Northern Territory Government

Monitoring for Marine Pests

GOVE HARBOUR, GROOTE EYLANDT AND MELVILLE ISLAND

2009–2010 Report

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DEPARTMENT OF **RESOURCES**

Monitoring for Marine Pests

Gove Harbour, Groote Eylandt and Melville Island

2009-10 Report

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Researched and compiled by
J. Maher, H. Cribb and A. Beatty
Department of Resources
GPO Box 3000, Darwin NT 0801, AUSTRALIA

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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, social, 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 aquaculture 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; Paulay 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.

Prior to the introduction of the DSS, 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 to 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 Department of 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 parts per thousand (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 forming 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 led 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.

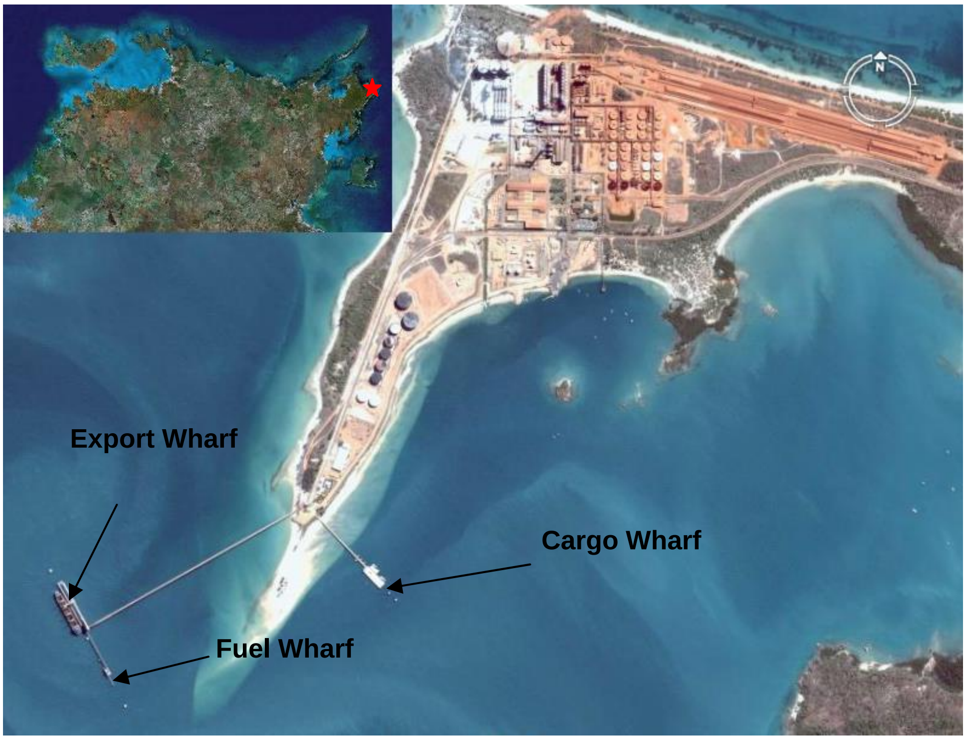

Figure 1. Aerial photograph of monitoring sites in Melville Bay, Gove Harbour

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’.

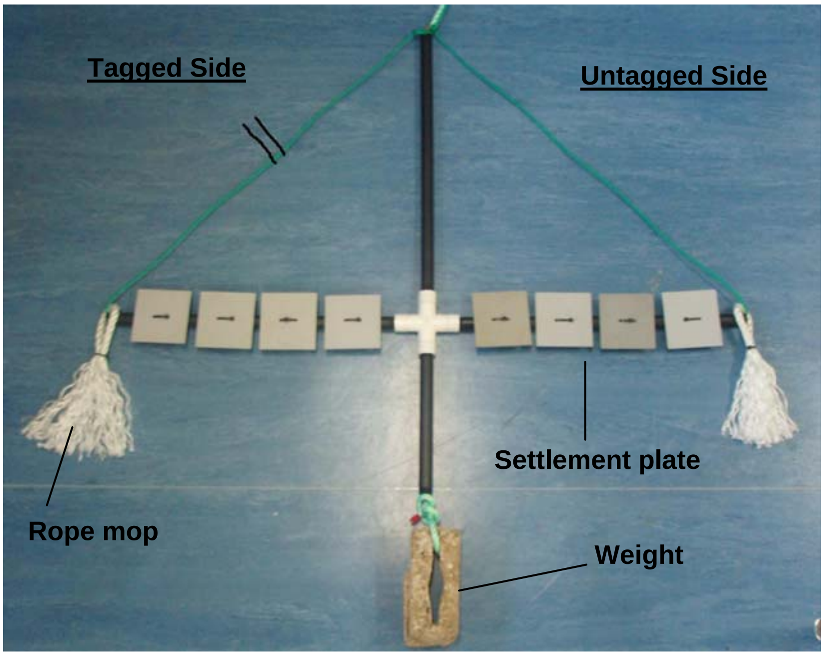

Figure 4. A settlement collector used to sample fouling organisms and detect marine pests

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, Groote Eylandt and Melville Island to Darwin, arriving within a day of collection. 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, Groote Eylandt and Melville Island sites are shown in Appendices A, B, C and D.

Collection Schedule

At the Gove Harbour site, there was damage to the Export Wharf settlement collector in November 2009 which was then replaced in February 2010 (Table 1). The scheduled January 2010 collection actually took place in early February and the incorrect plates were at first collected from the tagged side. These plates had been in the water for only one month. A few weeks later, the correct plates were collected. There was no data available for the Export Wharf site due to the damage to the collector in November. A new schedule began in April 2010 as a result of these issues and currently settlement collectors are in good working order.

All inspections and collections of settlement surfaces at the Groote Eylandt site took place with no damage to the settlement collector (Table 1). However, settlement surfaces were deployed one month early in January 2010 resulting in a schedule change with the new collection taking place in May 2010, rather than June 2010.

