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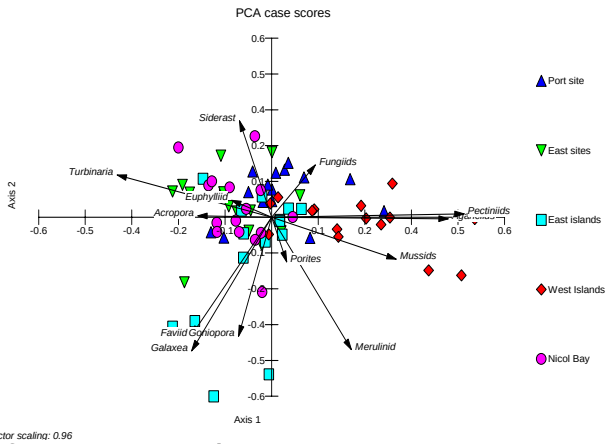
DAMPIER PORT AUTHORITY

Comparison of the Dampier Port Fringing Reef Benthic Community with Nearby Reef Areas

301012-01121

22-Dec-09



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EXECUTIVE SUMMARY

WorleyParsons was commissioned by DPA to undertake a reef benthic comparative assessment on a regional scale to identify any endemism and unique corals to the inner zone within the Dampier Archipelago.

Fringing reefs in the Port location were surveyed at three sites within the 1.2 km long section of coast adjacent to the Port. For comparison benthic communities were surveyed in 12 reference sites grouped in four locations.

The fringing reefs in the vicinity of Dampier Port are not true coral reefs where the structure and substratum is formed by successive layers of dead coral. Instead the reefs are rock and boulders with a veneer of living coral. Although some of the colonies are over a metre across and may be over 100 years old, corals have not yet provided a true reef structure. The reefs are narrow and fall quickly to a sand/mud substratum only a few metres below low tide level.

These reefs appear healthy with many large and long-lived coral colonies. Many small coral recruits of a wide range of species were observed on these reefs, also indicative of a healthy reef community.

Coral abundance and composition was also similar to Dampier reefs on the Cape Preston fringing reefs 60 km to the west of Dampier. Combined faviid, poritid and *Turbinaria* corals made up 73% of hard corals on the Cape Preston reefs.

The three coral groups that dominated the benthic communities in all three of these fringing reef locations are all relatively resistant to bleaching, able to withstand strong wave action and can cope with high levels of sedimentation

In summary it seems likely that the inshore fringing reefs of the Dampier and Cape Preston region are a single community dominated by bleach, sediment and wave-resistant coral groups. Most of the small differences recorded are due to historically mediated site effects whereby a 50-100 m long local reef area becomes dominated by a single long-lived species of coral.

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DAMPIER PORT AUTHORITY

PROJECT 301012-01121 - COMPARISON OF THE DAMPIER PORT FRINGING REEF BENTHIC COMMUNITY WITH NEARBY REEF AREAS

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for internal review	T Ayling	P Mellor	N/A	12-Nov-09	N/A	12-Nov-09
0	Issued for Use	T Ayling	P Mellor	P Mellor	22-Dec-09	W Young	22-Dec-09

CONTENTS

1. INTRODUCTION

DPA is proposing to increase the handling and export capacity of the cargo wharf by constructing the Dampier Marine Services Facility (DMSF). This will include a new jetty adjacent to the existing berth and reclaiming land to construct associated laydown area and a Land Backed Wharf (Heavy Load Out area).

During construction, approximately 2.2 million m^3 of sediment will be dredged to provide safe navigable depth for vessels using the facility. The dredged sediment will be dewatered and used for land reclamation.

WorleyParsons was commissioned by DPA to undertake a reef benthic comparative assessment following feedback from EPASU regarding the key factors for assessment. The specific feedback was: *The majority of the inshore coral communities of the Dampier Archipelago appear to be found in the inner sections of the Dampier Port and continue to be incrementally lost to development. Currently these communities are considered to be unique to this area; however this may be due to surveys and comparisons not having been undertaken in other similar habitats on the Pilbara coastline. It is recommended that the proponent consider the distribution of the inshore Dampier coral communities within a broader regional context.*

2. STUDY SITES AND METHODS

Fringing reefs in the Port location were surveyed at three sites within the 1.2 km long section of coast adjacent to the Port (Figure 1). For comparison benthic communities were surveyed in 12 reference sites grouped in four locations (Figure 2). The first location included three sites on coastal reefs between Withnell Bay and Searipple Passage to the east of the Port location, the second, three sites on nearshore islands to the east of the Port (Conzinc Is. and Angel Is.), the third, three sites on the near-shore islands to the west of the Port (East Lewis Is., Intercourse Is. and West Mid Intercourse Is.), while the fourth reference location included three coastal sites on the east side of Nickol Bay to the east of the Burrup Peninsula. The Dampier Port fringing reefs were also compared to fringing reefs at Cape Preston 60 km west of Dampier, surveyed by the same personnel using the same methods.

Dive surveys of the study area were conducted on the 30th and 31st of October 2009. It should be noted that all of these sites (with the exception of Nichol Bay) are in close proximity to the Pluto dredging project. Dredging for this project has been underway since late 2007 in various stages, and has been underway intensively within the swing basin and approach channels (within 300m of the Port sites) since July 2009. This project will ultimately see the removal of some 14Mcum of material, and will continue until approximately March 2010. The present survey, and the result pictures of corals in this area, should take this into account.

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DAMPIER PORT AUTHORITY

PROJECT: DAMPIER CARGO WHARF EXPANSION

TITLE:

CORAL HABITAT SURVEY SITES
NOVEMBER 2009

SCALE: 1:10,000 A3 | DRAWN: DAR | DATE: 18-11-2009 | DWG No: | REVISION A

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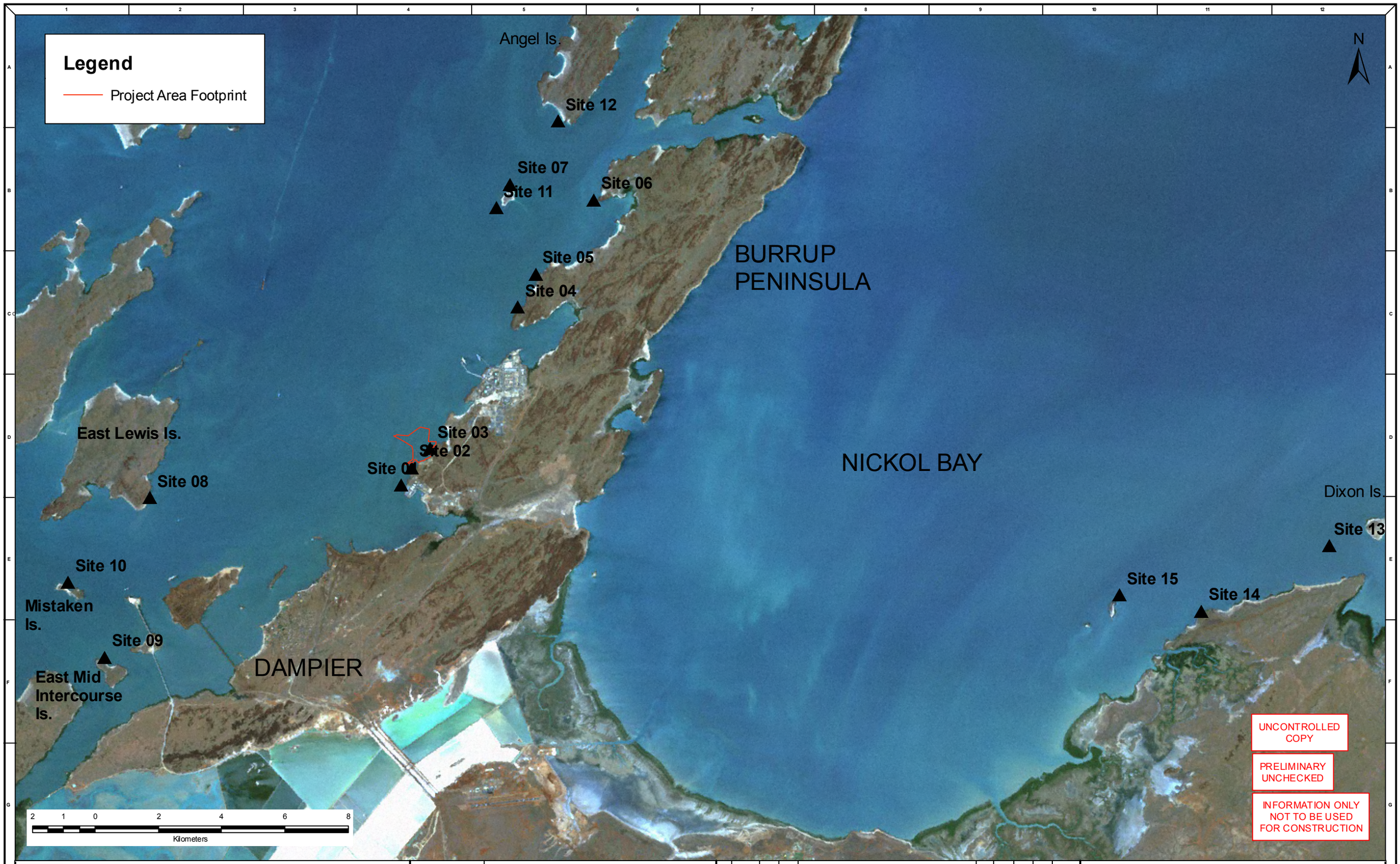

