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Implications of the Monck Head Boat Launching Facility on Adjacent Intertidal Sessile Assemblages (Coral Bay, Western Australia)

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Abstract

The aim of this study was to observe if the construction of the Monck Head boat launching facility in September 2007 has impacted the adjacent intertidal sessile assemblages. Through a series of linear transects and quadrats, data was gathered to look at diversity and species composition on both north and south sides of the boat launching facility. Measurements of sand accumulation and map interpretation of fetch also provided insight to local physical processes of water flow, sedimentation and wave energy. The results showed that there was a significant accumulation of sand on the south side of the boat launching facility and erosion on the north side. No trends of diversity existed in transects at distances away from the boat launching facility, but species composition greatly differed between the two sides. The largest differences were seen in species of the Littorinidae family, algal species of the Division Cyanophyta and the species *Sargassum ligulatum*. The total percent cover of *S. ligulatum* on the north side was 10.46% and on the south side was 2.51%. These results indicate a probable impact of the boat launching facility on the adjacent sessile invertebrate assemblages through the disruption of physical processes. This information is important to encourage the Department for Planning and Infrastructure to replace the rock causeway with a piled bridge in order to return the adjacent ecosystems a more natural state.

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I. Introduction

i. Statement of Problem

a. Coral Bay & Ningaloo Reef

Coral Bay is a small coastal town adjacent to the Ningaloo Reef located on the southern shore of Bills Bay, North West Cape, Western Australia (DALSE 2002). The primary driver of the economy is tourism related to the marine assets of the Ningaloo Marine Park. The Ningaloo Reef is the longest fringing reef in Australia and hosts high levels of biodiversity in a network of coral reef communities including 250 species of hard corals, over 500 species of fish and around 600 species of mollusks (Storrie & Morrison 2003). The most popular tourist activities in Coral Bay are snorkeling, recreational fishing and boating tours. Based on estimates in 2003, tourists contributed a minimum of $80 million annually to the local economy (Wood 2003). The Coral Bay community is highly reliant on the health and accessibility of the marine ecosystems offshore. It is imperative for the sustained economy of Coral Bay to maintain a high quality of the marine ecosystems which make up the Ningaloo Marine Park.

b. Boat Launching Facility Construction

Prior to 2007, recreational boat users and commercial vessels entered Coral Bay from the main beach which posed great concerns because boats needed to maneuver around complex coral assemblages and many swimmers (DALSE 2002). A proposal for a new boat launching facility was expressed to the Department for Planning and Infrastructure (DPI) and sites were considered at Point Maud and Monck Head. The Environmental Protection Authority (EPA) evaluated extensive environmental impact reports for each site and concluded that the boat launching facility at Monck Head (1.5km south of Coral Bay) would cause less damage to the surrounding marine ecosystems. The area now occupied by the boat launching facility was formerly protected in the Maud Sanctuary Zone, but was removed so that construction could occur. The fact that this intertidal area was previously considered important to protect in a sanctuary zone indicates its ecological importance. The EPA based their environmental judgment and permission on the construction plan of an offshore boat launching facility with piled bridge and culvert causeway to connect to the shoreline (EPA 2003) (Figure 1). Construction plans bisected a continuous limestone platform and it can be assumed that physical processes and sessile assemblages were consistent across the entire platform. Upon construction, the DPI discovered that to build a bridge strong enough to carry construction vehicles and limestone boulders would have been significantly more expensive than what would be required for carrying recreational vehicles and boats. The

DPI decided to build a temporary rock causeway for the construction of the boat launching facility and then build the piled bridge afterwards (DPI 2007). The EPA requires that the DPI make the alterations within five years of initial construction. The rock causeway has disrupted water circulation patterns near shore and significant erosion on the north side and deposition on the south side is already obvious after two years. What has not been documented is the effect of the boat launching facility on the adjacent intertidal sessile assemblages. This study provides insight on the effects of the boat launching facility on intertidal assemblages that can be used to persuade the DPI to commence the alterations of the rock causeway to the piled bridge soon and save the intertidal habitat from continued disturbance.