There were considerable disruptions with the collection and inspection schedule at the Garden Point, Melville Island site. A new settlement collector was installed in May 2009. No inspection was possible in June 2009. The first collection of settlement surfaces in September 2009 took place on schedule; however, no further collections occurred. In February 2010, the settlement collector went missing and was replaced in March 2010. Surfaces were inspected the following month; however, no inspections occurred in May or June 2010 and collection was not possible for July 2010.

Table 1. Chronology of settlement surface collection at Gove Harbour between June 2009 and August 2010; Groote Eylandt between May 2009 and May 2010; and Melville Island between May 2009 and June 2010

Location		Month	Date	Tagged side	Untagged side
Gove Harbour	2009	June	12th	Surfaces attached to collector	Surfaces inspected and photographed
		July	21st	Surfaces inspected and photographed	Surfaces collected
		Aug	20th	Surfaces inspected and photographed	No surfaces attached
		Sept	23rd	Surfaces inspected and photographed	Surfaces attached to collector
		Oct	?	Surfaces collected	Surfaces inspected and photographed
		Nov	23rd	No surfaces attached	Export wharf collector damaged Cargo Wharf surfaces inspected and photographed
		Dec	19th	Surfaces attached to collector	Surfaces inspected and photographed
	2010	Feb	5th	Tagged side surfaces incorrectly collected from Cargo Wharf – had only received a one month soak time	Correct surfaces collected from Cargo wharf a few weeks late Surfaces attached to collector
		Feb	?	Export wharf collector replaced	Surfaces inspected and photographed
		Mar	11th	No surfaces attached	Surfaces inspected and photographed
		April	24th	Surfaces attached to collector	Surfaces inspected and photographed
		May	26th	Surfaces inspected and photographed	Surfaces collected
		June	20th	Surfaces inspected and photographed	No surfaces attached
		July	25th	Surfaces inspected and photographed	Surfaces attached to collector
		August	23rd	Surfaces collected	Surfaces inspected and photographed

Groote Eylandt	2009	May	21st	Surfaces attached to collector	Surfaces inspected and photographed
		June	11th	Surfaces inspected and photographed	Surfaces collected. One plate missing.
		July	29th	Surfaces inspected and photographed	No surfaces attached
		Aug	12th	Surfaces inspected and photographed	Surfaces attached to collector
		Sept	17th	Surfaces collected	Surfaces Inspected and photographed
		Oct	13th	No surfaces attached	Surfaces inspected and photographed
		Nov	12th	Surfaces attached to collector	Surfaces inspected and photographed
		Dec	17th	Surfaces inspected and photographed	Surfaces collected
	2010	Jan	18th	Surfaces inspected and photographed	Surfaces attached one month ahead of schedule
		Feb	24th	Surfaces inspected and photographed	Surfaces inspected and photographed
		Mar	18th	Surfaces collected	Surfaces inspected and photographed
		May	4th	No surfaces attached	Surfaces inspected and photographed
		May	14th	Surfaces attached to collector	Surfaces collected
Melville Island	2009	May	?	Settlement collector reinstalled	Settlement collector reinstalled
		June	-	No inspection	No inspection
		July	3rd	Surfaces inspected and photographed	No surfaces attached
		Aug	20th	Surfaces inspected and photographed	Surfaces attached
		Sep	30th	Surfaces collected	Surfaces inspected and photographed
		Oct	30th	No surfaces attached	Surfaces inspected and photographed
		Nov	24th	Surfaces attached	Surfaces inspected and photographed
		Dec	-	No inspection	No inspection
	2010	Jan	-	No inspection	No inspection
		Feb	22nd	Settlement collector missing	Settlement collector missing
		Mar	4th	New settlement collector installed	No surfaces attached
		April	21st	Surfaces inspected and photographed	No surfaces attached
		May	-	No inspection	No inspection
		June	-	No inspection	No inspection
		July	-	No inspection	No inspection

Fouling Community Analysis

Fouling biomass

The highest biomass of marine fouling organisms on settlement plates was recorded at the Cargo Wharf site in Gove Harbour in February 2010 (Figure 5). At that site, biomass ranged between 42.3 g and 133.4 g. At the Export Wharf site in Gove Harbour, biomass ranged between 12.4 g and 76.2 g. There were three rather than four sample collections at that site due to the settlement collector being damaged in November 2009.

At the Groote Eylandt site, mean fouling biomass ranged between 13.8 g and 70.6 g (Figure 5). There was only one collection of settlement plates at the Melville Island, in September 2009. The average biomass on those plates was 12.9 g.

