

The composition and structure of shallow benthic reef communities in the Kimberley, north-west Australia

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ABSTRACT – The diversity, productivity and health of tropical reef ecosystems are at risk from cumulative anthropogenic and climate stressors. To provide insight into natural patterns of community structure and to set benchmarks to detect change, it is important to establish baselines for common community metrics, such as benthic cover, while ecosystems are near-pristine. Here we report the findings from six years of shallow-water marine benthic surveys (0–15 m depth) in the Kimberley, Western Australia. This dataset provides the first broad-scale quantification of the general composition and structure of reefs in this little known region. We show that the Kimberley reef system is heterogeneous, with distinct inshore-offshore, intertidal-subtidal and subregional patterns of community structure. The dominant category of live benthos in the Kimberley is hard coral (23.81% ± 1.28%), followed by turf algae (14.40% ± 1.51%) and macro-algae (7.05% ± 1.00%). At the regional scale, soft corals and sponges were minor contributors to benthic cover accounting for less than 3%. Benthic composition and structure was significantly different between all five subregions, with the exception of Inshore North and Inshore South, which share traits, such as a higher level of macroalgae and lower level of turf and coralline algae, than the level recorded in the Inshore Central subregion. Offshore, the southern subregion (Rowley Shoals) had the highest level of hard coral cover (27.92% ± 2.51%), and inshore the highest level of hard coral cover was recorded in the northern subregion (25.39% ± 3.00%). Overall, this dataset provides a reference for future marine conservation planning in the region and confirms that shallow benthic communities of the Kimberley are an important part of Australia's tropical reefscape.

KEYWORDS: baseline, benthos, coral cover, north-west Australia, Indian Ocean, Woodside Collection Project

INTRODUCTION

Tropical reefs are increasingly threatened by severe disturbances such as cyclones, in combination with more chronic threats like global warming. While reefs are naturally dynamic systems, there is growing concern that coral reef communities are being irrevocably damaged, changed, and/or simplified (Dornelas et al. 2014; Magurran et al. 2015; Smith et al. 2016). As a result, the ability for ecosystems to recover after disturbances is increasingly questioned (van Hooijdonk et al. 2016; Hughes et al. 2017). Globally, most coral reef ecosystems are moderately to severely damaged by human activities, such as fishing and pollution; hence it can be difficult to

separate natural from unnatural changes (Jackson 2001; Knowlton and Jackson 2008). The ability to detect significant change and substantiate recovery in long-term monitoring programs is dependent on the availability of comparative and rigorous pre-impact reference data. Obtaining baseline knowledge concerning the structure and functioning of ecosystems in the absence of human impacts is fundamental for the effective management and conservation of coral reef ecosystems.

In diverse tropical reef ecosystems, habitat attributes such as the percentage cover of benthic taxa and topographic complexity are relied upon to inform management about reef condition

(Wilkinson 2008; Sweatman et al. 2008, 2011; Arias-González et al. 2011; Ateweberhan et al. 2011). Percent live hard coral cover is the most commonly used metric to monitor and inform managers about coral reef status (Bruno and Selig 2007; De'ath et al. 2012; Gilmour et al. 2013). The abundance and composition of live hard coral is related to disturbance history (De'ath et al. 2012) and correlated with density-dependent ecosystem processes, such as disease prevalence (Bruno et al. 2007), the abundance of corallivorous reef fishes (Bell and Galzin 1984; Jones et al. 2004; Komyakova et al. 2013) and the abundance and diversity of other marine invertebrates (Przeslawski et al. 2008; Gibson et al. 2011).

While many studies focus on the level of hard coral cover as a proxy of reef condition, other benthic categories can also provide meaningful indicators of reef status and resilience. For example, monitoring the cover of macroalgae and soft corals is especially relevant for detecting phase shifts and for interpreting the implications of changes to ecosystem structure on food-web dynamics (Sandin et al. 2008; Cheal et al. 2010). Macroalgal overgrowth on tropical reefs can indicate a lack of herbivorous grazing (Hughes et al. 2007) which may signify overfishing (Jackson et al. 2001), or be a competitive response to coral mortality events (Diaz-Pulido et al. 2009). Similarly, a shift from hard coral to soft coral dominance can be associated with reef degradation (Przeslawski et al. 2008; Baum et al. 2016). Additionally, the extent and composition of abiotic substrate can influence the diversity of fish and other invertebrates such as echinoderms, marine worms, molluscs and crustaceans (Komyakova et al. 2013; Graham et al. 2014). Hence, monitoring and reporting on a variety of metrics, in addition to coral cover, can provide useful information to managers concerning the status of different taxa, enabling the overall resilience of dynamic tropical reef ecosystems to be assessed.

The reef ecosystems of the Kimberley are among the least impacted in the world due to low population density (Halpern et al. 2008) and provide a unique opportunity to examine the composition and structure of reef environments in the absence of land-based anthropogenic impacts. Coral reefs in the region, as first described by Teichert and Fairbridge (1948), fall into two general groups – fringing reefs that have formed around coastal islands across the inner Sahul Shelf and the large platform reefs, shoals and shelf-edge atolls occurring offshore. The inshore fringing

reefs are influenced by macrotides (>11m), turbid waters and low wave energy (DEC 2009; Wilson 2014). The large semi-diurnal tides culminate in intertidal reef communities being subaerially exposed during spring low tides for up to 3.5 hours (Richards et al. 2015), and subjected to high current velocities and turbidity levels during tidal ebb and flow (Ivey et al. 2016). Conversely, the submerged midshelf shoals and continental edge offshore atolls represent stable, clear-water, low productivity coral reef environments (Wilson 2013).

While the region has largely escaped land-based anthropogenic disturbances, there is a long history of traditional fishing and harvesting in the region (Fox 1998), modest commercial fishing operations (Molony et al. 2011) and increasing recreational fishing and tourism activities. Additionally, the region is an important reservoir of oil and gas reserves (Moore et al. 2016) and the exploration and exploitation of these resources presents environmental risks to species and habitats in the region (Butt et al. 2013; Kark et al. 2015). In 2009 Australia's largest oil spill event occurred in the vicinity of Ashmore Reef and the midshelf shoals (Li et al. 2010), but the lack of before-impact data made it difficult to determine the extent of the environmental effects (Watson et al. 2009).

The offshore atolls have also been impacted by numerous climate-induced coral bleaching and mortality events. In 1998 and 2016 widespread coral bleaching events severely impacted Scott Reef (Smith et al. 2008; Gilmour et al. 2013; Hughes et al. 2017) and in 2003 and 2010 Ashmore Reef was affected by coral bleaching (Ceccarelli et al. 2011; Heyward 2011). While the inshore Kimberley reefs appeared to escape the global bleaching events of 1998 and 2013, localised coral bleaching was recorded at reefs in the southern inshore Kimberley for the first time in 2016 (Le Nohaic et al. 2017). Hence, even though it is hypothesised that corals in the inshore Kimberley are tolerant of extreme environmental conditions (Richards et al. 2015); they are not immune to bleaching (Schoepf et al. 2015).

Here we report the findings from six years of baseline surveys in the marine environments of the Kimberley to provide a primary dataset quantifying the benthic composition and structure of Kimberley reefs. This dataset can be used as a reference for future monitoring and is available to inform managers about the variety of benthic communities in the region in order to facilitate the development of representative marine management reserves.

More specifically we seek to answer the following questions:

1. What are the major abiotic and biotic components that structure shallow water marine benthic communities in the Kimberley?
2. Are macro-scale environmental influences, such as tidal zone and shelf position major drivers of spatial structuring in Kimberley benthic communities?
3. Is there spatial partitioning at a subregional level?

METHODS

FIELD SURVEYS

Benthic community composition was recorded at single time-points from 2009–2014 at 164 stations, from 33 island/reef groups from a survey area within the Kimberley Project Area (Figure 1, see Sampey et al. 2014 for further descriptions of the Project Area and Bryce et al. 2017 for further

descriptions of the stations surveyed). One hundred survey stations were subtidal (mean depth 11.5 m, range 5–16 m, depending upon tidal amplitude) and 64 stations were intertidal (mean depth 0.5 m, range 0–4 m) (see Appendix 1). The subtidal sites were generally reef slopes, patch reef or submerged lagoonal habitats that were surveyed on SCUBA. Intertidal sites were mid to lower littoral reef flats surveyed by reef-walking or snorkeling at low tide when the reefs were subaerially exposed.

The number of stations surveyed at each reef varied depending on the size of the reef, the prevailing weather, oceanic conditions (tidal amplitude, currents, water visibility) and any overarching occupational safety considerations, such as the presence of crocodiles, diver nitrogen loads and vessel restrictions. Thus, while only a single station was surveyed at some reefs, six reefs were more intensively surveyed with over 10 separate stations surveyed (Ashmore Reef, Long Reef, Cassini Island, Montgomery Reef, Adele Island, and Rowley Shoals; see Figure 2). These reefs represent the extremes of any possible cross

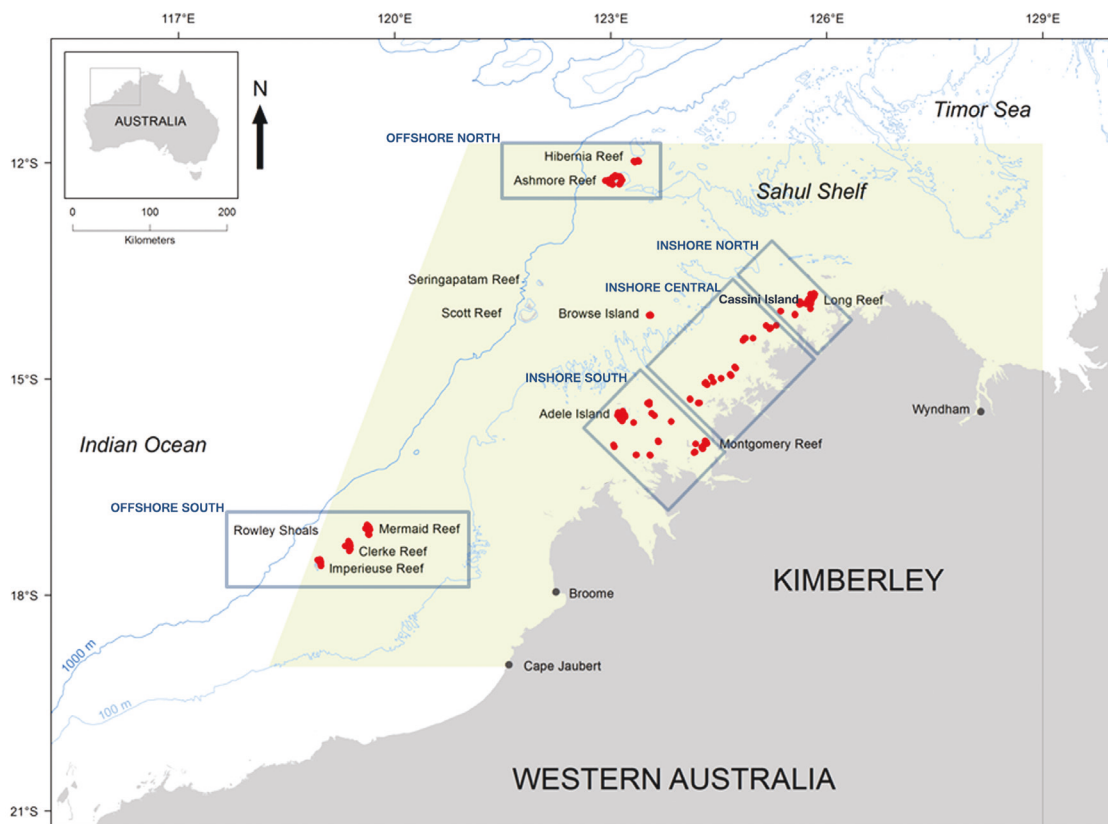


FIGURE 1 The Kimberley Project Area (green shaded area) with survey stations (red dots) and subregions (blue boxes). Browse Island was included in the Offshore North subregion. Locations with multiple survey stations are shown in Figure 2.

