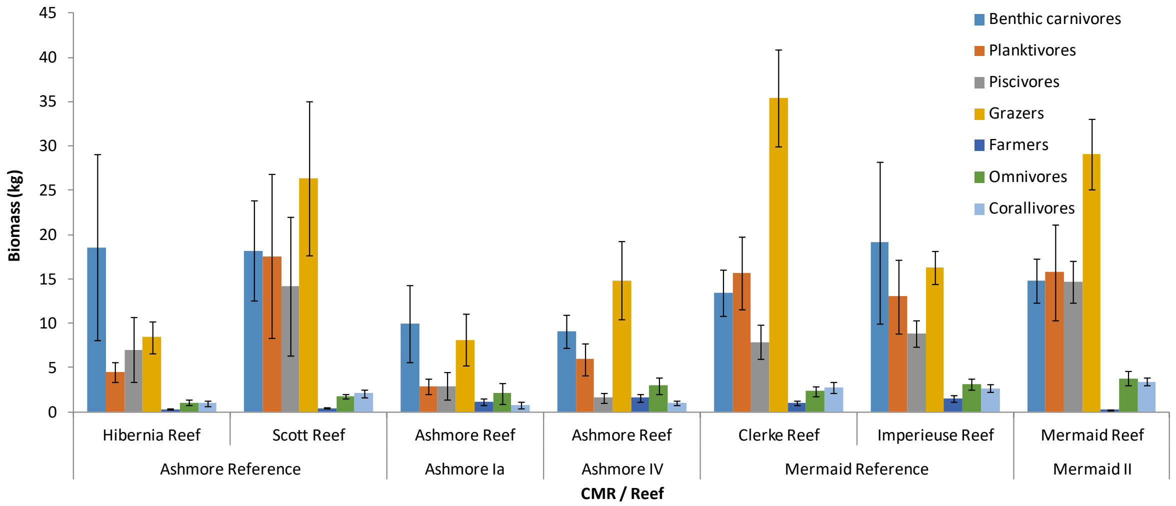

Figure 6. Biomass in kg per 500 m^2 transect of functional groups of reef fishes at Ashmore Reef CMR, Mermaid Reef CMR and reference sites in the North-west bioregion. Error Bars = 1 SE.

Table 1. ANOVA results for functional groups for which the biomass was significantly different between CMR categories, square-root transformed. Significant results are shown in bold.

Functional Group	$F_{4,159}$	p
Benthic carnivores	0.29	0.879
Planktivores	1.69	0.153
Piscivores	4.94	<0.001
Grazers	5.59	<0.001
Farmers	9.34	<0.001
Omnivores	3.80	0.006
Corallivores	5.94	<0.001

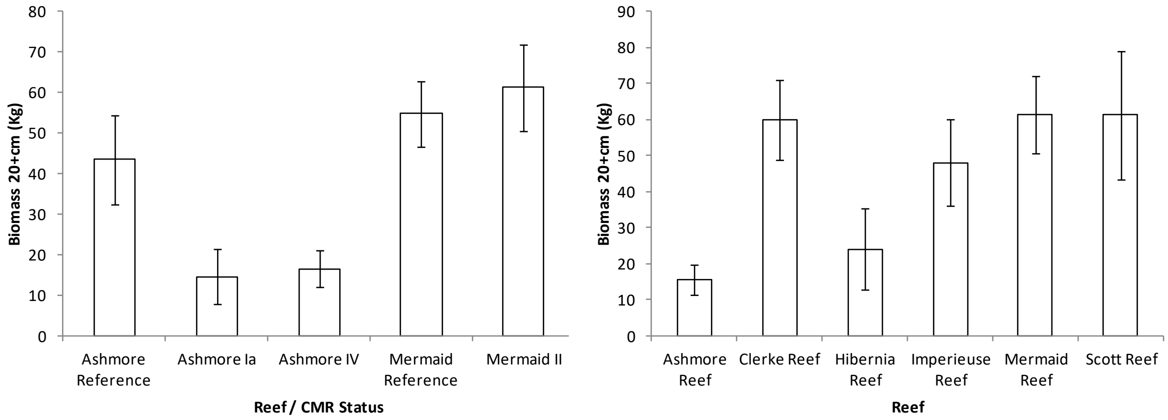

Figure 7. Biomass in kg per 500 m^2 transect of large (>20cm TL) reef fishes in the CMRs and reference sites, and at individual reefs in the North-west bioregion. Error Bars = 1 SE.

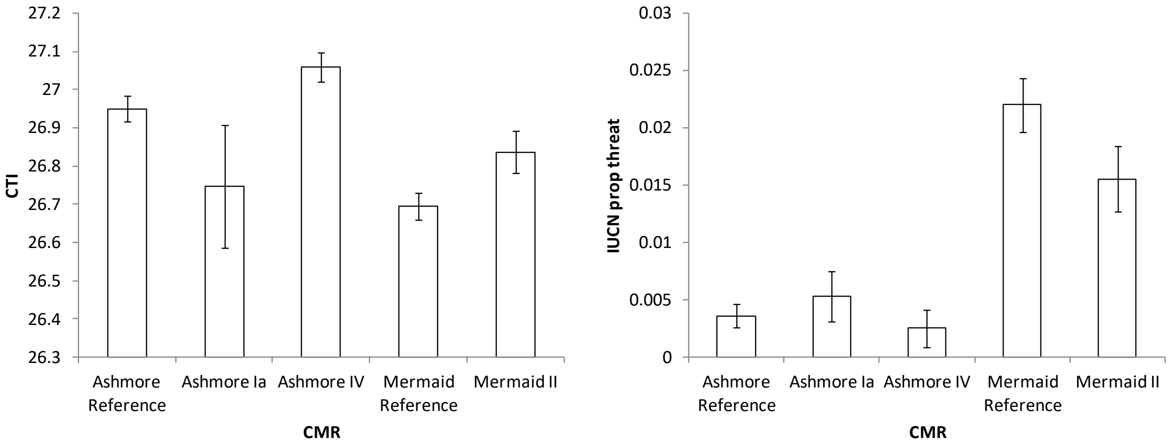

Figure 8. Indices of reef health – CTI and the proportion of threatened species listed in the IUCN Red Book - in the CMRs and reference sites. Error Bars = 1 SE.

BENTHIC COMMUNITY

The benthic community structure of corals reefs across the North-west bioregion was recorded along a total of 158 transects: 8 in Ashmore Reef CMR in the Sanctuary Zone (IUCN Ia), 8 in the adjacent Recreational Use Zone (IUCN IV), 36 in the Mermaid Reef CMR, 46 at Ashmore Reef CMR reference sites and 60 at Mermaid Reef CMR reference sites. The Ashmore Reef CMR was distinct from Mermaid Reef CMR and most reference sites in the structure of their benthic communities. The Ashmore Reef CMR sites were characterised by a coral-poor assemblage, dominated by sand, turf, sponges, calcified algae and soft coral. Some of the other sites (Mermaid Reef CMR, Ashmore and Mermaid reference sites) had similar benthic communities, but most had a greater proportion of living corals and crustose coralline algae. The analysis of individual reefs also showed significant differences, but suggested that Hibernia Reef and Ashmore Reef were more similar to each other, while Scott Reef was grouped with the Rowley Shoals (Figure 9).

The most common benthic categories were live hard corals and abiotic components such as sand, rubble and bare rock, which took up, on average, at least 25% of the substratum (Figure 10, Table 2). The total cover of live sessile biota was not significantly different between reefs, but tended to be relatively low in the Ashmore Reef CMR (Zone Ia) and the Mermaid Reef CMR. The total number of benthic categories recorded was highest at Ashmore Reef and its reference sites, and lowest at Mermaid Reef CMR and its reference sites. Ashmore Reef had the lowest percent cover of live corals, and more macroalgae and turf than the other reefs; the Ashmore reference sites and Rowley Shoals all had higher cover of crustose coralline algae. The cover of recently dead corals was low at all the surveyed reefs, indicating a low likelihood of recent disturbance.

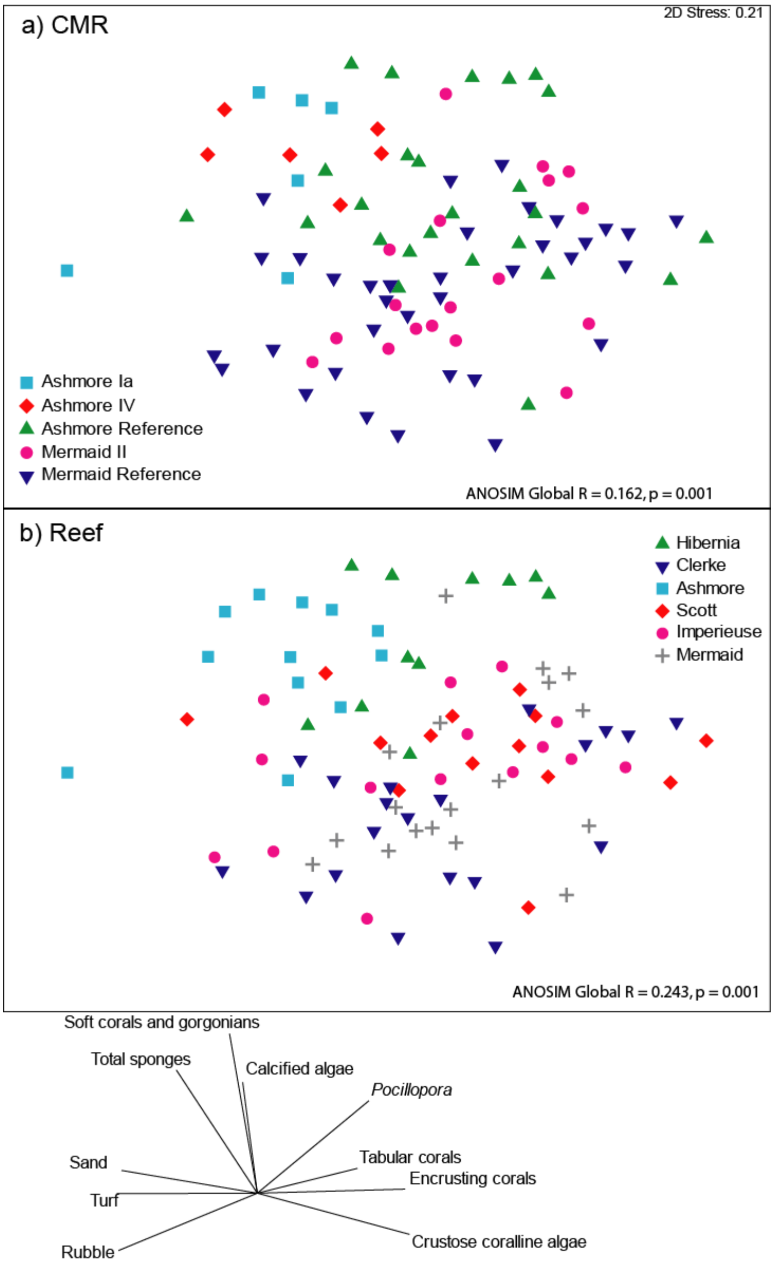

Figure 9. Multidimensional Scaling (MDS) plot of major benthic categories across Ashmore and Mermaid Reef CMRs and their reference sites, performed on the Bray-Curtis similarity matrix of the square-root transformed data. Sites are shown by a) CMR categories and b) individual reefs. Species vectors are shown if they had a correlation value of at least 0.5.

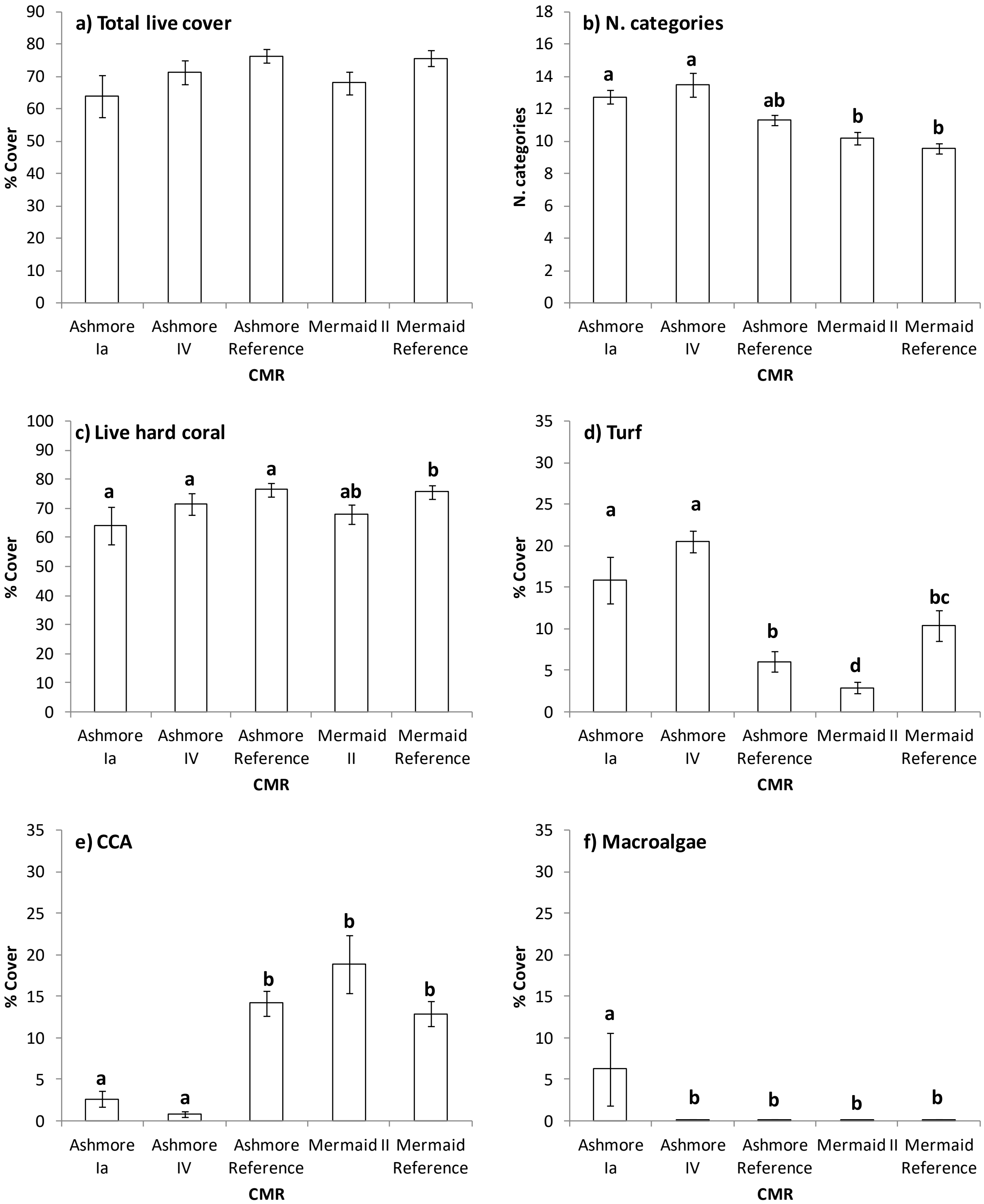

Figure 10. Percent cover of key benthic categories at Ashmore Reef CMR, Mermaid Reef CMR and reference sites in the North-west bioregion. a) Total live cover, b) number of benthic categories, c) live hard coral cover, d) turf cover, e) crustose coralline algae, and f) macroalgae. The same letters delineate CMRs or reefs that were similar. Error Bars = 1 SE.

Table 2. ANOVA on CMRs, results for major benthic categories, log (x+1) transformed.

Benthic category	MS	$F_{4,153}$	p
Total live cover	627.1	1.98	0.100
Number of benthic categories	50.84	10.01	<0.001
Live hard coral	2120.2	6.23	<0.001
Turf	2.21	9.43	<0.001
Crustose coralline algae	1.92	10.18	<0.001
Macroalgae	0.29	10.31	<0.001

MOBILE MACROINVERTEBRATE SURVEYS

Across all transects, 122 species of mobile invertebrates were recorded on the reefs of the North-west bioregion (APPENDIX 4), including some unidentified species. The most abundant species in both Zones of Ashmore Reef CMR was the blue starfish *Linckia laevigata*. All other species were less than half as abundant. Hibernia and Scott Reefswere had relatively high abundance of tridacnid clams and the sea urchin *Echinometra mathaei*. The most common invertebrate species in the Rowley Shoals were at least six times more abundant than those of the northern reefs; *Tridacna crocea*, which was the most abundant species at both Scott Reef and Imperieuse Reefs, had, on average, 2.5 individuals 100 m^{-2} in the former and 11.7 in the latter. Tridacnid clams (*T. crocea*, *T. maxima* and *T. squamosa*) were among the most abundant species across the Rowley Shoals.