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DAMPIER PORT AUTHORITY

PROJECT: DAMPIER CARGO WHARF EXPANSION

TITLE:
CORAL HABITAT SURVEY SITES
NOVEMBER 2009

SCALE: 1:120,000 A3 | DRAWN: DAR | DATE: 18-11-2009 | DWG No: | REVISION A

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2.1 Methods

Dampier Port and surrounding area benthic surveys were carried out in a single depth stratum between 1-2 m below low tide level in the zone of maximum hard coral cover. At each site, cover of the major benthic reef organisms was assessed along five 10 m line intercept transects run approximately parallel to the reef edge. A horizontal distance of about 10 m was left between each transect. The survey tapes were run out close to the substratum and the length of intercept with the tape of all benthic organisms directly beneath it was measured. Intercept lengths for all colonies of a species or benthic group along each transect were totalled and converted to a percentage cover measurement. Organisms or groups of organisms were recorded to the following levels of classification:

- All hard corals, identified to at least genus level (or to growth form if more appropriate).
- All soft corals, identified to at least genus level.
- All other key benthic groups (such as algae, sponges, zoanthids etc.).

These techniques have been successfully used in many other surveys of fringing and offshore reefs throughout other regions containing coral reef communities (Mapstone et al., 1989, Ayling & Ayling 1995, 2002).

2.2 Analysis

The significance of patterns in the benthic data was tested using a two factor Analysis of Variance (ANOVA) with five locations and three sites nested in each location.

3. RESULTS

Hard coral cover was moderate in the Dampier Port location, with a grand mean of almost 30% cover (Table 1). Massive faviid corals were the dominant hard coral group closely followed by *Turbinaria* spp. corals (family: Dentrophylliidae) and poritid corals. These three families made up 70% of all recorded hard corals (Figure 3). Agariciids (predominately the species *Pavona decussata*), pectiniids and mussids (mainly *Lobophyllia hemprichii*) were also present. Fast-growing acroporid and pocilloporid corals that often dominate coral reefs were rare or absent on these reefs covering a combined mean of less than 0.4% of the substratum. Sponges were moderately common on these reefs, covering a mean of 3.4% of the substratum but algae and soft corals were rare (Table 1).

Mean hard coral cover was about 50% higher in the reference sites than in the port sites (Table 1). Faviid corals were also the dominant coral group on these reefs, with poritids and *Turbinaria* spp. corals also common (Table 1). These three groups accounted for almost 70% of hard coral cover on the reference reefs as well as in the port sites.

The abundance ranking of the major coral groups was similar in the Port and Reference locations (Figure 4). As mentioned above faviids, poritids and *Turbinaria* corals were dominant at both locations. Agaricids, acroporids and pectiniids were next ranked in the reference locations but acroporids were replaced by mussids in the Port location ranking. The major difference between the port locations and the combined reference locations was the lower cover of *Porites* and *Acropora* corals at the port location. There was also a higher mean cover of algae in the reference location compared with the Port location (Table 1).

When examined at the community level using principal components analysis (pca) there was considerable overlap between the coral communities at the five locations. This suggested that the coral communities were variations on a theme rather than being distinct community types in the five different survey locations (Figure 4). The coral community at the Port location overlapped with all four of the other locations.

At the site level there were many significant differences in the abundance of the different benthic groups (Figure 5-16). The site factor, nested within location, was significant for eight of the 12 benthic groups analysed. Algae were rare or absent at many sites but were moderately common at one of the west island sites and at two of the Nickol Bay sites (Figure 5). Although there were 2x to 4x differences in sponge cover between sites in the Port and east coast locations overall site differences were not significant (Figure 6). Site differences were significant for total hard coral measurements (Figure 7) but not for acroporids (Figure 8), pectiniids (Figure 11) and mussid corals (Figure 14). Over 99% of the agariciid corals recorded were a single species *Pavona decussata* (Figure 9). This species was dominant at Reference site 7 where it covered over 25% of the substratum compared to a grand

mean of less than 3% for the other 14 sites and there were strongly significant site differences in the abundance of this coral group as a result. There were similar extremes in site abundance for poritid corals (Figure 16) with massive *Porites* corals covering almost 35% of the substratum at Reference site 5 compared to a grand mean of less than 9% for the other 14 sites. There were also significant site differences in the abundance of fungiid (Figure 10), merulinid (Figure 12), *Turbinaria* (Figure 13) and faviid corals (Figure 15).

Table 1: Summary of Benthic Cover at the Port and Reference Locations.
Figures show mean percentage cover from three sites of five 10 m line intersect transect transects at the Port location and 12 sites of five transects in the Reference location.

Benthic group	Port Location		Reference Location	
	mean	sd	mean	sd
Algae	0.8	1.2	4.9	7.8
Sponges	3.4	2.6	2.0	2.6
Total hard coral	29.9	13.1	43.9	12.3
Acroporidae	0.4	0.5	3.3	3.1
Agariciidae	2.4	3.0	4.9	8.2
Fungiidae	0.8	1.1	0.7	1.4
Pectiniidae	2.2	2.2	1.6	3.3
Merulinidae	0.4	0.9	1.1	1.6
Dendrophylliidae	7.6	5.1	8.5	8.5
Mussidae	1.8	3.3	1.3	1.8
Faviidae	8.7	6.4	11.3	5.5
Poritidae	4.7	4.1	10.5	10.6
Total soft coral	0.2	0.4	0.9	2.3

Figure 3: Relative Abundance of the Major Coral Groups on the Reference and Port Location Reefs