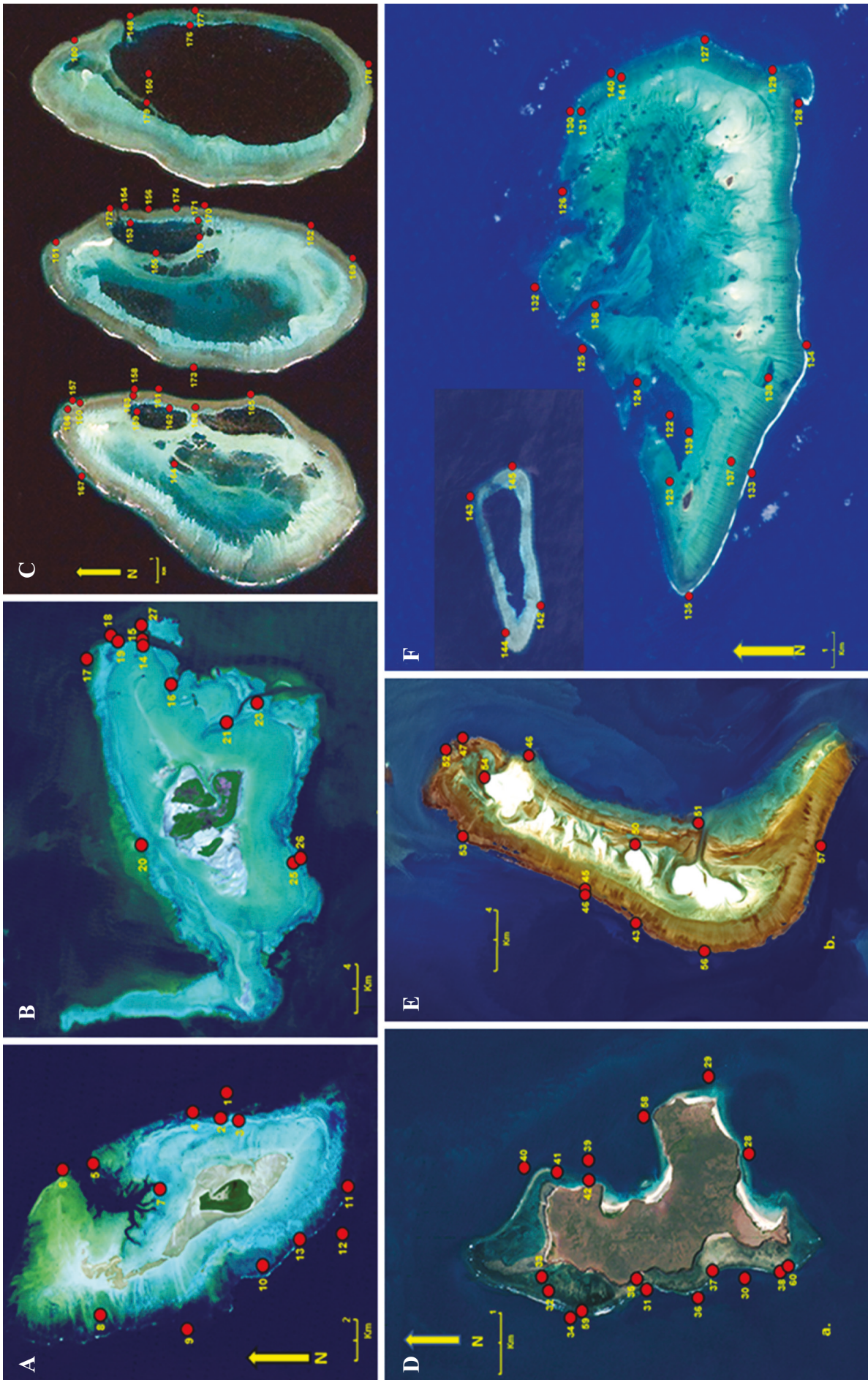


FIGURE 2 Six locations within the survey area were intensively surveyed. Locations were: A) Adele Island; B) Montgomery Reef; C) the Rowley Shoals (from left to right; Imperiuse, Clerke and Mermaid Reefs); D) Cassini Island; E) Long Reef, and; F) Ashmore Reef with inset for Hibernia Reef.

shelf and latitudinal benthic gradients. For further discussion of site choice refer to Bryce et al. (2017).

A combination of photo transects (2009, 2010, 2011 and 2012) and in-situ point-intercept (2013, 2014) assessments were undertaken. In the case of photo transects, 25 replicate 1 m² photographs were taken along each of three randomly placed 25 m transects. Coral Point Count with Excel extension software (Kohler and Gill 2006) was then used to determine the benthic composition directly below two randomly placed points per image (50 points per transect). For in-situ assessments (2013-2014), the benthic composition directly below 50 points (every 50 cm) was determined across each of three randomly placed 25 m transects. The photo-transect and in-situ point count methodologies are well accepted (Hill and Wilkinson 2004) and the data are comparable as the number of point counts were identical (Jokiel et al. 2015).

Given the large number of stations surveyed over such a large area, the stations were separated into five subregions, which were defined according to latitude and bathymetry and designated as: Offshore North, Offshore South, Inshore North, Inshore Central and Inshore South (Figure 1). For this analysis inshore and offshore were defined by bathymetry with respect to distance from the coast, where inshore extended from the mainland to the 100 m bathymetric contour and offshore extended deeper from 101 m (see Figure 1). To ameliorate occupational safety concerns only islands and reefs occurring at least 10 km from the mainland and distanced from river outflows were surveyed.

Benthic cover was classified into 13 coarse biotic and abiotic categories. Biotic categories were: hard corals, soft corals, sponges, seagrasses, macroalgae, turf algae, coralline algae (encrusting forms), crustose algae (branching calcareous forms incl. *Halimeda* sp.) and other invertebrates (including zooanthids, molluscs, holothurians, ascidians and bryozoans). Abiotic categories were: sand, shell grit, rubble, bare rock and silt.

DATA ANALYSIS

Summary statistics were calculated for the mean percent cover (\pm SE) of each benthic category in the area surveyed, according to shelf position (inshore/offshore), tidal zone (intertidal/subtidal) and subregion. To test whether environmental heterogeneity differed between factors we performed an analysis of homogeneity of multivariate dispersions (PERMDISP) in Primer-E Version 7 (Clarke and Gorley 2015). The benthic cover variables were square-root transformed to reduce the influence of the common taxa and increase the influence of the rare taxa and a

resemblance matrix of similarities was calculated using the Bray-Curtis coefficient. The Bray Curtis similarity coefficient was used because it does not consider joint absences and this is the standard coefficient used in biological assemblage and community analyses (Clarke and Gorley 2015). The resulting resemblance matrix was visualised using Principal Coordinates Analysis (PCO).

To test for the significance of differences in benthic community structure ANOSIM were conducted on the factors of shelf position (inshore/offshore), tidal zone (intertidal/subtidal) and subregion. The assumption of homogeneity of dispersions was satisfied in PERMDISP tests; hence we further explored the factors influencing community structure and the presence of interaction effects with Permutational ANOVA (PERMANOVA) (Clarke and Gorley 2015). This analysis was conducted with type III sums of squares using a fixed effects design where tidal zone and subregion were nested in shelf position. Furthermore, to examine which variables are contributing to the observed differences in community structure we conducted one-way analysis of similarity (SIMPER) and visualised the patterns for the key groups via PCO.

To better visualise significant differences identified through our PERMANOVA analysis we used bootstrapping of group means and ordination of these results with non-metric MDS, as suggested by Clarke and Gorley (2015). This approach is a multivariate analogue of univariate means plots with error bars, and is an effective way to display differences in groups that contain high sampling variability, which defines clear ordinations in two dimensions (i.e. high stress). Use of group means averaged over multiple bootstraps greatly reduces the sampling variability and provides for improved interpretability of ordinations.

RESULTS

REGIONAL PATTERNS IN BENTHIC COVER

The dominant category of live benthos in the Kimberley survey area was hard coral (23.81% \pm 1.28%) (Table 1). However, a large variation in the level of hard coral cover was recorded across the survey sites (Appendix 1). Turf algae was the second largest contributor to benthic cover in the region (14.40% \pm 1.51%) followed by macroalgae (7.05% \pm 1.00%). At the regional scale, soft corals, sponges and other benthic invertebrates were minor contributors to benthic cover as each accounted for less than 3% of the overall cover. Appendix 1 contains summary data for the mean cover of the remaining benthic categories at all stations surveyed.

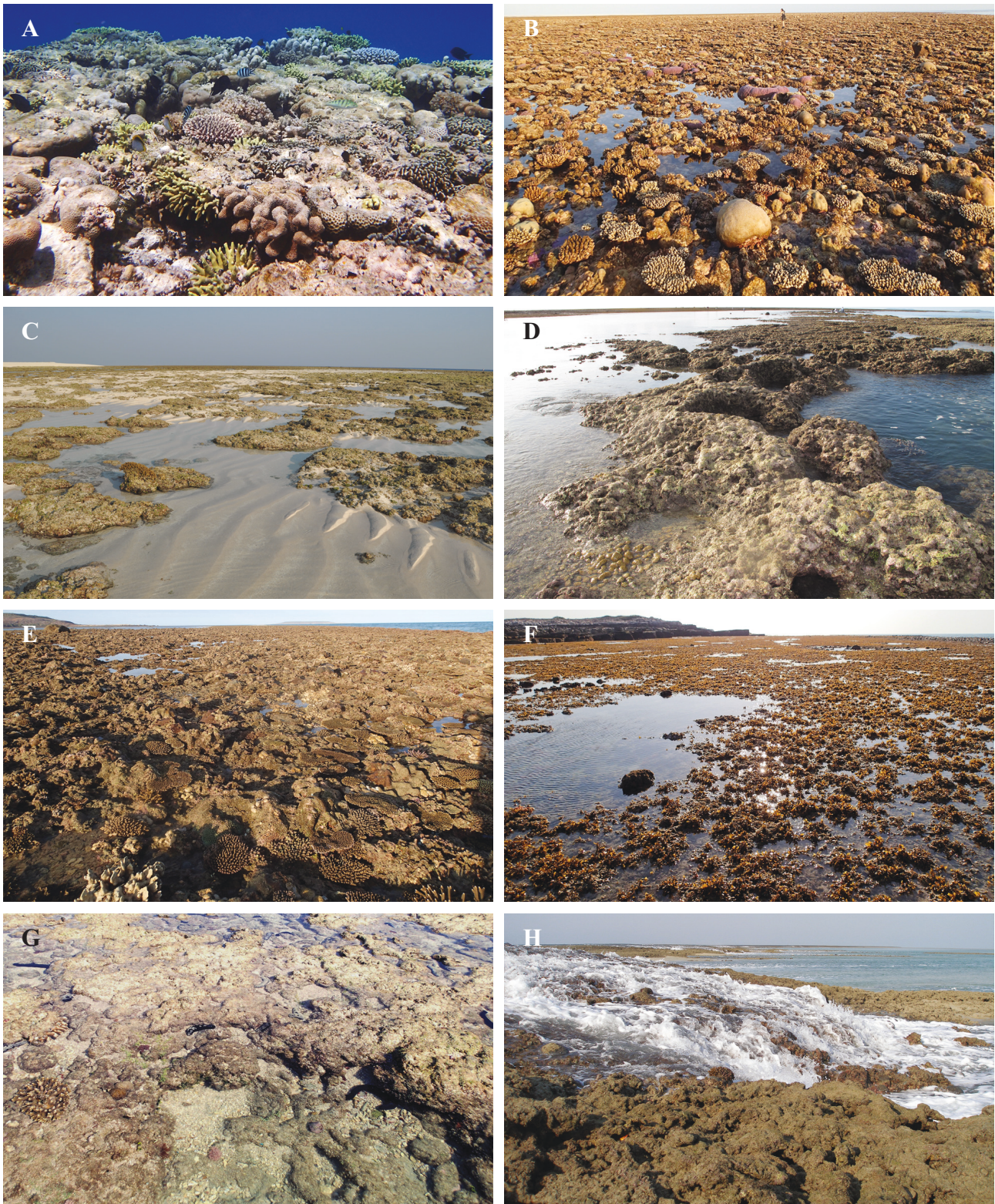


FIGURE 3 Intertidal habitat: offshore and inshore. A) Low-growing corals on the shallow outer reef flat at Ashmore Reef (129/K13); B) Consolidated reef pavement with high coral cover at Clerke Reef (Rowley Shoals: 172/K14); C) Flat cemented reef platform with turf algae and motile sand at Browse Island (104/K12); D) Mid-littoral reef pavement extending down to a narrow, honeycombed fore-reef ramp at Long Reef (56/K10). The tide pools are fringed with small coral colonies and the ramp has a high cover of *Tubipora musica* (28%) (Richards et al. 2013); E) Intertidal reef platform at Patricia Island (114/K12) with an abundance of hard coral colonies; F) The reef platform on the north side of Woodward Island (100/K12) is dominated by cropped *Sargassum* and turf algae; G) Cemented reef platform with many tide pools, coralline algae and turf algae at Condillac Island (112/K12); H) A steep forward ramp with drainage channels leading to a seaward terrace dominated by turf and coralline algae at Montgomery Reef (16/K09).



FIGURE 4 Subtidal Inshore habitat. A) Gently sloping reef at Long Reef (58/K10) with coral outcrops covered with sponges, hard corals, soft corals, sea fans, hydroids and encrusting molluscs; B) Long Reef (50/K10): inner lagoon habitat near a sand cay with coarse coralline sand, small rocky outcrops and a high abundance of the sponge, *Phyllospongia* sp.; C) High energy outer reef edge at Robroy Reefs (118/K12) with large *Montipora* plates; D) Station 119/K12 at Robroy Reefs: a plain of coarse coralline sand with large rocky outcrops covered with hard corals, sponges, hydroids and algae; E, F) A patch reef on the eastern side of the West Montalivet Island (117/K12). Sea whips, sea fans and sponges, such as the large barrel sponge, *Xestospongia testudinaria*, were well represented at the station, in addition to expansive areas of branching *Acropora* sp.; G) The seaward reef edge at Patricia Island (114/K12) is made up of single and coalesced outcrops covered with coralline algae, hard corals, soft corals, sponges, and a fine dusting of silt; H) Large rocky outcrops at Adele Island (06/K09) formed a deeply incised, ledged and undercut vertical wall covered with hard corals and encrusting soft corals.

