



# PORT OF THURSDAY ISLAND – BASELINE SURVEYS FOR INTRODUCED MARINE PESTS

Final Report of the March 2004  
Port-Wide Field Survey



May 2006



First Published 2006

© The state of Queensland, Department of Primary Industries and Fisheries 2006.  
Copyright protects this publication. Except for purposes permitted by the Copyright Act, reproduction by whatever means is prohibited without the prior written permission of the Queensland Department of Primary Industries and Fisheries.

#### Disclaimer

The Queensland Department of Primary Industries and Fisheries has taken all reasonable steps to ensure the information contained in this report is accurate at the time of the survey. Benthic habitat and benthic assemblage distribution and abundance can change seasonally and between years, and readers should ensure they make appropriate enquires to determine whether new information is available.

The correct citation of this document is:

Stafford, H., Neil, K.M., and Chalmers, S.J. 2006. Port of Thursday Island – Baseline Survey for Introduced Marine Pests. Final Report of the March 2004 Port-Wide Field Survey. CRC Torres Strait and Queensland Department of Primary Industries and Fisheries, 46pp.

Enquires should be directed to:

QDPI&F  
Northern Fisheries Centre  
P.O. Box 5396  
Cairns, QLD, 4870, Australia

#### Acknowledgements:

This was a joint project between Queensland Department of Primary Industries and Fisheries (Introduced Marine Species Group), Ports Corporation of Queensland and the CRC for the Torres Strait. We would like to thank Mr D. Sweeney from Queensland Boating and Fisheries Patrol, Thursday Island, Mr Toshi Nakata and staff of the Torres Strait Regional Authority, Ports Corporation of Queensland staff based at Thursday Island for their assistance during the survey.

# Table of Contents

<b>1. Introduction.....</b>	<b>1</b>
<b>2. Description of Port .....</b>	<b>2</b>
2.1 Location and Management.....	2
<b>3. Project Approach and Sampling Design.....</b>	<b>3</b>
3.1 Approach.....	3
3.2 Variations from the suggested sampling protocols .....	8
3.3 Variations from the proposed sampling design .....	9
<b>4 Methodology .....</b>	<b>10</b>
4.1 Subtidal and Intertidal Hard Substrate Sampling .....	10
4.2 Visual Surveys of Hard Substrates .....	10
4.3 Soft Substrate Sampling .....	10
4.3.1 Benthic Infauna (Grab samples) .....	10
4.3.2 Mobile Epibenthos.....	11
4.3.3 Crab and Shrimp Traps.....	11
4.3.4 Plankton Sampling .....	11
4.3.5 Fish .....	11
4.3.6 Dinoflagellate Cyst Samples .....	12
4.3.7 Beach Drift Surveys for Crab Exuviae.....	12
4.3.8 Sediment Sample.....	12
4.3.9 Environmental Data.....	12
4.4 Sorting and Identification Of Specimens .....	12
<b>5. Survey Results .....</b>	<b>14</b>
5.1 Hard Substrate Sampling .....	16
5.1.1 Wharf Pile Scrapings.....	16
5.1.2 Intertidal Rocky Substrates .....	16
5.2 Soft Substrate Biota (Beam Trawl, Sled, Grab Samples). .....	16
5.3 Mobile Biota .....	17
5.3.1 Phytoplankton .....	17
5.3.2 Crabs and Shrimps .....	17
5.3.3 Fish .....	18
5.4 Sediment Samples and Dinoflagellate Cyst Samples .....	19
5.5 Environmental Data.....	20
<b>6. Introduced taxa and summary .....</b>	<b>22</b>
6.1 Introduced Taxa .....	22
6.1.1 Presence of Target Species.....	22
6.1.2 Non Target Specie .....	23
6.1.3 Cryptogenic Species .....	23
6.2 Invasive taxa vectors.....	23

<b>7. Conclusions .....</b>	<b>27</b>
<b>8. References .....</b>	<b>29</b>
<b>Appendix 1 .....</b>	<b>30</b>

# 1. Introduction

The introduction and establishment of invasive marine species causes fundamental, and typically deleterious, impacts on fisheries and ecosystem resources, industrial development and infrastructure and human welfare (Carlton & Geller, 1993). Over 200 exotic marine species have been identified in Australian waters and most are believed to have been unintentional introductions associated with shipping and mariculture activities (Thresher, 1999). The Torres Strait region supports a number of critical fisheries habitats and ecosystem resources, which sustain much of the local economy. Due to the high level of vessel traffic through the Torres Strait areas their economic and ecological value are at high risk from invasive marine taxa.

Fundamental to controlling and managing the introduction and spread of introduced marine species is a knowledge of their present distribution and abundance. To determine the presence of introduced marine species within the Torres Strait, information on the present status of marine assemblages was collected during a port-wide baseline pest survey. Sampling was undertaken 18<sup>th</sup>-26<sup>th</sup> March 2004 and targeted areas within the port likely to harbour marine pests based on criteria given by Hewitt and Martin (1996 & 2001).

Port of Thursday Island facilities (wharves, pontoons and moorings) are present on both Horn and Thursday Island. Navigational buoys, mooring buoys and other infrastructure that may support marine pests are also present through the Torres Strait region. A number of locations within the Torres Strait are also used for safe anchorage by vessels. In addition to vessels that actually visit the area, the Torres Strait is also a thoroughfare for a large number of both recreational and commercial vessels that do not stop but transit through the region. The shipping channel that passes through the Torres Strait is shallow and vessels may need to dump ballast to provide safe passage. Areas within the Torres Strait region are, therefore, at high risk from marine pest introduction and sampled for introduced marine pests in March of 2004.

## 2. Description of Port

### 2.1 Location and Management

Ports Corporation of Queensland (PCQ) administers the Port of Thursday Island; the majority of port infrastructure are located on the south eastern side of Thursday Island (west Ellis Channel). Port facilities include the main cargo wharf that comprises a naval berth, customs berth and commercial berth; Fuel wharf facility; a wharf to accommodate recreational vessel berths and local passenger vessels; public and commercial mooring pontoons; floating buoys and channel markers; and the Horn Island wharf (east Ellis Channel).

The south western side of Horn Island (south west Ellis Channel) has anchorages for confiscated vessels. Ellis Channel is subject to significant public vessel traffic originating from Islands adjacent to Thursday Island and remote areas of the Torres Strait, Papua New Guinea and mainland Australia. Such traffic includes small and medium commercial passenger vessels and small to medium cargo vessels with regular cargo and passenger vessels from mainland Australia.

There are three main areas of the port that are categorised (under CRIMP criteria, Hewitt and Martin, 1996, 2001) as areas most likely to be exposed to marine species introductions and, therefore, sampling effort focussed on these areas:

- the main cargo, passenger, navy and customs wharf and fuel wharf along the western side of Ellis channel,
- the anchorage for confiscated vessels and shipping channel markers
- the Horn Island cargo and passenger wharf on the eastern side of Ellis Channel.

## 3. Project Approach and Sampling Design

### 3.1 Approach

The sampling regime implemented during the survey adopted a targeted approach focussing on habitats likely to house introduced marine pest species. It was proposed that samples be collected from a range of habitats during the baseline survey using 14 different sampling techniques. The locations proposed for sampling, the justification for sampling these areas and the type of sampling proposed to be undertaken in each area is detailed in Table 1 and 2. The sampling regime was developed in accordance with the national standard protocols for detecting marine pests in ports, developed by CRIMP (Hewitt & Martin, 1996 & 2001) and protocols for sampling for marine pests in tropical ports, developed by CRC Reef (Hoedt *et al.*, 2001). Variations to the suggested sampling provided in the protocols are outlined below. The sampling regime was critically reviewed by the CSIRO, and subsequently ratified by NIMPCG, prior to the survey and was noted to have met the national standards for port baseline surveys for marine pests.

Habitats identified above as being at risk from marine species introduction were sampled from 18<sup>th</sup>-26<sup>th</sup> March 2004 using techniques that included, but were not restricted to, grabs, pylon scrapes, beam trawls and benthic sledge-dredges. A total of 138 samples were collected from wharves, piles, moorings, anchorage areas and shipping channels. The exact locations from where samples were collected can be seen from Figure 1.

**Table 1: Sampling plan for the Port of Thursday Island Introduced Species Survey**

Site Description	Site Code	Priority Ranking (Hewitt & Martin 2001)	Ranking for Sampling (1=High, 3 = Low)	Justification	Activities
Main Cargo Wharf* (~ 30 piles, concrete and steel)	TI-MCW	1	2	Domestic traffic between Horn and Thursday Island and some from Cairns. Close proximity to Customs wharf.	Pile Scrapes: 3 piles (-0.5m, -3m & -7m ea pile) Visual record of piles: video/still camera Benthic grabs: 3 near base of piles = infauna, 1 = sediment analysis Settlement Plates: check for mussels Environmental data (temperature, salinity etc.)
Customs Wharf* (~ concrete 12 piles)	TI-CW	1	1	Contact with international traffic including FFV	Pile Scrapes: 3 piles (-0.5m, -3m & -7m ea pile) Visual record of piles: video/still camera Benthic grabs: 3 near base of piles = infauna, 1 = sediment analysis. Benthic sled: 2 x 100 m tows, -2m and -10m depth (if avail.) Benthic trawl: 2 x 100 m tows, -2m and -10m depth (if avail.) Crab/shrimp pots: 6 pots, 2 sizes Plankton samples: 20µm & 100 µm mesh, horizontal tow & vertical drop for both
Navy Wharf* (approx 20 concrete piles)	TI-NW	1	2	Contact with international traffic but potential difficulty in sampling due to clearance restrictions. Close proximity to Customs wharf.	If agreed to by Navy: Pile Scrapes: 3 piles (-0.5m, -3m & -7m ea pile) Visual record of piles: video/still camera Benthic grabs: 3 near base of piles = infauna, 1 = sediment analysis.
Old Fuel Wharf Head (~ 16 steel piles)	TI-OFWH	1	1	Wharf in poor condition. Potentially heavy fouling area. May be a reference site for main wharf structure. May be attractive to invasive taxa.	Pile Scrapes: 3 piles (-0.5m, -3m & -7m ea pile) Visual record of piles: video/still camera Benthic grabs: 3 near base of piles = infauna, 1 = sediment analysis. Benthic sled: 2 x 100 m tows, -2m and -10m depth (if avail.) Benthic trawl: 2 x 100 m tows, -2m and -10m depth (if avail.) Crab/shrimp pots: 6 pots, 2 sizes Plankton samples: 20µm & 100 µm mesh, horizontal tow & vertical drop for both Environmental data (temperature, salinity etc.)

**Table 1 continued:**

Horn Island Wharf	TI-HIW	1	3	Domestic/recreational traffic only which is being accounted for by sampling Main Cargo Wharf. High risk of crocodile presence.	Benthic grabs: 3 near wharf structure, 1 = sediment analysis Visual survey: of piles/pontoons via remote camera Settlement Plates: check for mussels Benthic sled: 2 x 100 m tows, 2 depths Benthic trawl: 2 x 100 m tows, 2 depths Crab/shrimp pots: 6 pots, 2 sizes Plankton samples: 20µm & 100 µm mesh, horizontal tow & vertical drop for both Environmental data (temperature, salinity etc.)
Public mooring pontoons*	TI-PM	1	3	Domestic traffic between islands only.	Visual surveys. Opportunistic collection only if necessary.
Floating buoys/channel markers (~ 20 through the port)	TI-BX TI-CHMX (X=#)	1	1	Artificial substrate available for settlement throughout the port.	Visual surveys: 10. Sample collection: opportunistic, quantitative if possible.
Ellis Channel East	TI-ECHE	3	2	Channel for vessel traffic and high current flow. Potential reference site for settlement of soft substrate taxa.	Benthic sled: 2 x 100 m tows, -2m and -10m depth (if avail.) Benthic trawl: 2 x 100 m tows, -2m and -10m depth (if avail.)
Ellis Channel West	TI-ECHW	3	2	Channel for vessel traffic and high current flow. Anchorage for confiscated vessels. Potential for settlement of soft substrate taxa.	Benthic sled: 2 x 100 m tows, -2m and -10m depth (if avail.) Benthic trawl: 2 x 100 m tows, -2m and -10m depth (if avail.)
Boat Channel (just off Smith Point, Horn Isl)	TI-BCH	3	2	Channel for vessel traffic and high current flow. Potential for settlement of soft substrate taxa.	Benthic sled: 2 x 100 m tows, -2m and -10m depth (if avail.) Benthic trawl: 2 x 100 m tows, -2m and -10m depth (if avail.)
Kiwain (Heath) Point, Prince of Wales Island	TI-KP	2	3	Rocky shore, sandy beach habitat. Current deposition area. Recreational vessel anchorage.	Beach wrack: 1 x 100m transect Rocky shore survey: 1 x 100m transect Beach seine: 1 x 100m transect
Thursday Island Sth W Point	TI-TISWP	2	3	Rocky shore, sandy/Muddy beach habitat. Current deposition area. Recreational vessel anchorage.	Beach wrack: 1 x 100m transect Rocky shore survey: 1 x 100m transect Beach seine: 1 x 100m transect
Thursday Island Nth E Point	TI-TINEP	2	3	Rocky shore, sandy/Muddy beach habitat. Current deposition area	Beach wrack: 1 x 100m transect Rocky shore survey: 1 x 100m transect Beach seine: 1 x 100m transect
Appropriate Substrate for Dinoflagellate cyst samples	TI-ZZZ (Z = to be decided)	1	1	Sediment likely to house dino. cysts will be sourced upon site inspection.	Dinoflagellate cyst sediment samples: 3 x samples per site. 2 sites minimum if appropriate sediment is available.