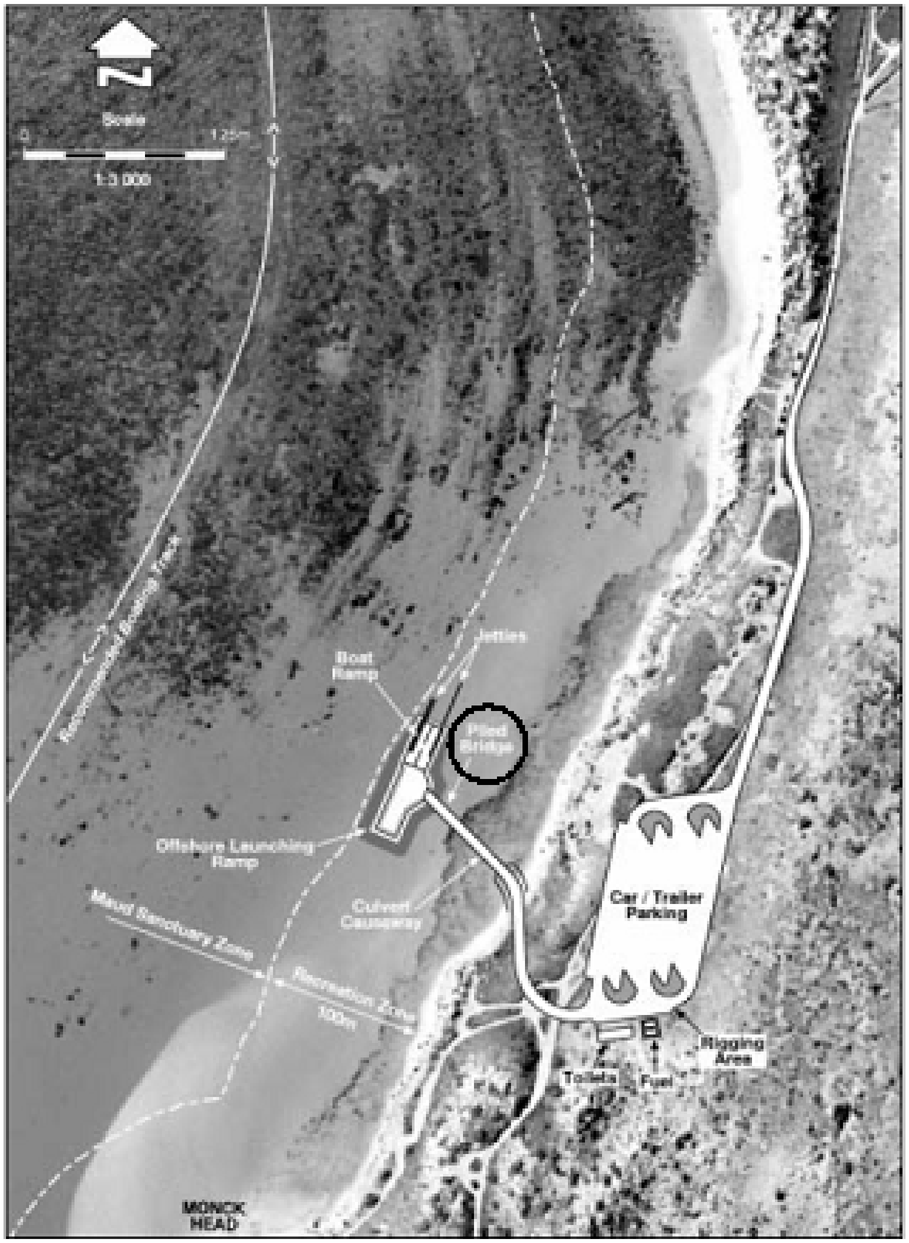

Figure 1. Construction Plan for the Monck Head Boat Launching Facility (Photos from Environmental Protection Authority, 2003)

ii. Justification for Study

This study had minimal to no disturbance on the intertidal communities adjacent to the Monck Head boat launching facility. The only disturbance was some specimens taken to the laboratory for further identification. Removal was minimal and did not have an effect on the overall assemblage. The study provides new information concerning the effects of the Monck Head boat launching facility on adjacent marine ecosystems which will be beneficial in convincing the DPI to make the aforementioned alterations to the rock causeway.

iii. Review of Previous Research

a. Artificial barriers

Human constructed artificial barriers have been observed to alter local sedimentation and water flow regimes. Historically, humans have constructed a variety of structures on the coast such as groins, jetties, harbors and breakwaters. The barriers typically run perpendicular to the shore and have significant local alterations to original physical and biological regimes (Valiela 2006). Many studies have looked at physical alterations such as beach erosion, sedimentation and water flow around the construction of artificial barriers (Como et al. 2007; Phillips & Williams 2007; Lee & Ryu 2008). In a study done around the Saemangeum dyke on the west coast of Korea, substantial erosion occurred on one side while accumulation of sediments occurred on the other side. Samples of suspended sediment loads in the water column also indicated a shift in the direction of sediment transport (Lee & Ryu 2008). Although studies of sedimentation and flow regimes around artificial barriers are abundant, there have been very few studies concerning the adjacent biological communities. It is common knowledge that physical changes in water flow and sedimentation alter habitats for local flora and fauna, but changes in community structure have been poorly documented (Valiela 2006). This experiment will provide insight into short-term community shifts around an artificial barrier.

b. Water flow regimes

Scientific research has also documented correlations between water flow regimes and marine ecosystems. Marine ecosystems are highly dependent on consistent ocean circulation patterns, and there are significant ecological effects from flow disturbance. Some important changes are low velocity zones, upwelling and downwelling which are associated with different nutrient and sediment inputs into the system (Connell & Gillanders 2007). Nutrients in the water are the source of energy and sessile organisms usually obtain them through filter feeding.

In addition to the transport of food particles, ocean currents also assist sessile organisms in reproduction. Sessile adults release larvae into the water column which are either fertilized internally or externally. Ocean currents then disperse the larvae to new areas where they settle and start new colonies (Connell & Gillanders 2007). Dispersal is important for genetic variability within populations and colonization in new areas or re-colonizing areas degraded by disturbance. Many studies have documented a reduction in colonization of sessile organisms with disrupted water flow (Como et al. 2007). Changes in circulation can result in patchiness of coral assemblages and gradients in species diversity (Connell & Gillanders 2007).

c. Sedimentation

Previous research also exists for the effect of sedimentation on marine ecosystems. Sedimentation may consist of addition of terrestrial sediments or re-suspension of marine sediments in the water column. Sources of sedimentation in marine habitats can be natural from wind, waves and tides or from anthropogenic activities such as coastal development or construction (Carballo 2006). Increased particulate matter causes changes in the physical and chemical properties of sea water which affects marine life. Some of these impacts are reduction in water pumping rates for filter-feeding sessile invertebrates (Carballo 2006). There also may be blocked larval production, settlement and therefore recruitment in sessile invertebrate species (Connell & Gillanders 2007). Increased turbidity can also limit light penetration into the water for photosynthetic organisms such as macroalgae and the symbiotic zooxanthellae in corals. Sedimentation has been characterized as one of the most common causes of degradation of coastal ecosystems, and studies have observed a prolonged negative effect on benthic communities (Carballo 2006; Connell & Gillanders 2007). A study on sponge assemblages in Mazaltán Bay, tropical Pacific, Mexico, observed a decrease in diversity with increased sedimentation (Carballo 2006). This can be attributed to a reduction in pumping rates for filter feeders. Certain species are more adaptable to survive under high sediment loads and these tend to dominate assemblages thereby reducing overall diversity.

iv. Aims of Study

The purpose of this study is to provide information on the effect of the Monck Head boat launching facility on adjacent intertidal sessile assemblages. In order to make these assertions this study…

1. Uses sand measurements and map interpretation of fetch to look at local physical processes of water flow, sedimentation and wave energy.

2. Assesses species diversity and species composition of intertidal sessile assemblages on the north and south sides of the Monck Head boat launching facility.

3. Draws conclusions concerning a possible correlation of the adjacent sessile assemblages to changes in physical processes caused by the boat launching facility.

II. Methods

i. Study Site

a. Location

This study took place on the intertidal platform adjacent to the Monck Head boat launching facility approximately 1.5km south of Coral Bay, North West Cape, Western Australia (Figure 2). The latitude and longitude coordinates of the boat ramp are S 23° 09.352' and E 113° 46.035'.

