Northern Territory Government

Monitoring for
Marine Pests

GOVE HARBOUR, GROOTE EYLANDT AND MELVILLE ISLAND

2008–2009 Report

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DEPARTMENT OF **RESOURCES**

Monitoring for Marine Pests

Gove Harbour, Groote Eylandt and Melville Island

2008-09 Report

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INTRODUCTION

There has been increasing public awareness of introduced marine pest species in the wake of various potential and actual outbreaks of invasive plant and animal species in Australian and international marine environments. This has created an urgent need for tackling the rapidly growing problem of exotic species entering our waterways.

An introduced species is not native to a region to which it has been introduced inadvertently or intentionally. The term ‘introduced species’ is often used interchangeably with various others, including exotic, non-indigenous, non-native or alien species (Ray 2005). The introduction of such species is perceived to be a threat to both terrestrial and marine biodiversity (Hewitt 2002; Tan and Morton 2006).

An ‘invasive species’ is an introduced species that has the potential to cause damage, which could be economic, environmental, health-related or a combination of these (Ray 2005). Geographic boundaries, such as mountain ranges and ocean basins, acted as natural barriers in the past, preventing the spread of many species. Australia’s isolated location once provided a natural quarantine against the introduction of exotic plants and animals (MacIsaac et al. 2001). However, an increase in commercial and recreational vessel traffic into and out of international ports now enables pest species to establish outside of their natural range (Gunasekera et al. 2005).

Means of Introduction

There is at least one introduced marine species present in all the coastal bioregions of Australia (Hewitt 2002). Over 130 non-native species are known to have established in Australian waters (Hayes et al. 2005). Such species have been introduced to Australian waters or translocated to new areas of Australia by a number of vectors. Two major vectors are ballast water and biofouling on commercial, recreational and illegal foreign fishing vessels. Other vectors may include the movement of marine equipment or infrastructure, translocation of species for aquaculture, intentional or accidental releases into waterways and movement of species across floodplains from one system to another after heavy rains (Gunasekera et al. 2005; Hewitt and Martin 2001; Russel et al. 2003; The Senate Committee Report 2004).

Shipping ports are considered a main entry point for invasive species, particularly due to the large quantities of ballast water that are picked up and discharged in such areas (The Senate Committee Report 2004). In Victoria’s Port Phillip Bay alone, an estimated three or more new species are establishing each year (Hewitt et al. 2004). As highly disturbed regions are more prone to invasion from pests, ports are very susceptible to incursions from such species (Paulay et al. 2002). Marinas can also act as habitat islands to support assemblages that are distinct from neighbouring communities (Glasby 1999). If these assemblages are formed from constituents of local native populations, there is no need for major concern. However, marinas have the potential to function as entry points for exotic species via fouling on commercial and recreational craft. From there, marinas are able to provide a network of suitable habitat for the continued spread of a species through domestic vessel activity (Ashton et al. 2006).

Impacts of Invasive Species

Biological invasions threaten natural ecosystems at all scales, from the genetic level to the entire population. The introduction of new viruses and diseases, displacement of native species, potential homogenisation of assemblages and adverse alteration of the physical structure of an ecosystem are all potential outcomes of introduced species (Hewitt and Martin 2001; Ray 2005).

With the steady rise of introduced plants and animals, a decline in the number and abundance of native species is a major concern. Many pest species possess advantageous competitive qualities, such as high fecundities, high growth rates and flexible habitat requirements allowing them to out-compete native species for resources, such as food, light, and habitat (Pimentel et al. 2000; Ray, 2005; The Senate Committee Report, 2004). A loss of, or reduction in, native species may also occur due to predation by introduced species. This is evident in the case of the northern Pacific sea star (*Asterias amurensis*), which was introduced to southern Tasmanian and Victorian waters in the 1980s (Deagle et al. 2003). *A. amurensis* is a voracious generalist predator in soft sediment habitats and is considered a major threat to benthic communities and in particular to commercial bivalves (Ross et al. 2002).

All of these outcomes lead to a less diverse ecological community, which in turn can threaten income derived from aquaculture, commercial and recreational fishing, and tourism. In the United States, approximately 50 000 introduced terrestrial and marine species, and introduced pathogens and diseases, were estimated to cause environmental damage and losses of $US137 billion per year (Pimental et al. 2000). In Australia, marine pests pose a substantial threat to the mariculture industry, which is worth over $AU600 million per year (The Senate Committee Report 2004). In New Zealand, the invasive colonial ascidian *Didemnum vexillum* has become a significant fouling pest on mussel farms, threatening aquaculture (Denny 2008). However, the costs associated with invasive pest species are not solely restricted to these industries. Tourism, shipping and port infrastructure, coastal amenities, human and environmental health, all have the potential to be adversely affected by invading pest species (The Senate Committee Report 2004).

The Northern Territory (NT) Perspective

Although tropical regions have often been considered fairly resilient to introduced species, there is growing evidence to suggest that communities in such areas are not immune to invasion (Hewitt 2002; Pauley et al. 2002; Russel et al. *2*003). In particular, highly disturbed habitats are known to be very susceptible to invasive species (Paulay et al. 2002). This is particularly true when such habitats are additionally subjected to either a high influx of exotic species or vectors of such species as happens in man-made marinas (Bax et al. 2002).

In July 2001, the Australian Quarantine and Inspection Service introduced the Ballast Water Decision Support System (DSS) as part of border control protocols. The DSS was designed to assist in managing the marine pest risk from ballast water. As a basis for the DSS, primary ports of Australia, including Darwin Harbour, were surveyed to obtain baseline information on established marine communities.

The Port of Darwin was surveyed in the dry season in August 1998 and in the wet season in March 1999. In the March 1999 survey, black-striped mussel (*Mytilopsis sallei*), a bivalve native of Central America, was detected in Cullen Bay Marina at densities up to 23 650 individuals/m^2 (Bax et al. 2002). A few days later, the mussel was also found in Tipperary Waters Marina and on the hull of a yacht in Frances Bay Mooring Basin. Considering it was not present during the dry season survey, just six months earlier, the mussel displayed potential for an extremely rapid growth in marina environments posing a significant environmental and economic threat.

The fortunate early detection of the black-striped mussel led to a swift response by the NT Government. Within three days of detection, emergency management teams were convened and the three marinas were quarantined to prevent further spread of the mussel. Laboratory and field trials were conducted to determine a suitable treatment, which resulted in the use of copper sulphate and sodium hypochlorite to destroy the pest in the marinas. In 28 days and at a cost of over $2.2 million, the black-striped mussel was successfully eradicated.

Due to the proximity of Darwin to Asian ports and its use as a first port of call into Australia by many visiting vessels, the risk of possible introductions of invasive marine pests is considered high. As a direct result of the black-striped mussel invasion, the Aquatic Biosecurity unit was established in the then Department of Regional Development, Primary Industry, Fisheries and Resources. It regularly monitors the marine fouling communities of the NT coastline, enabling early detection of new marine pest species.