The macroinvertebrate community at the northern sites (Ashmore Reef CMR and reference sites) was different from the Rowley Shoals, and there was more separation and variability among the northern sites than the three reefs of the Rowley Shoals (ANOSIM Global R = 0.223, p = 0.001; Figure 11). The northern sites were characterised by higher proportions of *Nembrotha kubaryana*, *Phyllidiella pustulosa* and *Linckia laevigata*; the Rowley Shoals hosted a richer variety of species including tridacnid clams, sea cucumbers, gastropods and sea urchins. SIMPER analysis showed that the tridacnid clams and *Linckia laevigata* were the strongest drivers of the dissimilarity between the northern sites and the Rowley Shoals. The strongest dissimilarity, at 92.77%, occurred between Ashmore Reef CMR and Mermaid Reef CMR. Ashmore Reef CMR sites were further differentiated from reference sites (Hibernia and Scott Reefs); Ashmore Reef CMR had a greater proportion of *Nembrotha kubaryana* and *Linckia laevigata*, Hibernia Reef had a higher abundance of *Phyllidiella pustulosa* and Scott Reef formed a central "cloud", suggesting a more even representation of all the dominant species. There was some overlap of the Rowley Shoals sites with the northern sites, especially Imperieuse and Clerke Reefs.

The abundance and species richness of macroinvertebrates were significantly higher at the Rowley Shoals than in the Ashmore CMR and reference sites (Figure 12). Abundance was more than twice as high in the Rowley Shoals than at the northern sites, with no difference between the Mermaid Reef CMR and its reference sites (ANOVA $F_{4,159} = 14.67$, $p < 0.001$). A similar pattern occurred for species richness; there were no differences between the CMRs and their respective reference sites, but the Rowley Shoals had approximately double the number of species than the northern sites (ANOVA $F_{4,159} = 10.9$, $p < 0.001$).

Molluscs dominated the abundance and, to a lesser extent, species richness across the North-west bioregion's reefs (Figure 13). Abundance of all groups was greater in the Rowley Shoals than on the northern reefs, with significantly higher echinoderm abundance in the Mermaid Reef CMR than at Hibernia and Scott Reefs, higher mollusc abundance at all Rowley Shoals reefs than any of the northern reefs, but no significant differences in crustacean abundance. Differences in the species richness of different groups across CMR and reference sites mirrored those found in their abundance.

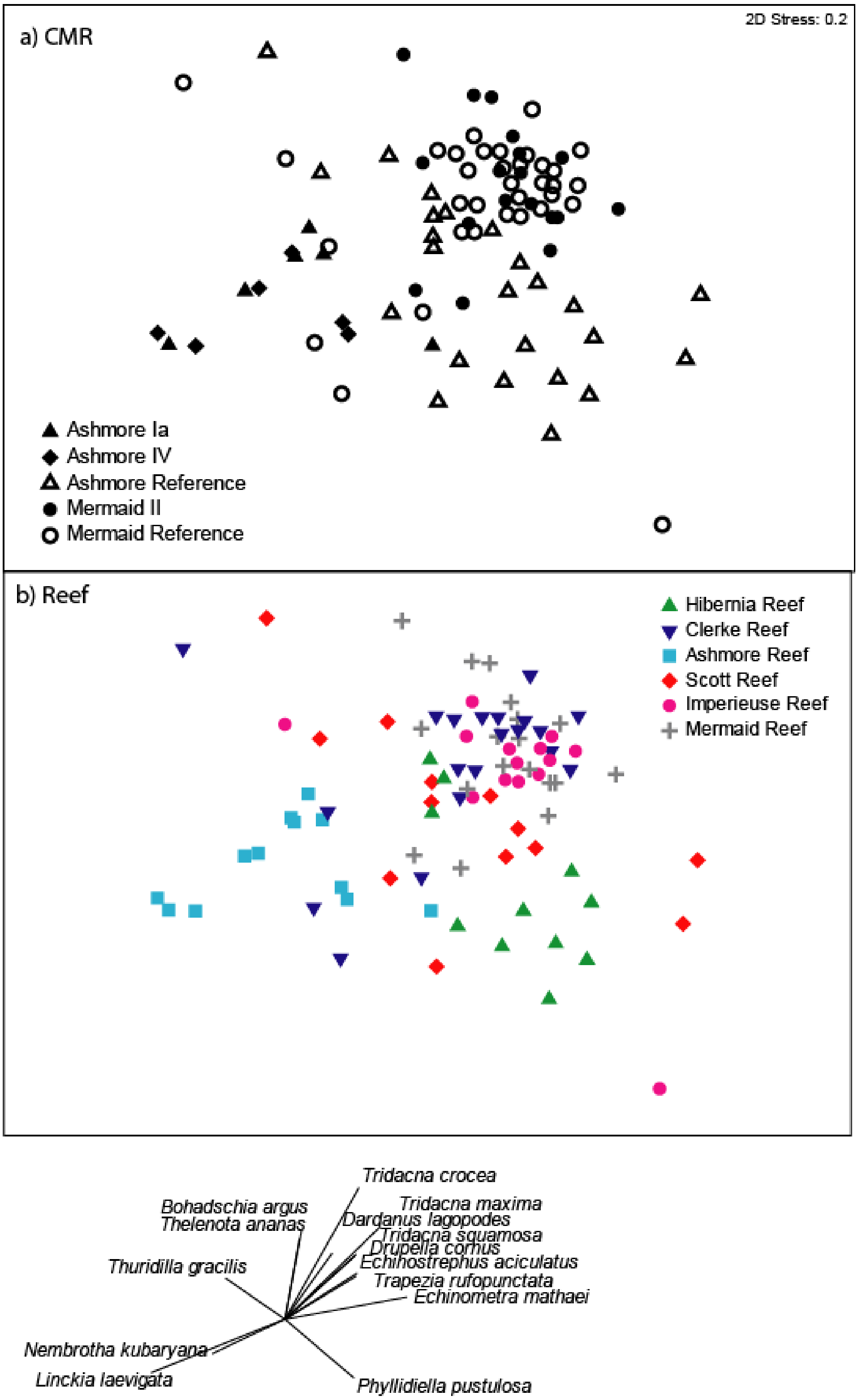

Figure 11. Multidimensional Scaling (MDS) plot of macroinvertebrate abundance across Ashmore and Mermaid Reef CMRs and their reference sites, performed on the Bray-Curtis similarity matrix of the square-root transformed data. Sites are shown by a) CMR categories and b) individual reefs. Species vectors are shown if they had a correlation value of at least 0.5.

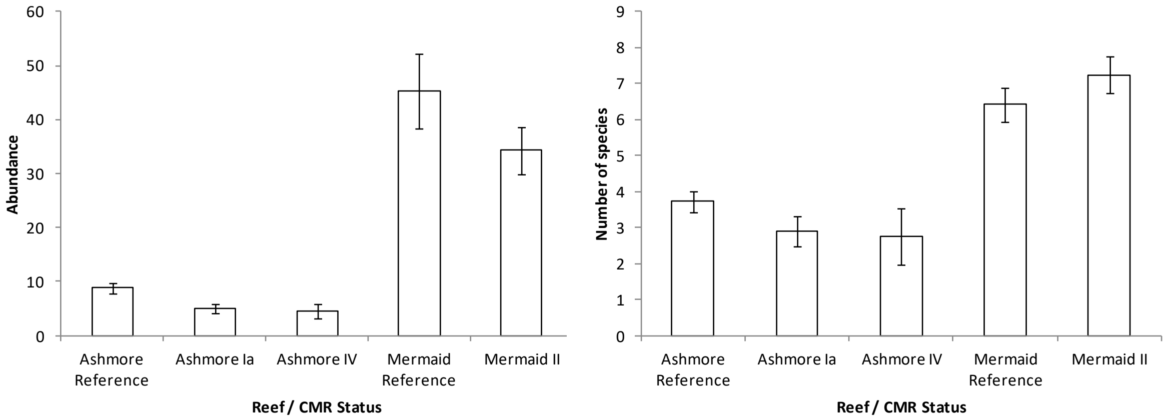

Figure 12. Abundance and species richness of macroinvertebrates per 100 m^2 transect in the CMRs and reference sites. Error Bars = 1 SE.

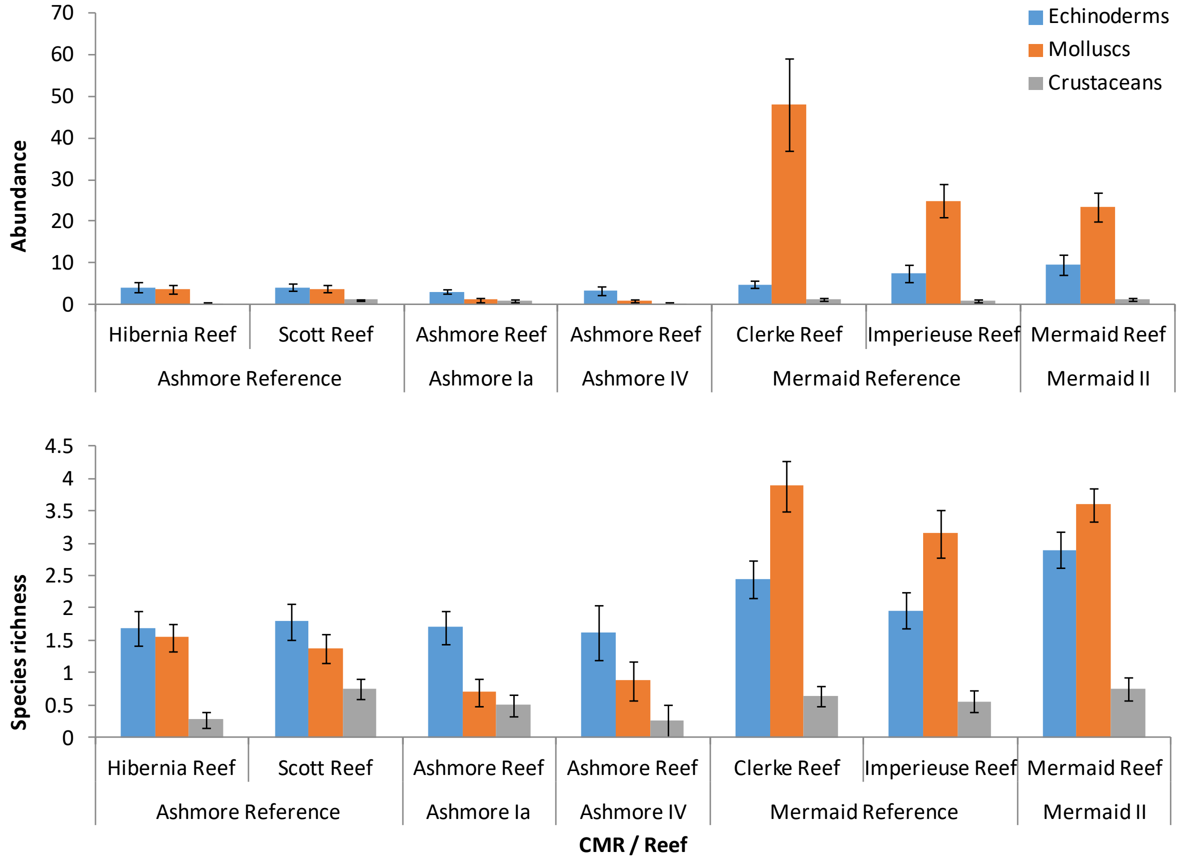

Figure 13. Abundance and species richness of the three key macroinvertebrate classes per 100 m^2 transect at Ashmore Reef CMR, Mermaid Reef CMR and reference sites in the North-west bioregion. Error Bars = 1 SE.

Table 3. ANOVA results for macroinvertebrate classes between CMR categories, square-root transformed.

Metric	Class	$F_{4,159}$	p
Abundance	Total	14.67	<0.001
	Echinoderms	2.8	0.028
	Molluscs	19.8	<0.001
	Crustaceans	0.694	0.597
Species richness	Total	10.9	<0.001
	Echinoderms	2.7	0.031
	Molluscs	20.3	<0.001
	Crustaceans	0.716	0.582

CRYPTIC FISH SURVEYS

Reef sites surveyed with Method 2 yielded 141 species of cryptic fish (this includes unidentified species) across all sites (APPENDIX 5). Ashmore, Hibernia and Imperieuse Reefs had about half the species of cryptic fish (between 30 and 40) than Scott, Mermaid and Clerke Reefs (61-62 species) (Figure 12). Of the identified species, *Istigobius rigilius* was the most abundant species at Ashmore Reef; in the IUCN IV Zone this was followed by a number of unidentified gobies, while in the Sanctuary Zone the next most abundant species were blennies (e.g. *Ecsenius lividanalis*) and cardinalfishes (e.g. *Cheilodipterus quinquelineatus*). Hibernia Reef had a different group of common species, including *Ostorhinchus wassinki*, *Ecsenius bicolor*, *Paracirrhites forsteri* and *Valenciennea strigata*; all are common members of a typical Indo-Pacific cryptic reef fish assemblage. Scott Reef had a combination of species that were also common at Ashmore and Hibernia Reefs; the two most abundant species were *Gobiodon quinquestrigatus* and *Ecsenius alleni*. The latter species was also the most abundant at the Rowley Shoals. The assemblage shifted again in the Rowley Shoals compared with the northern reefs, to species such as *Ecsenius schroederi*, *Ctenogobiops pomastictus*, *Gnatholepis cauerensis* and *Gobiodon spilophthalmus*.

The Ashmore Reef CMR had the highest abundance of cryptic fishes, and Hibernia and Imperieuse Reefs the lowest (Figure 14). The Recreational Use Zone of Ashmore Reef CMR had particularly high abundance of cryptic fishes, but this significantly differed only from the Sanctuary Zone and the reference sites of Ashmore Reef ($F_{3,20}$ = 5.354, p = 0.007). Species richness of cryptic fishes also differed significantly between CMRs ($F_{3,20}$ = 6.368, p = 0.003). Higher species richness was evident at Ashmore Reef and Scott Reef than elsewhere.

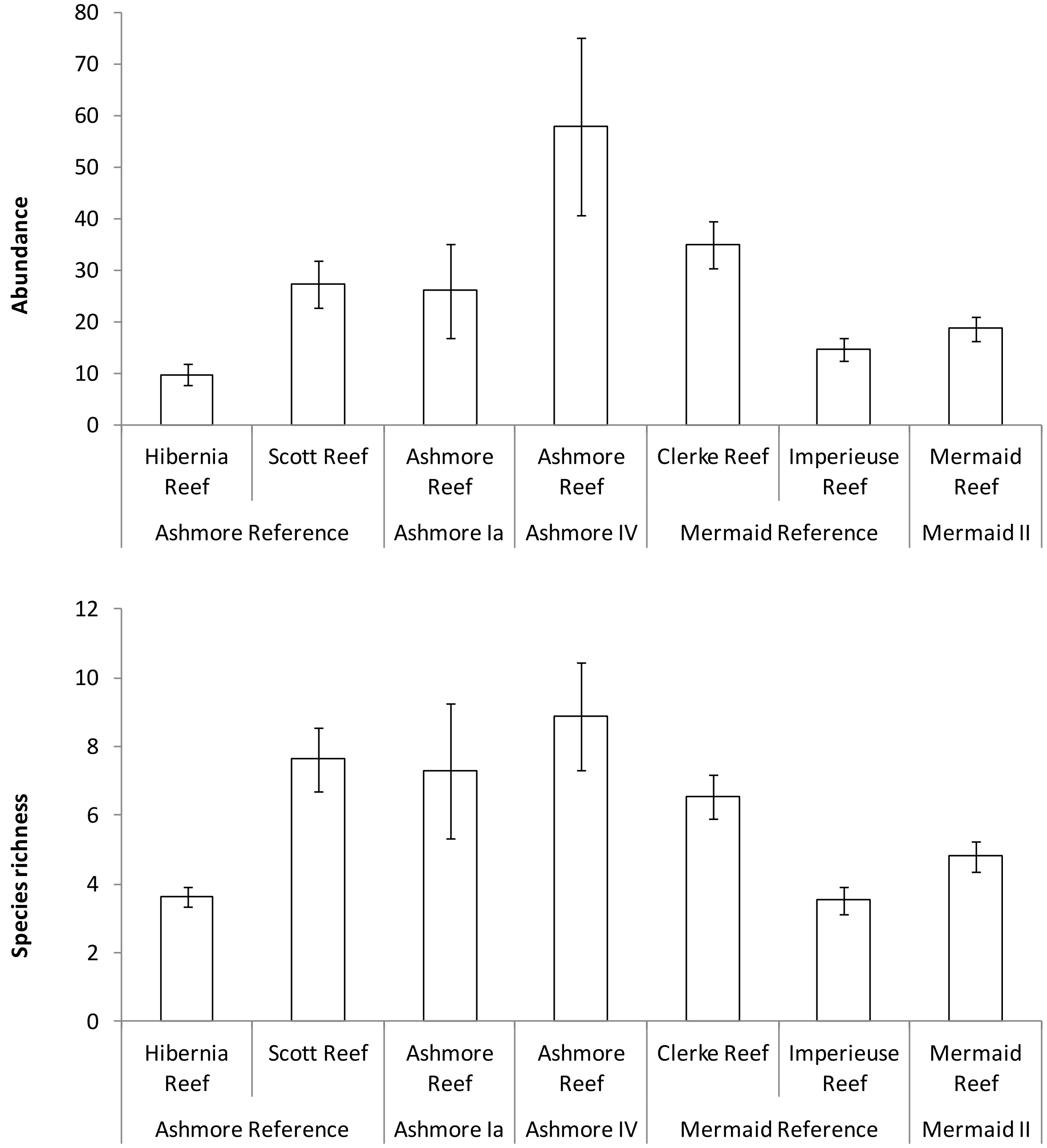

Figure 14. Abundance and species richness of cryptic fishes per 100 m^2 transect in the CMRs and reference sites. Error Bars = 1 SE.