\* All part of one wharf structure. Barge ramp immediately adjacent to public moorings and main wharf. Sled/trawls in this area (listed under Customs Wharf) are expected to sample any taxa that may have been brought in as a result of usage of the Public moorings and/or barge ramp.

**Table 2: Summary of the sampling plan for the Port of Thursday Island Introduced Species Survey**

Site \ Sampling type	PS	S	T	IG	SG	CP	PT	V	Env	BS	BW	RS	SP	DC	Total
TI-MCW	9			3	1			1	*				*		16
TI-CW	9	2	2	3	1	6	4	1							28
TI-NW	9			3	1			1							14
TI-OFWH	9	2	2	3	1	6	4	1	*						29
TI-HIW		2	2	3	1	6	4	1	*				*		21
TI-B	X							X							5
TI-CHM	X							X							5
TI-PM								1							1
TI-ECHE		2	2												4
TI-ECHW		2	2											3	7
TI-BCH		2	2											3	7
TI-KP								1		1	1	1			4
TI-TISWP								1		1	1	1			4
TI-TINEP								1		1	1	1			4
<b>Total</b>	36	12	12	15	5	18	12	19	3	3	3	3	2	6	149

For Site Codes refer to Table 1

PS = Pile scrape (X = opportunistic)

S = Benthic sled

T = Benthic trawl

IG = Benthic infaunal grab

SG = Sediment grab

CP = Crab and shrimp pots

PT = Plankton tow (zoo and phyto)

V = visual surveys (X = opportunistic)

Env = Environmental data

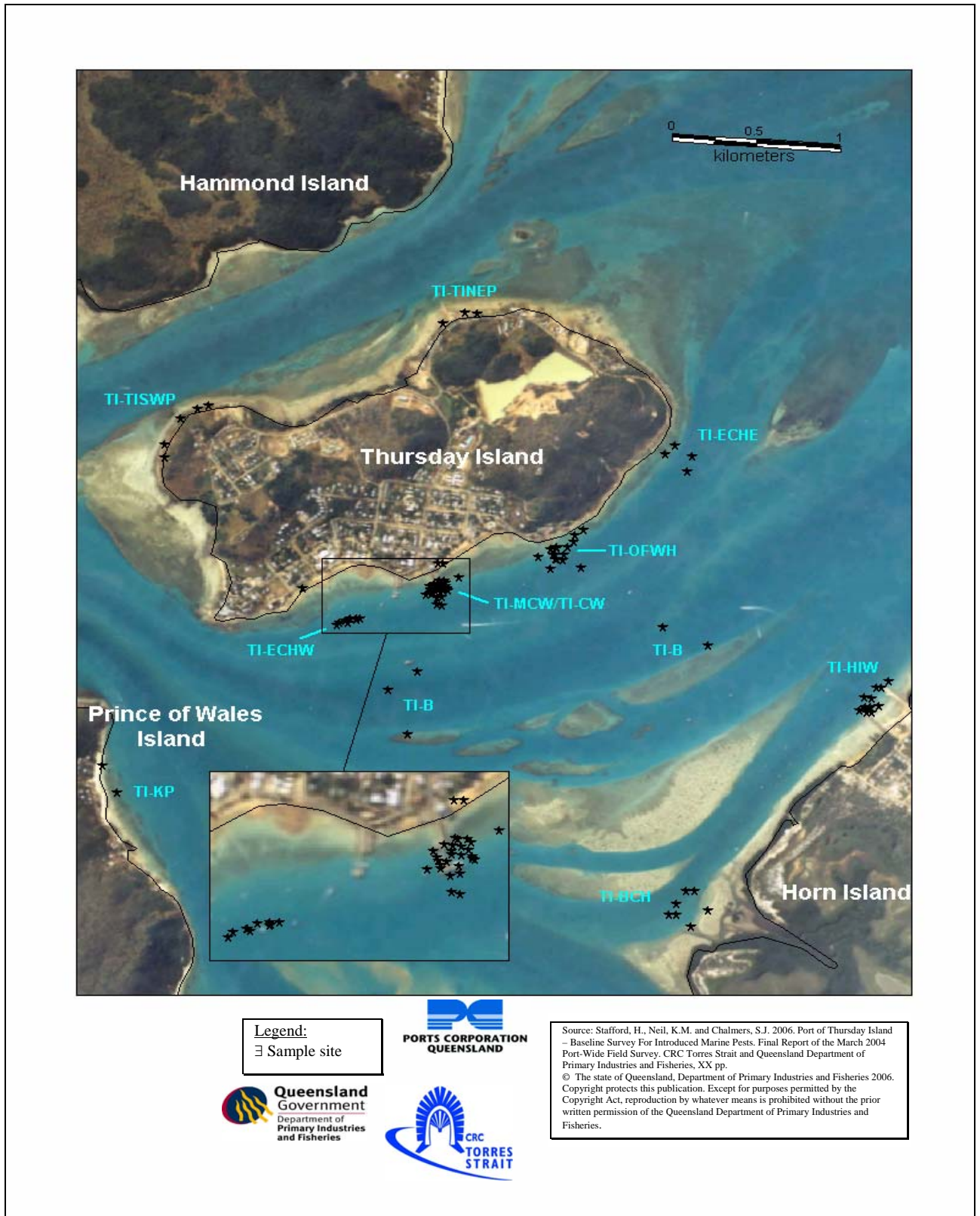
BS = Beach seine

BW = Beach wrack

RS = Rock Shore survey

SP = settlement plate check

DC = Dinoflagellate cyst sediment samples - opportunistic collection where appropriate sediment available. Indications of potential sampling sites provided



**Figure 1:** Location of sample sites in and adjacent to the Port of Thursday Island.

### **3.2 Variations from the suggested sampling protocols**

A number of sampling tools suggested for use in Hewitt and Martin (1996, 2001) during a port baseline survey for marine pests were not utilised during the Thursday Island baseline survey. These, and the justifications for not using them, are outlined below.

#### **Fish poison stations.**

In the high flow environment of the Port of Thursday Island currents carry the poison away from the area targeted prior to it taking effect. As such, this method would not prove effective for collection of small fish and was not used. Beach seines and trapping were instead used to provide a reference collection of mobile fishes and scrape samples were used to collect benthic fishes associated with piles.

#### **Underwater visual searches/sediment cores.**

During the survey underwater visual transects of seabed areas were not conducted due to a potential risk of attack by estuarine crocodiles, sharks and dangerous fish, which are common inhabitants of waters in the Thursday Island area. As an alternative to visual surveys of the seabed, benthic epifauna and infauna were sampled with two devices: a modified Ockelmann sledge-dredge (benthic sled) and a beam trawl. When used in conjunction, these devices effectively sample mobile and sessile benthic epifauna and infauna, and obtain a representative sample of organisms normally observed by divers during visual transect surveys (Hoedt et al., 2001c). We also used a van Veen grab as an alternative to diver hand coring (Hewitt and Martin, 1996). The grab is an efficient method of collecting large-sized samples of benthic sediment for benthic infauna, dinoflagellate cyst and sediment analysis (Wigley, 1967; Smith & Howard, 1972). These deviations from the original (1996) CRIMP port survey protocols have been endorsed by the CRIMP group for previous surveys undertaken by the CRC group and included as acceptable sampling methods in the revised CRIMP sampling protocols (Hewitt & Martin, 2001).

#### **Organic content of sediment (optional).**

Sediment granulometry was carried out, however, the organic content of sediments was not analysed due to funding restrictions.

### **3.3 Variations from the proposed sampling design**

Eleven samples originally proposed were not collected during the survey. Details of these deviations with justifications for such are outlined below.

#### **Hard Substrate Sampling**

Only one half-meter pile scrape (not three) was collected from two of the wharf areas noted for sampling (ie four half – meter scrapes were not collected). Visual inspection demonstrated that taxa present at a half-meter were sparsely distributed and sites were similar in their taxonomic composition. As such, four scrapes were not taken as they would not have contributed to the number of taxa collected, only the biomass, and then only marginally (i.e. by three or four barnacles per scrape).

At two wharf locations (Main Cargo Wharf and Customs Wharf) it was not possible to collect all three -7m samples as sufficient depth was not present across the entire area sampled. Instead of collecting three 7m (below MSL) samples at these locations, two 7m (below MSL) samples (where the depth was available) and one 6m (below MSL) sample was collected from the Main Cargo Wharf, and two 7m (below MSL) samples and one -6m sample was collected from the Customs Wharf.

#### **Soft Substrate Sampling**

A number of proposed trawls (6) and one proposed sled sample were not collected during the survey. In a number of locations coral/rocky substrate hindered the collection of benthic trawls, which trailed a fine mesh net. On several occasions poor weather (presence of two cyclones in northern Queensland waters) also hindered sampling efforts. In one location (north-eastern channel off Thursday Island) only one sled was collected as the presence of underwater cables/pipes restricted the ability to drag gear across the substrate. In locations where proposed trawls were not collected additional grab samples (17 additional grabs in total) were taken to contribute to the benthic infauna and epifauna information collected. It was anticipated that this additional sampling in combination with information collected from the sled samples would be sufficient to detect any marine invasive taxa in the areas sampled, if they were present.

#### **Pelagic Sampling**

Crab and shrimp pot sampling was attempted on two separate occasions. On both occasions the sampling gear was removed (suspected stolen) prior to the catch being checked by field staff. Crab and shrimp sampling was therefore abandoned. It was hoped that other sampling tools would provide information regarding the crustacean fauna that should have been

sampled using the pots, however, it is recognised that taxa that may have been collected through this technique will likely be underrepresented in this study.

## **4 Methodology**

### **4.1 Subtidal and Intertidal Hard Substrate Sampling**

Sampling of the hard substrata biota associated with engineered structures such as, wharf and jetty piles was undertaken at the main cargo wharf (TI-MCW), Customs wharf (TI-CW), old fuel wharf (TI-OFW) and Navy wharf (TI-NW). Scrape samples were collected (except for deviations noted above) from three piles per berth at three depths on each pile, i.e. 0.5m, 3m and 7m below Mean Sea Level (MSL), as recommended by Hewitt & Martin (1996, 2001). In addition to the quadrat scrape samples, close-up still photographs of the fouling community on the hard substrate surfaces were made immediately prior to the destructive sampling at each site. When scraping, all fouling organisms within the 0.1m<sup>2</sup> quadrat were carefully removed and guided into collection bags. Each sample was hauled to the surface and immediately sorted and processed. Samples were separated into those taxa to be preserved in alcohol (mainly sponges and hydroids) and those taxa to be fixed in seawater buffered formaldehyde, as per specimen preservation guidelines outlined in Hewitt & Martin (1996, 2001).

### **4.2 Visual Surveys of Hard Substrates**

Visual surveys of hard substrates were conducted at a number of locations within the Port of Thursday Island. Examples of the different taxa found within these areas were collected and preserved for taxonomic analysis. The locations of many of these surveys were decided following on-site assessment. The extent of these surveys was time restricted as workplace safety requirements limit time spent diving in areas known to harbour dangerous marine taxa (primarily crocodiles).

### **4.3 Soft Substrate Sampling**

#### **4.3.1 Benthic Infauna (Grab samples)**

Soft-bottom benthic infauna samples at Thursday Island were collected using a van Veen grab as outlined above. The van Veen grab used collects a block of sediment of approximate dimensions 25cm x 25cm wide and 13cm deep. Paired soft-bottom benthic infaunal samples were collected adjacent to each diver-sampled wharf pile. One grab sample was collected 2m from the base of these piles (to avoid the debris layer of dead pile-fouling organisms at the pile base), and a second grab sample was collected 50m from, and perpendicular to, the berth. A total of 15 grab samples were collected from TI-CW, TI-OFW, TI-MCW, TI-NW and Horn Island wharf (TI-HIW). An additional sediment grab was taken at each of these sites for granulometry analysis.

All samples were carefully washed through a 0.5mm sieve, with retained biota fixed in 10% formalin/seawater solution for a period of 24 hours before transfer to 70% alcohol for preservation.

### **4.3.2 Mobile Epibenthos**

#### **Beam Trawl Samples**

A lightweight aluminium beam trawl was used to sample mobile epibenthos. The beam trawl has mouth dimensions of 180 cm x 70 cm with a mesh of 3 mm. To optimise catches samples were collected at dusk (Hoedt *et al.*, 2001). For each sample the beam trawl was towed for 10 minutes across seafloor depths ranging -1m to -9m at six different locations. A total of 12 beam trawl samples were collected and sorted for fixing and preservation as per the method described for scrape samples.