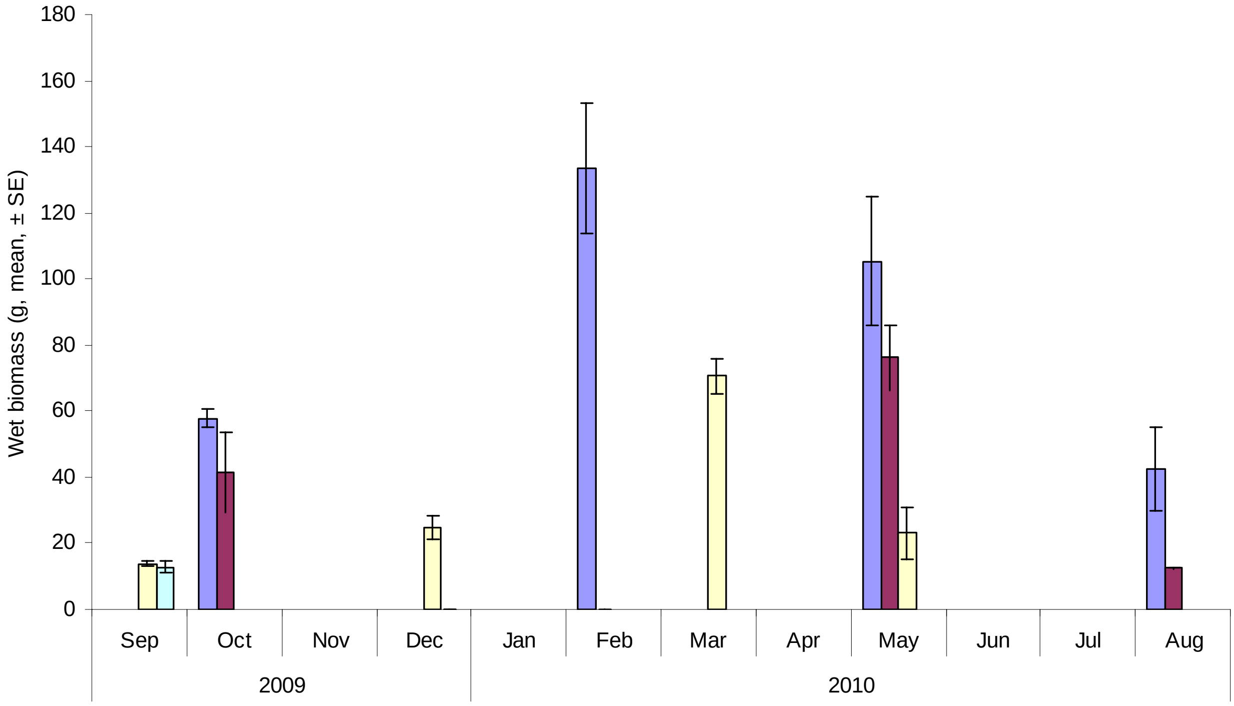

Figure 5. Wet biomass (g) mean ± standard error of bio-fouling recorded on settlement plates from sites at Groote Eylandt ( ), Melville Island ( ) and Gove Harbour [Cargo Wharf ( ) and Export Wharf ( )] over sampling periods during 2009-10

Taxonomic frequency

The average percent frequency of occurrence of each fouling taxonomic group recorded from the Cargo and Export wharf sites is shown in Figure 6. All of the common fouling taxonomic groups were represented on the settlement plates in at least one of the collection periods for both sites. The dominant fouling groups at the Cargo Wharf site were sponges, amphipods, hydroids, and bryozoans, with a maximum frequency of occurrence of 75.5%, 66%, 54%, and 48.5%, respectively (Figure 6a). However, across the four sample periods, the abundance within each of these groups fluctuated considerably.

At the Export Wharf site, the dominant groups found to be fouling settlement plates were amphipods, hydroids, algae, and barnacles, with a maximum frequency of occurrence of 36.7%, 36.7%, 22.0% and 17.5%, respectively (Figure 6b). Amphipods were fairly consistent across the three sample periods; however, similar to the Cargo Wharf site, the abundance of the other taxonomic groups varied noticeably from one collection to the next.

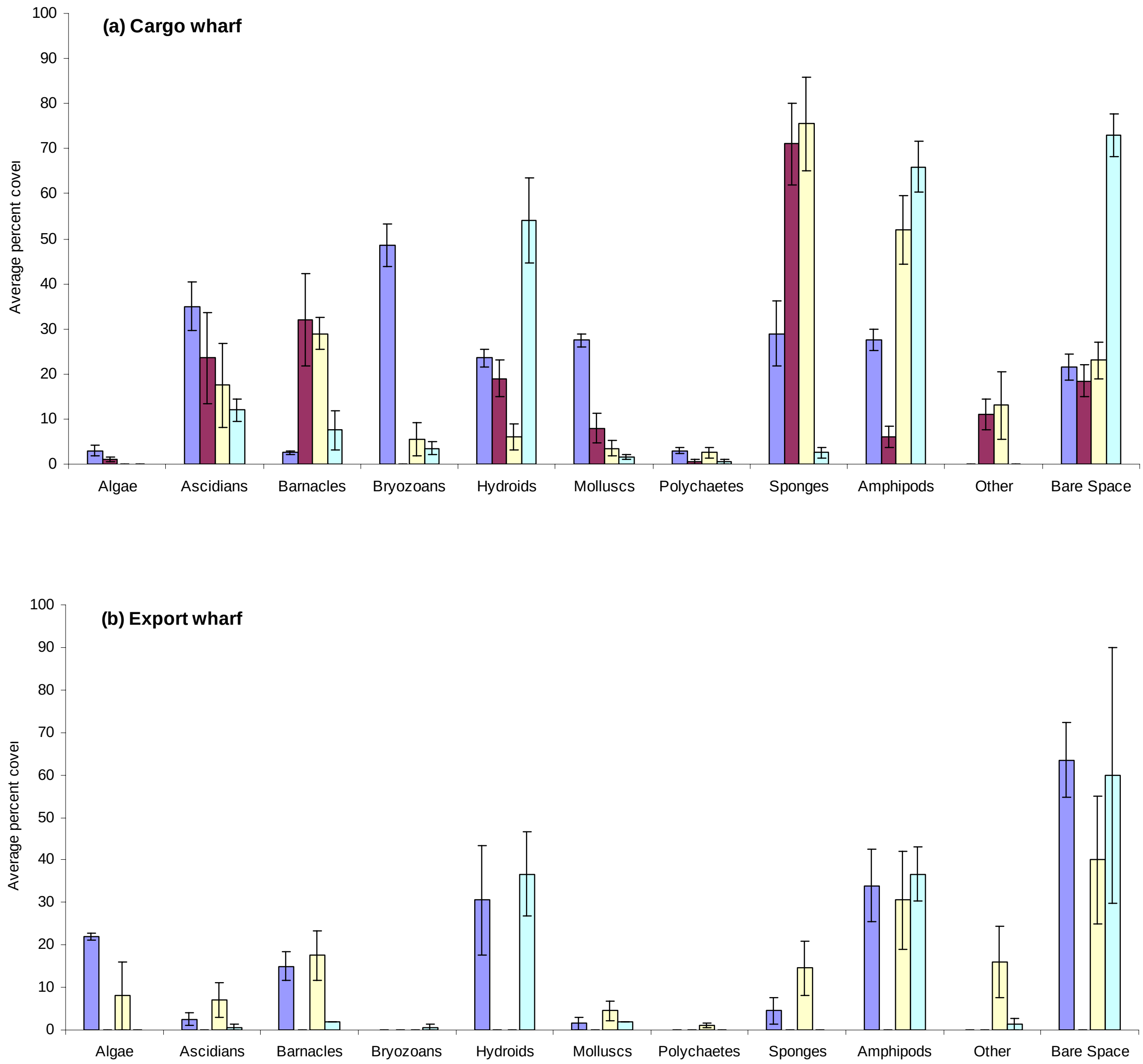

Figure 6. Percent frequency of occurrence (mean ± standard error) of each taxonomic group recorded on settlement plates and of the area remaining un-fouled; from (a) Cargo Wharf and (b) Export Wharf sites in Gove Harbour over four sampling periods: October 2009 (■), February 2010 (■), May 2010 (■) and August 2010 (■)