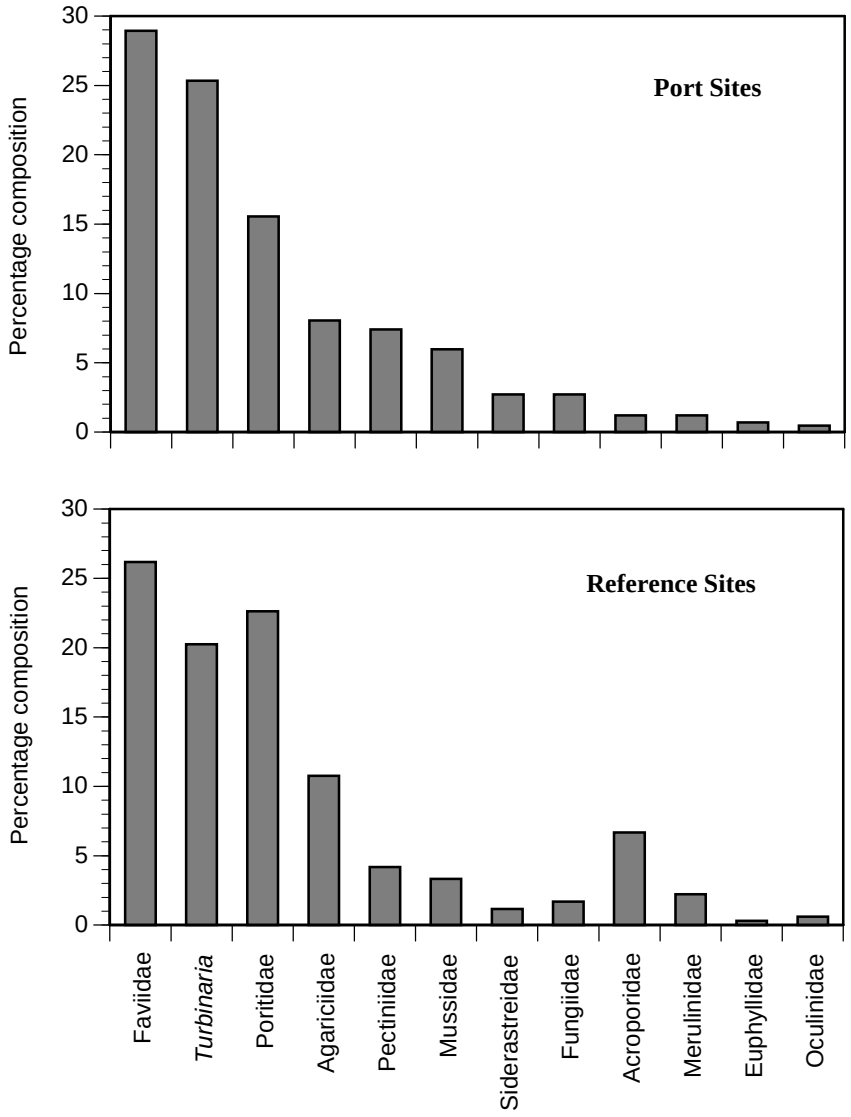
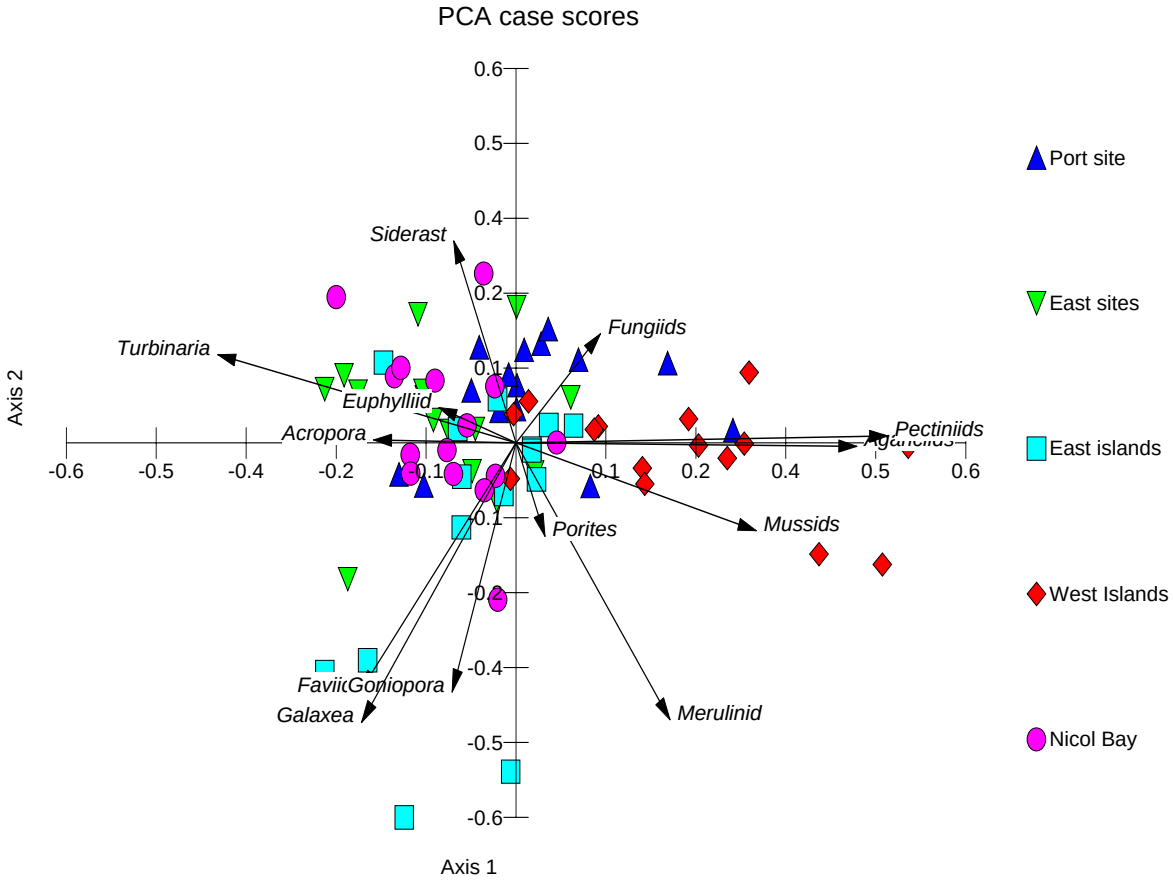


Figure 4: Principal Components Biplot Showing the Relationship Between Coral Group Composition and the Five Dampier Survey Locations.

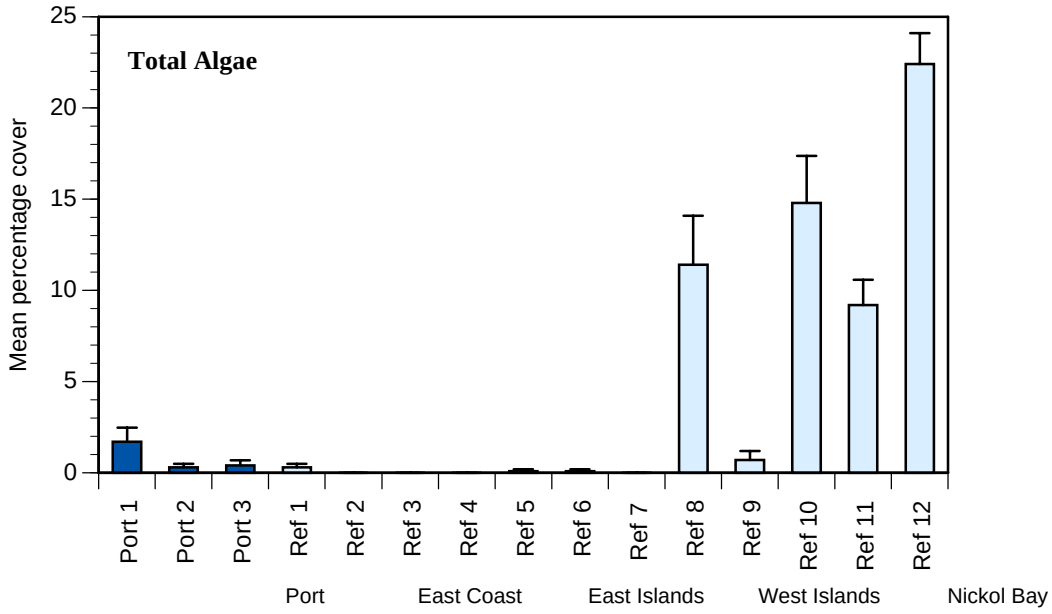
The variability in the data captured by this biplot is relatively high (PC axis 1: 14% variation explained; PC axis 2: 12% variation explained).



Vector scaling: 0.96

Figure 5: Distribution Patterns of Algae in the Dampier Region Survey Sites

Graphs show grand mean total algal cover for each site from five 10 m line intersect transects. Error bars are standard errors.



