Marine Pest Baseline Survey -Amrun Project
Final Report, 9 May 2016

Prepared for: RTA Weipa Pty Ltd

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EXECUTIVE SUMMARY

- This report describes a baseline survey for Invasive Marine Species (hereafter referred to as Marine Pests) conducted at Weipa and Amrun Ports, Gulf of Carpentaria, Queensland from 16 to 21 December 2015.
- The objective of the baseline MP survey was to detect established populations of marine pests listed on the National Monitoring Strategy Target Species List (NMTSL) if they existed in either the Weipa Port or Amrun Port areas.
- Sampling focused on high-risk locations and habitats where targeted marine pests were most likely to be detected.
- Diverless sampling methods were used to avoid the threat of interaction with dangerous marine animals (e.g. crocodiles, box jellyfish and sharks).
- The survey techniques included; benthic cores for sampling toxic dinoflagellates and diatoms, benthic sled tows for mobile and sessile benthic organism, baited traps for crabs and other mobile scavengers, beach wrack surveys for marine pests and pile scrapes for biofouling organisms. In addition, underwater video assessments of wharf pilings, jetty structures and channel markers were conducted to augment the assessment of biofouling from high risk artificial habitats.
- Sampling in Weipa Port included assessment of 12 benthic cores across four sites, 23 benthic sled tows across five sites, 21 baited traps across seven sites, ~1500 m of beach wrack surveys, 15 pile scraping samples from three wharves, two plankton samples and video assessments of 19 piles from three wharves, and six channel markers.
- No marine pests on the restricted NMTSL were detected in Weipa Port during the baseline survey.
- Sampling in the Amrun Port area included assessment of 9 benthic cores across three sites, 15 benthic sled tows across three sites, 12 baited traps across four sites, ~1500 m of beach wrack surveys, and two plankton samples.
- No marine pests on the restricted NMTSL were detected in the Amrun Port area during the baseline survey.
- A small (~3cm) fragment of a macroalgal *Caulerpa* species was detected in benthic sled tow No.1 in Boyd Bay. Macroscopically the specimen resembled *Caulerpa taxifolia,* and it was preserved for identification. However from microscopic examination it was concluded that the specimen more closely resembled another *Caulerpa* species, *C. sertularioides*. This conclusion was supported by the algal taxonomist Dr John Huisman (Murdoch University). *C. sertularioides* species is endemic to northern Australian waters.
- A settlement plate survey for marine pests at Amrun Port was established prior to dredging and the development of the Amrun Port jetty and bulk carrier loading facility.

TERMS AND ACRONYMS

TERMS AND ACRONYMS	DEFINITION
ALARP	As Low As Reasonably Practicable
Ballast Water	Water (including associated sediments) taken on board a vessel to maintain its trim and stability during a voyage. Can potentially be infected with marine pests
BFS	Biofouling Solutions Pty Ltd
Biosecurity	The exclusion, eradication or effective management of marine and terrestrial pests that could threaten economic, environmental, human health, social or cultural values
DoAWR	Department of Agriculture and Water Resources (Commonwealth), formally known as Department of Agriculture (DoA) and before that the Department of Agriculture Forestry and Fisheries (DAFF)
EIS	Environmental Impact Statement
EP	Environmental Plans
MBMP	Marine Biosecurity Management Plan
MDAP	Monitoring Design Assessment Panel
MDET	Monitoring Design Excel Template
MDP	Monitoring Design Package
MDRT	Monitoring Design Report Template
MP	Marine Pests
National System	The National System for the Prevention and Management of Marine Pest Incursions
NMN	National Monitoring Network
NMTSL	National Monitoring Target Species List
NMS	National Monitoring Strategy
OHS	Occupational Health and Safety
RTA Weipa	Rio Tinto Alcan Weipa Pty Ltd
SoW	Scope of Works
Translocation	The transport of marine pests from one area to another
Vector	Anything capable of introducing or translocating marine pests