#### **Modified Ockelmann Sled-Dredge**

A modified Ockelmann sledge-dredge was used to collect soft substrate epibenthos. The steel sledge-dredge has mouth dimensions of 50 cm x 14 cm and a 6mm steel mesh net. It was towed along the bottom with the mouth partially digging into the sediment to sample both mobile infauna and benthic epifauna. Tows were 100m in length (depending on sediment type) at depth range of -1m to -9m at the same locations described above for the beam trawl. A total of 12 sled samples were collected and sorted for fixing and preservation as per the method described for scrape samples.

### **4.3.3 Crab and Shrimp Traps**

For the reasons noted above crab and shrimp trapping was not conducted.

### **4.3.4 Plankton Sampling**

Zooplankton was collected using a 100 µm mesh ring net, and phytoplankton with a 20 µm mesh ring net. A horizontal surface tow (5 minutes duration) and a vertical tow (three vertical drops of the net) were taken from the TI-CW, TI-OFWH and TI-HIW with each net type.

Zooplankton samples were preserved in 10% formaldehyde/seawater solution while the phytoplankton samples were preserved in 2% glutaraldehyde-seawater solution. A total of 12 samples were collected (i.e. 6 phytoplankton and 6 zooplankton).

### **4.3.5 Fish**

Near-shore fish communities were sampled with a beach seine net (50m long with 12mm mesh). It was proposed that three samples be collected from three different sites; on the north east and south west points of Thursday Island (TI-NEP and TI-SWP). Based on on-site inspection, two additional sampling sites were added to the beach areas north and south of

the main cargo wharf. The distribution of these sites ensured a comprehensive coverage of the Thursday Island area. A total of 5 samples were collected, with each sample comprising a ~100m shore parallel tow, ending on the beach to facilitate catch sorting. Fish and other biota were identified in the field. Specimens not identified in the field were euthanised and preserved in 10% formalin/seawater solution for a period of 24 hours prior to transfer to 70% alcohol.

#### **4.3.6 Dinoflagellate Cyst Samples**

Six samples of sediment were collected, using a van Veen grab, for dinoflagellate cyst analysis. It was proposed samples be collected from two sites, Ellis Channel west (TI-ECHW) and Boating Channel (TI-BCH), after preliminary sampling it was determined that the sediment type in those areas was that which is deemed not suitable for dinoflagellate cysts. Two new sites were selected at the TI-MCW as the sediment type in those areas was that which is deemed suitable for dinoflagellate cysts. Within six hours of collection these samples had been despatched by priority airfreight to the University of Tasmania laboratories for cyst culture and identification.

#### **4.3.7 Beach Drift Surveys for Crab Exuviae**

Searches for crab exuviae on beach and rocky shorelines were undertaken during low tide at three sites. Beach and rocky areas that were examined were located along the TI-NEP, TI-SWP and Kiwain Point (TI-KP). Any crab exuviae that were found were identified in the field and replaced, or, if unable to be identified in the field the exuviae were collected for identification in the laboratory at a later date.

#### **4.3.8 Sediment Sample**

Sediment samples for particle size analysis were collected from four main areas around Thursday Island (TI-MCW, TI-NEP, TI-SWP, TI-HIW, TI-OFW), using the van Veen grab. A total of 14 sediment samples were taken representing of a range of seabed characteristics within the Port of Thursday Island.

#### **4.3.9 Environmental Data**

Environmental data was collected from three main areas around Thursday Island (TI-MCW, TI-OFW and TI-NW), using a hand held water quality meter. Conductivity, Turbidity, Temperature, Salinity and pH were measured at each of the three sites.

### **4.4 Sorting and Identification Of Specimens**

Samples collected during the Port of Cairns survey underwent preliminary sorting and taxonomic analysis at the Department of Primary Industries Northern Fisheries Centre. Any taxonomic groups requiring a taxonomist specialist for identification to the lowest possible

taxonomic unit were sent to the appropriate person/institution (Table 3). As a significant component of the coastal marine fauna of tropical Australia is yet to be formally described, it is not possible for experts to fully identify all taxa.

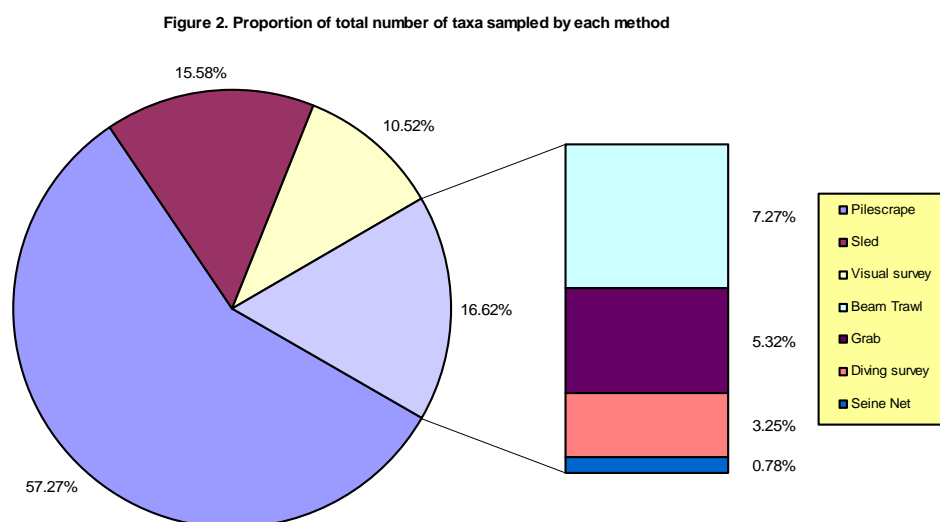
**Table 3: Marine taxonomists who cooperate with the CRC Group.**

<b>Taxonomist</b>	<b>Specialty</b>	<b>Institute</b>
Dr. P. Arnold (recently deceased)	Bryozoans	Museum Tropical QLD
Dr. G. Poore	Isopods	Museum Victoria
Dr. J. Lowry	Amphipods	Australian Museum
Dr. P. Davie	Crabs	Queensland Museum
Dr. J. Hooper	Sponges and ascidians	Queensland Museum
Dr. P. Hutchings	Polychaete worms	Australian museum
Dr. J. Watson	Hydrozoans	Private
Dr. G. Hallegraeff	Dinoflagellate cysts and phytoplankton	University of Tasmania
Dr. A. Bruce	Shrimps	Private
Dr. C. Watson	Polychaete worms	Private
Dr. I. Price	Algae/Seagrasses	Private
Ms J. Bite	Algae/Seagrasses	DPI Northern Fisheries
Dr. A. Dartnall	Echinoderms/sipunculids	Private
Dr. J. Wolstenholme	Corals/gorgonians/zooanthids	James Cook University
Ms G. Brodie	Nudibranchs	James Cook University
Ms C. Arango	Pycnogonids	James Cook University
Dr. B. Wilson	Tanaeidae/Ostracods	Australian Museum
Dr. R. Willan	Molluscs	Museum of Northern Territory

## 5. Survey Results

The survey sampling regime has yielded comprehensive, semi-quantitative, collections of marine plants, invertebrates, plankton, dinoflagellates and vertebrates that inhabit the various soft and hard substrata in and near the Port of Thursday Island at risk of marine pest introduction. Many of the samples collected from hard structures, particularly from the mooring buoys and channel markers, had a high proportion of encrusting calcareous taxa including corals, bivalves and bryozoa. In addition, sponges and ascidians were common. Samples collected from soft sediment habitats typically reflected the type of sediment sampled, for instance those collected from fine sediment areas were frequently dominated by seagrasses and their associated biota (polychaetes, shrimps and crabs), where as samples collected in areas where shell rubble was common were typically dominated by crustaceans and molluscs.

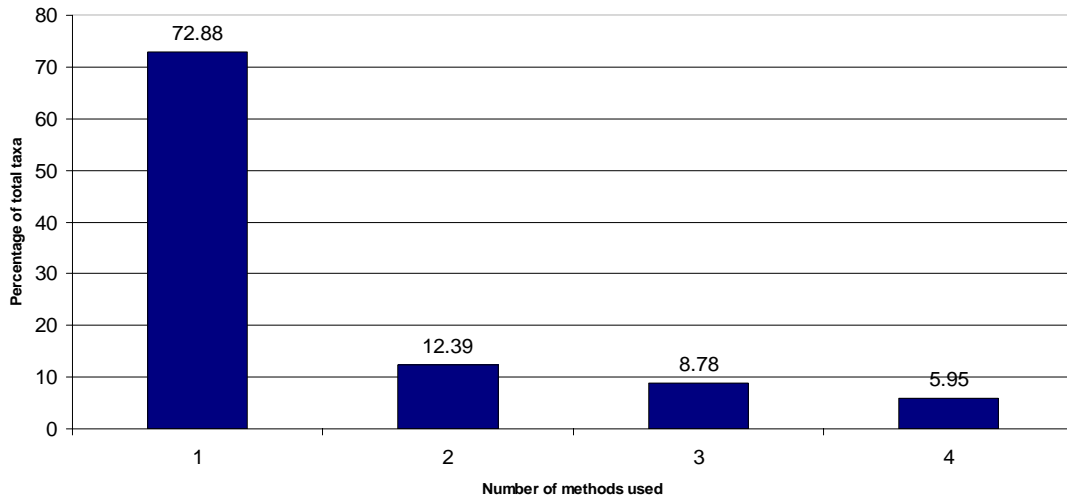
A total of 1118 individual comprising 778 different taxa that were categorised into 145 different families, belonging to 17 different phyla, were collected from scrape samples, grab samples, beam trawl samples, sled samples, visual surveys, seine nets and diving surveys in the Port of Thursday Island. Appendix 1 represents a complete list of these taxa from the Port of Thursday Island. In Thursday Island the greatest number of taxa were collected by pile scrapes, sleds, visual surveys and beam trawls with seine nets collecting the least number of taxa (Figure 2).



Of all the 1118 individuals sampled from Thursday Island approximately 1025 taxa (90%) were collected by the four main sampling methods (piles scapes, sleds, visual surveys and beam trawls) (Figure 3). Of the 1025 individuals collected by these four methods only 1 of these taxa with an abundance of 61 accounting for 5.95% was sampled by all four methods; a

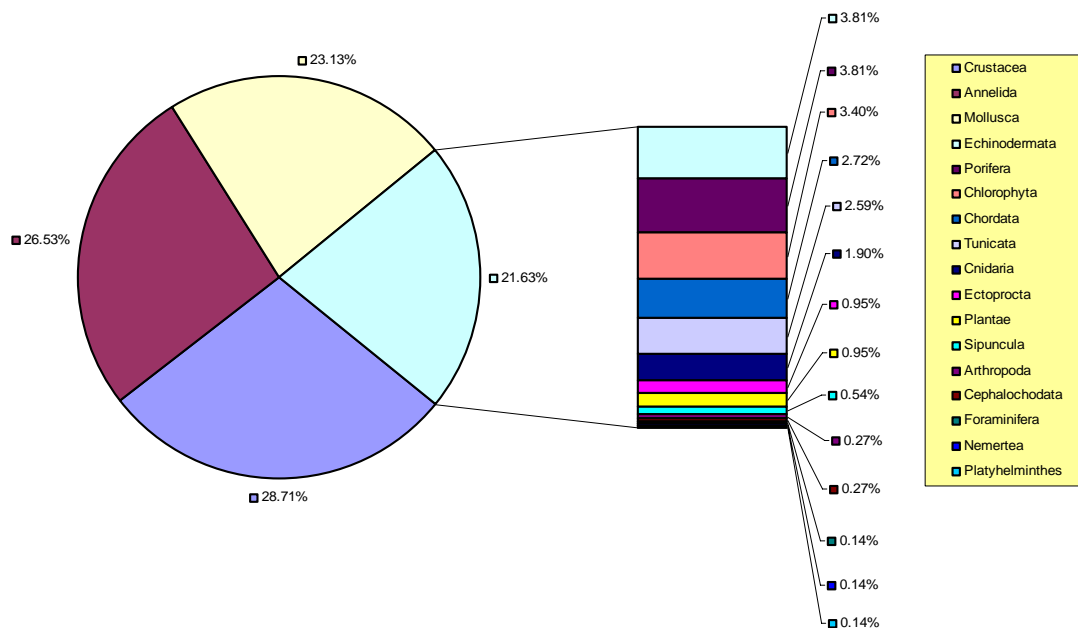
Bivalve Mollusc, *Pinctada fucata*. Approximately 72% of taxa (747 individuals) were, however, recorded from only one of the four major sampling methods. 12.39% (129) of individuals were sampled by two of the four major sampling methods and 8.78% (90) of individuals were sampled by three of the four main sampling methods (Figure 3).

Figure 3. Percentage of individuals sampled using a combination different methods



Phyla that dominated the port area were Crustaceans, Polychaetes and Molluscs. These three groupings accounted for over 78% of the 778 different taxa sampled (Figure 4). **None of the ABWMAC-listed marine pest species were detected from any of the samples.**

Figure 4. Distribution of taxa amongst phyla in the Port of Thursday Island



## 5.1 Hard Substrate Sampling

A total of 747 individuals were collected from hard substrates in the Port of Thursday Island.