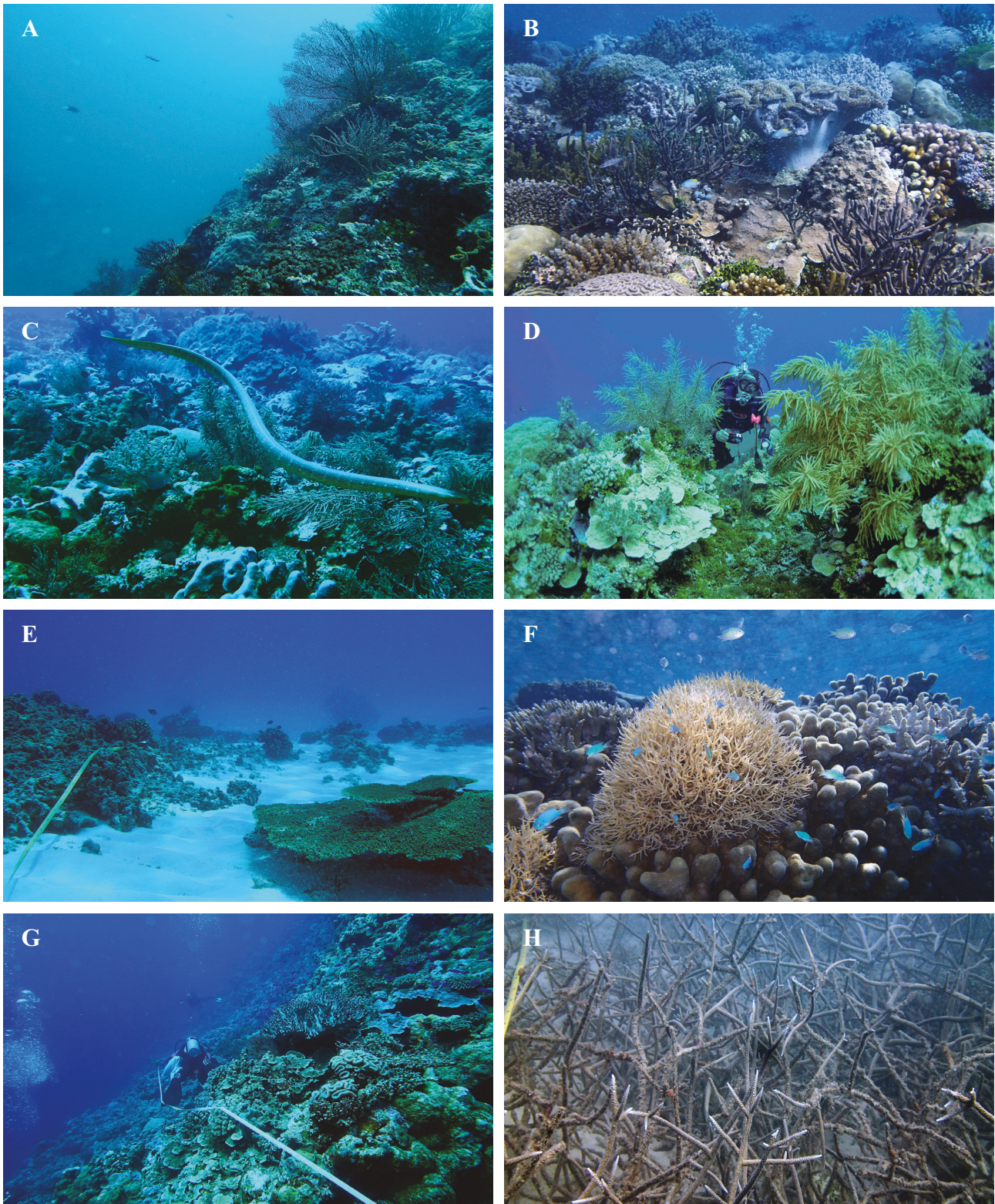


FIGURE 5 Subtidal Offshore habitat. A, B) Steep outer slope at north Ashmore Reef (130/K13) is deeply incised with caves and small ledges. The slope and slope crest (5–7 m) display a diverse assemblage of hard and soft corals; C) Station 142/K13, north Hibernia Reef. Reef crest of the fore-reef slope is mainly covered by hard corals and a diverse assemblage of algae including *Halimeda* sp.; D) The cemented fore-reef slope at north Hibernia Reef (144/K13) with 'hillocks' and 'gullies' and a diversity of soft and hard corals between; E) Low profile patch reef at Browse Island (101/K12) consisting of small, coalescing outcrops with colonies of hard corals and turf algae; F) The edge of a large mid-littoral tide pool (depth: 6 m) at Ashmore Reef (138/K13). *Acropora* thickets dominated throughout the base of the pool; G) A steep, high profile reef at the south east end of Mermaid Reef (Rowley Shoals: 178/K14) displays an impressive coverage of hard corals with a high abundance of turf and coralline algae; H) Thickets of *Acropora* sp. were dominant in the lagoon of Mermaid Reef (179/K14).

TABLE 1 Summary statistics for the overall mean cover (\pm SE) of the nine major biotic categories encountered in the Kimberley survey area, within tidal zone, shelf position and subregion. Maximum values within zone, position and subregion are marked in bold.

		Hard Coral	Soft Coral	Sponge	Other Inverts	Turf Algae	Coralline Algae	Macro Algae	Halimeda	Seagrass
Region Wide	Mean	23.81	2.66	2.30	0.65	14.40	4.21	7.05	1.61	0.18
	SE	1.28	0.33	0.23	0.10	1.51	0.50	1.00	0.42	0.10
Intertidal	Mean	14.38	0.77	1.45	0.17	19.19	1.85	15.48	0.23	0.41
	SE	1.92	0.19	0.34	0.10	3.31	0.52	2.15	0.13	0.26
Subtidal	Mean	29.85	3.88	2.85	0.96	11.34	5.72	1.65	2.48	0.04
	SE	1.41	0.50	0.31	0.15	1.21	0.71	0.27	0.68	0.03
Inshore	Mean	24.45	2.05	2.52	0.40	8.30	3.06	9.45	0.43	0.02
	SE	1.78	0.35	0.30	0.10	1.67	0.65	1.54	0.15	0.01
Offshore	Mean	22.76	3.67	1.94	1.06	24.45	6.10	3.10	3.54	0.45
	SE	1.72	0.66	0.37	0.20	2.42	0.73	0.46	1.06	0.27
Inshore North	Mean	23.59	2.56	3.37	0.36	3.54	2.72	7.58	0.08	0.00
	SE	3.00	0.80	0.64	0.18	1.90	0.75	2.55	0.04	0.00
Inshore Central	Mean	23.65	3.05	1.45	0.61	22.66	7.35	3.60	1.228	0.10
	SE	3.67	0.75	0.43	0.26	5.18	2.33	1.35	0.48	0.06
Inshore South	Mean	24.16	1.17	2.43	0.31	4.55	1.13	13.85	0.27	0.00
	SE	2.82	0.31	0.41	0.13	1.61	0.42	2.71	0.21	0.00
Offshore North	Mean	17.26	5.57	3.16	1.20	16.19	5.55	2.68	7.11	0.89
	SE	1.90	1.19	0.63	0.30	1.95	0.93	0.65	1.99	0.54
Offshore South	Mean	27.92	1.89	0.80	0.94	32.20	6.61	3.50	0.19	0.03
	SE	2.52	0.43	0.29	0.28	3.86	1.12	0.64	0.17	0.02

Important differences were observed in the level of cover of all major benthic categories between intertidal and subtidal zones. While some intertidal reefs had a high level of coral cover (e.g. Patricia Island, Figure 3E), hard coral cover was generally twice as high in subtidal zones (see Figures 4, 5). Similarly, soft corals, sponges, invertebrates and coralline algae were more commonly encountered in subtidal habitats. Other types of marine flora (turf algae, macroalgae, *Halimeda* spp. and seagrasses) were more commonly encountered in the intertidal habitats. Amongst the abiotic groups, rock, silt and sand dominated both intertidal and subtidal zones, but these groups reached their highest level of coverage in the intertidal zone (Table 2). In the subtidal zone there was a higher coverage of rubble and shell grit.

Substantial differences were also observed in the percentage composition of benthic categories

TABLE 2 Summary statistics for the overall mean cover (\pm SE) of the four major abiotic categories of benthos encountered in the Kimberley survey area, within tidal zone and shelf position. Maximum values are marked in bold.

		Sand	Rubble	Rock & Silt	Shell Grit
Intertidal	Mean	15.18	11.13	19.47	0.18
	SE	1.87	1.30	2.63	0.10
Subtidal	Mean	12.10	11.52	16.64	1.05
	SE	1.53	1.29	1.89	1.00
Inshore	Mean	12.09	8.64	27.56	1.03
	SE	1.36	1.01	1.85	0.98
Offshore	Mean	15.31	15.85	1.60	0.18
	SE	2.19	1.68	0.81	0.10

at inshore and offshore locations. Hard corals were the dominant taxa across the shelf, but overall, they reached a slightly higher level of cover inshore. The soft coral cover was at its highest level offshore as was turf algae, coralline algae, *Halimeda* spp., seagrasses and other invertebrates (holothurians, molluscs etc.). Sponges and macroalgae were more commonly encountered inshore. It should be noted that seagrasses were rarely encountered at any of the survey sites. Amongst the abiotic groups, rock and silt dominated the inshore bioregions, whilst the offshore bioregions had a higher coverage of sand and rubble (Table 2).

There was significant subregional variation in the level of cover recorded on individual transects. For hard corals the level of percent cover was greatest in the Offshore South subregion (Rowley Shoals, $27.92\% \pm 2.52\%$) and lowest in the Offshore North (Ashmore and Hibernia Reefs, $17.26\% \pm 1.90\%$). For soft corals, the reverse pattern was observed with the highest level of cover in the Offshore North ($5.57\% \pm 1.19\%$). Sponges reached their highest level of cover ($3.37\% \pm 0.64\%$) in

the Inshore North, while other invertebrates (holothurians, molluscs, anemones etc.) were more likely to be encountered in the Offshore North. Amongst the marine flora, turf algae reached its highest level of cover in the Offshore South, whilst seagrasses and *Halimeda* spp. were more prevalent in the Offshore North. The highest level of coralline algal cover was recorded in the Inshore Central, whilst macroalgae dominated in the Inshore South.

THE INFLUENCE OF SHELF POSITION AND TIDAL ZONE ON BENTHIC COVER

When visualised as a PCO, over 70% of the observed variation in benthic structure was accounted for by the first two axes (Figure 6). PERMANOVA results confirmed there is a highly significant difference between inshore and offshore communities ($t = 6.7804$, $P_{\text{perm}} = 0.0001$) and between subtidal and intertidal communities ($t = 5.3287$, $P_{\text{perm}} = 0.0001$). The SIMPER analysis of the group contributions to the average similarity between inshore and offshore locations (Table 3) supports the main vectors in the PCO (Figure 6) indicating

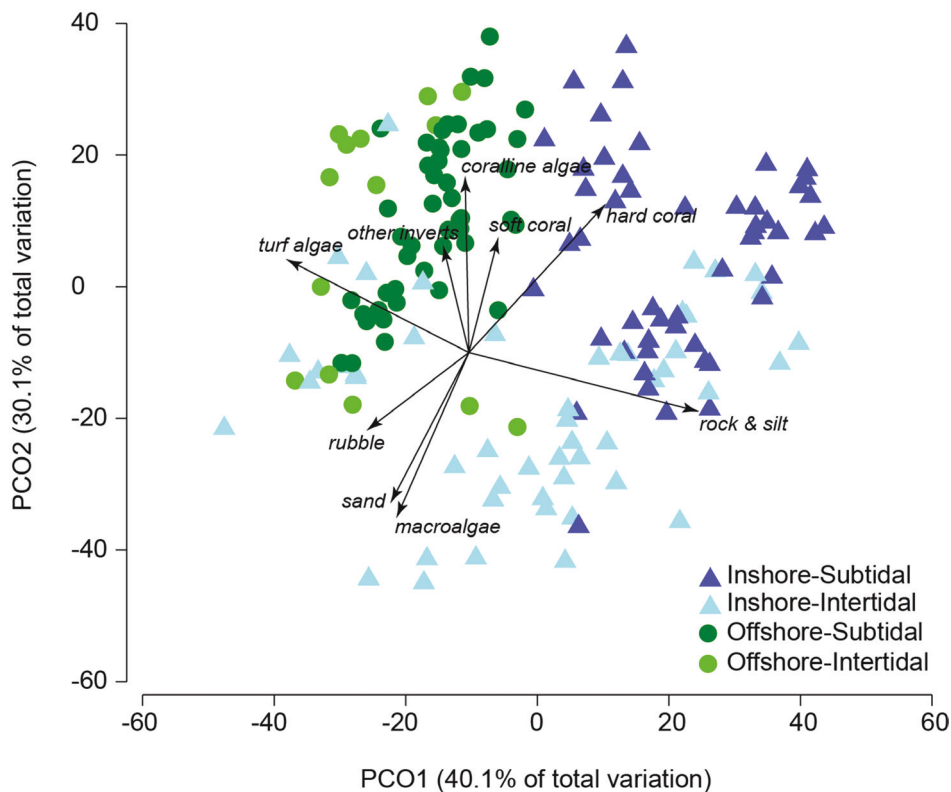


FIGURE 6 Principal coordinates analysis of benthic community composition in the Kimberley survey area. Stations clustered according to shelf position (inshore offshore) and tidal zone (intertidal/subtidal). The vectors indicate the principal drivers of similarity between stations.