This report describes the composition of marine fouling assemblages recorded during regular monitoring over a 12-month period in three coastal locations of the NT: Gove Harbour in Melville Bay, Milner Bay at Groote Eylandt and Garden Point on Melville Island.

MATERIALS AND METHODS

Locations

Gove Harbour

Gove Harbour lies in Melville Bay on the north eastern coast of Arnhem Land; it is approximately 11 km long and 10 km wide (Peerzada et al. 1990). From November to April, northwest monsoons prevail and the harbour receives a large amount of freshwater input due to high rainfall and terrestrial runoff. In the dry season from April to October, cooler ambient temperatures with southeast trade winds are experienced. Mining of bauxite commenced in 1971 on the shores of Gove, leading to increased vessel traffic in and out of the harbour.

With the assistance of Rio Tinto/Alcan staff, monitoring commenced at three sites (Cargo wharf, Export wharf, and Fuel wharf) within Gove Harbour in October 2004 (Figure 1). In March 2008, the collection of samples for analysis ceased from the Fuel Wharf site due to recurring damage from prevailing environmental conditions.

Milner Bay, Groote Eylandt

A manganese mine and an ore export facility were constructed by BHP at Milner Bay in 1966, resulting in increased shipping traffic to Groote Eylandt (Harris and O'Brien 1998). Temperature and salinity measured in March and November in the Gulf of Carpentaria ranged between 23.1^{o}C and 29.9^{o}C and from 31.6 ppt to 33.8 ppt, respectively. There is a net flow towards the north at the Milner Bay wharf, during both the wet and the dry seasons, with tides exhibiting a diurnal cycle with a maximum range of 1.2 m (Harris and O'Brien, 1998).

Marine pest monitoring commenced in November 2003 at Groote Eylandt with the deployment of a settlement collector from the wharf at Milner Bay by the Groote Eylandt Mining Company (Figure 2). The wharf lies on the eastern side of Groote Eylandt, south of Connexion Channel.

Garden Point, Melville Island

Garden Point (Melville Island) is located within the Apsley Strait, which is a long channel of water separating Bathurst Island from Melville Island (together, the Tiwi Islands) (Figure 3). The direction of water flow alternates with the high and low tide, making the Apsley Strait a treacherous, high energy area (Beringer and Tapper 2002). The establishment of a forestry enterprise on Melville Island let to an increase in international and domestic shipping traffic to Garden Point. As a result, monitoring activities commenced at Garden Point in August 2004 with the support of Great Southern Plantations and the Tiwi Marine Rangers.

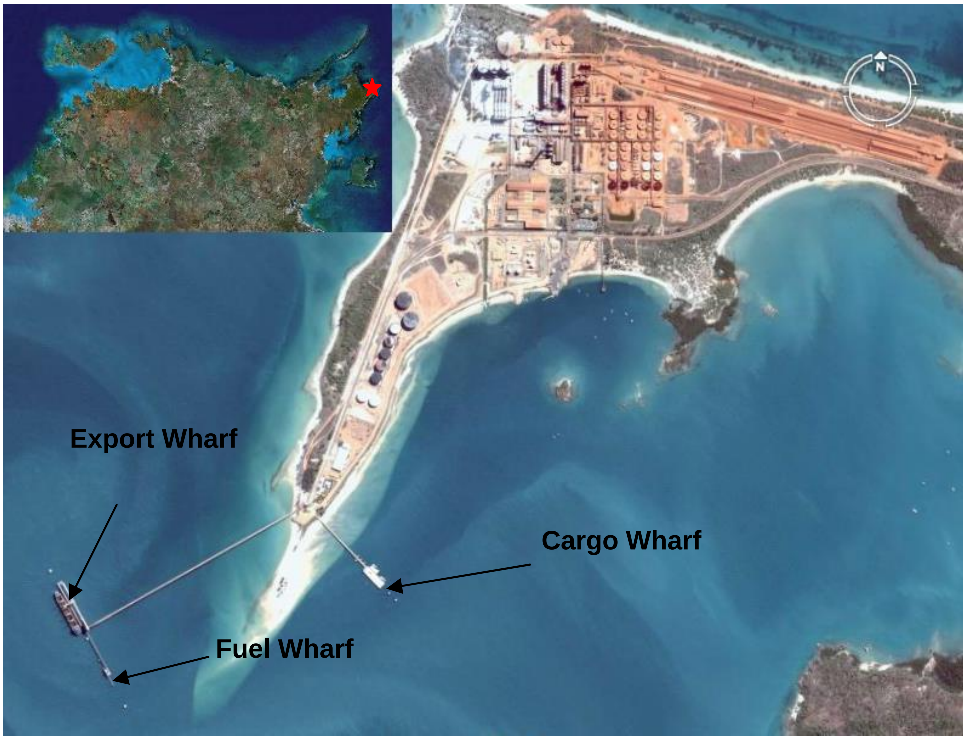


Figure 1. Aerial photograph of monitoring sites in Melville Bay, Gove Harbour

Figure 2. Aerial photograph of the monitoring site in Milner Bay, Groote Eylandt

Figure 3. Aerial photograph of the monitoring site at Garden Point, Melville Island

Settlement Collectors

The marine fouling communities at each location were sampled using settlement collectors. Each collector consisted of a rope backbone supporting horizontal pipe arms, to which artificial settlement surfaces were attached (PVC plates and rope mops) (Figure 4). The arms of the collector were two 600-mm lengths of 20-mm poly pipe, with holes drilled where settlement plates were attached with cable ties. A 600-mm (top piece) and a 300-mm (bottom piece) length of poly pipe were attached vertically to the cross piece, and a 10-mm rope was threaded through both these vertical pipes and a suitable weight was attached to the bottom of the rope. The top end of the rope was secured to an appropriate floating structure, such as a mooring buoy or pontoon. A 6-mm rope was also threaded through the horizontal arms and then secured to the 10-mm rope at the top of the settlement collector. Cable ties were attached to one side of the collector to identify each side as either 'tagged' or 'untagged'.

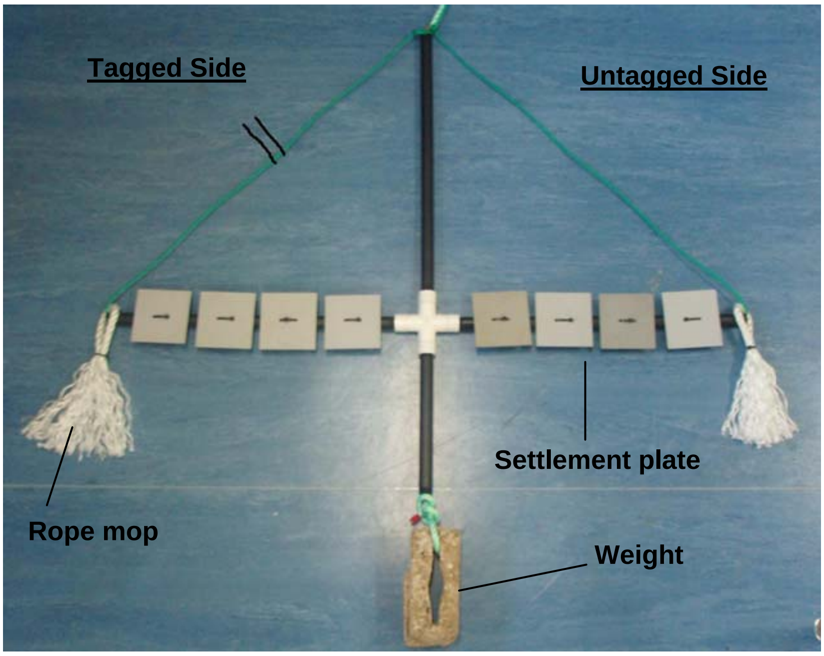


Figure 4. A settlement collector used to sample fouling organisms and detect marine pests