THREATENED AND PROTECTED SPECIES

The only species listed under the EPBC Act recorded in the North-west bioregion comprsied the green turtle *Chelonia mydas* (Vulnerable) at Mermaid Reef, and the turtle-headed seasnake *Emydocephalus annulatus*, Dubois' seasnake *Aipysurus duboisii* and the olive seasnake *Aipysurus laevis* (all Protected Marine Species) at Scott Reef. The manta ray *Manta birostris*, listed as a Protected Migratory species, was recorded at Scott and Clerke Reefs. The highest biomass of sharks was found at the Mermaid Reef CMR, and the lowest on Clerke Reef (Figure 15).

Species listed under international conservation legislation (CITES, Bonn Convention, IUCN Red List) that were recorded during the surveys included sea snakes (*Aipysurus laevis*, *A. duboisii*, *Emydocephalus annulatus*) and several species of grouper, of which five (*Epinephelus polyphekadion*, *Plectropomus areolatus*, *P. laevis*, *P. leopardus* and *P. oligacanthus*) are listed as 'Near Threatened' or 'Vulnerable' on the IUCN Red List. These species were found at most reefs except Ashmore Reef; only *P. leopardus* was found in the Recreational Use Zone of Ashmore Reef CMR. Sharks included the grey reef shark *Carcharhinus amblyrhynchos*, the whitetip reef shark *Triaenodon obesus* (IUCN 'Near Threatened) and the tawny nurse shark *Nebrius ferrugineus* ('Vulnerable'). These species were recorded primarily on the Rowley Shoals, with only one grey reef shark sighted in the Ashmore Reef CMR. The few rays recorded included the manta ray *Manta birostris* ('Vulnerable', Scott Reef and Clerke Reef), the round ribbontailed stingray *Taeniura meyeni* ('Vulnerable', Scott Reef), the ocellated eagle ray *Aetobatus ocellatus* ('Vulnerable', Hibernia Reef) and the porcupine ray *Urogymnus asperrimus* ('Vulnerable', Imperieuse Reef). The humphead Maori wrasse *Cheilinus undulatus* (IUCN 'Endangered') was recorded on several reefs of the North-west bioregion, including Scott Reef and the Rowley Shoals; biomass was between 2 and 3 times lower at Mermaid Reef than at other locations (0.21 kg vs 1.1-1.8 kg).

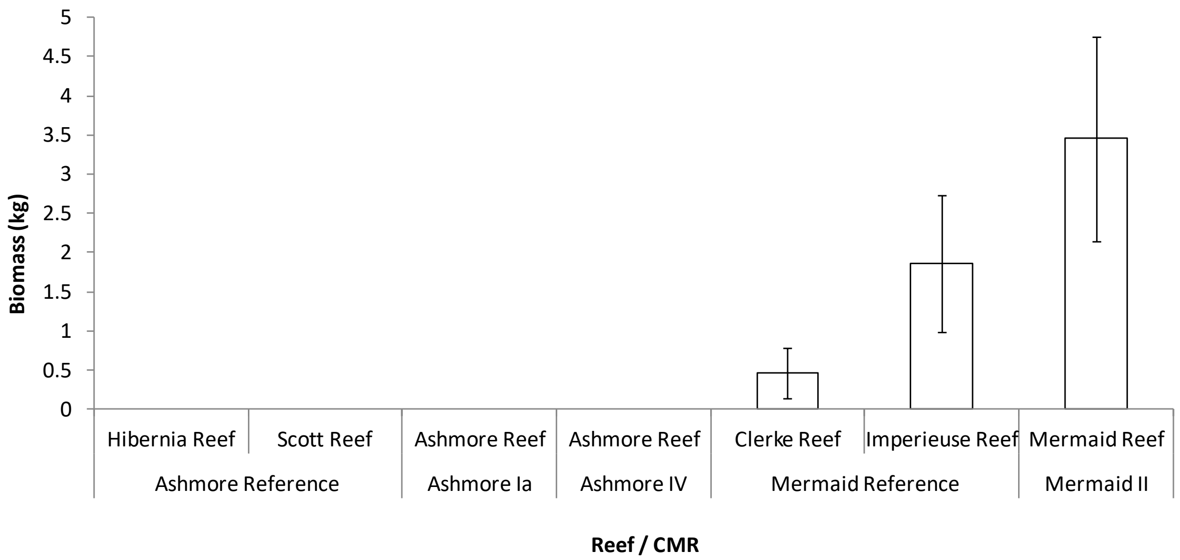

Figure 15. Biomass of sharks per 500 m^2 transect in the CMRs and reference sites. Error Bars = 1 SE.

4 Discussion

Surveys across the North-west bioregion revealed clear distinctions in the fish and invertebrate communities between the northern offshore reefs (Ashmore, Scott and Hibernia) and the Rowley Shoals (Mermaid, Clerke and Imperieuse). As expected, diversity was higher at Ashmore Reef than at reefs less protected (e.g. Hibernia and Scott) or further south (Rowley Shoals). The Rowley Shoals hosted higher biomass and abundance of sharks, fishes and invertebrates; this very likely reflects both the geomorphology of the reefs and the greater exploitation pressure, both legal and illegal, experienced by the northern reefs (Skewes et al. 1999). Illegal harvesting and fishing at Ashmore Reef, including within the IUCN Ia Sanctuary Zone, has occurred sporadically throughout recent decades, despite a Memorandum of Understanding between the Australian and Indonesian Governments (Commonwealth of Australia 2012). Additionally, the unexplained catastrophic decline of sea snakes from Ashmore Reef, which was noted in the past as a global sea snake biodiversity hotspot (Lukoschek et al. 2013), has further depleted Ashmore Reef.

Benthic communities were dominated by live hard coral at most surveyed reefs; only Ashmore Reef had comparatively low cover of all coral morphologies. Algae, abiotic components and soft corals were more abundant at Ashmore Reef than elsewhere. Of the northern reefs used as reference sites for Ashmore Reef, Hibernia Reef had comparable benthic cover, whereas Scott Reef was more similar to the Rowley Shoals, with high coral cover and low cover of turf, soft coral, calcified algae and sponges. The history of recent disturbances at Ashmore Reef, including an oil spill, could be one factor driving the lower coral cover at this reef. However, the orientation and geomorphology of the reef could also play a part. Ashmore Reef has large tracts of reef front oriented towards the prevailing ocean swell, and the flat, low-relief slope dominated by turf and pavement is typical of highly exposed oceanic reef fronts. These habitats typically host few fishes and invertebrates (Chabanet et al. 1997). After severe disturbances, coral larvae arriving in these types of habitats also struggle to settle and survive (Graham et al. 2006).

Ashmore Reef has shown an ability for rapid recovery of hard coral cover, especially at its more sheltered northern and lagoonal sites (Ceccarelli et al. 2011b), as have other reefs in the region (Smith et al. 2008). However, coral cover is still low, and recovering benthic communities do not always immediately lead to increases in fish and invertebrate communities (Bellwood et al. 2012). The Rowley Shoals appear to have maintained historically high cover of branching corals, despite also being affected by bleaching. Their orientation and deep lagoonal habitats may provide enough shelter for coral communities to thrive. Hibernia Reefs appears to have the most unique benthic community of those surveyed across the North-west bioregion, with a combination of hard and soft corals, calcified algae and sponges. Nevertheless, fish and invertebrate communities seemed more closely aligned to live coral cover, with richer assemblages at reefs with higher coral cover (Bell and Galzin 1984, Coker et al. 2014).

Fish and invertebrate communities were more distinct between Ashmore, Scott and Hibernia Reefs than they were between the Rowley Shoals, reflecting the greater geographic distance between the northern reefs. Therefore, Mermaid Reef CMR is more representative of the non-CMR reefs in its vicinity than Ashmore Reef CMR, which is more unique. Ashmore, Scott and Hibernia Reefs appear to host a general Indo-Pacific fauna, due to their proximity to the Indonesian archipelago and the Indonesian Throughflow, which would enhance connectivity to other south-east Asian reefs (Bellwood and Hughes 2001). In contrast, the Rowley Shoals also host some species typical of the Indian Ocean not found on the Pacific side of the Indo-Australian archipelago (Gilmour et al. 2007).

The Ashmore Reef CMR had lower biomass and species richness of reef fishes of most functional groups, lower abundance and species richness of invertebrates, and a lower proportion of IUCN-listed species, when compared with its reference sites and the Rowley Shoals. Only the abundance and species richness of cryptic fishes were highest in the Ashmore Reef CMR. The history of exploitation in the northern reefs may have depleted target populations to the extent where recovery will take place very slowly, and only with very strict protection (Edgar et al. 2014, Green et al. 2014). For some species, especially invertebrates, re-stocking may be the only way to enhance populations in the short term (Bell et al. 2011).

In contrast, Mermaid Reef CMR hosts high biomass of reef fishes, including sharks and other large fishes, and high abundance of invertebrates. Fishing and collecting on the Rowley Shoals is likely to occur less frequently than on reefs further north, due to lower accessibility by both Indonesian and Australian fishers (Commonwealth of Australia 2012). Previous surveys also found that the historically and currently fished northern reefs had fewer sharks than the Rowley Shoals (Meekan et al. 2006). Structural complexity may also play a part; large tracts of Ashmore Reef exposed to the prevailing swell have consistently low-relief benthic communities growing on calcium-carbonate pavement (Ceccarelli et al. 2011b). Fish communities in these habitats tend to be naturally depauperate (Graham and Nash 2013).

Reef fish species richness from previous studies varies from 351 species at Hibernia Reef to 530 species at Mermaid Reef and 756 species at Ashmore Reef (Gilmour et al. 2007, Richards et al. 2009). Baited Remote Underwater Video Stations (BRUVS) recorded a greater diversity of elasmobranchs at Ashmore Reef – with at least 11 species of sharks – than on the Rowley Shoals (Meekan et al. 2005). Overall, striking differences between fished and unfished reefs included 12 sharks of 2 species in 46 deployments at Scott Reef (fished) and 153 sharks of 4 species in 72 deployments at Mermaid Reef (unfished) (Meekan et al. 2005). Despite differences in sampling effort and methodology, Ashmore Reef's proximity to the Indonesian archipelago – which has the world's most diverse fish fauna – is thought to contribute to Ashmore's high fish diversity. Other atolls and reefs of the region (Seringapatam Reef, Scott Reef, and Rowley Shoals) have progressively fewer species with increasing latitude and decreasing temperature (Russell et al. 2001).

The success of management is clear in the case of the Mermaid Reef CMR; higher biomass, abundance and species richness of fishes and invertebrates, higher numbers of protected species and higher coral cover all indicate a well functioning ecosystem with an intact trophic structure and the key attributes of a biodiverse, resilient reef in place (Halford et al. 2004, Sandin et al. 2008, Emslie et al. 2015). Assessing the differences between the CMR and reference sites is assisted with an ideal situation of two almost identical reefs in close proximity, where some fishing occurs, albeit only in particular locations within these reefs. In the case of Ashmore Reef, the effects of management are more difficult to detect. There is a history of disturbance and illegal fishing, a much wider variety of distinct habitats, and the reference sites are further away and with different habitat structure. It may be more useful to analyse data collected at Ashmore Reef in the context of previous studies, or establish regular monitoring using the same sites and methods, to provide a continuing timeline of population change, especially in historically exploited species (Russ and Alcala 2004, Babcock et al. 2010, Ceccarelli et al. 2011a).

5 Recommendations

We recommend that:

- ongoing monitoring of North-west bioregion reefs takes place on a regular basis (5 years or less), using the methods and sites described here;
- data presented in recent RLS surveys be combined with previous surveys to guide efforts to select sites for long-term monitoring;
- research priorities include development of indicators that track changes in reef condition and biodiversity;
- factors contributing to low fish and invertebrate biomass, abundance and species richness at Ashmore Reef are investigated;
- detailed habitat mapping and categorisation of reef types, exposure and aspect is undertaken for inclusion in analyses of ecological patterns;
- detailed spatial and temporal mapping of distribution and impact of natural disturbances is carried out; and
- greater collaboration between agencies collecting data on reef fo the North-west bioregion is encouraged.

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Appendices

APPENDIX 1 – SITE DETAILS OF TRANSECTS SURVEYED IN THE NORTH-WEST BIOREGION.

Site No.	Reserve status	IUCN category	Site name	Latitude	Longitude	Depth	SurveyDate	Visibility
NWS14	Ashmore	IUCN Ia	Surge Crest East	-12.217	123.0039	4	3/09/2013	12
	Ashmore	IUCN Ia				3.5	3/09/2013	8
NWS15	Ashmore	IUCN Ia	Surge Crest West	-12.2159	123.0058	2.5	3/09/2013	13
	Ashmore	IUCN Ia				3	3/09/2013	13
NWS16	Ashmore	IUCN IV	Guardian Reef	-12.2396	122.9839	5	3/09/2013	15
	Ashmore	IUCN IV				8	3/09/2013	10
NWS17	Ashmore	IUCN IV	Turtle Patch	-12.2418	122.9906	3.5	3/09/2013	14
NWS18	Ashmore	IUCN IV	Busy Bommie	-12.2412	122.9849	5	4/09/2013	10
NWS19	Ashmore	IUCN IV	Grand Oculis Bommie	-12.2405	122.9833	5	4/09/2013	12
NWS20	Ashmore	IUCN Ia	Flat's Edge	-12.2441	123.0018	3	4/09/2013	12
NWS21	Ashmore	IUCN Ia	Hemiplage Bommie	-12.2441	122.9988	4.5	4/09/2013	8
NWS22	Ashmore	IUCN IV	Dotty Reef	-12.2411	122.9864	5	4/09/2013	12
	Ashmore	IUCN IV				4.5	4/09/2013	15
NWS23	Ashmore	IUCN Ia	Kuhlii Bommie	-12.2338	122.99	3.5	4/09/2013	10
	Ashmore	IUCN Ia				5	4/09/2013	10
NWS24	Ashmore	IUCN Ia	Reel Lost Bommie	-12.2426	122.9853	6	5/09/2013	8
	Ashmore	IUCN Ia				4.5	5/09/2013	10
NWS25	Ashmore	IUCN IV	Eviota Bommie	-12.2399	122.9864	5	5/09/2013	8
NWS65	Mermaid	IUCN II	Mermaid south M7	-17.1337	119.6339	7	25/09/2013	30
	Mermaid	IUCN II				10	25/09/2013	30
NWS66	Mermaid	IUCN II	Mermaid anchorage dropoff 1.3	-7.0764	119.6539	25	26/09/2013	20

	Mermaid	IUCN II				7	25/09/2013	12
	Mermaid	IUCN II				4	25/09/2013	12
Site No.	**Reserve status**	**IUCN category**	**Site name**	**Latitude**	**Longitude**	**Depth**	**SurveyDate**	**Visibility**
NWS67	Mermaid	IUCN II	Mermaid anchorage bommie	-7.0737	119.6455	5	26/09/2013	20
	Mermaid	IUCN II				4	26/09/2013	12
NWS68	Mermaid	IUCN II	Mermaid S channel entrance	-7.0626	119.647	10	26/09/2013	15
	Mermaid	IUCN II				9	26/09/2013	15
NWS69	Mermaid	IUCN II	Mermaid anchorage dropoff 1.1	-7.0658	119.6494	5	27/09/2013	25
	Mermaid	IUCN II				22	27/09/2013	25
NWS70	Mermaid	IUCN II	Mermaid SW bommie M11	-7.1641	119.6277	4.5	27/09/2013	15
	Mermaid	IUCN II				9	27/09/2013	15
NWS71	Mermaid	IUCN II	Mermaid S bommie	-7.1537	119.6311	5	27/09/2013	12
	Mermaid	IUCN II				7	27/09/2013	12
NWS72	Mermaid	IUCN II	Mermaid Reef Lagoon Dragon	-7.0754	119.6462	12	27/09/2013	10
	Mermaid	IUCN II				10	27/09/2013	10
NWS73	Mermaid	IUCN II	Mermaid channel mid bank	-7.0664	119.6417	4	28/09/2013	16
	Mermaid	IUCN II				5	28/09/2013	16
NWS74	Mermaid	IUCN II	Mermaid Lagoon Reef Dragon Escape	-7.0698	119.6437	4	28/09/2013	20
	Mermaid	IUCN II				4.5	28/09/2013	20
NWS75	Mermaid	IUCN II	Mermaid west lagoon	-7.0869	119.6148	9	28/09/2013	10
	Mermaid	IUCN II				3	28/09/2013	10
NWS76	Mermaid	IUCN II	Mermaid central bommie	-7.1147	119.6347	3	28/09/2013	15
	Mermaid	IUCN II				8	28/09/2013	15
NWS77	Mermaid	IUCN II	Mermaid Reef Cod Hole	-17.062	119.6482	5	29/09/2013	23
	Mermaid	IUCN II				22	29/09/2013	23
NWS78	Mermaid	IUCN II	Mermaid channel bommies	-7.0666	119.6403	5	29/09/2013	15
	Mermaid	IUCN II				6	29/09/2013	15
NWS79	Mermaid	IUCN II	Mermaid dropoff 1.2	-7.0721	119.6533	4	29/09/2013	20
	Mermaid	IUCN II				11	29/09/2013	20
NWS80	Mermaid	IUCN II	Mermaid Reef No Pygmy	-7.0818	119.6552	11	29/09/2013	20