At the Groote Eylandt site, all common fouling taxonomic groups were represented on settlement plates in at least one of the four collections (Figure 7). Hydroids, ascidians, and amphipods were the dominant fouling groups, with a maximum frequency of occurrence of 71.5%, 62%, and 38.5%, respectively. The majority of taxonomic groups experienced a large fluctuation in their frequency of occurrence across the four sampling periods. For example, hydroids were found to cover on average 71.5% of settlement plates in the September 2009 collection but only 13.5% in May 2010.

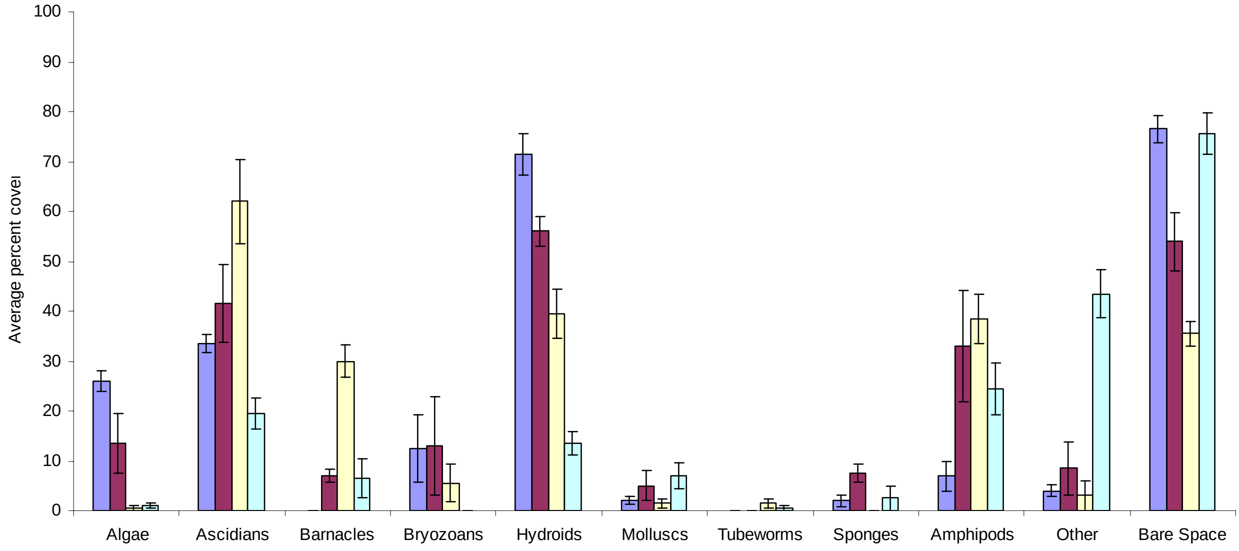

Figure 7. Percentage frequency of occurrence (mean ± standard error) of each taxonomic group recorded on settlement plates and of the area remaining un-fouled; from Milner Bay, Groote Eylandt, over four sampling periods: September 2009 (■), December 2009 (■), March 2010 (■) and May 2010 (■)

Five of the nine common fouling taxonomic groups were identified on settlement plates collected from Garden Point in September 2009 (Figure 8). Algae were the dominant fouling group covering an average of 49% of settlement plates. Ascidians, hydroids, bryozoans and molluscs were represented in smaller abundances, with mean frequencies of 10.5%, 7%, 4% and 4%, respectively.

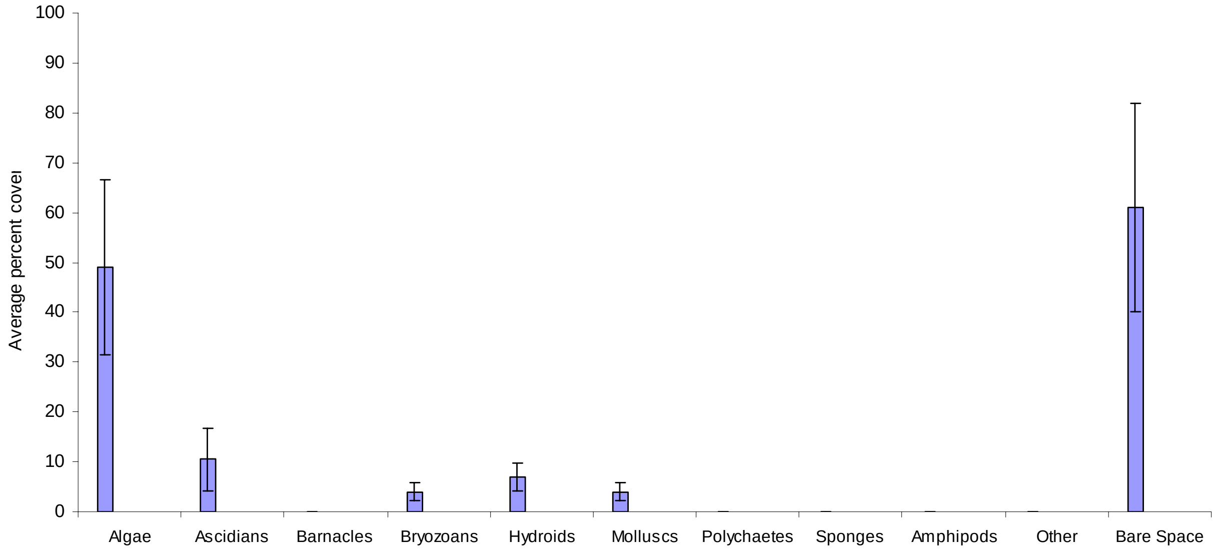

Figure 8. Percentage frequency of occurrence (mean ± standard error) of each taxonomic group recorded on settlement plates and of the area remaining un-fouled; from Garden Point, Melville Island, over one sampling period in September 2009