Deployment and Collection Schedule

A settlement collector was secured to the wharf or other suitable structure at each site and attached in such a way as to allow the device to move vertically with the tides whilst maintaining the settlement plates at a depth of approximately 2.5 m. For the first month, only the tagged side of the collector was fitted with four settlement plates and a rope mop. Inspections of the surfaces were carried out on a monthly basis. Monthly inspections involved recording a brief description of fouling organisms growing on the plates and within the rope mop, and photographing the plates (front and back) and rope mop using a digital camera. It was also noted whether or not any marine pests were present on the settlement surfaces.

After three months, settlement plates and a rope mop were fixed to the untagged side and similar monthly inspections were conducted. After four months of deployment, the plates were collected from the tagged side only. This arrangement allowed for two concurrent sampling regimes (one for each side of the settlement collector). Artificial settlement surfaces were left in the water for four months; however, a one-month overlap in deployment periods resulted in a quarterly collection regime (Table 1).

Following collection, settlement plates and rope mops were chilled and transported from Gove Harbour and Groote Eylandt to Darwin, arriving within a day of collection (no settlement plates were collected from the Melville Island site between May 2008 and June 2009 due to access issues and damage to the settlement collector). Both sides of each plate were photographed in the laboratory, the wet weights of each settlement plate were recorded and the plates and rope mops were inspected for known marine pest species before preserving the settlement plates in 70% ethanol for later analysis of the fouling communities.

Fouling Community Analysis

Analysis of the fouling communities on each settlement plate comprised three assessments: taxonomic frequency, species diversity and biomass.

Fouling biomass

The wet weight of each settlement plate was recorded prior to analysis. Following analysis, the plates were cleaned of fouling organisms and re-weighed to determine the wet biomass of biofouling on each settlement plate.

Taxonomic frequency

The percentage frequency of occurrence of individual taxonomic groups on each side of the settlement plates was assessed by recording the presence/absence of each taxonomic group (or bare space) in a series of regularly-spaced squares (frequency assessment grid) placed over the plate (Committee CH-003, 2004). The frequency assessment grid comprised 25, 5 x 5 mm squares. The total number of 'presence' scores for each taxonomic group represented the frequency of occurrence of that group. Following this assessment, any taxons present that remained unrecorded were given a score of one in order to record their presence. Frequencies of occurrence were then converted to a percentage.

This method of assessment allowed for the recording of species which may have been grown over by other species. As a result, the sum of all taxon abundances may be greater than 100%.

The biofouling taxonomic groups of interest were algae, ascidians, barnacles, hydroids, molluscs, polychaetes, sponges, tube forming amphipods and others. Areas remaining un-fouled (bare space) were also recorded.

Species diversity

Recognised marine pests are most often species in the ascidian (chordata), barnacle (crustacea), bivalve (mollusca), bryozoan and polychaete (annelida) taxonomic groups. Organisms observed on settlement plates from these groups were identified and recorded to species level. Species from lower risk taxonomic groups (such as algae, hydroids, and sponges) were not identified or recorded.

RESULTS

Marine Pest Observations

No known marine pest species were observed on artificial settlement surfaces collected from Gove Harbour, Groote Eylandt, or Melville Island in the past 12 months of monitoring. Representative photographs of the fouling communities that developed on settlement plates from Gove Harbour and Groote Eylandt sites are shown in Appendices A, B, and C.

Collection Schedule

Settlement surfaces were collected on slightly differing schedules between the three locations, as shown in Table 1. All inspections and collection of settlement surfaces at the two Gove Harbour sites went according to schedule. The majority of inspections at the Groote Eylandt site also went according to schedule apart from during July and December 2008 when wharf access issues prevented an inspection from taking place. Settlement surfaces were intended to be collected from the untagged side of the collector in December 2008. Instead, this took place one month later in January 2009. These settlement surfaces were still inspected for marine pests and a species list was compiled. However, as they were deployed for an extra month no quantitative analysis of fouling biomass or frequency of occurrence of each taxonomic group was recorded.

There were various issues with inspections and collections of settlement surfaces at the Melville Island site, including the loss of the settlement collector and the entire structure to which it was attached. The settlement collector was not reinstalled until May 2009. Hence, there is no fouling assemblage data or photographs of settlement plates for this report. No inspection took place in June 2009; however, the settlement collector is currently deployed and in good working condition.

Table 1. Chronology of settlement surface collection at Gove Harbour between June 2008 and July 2009; Groote Eylandt between May 2008 and June 2009; and Melville Island between May 2008 and June 2009

Location		Month	Date	Tagged side	Untagged side
Gove Harbour	2008	June	16th	Surfaces attached to collector	Surfaces inspected and photographed
		July	18th	Surfaces inspected and photographed	Surfaces collected
		Aug	28th	Surfaces inspected and photographed	No surfaces attached
		Sept	20th	Surfaces inspected and photographed	Surfaces attached to collector
		Oct	7th	Surfaces collected	Surfaces inspected and photographed
		Nov	16th	No surfaces attached	Surfaces inspected and photographed
		Dec	12th	Surfaces attached to collector	Surfaces inspected and photographed
	2009	Jan	18th	Surfaces inspected and photographed	Surfaces collected
		Feb	12th	Surfaces inspected and photographed	No surfaces attached
		Mar	24th	Surfaces inspected and photographed	Surfaces attached to collector
		April	15th	Surfaces collected	Surfaces inspected and photographed
		May	19th	No surfaces attached	Surfaces inspected and photographed
		June	12th	Surfaces attached to collector	Surfaces inspected and photographed
		July	21st	Surfaces inspected and photographed	Surfaces collected
Groote Eylandt	2008	May	16th	Surfaces attached to collector	Surfaces inspected and photographed
		June	13th	Surfaces inspected and photographed	Surfaces collected
		July	-	No inspection or photographs	No surfaces attached
		Aug	18th	Surfaces inspected and photographed	Surfaces attached to collector
		Sept	29th	Surfaces collected but went missing in transit, therefore no quantitative analysis	Surfaces Inspected and photographed
		Oct	30th	No surfaces attached	Surfaces inspected and photographed
		Nov	19th	Surfaces attached to collector	Surfaces inspected and photographed
		Dec	-	No inspection due to wharf access issues	No collection due to wharf access issues