Analysis results:

(results from 2-way ANOVA)

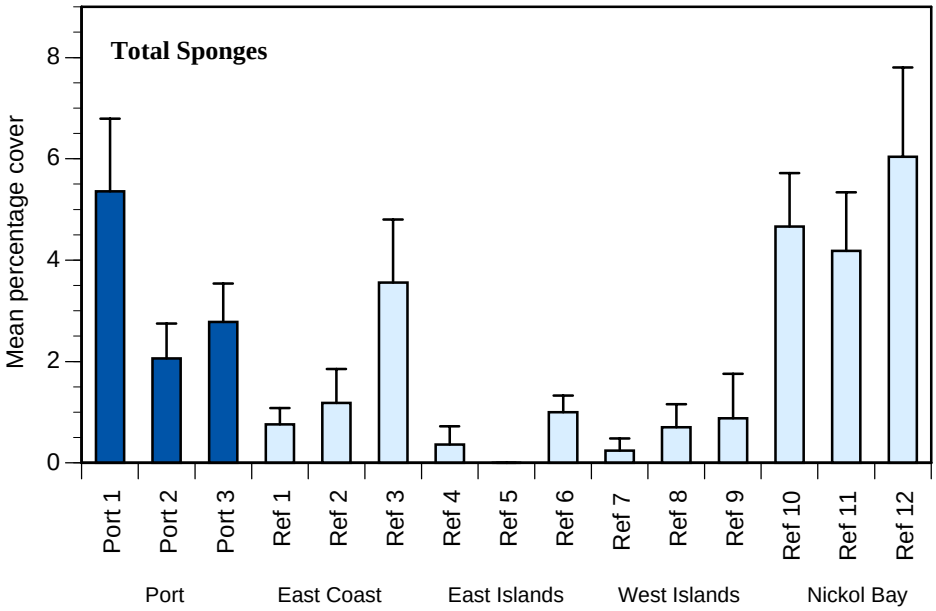
Location: F=7.57; p=0.004. Algal cover was significantly higher in Nickol Bay than in the other locations.

Site (Location): F=12.99; p<0.001. There were large differences between sites in each location.

Left: *Sargassum* and *Lobophora* algae with two sponge colonies at Reference site 10 in Nickol Bay. Algae covered a mean of 15% of the substratum in the Nickol Bay location.

Figure 6: Distribution Patterns of Sponges in the Dampier Region Survey Sites.

Graphs show mean total sponge cover for each site from five 10 m line intersect transects. Error bars are standard errors.



Analysis results:

(results from 2-way ANOVA)

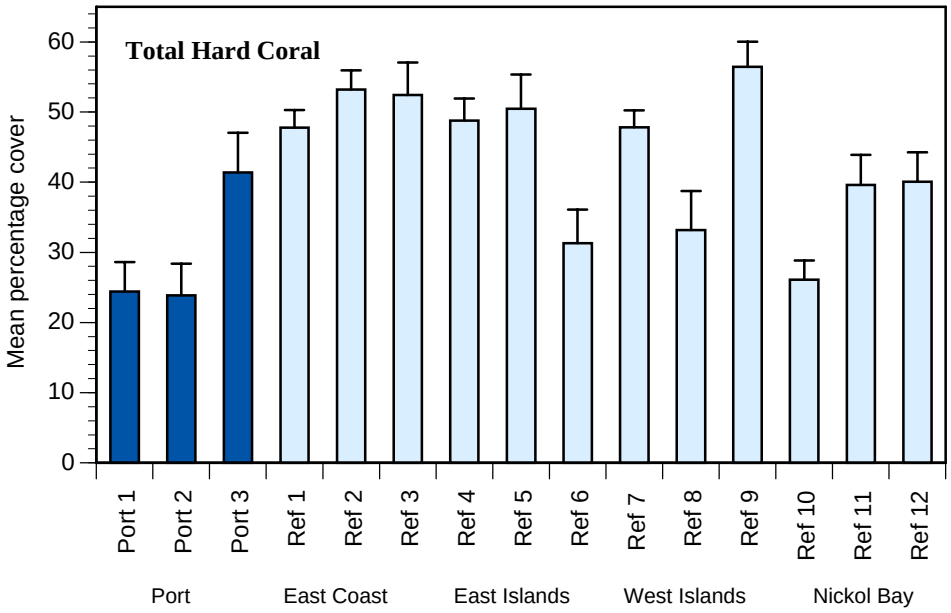
Location: F=8.41; p=0.003. Sponge cover was significantly higher in the coastal locations, including the Port, than in the two island locations.

Site (Location): F=1.64; p=0.116. There were no differences between sites in each location.

Left: A large sponge colony amongst corals on Nickol Bay coastal reefs. Sponges covered 3-6% of the substratum on the coastal sites.

Figure 7: Distribution Patterns of Total Hard Coral in the Dampier Region Survey Sites.

Graphs show grand mean total coral cover for each site from five 10 m line intersect transects. Error bars are standard errors.

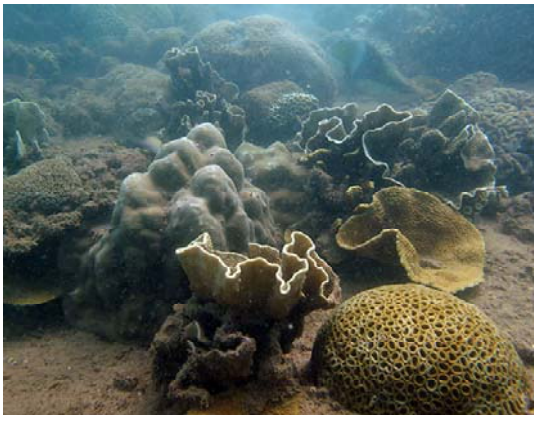


Analysis results:

(results from 2-way ANOVA)

Location: F=2.57; p=0.103. There were no significant differences in total coral cover amongst the five survey locations.

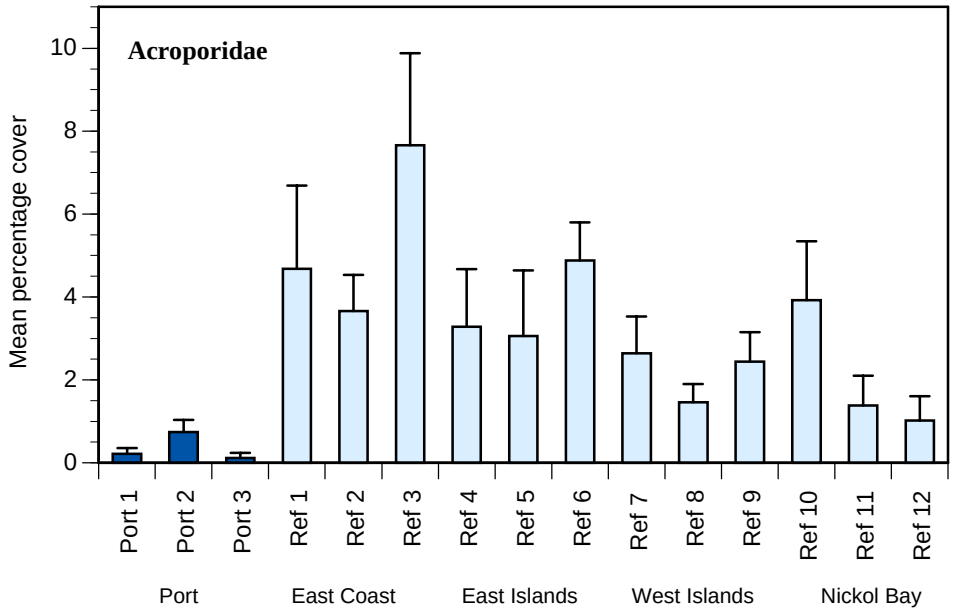
Site (Location): F=2.57; p<0.001. There were large differences between sites in each location.



Left: Fringing reefs in the Dampier region were dominated by faviid corals (bottom right), along with poritids (center left) and *Turbinaria* corals (center right).

Figure 8: Distribution Patterns of Acroporid Corals in the Dampier Region Survey Sites.

Graphs show mean total acroporid cover for each site from five 10 m line intersect transects. Error bars are standard errors.