### 5.1.1 Wharf Pile Scrapings

A total of 36 pile scrape samples and other hard substrate scrape samples were collected from 6 locations within the Port of Thursday Island. Areas examined by divers, had a diverse and extensive covering of fouling organisms that changed markedly with depth and location. Typically at 0.5m (below MSL), surfaces were dominated by barnacles and oysters. At 3m (below MSL) and 7m (below MSL) assemblages were primarily dominated by soft growth such as sponges, colonial ascidians and filamentous algae. However, polychaete worms, bivalves, hydroids, crustaceans and brittle stars (and other echinoderms) were also present in varying abundance. Macroalgae species were generally sparse on all wharf piles.

Taxonomic assemblage structure differed with location within the Port of Thursday Island. Filamentous fouling taxa (hydrozoans, erect bryozoans etc) were abundant on some mooring buoys and some wharf areas but were less common in other areas. Soft corals, encrusting polychaetes, sponges and mussels were also abundant.

**None of the Australia Ballast Water Management Advisory Committee (ABWMAC) target pest species (as listed in Hewitt & Martin, 2001) were observed during the field survey conducted within the Port of Thursday Island. None of the ABWMAC target species have been noted from samples that have undergone taxonomic analysis.**

### 5.1.2 Intertidal Rocky Substrates

Three intertidal collections were made from two separate habitats. Benthic invertebrates were common among the natural intertidal rocky substrata and sand beach environments that were examined. The assemblages were typically dominated by bivalve Molluscs (*Saccostrea amasa*, *Brachidontes maritimus* and various chitons) and herbivorous gastropods (Families Nassariidae and Neritidae). **None of the ABWMAC target species have been detected from samples collected from these locations.**

## 5.2 Soft Substrate Biota (Beam Trawl, Sled, Grab Samples)

A total of 223 taxa were collected from soft substrates in the Port of Thursday Island.

A total of 39 different samples of soft substrate biota were made. 15 different grab samples were collected from 6 different locations and 12 beam and 12 sled samples were each collected from 6 different locations. These samples yielded a diverse range of fauna and flora that, like the scrape samples, differed with depth and between the areas sampled. Often these differences in taxonomic composition between samples correspond to differences in the sediment characteristics of the areas examined. In some locations tube dwelling polychaete taxa and small bivalves and gastropods dominated samples where as in other locations small crustaceans and echinoderms predominated.

Within samples collected from the western edge of Ellis Channel there was a diverse array of small fish, caridean shrimps, amphipods and seagrasses (mostly *Halophila spp.* and *Cymodocea spp.*) in the trawl and sled with a number of crabs, echinoderms and bivalves also being sampled. Similarly, a diverse array of taxa were recorded from the grab samples collected from western Ellis Channel. These taxa were also represented in the samples collected from the other areas examined within the port. **None of the ABWMAC target species were detected from samples collected from areas sampled for benthic infauna.**

### 5.3 Mobile Biota

#### 5.3.1 Phytoplankton

The vertical and horizontal tows for phytoplankton yielded abundant samples from all sites. Taxonomic analysis of the phytoplankton samples found that the dominant taxa were three dinoflagellates (*Protoperidinium spp.*, *Gonyaulax polygramma*, *Goniodoma spp.*) and three diatoms (e.g. *Licmophora spp.* and *Rhizosolenia clevei*) (Table 4). There was no significant difference in the taxonomic composition of the three samples collected within the port (G. Hallegraeff, pers. comm.). No visually significant algal blooms were observed in the port's waters during the course of the survey and **no target or pest taxa were found within the phytoplankton samples.**

#### 5.3.2 Crabs and Shrimps

Crab and shrimp pot sampling was attempted on two separate occasions. On both occasions the sampling gear was removed (potentially stolen) prior to the catch being checked by field staff. Crab and shrimp sampling was therefore abandoned. From visual searches of shorelines and during visual surveys of hard substrates **no ABWMAC or CRIMP crustacean target species were seen.** It is recognised that this group is likely under-represented here.

**Table 4. Presence (+) / Absence (blank) of Plankton collected from Thursday Island**

Species	TI-CW	TI-OFW	TI-HIW
Dinoflagellates			
Amphisolenia	+		
<i>Blepharocysta</i>		+	
<i>Ceratium candelabrum</i>			+
<i>C. furca</i>	+		
<i>C. gibberum</i>	+	+	
<i>C. setaceum</i>	+	+	+
<i>C. tripos</i>		+	+
<i>Ceratocorys horrida</i>		+	
Goniodoma	+	+	+
<i>Gonyaulax polygramma</i>	+	+	+
Ornithocercus	+		
Phalacroma cuneus		+	
<i>Podolampas bipes</i>		+	+
<i>P. elegans</i>	+	+	+
<i>Prorocentrum cf. compressum</i>		+	
<i>Protoperidinium spp.</i>	+	+	+
<i>Protoperidinium pellucidum</i>	+		
<i>Scrippsiella</i>		+	
<i>Spiraulax</i>	+	+	
Diatoms			
Asteromphalus	+		
Bacteriastrum		+	
<i>Chaetoceros spp.</i>	+	+	+
<i>Chaetoceros dictyota</i>	+	+	
Coscinodiscus	+		
<i>Cylindrotheca closterium</i>			+
Diploneis			+
Entomoneis			+
<i>Licmophora</i>	+	+	+
<i>Proboscia</i>	+		
<i>Pseudo-nitzschia</i>		+	+
<i>Rhizosolenia clevei</i> + <i>Richelia symbiont</i>	+	+	+
<i>Streptothecca</i>		+	
<i>Surirella</i>	+		+

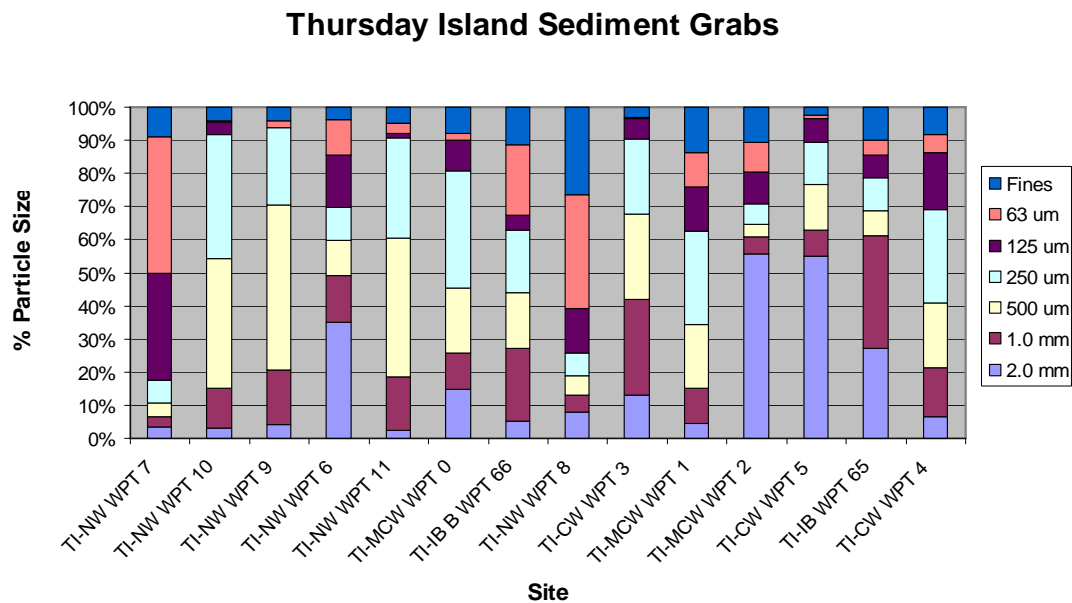
### 5.3.3 Fish

To determine whether any of the target or pest fish taxa were present within the Port of Thursday Island inshore fish assemblages were sampled using a seine net at a number of locations within the Port. Catches from the beach seines were dominated by whiting (*Sillago* spp.) and individuals belonging to the Familie Gerridae. Less common taxa included individuals belonging to the Family Scombridae, Carangidae, and Mullidae. Although a number of other fish taxa were also sampled by other techniques used during the survey; a

complete list of these species is found in Appendix 1. **None of the pest or target taxa have been recorded from samples.**

#### 5.4 Sediment Samples and Dinoflagellate Cyst Samples

Sediment samples collected for grain size analysis had a high level of variation between sites (Figure 5). Course sediments were generally more dominant; samples were comprised of coarser coralline sands with small rock and coral rubble. Fine sediments were less evident in samples, particularly from those taken adjacent to wharves that are subject to propeller disturbance. Regular disturbance likely resuspends such particles impacting the granulometry of surrounding habitats. These sediment grain size profiles of the areas sampled will also be subject to temporal variability in the deposition of sediments and the disturbance of the substrates as a result of vessel traffic within the area and dredging activities.



**Figure 5. Sediment grabs taken from the Port of Thursday Island.**

In addition to granulometry analysis, sediment samples were subject to analysis for dinoflagellate cysts. The results are noted in Table 5. Sediment cysts analysis revealed one diatom dominated samples (*Cymatoseira spp.*). **None of the target toxic dinoflagellate species were detected.**

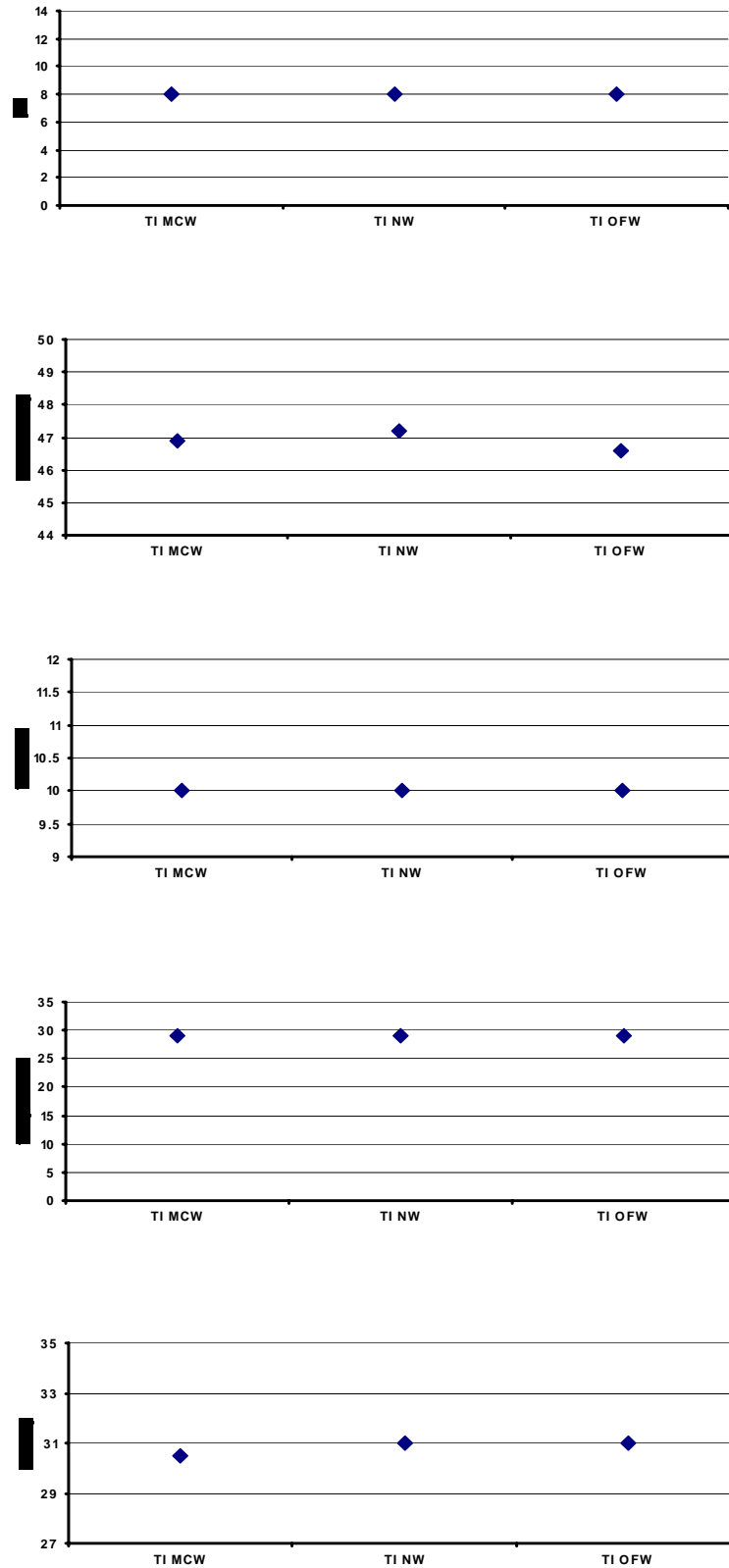
**Table 5. Presence (+) /absence (blank) of sediment cysts at Thursday Island**

Species	TI-MCW	TI-NW	TI-CW
Cysts			
Unidentified brown spore	+		
Small spinose gonyaulacoid cyst		+	
Scrippsiella		+	
<i>Diatoms</i>			
Actinoptychus	+		
Cymatoseira	+	+	+
Odontella	+		
Paralia	+		+
Pleurosigma	+		
Skeletonema		+	
Cyanobacteria			
<i>cf. Lyngbya</i>	+		

## 5.5 Environmental Data

Water temperature, salinity, turbidity, pH, conductivity, and dissolved oxygen levels did not vary greatly between the three collection sites (Figure 6).