	Mermaid	IUCN II				5	29/09/2013	20
NWS81	Mermaid	IUCN II	Mermaid North M1	-7.0277	119.6179	5	30/09/2013	30
Site No.	**Reserve status**	**IUCN category**	**Site name**	**Latitude**	**Longitude**	**Depth**	**SurveyDate**	**Visibility**
	Mermaid	IUCN II				12	30/09/2013	30
NWS82	Mermaid	IUCN II	Mermaid west dropoff M4	-7.0762	119.5962	5	30/09/2013	30
	Mermaid	IUCN II				8	30/09/2013	30
NWS10	Reference	Open	Rogaa Bommie	-1.9745	123.3214	8	2/09/2013	15
	Reference	Open				15	2/09/2013	15
NWS100	Reference	Open	Clerke east reef top C28	-7.2997	119.3758	1.5	4/10/2013	30
	Reference	Open				2	4/10/2013	30
NWS101	Reference	Open	Clerke Reef - BnB	-7.3552	119.3839	7.5	4/10/2013	30
	Reference	Open				5	4/10/2013	30
NWS102	Reference	Open	Clerke SE reef top C27	-7.3139	119.3782	1	4/10/2013	30
NWS11	Reference	Open	Hibernia Lagoon SW	-1.9806	123.3352	3	2/09/2013	18
	Reference	Open				2.5	2/09/2013	18
NWS12	Reference	Open	Hibernia Lagoon NW	-1.9763	123.3376	5	2/09/2013	15
	Reference	Open				6	2/09/2013	15
NWS13	Reference	Open	Golden Sleeper Corner	-1.9834	123.3271	9	2/09/2013	15
	Reference	Open				7	2/09/2013	15
	Reference	Open				7.1	2/09/2013	15
NWS27	Reference	Open	Election Day Reef	-4.0704	121.9613	3	7/09/2013	15
	Reference	Open				4	7/09/2013	15
NWS28	Reference	Open	Consolation Bommie	-4.1327	121.9422	6	8/09/2013	25
NWS29	Reference	Open	Moray Bommie	-4.1267	121.9455	6	8/09/2013	25
NWS3	Reference	Open	Cardinal Shoal	-1.9719	123.3878	6	1/09/2013	15
	Reference	Open				9	1/09/2013	15
NWS30	Reference	Open	Longnose Spur	-4.1418	121.9589	6	8/09/2013	30
NWS31	Reference	Open	Napoleon Reef	-4.1438	121.9569	10	8/09/2013	25
NWS32	Reference	Open	Goby Heaven	-4.1093	121.9647	4.1	8/09/2013	15
	Reference	Open				4	8/09/2013	10

NWS33	Reference	Open	NE Passage	-14.056	121.9585	9	9/09/2013	30
	Reference	Open				6	9/09/2013	30
Site No.	**Reserve status**	**IUCN category**	**Site name**	**Latitude**	**Longitude**	**Depth**	**SurveyDate**	**Visibility**
NWS34	Reference	Open	Table Tip	-4.0626	121.9653	7.5	9/09/2013	30
	Reference	Open				5	9/09/2013	30
NWS35	Reference	Open	Ian's Anchorage	-4.0717	121.9508	7	9/09/2013	15
	Reference	Open				6	9/09/2013	15
NWS36	Reference	Open	Fungiid Fields	-4.0747	121.7877	10	10/09/2013	35
	Reference	Open				8	10/09/2013	35
NWS37	Reference	Open	Stake Edge	-4.0453	121.7807	7	10/09/2013	35
	Reference	Open				6	10/09/2013	35
NWS38	Reference	Open	Chaetodontoides	-4.0687	121.7765	6	10/09/2013	25
	Reference	Open				5	10/09/2013	25
NWS39	Reference	Open	Odonus Dropoff	-4.0828	121.7482	7	11/09/2013	25
	Reference	Open				5	11/09/2013	25
NWS4	Reference	Open	Titan Reef	-11.969	123.3794	8	1/09/2013	20
	Reference	Open				5.5	1/09/2013	20
NWS41	Reference	Open	Dead West	-4.1082	121.7207	11.5	11/09/2013	25
	Reference	Open				12	11/09/2013	25
NWS5	Reference	Open	Hibernia Lagoon SE	-1.9796	123.3807	5	1/09/2013	15
	Reference	Open				3.1	1/09/2013	15
NWS50	Reference	Open	Imperieuse SE lagoon	-7.6101	118.97	1	21/09/2013	25
	Reference	Open				1.5	21/09/2013	25
NWS51	Reference	Open	Imperieuse West Lagoon	-7.6089	118.9636	7	21/09/2013	30
	Reference	Open				4	21/09/2013	30
NWS52	Reference	Open	Imperieuse SE reef edge	-7.6089	118.9636	4	21/09/2013	35
	Reference	Open				5	21/09/2013	35
NWS53	Reference	Open	Imperieuse SE reef top	-17.579	118.9687	0.1	22/09/2013	30
	Reference	Open				0.3	22/09/2013	30
NWS54	Reference	Open	Imperieuse east lagoon	-7.5804	118.9369	2	22/09/2013	10

	Reference	Open				1	22/09/2013	10
NWS55	Reference	Open	Imperieuse East	-7.5699	118.9719	4	22/09/2013	30
Site No.	**Reserve status**	**IUCN category**	**Site name**	**Latitude**	**Longitude**	**Depth**	**SurveyDate**	**Visibility**
	Reference	Open				5	22/09/2013	30
NWS56	Reference	Open	Imperieuse Reef Rage	-7.6102	118.9747	8	22/09/2013	40
	Reference	Open				7.5	22/09/2013	40
NWS57	Reference	Open	Imperieuse edge	-17.548	118.9737	10	23/09/2013	22
NWS58	Reference	Open	Rowley Shoals 3	-7.5531	118.9738	7.5	23/09/2013	40
NWS59	Reference	Open	Imperieuse lagoon bommie	-7.5473	118.9668	3	23/09/2013	22
	Reference	Open				5	23/09/2013	22
NWS6	Reference	Open	Hibernia Lagoon SE2	-1.9745	123.3812	4	1/09/2013	20
	Reference	Open				5	1/09/2013	20
NWS60	Reference	Open	Imperieuse 14	-7.5475	118.9688	1.5	23/09/2013	25
	Reference	Open				2.5	23/09/2013	25
NWS61	Reference	Open	Imperieuse edge RS3-3	-7.5582	118.9724	4	23/09/2013	22
	Reference	Open				7	23/09/2013	22
NWS62	Reference	Open	Imperieuse anchorage	-7.5071	118.9664	16	24/09/2013	25
NWS63	Reference	Open	Imperieuse north	-7.5022	118.9628	5	24/09/2013	32
	Reference	Open				7	24/09/2013	32
NWS64	Reference	Open	Imperieuse north lagoon	-7.5605	118.9421	1.5	24/09/2013	10
	Reference	Open				2	24/09/2013	10
NWS7	Reference	Open	Big Fish Gulch	-1.9671	123.3586	7	1/09/2013	20
	Reference	Open				4.5	1/09/2013	15
NWS8	Reference	Open	Hibernia Lagoon South	-1.9791	123.3608	5	1/09/2013	20
NWS83	Reference	Open	Clerke North C1B	-7.2461	119.352	7	1/10/2013	22
	Reference	Open				9	1/10/2013	22
NWS84	Reference	Open	Clerke North Point	-7.2461	119.3471	10	1/10/2013	30
	Reference	Open				6	1/10/2013	30
NWS85	Reference	Open	Clerke Reef - Far too early	-7.2461	119.352	4.5	1/10/2013	40
NWS86	Reference	Open	Clerke anchorage dropoff 2.1	-7.2909	119.3593	5	1/10/2013	33

Site No.	Reserve status	IUCN category	Site name	Latitude	Longitude	Depth	SurveyDate	Visibility
	Reference	Open				8	1/10/2013	33
NWS87	Reference	Open	Clerke Anchorage Dropoff 2.2	-17.288	119.3775	7	1/10/2013	30
	Reference	Open				5	1/10/2013	30
NWS88	Reference	Open	Clerke anchorage dropoff 2.3	-17.288	119.3775	8	1/10/2013	30
	Reference	Open				5	1/10/2013	30
NWS89	Reference	Open	Blue lagoon	-17.253	119.3604	18	2/10/2013	30
NWS9	Reference	Open	Spur and Groove Reef	-1.9685	123.3356	7	2/09/2013	15
	Reference	Open				8	2/09/2013	15
NWS90	Reference	Open	Clerke Reef Snorkelling Paradise	-7.2863	119.3724	2.5	2/10/2013	15
	Reference	Open				2	2/10/2013	15
NWS91	Reference	Open	Clerke NE C14	-7.2831	119.373	1.5	2/10/2013	30
	Reference	Open				2	2/10/2013	30
NWS92	Reference	Open	Clerke Reef Aquarium	-7.2832	119.3705	8	2/10/2013	13
NWS93	Reference	Open	Clerke west lagoon C26	-7.2977	119.3423	3	2/10/2013	8
	Reference	Open				4	2/10/2013	8
NWS94	Reference	Open	Clerke west C12	-7.3107	119.3675	6	2/10/2013	7
	Reference	Open				5.5	2/10/2013	7
NWS95	Reference	Open	Clerke lagoon bommie C13	-7.3107	119.3675	4	3/10/2013	12
	Reference	Open				6	3/10/2013	12
NWS96	Reference	Open	South Lagoon bommie C21	-7.3188	119.3605	6	3/10/2013	13
	Reference	Open				3	3/10/2013	13
NWS97	Reference	Open	Clerke south lagoon C25	-7.3155	119.3675	3	3/10/2013	15
	Reference	Open				4	3/10/2013	15
NWS98	Reference	Open	Clerke lagoon east C20	-7.3069	119.3706	2	3/10/2013	15
	Reference	Open				4	3/10/2013	15
NWS99	Reference	Open	Clerke lagoon NW bommie C29	-7.2909	119.3593	2	4/10/2013	10
	Reference	Open				3	4/10/2013	10

APPENDIX 2 – REEF LIFE SURVEY BENTHIC FUNCTIONAL GROUPS.

Broad group	RLS Functional group
Coral	Ahermatypic corals
Coral	Bleached coral
Coral	Branching *Acropora*
Coral	Encrusting corals
Coral	Hydrocoral
Coral	Large-polyp stony corals
Coral	Massive corals (Live)
Coral	Other branching/erect corals (Live)
Coral	*Pocillopora*
Coral	Soft corals and gorgonians
Coral	Tabular Coral (Live)
Other	Ascidians (stalked)
Other	Ascidians (unstalked)
Other	Bare Rock
Other	Barnacles
Other	Bryozoan (hard)
Other	Bryozoan (soft)
Other	Colonial Anemones, Zoanthids and Corallimorphs
Other	Dead Coral
Other	Hydroids
Other	Pebbles/unconsolidated rocky bottom/coral rubble
Other	Polychaete
Other	Sand
Other	Seagrass (*Halophila*)
Other	Seagrass (other)
Other	Sessile bivalves

Other	Sessile gastropods
Other	Solitary Anemones
Other	Sponges (encrusting)
Other	Sponges (erect)
Other	Sponges (hollow)
Other	Sponges (massive)
Algae	algal mat/slime
Algae	*Caulerpa*
Algae	Crustose coralline algae
Algae	cyanobacterial mat/slime
Algae	*Desmarestia* and *Himantothallus*
Algae	*Durvillaea*
Algae	Encrusting leathery algae
Algae	Filamentous epiphytic algae
Algae	Filamentous rock-attached algae
Algae	Foliose red algae
Algae	Geniculate coralline algae
Algae	Green calcified algae
Algae	Large brown laminarian kelps
Algae	Other foliose green algae
Algae	Other fucoids
Algae	*Phyllospora*
Algae	Small to medium foliose brown algae
Algae	Turfing algae (<2 cm high algal/sediment mat on rock)

APPENDIX 3 – SPECIES LIST OF FISHES SURVEYED ALONG 500 M2 TRANSECTS AND EACH REEF; ASHMORE REEF IS DIVIDED INTO THE TWO IUCN ZONES. FREQUENCY OF OCCURRENCE (TRANSECTS) AND BIOMASS ARE GIVEN FOR EACH SPECIES.

Species	Transects							Biomass						
	AshIV	AshIa	Hib	Scott	Imp	Mer	Cler	AshIV	AshIa	Hib	Scott	Imp	Mer	Cler
Abudefduf vaigiensis	1	3	1	4	2	3	2	1.09	0.54	0.09	2.12	6.88	20.49	14.04
Acanthochromis polyacanthus	6	4	9	0	0	0	0	2.99	1.13	3.1	0	0	0	0
Acanthurus auranticavus	0	0	0	1	0	0	0	0	0	0	0.27	0	0	0
Acanthurus blochii	0	0	0	3	4	5	7	0	0	0	7.59	25.36	22.75	69
Acanthurus dussumieri	0	0	0	0	1	4	0	0	0	0	0	1.02	5.41	0
Acanthurus grammoptilus	2	3	1	1	3	0	0	1.86	3.26	0.53	0.15	2.25	0	0
Acanthurus leucocheilus	0	1	0	0	0	0	0	0	0.27	0	0	0	0	0
Acanthurus lineatus	0	3	2	7	5	8	3	0	4.26	5.16	5.56	5.61	16.52	7.03
Acanthurus mata	0	0	0	1	0	0	0	0	0	0	4.42	0	0	0
Acanthurus nigricans	3	2	19	22	13	24	15	3.99	0.09	7.58	59.17	25.39	80.77	44.28
Acanthurus nigricauda	1	3	4	8	7	4	6	0.55	0.59	3.56	30.81	16.49	7.84	30.82
Acanthurus nigrofuscus	2	2	10	10	19	26	19	0.24	0.55	2.85	2.01	36.68	86.26	58.8
Acanthurus olivaceus	2	4	5	5	1	0	2	0.32	0.12	0.32	5.93	0.56	0	4.36
Acanthurus pyroferus	5	3	11	5	0	4	1	1.37	1.63	5.44	0.32	0	1.21	0.12
Acanthurus thompsoni	0	0	0	0	1	8	6	0	0	0	0	1.7	22.79	5.06
Acanthurus triostegus	0	0	0	1	2	0	0	0	0	0	0.05	0.45	0	0
Aethaloperca rogaa	2	3	7	6	3	2	4	0.74	1.16	4.37	10.51	1.81	0.57	1.4
Aetobatus ocellatus	0	0	1	0	0	0	0	0	0	227.38	0	0	0	0
Aluterus scriptus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Amanses scopas	0	1	0	0	0	0	0	0	0.06	0	0	0	0	0
Amblyglyphidodon aureus	0	0	0	3	0	5	0	0	0	0	0.26	0	3.27	0
Amblyglyphidodon curacao	8	6	9	4	7	8	14	15.6	9.62	8.05	0.54	2.9	1.95	4.33
Amblyglyphidodon leucogaster	2	3	1	3	0	0	0	0.22	0.45	0	0.12	0	0	0
Amphiprion clarkii	0	0	3	0	5	1	3	0	0	0.25	0	0.19	0.05	0.16
Amphiprion frenatus	0	0	1	0	0	0	0	0	0	0.01	0	0	0	0