Analysis results:

(results from 2-way ANOVA)

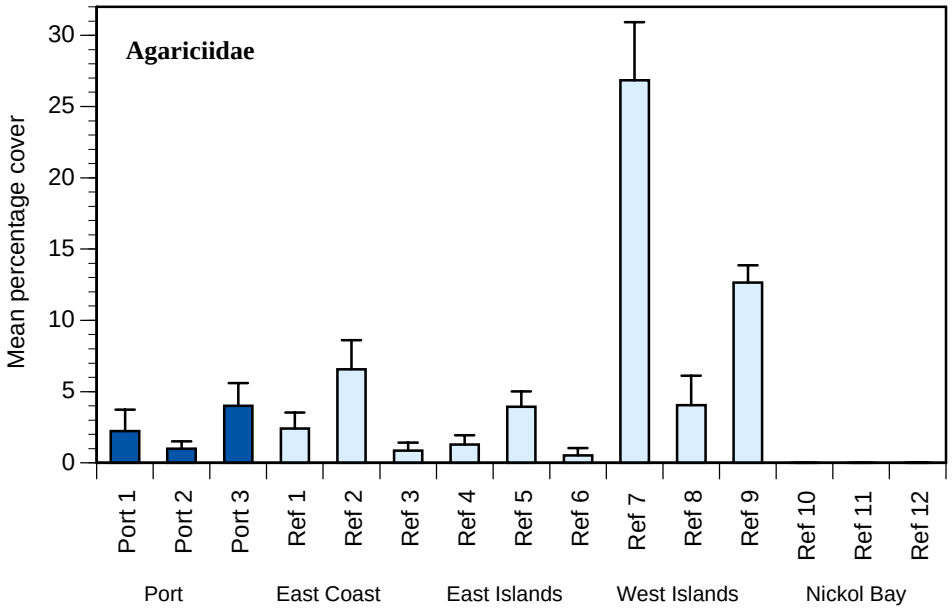
Location: F=6.36; p=0.008. Acroporid cover was significantly lower on the Port location reefs than in the other locations.

Site (Location): F=1.28; p=0.26. There were no differences between sites in each location.

Left: Fast growing acroporid corals were not common at any of the sites, covering a grand mean of 3.3% of the reference sites, but were rare in the Port location sites

Figure 9: Distribution Patterns of Agariciid Corals in the Dampier Region Survey Sites.

Graphs show mean total agariciid cover for each site from five 10 m line intersect transects. Error bars are standard errors.

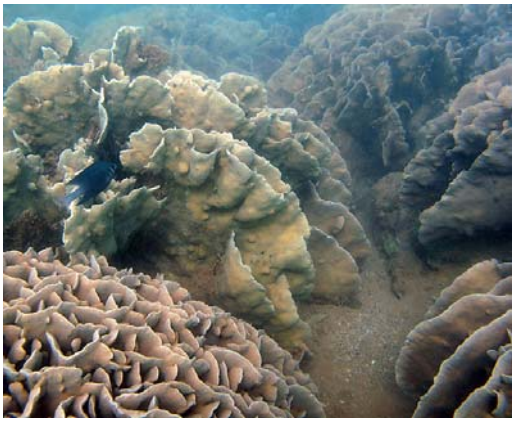


Analysis results:

(results from 2-way ANOVA)

Location: F=3.43; p=0.050. Agariciid cover was significantly higher on the west island reefs than in the other locations.

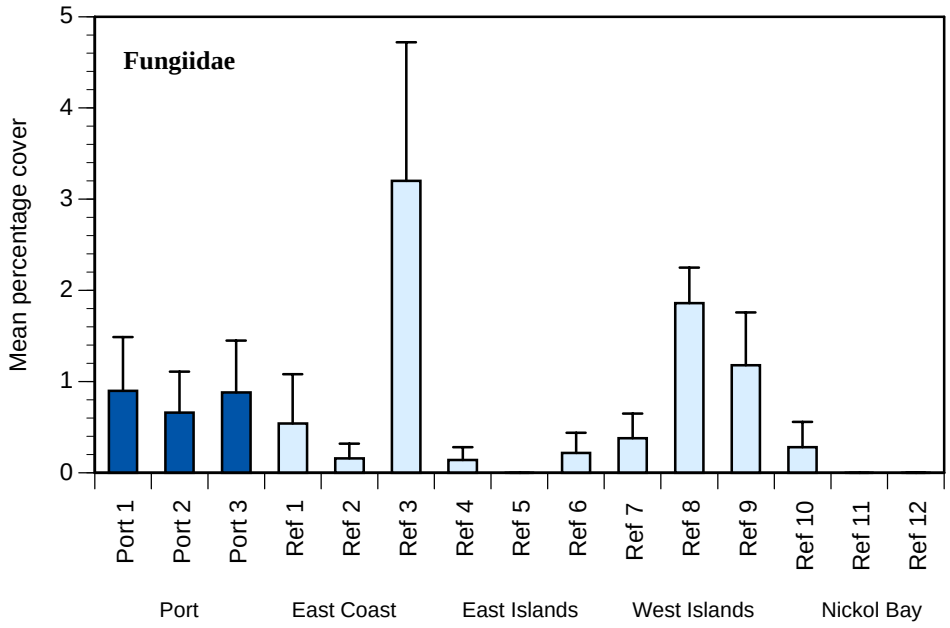
Site (Location): F=12.53; p<0.001. There were large differences between sites in each location.



Left: The agariciid coral *Pavona decussata* was very common in Reference site 7 on East Lewis Island where this species covered over 25% of the substratum.

Figure 10: Distribution Patterns of Fungiid Corals in the Dampier Region Survey Sites.

Graphs show mean total fungiid cover for each site from five 10 m line intersect transects. Error bars are standard errors.



Analysis results:

(results from 2-way ANOVA)

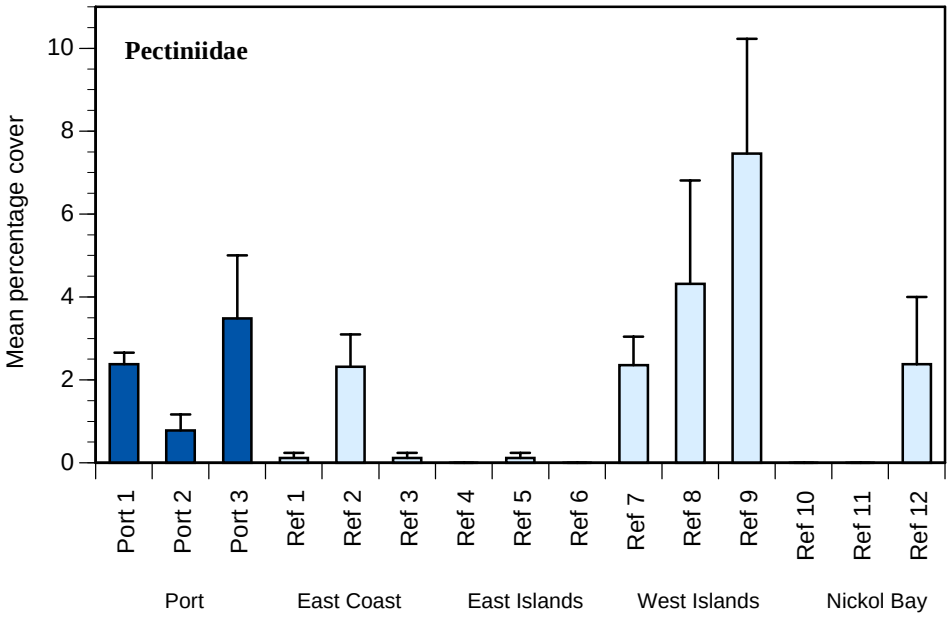
Location: F=7.57; p=0.004. Fungiid cover was not significantly different amongst the survey locations.

Site (Location): F=2.37; p=0.019. There were differences between sites in each location.

Left: The encrusting species *Lithophyllon undulatum* was the most abundant fungiid coral on the Dampier fringing reefs.

Figure 11: Distribution Patterns of Pectiniid Corals in the Dampier Region Survey Sites.

Graphs show mean total pectiniid cover for each site from five 10 m line intersect transects. Error bars are standard errors.