Species diversity

The largest number of species (from the selected taxonomic groups) was recorded at Cargo Wharf from the October 2009 collection where 18 species were identified (Figure 9). The number of species recorded from that site decreased in subsequent collections, with a total of 30 species identified between June 2009 and August 2010 (Table 2). For the three collections at the Export Wharf site, species diversity ranged between six and 10 with a total of 13 species recorded between June 2009 and August 2010 (Table 2).

The number of species observed on settlement surfaces at the Groote Eylandt site remained fairly consistent ranging from nine in the September 2009 collection to 12 in the March 2009 collection (Figure 9). Between May 2009 and May 2010 a total of 20 species were observed on settlement plates at that location (Table 3).

During the single collection in September 2009 at Melville Island, seven species were identified (Table 4).

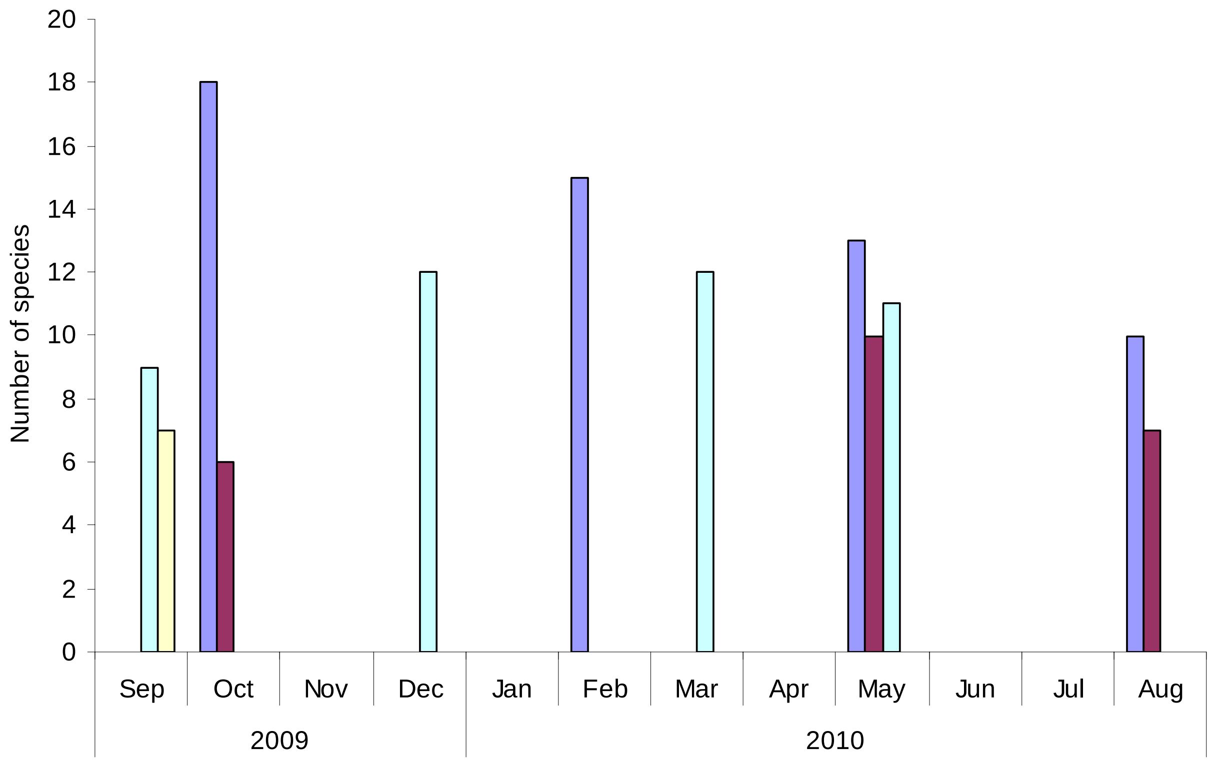

Figure 9. Number of species (within specific taxonomic groups) recorded on settlement surfaces from Groote Eylandt ( ), Melville Island ( ) and Gove Harbour, Cargo Wharf ( ) and Export Wharf ( )] over sampling periods during 2009-10

Table 2. Species (from specific taxonomic groups) observed on settlement surfaces collected from Cargo Wharf, Gove Harbour between June 2009 and August 2010

Gove - Cargo wharf								09	10		
Kingdom	Phylum	Subphylum	Class	Family	Taxa	Species No.	Scientific name	Oct	Feb	May	Aug
Animalia											
	Chordata										
			Ascidiacea		**Ascidians**						
						Spp. 2			✓	✓	✓
						Spp. 4		✓	✓	✓	✓
						Spp. 10		✓	✓	✓	
						Spp. 14					✓
						Spp. 16		✓	✓	✓	
						Spp. 17		✓			
	Arthropoda										
		Crustacea									
			Cirripedia		**Barnacles**						
						Spp. 2	*Amphibalanus variegatus*	✓		✓	
						Spp. 5	*Amphibalanus reticulatus*	✓			
						Spp. 6	*Striatobalanus amaryllis*	✓	✓	✓	✓
						Spp. 7	*Amphibalanus zhujiangensis*	✓	✓	✓	✓
	Mollusca				**Bivalves**						
			Bivalvia								
				Pteriidae		Spp. 1	*Planostrea pestigris*	✓			✓
						Spp. 5	*Electroma papilionacea*	✓			
						Spp. 10	*Electroma physoides*		✓		
						Spp. 15			✓		
						Spp. 25	*Dendostrea* sp.		✓	✓	
	Bryozoa				**Bryozoans**						
						Spp. 6		✓		✓	
						Spp. 17		✓			
						Spp. 21	*Savignyella lafontii*	✓	✓	✓	✓
						Spp. 31	*Watersipora subtorquata*	✓		✓	✓
						Spp. 34	*Parasimttina* sp.	✓	✓		
						Spp. 39			✓		
						Spp. 41	*Schizoporella errata*		✓		
						Spp. 50			✓		
						Spp. 55					✓
	Annelida										
			Polychaeta		**Polychaetes**						
						Spp. 1		✓			
						Spp. 4	*Ficopomatus uschakovi*	✓		✓	
						Spp. 8	*Hydroides elegans*	✓			
						Spp. 15	*Hydroides albiceps*				✓
						Spp. 16	*Branchiomma boholense*				
						Spp. 18	*Hydroides minax*		✓	✓	
							Total species observed	18	15	13	10