Species	Transects AshIV	AshIa	Hib	Scott	Imp	Mer	Cler	Biomass AshIV	AshIa	Hib	Scott	Imp	Mer	Cler
Amphiprion ocellaris	0	0	0	1	0	0	0	0	0	0	0.02	0	0	0
Amphiprion perideraion	0	1	0	1	1	3	2	0	0.07	0	0.03	0.11	0.08	0.15
Anampses caeruleopunctatus	0	0	1	1	0	0	1	0	0	0.14	0.06	0	0	0.06
Anampses twistii	0	0	3	6	4	11	1	0	0	0.17	0.23	0.2	0.71	0.04
Anyperodon leucogrammicus	1	0	0	6	4	2	0	0.52	0	0	3.34	1.45	0.58	0
Aphareus furca	0	0	1	0	11	11	12	0	0	0.1	0	6.89	4.29	10.52
Apolemichthys trimaculatus	0	0	5	1	1	2	0	0	0	0.62	0.18	0.43	1.15	0
Aprion virescens	0	0	4	3	3	1	0	0	0	6.17	4.11	3.16	0.56	0
Arothron hispidus	0	0	0	2	0	1	2	0	0	0	8.97	0	0.56	1.34
Arothron nigropunctatus	0	1	0	0	1	3	1	0	0.23	0	0	0.35	1.04	0.21
Arothron stellatus	0	0	0	0	2	0	1	0	0	0	0	9.23	0	11.31
Aspidontus taeniatus	1	0	0	1	0	0	0	0.01	0	0	0.01	0	0	0
Aulostomus chinensis	0	0	0	1	1	0	3	0	0	0	0.06	0.02	0	0.62
Balistapus undulatus	0	2	5	13	11	22	11	0	0.18	0.36	1.46	5	8.65	6.54
Balistoides conspicillum	0	0	2	0	0	0	0	0	0	1.79	0	0	0	0
Balistoides viridescens	0	0	3	0	2	0	0	0	0	10.72	0	6.29	0	0
Balenoperca chabanaudi	0	0	0	0	0	1	0	0	0	0	0	0	0.11	0
Bodianus axillaris	5	1	9	4	8	7	7	0.84	0.13	1.19	0.4	2.75	0.95	0.72
Bodianus diana	0	0	2	1	2	1	0	0	0	0.1	0.17	0.05	0.06	0
Bodianus mesothorax	1	0	3	0	0	0	0	0.02	0	0.22	0	0	0	0
Bolbometopon muricatum	0	0	0	1	4	0	5	0	0	0	211.34	17.49	0	3.59
Caesio caerulaurea	0	0	0	1	0	0	0	0	0	0	3.15	0	0	0
Caesio lunaris	2	0	2	4	2	8	2	6.08	0	0.42	1.13	117.22	40.56	35.43
Caesio teres	0	0	0	3	1	1	1	0	0	0	6.93	0.23	32.23	6.12
Calotomus spinidens	0	0	0	0	0	0	1	0	0	0	0	0	0	0.44
Cantherhines dumerilii	0	1	2	1	0	1	0	0	0.23	0.49	0.04	0	0.35	0
Cantherhines pardalis	0	0	3	3	1	0	3	0	0	0.28	0.15	0.12	0	0.5
Canthigaster janthinoptera	0	1	0	0	0	0	0	0	0.01	0	0	0	0	0
Canthigaster papua	0	0	1	8	2	0	5	0	0	0.01	0.25	0.44	0	0.27

Species	Transects AshIV	AshIa	Hib	Scott	Imp	Mer	Cler	Biomass AshIV	AshIa	Hib	Scott	Imp	Mer	Cler
Canthigaster valentini	5	1	6	0	0	0	1	0.47	0.01	0.07	0	0	0	0.01
Caracanthus unipinna	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Carangoides orthogrammus	0	0	0	1	0	0	1	0	0	0	34.99	0	0	6.6
Carangoides plagiotaenia	0	0	0	1	2	3	1	0	0	0	2.57	1.01	1.76	0.27
Caranx ignobilis	0	0	1	0	0	0	0	0	0	10.53	0	0	0	0
Caranx lugubris	0	0	0	1	4	5	0	0	0	0	2.61	9.72	40.2	0
Caranx melampygus	2	2	5	3	3	3	7	1.61	22.09	68.33	153.79	3.98	2.5	36.99
Caranx sexfasciatus	0	0	0	0	0	1	0	0	0	0	0	0	0.7	0
Carcharhinus amblyrhynchos	0	0	0	0	0	5	0	0	0	0	0	0	76.67	0
Centropyge bicolor	1	1	5	7	0	0	1	0.02	0.1	0.53	1.22	0	0	0.1
Centropyge bispinosa	0	0	0	1	0	0	0	0	0	0	0.01	0	0	0
Centropyge eibli	0	0	0	0	11	23	17	0	0	0	0	1.46	1.45	3.87
Centropyge tibicen	4	2	1	0	0	0	0	0.4	0.05	0.03	0	0	0	0
Centropyge vrolikii	7	7	18	15	2	0	0	1.01	0.82	2.78	3.76	0.1	0	0
Cephalopholis argus	5	6	12	20	21	31	26	2.19	1.6	9.94	14.45	45.53	52.93	35.93
Cephalopholis cyanostigma	0	1	0	0	0	0	0	0	0.21	0	0	0	0	0
Cephalopholis leopardus	1	0	1	4	0	0	0	0.01	0	0.1	0.26	0	0	0
Cephalopholis sexmaculata	0	0	0	1	0	0	0	0	0	0	0.1	0	0	0
Cephalopholis urodeta	0	2	7	14	11	3	9	0	0.35	4.77	5.12	6.45	0.59	3.7
Cetoscarus bicolor	2	1	5	6	5	10	15	0.02	0.02	0.78	2.93	2.46	8.25	8
Chaetodon adiergastos	1	0	4	6	6	4	7	0.11	0	1.18	5.52	2.06	2.48	3.96
Chaetodon auriga	4	4	1	8	13	13	15	1.04	1.27	0.09	4.13	5.1	6.98	6.52
Chaetodon baronessa	1	2	4	14	0	0	0	0.37	1.12	0.13	3.01	0	0	0
Chaetodon bennetti	0	0	0	1	2	7	9	0	0	0	0.16	0.19	1.09	2.58
Chaetodon citrinellus	0	0	5	6	4	1	5	0	0	0.92	1.07	0.48	0.04	0.43
Chaetodon ephippium	4	3	3	2	9	9	16	1.3	0.34	0.56	0.43	4.86	3.29	9.67
Chaetodon kleinii	2	3	15	2	0	0	0	0.08	0.69	4.8	0.11	0	0	0
Chaetodon lineolatus	0	0	0	0	5	0	2	0	0	0	0	1.7	0	0.79
Chaetodon lunula	4	3	4	4	9	14	13	0.67	0.59	0.78	0.79	4.64	8.89	7.6

Species	Transects AshIV	AshIa	Hib	Scott	Imp	Mer	Cler	Biomass AshIV	AshIa	Hib	Scott	Imp	Mer	Cler
Chaetodon lunulatus	8	6	14	19	19	23	29	4.82	3.78	3.07	8.64	3.82	7.39	12.2
Chaetodon melannotus	3	2	3	0	1	0	0	0.28	0.77	0.31	0	0.05	0	0
Chaetodon meyeri	0	0	6	5	4	11	5	0	0	0.44	1.72	1.02	4.03	0.99
Chaetodon ornatissimus	0	0	3	9	16	27	13	0	0	0.24	4.1	7.62	17.8	9.49
Chaetodon plebeius	0	0	0	0	0	1	0	0	0	0	0	0	0.07	0
Chaetodon punctatofasciatus	0	0	0	8	7	19	14	0	0	0	1.44	1.94	5.28	7.64
Chaetodon rafflesii	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chaetodon semeion	0	0	0	4	7	6	6	0	0	0	1.05	2.18	2.12	2.11
Chaetodon speculum	0	0	0	0	9	10	6	0	0	0	0	2.42	2.49	1.31
Chaetodon trifascialis	1	4	5	14	15	14	17	0.16	0.26	0.31	5.91	2.94	5.07	7.47
Chaetodon trifasciatus	0	0	0	0	0	1	0	0	0	0	0	0	0.2	0
Chaetodon ulietensis	3	3	2	12	15	23	23	0.76	0.67	0.42	3.6	6.03	10.15	8.73
Chaetodon unimaculatus	1	0	2	0	2	5	1	0.06	0	0.15	0	0.14	1.27	0.78
Chaetodon vagabundus	5	3	2	12	2	0	1	0.86	0.48	0.13	4	0.16	0	0.27
Chaetodontoplus mesoleucus	2	0	0	0	0	0	0	0.54	0	0	0	0	0	0
Cheilinus chlorourus	1	2	3	1	2	2	5	0.07	0.13	0.22	0.29	0.03	0.05	0.36
Cheilinus fasciatus	5	3	7	1	4	12	12	2.68	1.66	1.67	0.52	2.93	6.63	3.14
Cheilinus oxycephalus	1	1	4	0	0	0	0	0.08	0.06	0.19	0	0	0	0
Cheilinus trilobatus	0	5	7	3	0	2	3	0	0.47	2.43	0.07	0	1.42	1.21
Cheilinus undulatus	0	0	0	2	9	6	13	0	0	0	27.3	47.9	7.79	52.64
Cheilodipterus artus	1	0	1	0	0	1	0	0.16	0	0.05	0	0	0	0
Cheilodipterus macrodon	0	0	0	0	1	0	0	0	0	0	0	0.02	0	0
Cheilodipterus quinquelineatus	6	3	3	3	5	6	10	1.24	0.04	0.04	0.07	0.09	0.07	0.26
Chlorurus bleekeri	2	3	5	0	0	8	6	1.54	0.97	6.76	0	0	12.48	7.96
Chlorurus microrhinos	2	0	4	11	14	28	20	0.44	0	3.5	37.65	61.28	291.9	275.79
Chlorurus sordidus	8	10	20	22	23	31	34	46.84	28.86	19.88	63.03	37.47	58.84	86.98
Chromis alpha	0	0	0	0	0	1	0	0	0	0	0	0	0.07	0
Chromis amboinensis	0	0	0	0	0	4	5	0	0	0	0	0	0.3	3.04

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Chromis atripectoralis	3	2	4	0	0	1	1	0.34	0.28	0.08	0	0	1.12	4.17
Chromis atripes	1	1	1	6	3	17	6	0	0	0	0.2	0.17	1.57	0.16
Chromis lepidolepis	1	2	0	16	0	1	1	0.3	0.09	0	2.54	0	0.13	0.18
Chromis margaritifer	2	5	16	24	18	26	17	0.09	0.04	3.6	2.45	7.12	5.2	7.2
Chromis ternatensis	1	5	6	13	3	7	4	0.18	0.87	2.86	4.62	0.99	1.16	3.61
Chromis viridis	2	2	0	7	11	17	21	0.71	0.1	0	0.65	6.52	2.45	9.33
Chromis weberi	6	3	17	8	10	7	7	2.37	0.29	8.64	0.42	9.47	0.28	1.84
Chromis xanthochira	0	0	0	0	0	1	0	0	0	0	0	0	0.86	0
Chromis xanthura	0	0	7	19	5	14	14	0	0	1.55	22.69	2.59	10.75	3.89
Chrysiptera biocellata	0	0	0	2	8	0	8	0	0	0	0.02	0.59	0	0.51
Chrysiptera brownriggii	0	0	0	0	0	2	0	0	0	0	0	0	0.08	0
Chrysiptera cyanea	0	1	0	2	8	9	11	0	0	0	0.02	8.07	0.92	2.52
Chrysiptera hemicyanea	7	4	0	1	6	8	13	0.84	0.03	0	0.06	0.3	0.34	0.22
Chrysiptera rex	2	3	9	22	0	0	0	0.04	0.01	2.51	5.77	0	0	0
Chrysiptera talboti	4	4	2	0	0	0	0	0.02	0.04	0	0	0	0	0
Cirrhilabrus cyanopleura	2	0	0	0	0	0	0	0.18	0	0	0	0	0	0
Cirrhilabrus exquisitus	1	1	15	3	0	1	0	0.01	0.06	3.72	1.71	0	0.11	0
Cirrhilabrus randalli	0	3	4	1	3	5	4	0	0.84	0.18	0.02	0.16	0.25	0.14
Cirrhilabrus temminckii	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cirrhitichthys oxycephalus	0	1	0	0	1	2	0	0	0	0	0	0.07	0.04	0
Coris auricularis	0	0	0	0	0	0	1	0	0	0	0	0	0	0.01
Coris aygula	0	0	0	1	3	5	8	0	0	0	0.41	0.07	2.55	8.45
Coris batuensis	7	5	8	7	0	0	0	0.88	2.05	0.1	0.12	0	0	0
Coris gaimard	0	0	7	1	1	0	1	0	0	0.12	0.04	0	0	0
Ctenochaetus binotatus	7	6	10	19	2	3	0	5.96	3.78	1.82	10.47	2.04	0.04	0
Ctenochaetus cyanocheilus	0	2	6	10	2	1	0	0	1.26	3.7	9.32	0.01	0	0
Ctenochaetus striatus	8	10	19	21	26	36	36	26.48	13.43	107.48	141.38	118.61	308.17	421.01
Dascyllus aruanus	7	6	5	9	14	16	18	1.3	0.83	0.23	1.11	3.85	4.04	4.8
Dascyllus reticulatus	2	5	3	12	2	5	3	0.2	0.97	0.3	1.42	0.03	0.16	0.52

Species	Transects AshIV	AshIa	Hib	Scott	Imp	Mer	Cler	Biomass AshIV	AshIa	Hib	Scott	Imp	Mer	Cler
Dascyllus trimaculatus	2	2	1	8	2	9	5	0.05	1.89	0.01	3.43	0.25	0.98	1.26
Decapterus macarellus	0	0	0	1	0	0	0	0	0	0	1.79	0	0	0
Diagramma labiosum	0	0	0	0	0	1	0	0	0	0	0	0	2.13	0
Diodon hystrix	0	1	0	0	0	0	0	0	1.95	0	0	0	0	0
Diodon liturosus	0	0	0	0	0	1	0	0	0	0	0	0	0.43	0
Dischistodus melanotus	5	3	4	0	0	0	0	1.07	0.59	0.06	0	0	0	0
Dischistodus perspicillatus	5	6	1	2	3	6	12	5.74	6.09	0	0.19	1.81	0.25	1.12
Dischistodus prosopotaenia	5	0	0	0	0	3	6	1.39	0	0	0	0	0.12	0.21
Elagatis bipinnulata	0	0	1	1	0	0	0	0	0	9.67	36.27	0	0	0
Epibulus insidiator	2	1	4	2	7	17	24	0.07	0.03	1.03	0.55	2.28	8.42	8.67
Epinephelus fasciatus	0	0	0	0	3	0	2	0	0	0	0	1.66	0	1.2
Epinephelus merra	3	3	3	10	8	8	11	0.66	0.33	1.61	5.1	1.64	1.64	1.88
Epinephelus polyphekadion	0	0	1	0	7	8	11	0	0	0.42	0	7.07	7.22	8.46
Epinephelus spilotoceps	0	0	0	0	3	2	1	0	0	0	0	1.64	1.44	1.23
Epinephelus tauvina	0	0	1	0	3	3	0	0	0	0.61	0	1.33	0.97	0
Epinephelus tukula	0	0	0	0	0	1	0	0	0	0	0	0	45.84	0
Fistularia commersonii	0	0	0	0	0	1	0	0	0	0	0	0	0.47	0
Forcipiger flavissimus	0	0	4	8	4	24	10	0	0	0.34	0.65	0.17	3.68	1.46
Forcipiger longirostris	0	0	0	1	0	2	0	0	0	0	0.04	0	0.08	0
Gomphosus caeruleus	0	1	0	3	0	0	0	0	0	0	0	0	0	0
Gomphosus varius	4	7	15	18	25	33	28	0.34	0.59	2.53	0.94	3.39	4.08	3.81
Gracila albomarginata	0	0	0	0	1	1	1	0	0	0	0	0.56	0.83	0.56
Grammatorcynus bilineatus	0	0	2	0	0	0	0	0	0	2.31	0	0	0	0
Gymnosarda unicolor	0	0	1	1	0	1	0	0	0	0.98	0.5	0	11.99	0
Halichoeres biocellatus	3	2	12	2	9	13	6	0.69	0.2	0.86	0.03	0.33	0.27	0.7
Halichoeres chrysus	0	0	1	0	0	0	0	0	0	0.01	0	0	0	0
Halichoeres hortulanus	1	5	22	24	21	35	25	0.13	1.28	31.63	19.61	10.28	15.43	8.58
Halichoeres margaritaceus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Halichoeres marginatus	0	3	9	12	16	18	19	0	0.16	0.3	0.12	1.66	0.47	0.62