Figure 2. Aerial Photograph of Monck Head Boat Launching Facility and Adjacent Intertidal Platform (Photo courtesy of Mike Van Keulen)

b. Limestone Platform Geology

The specific area under study was the limestone platform extending between 21m and 51m from shore with an average distance of 32.7m (Figure 2). Coral reefs grew here during the last interglacial period when sea level was higher. When sea level dropped during the Pleistocene, the coral died and eroded leaving a limestone platform extending from shore (Cassata & Collins 2008). This creates a unique habitat which supports a range of marine communities including intertidal and subtidal fauna. These include mollusks, echinoderms, corals and algae (Cassata & Collins 2008).

c. Climate

The climate of the region is arid with a hot summer between October and April and a mild winter between May and September. The mean annual rainfall is 250-300 mm which is greatly exceeded by mean annual evaporation of 2,700 mm (D'Adamo & Simpson 2001). The predominant winds are the southeasterly trade winds in the winter and south or southwesterly winds in the summer.

d. Water Movement

There are many water circulation components which contribute to the marine life present at Coral Bay. The Leeuwin Current is an eastern boundary current which flows from north to south carrying warm, tropical water down the coast. Warm, nutrient-poor water allow corals to grow at a latitude which would normally be too cold (Connell & Gillanders 2007). The Leeuwin Current flows slightly offshore and the majority of water movement remains on the outer side of the reef and does not make it over the reef crest into the lagoon. Characteristic southerly or southwesterly winds generate a surface current near shore that flows northward. This is called the Ningaloo Current in the summer months, but a steady northward longshore drift exists year round (D'Adamo & Simpson 2001). Wave pumping over the reef crest and tidal movements also contribute to exchange between ocean and lagoonal waters. This hydraulic regime largely impacts the organisms living on the reef and the coastal habitats.

ii. Study Organisms

a. Algae

Marine algae exists in four main divisions. The Chlorophyta or green algae, Heterokontophyta or brown algae, Rhodophyta or red algae, and Cyanophyta or blue-green algae. There are also four structural types of categorization; encrusting species which are found higher up on shore, are flat and stuck down on the substrate; foliose algae which have branching and erect forms; canopy-forming species which are taller and emerge above the water; and microscopic forms which reside in the water column (Underwood & Chapman 2005). Specimens from all divisions except Chlorophyta were observed during this study. Foliose and canopy-forming structures were observed, and encrusting species were omitted because other algae would grow above encrusting species and this would complicate values of percent cover.

b. Corals

Corals are organisms in the phylum Cnidaria and have polyps which build calcium carbonate skeletons. All of the corals found at the study site were hard corals in the Class Anthozoa. The families of corals observed here were Poritidae, Favidae, Pocilloporidae and Acroporidae (genus *Acropora*).

c. Mollusks

In the phylum Mollusca, a variety of organisms were observed at the study site. These included chitons (Class Polyplacophora), limpets (Family Spiphonariidae) and oysters (Family Ostreidae) as well as many families of snails; nerites (Family Neritidae), periwinkles (Family Littorinidae), dove snails (Family Columbellidae) and creepers (Family Cerithiidae). All of these species are herbivorous and scrape algae off the substrate (Wells & Bryce 2000).

d. Echinoderms

Representatives of the phylum Echinodermata from this study were holothurians or sea cucumbers and sea urchins from the class Echinoidea. Holothurians are primarily plankton feeders, but will sift through sediment to find organic material. Sea urchins are scavenging omnivores which feed on plant and animal matter on the substrate (Edgar 1997).

ii. Data Collection

a. Transects

This data was obtained through a series of transects running perpendicular to the shore with quadrats spaced 5 m apart along the transects. Nine transects were sampled on each side of the boat ramp at 25 m intervals between 0 m and 200 m distance away from the ramp. The transects began at shore where the farthest extent of water spray reached and ran to the edge of the continuous limestone platform. There was not a consistent transect length, but the entire zonation of the limestone platform was observed.

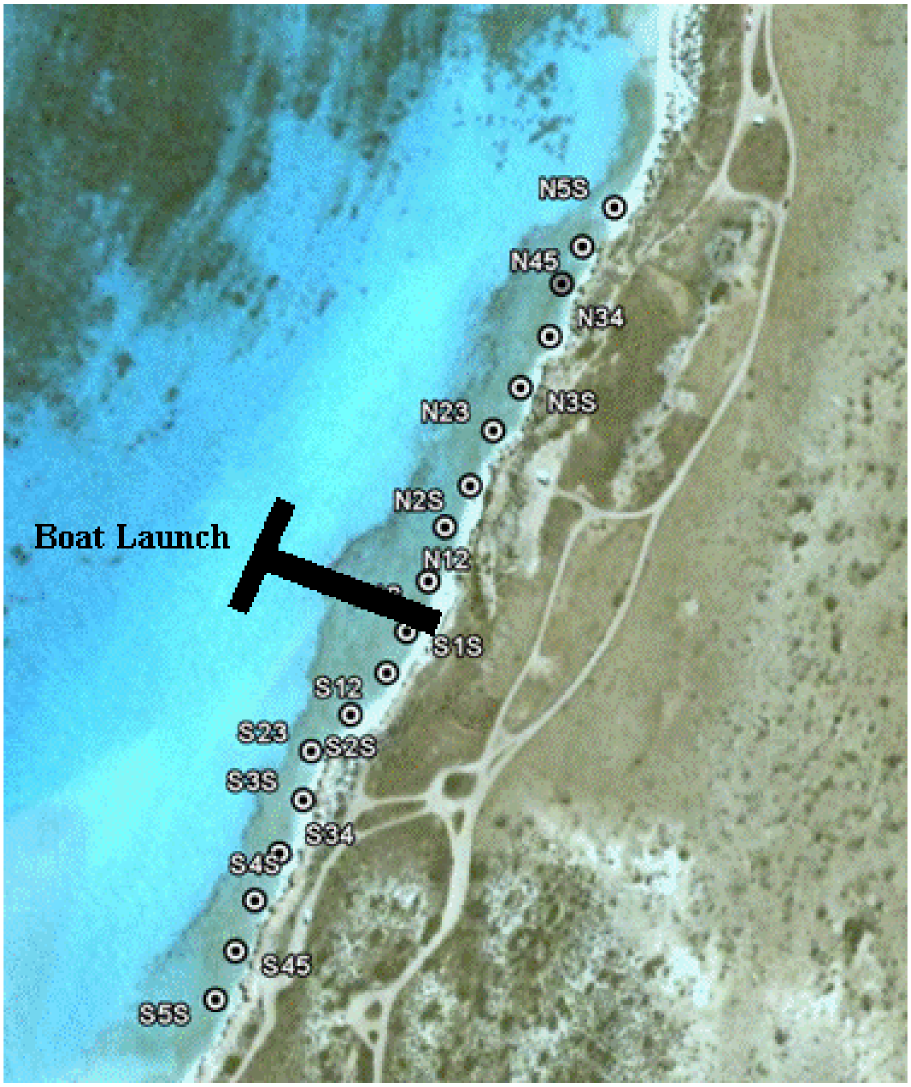

Figure 3. This map shows the extent of the limestone platform extending out from shore and all of the beginning points of each linear transect spaced 25 m apart. The location of the boat launching facility is indicated. (Photo courtesy of Google Earth.)

b. Quadrats

The quadrats were 0.5 m by 0.5 m, and comprised of a grid of strings spaced 5 cm apart. Nine strings on each side create a grid of 81 points of intersection. Every five meters, a quadrat was placed with the lower right corner at appropriate length on the transect and the species underneath each intersecting grid point were recorded.

c. Sand Measurements

In each quadrat, the depth of sand at grid cell E5 (the middle of the quadrat) was measured.

iii. Data Analysis

a. Percent Cover

Abundance values of sessile organisms were calculated as percent cover. This is the total area of the substratum which different species occupy. The number of points of intersection within the quadrat is divided by the total (81 points) and multiplied by 100.

b. Diversity

Three components were used to classify diversity. The first is species richness which is the total number of species present.