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1. Introduction

1.1 The Amrun Project

The Amrun project is located on the western side of Cape York Peninsula in far north Queensland. The proponent is RTA Weipa Pty Ltd (RTA), a wholly owned subsidiary of Rio Tinto Aluminium Limited. The Amrun (previously known as South of Embley) Project involves bauxite mining activities on part of Rio Tinto's existing lease south of the Embley River, between Weipa and Aurukun. The proposed major infrastructure is centred approximately 40 kilometres south of Rio Tinto's existing East Weipa and Andoom mines. The project includes construction of infrastructure required to support bauxite mining, processing and shipping. It includes a processing plant and port near Boyd Bay, a dam, tailings storage facility, roads, worker accommodation and a ferry terminal on the Hey River to transport workers from Weipa to the mine. The project was originally referred to as the South of Embley Project but was renamed in late 2015 in recognition of the Traditional Owners and the Wik-Waya name for the area where the processing and port facilities will be developed.

The main elements of the Project[1] are:

- Bauxite mining;
- Bauxite processing and disposal of fine waste materials in tailings storage facilities;
- Product bauxite stockpiles adjacent to the port facilities;
- Construction and operation of port and ship-loading facilities between Boyd Point and Pera Head;
- Dredging for the construction and maintenance of the port, and disposal of dredged spoil at an off-shore spoil ground;
- Ancillary infrastructure including diesel-fuelled power station, workshops, warehouse,
- Administration facilities, sewage treatment plants, general waste disposal and diesel storage;
- Water infrastructure including a water supply dam on a freshwater tributary of Norman Creek (Dam C), a pump on the Ward River, pipeline, and up to 12 artesian bores;
- A temporary on-site camp for the construction phase up to 630 beds;
- A roll on/roll off (RORO) barge facility at Humbug Point, and a new barge/ferry terminal on the western bank of the Hey River, and disposal of dredged spoil at the existing Albatross Bay spoil ground. The ferry and barge terminals would be used to transport workforce, materials and equipment between Weipa and the SoE Project.
- Modification of the east wharf at Lorim point to provide protected tug moorings.

[1] According to the Riot Tinto Alcan Environmental Impact Statement

1.2 Marine Pests

Invasive Marine Species (hereafter referred to as Marine Pests or MP) are widely cited as one of the most significant threats to marine ecosystems worldwide along with overfishing and human-driven atmospheric and oceanic alterations. Shallow coastal marine environments in particular are thought to be amongst the most heavily invaded ecosystems on earth which largely reflects the accidental transport of MP by international shipping (e.g. see Cohen and Carlton 1998; Ruiz *et al*. 1997, 1999 and 2000). A number of human-mediated vectors can transport MP outside their native ranges. For instance ocean-going vessels can transport marine species in ballast water, as biofouling attached to submerged immersible equipment, within internal seawater systems and/or on the exterior of the hull. For the past three decades, ballast water was considered the primary vector responsible for the dispersal of marine pests around the world (e.g. Carlton 1985; Thresher *et al*. 1999; Eldredge and Carlton 2002). However, recent research suggests the role of ballast water was probably overstated, and up to 69% of these introductions may have occurred via biofouling (Hewitt *et al*. 1999, 2004; Hewitt and Campbell 2010). To prevent further introductions, and limit the spread of marine pests, shipping and associated infrastructure require management for both ballast water and biofouling.

Around the globe there are approximately 2,000 non-indigenous species known to have been introduced to marine or estuarine systems. In Australian marine waters there are approximately 450 established species considered either non-indigenous or cryptogenic (whose origins are inconclusive) see Hewitt *et al*. 2011. Non-indigenous species that survive and establish reproductive populations in new biogeographic regions (where they did not previously occur), often have no demonstrated impacts. However some species have had catastrophic ecological, economic, human health and social/cultural consequences (Carlton 1996, 2001; Pimental *et al*. 2000; Hewitt *et al*. 2011). This subset of species with demonstrable impacts are referred to here as marine pests but are also commonly referred to as invasive marine species, invasive species of concern or alien species.

Once established, marine pests are often difficult or impossible to eradicate, particularly in open environments. Most attempts to eradicate marine pests are logistically challenging, complex, costly and unsuccessful. The pragmatic approach to protecting marine environments from the impacts of marine pests is to prevent their introduction and spread by human-mediated transport. This approach to marine biosecurity provides the fundamental rationale for most global and regional management initiatives. Prevention is ultimately cheaper and more reliable than attempts to control or eradicate marine pests once they are established and detected. To avoid marine pest introductions and environmental impacts, (and associated legal and financial consequences of mitigation and reputational damage), the construction phase for new infrastructure requires effective management of marine biosecurity risks.