Figure 6. Environmental data collected from three sites located on West Ellis Channel



## 6. Introduced taxa and summary

### 6.1 Introduced Taxa

#### 6.1.1 Presence of Target Species

Logistical and cost constraints limit both the taxonomic and spatial scope of any survey of species inhabiting a port. Recognition of these constraints led the AAPMA and CRIMP to adopt a targeted approach which concentrates on determining whether a known group of species are present in any one habitat. Species listed on the ABWMAC schedule of introduced pest species are summarised in Table 6. Detection of many of these can be achieved by simple visual recognition. The field team personnel involved in the Port of Thursday Island survey were familiar with their appearance to the extent they could readily recognise them during the field survey, and ensure samples were taken of these or suspected taxa for confirmatory expert analysis.

**Table 6: Occurrence ('x') of ABWMAC target species in different port habitats (adapted from Hewitt and Martin, 2001, includes black-striped mussel and Asian green mussel).**

Target species	Habitat				
	Soft substrata	Hard substrata	Seagrass/ algal bed	Plankton /nekton	Beach wrack (strand line)
Mediterranean Fan Worm					
<i>Savella spallanzanii</i>	X	X	X		X
European Green Crab					
<i>Carcinus maenas</i>	X	X	X	X	X
NW Pacific Sea Star					
<i>Asterias amurensis</i>	X	X			X
Japanese Oyster (feral)					
<i>Crassostrea gigas</i>		X			
Asian Clam					
<i>Corbula gibba</i>	X		X		X
Senhouse's Date Mussel					
<i>Musculista senhousia</i>	X	X	X		X
Black-striped mussel					
<i>Mytilopsis sallei</i>		X			X
Asian green mussel					
<i>Perna viridis</i>		X			
Toxic Dinoflagellates					
<i>Alexandrium cantenella</i>	X			X	
<i>Alexandrium minutum</i>	X			X	
<i>Alexandrium tamarense</i>	X			X	
<i>Gymnodinium catenatum</i>	X			X	
Japanese Kelp					
<i>Undaria pinnatifida</i>		X	X		X

**Following taxonomic analysis of samples collected during the Port of Thursday Island survey it has been determined that none of the ABWMAC or CRIMP target species were**

seen to be present either during the survey of the Port of Thursday Island and associated habitats or within any of the samples collected from Thursday Island during the survey. Note that restricted funding for this project limited the taxonomic analysis of samples. Only key target groups, being those Families or Phyla noted above (Table 6) were subject to detailed taxonomic analysis. All samples have been lodged with the Museum and Art Gallery of Northern Territory and if further support is obtained remaining unidentified taxa will be subject to taxonomic analysis.

### 6.1.2 Non Target Specie

No black-striped mussels (*Mytilopsis salleri*) or Asian Green Mussels (*Perna viridis*) and none of the ABWMAC target pest species (as listed in Hewitt & Martin, 2001) were observed during the Port of Thursday Island baseline survey.

### 6.1.3 Cryptogenic Species

A cryptogenic species is one 'of uncertain origin that is neither demonstratively native or introduced' (Carlton, 1996). A native species is one that has a distributional and historical record implying that it occurs naturally in a region where they are found. A number of species collected at the port were tentatively classed as cryptogenic. After expert taxonomic analysis no taxa collected in the Port of Thursday Island survey were classified as cryptogenic.

## 6.2 Invasive taxa vectors

Introduction of exotic species to the Port of Thursday Island could potentially occur via:

- Direct introduction from international ports via shipping, either by ballast water or hull fouling
- Domestic translocation from commercial or recreational vessels
- Natural range expansion if species had previously been introduced to other parts of the coast of Australia

The Port of Thursday Island is subject to a large volume of small to medium sized commercial and recreational shipping and has facilities to accommodate illegal foreign vessels. A number of the Asian destinations that are the source ports for recreational and commercial vessels visiting Thursday Island include Singapore, Taiwan and Hong Kong. These areas are suggested to pose a moderate to high risk of being a source of introduced taxa to the Port of Thursday Island. A thorough analysis of risks associated with pest vectors, their management for the Torres Strait area was captured in a recent desktop study conducted for the Northern Planning Area. This study indicated that within the Northern Planning Area the Torres Strait region was classed as one of the highest risk areas for potential marine pest introduction due to the vector movements through the area and management arrangements of those vectors (Neil *et al.* 2005). The study also indicated that the Asian green mussel (*Perna viridis*) and the black striped mussel (*Mytilopsis salleri*) were of high concern for being introduced to the

region. These taxa are prolific fouling organisms and may be transported as a result of hull fouling on recreational or commercial vessels. These taxa are known to have detrimentally impacted the ecology and economy of areas they have previously been introduced to by outcompeting native taxa for resources and therefore altering trophic dynamics and biodiversity, and by impacting through fouling on users of marine areas.

Asian green mussels were first discovered in Cairns in 2001 and it is possible they are still present in Cairns Harbour. This raises concerns that they could be transferred to other ports such as the Thursday Island, which receives weekly shipping from Cairns (barges) as a result of domestic and commercial shipping and natural dispersal mechanisms.

The black striped mussel has been eradicated successfully from Darwin (A. Marshall, pers. comm.). Since that event black striped mussels, Asian green mussels and other potential pests have been detected, as a result of a preventative inspection protocol, fouling recreational and foreign fishing vessels entering the Darwin area. Repeated inoculation of the Darwin region with black striped mussels has been avoided through early detection and removal of these pests prior to vessels entering Darwin marinas or being moored. This demonstrates a risk that vessels entering the Torres Strait that are not undergoing similar inspections for pests, especially foreign fishing vessels being quarantined for prosecution, may be transferring marine pests of concern to the Torres Strait region. Management options to mitigate this vector risk are discussed by Neil *et al.* 2005.

The risks associated with the domestic translocation of introduced marine pests as a result of hull fouling, ballast water, and natural dispersal within a port, between ports and to other habits are largely unknown and unexplored. It is widely recognised that vectors such as hull fouling and ballast water discharge practices (among others) have repeatedly resulted in the unintentional transfer of exotic aquatic organisms between and within many regions of the world. While natural dispersal mechanisms may have real potential to increase the range of the pest infestations within a port, the risk of these taxa naturally dispersing to other areas within Queensland are unknown.

There is a greater risk that the taxa could be transferred as a result of fouling or the domestic transfer of ballast water. The discovery of these taxa on various vessel types in Cairns indicates the taxa are robust enough to survive translocation between international harbours via fouling. The discovery of the Asian green mussel on a vessel that was entering Darwin also indicates the strong potential for the introduction of this taxa through fouling mechanisms to other tropical ports.

There is relatively little information on introduced species in tropical Australian waters, possibly in part due to a lack of research. The series of surveys undertaken by the CRC

Torres Strait Introduced Marine Pest Group within tropical Australia is helping to address this and information from this series was used to support the assessment of marine pest risks, vectors and management options for the Torres Strait region (see Neil *et al.* 2005).

Hayes *et al.* (2002) has also conducted a study that identified taxa that are not yet introduced to Australian waters but which pose a potential for introduction and a hazard with respect to human, ecological and economic impacts. This study identified 33 exotic taxa that have been responsible for environmental and/or economic harm and have a demonstrated capability of ship-mediated invasion. The approach adopted by Hayes *et al.* (2002) for developing their list was an inductive hazard assessment that allowed taxa to be ranked into high, medium and low impact hazard groups relative to human impacts, and ecological and economic impacts. In all cases only one taxa ranked as a high priority regarding potential impacts on all categories and had a high potential for invading; the Asian green mussel (Table 7). The closely related brown mussel, *Perna perna*, that is native to South Africa was ranked as having a medium human, ecological and economic impact but low invasion potential.

The risk assessment undertaken by Hayes *et al.* (2002) listed Asian green mussel as having a high potential for introduction to Queensland waters and agreed with the assessment undertaken by Neil *et al.* (2005). Clearly the presence of this taxa in both Queensland and the Northern Territory waters (although eliminated from the latter) is strong evidence of the capabilities of this taxa (and other similar taxa) to be transported to and colonise tropical Australian coastal habitats. Furthermore, its introduction (along with taxa such as the Caribbean tube worm) to tropical regions in Australia highlights the need to further examine hull fouling as a vector for introduced marine pests.

**Table 7: Taxa considered to pose a risk of introduction to Australian waters ranked according to their potential human, ecological and economic impacts (adapted from Hayes *et al.*, 2002).**

Species	Common Name	Ranking (Impact potential; Invasion potential)	
		Human	Ecological/Economic
<i>Perna viridis</i>	Asian green mussel	Med - High; High	Med - High; High
<i>Blackfordia virginica</i>	Jellyfish	Med - High; Low	Low - Med; Low
<i>Dinophysis norvegica</i>	Dinoflagellate	Med - High; Low	Low - Med; Low
<i>Maeotias marginata</i>	Jellyfish	Med - High; Low	Low - Med; Low
<i>Perna perna</i>	Sth African brown mussel	Med - High; Low	Low - Med; Low
<i>Pseudo-nitzschia seriata</i>	Diatom (pennate)	Med - High; Low	Low - Med; Low
<i>Limnoperna fortunei</i>	Golden mussel	Low - Med; Med	Med - High; Med
<i>Balanus eburneus</i>	Ivory barnacle	Low - Med; Med	Low - Med; Med
<i>Hemigrapsus penicillatus</i>	Japanese shore crab	Low - Med; Med	Low - Med; Med
<i>Pseudodiaptomus marinus</i>	Asian copepod	Low - Med; Med	Low - Med; Med
<i>Womersleyella setacea</i>	Filamentous red algae	Low - Med; Med	Low - Med; Med
<i>Siganus rivulatus</i>	Rabbit fish		Low - Med; Low
<i>Crepidula fornicata</i>	Gastropod	Low; Low	Low - Med; Med
<i>Callinectes sapidus</i>	Blue crab	Low; Low	Low - Med; Low
<i>Chaetoceros concavicornis</i>	Diatom (centric)	Low; Low	Low - Med; Low
<i>Chaetoceros convolutus</i>	Diatom (centric)	Low; Low	Low - Med; Low
<i>Ensis directus</i>	Jack knife or Razor clam	Low; Low	Low - Med; Low
<i>Grateloupia doryphora</i>	Red marine algae	Low; Low	Low - Med; Low
<i>Hydroides dianthus</i>	Serpulid polychaete	Low; Low	Low - Med; Low
<i>Limulus polyphemus</i>	Horseshoe crab	Low; Low	Low - Med; Low
<i>Marenzelleria viridis</i>	Spionid polychaete	Low; Low	Low - Med; Low
<i>Mya arenaria</i>	Soft shelled clam	Low; Low	Low - Med; Low
<i>Rhithropanopeus harrisi</i>	Dwarf crab	Low; Low	Low - Med; Low
<i>Ampelisca abdita</i>	Tube-dwelling amphipod		
<i>Charybdis japonica</i>	Lady crab		
<i>Liza ramada</i>	Thinlip mussel		
<i>Neogobius melanostomus</i>	Round goby		
<i>Nippoleucon hinumensis</i>	Cumacean		
<i>Pagrus major</i>	Red sea bream		
<i>Petricolaria pholadiformis</i>	False angelwing shell		
<i>Pileolaria berkeleyana</i>	Polychaete tube worm		
<i>Tortanus dextrilobatus</i>	Calanoid copepod		
<i>Tridentiger bifasciatus</i>	Japanese goby		

## 7. Conclusions

The surveys conducted in and around the Port of Thursday Island employed a large range of sampling methods that yielded a large collection of marine organisms associated with the hard substrata and benthic environments. The ABWMAC target pest species, listed in Hewitt and Martin (1996, 2001), were not identified during visual diver surveys or when preserving samples in the field or during the taxonomic analysis of samples. However, only key taxonomic groups, those known to be of high risk to the region (bivalves, crustaceans, polychaetes) were analysed to lowest taxonomic unit due to limited resources supporting this study. Gross taxonomic analysis (not to lowest taxonomic unit) of all other samples was undertaken and preliminary observations indicate that no pest taxa or cryptogenic species of concern were detected in the Port of Thursday Island. It is recognised, however, that not all crustacean taxa may have been sampled due to an inability to utilise pots and traps to sample for this fauna.