The second is the Shannon-Wiener Index which takes into account richness and evenness to generate a single diversity value. The higher the value, the higher the corresponding diversity. The formula for the Shannon-Wiener Index is

$$H' = -\Sigma(X_i/N)\log_e(X_i/N).$$

Where H' is the Shannon-Weiner Index, X_i is the number of individuals in species i and N is the total number of individuals in the sample.

The third is Pielou's Evenness Index which measures how evenly the species are distributed over a given area. Higher values indicate more equitability in the sample area. The formula for Pielou's Evenness Index is

$$J'=H'/(\log_e S)$$

Where J' is Pielou's Evenness Index, H' is the Shannon-Wiener Index and S is the total number of species.

III. Results

Over the course of sampling, a total of 18 linear transects were sampled, nine on both the south and north sides of the Monck Head boat launching facility. These varied in length between 21 and 51 m with an average of 32.7 m. On the south side 60 quadrats were sampled, covering a total area of 15 m^2. On the north side 68 quadrats were sampled, covering a total area of 17 m^2. A total of 27 species were recorded with 22 observed on the south side and 23 observed on the north side. Total percentage cover of all species was 13.2 % on the south side and 18.6 % on the north side.

i. Physical Environment

This study quantified aspects of the physical environment through sand accumulation and map interpretation of fetch.

a. Sand Accumulation

Sand measurements were taken in the middle of each quadrat if applicable. The sum of all sand measurements on the south side was greater than 7.52 m while only 0.57 m on the north side. The measuring device used gather depths was 0.88 m long and four of the samples on the south side were deeper than this value making 7.52 m a low estimate. Sand accumulation was significantly higher on the south side than the north side (Figure 4). Both sides experienced the majority of sand accumulation nearest the boat launching facility and this decreased further along the shore (Figure 4).

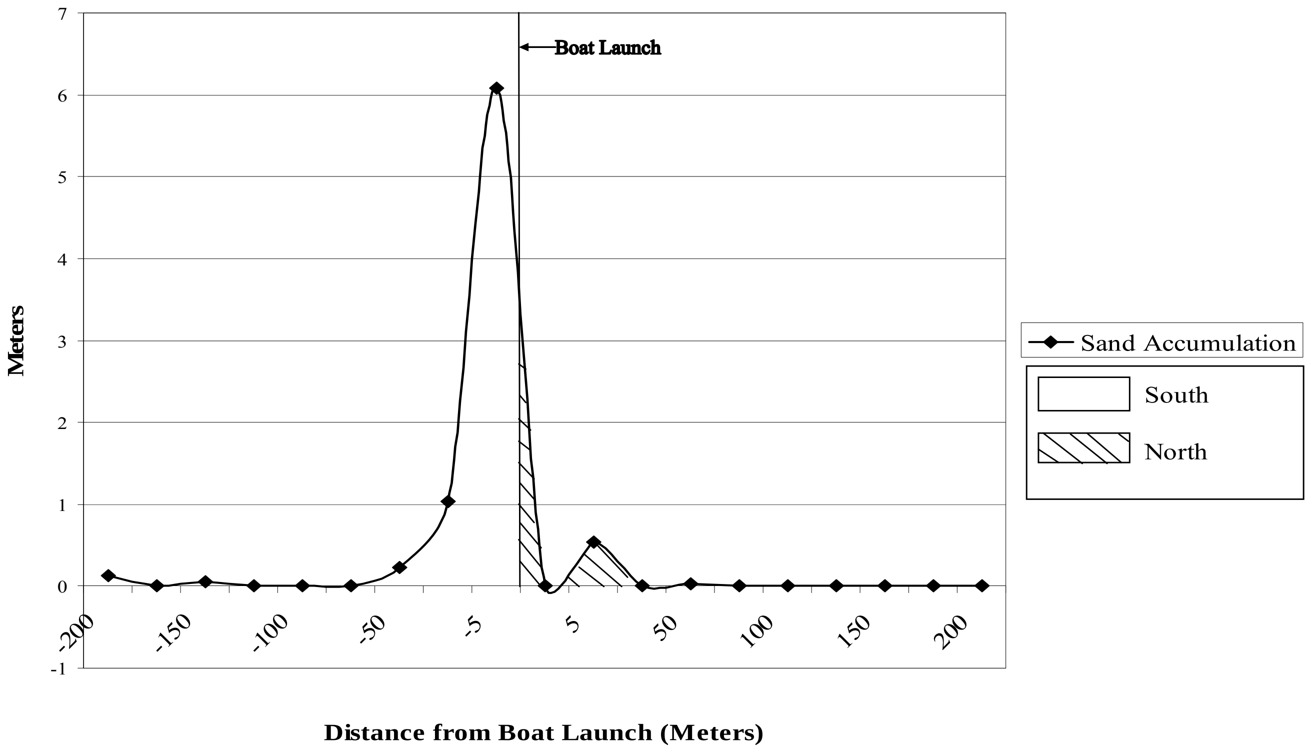

Figure 4. The total sand accumulation for each linear transect at distances away from the boat launching facility. The middle line indicates the position of the boat launching facility and the area under the graph on each side corresponds to the amount of sand accumulation on each side. On the x-axis the transects at (5 m) and (-5 m) were actually zero meters away from the boat launching facility, but are graphed as five for a better visual. This trend is present on all following graphs.

b. Fetch

Fetch is defined as the unobstructed distance which wind has to move water in a constant direction. The greater this distance, the larger the waves generated (Rohweder et al. 2008). The prevailing winds at Coral Bay are southwesterly and direct waves in this direction as seen in Figure 5. The outer edge of the reef is an obstruction and causes the wave to break. The distance from the reef to the shore is the fetch for waves reaching the limestone platform. Because the boat ramp sits perpendicular to the prevailing winds, this is an obstruction and the fetch for the waves immediately adjacent to the boat launching facility on the north side is only the distance from the boat launching facility to the shore (Figure 5).