Analysis results:

(results from 2-way ANOVA)

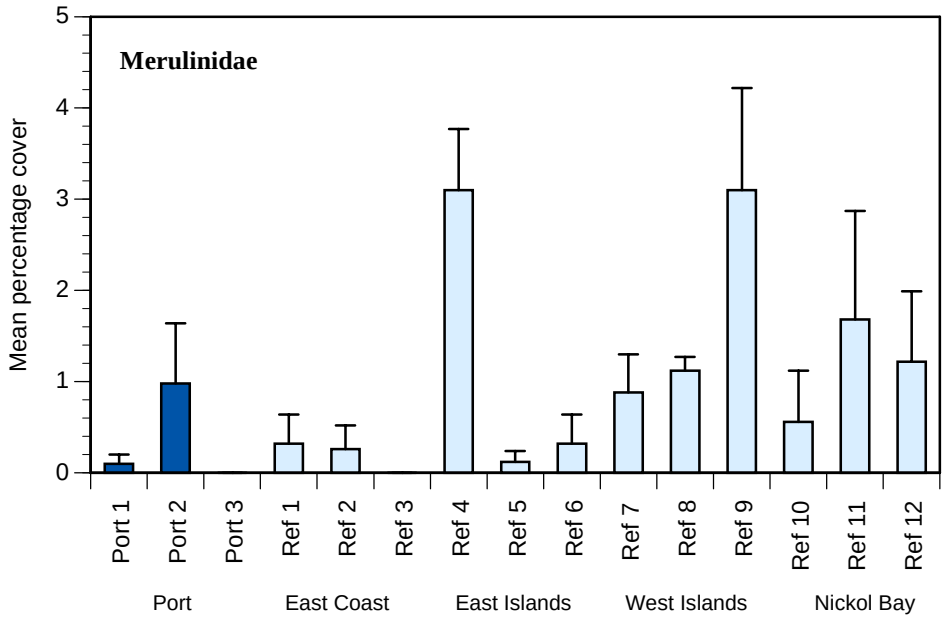
Location: F=4.27; p=0.028. Pectiniid cover was significantly higher on the west island reefs than in the other locations.

Site (Location): F=1.79; p=0.08. There were no differences between sites in each location.

Left: Pectiniid corals including *Mycedium elephantotus* were most abundant on the west island reefs where they covered a mean of almost 5% of the substratum.

Figure 12: Distribution Patterns of Merulinid Corals in the Dampier Region Survey Sites.

Graphs show mean total merulinid cover for each site from five 10 m line intersect transects. Error bars are standard errors.



Analysis results:

(results from 2-way ANOVA)

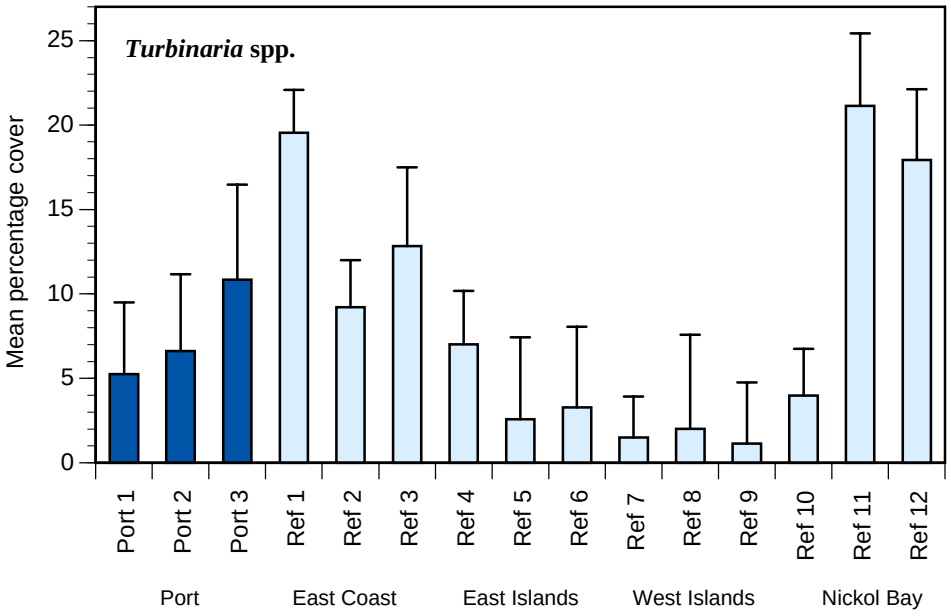
Location: F=1.40; p=0.30. Merulinid cover was not significantly different amongst the five survey locations.

Site (Location): F=1.40; p=0.006. There were large differences between sites in each location.

Left: Encrusting and convoluted colonies of the coral *Merulina ampliata* were the most abundant of the merulinid corals on these reefs.

Figure 13: Distribution Patterns of Turbinaria Corals in the Dampier Region Survey Sites.

Graphs show mean total Turbinaria cover for each site from five 10 m line intersect transects. Error bars are standard errors.

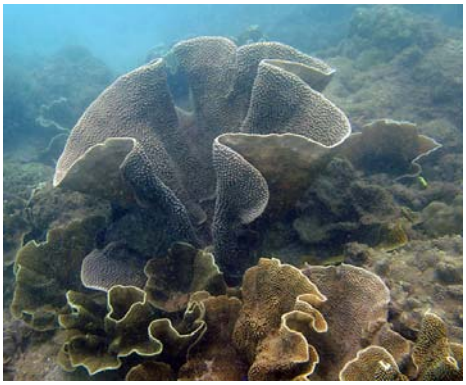


Analysis results:

(results from 2-way ANOVA)

Location: F=3.89; p=0.037. *Turbinaria* cover was significantly higher on the coastal survey reefs than in the island locations.

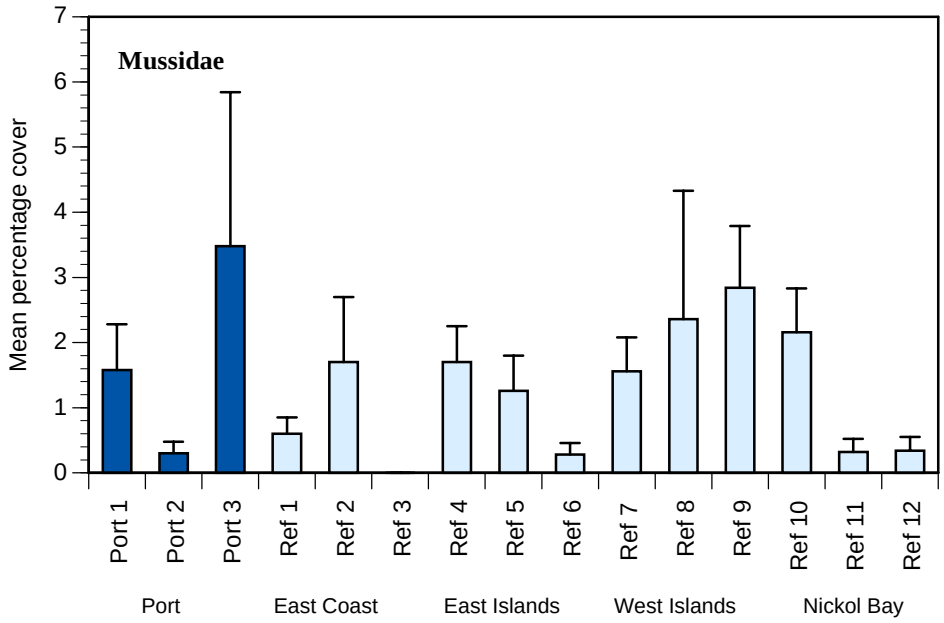
Site (Location): F=5.28; p<0.001. There were large differences between sites in each location.



Left: Several species of *Turbinaria* corals in the family Dendrophylliidae were common on all the coastal survey reefs and covered over 20% of the substratum at some sites.

Figure 14: Distribution Patterns of Mussid Corals in the Dampier Region Survey Sites.

Graphs show mean total mussid cover for each site from five 10 m line intersect transects. Error bars are standard errors.