	2009	Jan	20th	Surfaces inspected and photographed	Surfaces collected (one month late)
		Feb	11th	Surfaces inspected and photographed	Surfaces attached to collector
		Mar	11th	Surfaces collected	Surfaces inspected and photographed
		April	17th	No surfaces attached	Surfaces inspected and photographed
		May	21st	Surfaces attached to collector	Surfaces inspected and photographed
		June	11th	Surfaces inspected and photographed	Surfaces collected
Melville Island	2008	May	-	No surfaces able to be attached	No inspection
		June	6th	Surfaces attached (one month late)	No surfaces collected
		July	18th	Surfaces inspected and photographed	Surfaces collected (one month late)
		Aug	-	No inspection	No surfaces able to be attached
		Sep	5th	Surfaces inspected and photographed	Surfaces attached to collector (one month late)
		Oct	-	Settlement collector missing	Settlement collector missing
		Nov	-	-	-
		Dec	-	-	-
	2009	Jan	-	-	-
		Feb	-	-	-
		Mar		-	-
		April	-	-	-
		May	7th?	Settlement collector reinstalled	Settlement collector reinstalled
		June	-	No inspection or photographs	No inspection or photographs

Fouling Community Analysis

Fouling biomass

On average, the biomass of marine fouling organisms was highest at the two Gove Harbour sites: Cargo wharf and Export wharf (Figure 5). The highest amount of fouling biomass was recorded at the Export wharf site between December 2008 and March 2009 (denoted by the April 2009 collection). At this site, average biomass ranged between 17 g and 202 g and was higher over the wet season periods (January 2009 and April 2009 collections) compared with the dry season months (October 2008 and July 2009 collections). Similarly, at the Cargo wharf site, average fouling biomass was higher over the wet season period; however, the highest recording was between September 2008 and December 2008 (January 2009 collection). At this site, the average fouling biomass ranged between 12 g and 147 g (Figure 5).

For the two collections of settlement surfaces at the Groote Eylandt site, average biomass of fouling organisms was very low. Between November 2008 and February 2009 (March 2009 collection) the mean biomass was 16 g and for the February 2009 to May 2009 period (June 2009 collection), the average was just 10 g (Figure 5).

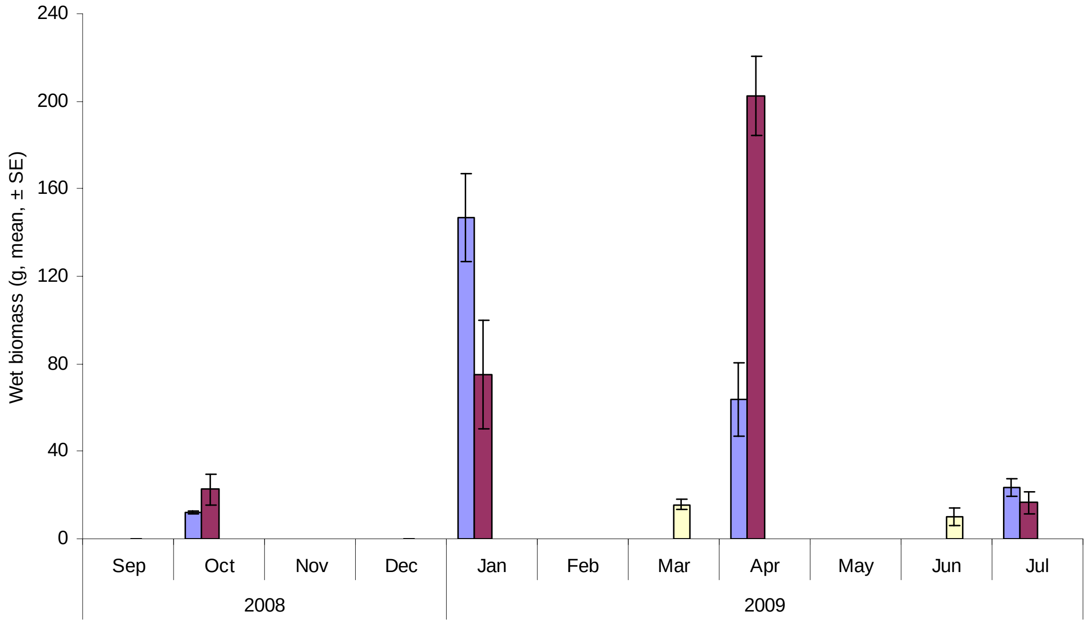
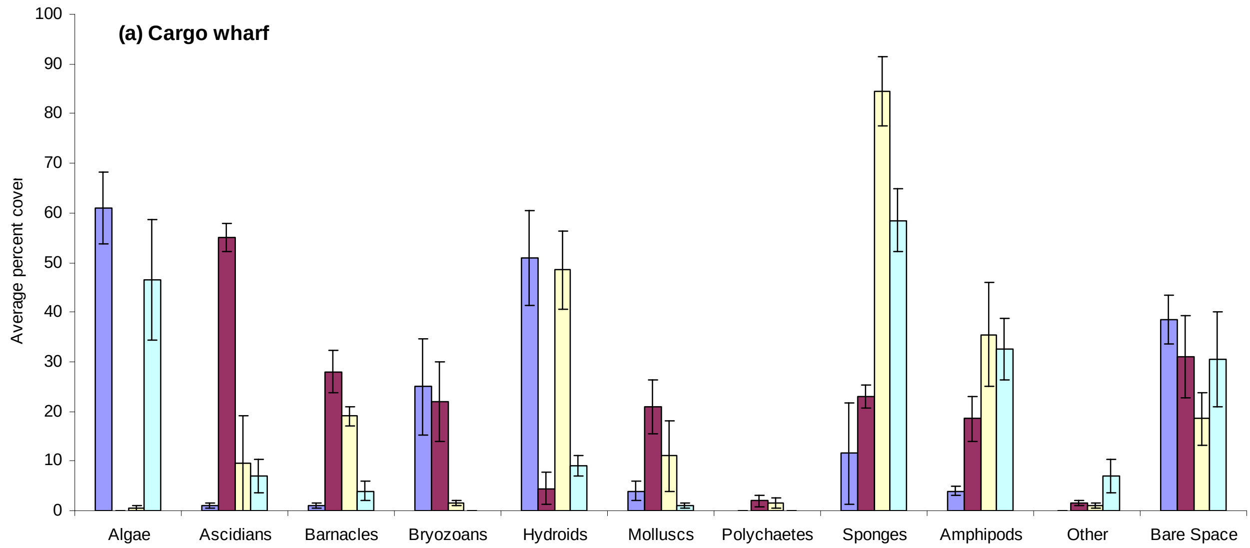


Figure 5. Wet biomass (g) mean ± standard error of bio-fouling recorded on settlement plates from sites at Groote Eylandt ( ) and Gove Harbour [Cargo wharf ( ) and Export wharf ( )] over sampling periods during 2008-2009

Taxonomic frequency

The average percent frequency of occurrence of each fouling taxonomic group recorded from the Cargo wharf and Export wharf sites are shown in Figure 6. All common fouling taxonomic groups were represented on the settlement plates in at least one of the collection periods. The dominant groups at Cargo wharf were sponges, algae, ascidians, hydroids and tube forming amphipods, with a maximum frequency of occurrence of 85%, 61%, 55%, 51%, and 36% respectively (Figure 6a). The frequency of occurrence for all of these taxonomic groups fluctuated considerably between each of the sampling periods.