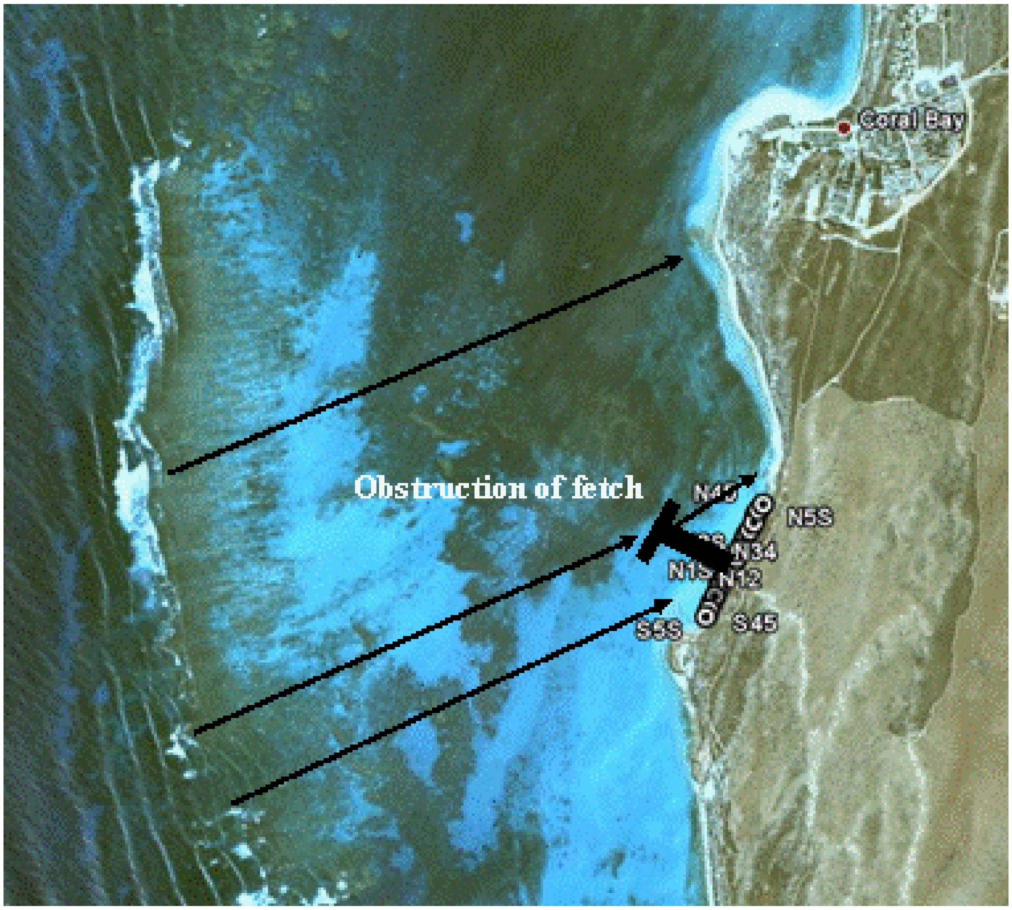

Figure 5. Observations of Fetch on Satellite Image. This image was taken from Google Earth and shows wave breaking on the outer reef crest and inner lagoon waters. Arrows represent wind direction and distance the wind has to generate waves (fetch).

ii. Species Diversity

There were no significant patterns in diversity of linear transects with distance from the boat launching facility. Values of species richness, Pielou's Evenness Index and Shannon-Weiner Index all showed remarkable variability and no trends existed (Figure 6).

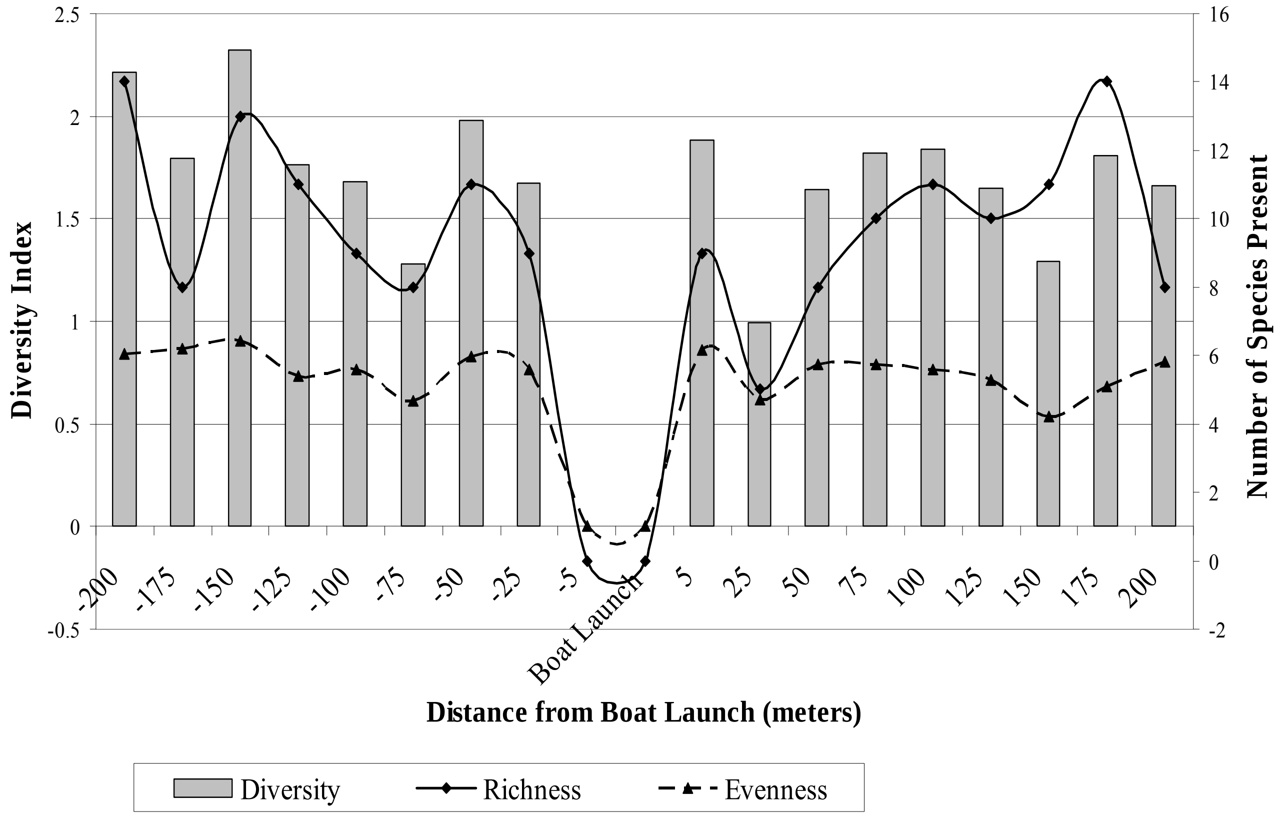

Figure 6. Shannon-Weiner Diversity Index for the totals of each linear transect at distances away from the boat launching facility. The two components of diversity, richness and evenness, are also both plotted for each transect. Pielou's Evenness Index was used to calculate evenness values which are plotted against the diversity index axis, while richness is plotted against the number of species present axis.