The ongoing surveys of Australian ports are an important step in the management of introduced marine species. The incidents of the black-striped mussel invasion at Darwin and the Asian green mussel invasion in Cairns have both highlighted the importance of discovering introduced species early to allow action to be taken to implement a program of control/eradication. Actions to eradicate both of these taxa followed their discovery in the respective harbours during port-wide baseline surveys. The monitoring of ports that have previously been surveyed should be continued on a periodic basis to screen for introduced species enabling appropriate action to be taken should a problem arise. This is particularly important given the lack of regulations regarding hull fouling, and the high probability that non-indigenous marine taxa, with a propensity to become pests, could be transferred to Australian waters via this mechanism. Regular port surveys are a principal means of detecting invasive taxa that may be introduced via hull fouling. An appropriate time frame for periodic surveys is every two - three years and, where applicable, surveys should incorporate a wet and dry season component to consider potential seasonal changes in species assemblages. The National System for the Prevention and Management of Introduced Marine Pest Species is addressing the need to undertake regular surveys for pests, and addressing management considerations to mitigate the risks of pest translocation. Information on the National System can be obtained from the Department of Agriculture, Fisheries and Forestry.

The port surveys currently underway were primarily designed to target ABWMAC defined pest species and other recognised introduced species, many of which are temperate species. Given the costs involved in large-scale port surveys, it is suggested that future surveys utilise information gained from a baseline survey to identify habitats within a port that pose a high risk of receiving introduced taxa and to identify sampling mechanisms that gain the most information in the most cost effective manner. As the highest risk species for tropical

Queensland ports are those from tropical regions overseas, ecological information, gained from the source ports, on the taxa that may pose a risk of being transferred to Australian waters (including those identified by Hayes et al., 2002), should also be considered when designing monitoring surveys for Australian ports.

The survey conducted in and around the Port of Thursday Island in March 2004 drew upon knowledge of tropical port baseline surveys conducted in Queensland to date by the CRC Reef and CRC Torres Strait team and utilised a range of recommended sampling equipment, methods and sites, to yield a collection of marine biota. No black-striped mussels and none of the other larger ABWMAC target pest species (as listed in Hewitt and Martin, 2001) were observed during the intertidal censuses and at the completion of sorting and preserving the samples that were collected.

Further information on marine pest risks, vectors and management arrangements for the Torres Strait region are discussed in detail in Neil *et al.* (2005) and further information on the National System is available from the Department of Agriculture, Fisheries and Forestry.

## 8. References

- Carlton, J.T. 1996. Biological invasions and cryptogenic species. *Ecology* 77(6): 1653-1655.
- Carlton, J.T. and Geller, J. 1993. Ecological roulette: the global transport and invasion of nonindigenous marine organisms. *Science* 261: 78-92.
- Hayes, K.R., McEnnulty, F.R. and Sliwa, C. 2002. Identifying potential marine pests – an inductive approach. Final report for Environment Australia National Priority Pests Project, CSIRO Marine Research, Centre for Research on Introduced Marine Pests.
- Hewitt, C.L. and Martin, R.B. 1996. Port surveys for introduced marine species - background considerations and sampling protocols. Centre for Research on Introduced Marine Species Technical Report No. 4. CSIRO Hobart, Tasmania.
- Hewitt, C.L. and Martin, R.B. 2001. Revised protocols for baseline port surveys for introduced marine species: survey design, sampling protocols and specimen handling. Centre for Research on Introduced Marine Species Technical Report No. 22. CSIRO Hobart, Tasmania.
- Hoedt, F.E., Choat, J.H., Collins J.C., and Cruz, J.J. 2001c. Sample collection methods and practical considerations for introduced species surveys at tropical ports. CRC Reef Research Technical Report No. 35, Townsville, Qld.
- Neil, K.M., Hilliard, R., Clark, P. and Russell, B.C. 2005. *A Situation and Gaps Analysis of IMS, Vectors, Nodes and Management Arrangements for the Northern Planning Area*. An independent report by CRC Reef, URS Perth and the MAGNT for National Oceans Office Branch of the Department of Environment and Heritage. 177 pp.
- Smith, K.L. and Howard, J.D. 1972. Comparison of a grab sampler and large volume corer. *Limnology and Oceanography*, 17: 142-145.
- Thresher, R. 1999. Diversity, impacts and options for managing invasive marine species in Australian waters. *Australian Journal of Environmental Management* 6: 137-148.
- Wigley, R.L. 1967. Comparative efficiencies of van Veen and Smith-McIntyre grab samplers as revealed by motion pictures. *Ecology*, 48: 168-169.

# Appendix 1

**Taxa sampled (by method) from the Port of Thursday Island during the port-wide baseline survey for introduced marine pests.**

**Taxa sampled (by method) from the Port of Thursday Island during the port-wide baseline survey for introduced marine pests. BW = beach wrack, BT = beam trawl, BG = benthic grab, PS = pile scrape, SN = seine net, S = sled, FD = free dive.**

Phylum	Family	Species	BT	FD	BG	PS	SN	S	BW
Annelida	Acrocirridae	sp1				1			
Annelida	Acrocirridae	sp2				1			
Annelida	Capitellidae	sp1				1			
Annelida	Cirratulidae	sp1				1			
Annelida	Dorvilleidae	sp1			1				
Annelida	Eunicidae	afra paupera				1			
Annelida	Eunicidae	collaris		1		4			
Annelida	Eunicidae	siciliensis				3			
Annelida	Eunicidae	sp1				2			
Annelida	Eunicidae	sp10				2			
Annelida	Eunicidae	sp11				16			
Annelida	Eunicidae	sp13				1			
Annelida	Eunicidae	sp14				1			
Annelida	Eunicidae	sp16				4			
Annelida	Eunicidae	sp17		1					
Annelida	Eunicidae	sp2				1			
Annelida	Eunicidae	sp20				1			
Annelida	Eunicidae	sp21				1			
Annelida	Eunicidae	sp23				1			
Annelida	Eunicidae	sp24				1			
Annelida	Eunicidae	sp25				5			
Annelida	Eunicidae	sp26				1			
Annelida	Eunicidae	sp27				3			
Annelida	Eunicidae	sp28			1	1			
Annelida	Eunicidae	sp3				1			
Annelida	Eunicidae	sp3						1	
Annelida	Eunicidae	sp30				1			
Annelida	Eunicidae	sp4				1			
Annelida	Eunicidae	sp6				1			
Annelida	Eunicidae	sp7				1			
Annelida	Eunicidae	sp8				1			
Annelida	Eunicidae	sp9				2			
Annelida	Eunicidae	torresiensis		1		10			
Annelida	Eunicidae	tribranchiata				1			
Annelida	Flabelligeridae	cf monroi				1			
Annelida	Glyceridae	lancadivae	1		1				
Annelida	Glyceridae	sp3			1				
Annelida	Goniadidae	cf aciculata			1				
Annelida	Hesionidae	sp.			1				
Annelida	Hesionidae	sp2			1				
Annelida	Lumbrinereidae	cf coccinea				6			
Annelida	Lumbrinereidae	sp1				14			

Annelida	Lumbrinereidae	sp2				2			
Annelida	Lumbrinereidae	sp4				1			
Annelida	Lumbrinereidae	sp5				1			
Annelida	Maldanidae	sp 24							1
Annelida	Nereididae	antipoda			1			2	
Annelida	Nereididae	maxillodentata				1		1	
Annelida	Nereididae	sp1				4			
Annelida	Nereididae	sp1				1			
Annelida	Nereididae	sp10				1			
Annelida	Nereididae	sp12						1	
Annelida	Nereididae	sp15				1			
Annelida	Nereididae	sp16	1						
Annelida	Nereididae	sp17							
Annelida	Nereididae	sp2				1			
Annelida	Nereididae	sp4				1			
Annelida	Nereididae	sp5				1			
Annelida	Nereididae	sp8						1	
Annelida	Oeonidae	sp1				1		1	
Annelida	Onuphidae	cf taeniata			1				
Annelida	Onuphidae	sp2			1				
Annelida	Opheliidae	pictus				1			
Annelida	Opheliidae	sp2						1	
Annelida	Orbiniidae	cf johnstonei			2				
Annelida	Phyllodocidae	fuscoculata				1			
Annelida	Phyllodocidae	sp1	1			1		1	
Annelida	Phyllodocidae	sp11			1				
Annelida	Phyllodocidae	uschakovi				1		1	
Annelida	Polychaetae	sp10				1			
Annelida	Polychaetae	sp13			1				
Annelida	Polychaetae	sp14			1				
Annelida	Polychaetae	sp15			1				
Annelida	Polychaetae	sp18			1				
Annelida	Polychaetae	sp20				1			
Annelida	Polychaetae	sp23			1	1			
Annelida	Polychaetae	sp24				1			
Annelida	Polychaetae	sp4						1	
Annelida	Polychaetae	sp5				1			
Annelida	Polychaetae	sp7				1			
Annelida	Polychaetae	sp8				1			
Annelida	Polynoidae	carinulatus		1		1			
Annelida	Polynoidae	cf carinulatus				1			
Annelida	Polynoidae	cristatus							
Annelida	Polynoidae	glaucus				2			
Annelida	Polynoidae	indicus							
Annelida	Polynoidae	jukesii				1			
Annelida	Polynoidae	sp1				1			
Annelida	Polynoidae	sp11				1			
Annelida	Polynoidae	sp12			1				
Annelida	Polynoidae	sp14				1			
Annelida	Polynoidae	sp15				1			

Annelida	Polynoidae	sp17							
Annelida	Polynoidae	sp18							
Annelida	Polynoidae	sp19				1			
Annelida	Polynoidae	sp4				1			
Annelida	Polynoidae	sp6				2			1
Annelida	Polynoidae	sp7				1			
Annelida	Polynoidae	sp8				1			
Annelida	Polynoidae	striata				1			
Annelida	Sabellariidae	australiensis				1		1	
Annelida	Sabellidae	branchiomma sp.				1			
Annelida	Sabellidae	lacionosa				1			
Annelida	Sabellidae	sp1						1	
Annelida	Sabellidae	sp10				1			
Annelida	Sabellidae	sp11							
Annelida	Sabellidae	sp12	1						
Annelida	Sabellidae	sp3				1			
Annelida	Sabellidae	sp6				1			
Annelida	Sabellidae	sp7				1			
Annelida	Serpulidae	cf dewae							
Annelida	Serpulidae	cf. gaymardi				1			
Annelida	Serpulidae	sp 13				1			
Annelida	Serpulidae	sp1				1			
Annelida	Serpulidae	sp11				1			
Annelida	Serpulidae	sp14				1			
Annelida	Serpulidae	sp15				1			
Annelida	Serpulidae	sp5				2			
Annelida	Serpulidae	sp7				1			
Annelida	Serpulidae	stellatus				3			
Annelida	Serpulidae	tambalagamensis	1			2			
Annelida	Serpulidae	vermicularis				1			
Annelida	Sigalionidae	sp3						1	
Annelida	Spionidae	glabrilamellata				3			
Annelida	Spionidae	queenslandica				2		1	
Annelida	Spionidae	tentaculata				1			
Annelida	Sternaspidae	scutata						1	
Annelida	Syllidae	australiensis				12			
Annelida	Syllidae	cf armillaris				1			
Annelida	Syllidae	cf hyalina				3			
Annelida	Syllidae	cf taeniformis				3			
Annelida	Syllidae	sp1				1			
Annelida	Syllidae	sp10				1			
Annelida	Syllidae	sp11				16			1
Annelida	Syllidae	sp13				3			
Annelida	Syllidae	sp15							1
Annelida	Syllidae	sp18				4			2
Annelida	Syllidae	sp19				6			
Annelida	Syllidae	sp2				1			
Annelida	Syllidae	sp21				7			1
Annelida	Syllidae	sp23				1			
Annelida	Syllidae	sp25				1			

Annelida	Syllidae	sp26				2			
Annelida	Syllidae	sp29				3			
Annelida	Syllidae	sp3				1			
Annelida	Syllidae	sp3				1			
Annelida	Syllidae	sp30							
Annelida	Syllidae	sp31				1			
Annelida	Syllidae	sp32				1			
Annelida	Syllidae	sp34				1			
Annelida	Syllidae	sp36				1			
Annelida	Syllidae	sp37				1			
Annelida	Syllidae	sp38				1			
Annelida	Syllidae	sp39						1	
Annelida	Syllidae	sp4				1			
Annelida	Syllidae	sp40						1	
Annelida	Syllidae	sp41			1	1			
Annelida	Syllidae	sp42			1				
Annelida	Syllidae	sp43						1	
Annelida	Syllidae	sp46				1			
Annelida	Syllidae	sp47			1	1			
Annelida	Syllidae	sp48			1				
Annelida	Syllidae	sp49							1
Annelida	Syllidae	sp5				1			
Annelida	Syllidae	sp50							1
Annelida	Syllidae	sp51							
Annelida	Syllidae	sp52				1			
Annelida	Syllidae	sp6		1					
Annelida	Syllidae	sp7				1			
Annelida	Syllidae	sp8							1
Annelida	Syllidae	spongicola				4			
Annelida	Terebellidae	batilla						1	
Annelida	Terebellidae	cf pacifica				4			
Annelida	Terebellidae	ingens				1			
Annelida	Terebellidae	sp3				1			
Arthropoda	Pycnogonid	sp1						1	
Arthropoda	Pycnogonid	sp2							1
Cephalochordata	Cephalochordata	sp2				1			
Cephalochordata	Cephalochordata	sp1			1				
Chlorophyta	Algae	sp1							1
Chlorophyta	Algae	sp10							1
Chlorophyta	Algae	sp11						1	
Chlorophyta	Algae	sp12		1					
Chlorophyta	Algae	sp13						1	
Chlorophyta	Algae	sp14						1	
Chlorophyta	Algae	sp15				1			
Chlorophyta	Algae	sp16				1			
Chlorophyta	Algae	sp17	1						
Chlorophyta	Algae	sp2							1
Chlorophyta	Algae	sp3				1			
Chlorophyta	Algae	sp4							1
Chlorophyta	Algae	sp5				1			