TABLE 3 SIMPER analysis of the species contributions to the average similarity between shelf position, tidal zone and subregion. Included are the top three benthic groups explaining the largest percent of the variance. The principal driver is marked in bold.

Species	Avg Abund.	Avg Abund.	Avg Diss.	Diss./SD	Cont. %
	Inshore	Offshore			
Rock/Silt	4.75	0.48	9.69	1.88	18.55
Turf Algae	1.52	4.64	8.50	1.68	16.28
Sand	3.85	3.18	5.43	1.31	10.40
	Subtidal	Intertidal			
Rock/Silt	2.96	3.42	7.20	1.28	14.22
Turf Algae	2.57	2.90	7.10	1.23	14.02
Macroalgae	0.85	3.24	6.05	1.24	11.95
	Inshore Intertidal	Inshore Subtidal			
Macroalgae	3.69	0.31	7.95	1.49	16.21
Hard Coral	3.35	5.66	6.61	1.50	13.48
Rock/Silt	4.11	5.47	6.14	1.28	12.53
	Offshore Intertidal	Offshore Subtidal			
Hard Coral	2.76	4.97	5.83	1.57	14.23
Turf Algae	6.19	4.19	5.67	1.32	13.85
Rubble	2.67	3.85	4.29	1.37	10.46
	Inshore Intertidal	Offshore Intertidal			
Turf Algae	1.98	6.19	11.52	1.69	21.22
Rock/Silt	4.11	0.94	8.85	1.44	16.30
Macroalgae	3.69	1.62	6.14	1.32	11.31
	Inshore Subtidal	Offshore Subtidal			
Rock/Silt	5.47	0.35	11.00	2.93	22.22
Turf Algae	1.11	4.19	7.21	1.79	14.58
Rubble	1.63	3.85	6.04	1.48	12.21
	Offshore North	Offshore South			
Sand	4.15	2.27	6.01	1.35	15.69
Turf Algae	3.81	5.42	4.29	1.12	11.21
Hard Coral	3.80	5.09	4.12	1.20	10.75
	Offshore South	Inshore South			
Turf Algae	5.42	0.96	10.79	1.98	19.92
Rock/Silt	0.00	4.62	10.46	1.88	19.29
Rubble	3.79	2.41	5.39	1.32	9.94
	Offshore North	Inshore North			
Rock/Silt	0.99	5.33	9.57	2.02	17.96
Turf Algae	3.81	0.65	7.60	2.29	14.25
Sand	4.15	2.76	6.04	1.33	11.34

Species	Avg Abund.	Avg Abund.	Avg Diss.	Diss./SD	Cont. %
	Inshore North	Inshore Central			
Turf Algae	0.65	3.92	8.67	1.31	18.40
Rock/Silt	5.33	4.15	5.85	1.19	12.36
Sand	2.76	2.35	5.22	1.28	11.09
	Inshore North	Inshore South			
Macroalgae	1.54	2.74	6.55	1.15	15.29
Rock/Silt	5.33	4.62	5.98	1.19	13.96
Hard Coral	4.65	4.36	5.85	1.24	13.66
	Inshore Central	Inshore South			
Turf Algae	3.92	0.96	8.34	1.32	17.15
Rock/Silt	4.15	4.62	6.08	1.22	12.50
Macroalgae	1.07	2.74	5.91	1.18	12.15

the cross shelf separation is driven by the high cover of rock and silt at inshore locations, and the higher cover of turf algae and sand offshore (see also Tables 1, 2). The SIMPER analysis also supports the main vectors of the PCO, which suggest there is higher cover of rock and silt, turf algae and macroalgae in intertidal zones. Within the inshore region, the intertidal zone is distinguished from the subtidal zone by a higher coverage of macroalgae and a lower coverage of hard corals and rock/silt. However, offshore, the main dissimilarity between the intertidal and subtidal communities is a higher level of hard coral and rubble cover in the subtidal zone while the intertidal zone has a higher level of turf algae cover. Overall, turf algae, hard corals and macroalgae are the main biotic drivers of significant differences and PCOs of community composition provides strong visual support for the way these groups are structured across the shelf and depth gradients (Figure 7).

SUBREGIONAL TRENDS IN BENTHIC COVER

The PERMANOVA results demonstrate highly significant differences between benthic assemblages from all subregions with the exception of the Inshore North and Inshore South, which were non-significant at the $p < 0.05$ level (Table 4). These patterns are visualised in the non-Metric multidimensional scale plot which shows bootstrapped subregional means ($n = 100$ resamples with replacement) with 95% confidence (Figure 8). The ordination provides powerful visual support for the PERMANOVA results

signifying a strong similarity between the intertidal communities of the Inshore North and Inshore South, along with a strong similarity between the subtidal communities of these subregions. There is also a small amount of overlap between the subtidal communities in the Inshore North and Inshore Central (Figure 8).

The SIMPER analysis shows the main groups driving the differences between the Offshore South and Offshore North are the higher levels of turf algae and hard coral cover in the former and the higher level cover of sand in the latter (Table 3). Within the inshore subregions the higher level of turf algae in Inshore Central distinguishes it from the Inshore South or Inshore North, with the former distinguished by higher hard coral cover and the latter by higher macroalgae cover. Abiotic groups are also important drivers of difference between inshore subregions, with the lower level of rock and silt in the Inshore Central distinguishing it from the Inshore North and Inshore South (Table 3).

FINE-SCALE PATTERNS IN HARD CORAL COVER

Based on the results from the six locations that were intensively surveyed (see Figure 2), there is considerable heterogeneity in the level of hard coral cover within reefs (Figure 9). Cassini Island had the highest reef-wide hard coral cover with $29.64\% \pm 5.36\%$ followed by the Rowley Shoals ($27.92\% \pm 2.51\%$), Adele Island ($27.64\% \pm 5.78\%$), Montgomery Reef ($17.67\% \pm 3.28\%$) and Ashmore Reef ($15.83\% \pm 2.20\%$). Furthermore, there was a

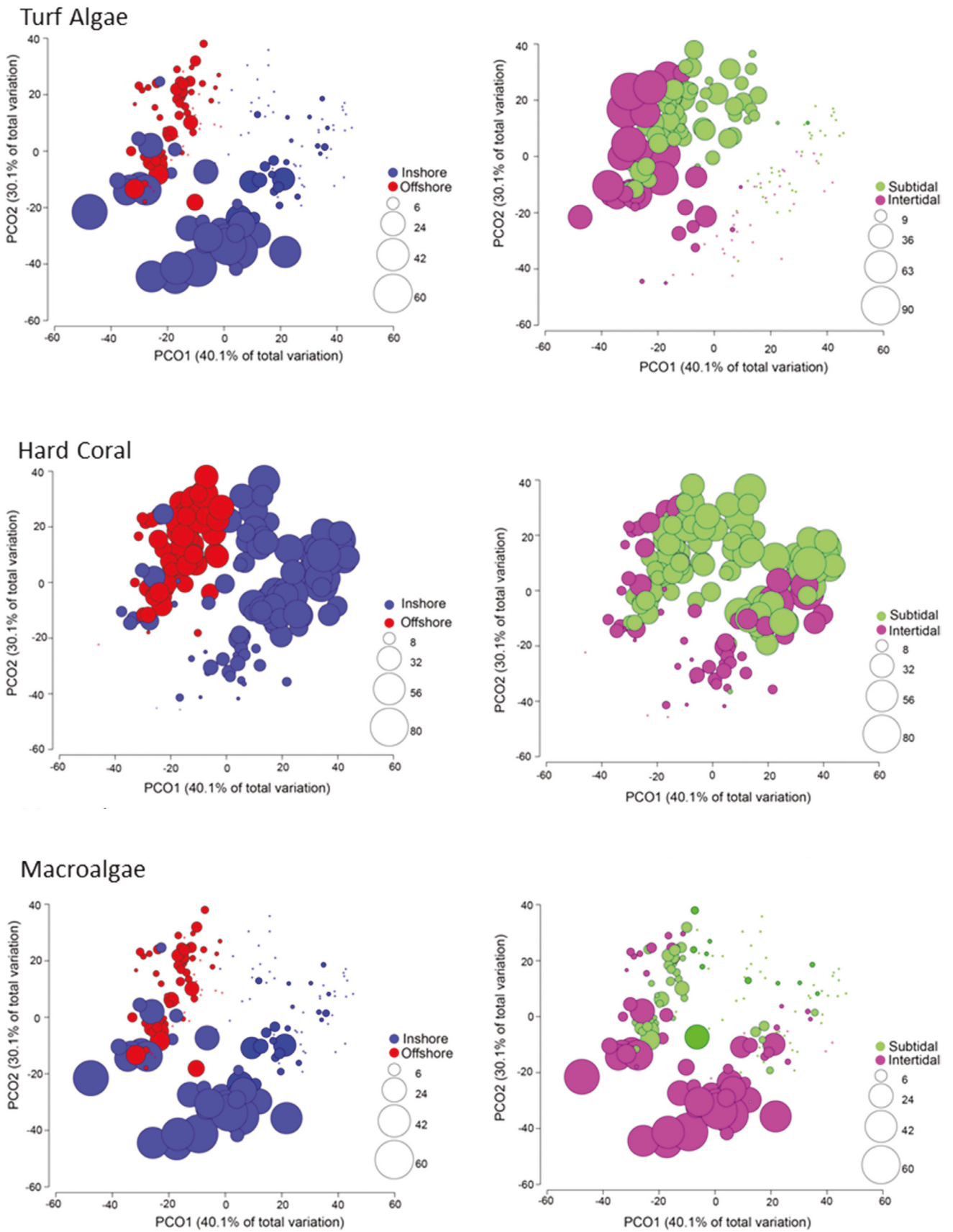


FIGURE 7 Principal coordinates analysis of community composition of the three main biotic drivers of regional patterns in community structure. Bubbles are proportional to the abundance of each taxa.

TABLE 4 PERMANOVA results from pairwise tests of the factors influencing community structure and the presence of interaction effects.

Factor	Test	t	P(perm)
Shelf position (Inshore)	Inshore South, Inshore Central	3.1952	0.0001***
	Inshore South, Inshore North	1.2992	0.1605 <i>ns</i>
	Inshore Central, Inshore North	3.3794	0.0001***
Shelf position (Offshore)	Offshore North, Offshore South	4.1204	0.0001***
Shelf position x habitat	Subtidal: inshore, offshore	8.1415	0.0001***
	Intertidal: inshore, offshore	3.4196	0.0001***
	Inshore: subtidal, intertidal	5.9987	0.0001***
	Offshore: subtidal, intertidal	2.9701	0.0001***
Shelf position (inshore) x tidal zone (subtidal)	Inshore South, Inshore Central	2.5832	0.0001***
	Inshore South, Inshore North	1.2267	0.1911 <i>ns</i>
	Inshore Central, Inshore North	1.8092	0.0201 <i>ns</i>
Shelf position (inshore) x tidal zone (intertidal)	Inshore South, Inshore Central	2.4787	0.0016*
	Inshore South, Inshore North	1.5463	0.0713 <i>ns</i>
	Inshore Central, Inshore North	2.9149	0.0002**
Shelf position (offshore) x tidal zone (subtidal)	Offshore North, Offshore South	3.2789	0.0001***
Shelf position (offshore) x tidal zone (intertidal)	Offshore North, Offshore South	3.6862	0.0004**

slight tendency for hard coral cover to be high on north-east exposures of individual reefs, although all reef aspects were not comprehensively surveyed.

Across all surveyed stations the highest mean coral cover was recorded on the mid-littoral reef platform at station 41/K10, Cassini Island (76.00% \pm 6.23%). High coral cover was also recorded in subtidal habitats at station 83/K11, Brue Reef (73.67% \pm 7.06%); on the reef slope within the channel at 5/K09 Adele Island (66.00% \pm 5.03%); on the slope at 69/K11 on an unnamed patch-reef outcrop (62.00% \pm 2.31%) and on the reef slope at 149/K14, Mermaid Reef (56.00% \pm 0.10%). Intertidally, the station with the highest mean level of hard coral cover was station 163/K14 at Imperieuse Reef (45.00% \pm 3.00%) followed by 21/K09, Montgomery Reef (42.00% \pm 0.00%); station 172/K14, Clerke Reef (37.00% \pm 10.00%) and at 3/K09, Adele Island (33.34% \pm 2.67%) (Appendix 1).

DISCUSSION

This dataset consisting of 164 stations across 33 reef/island groups is the first region wide compilation of benthic community structure and composition data for the Kimberley marine wilderness area. It shows that the Kimberley reefs are heterogeneous and confirms the assumption that distinct offshore and inshore communities exist off the Kimberley coast (Wilson 2013; Richards et al. 2014). There are also clear distinctions between the intertidal and subtidal communities and spatial partitioning that reflects macro-scale environmental influences.