Table 3. Species (from specific taxonomic groups) observed on settlement surfaces collected from Export Wharf, Gove Harbour between June 2009 and August 2010

Gove - Export wharf								09	10		
Kingdom	Phylum	Subphylum	Class	Family	Taxa	Species No.	Scientific name	Oct	Feb	May	Aug
Animalia											
	Chordata										
			Ascidiacea		**Ascidians**						
						Spp. 2		✓		✓	
						Spp. 4				✓	
						Spp. 10		✓		✓	✓
	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**						
						Spp. 1	*Planostrea pestigris*	✓		✓	✓
						Spp. 5	*Electroma papilionacea*			✓	
						Spp. 25	*Dendostrea* sp.			✓	✓
	Bryozoa				**Bryozoans**						
						Spp. 46					✓
	Annelida										
			Polychaeta		**Polychaetes**						
						Spp. 13				✓	
							Total species observed	6	-	10	7

Table 4. Species (from specific taxonomic groups) observed on settlement surfaces collected from Milner Bay, Groote Eylandt between May 2009 and May 2010

Groote Eylandt								09		10	
Kingdom	Phylum	Subphylum	Class	Family	Taxa	Species No.	Scientific name	Sep	Dec	Mar	May
Animalia											
	Chordata										
			Ascidiacea		**Ascidians**						
						Spp. 1		✓		✓	✓
						Spp. 2		✓	✓	✓	✓
						Spp. 4			✓		
						Spp. 10		✓	✓	✓	✓
						Spp. 16		✓	✓	✓	
	Arthropoda										
		Crustacea									
			Cirripedia		**Barnacle**						
						Spp. 1	*Amphibalanus amphitrite*	✓			
						Spp. 2	*Amphibalanus variegatus*		✓	✓	
						Spp. 5	*Amphibalanus reticulatus*			✓	✓
						Spp. 6	*Striatobalanus amaryllis*			✓	✓
						Spp. 7	*Amphibalanus zhujiangensir*		✓	✓	✓
	Mollusca										
			Bivalvia		**Bivalve**						
						Spp. 1	*Planostrea pestigris*	✓	✓	✓	✓
						Spp. 5	*Electroma papilionacea*				✓
						Spp. 9	*Musculus miranda*	✓	✓		✓
						Spp. 11	*Pinctada sugillata*			✓	
						Spp. 25	*Dendostrea* sp.	✓	✓		✓
	Bryozoa				**Bryozoan**						
						Spp. 15		✓	✓	✓	
						Spp. 34			✓		
						Spp. 54			✓		
	Annelida										
		Polychaeta			**Polychaetes**						
						Spp. 9	*Hydroides malleolaspina*				✓
						Spp. 17	*Demonax* sp.			✓	
							Total species observed	9	12	12	11

Table 5. Species (from specific taxonomic groups) observed on settlement surfaces collected from Garden Point, Melville Island between May 2009 and July 2010

Garden Point

Kingdom	Phylum	Subphylum	Class	Family	Taxa	Species No.	Scientific name	09 Sep	Dec	10 Mar	July
Animalia											
	Chordata										
			Ascidiacea		**Ascidians**						
						Spp. 2		✓			
	Mollusca										
			Bivalvia		**Bivalves**						
						Spp. 1	*Planostrea pestigris*	✓			
						Spp. 25	*Dendostrea* sp.	✓			
	Bryozoa				**Bryozoans**						
						Spp. 6	*? Celleporina sp.*	✓			
						Spp. 14	*Scrupocellaria sp.*	✓			
						Spp. 21		✓			
						Spp. 40		✓			
							Total species observed	7	-	-	-

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.

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.

The species diversity and biomass of fouling communities varied considerably both between and within locations. At the Gove sites, biomass was highest during the wet season collection periods of February and May 2010. Similarly, at Groote Eylandt, the highest biomass was recorded in March 2010. In both instances this was due to barnacle species dominating the fouling assemblage on settlement plates for these collection periods. However, a large biomass did not necessarily correspond to a greater number of species on settlement surfaces. For the Cargo Wharf site, the largest number of species was observed in October 2009, a period when biomass was considerably lower than in the February and May 2010 collection periods.

For both Gove and Groote Eylandt locations, the frequency of occurrence of individual taxonomic groups varied within locations over the four sampling periods. The taxonomic group(s) dominating settlement plates also tended to change between sites and over time.

It is apparent that there are seasonal factors that impact on the biofouling assemblages at each location. However, to identify what factors influence these seasonal environmental conditions, and the degree with which they do, would require a much more detailed study. The constraint of limited data, particularly from the Melville Island site, further hinders making any assumptions.