Chlorophyta	Algae	sp6	1						
Chlorophyta	Algae	sp7				1			
Chlorophyta	Algae	sp8						1	
Chlorophyta	Algae	sp9						1	
Chlorophyta	Ceramiaceae	sp1							
Chlorophyta	Halimediaceae	sp1	1					2	
Chlorophyta	Halimediaceae	sp2						1	
Chlorophyta	Polyphysacea	major sp1	1						
Chlorophyta	Rhodophyta	sp1							
Chlorophyta	Sargassaceae	sp1	1					1	
Chlorophyta	Sargassaceae	sp2	1						
Chordata	Belonidae	crocodilus crocodilus							
Chordata	Carangidae	lysan					1		
Chordata	Centropomidae	calcarifer	1						
Chordata	Chordata	sp1						1	
Chordata	Clupeidae	sp1					1		
Chordata	Gerreidae	subfasciatus					3		
Chordata	Gobiidae	sp1				2			
Chordata	Gobiidae	sp2				1			
Chordata	Hemiramphidae	quoyi					4		
Chordata	Monacanthidae	barbatus	1						
Chordata	Monacanthidae	japonicus				1			
Chordata	Monacanthidae	sp2	2						
Chordata	Monacanthidae	sp32						1	
Chordata	Mullidae	asymmetricus					1		
Chordata	Scorpaenidae	sp1						1	
Chordata	Sillaginidae	maculata					2		
Chordata	Syngnathidae	sp1	1						
Chordata	Syngnathidae	sp2						1	
Chordata	Tetradontidae	sp1	1						
Cnidaria	Acroporidae	sp1				1			
Cnidaria	Acroporidae	sp2				1			
Cnidaria	Acroporidae	sp3							
Cnidaria	Actinaria	sp1				1			
Cnidaria	Hydrozoan	sp1	1						1
Cnidaria	Hydrozoan	sp3				1			
Cnidaria	Hydrozoan	sp4				1			
Cnidaria	Hydrozoan	sp5				1			
Cnidaria	Hydrozoan	sp6				3			
Cnidaria	Hydrozoan	sp7						1	
Cnidaria	Hydrozoan	sp8				1			
Cnidaria	Plumanidae	sp1	1						
Cnidaria	Plumanidae	sp2	1						
Crustacea	Crustacean	sp1	1						
Crustacea	Crustacean	sp2	1						
Crustacea	Crustacean	sp6				1			
Crustacea	Upogebiidae	sp1				1			
Crustacea	Alpheidae	sp1				28		1	
Crustacea	Alpheidae	sp2				3			
Crustacea	Alpheidae	sp3			1	1			

Crustacea	Balanidae	sp1				1			
Crustacea	Balanidae	sp1				1			
Crustacea	Balanidae	sp2				3			
Crustacea	Balanidae	sp3				2			
Crustacea	Balanidae	sp4				1			
Crustacea	Balanidae	sp4				1			
Crustacea	Balanomorpha	sp1				2			
Crustacea	Balanomorpha	sp10				1			
Crustacea	Balanomorpha	sp11				1			
Crustacea	Balanomorpha	sp12				1			
Crustacea	Balanomorpha	sp13							1
Crustacea	Balanomorpha	sp14				1			
Crustacea	Balanomorpha	sp2							1
Crustacea	Balanomorpha	sp3				3			
Crustacea	Balanomorpha	sp5				1			
Crustacea	Balanomorpha	sp6				1			
Crustacea	Balanomorpha	sp7						1	
Crustacea	Balanomorpha	sp8				1			
Crustacea	Balanomorpha	sp9				1			
Crustacea	Caridea	sp1	1					1	
Crustacea	Cirripedia	sp33			1				
Crustacea	Crustacean	sp3				1			
Crustacea	Crustacean	sp4				1			1
Crustacea	Dikonophora	sp1	1						
Crustacea	Dikonophora	sp2							1
Crustacea	Diogenidae	sp1						1	
Crustacea	Diogenidae	sp3						1	
Crustacea	Flabellifera	sp1	1			8		2	
Crustacea	Flabellifera	sp10				1			
Crustacea	Flabellifera	sp11				1			
Crustacea	Flabellifera	sp12				1			
Crustacea	Flabellifera	sp13						1	
Crustacea	Flabellifera	sp14						1	
Crustacea	Flabellifera	sp15						1	
Crustacea	Flabellifera	sp16				1			
Crustacea	Flabellifera	sp2				2			
Crustacea	Flabellifera	sp3				2			
Crustacea	Flabellifera	sp4	1			1			
Crustacea	Flabellifera	sp5				1			
Crustacea	Flabellifera	sp6				2			
Crustacea	Flabellifera	sp7				1			
Crustacea	Flabellifera	sp8				1			
Crustacea	Flabellifera	sp9				1			
Crustacea	Galatheidae	sp1				1			
Crustacea	Gammaridea	sp1				5			
Crustacea	Gammaridea	sp10							1
Crustacea	Gammaridea	sp11				1			
Crustacea	Gammaridea	sp12				1			
Crustacea	Gammaridea	sp13				1			
Crustacea	Gammaridea	sp14				1			

Crustacea	Gammaridea	sp15				1			
Crustacea	Gammaridea	sp16				2			
Crustacea	Gammaridea	sp17				1			
Crustacea	Gammaridea	sp18				7		2	
Crustacea	Gammaridea	sp19				1			
Crustacea	Gammaridea	sp2							1
Crustacea	Gammaridea	sp20				1			
Crustacea	Gammaridea	sp21				1			
Crustacea	Gammaridea	sp22				1			
Crustacea	Gammaridea	sp23				2			
Crustacea	Gammaridea	sp26				1			
Crustacea	Gammaridea	sp27				1			
Crustacea	Gammaridea	sp28				1			
Crustacea	Gammaridea	sp29				1			
Crustacea	Gammaridea	sp3				1			
Crustacea	Gammaridea	sp30				1			
Crustacea	Gammaridea	sp31				1			
Crustacea	Gammaridea	sp32				1			
Crustacea	Gammaridea	sp33				1			
Crustacea	Gammaridea	sp34	1						
Crustacea	Gammaridea	sp35				1			
Crustacea	Gammaridea	sp36				1			
Crustacea	Gammaridea	sp37				1			
Crustacea	Gammaridea	sp38				1			
Crustacea	Gammaridea	sp39				1			
Crustacea	Gammaridea	sp4				1			
Crustacea	Gammaridea	sp40				1			
Crustacea	Gammaridea	sp41				1			
Crustacea	Gammaridea	sp42				1			
Crustacea	Gammaridea	sp43		1					
Crustacea	Gammaridea	sp44			1				
Crustacea	Gammaridea	sp45						1	
Crustacea	Gammaridea	sp46						1	
Crustacea	Gammaridea	sp47				1			
Crustacea	Gammaridea	sp48				1			
Crustacea	Gammaridea	sp49				1			
Crustacea	Gammaridea	sp5				1			
Crustacea	Gammaridea	sp50						1	
Crustacea	Gammaridea	sp51				1			
Crustacea	Gammaridea	sp52				1			
Crustacea	Gammaridea	sp53				1			
Crustacea	Gammaridea	sp54				1			
Crustacea	Gammaridea	sp55				1			
Crustacea	Gammaridea	sp56				1			
Crustacea	Gammaridea	sp57				1			
Crustacea	Gammaridea	sp58				1			
Crustacea	Gammaridea	sp59				1			
Crustacea	Gammaridea	sp6				1			
Crustacea	Gammaridea	sp60				1			
Crustacea	Gammaridea	sp61				1			

Crustacea	Gammaridea	sp62				1			
Crustacea	Gammaridea	sp63				1			
Crustacea	Gammaridea	sp64				2			
Crustacea	Gammaridea	sp65				1			
Crustacea	Gammaridea	sp66				1			
Crustacea	Gammaridea	sp67				1			
Crustacea	Gammaridea	sp68				1			
Crustacea	Gammaridea	sp69				1			
Crustacea	Gammaridea	sp7				1			
Crustacea	Gammaridea	sp70							1
Crustacea	Gammaridea	sp71							
Crustacea	Gammaridea	sp72							
Crustacea	Gammaridea	sp73							
Crustacea	Gammaridea	sp74							1
Crustacea	Gammaridea	sp75				1			
Crustacea	Gammaridea	sp8				1			
Crustacea	Gammaridea	sp9							1
Crustacea	Hippidae	sp1						1	
Crustacea	Leucosiidae	sp1						1	
Crustacea	Luciferidae	sp1	2						
Crustacea	Luciferidae	sp2	1						
Crustacea	Majidae	sp2						1	
Crustacea	Majidae	sp3						1	
Crustacea	Malacostraca	sp1				3			
Crustacea	Malacostraca	sp10				1			
Crustacea	Malacostraca	sp11				1			
Crustacea	Malacostraca	sp12				1			
Crustacea	Malacostraca	sp13				1			
Crustacea	Malacostraca	sp14				1			
Crustacea	Malacostraca	sp15				1			
Crustacea	Malacostraca	sp16				1			
Crustacea	Malacostraca	sp17				1			
Crustacea	Malacostraca	sp18				1			
Crustacea	Malacostraca	sp19				1			
Crustacea	Malacostraca	sp2	1			1			1
Crustacea	Malacostraca	sp20				1			
Crustacea	Malacostraca	sp21				1			
Crustacea	Malacostraca	sp22				1			
Crustacea	Malacostraca	sp23				1			
Crustacea	Malacostraca	sp24						1	
Crustacea	Malacostraca	sp25				1			
Crustacea	Malacostraca	sp26				1			
Crustacea	Malacostraca	sp27				1			
Crustacea	Malacostraca	sp28				1			
Crustacea	Malacostraca	sp29				1			
Crustacea	Malacostraca	sp3				1			1
Crustacea	Malacostraca	sp30				1			
Crustacea	Malacostraca	sp31				1			
Crustacea	Malacostraca	sp32						1	
Crustacea	Malacostraca	sp33						1	

Crustacea	Malacostraca	sp34				1			
Crustacea	Malacostraca	sp35				1			
Crustacea	Malacostraca	sp36				1			
Crustacea	Malacostraca	sp37				1			
Crustacea	Malacostraca	sp38				1			
Crustacea	Malacostraca	sp39							
Crustacea	Malacostraca	sp4				1			
Crustacea	Malacostraca	sp5				1			
Crustacea	Malacostraca	sp6				1			
Crustacea	Malacostraca	sp7						1	
Crustacea	Malacostraca	sp8				1			
Crustacea	Malacostraca	sp9				1			
Crustacea	Melitidae	sp1				1			
Crustacea	Melitidae	sp25				4			
Crustacea	Melitidae	sp26				1			
Crustacea	Melitidae	sp5				1			
Crustacea	Melitidae	sp25				1			
Crustacea	Metapeaneus	sp3	1						
Crustacea	Monokonophora	sp1				3			
Crustacea	Monokonophora	sp2				2			
Crustacea	Mysidacea	sp1	1						
Crustacea	Ostracoda	sp1	1						
Crustacea	Paguroidea	sp1						2	
Crustacea	Pandalidae	sp1	1						
Crustacea	Parthenopidae	sp1						1	
Crustacea	Parthenopidae	sp2						1	
Crustacea	Parthenopidae	sp3							
Crustacea	Penaeidae	Metapenaeopsis	1						
Crustacea	Penaeidae	sp1						1	
Crustacea	Penaeidae	sp2						1	
Crustacea	Penaeidae	sp3	1						
Crustacea	Penaeidae	sp4						1	
Crustacea	Penaeidae	sp5						1	
Crustacea	Penaeidae	sp6						1	
Crustacea	Penaeidae	sp7						1	
Crustacea	Portunidae	miles	1						
Crustacea	Sergestidae	sp1	2						
Crustacea	Sergestidae	sp2	3						
Crustacea	Sphaeromatidae	sp1				2			
Crustacea	Sphaeromatidae	sp2				1			
Crustacea	Sphaeromatidae	sp3				2			
Crustacea	Sphaeromatidae	sp4				1			
Crustacea	Sphaeromatidae	sp5				1			
Crustacea	Tanaidacea	sp1				1			
Crustacea	Tanaidacea	sp3				1			
Crustacea	Xanthidae	sp1				2			
Crustacea	Xanthidae	sp2				1			
Crustacea	Xanthidae	sp3				1			
Crustacea	Xanthidae	sp4				2			
Crustacea	Xanthidae	sp5				1			