iii. Species Composition

Although values of diversity did not indicate any patterns, there were significant differences in species composition between the north and south sides of the Monck Head boat launching facility. Of the 27 total species recorded, 22 were observed on the south side and 23 were observed on the north side. The percent cover of many species was significantly different between sides.

a. Family Littorinidae (Periwinkle) Abundance

One of the most striking differences was distribution of species from the mollusk Family Littorinidae (Periwinkles) which were only found in the 0 m quadrats in the upper intertidal zone. Of the four species observed *Echinolittorina australis*, *Nodolittorina pyramidalis* and *Nodilittorina unifascata* were more abundant on the south side (Figure 7). *E. australis* dominated assemblages on the south side, while *Littoraria. scabra* dominated assemblages on the north side. *L. scabra* was never found on the south and *E. australis* was only observed 175 m away from the boat launching facility. Standard error bars illustrate the variability around the mean and these do not overlap for *E. australis*, *N. pyramidalis* or *L. scabra* and this indicates a significant difference between abundances.

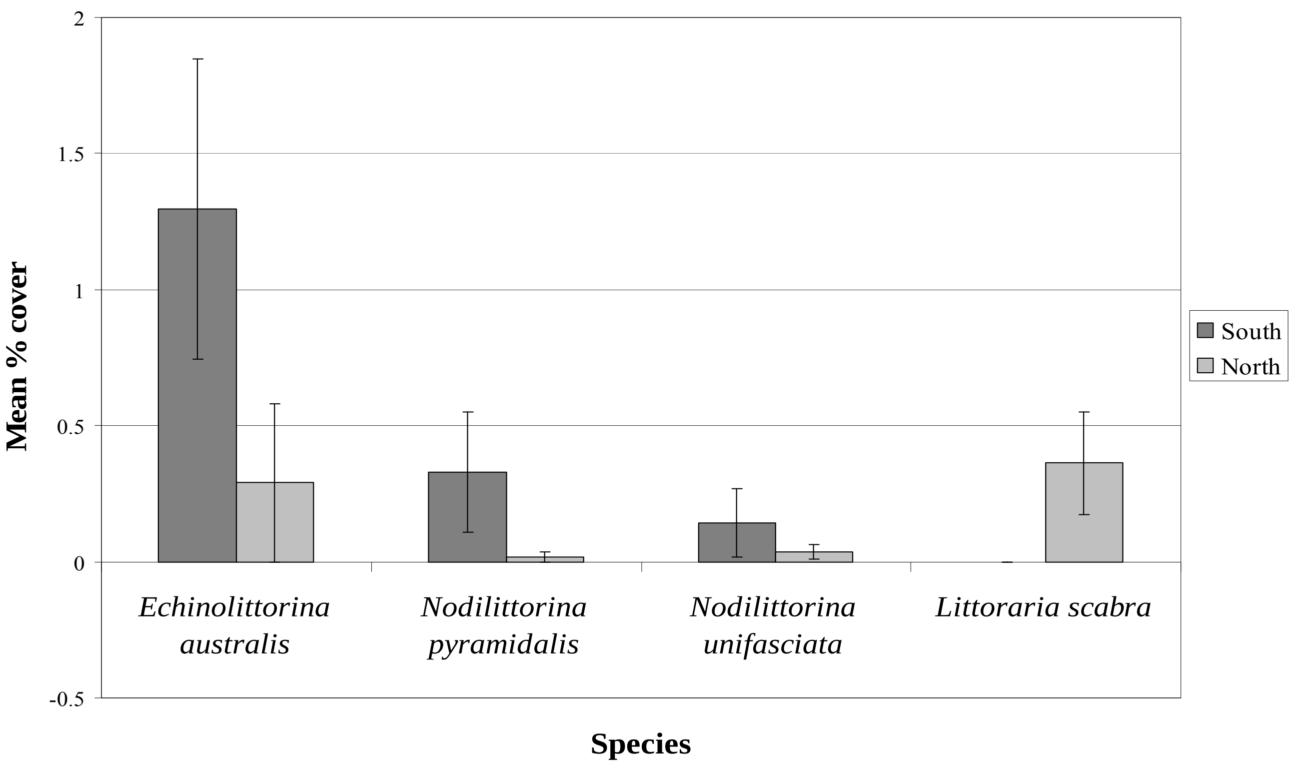

Figure 7. Mean percent cover of various Littorinid species on both the north and south sides of the boat launching facility.

b. Algae Species Abundance

A total of nine species of algae were observed over both sites. Six were found on both sites, while *Cottoniella filamentosa* was only found on the north side and *Calothrix* sp. and *Schizothrix calicola* were only found on the south side. The only algal species which did not show a distinct difference between sides was *Dictyota* sp. However there were multiple *Dictyota* species which were not differentiated in the field (Table 1). The abundance differences between north and south sides of the boat launching facility for seven species with significant differences is illustrated in Figure 8. The species *Sargassum ligulatum* is omitted from this graph because of its much higher percent cover which made the graph difficult to read. *Chondrophycus papillosa*, *Calothrix* sp., *Turbinaria ornata*, and *S. calicola* were more abundant on the south side, while *Turbinaria gracillis*, *Lobophora variegata* and *C. filamentosa* were more abundant on the north side (Figure 8).