Analysis results:

(results from 2-way ANOVA)

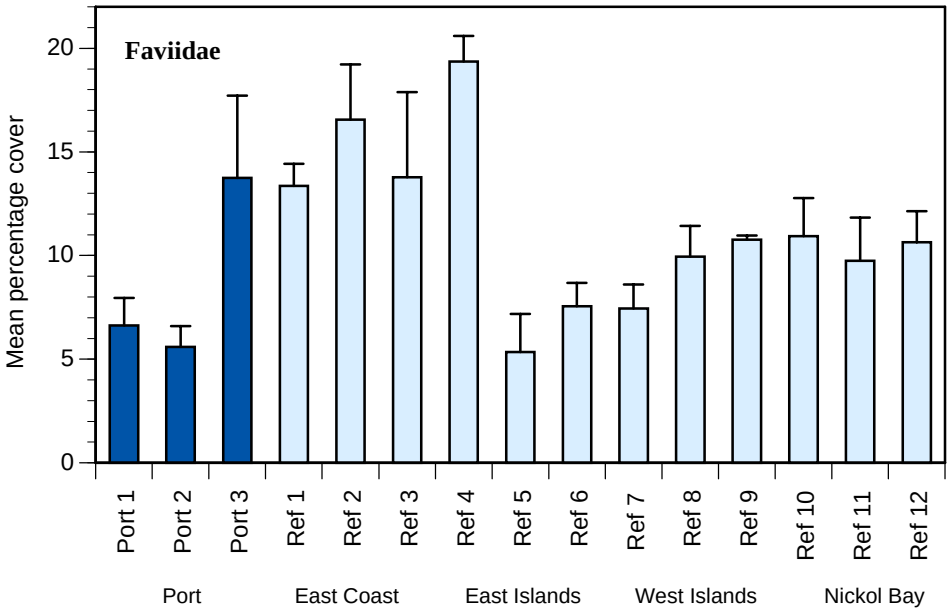
Location: F=0.97; p=0.46. Mussid cover was not significantly different amongst the five survey locations.

Site (Location): F=0.95; p=0.49. There were no differences between sites in each location.

Left: Colonies of the mussid coral *Lobophyllia hemprichii* were present at most sites but were nominally most abundant at Port site 3.

Figure 15: Distribution Patterns of Faviid Corals in the Dampier Region Survey Sites.

Graphs show mean total faviid cover for each site from five 10 m line intersect transects. Error bars are standard errors.

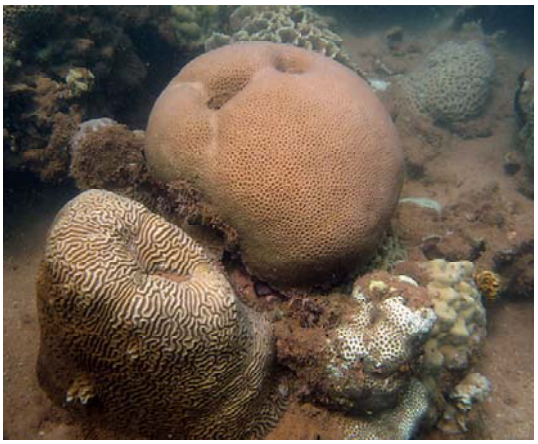


Analysis results:

(results from 2-way ANOVA)

Location: F=0.95; p=0.48. Faviid cover was not significantly different amongst the five survey locations.

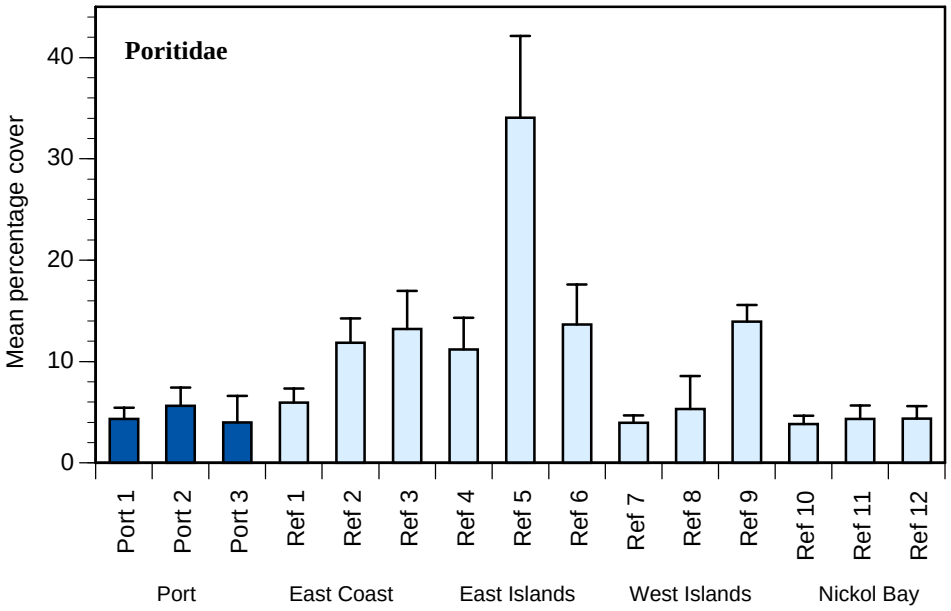
Site (Location): F=3.92; p<0.001. There were large differences between sites in each location.



Left: Long-lived, slow-growing faviid corals dominated the Dampier fringing reefs, including the genera *Favia* (top right), *Goniastrea* (center), *Platygyra* (bottom left) and *Leptastrea* (bottom right).

Figure 16: Distribution Patterns of Poritid Corals in the Dampier Region Survey Sites.

Graphs show mean total poritid cover for each site from five 10 m line intersect transects. Error bars are standard errors.



Analysis results:

(results from 2-way ANOVA)

Location: F=2.92; p=0.077. Poritid cover was not significantly different amongst the five survey locations in spite of the very high cover on Reference site 5 reefs.

Site (Location): F=4.28; p<0.001. There were large differences between sites in each location.

Left: Poritids were the second most abundant coral family overall and covered 35% of the substratum in Reference site 5. Massive *Porites* colonies accounting for 95% of this coral group.

3.1 Features of the Dampier Fringing Reefs

These fringing reefs were not true reefs but rather had a thin veneer of living corals growing on a rock and boulder substratum (Figure 17).

The Port location reefs showed some signs of stress and damage with sediment sitting on the surface of some coral colonies (Figure 18), a few partially bleached corals (Figure 19) and some partially or completely dead corals (Figure 20). Fine sediment was also present on most of the reference reefs and some dead corals were also found on these reefs.

There was evidence of new coral recruitment at most sites, including the Port sites, with small colonies between 2-10 cm across being relatively common on suitable dead coral substratum (Figure 21).

3.2 Comparison of Dampier Region Reefs with Cape Preston Fringing Reefs

Fringing reefs were surveyed near Cape Preston, 60 km west of Damper, as part of a recent port impact monitoring program. These reefs supported a similar benthic community to that described here for Damper region reefs. Mean coral cover from 12 sites of five 10 m transects on the Cape Preston reefs was 36%, compared with 41% on the Dampier reefs. The Cape Preston reefs were also dominated by faviid corals with poritid and *Turbinaria* corals also important and these three coral groups accounted for 73% of hard corals on these reefs. This is very similar to the almost 70% of hard corals accounted for by these three groups on the Dampier survey reefs (Figure 22). Mussids, merulinids and acroporid corals were also important on the Cape Preston reefs. The only significant difference between Dampier and Cape Preston fringing reefs was the presence of the agariciid coral Pavona decussata on Dampier reefs where this species accounted for over 10% of hard corals. This species was rare on Cape Preston reefs where only a few colonies were encountered, accounting for less than 0.5% of hard corals (Figure 22).

There were similar significant site effects in coral group abundance on the Cape Preston reefs to those recorded on Dampier reefs. The mussid coral *Lobophyllia hemprichii* dominated one of the Cape Preston sites, accounting for 60% of hard corals and the poritid coral *Goniopora* accounted for over 45% of hard corals at another site.

Figure 17: The fringing reefs of the Dampier Port and Reference sites were composed of a veneer of corals on rock and boulder substratum.

Figure 18: Fine sediment was present of the surface of some coral colonies in the Dampier Port sites and at most of the reference sites.

Figure 19: A partially bleached Goniopora colony (family Poritidae) at one of the Port location survey sites

Figure 20: A few coral colonies had suffered complete mortality at the Port sites and in the Reference sites: dead Acropora colony at Reference site 4 on Conzinc Island.