The dominant fouling taxonomic groups at the Export wharf site were sponges, barnacles, tube forming, amphipods, hydroids and ascidians, consisting of a maximum frequency of occurrence of 69%, 58%, 54%, 42%, and 34% respectively (Figure 6b). Sponges tended to be present in high frequencies across all four sampling periods; however, similar to the Cargo wharf site, the mean frequency of occurrence of the other dominant taxonomic groups varied a great deal across the sampling periods.



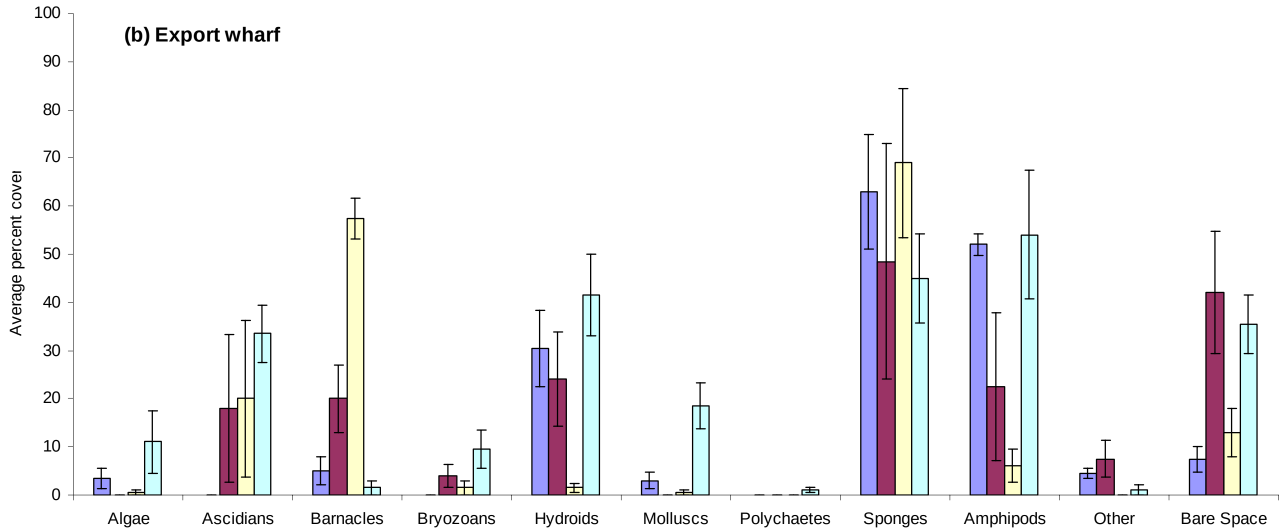


Figure 6. Percent frequency of occurrence (mean ± standard error) of each taxonomic group recorded on settlement plates and of the area remaining unfouled; from (a) Cargo wharf and (b) Export wharf sites in Gove Harbour over four sampling periods: October 2008 ( ), January 2009 ( ), April 2009 ( ) and July 2009 ( )

At the Groote Eylandt site, all common taxonomic groups except bryozoans and polychaete tubeworms were represented across the two sampling periods (Figure 7). Hydroids, sponges and ascidians were the dominant groups, with a maximum frequency of occurrence of 59%, 46%, and 44% respectively. With the exception of ascidians, there was again a considerable fluctuation in frequency of occurrence of each group between the two collection periods. For example, a 46% cover of sponges was recorded on plates collected in March 2009, but sponges were then absent from plates collected in June 2009.

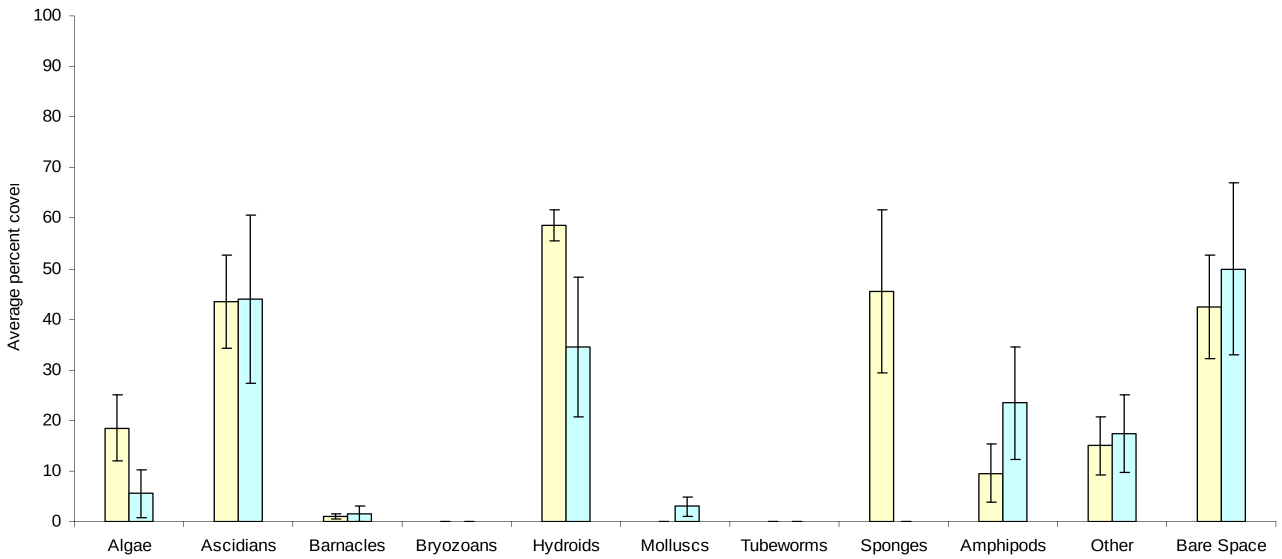


Figure 7. Percentage frequency of occurrence (mean ± standard error) of each taxonomic group recorded on settlement plates and of the area remaining unfouled; from Milner Bay, Groote Eylandt, over two sampling periods: March 2009 ( ) and June 2009 ( )

Species diversity

The largest number of species (from the selected taxonomic groups) on settlement surfaces was recorded at both the Groote Eylandt site between August 2008 and November 2008 (denoted by the December 2008 collection) and at the Cargo wharf site in Gove Harbour between March 2009 and June 2009 (July 2009 collection) where 15 species were identified (Figure 8).

In Gove Harbour, higher species diversity was recorded on settlement surfaces collected from the Cargo wharf site compared with the Export wharf site across all collection periods. At the Cargo wharf site the number of species present ranged between 10 and 15 and at the Export wharf site between five and eight (Figure 8). Species diversity at both sites remained fairly constant throughout the year.