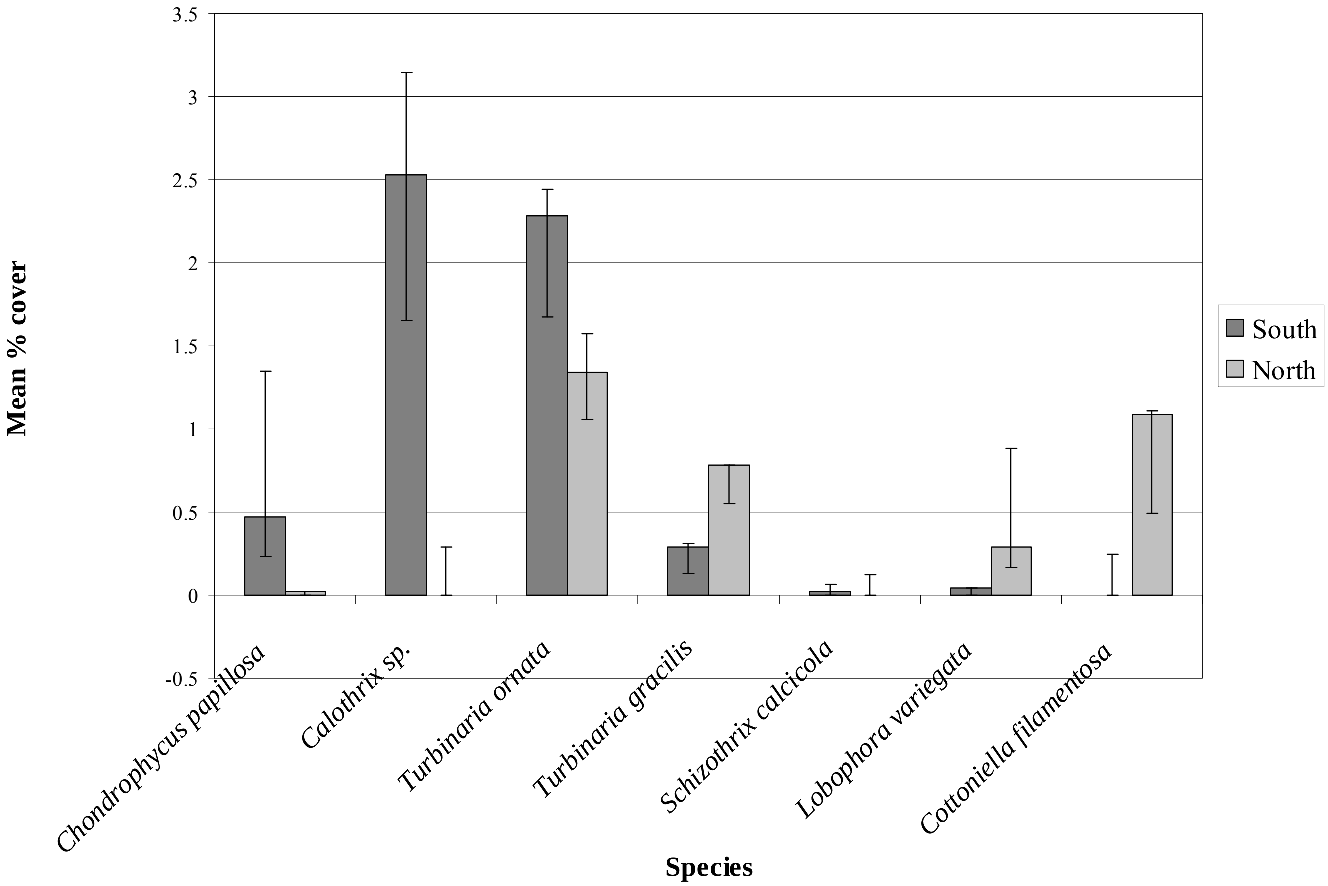

Figure 8. Mean percent coverage of various algal species on the north and south sides of the boat launching facility.

c. *Sargassum ligulatum*

The algal species *S. ligulatum* was the most abundant species observed over both north and south sides. The total percent cover of *S. ligulatum* on the north side was 10.46 % and on the south side was 2.51 %. This is the most abundant species on the north side and second most abundant species on the south (second to *Calothrix* sp.). These species showed the greatest difference between mean abundances of all algal species observed.

IV. Discussion

i. Physical Environment

Various aspects of the physical environment appear to be altered as a result of the Monck head boat launching facility. Sand accumulation was much greater on the south side than the north side (Figure 4). This can be attributed to a disruption in northwards longshore drift along the coast. The predominant winds are southerly or southwesterly which generate waves over the surface of the water. The waves are not usually parallel to the shore and one side of the wave breaks reaches shore first and breaks before the other side. The timing of waves breaking results in wave refraction in a northward direction. This water movement creates a narrow longshore current which flows in the direction of the predominant winds, in this case a northward flowing current (Monroe et al. 2007). Near shore currents transport large amounts of sediments along the coast and normally exist in equilibrium of sand deposition and erosion (Hernandez et al. 2007). The Monck Head boat launching facility runs perpendicular to the shore and bisects northward longshore drift. As moving water decreases in velocity its capacity to hold sediments in the water column decreases and sediments drop out and accumulate on the substrate (Valiela 2006). A disruption of water flow explains the sand accumulation patterns observed in this study and are indicators of change to the physical environment due to the Monck Head boat launching facility.

Map interpretations of fetch show a significantly greater distance to generate waves on the south side than in the immediate area adjacent to the boat launching facility on the north side (Figure 5). Visual observations support a difference in wave action showing the south side having significantly higher wave energy while the north side is much calmer. Wave energy is another physical difference between the north and south sides of the boat launching facility which may affect the intertidal assemblages.

ii. Littorinidae Family

Snail species of the family Littorinidae differed remarkably between the north and south sides of the Monck Head boat launching facility. A single Littorinid species dominated the high shore intertidal assemblages on each side. *Echinolittorina australis* dominated the south side, while *Littoraria scabra* dominated the north side (Figure 6). Littorinids are well-known to exhibit vertical and horizontal zonation patterns over a wide range of physical characteristics. Different species have different physiological tolerances for aspects such as wave energy, quality and quantity of food and biological interactions (Johnson & Black 1999). Studies have documented the movement of Littorinids in response to environmental factors, and they move to where their niche requirements are met (Chapman 1999). From the distinct populations of Littorinds on the north and south sides of the boat launching facility, it can be inferred that either physical or ecological characteristics are different on each side of the boat launching facility which has caused different species to reside on different sides. Wave energy plays an important role through the delivery of food and avenue for larvae dispersal (Chapman 1999). As wave energy has been impacted by the construction of the boat launching facility, this supports the premise that the Monck Head boat launching facility may have altered the adjacent intertidal sessile assemblages.

iii. Cyanophyta (Blue-Green Algae)