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Halichoeres melanurus	8	5	6	16	0	0	0	4.16	3.51	0.14	4.5	0	0	0
Halichoeres nebulosus	0	4	3	0	0	1	0	0	0.74	1.23	0	0	0.01	0
Halichoeres prosopeion	6	2	2	7	0	0	0	0.27	0.11	0.27	0.34	0	0	0
Halichoeres trimaculatus	2	3	4	6	12	11	21	4.17	0.27	0.15	5.85	2.97	1.3	3.18
Hemiglyphidodon plagiometopon	3	3	0	0	4	0	13	2.45	2.15	0	0	9.17	0	2.3
Hemigymnus fasciatus	1	3	7	2	7	3	13	0.01	0.01	0.22	0.23	0.12	1.25	4.33
Hemigymnus melapterus	8	7	6	4	12	12	20	4.02	1.04	0.19	0.25	4.18	3.14	5.3
Hemitaurichthys polylepis	0	0	0	0	0	1	0	0	0	0	0	0	0.78	0
Heniochus acuminatus	0	0	0	0	2	4	4	0	0	0	0	4.02	3.73	2.4
Heniochus chrysostomus	1	0	5	8	8	16	8	0.45	0	4.64	4.89	17.1	21.24	10.33
Heniochus monoceros	0	0	0	0	0	3	0	0	0	0	0	0	3.57	0
Heniochus singularius	0	0	0	0	3	5	2	0	0	0	0	3.07	6.64	2.87
Heniochus varius	1	1	7	9	11	20	9	0.4	0.02	3.26	7.92	12.52	19.63	16.47
Heteroconger hassi	0	0	0	0	0	0	1	0	0	0	0	0	0	0.26
Hipposcarus longiceps	8	6	12	2	8	8	17	3.45	9.53	4.3	0.27	3.98	5.41	16.79
Hologymnosus doliatus	0	0	2	0	0	0	0	0	0	0.07	0	0	0	0
Hoplolatilus starcki	0	0	0	0	0	1	0	0	0	0	0	0	0.07	0
Kyphosus bigibbus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kyphosus cinerascens	0	0	0	0	0	1	0	0	0	0	0	0	0.88	0
Kyphosus vaigiensis	0	0	0	0	1	0	0	0	0	0	0	2.86	0	0
Labracinus cyclophthalmus	0	2	1	0	0	0	0	0	0.2	0.04	0	0	0	0
Labrichthys unilineatus	5	5	5	16	16	21	24	0.29	0.13	0.03	1.43	1.51	0.54	1.08
Labroides bicolor	5	5	5	14	15	26	20	0.27	0.12	0.06	0.2	0.45	0.69	0.57
Labroides dimidiatus	8	10	20	22	25	32	32	0.4	0.22	0.89	0.58	1.26	1.04	1.2
Labroides pectoralis	0	0	3	3	17	20	17	0	0	0.05	0.01	0.61	0.59	0.73
Labropsis australis	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Labropsis xanthonota	0	0	0	0	2	1	2	0	0	0	0	0.2	0.01	0.01
Lethrinus amboinensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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Lethrinus atkinsoni	0	1	0	0	0	0	0	0	0.22	0	0	0	0	0
Lethrinus erythracanthus	0	0	0	0	0	2	1	0	0	0	0	0	1.22	0.06
Lethrinus erythropterus	0	2	0	1	7	6	18	0	0.71	0	0.22	4.34	3.99	13.91
Lethrinus obsoletus	0	0	0	0	1	0	2	0	0	0	0	0.48	0	0.81
Lethrinus olivaceus	0	0	1	4	4	7	8	0	0	19	117.47	5.62	11.81	23.12
Lethrinus rubrioperculatus	0	0	0	0	0	0	1	0	0	0	0	0	0	1.4
Lutjanus bohar	1	3	6	7	7	23	9	1.83	0.44	28.6	10.03	12.08	55.91	58.15
Lutjanus decussatus	6	6	10	21	20	30	31	2.34	2.76	8.34	44.96	38.32	100.7	65.67
Lutjanus fulviflamma	1	0	0	0	0	0	0	3.22	0	0	0	0	0	0
Lutjanus fulvus	2	1	0	0	0	0	0	1.34	0.21	0	0	0	0	0
Lutjanus gibbus	0	4	1	4	4	8	9	0	46.86	1.2	102.92	9.23	51.5	54.72
Lutjanus kasmira	0	0	1	0	0	4	3	0	0	1.68	0	0	14.7	65.13
Lutjanus monostigma	0	0	0	0	0	0	1	0	0	0	0	0	0	0.41
Lutjanus rivulatus	0	0	0	0	0	6	1	0	0	0	0	0	6.37	0.74
Macolor macularis	0	0	2	1	0	2	2	0	0	1.95	1.1	0	4.75	27.86
Macolor niger	3	0	1	2	4	13	2	0.59	0	0.53	13.8	4.62	36.49	13.22
Macropharyngodon kuiteri	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macropharyngodon meleagris	0	0	0	0	3	2	2	0	0	0	0	0.05	0.01	0.04
Macropharyngodon ornatus	1	6	21	9	0	0	1	0	0.14	3.77	0.3	0	0	0.03
***Macropharyngodon* spp.**	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Manonichthys splendens	0	0	0	1	0	0	0	0	0	0	0.01	0	0	0
Melichthys niger	0	0	0	1	7	8	9	0	0	0	0.11	3.73	7.85	12.97
Melichthys vidua	0	0	0	0	9	16	12	0	0	0	0	24.21	46.46	56.82
Monotaxis grandoculis	7	5	4	6	0	0	0	10.61	3.19	2.44	1.78	0	0	0
Monotaxis heterodon	0	0	0	3	16	27	22	0	0	0	4.89	23.22	67.58	107.08
Mulloidichthys flavolineatus	0	1	1	0	0	0	2	0	1.23	0.25	0	0	0	4.37
Mulloidichthys vanicolensis	1	0	1	0	2	0	0	10.43	0	2.1	0	2.31	0	0
Myripristis adusta	0	0	1	3	1	5	3	0	0	0.14	6.88	0.69	2.5	1.92
Myripristis berndti	0	0	0	5	5	8	7	0	0	0	9.36	13.74	21.04	14.19

Species	Transects AshIV	AshIa	Hib	Scott	Imp	Mer	Cler	Biomass AshIV	AshIa	Hib	Scott	Imp	Mer	Cler
Myripristis kuntee	0	0	0	0	0	1	0	0	0	0	0	0	1.69	0
Myripristis murdjan	0	0	0	4	1	0	0	0	0	0	8.01	2.46	0	0
Myripristis violacea	0	3	2	6	10	7	3	0	1.34	0.66	5.31	35.14	16.41	10.68
Myripristis vittata	0	0	0	0	0	1	0	0	0	0	0	0	2.86	0
Naso annulatus	0	0	1	0	0	0	0	0	0	0.03	0	0	0	0
Naso brachycentron	0	0	0	1	0	0	0	0	0	0	1.49	0	0	0
Naso brevirostris	0	0	0	5	1	6	9	0	0	0	8.46	1.28	68.52	67.16
Naso caesius	0	0	0	3	0	4	4	0	0	0	7.5	0	11.29	20.93
Naso hexacanthus	0	0	0	3	0	0	0	0	0	0	7.86	0	0	0
Naso lituratus	4	2	5	10	14	33	24	1.34	0.24	0.8	2.47	30.21	64.12	69.56
Naso thynnoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naso tonganus	0	0	0	1	0	0	0	0	0	0	2.08	0	0	0
Naso unicornis	0	2	1	1	9	7	2	0	0.03	0.61	0.36	40.99	9.8	2.95
Naso vlamingii	1	0	5	2	1	10	3	0.12	0	0.19	0.23	6.18	20.86	4.98
Nebrius ferrugineus	0	0	0	0	1	0	0	0	0	0	0	1.88	0	0
Nemateleotris magnifica	0	0	2	7	1	6	2	0	0	0.01	0.08	0.02	0.07	0.01
Neoglyphidodon melas	7	5	7	3	0	0	0	5.59	2.64	0.23	0.04	0	0	0
Neoglyphidodon nigroris	7	6	14	0	0	0	0	0.75	1.29	2.9	0	0	0	0
Neoniphon argenteus	0	0	1	0	2	1	0	0	0	0.09	0	1.58	0.09	0
Neoniphon opercularis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Neoniphon sammara	0	0	3	6	0	0	0	0	0	1.33	1.59	0	0	0
Neopomacentrus azysron	3	0	1	0	0	0	0	0.4	0	0.03	0	0	0	0
Neotrygon kuhlii	0	1	0	0	0	0	0	0	7.03	0	0	0	0	0
Novaculichthys taeniourus	0	0	3	0	0	0	0	0	0	0.08	0	0	0	0
Odonus niger	0	0	0	3	0	0	0	0	0	0	216.22	0	0	0
Ostorhinchus cyanosoma	0	0	0	1	0	0	0	0	0	0	0.07	0	0	0
Ostorhinchus wassinki	0	0	2	0	0	0	0	0	0	0.09	0	0	0	0
Ostracion cubicus	1	0	0	0	0	3	0	0.03	0	0	0	0	0.75	0
Ostracion meleagris	0	0	0	2	1	1	0	0	0	0	0.05	0.18	0.18	0

Species	Transects AshIV	Ashla	Hib	Scott	Imp	Mer	Cler	Biomass AshIV	Ashla	Hib	Scott	Imp	Mer	Cler
Oxycheilinus digrammus	7	4	13	8	1	0	4	1.79	0.57	0.52	0.53	0.13	0	0.1
Oxycheilinus orientalis	8	3	11	5	3	6	2	0.96	0.39	0.51	0.19	0.04	0.11	0.06
Oxycheilinus unifasciatus	0	0	2	0	2	3	3	0	0	0.02	0	0.11	0.05	1.52
Oxymonacanthus longirostris	0	0	2	5	3	1	3	0	0	0.01	0.04	0.07	0.03	0.07
Paracanthurus hepatus	0	1	0	0	0	0	0	0	0.22	0	0	0	0	0
Paracirrhites arcatus	0	0	1	2	0	0	2	0	0	0.01	0.01	0	0	0.02
Paracirrhites forsteri	0	2	12	17	15	23	12	0	0.02	1.57	1.3	3.11	1.27	2.24
Parapercis clathrata	1	2	11	1	0	0	0	0.04	0.39	0.73	0.04	0	0	0
Parapercis millepunctata	0	0	0	1	2	0	2	0	0	0	0.04	0.04	0	0.15
Parapercis multiplicata	0	0	0	0	0	0	1	0	0	0	0	0	0	0.01
Parapercis pacifica	4	2	5	4	0	0	0	0.75	0.16	0.31	0.52	0	0	0
Parapriacanthus ransonneti	0	0	1	0	1	0	0	0	0	0.07	0	0.13	0	0
Parupeneus barberinoides	2	1	0	1	0	0	0	0.41	0.27	0	0.04	0	0	0
Parupeneus barberinus	5	7	2	4	7	6	10	1.45	2.51	0.17	0.97	2.84	2.57	2.94
Parupeneus ciliatus	0	0	0	0	1	0	0	0	0	0	0	1.46	0	0
Parupeneus crassilabris	0	0	0	3	0	0	0	0	0	0	0.99	0	0	0
Parupeneus cyclostomus	0	0	4	1	0	2	0	0	0	0.43	0.2	0	1.1	0
Parupeneus multifasciatus	7	7	17	10	3	6	2	1	0.48	13.15	1.42	0.2	2.27	1.1
Parupeneus pleurostigma	0	0	0	1	0	0	0	0	0	0	0.05	0	0	0
Pempheris oualensis	0	0	0	1	0	0	1	0	0	0	0.07	0	0	0.04
Pentapodus emeryii	0	1	1	2	0	0	0	0	0.08	0.15	0.53	0	0	0
Pictichromis paccagnellae	0	0	0	1	1	3	2	0	0	0	0	0	0.07	0.03
Platax batavianus	0	0	0	0	0	2	0	0	0	0	0	0	11.61	0
Platax teira	1	1	0	0	0	0	0	7.3	7.3	0	0	0	0	0
Plectorhinchus chaetodonoides	0	0	2	5	5	12	5	0	0	2.15	26.15	259.97	84.05	8.75
Plectorhinchus lessonii	0	0	0	0	1	0	1	0	0	0	0	0.67	0	0.52
Plectorhinchus vittatus	0	0	1	1	0	0	0	0	0	1.13	1.96	0	0	0
Plectroglyphidodon dickii	0	3	8	15	12	8	9	0	0.12	0.44	0.89	3.82	0.6	2.51

Species	Transects AshIV	AshIa	Hib	Scott	Imp	Mer	Cler	Biomass AshIV	AshIa	Hib	Scott	Imp	Mer	Cler
Plectroglyphidodon johnstonianus	0	1	9	9	6	1	6	0	0.09	1.03	0.18	0.56	0.01	0.27
Plectroglyphidodon lacrymatus	4	5	14	18	0	1	0	0.83	0.31	2.33	1.88	0	0.02	0
Plectropomus areolatus	0	0	0	1	5	5	8	0	0	0	0.23	7.37	3.99	10.75
Plectropomus laevis	0	0	3	1	13	15	3	0	0	2.56	2.64	29.19	73.63	22.48
Plectropomus leopardus	1	0	3	5	0	0	0	2.6	0	3.24	21.42	0	0	0
Plectropomus oligacanthus	0	0	0	2	0	0	0	0	0	0	1.04	0	0	0
Pomacanthus imperator	1	0	3	0	0	1	0	0.61	0	3.68	0	0	1.19	0
Pomacanthus navarchus	0	0	0	0	4	14	10	0	0	0	0	2.29	11.96	5.3
Pomacanthus sexstriatus	0	0	1	1	1	4	4	0	0	2.99	1.49	0.49	3.07	3.56
Pomacentrus adelus	6	7	8	8	6	14	16	1.49	2.03	0.37	0.3	0.75	1.59	2.09
Pomacentrus alexanderae	6	1	0	0	0	0	0	0.44	0.05	0	0	0	0	0
Pomacentrus amboinensis	7	7	3	14	0	1	0	2.08	4.98	0.05	6.04	0	0.01	0
Pomacentrus bankanensis	6	6	7	12	5	14	8	0.5	0.76	0.37	0.28	0.04	0.38	0.06
Pomacentrus chrysurus	0	1	0	4	0	0	0	0	0.14	0	0.44	0	0	0
Pomacentrus coelestis	2	4	15	1	12	8	8	0.08	3.11	32.37	0	8.43	0.97	1.25
Pomacentrus grammorhynchus	0	0	0	0	3	1	6	0	0	0	0	0.09	0.01	0.48
Pomacentrus lepidogenys	6	6	18	22	0	0	0	1.11	2.86	16.34	12.8	0	0	0
Pomacentrus moluccensis	6	5	7	13	12	18	14	0.26	0.3	0.19	2.14	10.99	11.78	7.87
Pomacentrus nigromarginatus	0	0	0	0	0	3	0	0	0	0	0	0	0.45	0
Pomacentrus pavo	6	6	1	3	7	12	11	0.53	0.92	0.01	0.33	0.33	3.13	2.06
Pomacentrus philippinus	6	5	7	24	18	36	24	1.08	0.42	3.24	14.78	43.76	55.53	31
Pomacentrus vaiuli	5	4	21	23	18	34	24	0.15	0.05	2.75	2.11	9.06	24.28	8.53
Pomachromis richardsoni	0	0	0	3	12	19	12	0	0	0	0.19	15.43	7.3	7.95
Premnas biaculeatus	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Pristiapogon exostigma	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Pristiapogon kallopterus	0	0	0	1	0	0	0	0	0	0	0.14	0	0	0

Species	Transects AshIV	AshIa	Hib	Scott	Imp	Mer	Cler	Biomass AshIV	AshIa	Hib	Scott	Imp	Mer	Cler
Pseudanthias tuka	0	1	0	9	0	0	0	0	0	0	4.62	0	0	0
Pseudanthias evansi	0	0	0	0	0	0	1	0	0	0	0	0	0	0.02
Pseudanthias huchtii	0	0	2	0	0	0	0	0	0	0.04	0	0	0	0
Pseudanthias squamipinnis	0	0	0	1	0	0	0	0	0	0	0.07	0	0	0
Pseudanthias tuka	0	0	0	0	5	14	9	0	0	0	0	14.25	18.14	31.59
Pseudobalistes flavimarginatus	1	3	0	1	1	1	3	0.21	5.48	0	2.82	1.52	0.03	4.22
Pseudocheilinus evanidus	0	0	1	0	1	3	1	0	0	0	0	0.04	0.04	0
Pseudocheilinus hexataenia	6	8	15	19	16	23	16	0.16	0.08	0.41	0.18	0.16	0.18	0.17
Pseudocheilinus octotaenia	0	0	2	5	3	6	5	0	0	0.04	0.13	0.06	0.07	0.05
Pseudochromis andamanensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudochromis bitaeniatus	0	0	1	3	0	0	0	0	0	0	0.02	0	0	0
Pseudochromis cyanotaenia	0	0	0	2	0	0	0	0	0	0	0.01	0	0	0
Pseudochromis fuscus	5	2	5	7	6	6	9	0.05	0.01	0.03	0.1	0.15	0.04	0.09
Pseudodax moluccanus	0	0	0	2	0	1	1	0	0	0	0.13	0	0.27	0.02
Pteragogus flagellifer	0	0	1	0	0	0	0	0	0	0.03	0	0	0	0
Ptereleotris evides	1	3	6	5	1	1	4	0.12	0.1	0.32	1.47	0.01	0.01	0.05
Ptereleotris heteroptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptereleotris microlepis	0	0	0	0	0	2	0	0	0	0	0	0	0.1	0
Pterocaesio digramma	0	0	1	2	0	0	1	0	0	0.71	0.01	0	0	0.06
Pterocaesio marri	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pterocaesio pisang	0	0	1	4	0	0	0	0	0	5.62	66.99	0	0	0
Pterocaesio tile	0	0	0	5	2	4	1	0	0	0	25.08	10.08	62.16	25.35
Pterocaesio trilineata	0	0	1	3	0	0	0	0	0	0.25	12.09	0	0	0
Pygoplites diacanthus	5	2	6	12	6	10	5	3.22	0.67	4.08	4.41	4.87	16.92	4.76
Rhabdamia gracilis	0	0	3	0	0	0	0	0	0	23.38	0	0	0	0
Rhinecanthus aculeatus	0	0	0	0	0	1	3	0	0	0	0	0	0.02	0.33
Rhinecanthus rectangulus	0	0	0	0	3	0	1	0	0	0	0	0.12	0	0.02