The major biotic components that structure reefs in the region are hard corals, turf algae and macroalgae. The offshore reefs have a higher coverage of turf algae, *Halimeda* spp., coralline algae and soft corals than the inshore reefs, but the inshore reefs have a higher coverage of hard corals,

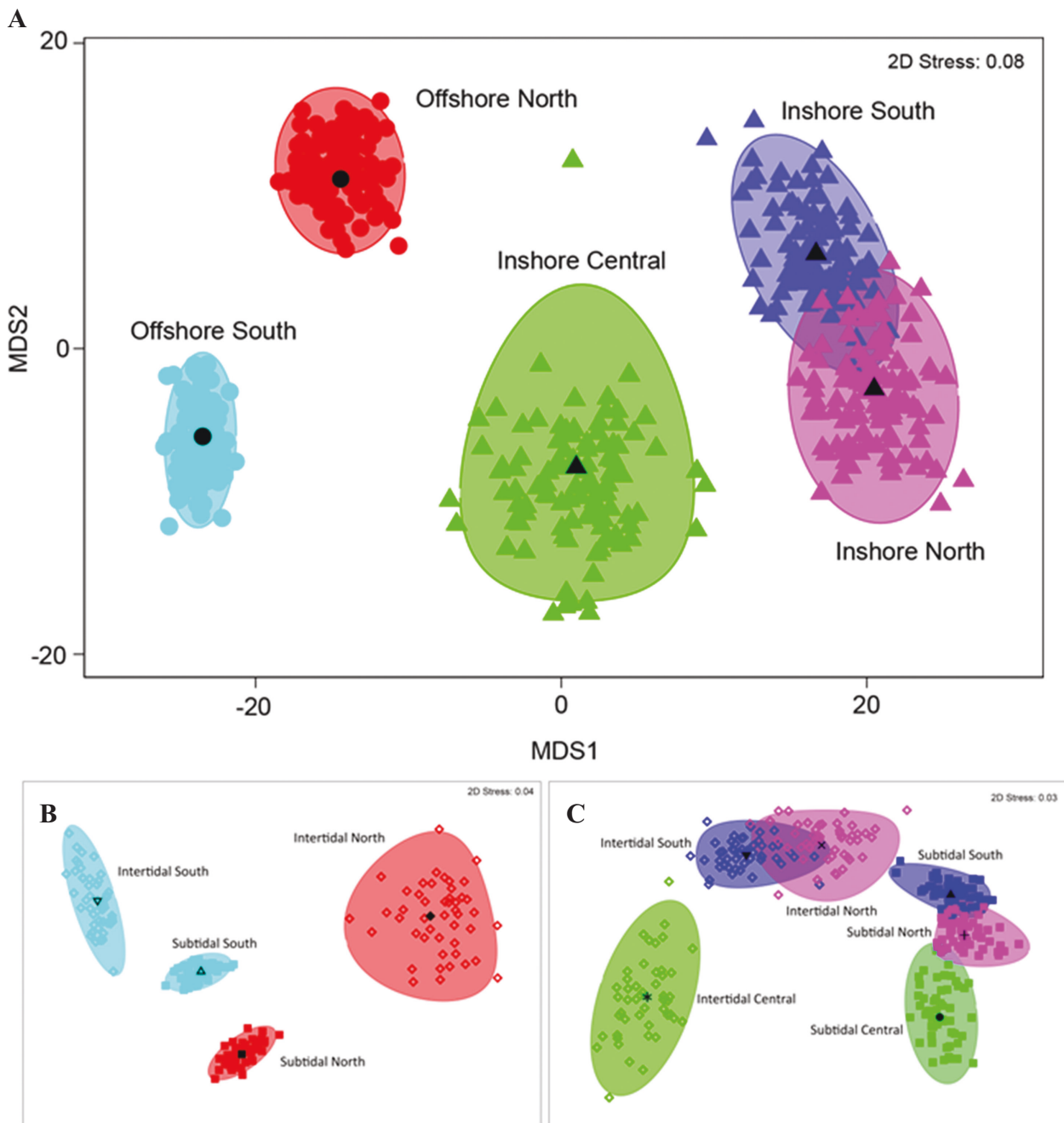


FIGURE 8 Non-Metric multidimensional scale plot illustrating the 95% confidence for A. subregions; B. offshore tidal zones, and; C. inshore tidal zones.

sponges and macroalgae. Subtidally, there is higher cover of hard corals, soft corals, sponges, *Halimeda* spp., coralline algae and other invertebrates, but intertidally there is a higher cover of turf algae, macroalgae and seagrasses. The highest level of macroalgal cover is found in inshore intertidal zones and the inshore subtidal zones have the highest level of hard coral cover. Soft corals reached their highest level of coverage in offshore subtidal zones, and sponges attained the highest level of

cover in inshore subtidal regions. Such differences in community composition are not surprising given the distinctly different environmental settings experienced across the shelf and across depths (Thackway and Cresswell 1998; Wilson 2013; Bryce et al. 2017).

We did not measure environmental parameters in this study. However, benthic organisms living at the land-sea interface in the inshore Kimberley are governed by a daily macrotidal

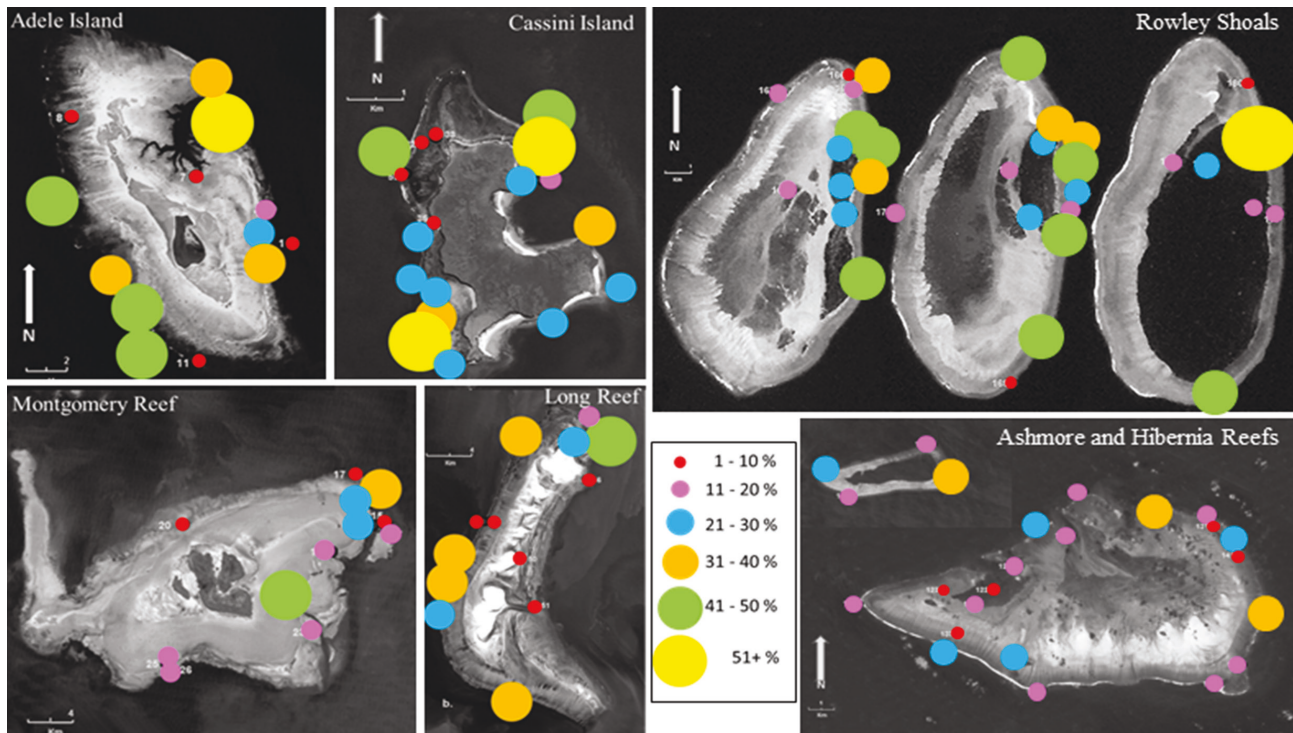


FIGURE 9 Mean percentage hard coral cover at the six reefs where multiple stations were surveyed.

cycle and a fortnightly neap-spring tidal cycle that sees tidal oscillations range in amplitude from 3–11 m (Thackway and Cresswell 1998). Intertidal communities must withstand multiple stressors including subaerial exposure at low tide, fluctuating and sometimes extreme temperature, sunlight and wind conditions and physical damage from waves and freshwater inundation (Glynn 1976; Le Tissier and Brown 1996; Dunne and Brown 2001). Despite extreme environmental conditions, previous studies have shown exceptionally diverse intertidal coral communities exist in the inshore Kimberly (Wilson et al. 2011; Richards et al. 2015). We show the mean level of hard coral cover on inshore intertidal reefs ($14.94\% \pm 2.34\%$) is three times higher than an earlier estimate of intertidal hard coral cover ($<5\%$ see Purcell 2002) and higher than the level of intertidal hard coral cover recorded offshore ($11.91\% \pm 3.60\%$). While this finding may at first seem surprising, it most likely relates to the higher level of wave energy and subsequent scouring experienced by offshore reef systems, especially during cyclone and storm events (Fabricius et al. 2008). Compared to the exposed offshore locations, the 2500 islands along the inshore Kimberley would afford greater opportunities for protection.

The offshore and inshore habitats also differed in the level of suspended sediment. The offshore

environment is best described as oligotrophic (Wilson 2013). While inshore monsoonal rainfall causes flooding of approximately 30 major rivers that drain into the shallow nearshore marine environment of the Sahul Shelf. During the wet season the large river systems of the region flood, transporting huge quantities of terrigenous sediment containing a high mineral clay composition into the nearshore environments (Gingele et al. 2001). These fine clay sediments are constantly mobilised, resuspended and deposited by tide-driven currents and strong prevailing winds across the reefs. Hence, it is not surprising that we found rock and silt to be the dominant abiotic groups inshore.

Traditional ecological theory asserts that photosynthetic animals prefer clear oligotrophic conditions and that sediment detrimentally affects the metabolism, reproductive behaviour and growth of benthic invertebrates such as corals (Loya 1976; Stafford-Smith and Ormond 1992; Reigl and Branch 1995; Gilmour 1999; Fabricius and Wolanski 2000; Humanes et al. 2017). However, more recently it has been hypothesised that in areas where there are naturally high levels of suspended sediments, such as the inshore Kimberley (Richards et al. 2015) and Great Barrier Reef (GBR; Morgan et al. 2017), suspended solids may protect photosynthetic benthos from solar radiation by lowering the

intensity of down welling irradiance (Anthony et al. 2007; Devlin et al. 2008). Furthermore, the high load of organic nutrients may actually enhance the opportunities for heterotrophic feeding (Anthony 2000; Anthony and Fabricius 2000) and our finding of high levels of both hard coral and sponge cover in the inshore subtidal zone supports this premise for these taxa.

Our analysis supports the findings of others (Hooper 1994; Fromont and Vanderklift 2009) that the northern and southern offshore subregions are distinct from each other and should be treated as separate management units. In the southern subregion (Rowley Shoals), the mean level of hard coral cover ($27.92\% \pm 2.52\%$) was higher than in the northern subregion (Ashmore and Hibernia Reefs, Browse Island, $17.26\% \pm 5.57\%$). However, the northern subregion was uniquely characterised by higher levels of cover of a variety of other taxa, including soft corals, *Halimeda* spp., seagrasses and other invertebrates (molluscs, anemones etc.). That soft corals are a prominent part of the reef community at Ashmore, Hibernia and Cartier Reefs has been alluded to in the past (Kospartov et al. 2006; Richards et al. 2009; Bryce and Sampey 2014). Similarly, based on historical records Ashmore and Hibernia Reefs appear to host far greater molluscan diversity than the Rowley Shoals (Willan et al. 2014). Hence, while Rowley Shoals is an important refuge for hard corals, Ashmore and surrounding reefs are important refuges for a wider diversity of benthic taxa.

Ashmore Reef is a Commonwealth Marine Reserve and the level of benthic cover at this location has been intermittently monitored over the last decade (Kospartov et al. 2006; Richards et al. 2009; Heyward et al. 2012) facilitating temporal comparisons. The mean level of hard coral cover recorded at the 22 stations surveyed at Ashmore Reef in 2013 ($14.9\% \pm 2.12\%$, excluding Hibernia and Browse Island) is lower than the mean level of coral cover recorded at eight sites in 2009 ($29.4\% \pm 1.83\%$), but higher than the level recorded at the same sites in 2005 ($10.2\% \pm 1.46\%$) (Ceccarelli et al. 2011). This level of hard coral cover is also lower than the levels recorded at the same eight sites in 2010 and 2011 ($24.36\% - 26.23\%$, Heyward et al. 2012). For soft corals, the mean level of soft coral cover recorded in 2013 ($4.44\% \pm 0.98\%$) is approximately half that recorded in 2009 ($8.3\% \pm 1.4\%$) and similar to the level recorded in 2005 ($4.5\% \pm 0.63\%$) (Ceccarelli et al. 2011). It is also lower than the levels recorded in 2010 and 2011 ($6.86\% \pm 6.54\%$, Heyward et al. 2012). Whether the observed decline in hard and soft coral cover between 2011 and 2013 represents biologically meaningful region wide

declines or artifacts of sampling in different habitat zones (intertidal and 12 m in this survey versus 3–5 m and 8–10 m in Ceccarelli and Heyward) or methodological inconsistencies cannot be resolved at this point.