Only two species of blue-green algae (Division Cyanophyta) were observed over the course of this study (*Schizothrix calciloa* and *Calothrix* sp.), and both were only found on the south side of the Monck Head boat launching facility (Figure 8). This distribution indicates that physical or ecological differences exist between sides of the boat launching facility and foster the growth of separate algal communities. *Calothrix* sp. was filamentous and very flexible which are strategies to allow algae to cope with wave action (Underwood & Chapman 2005). *S. calcicola* formed a mat adjacent to the substrate which also reduces the probability of removal from the substrate from waves by reducing the impacted surface area. Both species have strategies to cope with high wave energy which would allow them to dominate areas with high wave action over other species which are more susceptible to removal from the substrate. There may be other physiological, ecological or physical characteristics which influence the distribution pattern of blue-green algae, but because there are differences between sides of the boat launching facility, it can be inferred that the boat launching facility is the source of the physical conditions.

iv. Sargassum ligulatum

Differences in abundance of *S. ligulatum* between north and south sides of the Monck Head boat launching facility were significant. *S. ligulatum* dominated the sessile assemblage on the north side of the boat launching facility and was found in patches with much larger areas. This distribution pattern could be attributed to a difference in wave energy between sides. Waves are a form of disturbance and physically remove algae from the substrate as well as alter the physical conditions through changes in light, water movement, oxygen, and sediment and nutrient availability (Wernberg & Connell 2008). Areas with more wave energy will have more drag forces to dislodge patches of algae. More wave energy for dislodgement may be the cause for *S. ligulatum* being less abundant on the south side of the boat launching facility.

Another hypothesis is that *S. ligulatum* can out-compete other organisms, such as corals, under conditions of higher turbidity. Uman et al. (1998) observed an increase in percent cover of *Sargassum* sp. where sedimentation was high effects of sedimentation were found to be indirect on *Sargassum* sp. either from hard corals dying and leaving more available substrate to colonize or less grazing pressure from herbivorous fish. Increased sedimentation was a probable result after the construction of the boat launching facility and may have caused coral die off. Coral die-off is impossible to determine without an intertidal survey being completed before construction commenced. The boat launching facility has altered wave energy patterns and this supports the hypothesis that larger canopies of *S. ligulatum* are able to persist on the north and calmer side of the boat launching facility. In either case, the distinct difference in *S. ligulatum* abundance between north and south sides of the boat launching facility indicates that different physical or ecological characteristics are shaping distribution patterns of marine algae. These differences can be attributed to probable sediment and water flow alterations from the construction of the Monck Head boat launching facility.

V. Conclusion

i. Monck Head Boat Launching Facility Impacts and Implications for the DPI

In 2007, the DPI decided to construct a rock causeway instead of a piled bridge to connect to the boat launching facility off shore. The largest difference between the rock causeway and piled bridge is a disruption of water flow along the coast. Local physical processes of water flow, sedimentation and wave energy appear to be affected by the Monck Head boat launching facility. The boat launching facility bisects northward longshore drift causing suspended sediments to accumulate on the south side and severe erosion on the north side. Fetch is also impacted, with a much smaller distance to generate waves on the north side which results in less wave energy than the south side. Species composition of sessile organisms on the intertidal platform is remarkably different between sides especially in regards to Littorinids and algae assemblages. It is highly likely that these distribution patterns are a result of altered local physical processes from the boat launching facility. One can then infer that the construction of the Monck Head boat launching facility as a rock causeway has caused changes to the adjacent marine ecosystems. Alteration to the natural sessile assemblages is a serious effect to consider because the town of Coral Bay is highly reliant on the tourism provided by the Ningaloo Marine Park. The DPI should therefore commence the alterations of the rock causeway to the piled bridge as soon as possible to return water flow patterns to previous states and sustain the adjacent marine assemblages in their natural state.

ii. Further Study

This study provides insight into differences in sessile assemblages on both sides of the Monck Head boat launching facility, and general differences in local physical processes of water flow, sedimentation and wave energy resulting from construction of this facility. Other possible ecological effects were not explored, such as competition, predation and inter-species interactions. Further studies on ecological topics would provide more information on the cause and effect of the boat launching facility on adjacent intertidal assemblages. It would also be beneficial to isolate specific groups of organisms such as the Littorinids or one of the algae species which showed significant distribution differences and perform more detailed spatial observations. Because of the high variability in the topography of the limestone platform there are many microhabitats which may skew abundance data, and taking note of quadrats in these areas would provide another viewpoint of species distribution. Continued studies on species composition and abundance over the next few years would be extremely informative in addressing whether ecosystems continue to change if the boat launching facility remains as it is, and also how they respond if the piled bridge is constructed.

VI. References

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VII. Appendices

Taxonomic Level	Species	% cover North	% cover South
	<u>Algae</u>		
Division	**Rhodophyta (Red Algae)**		
	Chondrophycus papillosa	0.01816	0.47325
	Cottoniella filamentosa	1.089	0
Division	**Heterokontophyta (Brown Algae)**		
	*Dictyota sp.****	1.18	0.597
	*Dictyota ciliolata****		
	*Dictyota friabilis****		
	*Canistrocarpus cervicornis****		
	Turbinaria ornate	1.34	2.28
	Turbinaria gracilis	0.78	0.29
	Sargassum ligulatum	10.46	2.51
	Lobophora variegate	0.29	0.041
Division	**Chlorophyta (Green Algae)**		
Division	**Cyanophyta (Blue-green Algae)**		
	Calothrix sp.	0	2.53
	Schizothrix calicola	0	0.021
Phylum	**<u>Mollusca</u>**		
	Acanthopleura spinosa	0.036	0
	*Pyrene bidentata***	0	0.021
	*Cerithium tenellum***	0.036	0
	Siphonaria zelandica	0.29	0.185
	Xenostrous pulex	0.635	0.144
Family	Tridacnidae	0.018	0.247
	Saccostrea cucculata	0.145	0.535
	Nerita undata	0.018	0.021
Family	**Littorinidae**		
	Nodilittorina unifasciata	0.036	0.144
	Nodilittorina pyramidalis	0.02	0.33
	Littoraria scabra	0.363	0
	Echinolittorina australis	0.29	1.296
Phylum	**<u>Cnidarians</u>**		
Genus	Acropora*	0	0.41
Family	Poritidae	0.49	0.041
Family	Pocilloporidae	0.454	0.638
Family	Favidae	0.472	0.309
Phylum	**<u>Echinoderms</u>**		
	*Holothuria atra**	0.109	0
	Echinometra mathaei	0.018	0.123

*	These species were observed out side of quadrats on both sides.
**	Only one individual of these species was observed, so no conclusions can be drawn about their distribution.
***	I recorded these three species as Dictyota and upon further identification later found out they were three different species.

Table 1. Complete Species List of all organisms observed over sample area.