Species	Transects AshIV	AshIa	Hib	Scott	Imp	Mer	Cler	Biomass AshIV	AshIa	Hib	Scott	Imp	Mer	Cler
Sargocentron caudimaculatum	0	0	4	11	5	7	9	0	0	0.82	3.22	1.52	2.94	5.65
Sargocentron cornutum	0	0	0	1	0	0	0	0	0	0	0.06	0	0	0
Sargocentron diadema	0	0	0	1	0	0	1	0	0	0	0.22	0	0	0.13
Sargocentron microstoma	0	0	0	0	1	0	0	0	0	0	0	0.06	0	0
Sargocentron spiniferum	1	0	0	10	7	5	8	0.23	0	0	7.82	9.6	7.42	12.9
Sargocentron tiere	0	0	0	0	0	1	0	0	0	0	0	0	0.37	0
Sargocentron violaceum	0	0	0	2	0	0	1	0	0	0	0.34	0	0	0.37
Saurida gracilis	3	0	2	1	0	0	0	0.04	0	0.14	0	0	0	0
Saurida nebulosa	0	0	0	0	1	0	1	0	0	0	0	0.05	0	0.01
Scarus altipinnis	0	0	0	0	1	0	0	0	0	0	0	0.03	0	0
Scarus chameleon	0	0	1	0	0	0	1	0	0	0.07	0	0	0	0.62
Scarus dimidiatus	1	1	6	0	14	16	28	0.07	0.12	1.12	0	7.29	14.74	40.65
Scarus flavipectoralis	4	3	0	0	0	0	0	2.34	1.22	0	0	0	0	0
Scarus forsteni	0	0	2	0	4	10	3	0	0	0.43	0	3.08	9.55	3.1
Scarus frenatus	1	2	3	4	6	7	6	1.03	1.12	0.21	0.24	6.3	11.33	7.1
Scarus globiceps	0	0	0	2	1	0	2	0	0	0	0.59	0.72	0	0.9
Scarus niger	3	4	8	10	1	4	3	0.95	0.4	2.12	1.04	0	4.4	2.18
Scarus oviceps	0	1	1	0	7	9	20	0	0.01	0	0	2.58	3.97	16.11
Scarus prasiognathos	1	1	1	5	4	6	20	0	0	0.06	10.12	3.34	4.16	47.26
Scarus psittacus	0	1	0	5	0	0	0	0	0.47	0	1.31	0	0	0
Scarus rubroviolaceus	0	0	1	3	0	2	0	0	0	0.62	6.59	0	1.69	0
Scarus schlegeli	2	1	0	2	1	6	0	3.49	0.4	0	1.12	0.56	7.4	0
Scarus spinus	0	0	1	2	0	1	2	0	0	0.13	0.6	0	0.23	1.06
Scolopsis affinis	0	1	0	0	0	0	0	0	0.08	0	0	0	0	0
Scolopsis bilineata	4	6	9	9	6	14	13	0.67	0.79	0.83	0.92	1.45	2.95	3.79
Scolopsis margaritifer	7	6	1	4	0	0	0	4.31	5.26	0.04	0.47	0	0	0
Scolopsis trilineata	4	4	1	0	0	0	2	3.28	1.44	0.01	0	0	0	1.68
Scolopsis xenochrous	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Species	Transects AshIV	AshIa	Hib	Scott	Imp	Mer	Cler	Biomass AshIV	AshIa	Hib	Scott	Imp	Mer	Cler
Scomberoides lysan	0	0	0	1	0	0	1	0	0	0	15.27	0	0	0.21
Siganus argenteus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Siganus corallinus	0	0	0	2	0	2	1	0	0	0	0.48	0	0.61	0.17
Siganus doliatus	2	0	0	0	3	2	5	1.34	0	0	0	0.58	0.08	3.53
Siganus puellus	0	1	1	1	5	7	10	0	0.01	0.27	0.27	4.02	2.12	6.64
Siganus punctatus	0	0	0	1	2	5	4	0	0	0	0.15	0.67	2.36	1.8
Siganus vulpinus	0	0	1	3	9	15	12	0	0	0.33	0.58	3.26	11.07	7.57
Sphyraena flavicauda	1	0	0	0	0	0	0	0.02	0	0	0	0	0	0
Spratelloides gracilis	0	0	2	1	0	0	0	0	0	1.18	2.01	0	0	0
Stegastes fasciolatus	0	2	0	2	2	6	5	0	0.03	0	0.02	0.4	0.68	0.6
Stegastes nigricans	1	2	5	5	15	7	22	0.01	0.06	0.39	0.94	21.58	4.55	14.14
Stegastes punctatus	0	0	0	0	3	3	11	0	0	0	0	0.86	0.42	10.94
Stethojulis bandanensis	0	4	15	4	10	6	13	0	0.1	0.95	0.06	0.29	0.08	0.35
Stethojulis interrupta	0	1	0	1	0	0	5	0	0	0	0	0	0	0.06
Stethojulis strigiventer	0	0	0	0	0	0	1	0	0	0	0	0	0	0.01
Stethojulis trilineata	0	0	0	2	0	0	0	0	0	0	0.07	0	0	0
Strongylura incisa	0	0	0	1	0	1	0	0	0	0	0.12	0	3	0
Sufflamen bursa	0	0	1	2	5	4	5	0	0	0.18	0.09	0.88	0.62	2.08
Sufflamen chrysopterum	0	3	1	3	1	0	0	0	1.05	0.1	0.39	0.09	0	0
Symphorichthys spilurus	0	0	0	3	2	2	3	0	0	0	14.92	4.61	1.25	3.45
Synodus binotatus	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Synodus dermatogenys	1	0	2	2	0	0	0	0.05	0	0.04	0.11	0	0	0
Synodus jaculum	0	0	1	2	2	0	1	0	0	0.12	0.11	0.03	0	0.01
Synodus variegatus	1	1	4	0	0	1	2	0.03	0.06	0.12	0	0	0.01	0.07
Thalassoma amblycephalum	2	7	13	21	15	25	16	0.24	0.83	5.47	7.72	11.74	27.31	25.18
Thalassoma hardwicke	3	7	8	22	24	27	31	0.17	1.36	1.19	5.29	6.29	5.78	8.09
Thalassoma lunare	8	9	19	16	6	5	4	9.04	3.84	5.63	3.19	0.33	0.05	0.15
Thalassoma lutescens	0	0	1	0	1	0	0	0	0	0	0	0	0	0
Thalassoma quinquevittatum	0	1	2	7	12	16	15	0	0.01	0.13	0.77	3.67	5.17	6.41

Species	Transects AshIV	AshIa	Hib	Scott	Imp	Mer	Cler	Biomass AshIV	AshIa	Hib	Scott	Imp	Mer	Cler
Trachinotus blochii	0	0	0	0	0	0	1	0	0	0	0	0	0	4.99
Triaenodon obesus	0	0	0	0	4	5	2	0	0	0	0	48.5	51.04	16.52
Tylosurus crocodilus	0	0	0	0	0	1	2	0	0	0	0	0	1.47	1.22
Upeneus tragula	2	3	0	0	0	0	0	0.12	0.25	0	0	0	0	0
Variola louti	0	0	0	0	2	2	0	0	0	0	0	0.53	1.04	0
Zanclus cornutus	6	1	14	15	10	27	19	4.95	0.14	9.18	21.66	21.52	187.41	75.08
Zebrasoma scopas	8	6	11	17	19	28	20	15.72	8.87	2.36	18.36	21.57	58.08	36.35
Zebrasoma velifer	3	1	4	4	16	24	27	0.63	0.14	1.63	0.83	24.97	35.56	62.89

APPENDIX 4 – SPECIES LIST OF MOBILE MACROINVERTEBRATES SURVEYED ALONG 100 M2 TRANSECTS AND EACH REEF; ASHMORE REEF IS DIVIDED INTO THE TWO IUCN ZONES. FREQUENCY OF OCCURRENCE (TRANSECTS) AND MEAN ABUNDANCE ARE GIVEN FOR EACH SPECIES.

Species	Transects AshIV	AshIa	Hib	Scott	Imp	Mer	Cler	Abund AshIV	AshIa	Hib	Scott	Imp	Mer	Cler
Acanthaster planci	0	0	1	0	1	0	0	0	0	0.05	0	0.04	0	0
Asteroidea spp.	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0
Choriaster granulatus	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0
Culcita novaeguineae	0	0	0	1	1	3	1	0	0	0	0.04	0.11	0.08	0.03
Echinaster luzonicus	1	0	0	2	0	0	0	0	0.13	0	0.17	0	0	0
Fromia hemiopla	0	0	1	0	0	0	0	0	0	0.05	0	0	0	0
Fromia monilis	1	0	0	1	0	6	4	0	0.13	0	0.04	0	0.19	0.11
Fromia nodosa	0	0	0	0	0	1	0	0	0	0	0	0	0.05	0
Linckia guildingi	0	1	0	0	0	0	0	0.2	0	0	0	0	0	0
Linckia laevigata	7	8	0	0	1	0	10	1.7	1.88	0	0	0.04	0	0.33
Linckia multifora	0	0	0	0	1	1	3	0	0	0	0	0.04	0.03	0.14
Nardoa spp.	0	0	0	1	0	0	0	0	0	0	0.04	0	0	0
Neoferdina cumingi	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Neoferdina offreti	0	0	0	0	0	1	0	0	0	0	0	0	0.05	0
Nepanthia crassa	0	0	0	0	0	0	1	0	0	0	0	0	0	0.03
Colobometra perspinosa?	0	0	2	0	0	0	0	0	0	0.18	0	0	0	0
Comanthus parvicirrus	0	0	0	4	0	0	0	0	0	0	0.25	0	0	0
Comanthus sp. (black)	0	0	0	0	3	2	0	0	0	0	0	0.22	0.14	0
Comanthus sp. (cf schlegeli)	0	0	0	0	1	2	1	0	0	0	0	0.04	0.19	0.06
Comanthus spp.	0	0	4	6	11	12	8	0	0	0.23	0.29	1.19	1.35	0.83
Comaster nobilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Comasterid spp.	0	0	1	0	1	0	1	0	0	0.14	0	0.04	0	0.03
Comasteridae spp.	0	1	5	4	0	0	0	0.1	0	0.36	0.21	0	0	0
Comatella stelligera?	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crinoidea spp.	0	0	0	0	0	0	3	0	0	0	0	0	0	0.08

Himerometra robustipinna	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Species	**Transects AshIV**	**AshIa**	**Hib**	**Scott**	**Imp**	**Mer**	**Cler**	**Abund AshIV**	**AshIa**	**Hib**	**Scott**	**Imp**	**Mer**	**Cler**
Oxycomanthus bennetti	0	0	0	3	0	2	0	0	0	0	0.38	0	0.05	0
Diadema setosum	0	0	0	0	1	1	0	0	0	0	0	0.04	0.03	0
Echinometra mathaei	0	2	6	10	14	11	14	0.3	0	1.45	1.33	3.19	0.89	1.47
Echinostrephus aciculatus	0	0	0	0	6	14	6	0	0	0	0	1.81	4.3	0.44
Echinostrephus spp.	0	1	6	9	0	0	0	0.4	0	1	1.33	0	0	0
Echinothrix spp.	0	0	1	0	0	0	0	0	0	0.05	0	0	0	0
Eucidaris metularia	0	0	0	0	0	1	0	0	0	0	0	0	0.08	0
Heterocentrotus mammillatus	0	0	0	0	2	2	1	0	0	0	0	0.07	0.05	0.03
Phyllacanthus imperialis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Actinopyga echinites	0	0	0	0	0	0	1	0	0	0	0	0	0	0.03
Actinopyga miliaris	0	0	0	0	0	2	0	0	0	0	0	0	0.05	0
Bohadschia argus	0	0	0	0	1	10	6	0	0	0	0	0.07	0.46	0.19
Bohadschia graeffei	1	1	7	0	1	9	6	0.1	0.75	0.55	0	0.19	0.3	0.22
Holothuria atra	0	0	0	0	3	12	4	0	0	0	0	0.19	0.62	0.14
Holothuria edulis	3	3	2	2	2	10	13	0.3	0.38	0.09	0.08	0.07	0.41	0.44
Stichopus chloronotus	0	0	1	0	0	0	1	0	0	0.05	0	0	0	0.06
Thelenota ananas	0	0	0	0	3	3	4	0	0	0	0	0.11	0.16	0.14
Hippopus hippopus	0	1	3	0	0	0	4	0.1	0	0.14	0	0	0	0.14
Spondylus varius	0	0	0	0	0	2	2	0	0	0	0	0	0.08	0.06
Tridacna crocea	1	3	6	14	22	28	27	0.5	0.13	0.86	2.46	11.7	10.62	31.03
Tridacna derasa	0	0	0	0	2	2	0	0	0	0	0	0.07	0.22	0
Tridacna gigas	0	0	2	0	2	4	11	0	0	0.09	0	0.11	0.46	1.03
Tridacna maxima	2	2	10	11	20	28	25	0.4	0.38	1.82	0.96	9	6.84	10
Tridacna spp.	0	0	1	0	0	0	0	0	0	0.05	0	0	0	0
Tridacna squamosa	0	0	7	1	9	21	15	0	0	0.64	0.04	0.89	3.19	3.11
Astralium spp.	0	0	0	0	1	0	0	0	0	0	0	0.04	0	0
Benimakia nodata	0	0	0	0	1	2	0	0	0	0	0	0.04	0.05	0
Cerithium nodulosum	0	0	0	0	0	0	1	0	0	0	0	0	0	0.06

Chicoreus microphyllus	0	0	0	0	0	1	3	0	0	0	0	0	0.03	0.11
Species	**Transects AshIV**	**Ashla**	**Hib**	**Scott**	**Imp**	**Mer**	**Cler**	**Abund AshIV**	**Ashla**	**Hib**	**Scott**	**Imp**	**Mer**	**Cler**
Chromodoris elisabethina	0	0	0	0	1	2	2	0	0	0	0	0.04	0.05	0.06
Conus boeticus	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0
Conus eburneus	0	0	0	0	0	0	1	0	0	0	0	0	0	0.03
Conus flavidus	0	0	0	0	0	0	2	0	0	0	0	0	0	0.06
Conus marmoreus	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0
Conus miles	1	0	0	0	2	1	0	0	0.13	0	0	0.07	0.05	0
Conus spp.	0	0	0	0	1	4	0	0	0	0	0	0.04	0.11	0
Cypraea spp.	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0
Cypraea tigris	0	0	0	0	1	1	2	0	0	0	0	0.04	0.03	0.06
Drupa ricinus	0	0	0	0	1	1	1	0	0	0	0	0.04	0.03	0.03
Drupella cornus	0	0	0	0	9	7	10	0	0	0	0	2.33	0.54	0.72
Drupella rugosa	0	0	0	0	0	0	1	0	0	0	0	0	0	0.03
Lambis chiragra	0	0	0	0	0	0	1	0	0	0	0	0	0	0.03
Lambis truncata	0	0	0	0	0	1	4	0	0	0	0	0	0.03	0.14
Latirolagena smaragdula	0	0	0	0	2	0	1	0	0	0	0	0.15	0	0.03
Latirus spp.	0	0	0	0	0	1	1	0	0	0	0	0	0.05	0.06
Lyncina vitellus	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0
Mancinella alouina	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0
Mauritia histrio	0	0	0	0	0	0	1	0	0	0	0	0	0	0.03
Nembrotha kubaryana	2	1	0	0	0	0	0	0.1	0.25	0	0	0	0	0
Peristernia nassatula	0	0	0	0	0	3	5	0	0	0	0	0	0.19	0.69
Peristernia spp.	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0
Phyllidia elegans	0	0	0	0	1	3	3	0	0	0	0	0.04	0.08	0.11
Phyllidia varicosa	0	0	1	0	0	0	0	0	0	0.05	0	0	0	0
Phyllidiella nigra	0	0	0	0	0	0	2	0	0	0	0	0	0	0.06
Phyllidiella pustulosa	1	0	2	3	3	3	1	0	0.13	0.09	0.13	0.11	0.08	0.03
Phyllidiella rudmani	0	0	0	0	0	0	1	0	0	0	0	0	0	0.03
Phyllidiella striata	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0

Species	Transects AshIV	Ashla	Hib	Scott	Imp	Mer	Cler	Abund AshIV	Ashla	Hib	Scott	Imp	Mer	Cler
Phyllidiella zeylanica	0	0	0	0	0	0	1	0	0	0	0	0	0	0.03
Pollia undosa	0	0	0	0	0	2	0	0	0	0	0	0	0.05	0
Pteraeolidia ianthina	0	0	0	1	0	0	0	0	0	0	0.04	0	0	0
Tectus niloticus	0	0	0	0	0	0	2	0	0	0	0	0	0	0.08
Tectus pyramis	0	0	2	1	3	1	3	0	0	0.09	0.08	0.15	0.03	0.11
Tectus spp.	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0
Tectus virgatus	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0
Thuridilla gracilis	0	0	0	0	0	0	1	0	0	0	0	0	0	0.03
Trochid spp.	0	0	0	0	1	0	0	0	0	0	0	0.04	0	0
Trochus niloticus	0	0	0	1	0	0	0	0	0	0	0.04	0	0	0
Turbo argyrostomus	0	0	0	0	0	1	1	0	0	0	0	0	0.03	0.03
Turrilatirus turritus	0	0	0	0	1	2	1	0	0	0	0	0.04	0.11	0.03
Tutufa tenuigranosa	0	0	0	0	1	0	0	0	0	0	0	0.04	0	0
Tutufa rubeta	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0
Vasum turbinellum	0	0	0	1	1	0	3	0	0	0	0.04	0.04	0	0.08
Vexillum spp.	0	0	0	0	0	0	1	0	0	0	0	0	0	0.03
Alpheus spp.	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0
Brachyura spp.	0	0	0	0	0	0	1	0	0	0	0	0	0	0.03
Calcinus latens	0	0	0	0	0	1	1	0	0	0	0	0	0.03	0.03
Calcinus minutus	0	0	0	0	1	2	1	0	0	0	0	0.04	0.05	0.06
Calcinus morgani	0	0	0	0	0	2	2	0	0	0	0	0	0.19	0.08
Calcinus pulcher	0	0	0	0	0	0	1	0	0	0	0	0	0	0.03
Calcinus sp. [NWS]	0	0	0	0	0	1	3	0	0	0	0	0	0.03	0.11
Calcinus spp.	0	0	0	0	0	2	0	0	0	0	0	0	0.05	0
Clibanarius seurati	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0
Dardanus guttatus	0	0	0	1	0	0	0	0	0	0	0.13	0	0	0
Dardanus lagopodes	0	0	0	0	4	4	3	0	0	0	0	0.3	0.11	0.14
Dardanus megistos	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0