Crustacea	Xanthidae	sp6				1			
Crustacea	Xanthidae	sp7							
Echinodermata	Clypeasteridae	sp1						1	
Echinodermata	Clypeasteridae	sp2						1	
Echinodermata	Echinoderm	sp1			1				
Echinodermata	Echinoderm	sp3			2				
Echinodermata	Echinoidea	sp5						1	
Echinodermata	Goniasteridae	sp1						1	
Echinodermata	Ophiuroidea	sp1							1
Echinodermata	Ophiuroidea	sp10			1				
Echinodermata	Ophiuroidea	sp11							
Echinodermata	Ophiuroidea	sp13			1				
Echinodermata	Ophiuroidea	sp14				1			
Echinodermata	Ophiuroidea	sp15				1			
Echinodermata	Ophiuroidea	sp16							
Echinodermata	Ophiuroidea	sp17							1
Echinodermata	Ophiuroidea	sp18							1
Echinodermata	Ophiuroidea	sp19				1		1	
Echinodermata	Ophiuroidea	sp2	1			2			
Echinodermata	Ophiuroidea	sp20							1
Echinodermata	Ophiuroidea	sp21				1			
Echinodermata	Ophiuroidea	sp22				1			
Echinodermata	Ophiuroidea	sp3				32		1	2
Echinodermata	Ophiuroidea	sp4							1
Echinodermata	Ophiuroidea	sp5						1	
Echinodermata	Ophiuroidea	sp6				1			
Echinodermata	Ophiuroidea	sp7				2			
Echinodermata	Ophiuroidea	sp8				1			
Echinodermata	Ophiuroidea	sp9				1			
Ectoprocta	Ectoprocta	sp1							1
Ectoprocta	Ectoprocta	sp2							1
Ectoprocta	Ectoprocta	sp3				1			
Ectoprocta	Ectoprocta	sp4				1			
Ectoprocta	Ectoprocta	sp5							1
Ectoprocta	Ectoprocta	sp6				2			
Ectoprocta	Ectoprocta	sp7				1			
Foraminifera	Foraminifera	sp1	1						
Mollusca	Arcidae	avellana						1	
Mollusca	Arcidae	sp1				1			
Mollusca	Arcidae	sp2				1			
Mollusca	Bivalvia	sp1							1
Mollusca	Bivalvia	sp100				1			
Mollusca	Bivalvia	sp101						1	
Mollusca	Bivalvia	sp4				1			
Mollusca	Bivalvia	sp5				1			
Mollusca	Bivalvia	sp6				11			1
Mollusca	Cardiidae	flavum			1			1	
Mollusca	Cardiidae	sp1				1			
Mollusca	Cardiidae	sp2							
Mollusca	Cerithidae	sp1	1						

Mollusca	Cerithidae	sp2						1	
Mollusca	Chamidae	fibula				1		1	
Mollusca	Collumbellidae	sp1	1						
Mollusca	Donacidae	veruinus							
Mollusca	Echinoidea	sp3						1	
Mollusca	Echinoidea	sp4			1				
Mollusca	Galeommatidae	sp1				1			
Mollusca	Gastropoda	sp1	1						
Mollusca	Gastropoda	sp2	1						
Mollusca	Gastropoda	sp3						1	
Mollusca	Gastropoda	sp4				1			
Mollusca	Gastropoda	sp5						1	
Mollusca	Gastropoda	sp6						1	
Mollusca	Gastropoda	sp7						1	
Mollusca	Gastropoda	sp8						1	
Mollusca	Idiosepiidae	sp1						1	
Mollusca	Insognomonidae	sp1				1			
Mollusca	Isognomonidae	nigrina							
Mollusca	Isognomonidae	picta	1						1
Mollusca	Laganidae	sp1						1	
Mollusca	Lyonsiidae	sp1							1
Mollusca	Mollusca	sp1				1			
Mollusca	Mollusca	sp4				1			
Mollusca	Mollusca	sp7				1			
Mollusca	Mytilidae	chinensis				2			
Mollusca	Mytilidae	malaccana				1			
Mollusca	Mytilidae	maritimus				3			1
Mollusca	Mytilidae	micropterus						1	
Mollusca	Mytilidae	miranda							1
Mollusca	Mytilidae	sp 12							1
Mollusca	Mytilidae	sp 8							1
Mollusca	Mytilidae	sp1							2
Mollusca	Mytilidae	sp10				4			
Mollusca	Mytilidae	sp11				1			
Mollusca	Mytilidae	sp13				1			
Mollusca	Mytilidae	sp15						1	
Mollusca	Mytilidae	sp16							1
Mollusca	Mytilidae	sp17							
Mollusca	Mytilidae	sp18				1			
Mollusca	Mytilidae	sp19							
Mollusca	Mytilidae	sp2							1
Mollusca	Mytilidae	sp20							
Mollusca	Mytilidae	sp22							1
Mollusca	Mytilidae	sp3				3			
Mollusca	Mytilidae	sp33							1
Mollusca	Mytilidae	sp5				1			
Mollusca	Mytilidae	sp8				2			
Mollusca	Mytilidae	sp9				2			
Mollusca	Mytilidae	teres				1			
Mollusca	Narsariidae	sp2						1	

Mollusca	Nassariidae	sp1						1	
Mollusca	Nuculidae	superba							
Mollusca	Opisthobranch	sp1						1	
Mollusca	Ostreidae	amasa				1			
Mollusca	Ostreidae	crisagalli				1			
Mollusca	Ostreidae	folium							1
Mollusca	Ostreidae	sandvichensis	1			1			1
Mollusca	Ostreidae	sp1				1		1	
Mollusca	Ostreidae	sp10				1			
Mollusca	Ostreidae	sp102						1	
Mollusca	Ostreidae	sp103				1			
Mollusca	Ostreidae	sp104				1			
Mollusca	Ostreidae	sp11				1			
Mollusca	Ostreidae	sp12							1
Mollusca	Ostreidae	sp14				1			
Mollusca	Ostreidae	sp15				1			
Mollusca	Ostreidae	sp16				1			
Mollusca	Ostreidae	sp17				1			
Mollusca	Ostreidae	sp18				1			
Mollusca	Ostreidae	sp19				1			
Mollusca	Ostreidae	sp2							1
Mollusca	Ostreidae	sp20							1
Mollusca	Ostreidae	sp21				2			1
Mollusca	Ostreidae	sp22				1			
Mollusca	Ostreidae	sp23				1			
Mollusca	Ostreidae	sp24				1			
Mollusca	Ostreidae	sp25				1			
Mollusca	Ostreidae	sp26				1			
Mollusca	Ostreidae	sp27				1			
Mollusca	Ostreidae	sp28				1			
Mollusca	Ostreidae	sp29				1			
Mollusca	Ostreidae	sp3							1
Mollusca	Ostreidae	sp30				1			
Mollusca	Ostreidae	sp31				1			
Mollusca	Ostreidae	sp32				1			
Mollusca	Ostreidae	sp33						1	
Mollusca	Ostreidae	sp34				1			
Mollusca	Ostreidae	sp35				1			
Mollusca	Ostreidae	sp36				1			
Mollusca	Ostreidae	sp37							
Mollusca	Ostreidae	sp39							
Mollusca	Ostreidae	sp4				1			
Mollusca	Ostreidae	sp40				1			
Mollusca	Ostreidae	sp41				1			
Mollusca	Ostreidae	sp42				1			
Mollusca	Ostreidae	sp43				1			
Mollusca	Ostreidae	sp44						1	
Mollusca	Ostreidae	sp45							1
Mollusca	Ostreidae	sp46							1
Mollusca	Ostreidae	sp5				2			

Mollusca	Ostreidae	sp6				1			
Mollusca	Ostreidae	sp7				1			
Mollusca	Ostreidae	sp8				2			
Mollusca	Ostreidae	sp9				1			1
Mollusca	Ostreidae	tuberculosa				1			
Mollusca	Patelloidea	sp1				1			
Mollusca	Patelloidea	sp2				1			
Mollusca	Patelloidea	sp3				1			
Mollusca	Periplomatidae	sp1							1
Mollusca	Periplomatidae	sp2							1
Mollusca	Pharidae	cultellus						1	
Mollusca	Polyplacophora	sp1						1	
Mollusca	Psammobiidae	gracilentata			1				
Mollusca	Pteriidae	cf. nigra				1			
Mollusca	Pteriidae	fucata	1			1		1	4
Mollusca	Pteriidae	malleoides				1			
Mollusca	Pteriidae	margaritifera							1
Mollusca	Pteriidae	maxima							4
Mollusca	Pteriidae	papilionacea							
Mollusca	Pteriidae	sp 19							1
Mollusca	Pteriidae	sp 24							
Mollusca	Pteriidae	sp1							1
Mollusca	Pteriidae	sp16							1
Mollusca	Pteriidae	sp17				1			
Mollusca	Pteriidae	sp18				1			
Mollusca	Pteriidae	sp2							1
Mollusca	Pteriidae	sp20							
Mollusca	Pteriidae	sp21							1
Mollusca	Pteriidae	sp22						1	
Mollusca	Pteriidae	sp23							1
Mollusca	Pteriidae	sp26							
Mollusca	Pteriidae	sp27							1
Mollusca	Pteriidae	sp29							
Mollusca	Pteriidae	sp3							1
Mollusca	Pteriidae	sp30							1
Mollusca	Pteriidae	sp31							
Mollusca	Pteriidae	sp4							1
Mollusca	Pteriidae	sp5				1			
Mollusca	Pteriidae	sp7							1
Mollusca	Pteriidae	sugillata							1
Mollusca	Sepioidae	sp1	1						
Mollusca	Solemyidae	cf. velesiana							
Mollusca	Solemyidae	veruinus						1	
Mollusca	Spondylidae	sp1						1	
Mollusca	Tellinidae	inflata							
Mollusca	Tellinidae	sp2						1	
Mollusca	Trochiidae	sp1	1						
Mollusca	Ungulinidae	sp1							
Mollusca	Veneridae	sp4						1	
Mollusca	Veneridae	torresiana						3	

Mollusca	Vesiculariidae	sp1				1			
Nemertea	Nemertean	sp1				1			
Plantae	Cymodoceacea	isoetifohium	1						
Plantae	Cymodoceacea	serrulata	1						
Plantae	Cymodoceacea	serrulata	1		1				
Plantae	Cymodoceacea	servulata	1						
Plantae	Hydrocharitaceae	decipiens							1
Plantae	Hydrocharitaceae	ovalis	1						1
Plantae	Seagrass	sp1	1						
Platyhelminthes	Platyhelminthes	sp1				1			
Porifera	Porifera	sp1				4			
Porifera	Porifera	sp10							1
Porifera	Porifera	sp11							1
Porifera	Porifera	sp12							1
Porifera	Porifera	sp14				1			
Porifera	Porifera	sp15				1			
Porifera	Porifera	sp16				1			
Porifera	Porifera	sp17				1			
Porifera	Porifera	sp18				1			
Porifera	Porifera	sp19				1			
Porifera	Porifera	sp2				1			
Porifera	Porifera	sp20				1			
Porifera	Porifera	sp22				1			
Porifera	Porifera	sp23							1
Porifera	Porifera	sp24							1
Porifera	Porifera	sp25							1
Porifera	Porifera	sp26				1			
Porifera	Porifera	sp27							1
Porifera	Porifera	sp28				1			
Porifera	Porifera	sp29				1			
Porifera	Porifera	sp3				1			
Porifera	Porifera	sp30				1			
Porifera	Porifera	sp4				1			
Porifera	Porifera	sp5				1			
Porifera	Porifera	sp6				1			
Porifera	Porifera	sp7				1			
Porifera	Porifera	sp8							1
Porifera	Porifera	sp9	1						
Sipuncula	Aspidosiphonidae	sp1				1			
Sipuncula	Aspidosiphonidae	sp2							1
Sipuncula	Phascolomalidea	sp1							1
Sipuncula	Sipunculid	sp1							1
Tunicata	Aplousobranchia	sp1				23			1
Tunicata	Aplousobranchia	sp2				1			
Tunicata	Aplousobranchia	sp3				1			
Tunicata	Aplousobranchia	sp4				1			
Tunicata	Aplousobranchia	sp5				1			
Tunicata	Ascidian	sp1				5			
Tunicata	Ascidian	sp2				1			
Tunicata	Ascidian	sp3							1

Tunicata	Ascidian	sp4				1			
Tunicata	Ascidian	sp5				1			
Tunicata	Ascidian	sp6				1			
Tunicata	Ascidian	sp7				1		1	
Tunicata	Ascidian	sp8				1			
Tunicata	Molgulidae	sp1						1	
Tunicata	Molgulidae	sp2							
Tunicata	Stolidobranchia	sp1				5			
Tunicata	Styelidae	sp1				1			
Tunicata	Styelidae	sp4				1			
Tunicata	Styelidae	sp6							1