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 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

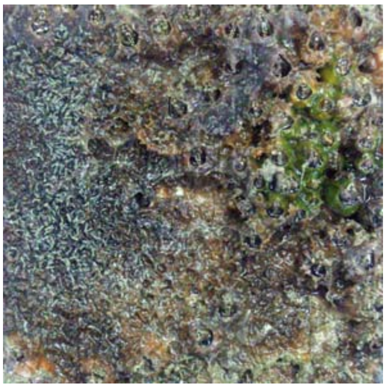
APPENDIX A: Representative photographs of biofouling communities on settlement plates collected from Cargo wharf, Gove Harbour, between June 2009 and August 2010

Oct 09 - Plate 1 (front)

Oct 09 – Plate 4 (rear)

Feb 10 - Plate 4 (front)

Feb 10 – Plate 4 (rear)



May 10 - Plate 2 (front)

May 10 - Plate 1 (rear)

Aug 10 - Plate 1 (front)

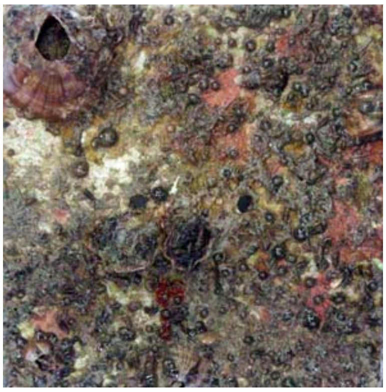
Aug 10 - Plate 4 (rear)

APPENDIX B: Representative photographs of biofouling communities on settlement plates collected from Export wharf, Gove Harbour, between June 2009 and August 2010

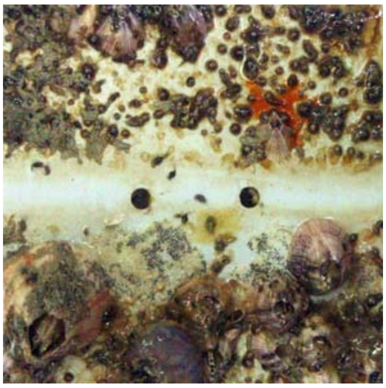
Oct 09 – Plate 3 (front)

Oct 09 - Plate 3 (rear)

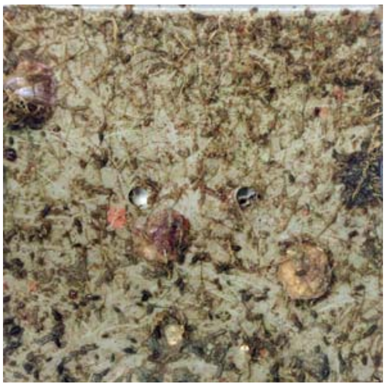
NO PHOTOGRAPHS AVAILABLE FOR JANUARY 2010



May 10 - Plate 1 (front)



May 10 - Plate 1 (rear)

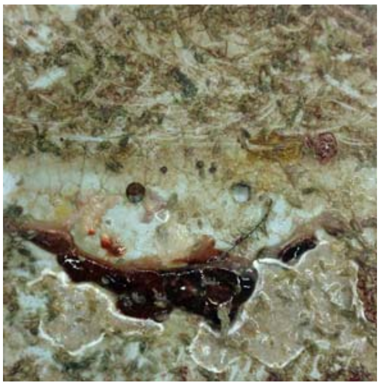


Aug 10 - Plate 3 (front)

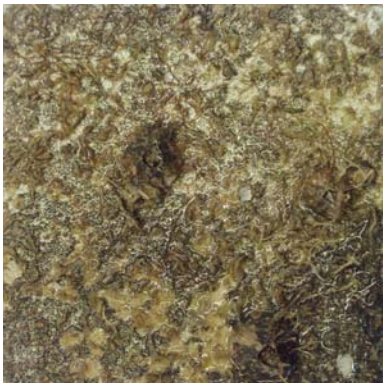
Aug 10 - Plate 3 (rear)

APPENDIX C: Representative photographs of biofouling communities on settlement plates collected from Milner Bay, Groote Eylandt between May 2009 and June 2010

Sep 09 - Plate 1 (front)

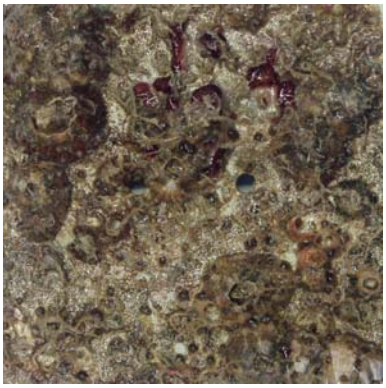


Sep 09 - Plate 2 (front)



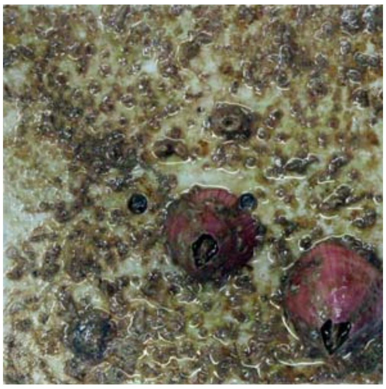
Dec 09 - Plate 2 (front)

Dec 09 - Plate 3 (rear)

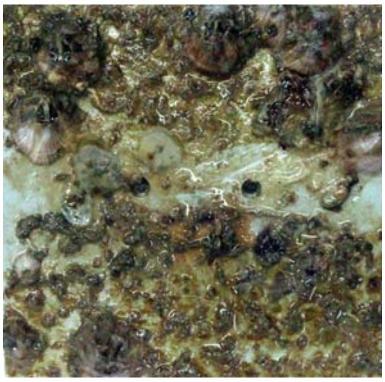


Mar 10 - Plate 4 (front)

Mar 10 - Plate 1 (rear)

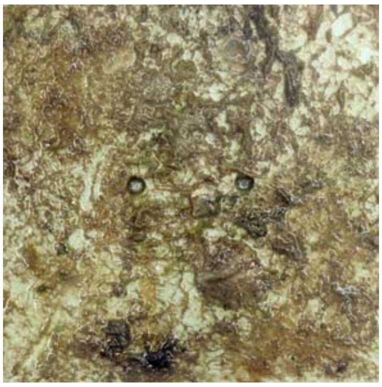


May 10 - Plate (front)