Species	Transects AshIV	Ashla	Hib	Scott	Imp	Mer	Cler	Abund AshIV	Ashla	Hib	Scott	Imp	Mer	Cler
Diogenid sp. [white claw black blotch]	0	0	0	0	1	1	1	0	0	0	0	0.07	0.03	0.31
Paguroidea sp. [longitudinal striped legs]	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0
Paguroidea spp.	0	4	4	12	7	5	6	0.7	0	0.23	0.83	0.3	0.24	0.28
Palaemonid spp.	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0
Panulirus versicolor	1	0	0	0	0	1	0	0	0.13	0	0	0	0.03	0
Percnon planissimum	0	0	1	0	0	0	0	0	0	0.05	0	0	0	0
Stenopus hispidus	0	0	0	0	0	0	1	0	0	0	0	0	0	0.03
Trapezia rufopunctata	0	0	0	2	2	4	2	0	0	0	0.08	0.19	0.38	0.11
Trapezia spp.	1	1	1	3	0	0	1	0.1	0.13	0.09	0.13	0	0	0.03

APPENDIX 5 – SPECIES LIST OF CRYPTIC FISHES SURVEYED ALONG 100 M2 TRANSECTS AND EACH REEF; ASHMORE REEF IS DIVIDED INTO THE TWO IUCN ZONES. FREQUENCY OF OCCURRENCE (TRANSECTS) AND MEAN ABUNDANCE ARE GIVEN FOR EACH SPECIES.

Species	Transects AshIV	AshIa	Hib	Scott	Imp	Mer	Cler	Abund AshIV	AshIa	Hib	Scott	Imp	Mer	Cler
Amblyeleotris steinitzi	0	0	0	1	2	4	1	0	0	0	0.04	0.15	0.54	0
Amblyeleotris wheeleri	0	0	2	0	0	1	0	0	0	0.09	0	0	0.05	0
Amblygobius decussatus	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Amblygobius nocturnus	0	0	0	0	0	0	1	0	0	0	0	0	0	0.03
Amblygobius phalaena	4	0	1	1	0	1	4	0.75	0	0.09	0.04	0	0.03	0
Amblygobius spp.	1	0	0	0	0	0	0	0.13	0	0	0	0	0	0
Apogonid spp.	1	0	0	0	0	0	0	6.25	0	0	0	0	0	0.11
Asterropteryx semipunctata	0	0	0	0	2	1	4	0	0	0	0	0.15	0.03	0
Atrosalarias holomelas	0	1	0	0	0	0	0	0	0.2	0	0	0	0	0
Blenniid sp. [green spots]	0	0	0	0	3	5	3	0	0	0	0	0.11	0.35	0.33
Blenniid spp.	0	0	1	0	0	1	0	0	0	0.14	0	0	0.27	0.14
Bryaninops natans	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Bryaninops spp.	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0
Canthigaster papua	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Caracanthus maculatus	0	0	0	1	0	0	0	0	0	0	0.13	0	0	0.03
Caracanthus spp.	0	0	0	0	2	0	0	0	0	0	0	0.11	0	0
Caracanthus unipinna	0	1	0	3	0	0	0	0	0.2	0	0.46	0	0	0
Cheilodipterus artus	1	0	0	1	0	1	0	0.13	0	0	0.04	0	0.05	0
Cheilodipterus quinquelineatus	3	3	3	5	1	2	9	2.25	1.3	0.18	2.04	0.7	0.19	0.06
Cirrhitichthys oxycephalus	0	1	0	0	1	2	0	0	0.1	0	0	0.15	0.05	0.83
Cirripectes ?variolosus	0	0	0	1	0	0	0	0	0	0	0.04	0	0	0
Cirripectes castaneus	0	0	0	0	0	0	1	0	0	0	0	0	0	0.03
Cirripectes sp. [dark eye]	0	0	0	0	0	2	0	0	0	0	0	0	0.27	0
Cirripectes spp.	0	0	0	1	0	0	2	0	0	0	0.04	0	0	0

Corythoichthys conspicillatus	0	0	0	1	0	0	0	0	0	0	0.04	0	0	0.08
Corythoichthys sp. [10 RK]	0	0	0	0	4	1	4	0	0	0	0	0.3	0.11	0
Ctenogobiops mitodes	0	0	0	3	0	0	2	0	0	0	0.25	0	0	0
Ctenogobiops pomastictus	1	3	2	2	2	2	4	0.25	0.5	0.09	0.13	1.07	0.27	0
Ctenogobiops spp.	0	0	0	0	0	0	4	0	0	0	0	0	0	1.47
Diplogrammus goramensis	0	0	0	1	0	0	0	0	0	0	0.04	0	0	0.44
Discotrema crinophilum	0	0	0	0	0	1	0	0	0	0	0	0	0.05	0
Ecsenius alleni	0	0	0	15	18	29	23	0	0	0	3.79	5.26	5.92	0
Ecsenius bicolor	0	1	5	6	2	2	1	0	0.2	1.5	0.75	0.11	0.14	0
Ecsenius lividanalis	4	5	0	0	0	0	0	1.75	2.3	0	0	0	0	0.03
Ecsenius schroederi	0	0	0	3	6	3	7	0	0	0	0.13	1.22	0.16	0
Ecsenius trilineatus	0	0	2	1	0	0	0	0	0	0.23	0.04	0	0	0.03
Ecsenius yaeyamaensis	5	5	5	0	0	0	0	2	1.5	0.5	0	0	0	0
Enneapterygius spp.	0	0	0	0	1	1	0	0	0	0	0	0.04	0.27	0.19
Eviota guttata	0	0	0	11	1	3	6	0	0	0	1.71	0.04	0.14	0.22
Eviota nigriventris	0	0	0	0	0	0	3	0	0	0	0	0	0	0.14
Eviota prasites	2	3	0	3	1	5	17	2.38	1.2	0	0.17	0.04	0.35	0.44
Eviota punctulata	1	0	3	0	0	0	1	0.38	0	0.14	0	0	0	0.06
Eviota sebreei	0	1	0	0	1	2	4	0	0.1	0	0	0.04	0.08	0.14
Eviota sp. (red)	0	0	0	0	0	3	0	0	0	0	0	0	0.35	0.14
Eviota sp. [green]	3	3	1	0	0	0	0	2.75	0.9	0.05	0	0	0	0.06
Eviota spilota	1	0	0	0	0	0	0	0.25	0	0	0	0	0	31.03
Eviota spp.	0	1	2	2	3	2	12	0	0.1	0.45	0.17	0.63	0.51	0
Exyrias belissimus	4	0	0	0	0	2	2	0.63	0	0	0	0	0.08	1.03
Fusigobius duospilus	0	1	0	0	0	0	2	0	0.2	0	0	0	0	10
Fusigobius neophytus	1	1	1	0	1	1	2	0.13	0.1	0.05	0	0.22	0.05	0
Fusigobius signipinnis	4	2	0	2	0	2	4	1.38	0.4	0	0.13	0	0.11	3.11
Fusigobius sp.	0	0	0	0	0	4	7	0	0	0	0	0	0.24	0
Fusigobius sp. [fine spots]	0	0	0	1	0	0	0	0	0	0	0.04	0	0	0
Fusigobius spp.	0	0	0	0	0	1	2	0	0	0	0	0	0.11	0.06
Gnatholepis anjerensis	0	2	0	0	0	0	0	0	0.6	0	0	0	0	0.11

Gnatholepis cauerensis	2	2	0	4	7	9	11	0.88	0.6	0	0.67	0.78	2.89	0.06
Gobiid spp.	1	0	0	1	2	5	1	12.5	0	0	0.17	0.07	0.22	0
Gobiodon ?histrio	1	1	0	4	0	0	0	0.25	0.1	0	0.29	0	0	0.03
Gobiodon quinquestrigatus	0	0	0	5	0	0	0	0	0	0	3.96	0	0	0.06
Gobiodon rivulatus	0	0	2	0	0	0	0	0	0	0.27	0	0	0	0
Gobiodon spilophthalmus	0	0	0	1	3	1	11	0	0	0	0.08	0.11	0.05	0
Gobiodon spp.	0	1	0	2	0	0	0	0	0.5	0	1.33	0	0	0
Gymnothorax javanicus	0	0	0	7	1	1	0	0	0	0	0.29	0.04	0.03	0
Helcogramma chica	0	0	0	1	1	3	2	0	0	0	0.04	0.04	0.22	0.06
Helcogramma rhinoceros	0	0	2	0	0	0	0	0	0	0.45	0	0	0	0.03
Helcogramma sp. [orange scales]	0	0	0	0	4	5	7	0	0	0	0	0.7	0.3	0.72
Helcogramma spp.	0	0	0	0	0	1	0	0	0	0	0	0	0.14	0.03
Helcogramma striatum	0	2	2	0	0	0	0	0	0.2	0.14	0	0	0	0.03
Hippocampus bargibanti	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0.14
Istigobius decoratus	2	2	0	0	0	0	0	0.88	0.4	0	0	0	0	0.03
Istigobius goldmanni	0	1	0	0	0	1	0	0	0.1	0	0	0	0.3	0.06
Istigobius rigilius	6	4	0	5	1	3	3	16.5	7.9	0	0.46	0.3	0.16	0
Istigobius spp.	0	0	0	0	1	0	2	0	0	0	0	0.07	0	0
Koumansetta rainfordi	5	3	0	7	5	9	11	1.75	1.3	0	0.83	0.59	0.57	0.03
Labracinus cyclophthalmus	0	1	1	0	0	1	0	0	0.1	0.05	0	0	0.03	0
Meiacanthus atrodorsalis	1	0	0	11	0	0	5	0.13	0	0	0.83	0	0	0.69
Meiacanthus grammistes	0	0	0	0	1	1	0	0	0	0	0	0.07	0.05	0
Meiacanthus sp. [yellow tail]	0	0	0	0	0	0	4	0	0	0	0	0	0	0.11
Meiacanthus spp.	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Myripristis adusta	0	0	1	1	0	2	1	0	0	0.05	0.17	0	0.08	0.06
Myripristis berndti	0	0	0	2	2	3	1	0	0	0	0.13	0.19	0.27	0.03
Myripristis murdjan	0	0	0	2	0	0	0	0	0	0	0.29	0	0	0.03
Myripristis spp.	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Myripristis violacea	0	2	1	6	1	3	0	0	0.2	0.05	0.79	0.07	0.16	0.03
Myripristis vittata	0	0	0	0	0	1	1	0	0	0	0	0	0.05	0

Nectamia ?luxuria	0	0	0	1	0	0	0	0	0	0	0.08	0	0	0
Nemateleotris magnifica	0	0	0	5	0	3	0	0	0	0	0.46	0	0.11	0.08
Neoniphon argenteus	0	0	0	1	0	1	0	0	0	0	0.08	0	0.03	0.11
Neoniphon opercularis	0	0	1	0	0	0	0	0	0	0.05	0	0	0	0
Neoniphon sammara	0	0	1	4	0	0	0	0	0	0.09	0.71	0	0	0
Oplopomus atherinoides?	1	0	0	0	0	0	0	0.13	0	0	0	0	0	0.03
Ostorhinchus compressus	0	2	1	0	0	0	0	0	1.3	0.09	0	0	0	0
Ostorhinchus cyanosoma	0	0	0	1	0	0	0	0	0	0	0.83	0	0	0
Ostorhinchus wassinki	0	0	1	0	0	0	0	0	0	2.05	0	0	0	0.03
Oxymonacanthus longirostris	0	0	0	0	0	1	0	0	0	0	0	0	0.08	0.03
Paracirrhites arcatus	0	0	1	2	0	0	3	0	0	0.05	0.08	0	0	0
Paracirrhites forsteri	1	0	9	15	5	15	11	0.13	0	0.55	1.79	0.52	1.22	0
Parapercis clathrata	1	3	6	0	2	0	0	0.13	0.5	0.45	0	0.26	0	0.08
Parapercis millepunctata	0	0	0	2	0	0	0	0	0	0	0.08	0	0	0.03
Parapercis multiplicata	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Parapercis pacifica	1	1	1	3	0	0	0	0.13	0.2	0.05	0.17	0	0	0.03
Petroscirtes breviceps	0	0	0	0	1	0	0	0	0	0	0	0.04	0	0.03
Petroscirtes variabilis	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0.06
Pictichromis paccagnellae	0	0	0	1	0	0	0	0	0	0	0.04	0	0	0.08
Plagiotremus laudandus	0	0	0	1	0	0	3	0	0	0	0.04	0	0	0.03
Plagiotremus tapeinosoma	0	0	0	0	0	2	1	0	0	0	0	0	0.05	0.11
Pristiapogon kallopterus	0	0	0	1	0	0	0	0	0	0	0.83	0	0	0
Pristicon rhodopterus	0	0	1	0	0	0	0	0	0	0.05	0	0	0	0
Pseudochromis bitaeniatus	0	0	3	1	0	0	0	0	0	0.14	0.08	0	0	0
Pseudochromis cyanotaenia	0	0	0	1	0	0	0	0	0	0	0.04	0	0	0.14
Pseudochromis fuscus	4	3	4	5	2	4	4	1.13	0.7	0.23	0.46	0.22	0.16	0
Ptereleotris evides	0	0	1	0	0	0	1	0	0	0.09	0	0	0	0.31
Pterois antennata	0	0	0	1	0	0	0	0	0	0	0.04	0	0	0
Salarias alboguttatus	0	0	0	0	0	2	1	0	0	0	0	0	0.05	0.28
Salarias fasciatus	0	2	0	0	0	0	0	0	0.6	0	0	0	0	0
Salarias spp.	0	0	0	1	0	0	0	0	0	0	0.04	0	0	0

Sargocentron caudimaculatum	0	0	2	3	0	1	3	0	0	0.09	0.29	0	0.14	0
Sargocentron cornutum	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03
Sargocentron diadema	0	0	0	0	1	1	0	0	0	0	0	0.07	0.03	0.11
Sargocentron microstoma	0	0	0	0	0	1	0	0	0	0	0	0	0.03	0.03
Sargocentron spiniferum	0	0	0	1	0	2	0	0	0	0	0.04	0	0.08	
Sargocentron spp.	0	0	0	0	0	1	1	0	0	0	0	0	0.03	
Saurida gracilis	1	3	0	0	2	1	1	0.13	0.4	0	0	0.07	0.03	
Saurida nebulosa	0	0	0	0	1	0	2	0	0	0	0	0.04	0	
Signigobius biocellatus	3	0	0	0	0	0	0	1	0	0	0	0	0	
Synodus binotatus	0	0	0	0	0	3	0	0	0	0	0	0	0.19	
Synodus dermatogenys	0	1	2	2	0	0	0	0	0.2	0.14	0.17	0	0	
Synodus jaculum	0	0	1	0	0	0	0	0	0	0.09	0	0	0	
Synodus spp.	0	1	0	0	0	0	0	0	0.1	0	0	0	0	
Synodus variegatus	2	1	4	3	0	1	0	0.25	0.1	0.5	0.29	0	0.03	
Trimma hayashii	0	0	0	0	0	0	1	0	0	0	0	0	0	
Trimma lantana	0	0	0	1	0	0	0	0	0	0	0.04	0	0	
Trimma spp.	0	0	1	0	0	0	0	0	0	0.05	0	0	0	
Trimma striata	1	1	0	0	0	0	0	0.25	0.2	0	0	0	0	
Tripterygiid spp.	0	0	1	1	0	0	0	0	0	0.05	0.04	0	0	
Ucla xenogrammus	0	0	0	1	1	3	2	0	0	0	0.04	0.19	0.11	
Valenciennea longipinnis	0	0	0	0	0	0	0	0	0	0	0	0	0	
Valenciennea sexguttata	2	2	0	0	0	0	0	0.5	0.5	0	0	0	0	
Valenciennea spp.	0	0	0	0	0	0	1	0	0	0	0	0	0	
Valenciennea strigata	0	0	2	1	0	0	1	0	0	0.55	0.04	0	0	