At the Groote Eylandt site there was more noticeable variation within species diversity, ranging between five species present on settlement surfaces between November 2008 and February 2009 (March 2009 collection) and 15 species between August 2008 and November 2008 (December 2008 collection).

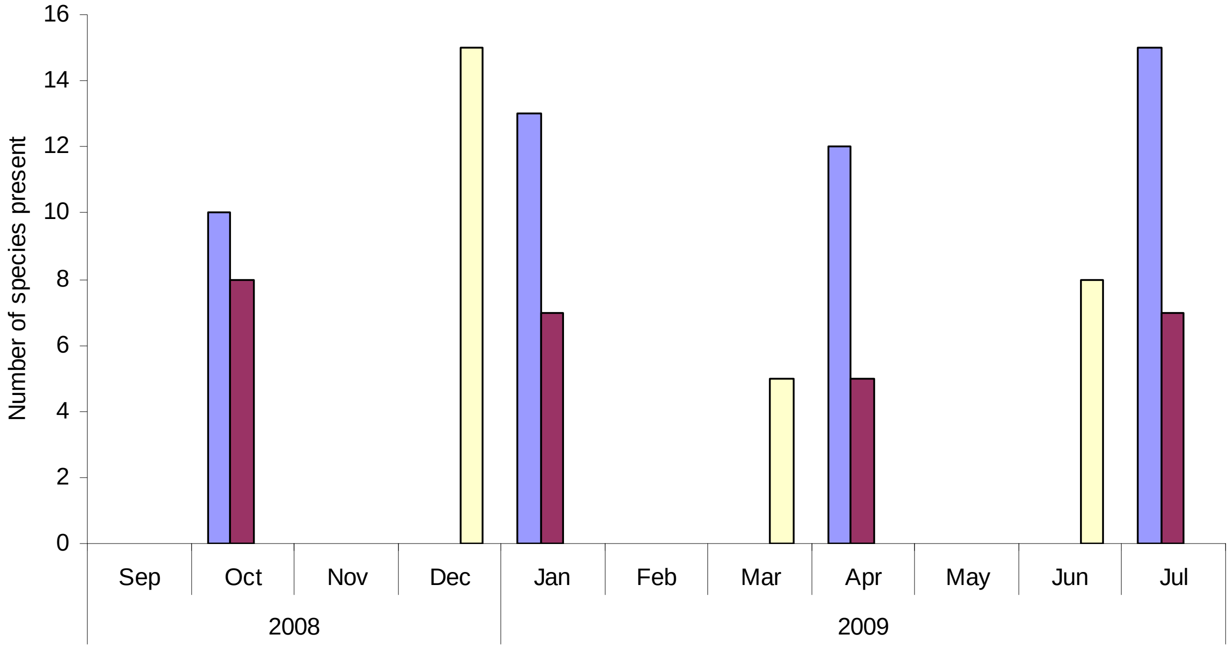


Figure 8. Number of species (within specific taxonomic groups) recorded on settlement surfaces from Groote Eylandt ( ) and Gove Harbour [Cargo wharf ( ) and Export wharf ( )] over sampling periods during 2008-2009

Table 2. Species (from specific taxonomic groups) observed on settlement surfaces collected from sites at Cargo wharf and Export wharf in Gove Harbour from June 2008 to July 2009

Gove - Cargo wharf								08	09		
Kingdom	Phylum	Subphylum	Class	Family	Taxa	Species No.	Scientific name	Oct	Jan	Apr	Jul
Animalia											
	Chordata										
			Ascidiacea		**Ascidians**						
						Spp. 2				✓	✓
						Spp. 4		✓	✓		✓
						Spp. 10			✓	✓	✓
						Spp. 16			✓	✓	✓
						Spp. 23		✓			
	Arthropoda										
		Crustacea									
			Cirripedia		**Barnacles**						
						Spp. 2	*Amphibalanus variegatus*				✓
						Spp. 6	*Striatobalanus amaryllis*		✓	✓	✓
						Spp. 7	*Amphibalanus zhujiangensis*	✓	✓	✓	✓
	Mollusca				**Bivalves**						
			Bivalvia								
				Pteriidae		Spp. 1	*Planostrea pestigris*	✓	✓	✓	✓
				(Oysters)		Spp. 3	*Stiostrea mytiloides*		✓	✓	
						Spp. 5	*Electroma papilionacea*		✓		
						Spp. 12	*Saccostrea cucullata*			✓	
	Bryozoa				**Bryozoans**						
						Spp. 9					✓
						Spp. 13		✓			✓
						Spp. 15		✓	✓	✓	
						Spp. 20		✓			
						Spp. 21	*Savignyella lafontii*	✓	✓	✓	✓
						Spp. 31	*Watersipora subtorquata*	✓			
						Spp. 34	*Parasimttina* sp.			✓	
						Spp. 41	*Schizoporella errata*	✓	✓		✓
	Annelida										
			Polychaeta		**Polychaetes**						
						Spp. 4	*Ficopomatus uschakovi*		✓		✓
						Spp. 16	*Branchiomma boholense*		✓		
						Spp. 17	*Demonax sp.*				✓
						Spp. 18	*Hydroides minax*			✓	✓
							Total species observed	10	13	12	15

Gove - Export wharf								08	09		
Kingdom	Phylum	Subphylum	Class	Family	Taxa	Species No.	Scientific name	Oct	Jan	Apr	Jul
Animalia											
	Chordata										
			Ascidiacea		**Ascidians**						
						Spp. 2			✓	✓	✓
	Arthropoda										
		Crustacea									
			Cirripedia		**Barnacles**						
						Spp. 1	*Amphibalanus amphitrite*				✓
						Spp. 2	*Amphibalanus variegatus*	✓	✓		✓
						Spp. 5	*Amphibalanus reticulatus*	✓		✓	
						Spp. 6	*Striatobalanus amaryllis*	✓	✓	✓	
						Spp. 7	*Amphibalanus zhujiangensis*	✓	✓		✓
	Mollusca										
			Bivalvia		**Bivalves**						
				Pteriidae		Spp. 1	*Planostrea pestigris*	✓		✓	✓
				(Oysters)		Spp. 10	*Electroma physoides*	✓			
						Spp. 18	*Pteria chinensis*	✓			
	Bryozoa				**Bryozoans**						
						Spp. 14	*Scrupocellaria* sp.		✓		
						Spp. 15		✓	✓	✓	✓
						Spp. 21	*Savignyella lafontii*		✓		
	Annelida										
			Polychaeta		**Polychaetes**						
						Spp. 17	*Demonax sp.*				✓
							Total species observed	8	7	5	7

Table 3. Species (from specific taxonomic groups) observed on settlement surfaces collected from Milner Bay, Groote Eylandt between May 2008 and June 2009