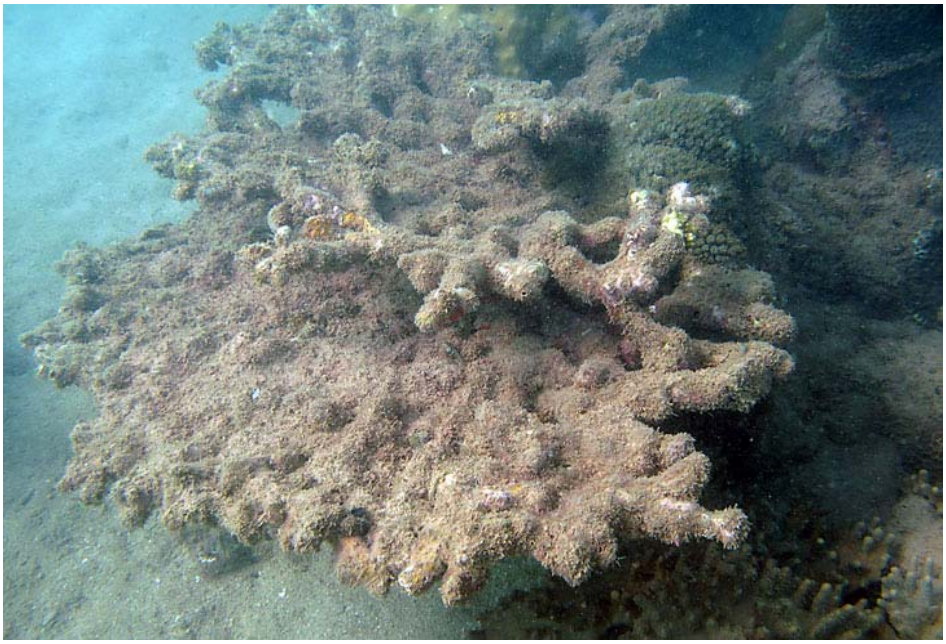
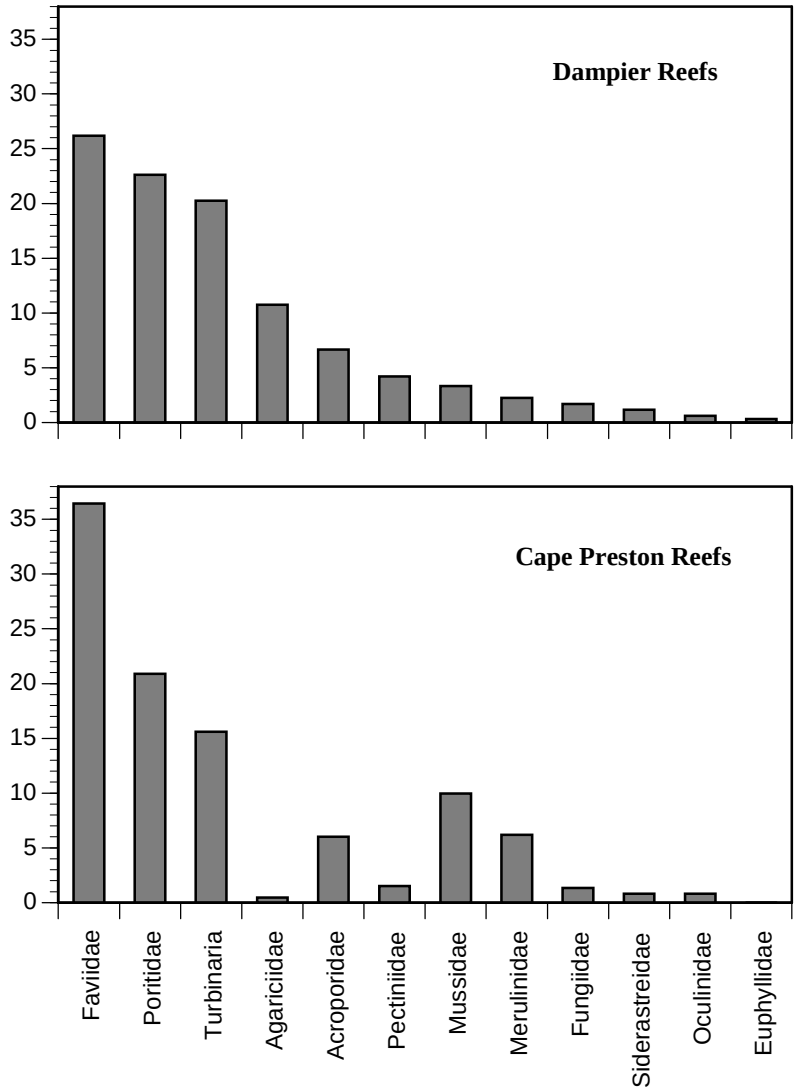


Figure 21: Newly recruited coral colonies less than 10 cm across were common on suitable substratum at most of the survey sites.

Figure 22: Hard Coral Composition of Dampier Region Fringing Reefs Compared with Fringing Reefs at Cape Preston

Cape Preston reefs, 60 km west of Dampier, were also surveyed in October 2009 using the same methods as the Dampier surveys.



4. DISCUSSION

The fringing reefs surveyed during this project in the Dampier region are not true coral reefs where the structure and substratum is formed by successive layers of dead coral. Instead the reefs are rock boulders with a veneer of living coral. Although some of the colonies are over a metre across and may be over 100 years old, corals have not yet provided a true reef structure. The reefs are narrow and fall quickly to a sand/mud substratum only a few metres below low tide level.

These reefs appear healthy with many large and long-lived coral colonies. Many small coral recruits of a wide range of species were observed on these reefs, also indicative of a healthy reef community.

Although grand mean coral cover was nominally lower on the three Port location sites compared with the mean from all the reference sites these differences were not significant. Coral composition was similar at the Port sites to that in the Reference sites with the three coral groups Favidae, Poritidae and Turbinaria spp. accounting for about 70% of total hard coral cover. The major differences between the two locations were a slightly lower proportion of poritid corals at the Port location coupled with a lower proportion of Acroporid corals. Some differences resulted from the significant site effects that are a distinctive feature of most fringing reefs (Ayling and Ayling 2006; WorleyParsons 2009).

Coral abundance and composition was also similar to Dampier reefs on the Cape Preston fringing reefs 60 km to the west of Dampier. Combined faviid, poritid and *Turbinaria* corals made up 73% of hard corals on the Cape Preston reefs with most differences resulting from significant site differences in the two regions.

The three coral groups that dominated the benthic communities in all three of these fringing reef locations are all relatively resistant to bleaching, able to withstand strong wave action and can cope with high levels of sedimentation (Ayling and Ayling 2006, Berkelmans and Oliver 1999, GHD 2008). The coral groups that are most susceptible to bleaching and wave impacts, acroporids and pocilloporids, are rare or absent on these reefs. These fast growing groups are usually dominant on many coral reefs but conditions on Dampier and Cape Preston region fringing reefs have not been suitable for their establishment and/or survival.

It is possible that the particularly low acroporid cover in the Port location has resulted from bleaching mortality of this susceptible group following port dredging sedimentation and stress. The bleaching and partial mortality of a Goniopora (poritid) colony observed in the Port location during this survey may also indicate that poritid cover has been reduced in the Port location by past dredging sedimentation and stress.

This assessment was conducted during a 6 day window of no dredging from the neaby Pluto project. Dredging for this project has been underway since late 2007 in various stages, and has been underway intensively within the swing basin and approach channels (within 300m of the Port sites) since July 2009. The observed bleaching will recover, which typically takes only 5-15 years. Once the disturbance caused by development processes is over marine communities can re-establish themselves in disturbed areas and expand into newly provided habitat such as rock retaining walls and pilings.

In summary it seems likely that the inshore fringing reefs of the Dampier and Cape Preston region are a single community dominated by bleach, sediment and wave-resistant coral groups. Most of the small differences recorded are due to historically mediated site effects whereby a 50-100 m long local reef area becomes dominated by a single long-lived species of coral.

The fringing reefs in the vicinity of Dampier Port are not true coral reefs where the structure and substratum is formed by successive layers of dead coral. Instead the reefs are rock and boulders with a veneer of living coral. Although some of the colonies are over a metre across and may be over 100 years old, corals have not yet provided a true reef structure. The reefs are narrow and fall quickly to a sand/mud substratum only a few metres below low tide level.

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