When comparing the offshore regions, the higher level of coral cover recorded at the Rowley Shoals is likely to relate Ashmore Reef experiencing at least two historical bleaching events (2003 and 2010, see Ceccarelli et al. 2012; Heyward et al. 2012), whilst only minor coral bleaching has been observed at the Rowley Shoals. The factors underpinning the observed resilience of the Rowley Shoals to previous thermal stress events are not well understood, but a recent comparative study of environmental conditions on south-east Indian Ocean reefs shows the Rowley Shoals is exposed to a wider range of temperature variation than the northern atolls (see Zinke et al. 2018) and this may in part explain the greater inherent thermo-tolerance of the Rowley Shoals system. Alternatively, favorable local conditions at the time of these events (cooler sea surface temperatures and increased wind and cloud) may have mitigated the stress.

Inshore, there were some interesting patterns of subregional differentiation. The Inshore Central was significantly different from both the Inshore North and Inshore South, yet these latter subregions were not significantly different from each other. The disparity is largely driven by latitudinal variation in the composition of floral communities, whose structure shifted from macroalgal domination in the north and south to turf algae and coralline algal domination in the Inshore Central. There are numerous possible explanations for this pattern. High macroalgae cover on tropical reefs can be indicative of low herbivore abundance (Przeslawski 2008; Hughes et al. 2010). However, herbivorous fishes are generally not targeted in the regions recreational or commercial fisheries, and the level of fishing for carnivorous fishes in the Kimberley is considered to be relatively low, hence overfishing is not a likely explanation for the abundance of macroalgae. Given the Kimberley waters have been described as some of the least productive waters for finfish in the world (Molony et al. 2011), it is possible there are naturally low levels of herbivore abundance or alternatively, high algal cover may be a natural phenomenon, but further research should be undertaken to substantiate this.

The higher level of macroalgal cover in the Inshore North and Inshore South may also reflect differing nutrient levels. Macroalgae such as *Sargassum* use particulate matter as a nutrient

source (Schaffelke 1999); hence the finding of a higher level of macroalgal cover may indicate higher nutrient levels in those subregions (Huisman and Sampey 2014). However, further data are needed to test that hypothesis. Nevertheless, a high level of macroalgal cover may not be restrictive to the corals growing in the Kimberley because distinct patterns of zonation were apparent across the intertidal platforms (unpublished data). In the Kimberley, there is a tendency for macroalgae to dominate the upper littoral and hard corals to dominate the lower littoral and reef crest, hence both these important functional groups coexist, albeit partitioned, on a single narrow fringing-reef platform.

Coralline algae are commonly associated with high wave energy reef crest locations, and as expected reached the greatest levels of abundance offshore, but coralline algal terraces are also an important feature of the inshore reefs (Wilson and Blake 2011; Richards and O'Leary 2015; Solihuddin et al. 2015), with the highest level of coralline algae cover recorded in the Inshore Central. This may be another indicator that nutrient levels are lower in the central Kimberley, but could also be a result of other physical (e.g. temperature, light, currents, substrate); chemical (e.g. water chemistry, dissolved salts, gases), or biological factors (e.g. competition and grazing pressure) (Wray 2009). Overall, marine flora forms the foundation of the inshore Kimberley marine food web and play essential functional roles, such as habitat provision and reef consolidation (Huisman and Sampey 2014).

Region wide, the mean level of hard coral cover was 23.3% (31% in the subtidal and 14% in the intertidal zone), but the percent cover of hard coral varied dramatically between stations (e.g. 76% was recorded at Cassini Island station 41/K10), and was dependent on tidal zonation (intertidal or subtidal), cross shelf placement (inshore or offshore) and the subregion (latitude). The regional mean reported here is slightly higher than the whole-of-reef average recorded on the GBR in 2004 (21.7%, Sweatman et al. 2011), but lower than the average of 27%–33% reported in Osborne et al. (2011). However, it is very similar to the regional average reported from the entire Indo-Pacific in 2003 (22.1%, Bruno and Selig 2007). Considering the Kimberley is a minimally impacted tropical reef ecosystem, the most relevant comparison is to the northern GBR. Based on surveys conducted from 1985–2012 the mean level of hard coral cover in the northern GBR was ~35% (De'ath et al. 2014). However, this has dramatically declined following the 2016–2017 bleaching events with the latest estimates of hard coral cover in the two most northerly sectors of the GBR to be 10–20% (AIMS 2017 a,b).

It is worth noting the regional estimate of hard coral cover presented here is likely to be an underestimate because, unlike the sites chosen for long-term monitoring of the GBR, a variety of non-coral habitat was surveyed in the present study. These Kimberley surveys were undertaken as part of a wider multi-taxa biodiversity study, which necessitated surveying a diversity of habitat types. Furthermore, habitats where corals are known to dominate, such as the reef crest and upper slope, were not surveyed in this study and neither were numerous intertidal sites in the Bonaparte Archipelago and Buccaneer Archipelagos, which are renowned as hotspots for the diversity and abundance of hard corals (Wilson et al. 2011; Richards et al. 2015).

Previously there has been a shortage of quantitative baseline data concerning benthic communities for Kimberley marine environments (see Waples 2007). This study characterises benthic communities throughout the survey area highlighting similarities and differences in benthic composition across various habitat types and geographic locations. Although this dataset provides insight into the most dominant biotic and abiotic benthos occurring at each location, the stations were typically located either intertidally or at approximately 12 m depth and only serve as representatives of these habitats and zones. Some well-known seagrass habitats were not surveyed, for example the Sunday Island group (Walker 1995; Kendrick et al. 2016). Neither were other locations where coralline algae are known to dominate (Jalan Island, Richards and O'Leary 2015; Solihuddin et al. 2016), deeper reef zones where soft corals are likely to occur in greater abundance (Bryce et al. 2014), nearshore reefs, or reefs to the north of Cape Bougainville or south of Bathurst Island.

Similarly, it should be noted that this dataset does not represent seasonal change, as all surveys were conducted during September and October of each survey year (2009–2014). Macro-algae cover can fluctuate seasonally and so caution should be exercised when comparing algal percent cover from different seasons. Furthermore, coral communities are disturbance driven (e.g. cyclones and bleaching) and so coral populations are often in flux. As such, a single snapshot of coral cover is an inadequate representation of the health or resilience of a particular reef (Smith et al. 2016). Nevertheless, the data presented here offers a quantitative glimpse of the most common taxa and forms a critical reference dataset for future monitoring. Ongoing monitoring of reefs and across habitat zones is required to provide accurate health assessments of these communities.

Overall we provide data to substantiate that the intertidal and subtidal habitats of the inshore and offshore Kimberley are significant parts of the Australian reefscape. Parts of the offshore reef ecosystems examined in this study receive either federal (Ashmore and Cartier National Marine Reserve) or state (Rowley Shoals Marine Protected Area) protection and parts of our inshore survey area fall within the Larang Garam (Camden Sound) Protected Area and North Kimberley Marine Park. Our data indicate that managing the subregions as defined here as discrete units is warranted. Given the Inshore Central and Inshore Northern subregions have distinctive biotic and abiotic characters, and that both of these subregions fall within the North Kimberley Marine Park planning area, further spatial planning may be warranted to ensure the diversity of benthic communities within this expansive management area is adequately represented within protected areas.

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APPENDIX 1 Mean percentage cover of the 13 dominant benthic categories recorded at 164 stations in the Kimberley survey area.

Station No. / Year	Location	Subregion	Habitat	Depth (m)	Hard Coral	Soft Coral	Sponge	Other Inverts	Seagrass	Turf Algae	Coralline Algae	Crustose Algae	Macro Algae	Sand	Rubble	Rock & Silt	Shell Grit
1/K09	Adele I.	Inshore South	Subtidal	14	0.7	1.3	1.3	1.3	0.0	0.0	2.7	0.0	0.0	42.0	0.0	50.7	0.0
2/K09	Adele I.	Inshore South	Subtidal	11	25.3	2.0	6.7	4.7	0.0	0.0	0.0	0.0	4.0	3.3	27.3	26.7	0.0
3/K09	Adele I.	Inshore South	Intertidal	0	33.3	0.0	3.3	0.0	0.0	0.0	0.0	0.0	2.7	10.7	11.3	38.7	0.0
4/K09	Adele I.	Inshore South	Subtidal	13	17.3	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	10.7	26.0	44.0	0.0
5/K09	Adele I.	Inshore South	Subtidal	12	66.0	0.0	3.3	0.7	0.0	0.0	3.3	0.0	0.0	3.3	0.0	23.3	0.0
6/K09	Adele I.	Inshore South	Subtidal	12	31.3	4.7	11.3	0.7	0.0	0.0	2.0	0.0	0.0	0.0	0.0	50.0	0.0
7/K09	Adele I.	Inshore South	Intertidal	0	8.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	26.7	11.3	9.3	41.3	0.0
8/K09	Adele I.	Inshore South	Intertidal	4	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	39.3	22.0	30.7	7.3	0.0
9/K09	Adele I.	Inshore South	Subtidal	12	46.7	4.0	2.0	2.0	0.0	0.0	3.3	0.0	0.7	2.7	0.0	38.7	0.0
10/K09	Adele I.	Inshore South	Intertidal	4	35.3	0.7	1.3	0.0	0.0	0.0	1.3	0.7	0.0	1.3	9.3	50.0	0.0
11/K09	Adele I.	Inshore South	Intertidal	3	3.3	0.0	0.7	0.0	0.0	0.0	0.0	0.0	56.7	6.7	11.3	21.3	0.0
12/K09	Adele I.	Inshore South	Subtidal	8	48.7	1.3	4.7	2.7	0.0	0.7	4.0	0.7	0.7	2.7	1.3	32.7	0.0
13/K09	Adele I.	Inshore South	Subtidal	11	43.3	1.3	3.3	0.7	0.0	0.7	1.3	0.0	0.0	1.3	0.0	48.0	0.0
14/K09	Montgomery Reef	Inshore South	Intertidal	0	21.3	0.0	6.0	0.0	0.0	0.0	0.0	0.7	4.7	4.7	10.0	52.7	0.0
15/K09	Montgomery Reef	Inshore South	Intertidal	0	4.7	0.0	1.3	0.0	0.0	0.0	2.7	0.0	6.0	14.7	16.7	54.0	0.0
16/K09	Montgomery Reef	Inshore South	Intertidal	0	10.7	0.0	1.3	0.0	0.0	0.0	0.0	0.0	53.3	24.0	2.0	8.7	0.0
17/K09	Montgomery Reef	Inshore South	Intertidal	0	6.7	0.0	0.7	0.0	0.0	0.0	0.0	0.0	56.0	13.3	8.7	14.7	0.0
18/K09	Montgomery Reef	Inshore South	Intertidal	0	33.3	3.3	6.7	0.0	0.0	0.0	4.7	0.7	0.7	9.3	1.3	40.0	0.0
19/K09	Montgomery Reef	Inshore South	Intertidal	0	24.0	0.7	2.0	0.0	0.0	0.0	2.7	0.0	8.7	8.0	16.7	37.3	0.0
20/K09	Montgomery Reef	Inshore South	Intertidal	0	8.0	0.0	2.0	1.3	0.0	1.3	0.0	0.0	28.0	26.0	1.3	32.0	0.0
21/K09	Montgomery Reef	Inshore South	Intertidal	0	42.0	1.0	8.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	46.0	0.0
23/K09	Montgomery Reef	Inshore South	Intertidal	0	12.7	0.0	2.7	0.0	0.0	0.0	0.0	0.0	35.3	26.0	18.7	4.7	0.0
24/K09	Montgomery Reef	Inshore South	Intertidal	0	18.7	0.0	7.3	0.0	0.0	0.0	0.0	0.0	1.3	12.0	0.7	60.0	0.0