Groote Eylandt								08		09	
Kingdom	Phylum	Subphylum	Class	Family	Taxa	Species No.	Scientific name	Sep	Dec	Mar	Jun
Animalia											
	Chordata										
			Ascidiacea		**Ascidians**						
						Spp. 1		-	✓	✓	✓
						Spp. 2		-	✓	✓	✓
						Spp. 6		-			✓
						Spp. 10		-	✓	✓	✓
						Spp. 16		-	✓		✓
						Spp. 17		-	✓		
	Arthropoda										
		Crustacea									
			Cirripedia		**Barnacle**						
						Spp. 1	*Amphibalanus amphitrite*	-	✓	✓	
						Spp. 2	*Amphibalanus variegatus*	-	✓		
						Spp. 6	*Striatobalanus amaryllis*	-	✓		
						Spp. 7	*Amphibalanus zhujiangensir*	-	✓	✓	✓
	Mollusca										
			Bivalvia		**Bivalve**						
				Pteriidae		Spp. 1	*Planostrea pestigris*	-	✓		
				(Oysters)		Spp. 4	*Dendostrea sandvichensis*	-	✓		
						Spp. 5	*Electroma papilionacea*	-	✓		
						Spp. 12	*Saccostrea cucullata*	-	✓		✓
						Spp. 21	*Pinctada maxima*	-			✓
	Bryozoa				**Bryozoan**						
						Spp. 15		-	✓		
						Spp. 49		-	✓		
							Total species observed	-	15	5	8

DISCUSSION

No recognised marine pest species were observed on artificial settlement surfaces collected from Gove Harbour and Groote Eylandt in the past 12 months of monitoring. Due to limited taxonomic resources, it has not been possible to identify all fouling organisms to a genus or species level. It is also uncertain whether all species recorded on settlement plates are native to the region where they were observed. This is in part due to some species being cryptogenic, making it unclear if they have been introduced or not. Secondly, the taxonomic knowledge of some tropical systems may be insufficiently advanced to aid in determining which species are introduced (Hewitt, 2002). For example, little was known about the distribution of barnacles in Australian waters until the early 1990s (Jones, 2003). It therefore becomes difficult to establish if a species is indeed native to a region or had been introduced before such data was collated. However, no acknowledged marine pests were found on settlement surfaces at any of the monitoring locations and no species were observed that displayed invasive characteristics. Unfortunately, no data was available for fouling assemblages for the Melville Island site between June 2008 and June 2009 due to various complications mentioned previously. However, the settlement collector has since been reinstalled at that site and monitoring will resume as normal over the following months.

The monitoring program is intended to provide an early warning system in the event that a marine pest is introduced into NT waters. In addition to gathering information on the presence or absence of introduced species, the monitoring program also provides data on natural fouling communities, and some indication as to temporal and spatial variations found in fouling assemblages.

It is clear that fouling communities vary between sites, both in species diversity and abundance. It also appears that seasonal factors impact on the fouling assemblages at each location. At the Gove and Groote Eylandt sites, the frequency of occurrence of individual taxonomic groups varied both between locations and within locations across the collection periods. The taxonomic group dominating settlement plates also tended to change between sites and over time. At the two Gove sites, the biomass of fouling organisms developing on settlement plates also fluctuated considerably both between sites and within sites across sampling periods.

Although these variations were observed, the identification of patterns or the influences of seasonal environmental conditions on fouling communities is outside the scope of this study. A more detailed study would be required to ascertain the dominant factors contributing to the variability in fouling assemblages and to what extent each factor may impact on biofouling communities. The constraint of limited data was exacerbated at the Groote Eylandt and Melville Island sites by various problems encountered with collection of settlement surfaces.

Exotic marine organisms possess the potential to endanger the biodiversity and amenity of coastal waters. Along with the current expansion of many industries in the NT, come associated risks of the introduction of pest species through increased international and domestic maritime traffic into and out of NT ports. With this fact in mind, the Aquatic Biosecurity unit will continue to monitor the coastline for the presence of introduced species to assist in keeping NT waters free of marine pests.

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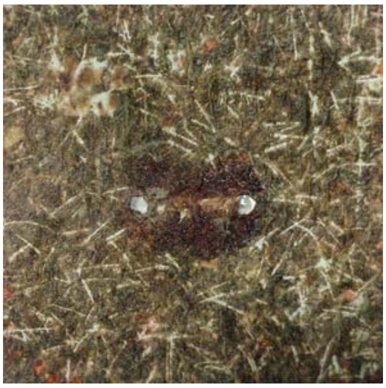
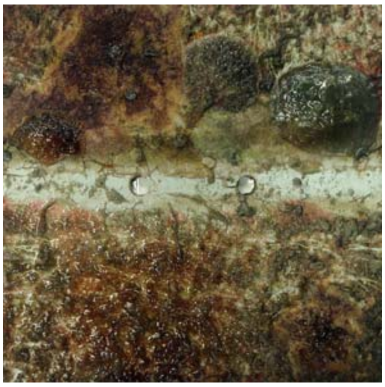
APPENDICES

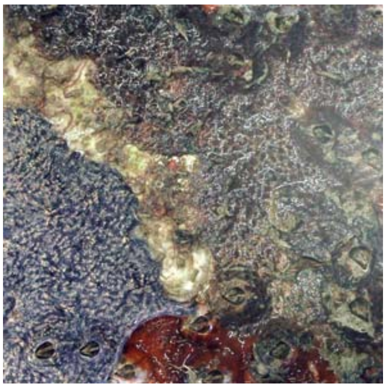
APPENDIX A: Representative photographs of biofouling communities on settlement plates collected from Cargo wharf, Gove Harbour, from June 2008 to July 2009



Oct 08 - Plate 3 (Front)

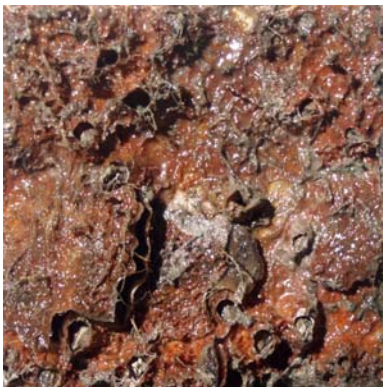


Oct 08 – Plate 2 (Rear)



Jan 09 - Plate 3 (Front)

Jan 09 – Plate 4 (Rear)



Apr 09 - Plate 4 (Front)

Apr 09 - Plate 1 (Rear)

July 09 - Plate 1 (Front)

July 09 - Plate 3 (Rear)

APPENDIX B: Representative photographs of biofouling communities on settlement plates collected from Export wharf, Gove Harbour, from June 2008 to July 2009

Oct 08 - Plate 1 (Front)

Oct 08 - Plate 3 (Rear)

Jan 09 - Plate (Front)

Jan 09 - Plate (Rear)

Apr 09 - Plate (Front)

Apr 09 - Plate (Rear)

July 09 - Plate 3 (Front)