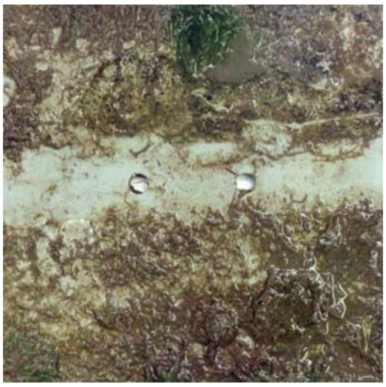


May 10 - Plate (rear)

APPENDIX D: Representative photographs of biofouling communities on settlement plates collected from Garden Point, Melville Island between May 2009 and July 2010



Sep 09 - Plate (front)



Sep 09 - Plate (rear)

NO PHOTOGRAPHS AVAILABLE FOR DECEMBER 2010

NO PHOTOGRAPHS AVAILABLE FOR MARCH 2010

NO PHOTOGRAPHS AVAILABLE FOR JULY 2010

APPENDIX E: 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 2009-10

Year	Month	Gove Harbour				Groote Eylandt		Melville Island	
		Cargo Wharf		Export Wharf					
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
2009	Sep					13.78	0.73	12.87	1.56
	Oct	57.78	2.65	41.40	12.02				
	Nov								
	Dec					24.80	3.53	-	-
2010	Jan			-	-				
	Feb	133.40	19.75						
	Mar					70.63	5.41		
	Apr								
	May	105.25	19.44	76.23	9.89	23.03	8.06		
	Jun								
	Jul								
	Aug	42.45	12.43	12.43	0.45				

APPENDIX F: 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 2009-10

Gove Harbour - Cargo Wharf

	Oct-09		Feb-10		May-10		Aug-10	
Taxonomic group	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Algae	3.00	1.29	1.00	0.58	0.00	0.00	0.00	0.00
Ascidians	35.00	5.45	23.50	10.14	17.50	9.39	12.00	2.45
Barnacles	2.50	0.50	32.00	10.13	29.00	3.42	7.50	4.35
Bryozoans	48.50	4.72	0.00	0.00	5.50	3.59	3.50	1.50
Hydroids	23.50	1.89	19.00	4.12	6.00	2.94	54.00	9.42
Molluscs	27.50	1.50	8.00	3.37	3.50	1.71	1.50	0.50
Polychaetes	3.00	0.58	0.50	0.50	2.50	1.26	0.50	0.50
Sponges	29.00	7.14	71.00	8.96	75.50	10.37	2.50	1.26
Amphipods	27.50	2.36	6.00	2.31	52.00	7.57	66.00	5.60
Other	0.00	0.00	11.00	3.42	13.00	7.55	0.00	0.00
Bare Space	21.50	2.87	18.50	3.50	23.00	4.12	73.00	4.80

Gove Harbour - Export Wharf

	Oct-09		Feb-10		May-10		Aug-10	
Taxonomic group	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Algae	22.00	0.82	-	-	8.00	8.00	0.00	0.00
Ascidians	2.50	1.50	-	-	7.00	4.04	0.67	0.67
Barnacles	15.00	3.32	-	-	17.50	5.85	2.00	0.00
Bryozoans	0.00	0.00	-	-	0.00	0.00	0.67	0.67
Hydroids	30.50	12.92	-	-	0.00	0.00	36.67	9.96
Molluscs	1.50	1.50	-	-	4.50	2.22	2.00	0.00
Polychaetes	0.00	0.00	-	-	1.00	0.58	0.00	0.00
Sponges	4.50	3.20	-	-	14.50	6.34	0.00	0.00
Amphipods	34.00	8.60	-	-	30.50	11.53	36.67	6.36
Other	0.00	0.00	-	-	16.00	8.49	1.33	1.33
Bare Space	63.50	8.88	-	-	40.00	15.03	60.00	30.09

Groote Eylandt

Taxonomic group	Sep-09		Dec-10		Mar-10		May-10	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Algae	26.00	2.16	13.50	5.85	0.50	0.50	1.00	0.58
Ascidians	33.50	1.89	41.50	7.80	62.00	8.37	19.50	3.10
Barnacles	0.00	0.00	7.00	1.29	30.00	3.37	6.50	3.86
Bryozoans	12.50	6.85	13.00	9.95	5.50	3.77	0.00	0.00
Hydroids	71.50	4.11	56.00	2.94	39.50	4.92	13.50	2.22
Molluscs	2.00	0.82	5.00	3.00	1.50	0.96	7.00	2.65
Polychaetes	0.00	0.00	0.00	0.00	1.50	0.96	0.50	0.50
Sponges	2.00	1.15	7.50	1.89	0.00	0.00	2.50	2.50
Amphipods	7.00	3.00	33.00	11.27	38.50	4.99	24.50	5.19
Other	4.00	1.15	8.50	5.32	3.00	3.00	43.50	4.79
Bare Space	76.50	2.63	54.00	5.83	35.50	2.50	75.50	4.19

Melville Island

Taxonomic group	Sep-09		Dec-10		Mar-10		Jul-10	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Algae	49.00	17.64	-	-	-	-	-	-
Ascidians	10.50	6.18	-	-	-	-	-	-
Barnacles	0.00	0.00	-	-	-	-	-	-
Bryozoans	4.00	1.83	-	-	-	-	-	-
Hydroids	7.00	2.89	-	-	-	-	-	-
Molluscs	4.00	1.83	-	-	-	-	-	-
Polychaetes	0.00	0.00	-	-	-	-	-	-
Sponges	0.00	0.00	-	-	-	-	-	-
Amphipods	0.00	0.00	-	-	-	-	-	-
Other	0.00	0.00	-	-	-	-	-	-
Bare Space	61.00	20.86	-	-	-	-	-	-

APPENDIX G: 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 2009-10.

Year	Month	Gove Harbour		Groote Eylandt	Melville Island
		Cargo wharf	Export wharf		
		No of spp.	No of spp.	No of spp.	No of spp.
2009	Sep			9	7
	Oct	18	6		
	Nov				
	Dec			12	-
2010	Jan		-		
	Feb	15			
	Mar			12	-
	Apr				
	May	13	10	11	
	Jun				
	Jul				-