Station No. / Year	Location	Subregion	Habitat	Depth (m)	Hard Coral	Soft Coral	Sponge	Other Inverts	Seagrass	Turf Algae	Coralline Algae	Crustose Algae	Macro Algae	Sand	Rubble	Rock & Silt	Shell Grit
25/K09	Montgomery Reef	Inshore South	Intertidal	0	12.7	0.0	1.3	0.0	0.0	0.0	0.0	0.0	13.3	22.7	27.3	22.7	0.0
27/K09	Montgomery Reef	Inshore South	Intertidal	0	17.3	2.7	0.7	0.0	0.0	0.0	0.0	0.0	4.0	24.0	33.3	18.0	0.0
28/K10	Cassini I.	Inshore North	Subtidal	12	24.0	3.3	6.0	0.0	0.0	0.0	0.0	0.0	0.0	30.0	12.7	24.0	0.0
29/K10	Cassini I.	Inshore North	Subtidal	13	29.3	2.7	7.3	0.0	0.0	0.0	0.0	0.0	0.0	13.3	26.0	21.3	0.0
30/K10	Cassini I.	Inshore North	Subtidal	11	38.7	6.7	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	50.0	0.0
31/K10	Cassini I.	Inshore North	Subtidal	10	26.0	0.0	4.7	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	52.7	0.0
32/K10	Cassini I.	Inshore North	Intertidal	0	0.7	0.0	3.3	0.0	0.0	0.0	0.0	0.0	60.0	19.3	12.7	4.0	0.0
33/K10	Cassini I.	Inshore North	Intertidal	2	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.3	22.0	28.7	2.7	0.0
34/K10	Cassini I.	Inshore North	Subtidal	12	43.3	26.0	3.3	0.7	0.0	0.0	0.0	0.0	0.0	4.7	0.0	22.0	0.0
35/K10	Cassini I.	Inshore North	Intertidal	3	10.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	20.0	40.7	13.3	13.3	0.0
36/K10	Cassini I.	Inshore North	Subtidal	11	30.0	3.3	2.0	0.0	0.0	0.0	7.3	0.0	0.0	4.7	0.0	52.7	0.0
37/K10	Cassini I.	Inshore North	Intertidal	3	21.3	1.3	2.0	0.0	0.0	0.0	0.7	0.0	1.3	1.3	10.7	61.3	0.0
38/K10	Cassini I.	Inshore North	Intertidal	4	62.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	2.7	34.0	0.0
39/K10	Cassini I.	Inshore North	Subtidal	11	12.7	2.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	63.3	12.0	8.0	0.0
40/K10	Cassini I.	Inshore North	Subtidal	12	42.7	4.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	11.3	11.3	26.7	0.0
41/K10	Cassini I.	Inshore North	Intertidal	3	76.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	6.7	14.0	0.0
42/K10	Cassini I.	Inshore North	Intertidal	3	24.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	1.3	22.0	40.7	11.3	0.0
43/K10	Long Reef	Inshore North	Subtidal	12	33.0	7.0	10.0	0.0	0.0	0.0	11.0	0.0	1.0	0.0	0.0	38.0	0.0
44/K10	Long Reef	Inshore North	Subtidal	10	31.3	2.0	7.3	0.0	0.0	0.0	8.7	0.0	0.0	0.0	0.0	50.7	0.0
45/K10	Long Reef	Inshore North	Intertidal	0	6.7	0.0	1.3	0.0	0.0	0.0	11.3	0.0	20.7	0.0	2.0	58.0	0.0
46/K10	Long Reef	Inshore North	Intertidal	3	10.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	27.3	6.0	30.0	24.0	0.0
47/K10	Long Reef	Inshore North	Subtidal	6	48.7	1.3	0.7	0.0	0.0	0.0	0.0	0.0	0.0	12.0	31.3	6.0	0.0
50/K10	Long Reef	Inshore North	Intertidal	2	2.0	0.0	15.3	0.0	0.0	0.0	2.0	0.0	6.0	58.7	4.0	12.0	0.0
51/K10	Long Reef	Inshore North	Intertidal	0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	28.7	29.3	34.0	0.0

Station No. / Year	Location	Subregion	Habitat	Depth (m)	Hard Coral	Soft Coral	Sponge	Other Inverts	Seagrass	Turf Algae	Coralline Algae	Crustose Algae	Macro Algae	Sand	Rubble	Rock & Silt	Shell Grit
52/K10	Long Reef	Inshore North	Intertidal	0	16.0	0.0	6.7	0.0	0.0	0.7	4.0	0.0	19.3	2.0	19.3	32.0	0.0
5/K103	Long Reef	Inshore North	Subtidal	12	30.7	0.0	6.7	0.0	0.0	0.0	2.0	0.7	0.0	0.0	0.0	60.0	0.0
54/K10	Long Reef	Inshore North	Intertidal	2	30.0	1.3	6.0	0.0	0.0	0.0	0.7	0.0	1.3	23.3	11.3	26.0	0.0
56/K10	Long Reef	Inshore North	Intertidal	0	23.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	73.3	0.0
57/K10	Long Reef	Inshore North	Subtidal	11	32.0	3.3	10.0	0.0	0.0	0.0	0.7	0.0	0.0	11.3	16.7	26.0	0.0
58/K10	Long Reef	Inshore North	Subtidal	12	35.3	2.0	4.7	2.0	0.0	0.0	0.0	0.0	0.0	8.7	14.7	32.7	0.0
59/K10	Long Reef	Inshore North	Intertidal	0	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.7	6.0	0.0	48.7	0.0
60/K10	Long Reef	Inshore North	Intertidal	0	26.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	0.0	66.0	0.0
61/K11	Wildcat Rocks	Inshore Central	Intertidal	0	6.4	0.0	0.0	0.0	0.0	59.2	0.0	0.0	10.4	23.2	0.0	0.0	0.8
62/K11	Champagney Is.	Inshore Central	Intertidal	0	0.8	0.0	2.3	0.0	0.5	9.7	0.0	0.0	7.7	14.6	41.1	23.3	0.0
63/K11	Champagney Is.	Inshore Central	Intertidal	0	2.4	0.0	0.0	0.0	0.5	4.5	0.0	0.0	18.1	30.9	14.9	26.9	1.6
64/K11	White Is.	Inshore Central	Subtidal	12	44.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	12.0	5.3	35.3	0.0
65/K11	White I.	Inshore Central	Intertidal	0	23.2	2.3	0.0	0.0	1.2	68.8	0.0	0.0	4.1	0.0	0.4	0.0	0.0
66/K11	White I.	Inshore Central	Intertidal	0	10.9	0.5	0.0	0.0	0.0	74.4	0.0	0.0	7.7	4.0	2.4	0.0	0.0
67/K11	Black Rocks	Inshore Central	Subtidal	14	44.7	8.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	11.3	33.3	0.0
68/K11	White I.	Inshore Central	Subtidal	14	20.7	2.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	1.3	2.0	71.3	0.0
69/K11	Outcrop NW Black Rocks	Inshore Central	Subtidal	14	62.0	9.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	26.0	0.0
72/K11	Beagle Reef	Inshore South	Intertidal	0	2.2	0.0	0.0	0.0	0.0	12.2	0.0	0.0	25.7	15.6	22.9	21.4	0.0
73/K11	Beagle Reef	Inshore South	Intertidal	0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	40.2	44.2	12.2	2.2	0.0
74/K11	Beagle Reef	Inshore South	Subtidal	16	1.3	0.0	1.3	0.0	0.0	0.0	0.0	0.0	1.3	64.0	12.0	20.0	0.0
75/K11	Beagle Reef	Inshore South	Subtidal	12	44.7	1.3	6.0	0.0	0.0	0.0	2.7	0.0	4.0	14.0	2.0	25.3	0.0
76/K11	Mavis Reef	Inshore South	Subtidal	10	37.3	1.1	2.8	0.0	0.0	3.8	17.7	9.3	1.7	5.1	1.2	20.0	0.0
77/K11	Mavis Reef	Inshore South	Subtidal	13	44.7	1.3	0.7	0.0	0.0	0.0	0.0	0.0	3.3	8.7	18.7	22.7	0.0
78/K11	Mavis Reef	Inshore South	Subtidal	13	30.7	3.3	8.0	0.0	0.0	0.0	0.0	0.0	2.0	9.3	15.3	31.3	0.0

Station No. / Year	Location	Subregion	Habitat	Depth (m)	Hard Coral	Soft Coral	Sponge	Other Inverts	Seagrass	Turf Algae	Coralline Algae	Crustose Algae	Macro Algae	Sand	Rubble	Rock & Silt	Shell Grit
79/K11	Albert Reef	Inshore South	Subtidal	12	28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	26.7	1.3	42.0	0.0
80/K11	Brue Reef	Inshore South	Subtidal	12	30.7	4.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	18.7	3.3	41.3	0.0
81/K11	Brue Reef	Inshore South	Intertidal	0	13.5	0.0	0.8	0.0	0.0	31.2	0.0	0.0	28.6	10.9	13.0	0.0	2.1
82/K11	Brue Reef	Inshore South	Intertidal	0	10.9	0.0	0.0	0.0	0.0	31.8	0.5	0.0	27.3	23.6	5.8	0.0	0.0
83/K11	Brue Reef	Inshore South	Subtidal	12	72.7	7.3	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	0.0
84/K11	Fraser I.	Inshore South	Intertidal	0	10.7	0.0	0.0	0.0	0.0	33.9	0.0	0.0	28.0	11.5	15.5	0.0	0.5
85/K11	Fraser I.	Inshore South	Subtidal	12	47.3	0.7	2.0	0.0	0.0	0.0	0.0	0.0	2.0	0.7	0.0	47.3	0.0
86/K11	King and Conway Is.	Inshore South	Subtidal	11	41.3	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.3	0.7	34.0	0.0
87/K11	King and Conway Is.	Inshore South	Intertidal	0	0.0	0.0	0.0	0.0	0.0	35.2	0.0	0.0	50.9	13.9	0.0	0.0	0.0
88/K11	King and Conway Is.	Inshore South	Subtidal	12	54.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.7	0.0	34.7	0.0
89/K11	Irvine and Bathurst Is.	Inshore South	Intertidal	0	26.9	0.0	0.3	0.0	0.0	34.6	0.0	0.0	25.0	0.0	13.3	0.0	0.0
90/K11	Irvine and Bathurst Is.	Inshore South	Intertidal	0	18.9	0.0	0.0	0.0	0.0	17.3	0.0	0.0	37.6	14.4	11.7	0.0	0.0
91/K12	Rosella Shoals	Inshore South	Subtidal	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100
93/K12	White Island	Inshore Central	Subtidal	14	10.8	3.1	0.0	0.6	0.0	22.4	1.2	7.7	0.0	13.9	0.0	40.2	0.0
94/K12	De Freycinet I.	Inshore Central	Subtidal	12	55.3	0.6	0.0	0.0	0.0	3.1	34.1	3.1	0.0	0.0	0.0	3.8	0.0
95/K12	De Freycinet I.	Inshore Central	Subtidal	11	26.5	5.7	3.8	0.7	0.0	11.2	14.7	2.0	0.0	3.8	9.6	22.0	0.0
96/K12	Hedley I.	Inshore Central	Subtidal	11	23.0	0.0	0.0	0.0	0.0	19.2	5.1	2.1	0.0	6.9	2.9	40.8	0.0
97/K12	Hedley I.	Inshore Central	Intertidal	0	2.3	0.3	0.3	0.0	0.0	68.7	0.3	0.0	5.3	13.3	1.0	8.3	0.0
98/K12	Hedley I.	Inshore Central	Intertidal	0	1.7	0.3	0.7	0.0	0.0	59.0	0.0	0.0	5.0	25.3	5.0	3.0	0.0
99/K12	Outcrop N Colbert I.	Inshore Central	Subtidal	12	33.2	2.9	0.7	1.4	0.0	25.5	13.2	7.1	0.0	0.0	0.7	15.3	0.0
100/K12	Woodward I.	Inshore Central	Intertidal	0	10.3	0.0	0.7	0.0	0.0	28.0	2.3	0.0	24.3	3.7	6.0	24.7	0.0
101/K12	Browse I.	Offshore North	Subtidal	11	27.1	2.6	2.0	0.6	0.0	24.7	1.3	1.3	0.0	35.1	0.0	5.3	0.0
102/K12	Browse I.	Offshore North	Subtidal	12	28.8	0.0	0.7	0.0	0.0	25.2	7.9	0.6	0.0	3.4	21.6	11.7	0.0
103/K12	Browse I.	Offshore North	Intertidal	0	3.0	0.0	0.3	0.0	0.0	14.7	2.7	0.0	11.0	34.7	10.7	23.0	0.0