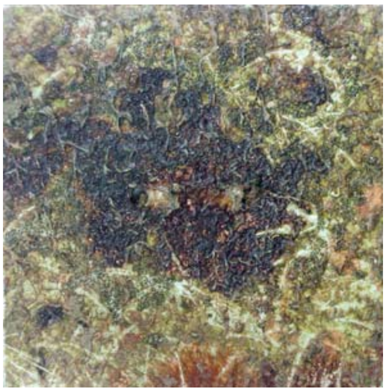
Jul 09 - Plate 1 (Rear)

APPENDIX C: Representative photographs of biofouling communities on settlement plates collected from Milner Bay, Groote Eylandt from May 2008 to June 2009

NO PHOTOGRAPHS FOR SEPTEMBER 2008

Dec 08 (Jan 09) - Plate 2 (Front)

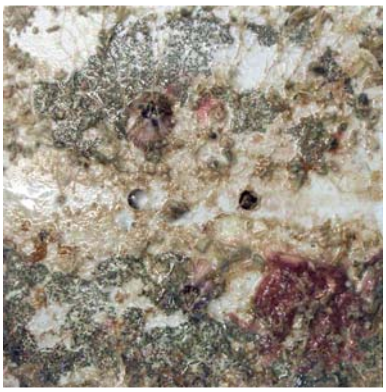
Dec 08 (Jan 09) - Plate 1 (Rear)



Mar 09 - Plate 2 (Front)

Mar 09 - Plate 4 (Rear)

June 09 - Plate 3 (Front)



June 09 - Plate 3 (Rear)

APPENDIX D: Average wet biomass (g) of biofouling communities developing on settlement surfaces from sites at Gove Harbour, Groote Eylandt, and Melville Island over four sampling periods during 2008-2009

Year	Month	Gove Harbour Cargo wharf Mean	Gove Harbour Cargo wharf SE	Gove Harbour Export wharf Mean	Gove Harbour Export wharf SE	Groote Eylandt Mean	Groote Eylandt SE	Melville Island Mean	Melville Island SE
2008	Sep					-	-	-	-
	Oct	12.13	0.82	22.58	6.95				
	Nov								
	Dec					-	-	-	-
2009	Jan	146.70	20.23	75.20	24.67				
	Feb								
	Mar					15.73	2.23	-	-
	Apr	63.75	17.03	202.20	18.08				
	May								
	Jun					10.10	4.02	-	-
	Jul	23.48	4.28	16.50	5.20				

APPENDIX E: Average frequency (%) of occurrence of each taxonomic group recorded on settlement surfaces from sites at Gove Harbour, Groote Eylandt, and Melville Island over four sampling periods during 2008-2009

Gove Harbour - Cargo wharf

	Oct-08		Jan-09		Apr-09		Jul-09	
Taxonomic group	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
Algae	61.00	7.23	0.00	0.00	0.50	0.50	46.50	12.20
Ascidians	1.00	0.58	55.00	2.89	9.50	9.50	7.00	3.32
Barnacles	1.00	0.58	28.00	4.32	19.00	1.91	4.00	2.00
Bryozoans	25.00	9.68	22.00	8.04	1.50	0.50	0.00	0.00
Hydroids	51.00	9.54	4.50	3.30	48.50	7.85	9.00	2.08
Molluscs	4.00	2.00	21.00	5.45	11.00	7.05	1.00	0.58
Polychaetes	0.00	0.00	2.00	1.15	1.50	0.96	0.00	0.00
Sponges	11.50	10.18	23.00	2.38	84.50	6.90	58.50	6.24
Amphipods	4.00	0.82	18.50	4.50	35.50	10.56	32.50	6.24
Other	0.00	0.00	1.50	0.50	1.00	0.58	7.00	3.32
Bare Space	38.50	4.92	31.00	8.27	18.50	5.32	30.50	9.60

Gove Harbour - Export wharf

	Oct-08		Jan-09		Apr-09		Jul-09	
Taxonomic group	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Algae	3.50	2.06	0.00	0.00	0.50	0.50	11.00	6.45
Ascidians	0.00	0.00	18.00	15.45	20.00	16.25	33.50	5.91
Barnacles	5.00	3.00	20.00	6.98	57.50	4.19	1.50	1.50
Bryozoans	0.00	0.00	4.00	2.45	1.50	1.50	9.50	3.86
Hydroids	30.50	7.93	24.00	9.83	1.50	0.96	41.50	8.38
Molluscs	3.00	1.73	0.00	0.00	0.50	0.50	18.50	4.79
Polychaetes	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.58
Sponges	63.00	11.90	48.50	24.54	69.00	15.44	45.00	9.33
Amphipods	52.00	2.31	22.50	15.39	6.00	3.46	54.00	13.37
Other	4.50	0.96	7.50	3.86	0.00	0.00	1.00	1.00
Bare Space	7.50	2.63	42.00	12.73	13.00	5.00	35.50	6.02

Groote Eylandt

Taxonomic group	Oct-08 Mean	Oct-08 SE	Jan-09 Mean	Jan-09 SE	Apr-09 Mean	Apr-09 SE	Jul-09 Mean	Jul-09 SE
Algae	-	-	-	-	18.50	6.50	5.50	4.86
Ascidians	-	-	-	-	43.50	9.14	44.00	16.51
Barnacles	-	-	-	-	1.00	0.58	1.50	1.50
Bryozoans	-	-	-	-	0.00	0.00	0.00	0.00
Hydroids	-	-	-	-	58.50	3.10	34.50	13.89
Molluscs	-	-	-	-	0.00	0.00	3.00	1.91
Polychaetes	-	-	-	-	0.00	0.00	0.00	0.00
Sponges	-	-	-	-	45.50	16.03	0.00	0.00
Amphipods	-	-	-	-	9.50	5.74	23.50	11.15
Other	-	-	-	-	15.00	5.80	17.50	7.68
Bare Space	-	-	-	-	42.50	10.24	50.00	17.07

Melville Island

Taxonomic group	Oct-08 Mean	Oct-08 SE	Jan-09 Mean	Jan-09 SE	Apr-09 Mean	Apr-09 SE	Jul-09 Mean	Jul-09 SE
Algae	-	-	-	-	-	-	-	-
Ascidians	-	-	-	-	-	-	-	-
Barnacles	-	-	-	-	-	-	-	-
Bryozoans	-	-	-	-	-	-	-	-
Hydroids	-	-	-	-	-	-	-	-
Molluscs	-	-	-	-	-	-	-	-
Polychaetes	-	-	-	-	-	-	-	-
Sponges	-	-	-	-	-	-	-	-
Amphipods	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-
Bare Space	-	-	-	-	-	-	-	-

APPENDIX F: Number of species (within specific taxonomic groups) developing on settlement surfaces from sites at Gove Harbour, Groote Eylandt, and Melville Island over four sampling periods during 2008-2009.

Year	Month	Gove Harbour Cargo wharf No of spp.	Gove Harbour Export wharf No of spp.	Groote Eylandt No of spp.	Melville Island No of spp.
2008	Sep			-	-
	Oct	10	8		
	Nov				
	Dec			15	-
2009	Jan	13	7		
	Feb				
	Mar			5	-
	Apr	12	5		
	May				
	Jun			8	-
	Jul	15	7		