Station No. / Year	Location	Subregion	Habitat	Depth (m)	Hard Coral	Soft Coral	Sponge	Other Inverts	Seagrass	Turf Algae	Coralline Algae	Crustose Algae	Macro Algae	Sand	Rubble	Rock & Silt	Shell Grit
104/K12	Browse I.	Offshore North	Intertidal	0	0.0	0.0	0.0	0.0	0.0	28.0	0.0	0.0	0.0	23.7	4.7	43.7	0.0
105/K12	Browse I.	Offshore North	Subtidal	12	23.5	1.4	0.0	1.4	0.0	42.2	3.4	11.0	1.4	0.0	9.6	6.1	0.0
106/K12	Browse I.	Offshore North	Subtidal	13	16.4	4.9	0.0	0.0	0.0	2.0	1.3	0.0	0.0	69.4	4.6	1.3	0.0
110/K12	Jamieson Reef	Inshore North	Subtidal	12	32.1	0.7	0.0	4.1	0.0	19.1	8.2	0.7	0.0	4.8	0.0	30.4	0.0
111/K12	Jamieson Reef	Inshore North	Subtidal	12	33.5	6.4	0.7	4.3	0.0	28.0	9.2	0.7	0.0	3.4	2.8	11.1	0.0
112/K12	Condillac I.	Inshore North	Intertidal	0	1.3	3.7	0.0	0.0	0.0	55.0	6.7	0.0	7.3	6.0	8.7	11.3	0.0
113/K12	Condillac I.	Inshore North	Subtidal	13	20.5	4.6	6.0	1.3	0.0	17.8	3.3	0.6	0.0	0.0	0.6	45.2	0.0
114/K12	Patricia I.	Inshore Central	Subtidal	12	20.7	4.7	3.4	2.1	0.0	8.9	21.4	0.7	0.0	3.5	2.1	32.6	0.0
115/K12	Heritage Reef	Inshore Central	Subtidal	12	46.0	4.7	1.9	5.3	0.0	10.9	16.5	0.7	0.0	2.1	0.7	11.3	0.0
116/K12	West Montalivet I.	Inshore Central	Subtidal	16	18.7	13.0	0.7	0.7	0.0	19.9	11.1	1.4	0.0	4.9	0.7	29.0	0.0
117/K12	West Montalivet I.	Inshore Central	Subtidal	12	34.7	7.3	0.7	0.7	0.0	7.3	8.0	0.0	0.0	3.3	4.0	34.0	0.0
118/K12	Robroy Reefs	Inshore Central	Subtidal	12	24.9	0.7	8.9	2.7	0.0	8.1	38.4	4.8	0.0	0.0	0.0	11.6	0.0
119/K12	Robroy Reefs	Inshore Central	Subtidal	12	20.8	4.0	1.3	0.0	0.0	12.1	2.7	0.0	0.0	38.3	7.4	13.4	0.0
122/K13	Ashmore Reef	Offshore North	Subtidal	10	8.0	11.3	4.3	1.0	0.0	15.3	1.0	1.3	0.0	41.7	15.3	0.3	0.3
123/K13	Ashmore Reef Lagoon	Offshore North	Intertidal	0	0.0	0.0	0.3	0.3	9.3	21.7	0.0	3.3	5.0	55.0	3.7	0.7	0.7
124/K13	Ashmore Reef Channel	Offshore North	Subtidal	12	11.3	5.3	4.7	0.3	0.7	19.0	0.0	0.0	2.0	46.0	10.7	0.0	0.0
125/K13	North Ashmore Reef	Offshore North	Subtidal	12	28.3	1.0	8.0	4.0	0.0	16.7	0.3	1.3	2.0	8.3	26.3	1.3	2.3
126/K13	North Ashmore Reef	Offshore North	Subtidal	12	31.0	10.0	12.0	5.7	0.0	21.0	15.7	1.3	2.3	1.0	0.0	0.0	0.0
127/K13	East Ashmore Reef	Offshore North	Subtidal	12	32.7	9.3	11.3	1.3	0.0	8.0	8.7	8.3	1.0	7.3	11.3	0.7	0.0
128/K13	South Ashmore Reef	Offshore North	Subtidal	12	16.0	5.0	0.7	1.3	0.0	20.0	3.7	2.3	1.0	39.3	10.7	0.0	0.0
129/K13	East Ashmore Reef	Offshore North	Intertidal	0.5	11.0	0.0	1.7	0.3	2.3	13.0	3.0	9.3	6.3	23.0	30.0	0.0	0.0
130/K13	North Ashmore Reef	Offshore North	Subtidal	12	17.5	17.5	11.0	5.5	0.0	12.5	13.5	16.0	4.5	2.0	0.0	0.0	0.0
131/K13	North Ashmore Reef	Offshore North	Intertidal	1	0.3	0.7	0.7	0.3	0.7	16.7	1.7	2.0	15.3	28.3	26.7	1.0	5.7
132/K13	North Ashmore Reef	Offshore North	Subtidal	12	19.0	10.3	6.0	0.3	0.0	7.0	4.0	46.0	1.7	3.0	2.7	0.0	0.0

Station No. / Year	Location	Subregion	Habitat	Depth (m)	Hard Coral	Soft Coral	Sponge	Other Inverts	Seagrass	Turf Algae	Coralline Algae	Crustose Algae	Macro Algae	Sand	Rubble	Rock & Silt	Shell Grit
133/K13	South Ashmore Reef	Offshore North	Subtidal	12	21.0	2.7	2.0	0.3	0.0	11.7	17.7	1.0	1.3	11.3	28.0	1.3	1.7
134/K13	South Ashmore Reef	Offshore North	Subtidal	12	11.3	4.7	1.3	0.3	0.0	23.7	6.0	7.3	2.3	25.3	16.7	1.0	0.0
135/K13	West Ashmore Reef	Offshore North	Subtidal	12	20.0	4.3	2.0	1.3	0.0	26.0	11.7	24.0	5.0	4.0	1.0	0.3	0.3
136/K13	Ashmore Reef Channel	Offshore North	Subtidal	6	20.3	2.0	5.3	5.0	0.0	10.7	6.0	0.7	0.0	25.3	24.7	0.0	0.0
137/K13	South Ashmore Reef	Offshore North	Intertidal	2	0.7	0.0	1.0	0.3	13.7	4.7	0.7	0.0	0.7	68.0	10.3	0.0	0.0
138/K13	South Ashmore Reef	Offshore North	Subtidal	5	23.3	3.7	1.7	0.3	0.0	12.0	4.7	0.0	0.0	31.7	22.7	0.0	0.0
139/K13	Ashmore Reef Lagoon	Offshore North	Subtidal	10	15.7	6.0	2.7	0.0	0.0	6.0	1.7	0.3	1.0	24.0	42.7	0.0	0.0
140/K13	East Ashmore Reef	Offshore North	Subtidal	13	24.3	7.7	4.7	2.7	0.0	17.7	9.7	0.7	2.3	7.3	23.0	0.0	0.0
141/K13	East Ashmore Reef	Offshore North	Intertidal	0.5	4.7	0.0	1.3	0.0	0.0	46.0	2.7	7.7	3.7	10.7	23.3	0.0	0.0
142/K13	SW Hibernia Reef	Offshore North	Subtidal	10	19.7	5.0	2.0	0.3	0.0	4.7	13.3	8.0	8.3	4.3	34.0	0.3	0.0
143/K13	NE Hibernia Reef	Offshore North	Subtidal	13	18.7	15.7	0.7	1.0	0.0	3.3	4.3	21.7	0.7	29.3	4.7	0.0	0.0
144/K13	NW Hibernia Reef	Offshore North	Subtidal	13	28.3	29.7	4.7	1.0	0.0	8.0	11.3	5.7	0.7	7.0	3.0	0.7	0.0
145/K13	SE Hibernia Reef	Offshore North	Subtidal	13	35.7	6.3	1.7	0.7	0.0	3.7	8.7	32.0	0.7	0.3	10.0	0.3	0.0
149/K14	Mermaid Reef	Offshore South	Subtidal	12	56.0	4.0	1.5	1.5	0.0	19.0	0.0	5.5	0.0	2.5	10.0	0.0	0.0
150/K14	Mermaid Reef	Offshore South	Subtidal	12	21.0	0.0	0.5	0.0	0.0	20.0	0.0	0.5	4.0	10.5	43.5	0.0	0.0
151/K14	Clerke Reef	Offshore South	Subtidal	12	40.5	1.0	2.0	0.5	0.0	19.5	12.5	0.0	2.0	14.0	8.0	0.0	0.0
152/K14	Clerke Reef	Offshore South	Subtidal	12	47.5	1.5	2.0	1.5	0.0	24.5	11.0	0.0	4.5	0.5	7.0	0.0	0.0
153/K14	Clerke Reef	Offshore South	Subtidal	12	24.0	0.0	1.0	1.0	0.0	22.5	0.5	0.0	14.5	17.0	19.5	0.0	0.0
154/K14	Clerke Reef	Offshore South	Subtidal	12	38.5	2.0	0.0	0.5	0.0	15.0	7.5	0.0	2.5	1.0	33.0	0.0	0.0
155/K14	Clerke Reef	Offshore South	Subtidal	12	14.0	0.0	8.5	7.0	0.0	22.0	1.0	0.0	2.5	18.0	27.0	0.0	0.0
156/K14	Clerke Reef	Offshore South	Subtidal	12	48.5	1.5	0.0	1.5	0.0	20.5	11.5	0.0	4.5	2.5	9.5	0.0	0.0
157/K14	Imperieuse Reef	Offshore South	Subtidal	12	32.0	3.0	1.0	1.5	0.0	24.5	10.5	0.0	3.0	15.5	9.0	0.0	0.0
158/K14	Imperieuse Reef	Offshore South	Subtidal	12	40.5	4.5	0.0	0.0	0.0	15.0	9.5	0.0	1.5	0.0	29.0	0.0	0.0
159/K14	Imperieuse Reef	Offshore South	Subtidal	12	23.5	0.0	0.5	1.0	0.0	14.5	0.5	0.0	16.0	27.0	17.0	0.0	0.0

Station No. / Year	Location	Subregion	Habitat	Depth (m)	Hard Coral	Soft Coral	Sponge	Other Inverts	Seagrass	Turf Algae	Coralline Algae	Crustose Algae	Macro Algae	Sand	Rubble	Rock & Silt	Shell Grit
160/K14	Imperieuse Reef	Offshore South	Intertidal	0	12.0	0.5	0.0	6.0	0.0	68.5	5.5	0.0	1.5	1.5	4.5	0.0	0.0
161/K14	Imperieuse Reef	Offshore South	Subtidal	9	40.0	1.0	0.0	0.0	0.0	20.5	11.0	0.0	3.5	1.0	23.0	0.0	0.0
162/K14	Imperieuse Reef	Offshore South	Subtidal	8	28.5	1.0	1.5	0.5	0.0	32.0	1.5	0.0	9.0	6.0	20.0	0.0	0.0
163/K14	Imperieuse Reef	Offshore South	Intertidal	0	45.0	4.5	0.0	0.5	0.0	19.0	21.5	0.0	1.0	1.0	7.5	0.0	0.0
164/K14	Imperieuse Reef	Offshore South	Subtidal	7	17.0	0.0	2.0	1.0	0.5	30.5	0.0	0.0	3.0	20.5	25.5	0.0	0.0
165/K14	Imperieuse Reef	Offshore South	Subtidal	7	43.5	0.5	0.0	1.5	0.0	16.5	13.5	0.0	6.0	0.0	18.5	0.0	0.0
166/K14	Imperieuse Reef	Offshore South	Intertidal	0	4.5	3.5	0.0	0.0	0.0	82.5	0.5	0.0	0.5	0.5	8.0	0.0	0.0
167/K14	Imperieuse Reef	Offshore South	Subtidal	12	16.5	10.0	0.0	0.0	0.0	44.5	5.5	0.0	1.5	18.0	4.0	0.0	0.0
168/K14	Imperieuse Reef	Offshore South	Subtidal	12	29.5	0.5	0.0	0.5	0.0	7.5	4.5	0.0	3.0	0.0	54.5	0.0	0.0
169/K14	Clerke Reef	Offshore South	Intertidal	0	8.5	0.5	0.0	0.0	0.0	83.0	3.5	0.0	1.5	0.5	2.5	0.0	0.0
170/K14	Clerke Reef	Offshore South	Subtidal	12	45.5	0.5	1.0	0.0	0.0	22.0	12.5	0.0	5.5	0.0	13.0	0.0	0.0
171/K14	Clerke Reef	Offshore South	Subtidal	6	16.5	0.0	0.0	0.5	0.0	25.5	1.5	0.0	2.5	17.0	36.5	0.0	0.0
172/K14	Clerke Reef	Offshore South	Intertidal	0	37.0	7.0	0.0	2.0	0.0	33.5	9.0	0.0	4.5	3.5	3.5	0.0	0.0
173/K14	Clerke Reef	Offshore South	Subtidal	12	18.0	1.5	0.0	0.5	0.0	65.0	6.5	0.0	3.5	0.5	4.5	0.0	0.0
174/K14	Clerke Reef	Offshore South	Intertidal	0	25.0	6.5	0.0	0.0	0.0	44.5	18.0	0.0	2.0	2.5	1.5	0.0	0.0
175/K14	Clerke Reef	Offshore South	Subtidal	12	24.5	2.0	0.0	0.0	0.0	23.5	0.0	0.0	1.0	39.5	9.5	0.0	0.0
176/K14	Mermaid Reef	Offshore South	Subtidal	12	11.5	0.0	0.0	0.0	0.0	15.0	0.0	0.0	1.5	18.0	54.0	0.0	0.0
177/K14	Mermaid Reef	Offshore South	Intertidal	0	20.0	0.0	0.0	0.0	0.0	53.5	11.5	0.0	1.5	4.0	9.5	0.0	0.0
178/K14	Mermaid Reef	Offshore South	Subtidal	12	43.5	1.0	3.5	1.0	0.0	23.0	19.5	0.0	0.0	0.5	8.0	0.0	0.0
179/K14	Mermaid Reef	Offshore South	Subtidal	12	14.0	0.0	0.5	0.0	0.5	19.0	0.0	0.0	2.0	36.0	28.0	0.0	0.0
180/K14	Mermaid Reef	Offshore South	Intertidal	0	7.0	2.5	0.0	0.0	0.0	84.5	1.5	0.0	2.5	0.0	2.0	0.0	0.0