1.3 Scope of Works

The main objectives of this work were to develop and implement a baseline marine pest survey at both the Weipa and Amrun Ports for the 2015-2016 wet season (prior to the commencement of Amrun Project dredging and infrastructure development).

RTA Weipa Pty Ltd required the development and implementation of a pragmatic and cost-effective survey strategy consistent with the principles of the Department of Agriculture Forestry and Fisheries (DAFF) Australian Marine Pest Monitoring Manual and Guidelines.

The survey aimed to detect established populations of targeted marine pests listed on the National Monitoring Strategy Target Species List (NMTSL) if they existed in either the Weipa or Amrun Port areas. Due to the threat of dangerous marine species (e.g. crocodiles and box jellyfish), 'diverless'survey methods were required.

2. WEIPA PORT

The Weipa Port is located inside Albatross Bay on the west coast of Cape York Peninsula in the Gulf of Carpentaria. It is approximately 850 km from Cairns and 320 km south of the tip of Cape York (See **Figure 1**). The Weipa Township currently has around 3500 residents and was developed by Comalco in the 1960's to house its mining workforce. Weipa is now the regional hub of the Western Cape, hosting many businesses and government services. It is not reliably accessible by road during the wet season. It is serviced from Karumba and, in turn, provides a local service hub for the communities at Napranum, Marpuna and, to a lesser extent, Aurukun. Apart from mining, the region's other significant industries are tourism, commercial and recreational fishing and cattle ranching (Neill *et al* 2005).

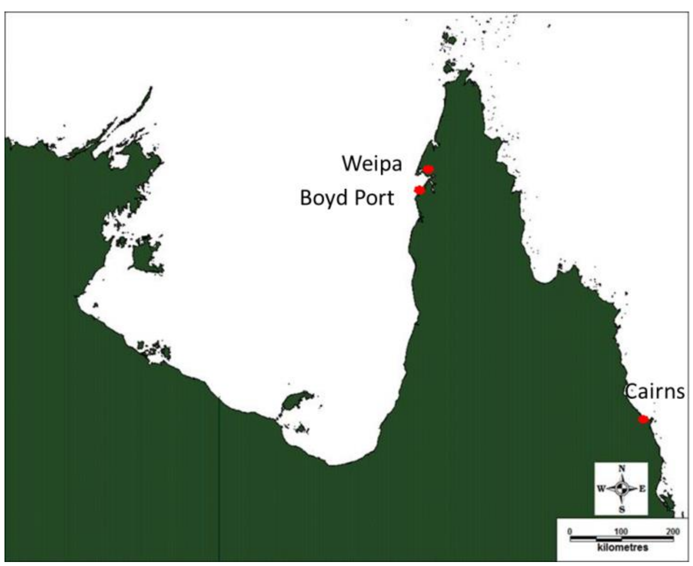

Figure 1. Gulf of Carpentaria

Weipa port is accessed via a 14 km shipping channel from Albatross Bay, which is maintenance dredged to at least 10.8m (Hilliard *et al.* 1997). The port facilities are located along the north side of the lower Embley River and are predominantly used for the importation of fuel and general cargo and the export of bauxite. Live cattle have also been exported from Weipa although these shipments have been irregular (Neil *et al* 2005). Most bauxite has been shipped to two refineries in Gladstone (QAL and RT Yarwun), although some is also exported to the Euralumina refinery in Italy and to a hydrating plant in Korea. The proportion of the shipments to Gladstone increased to 85% in the mid 2000's with the opening of the Comalco Alumina Refinery (CAR) at Port Curtis.

Within the port there are currently three wharves (Lorim Point, Evans Landing and Humbug). An overview of the existing wharf infrastructure in the Port of Weipa is provided in Figure 2. Lorim Point wharf (~700m long) is the largest submerged artificial structure in the Port of Weipa and is associated with bauxite processing and stockpiling facilities. Lorim Point Wharf has a tug harbour and shiploader facility for bauxite transfer to bulk carriers. Lorim Point has two export berths and has regularly handled four 'River' class coal-burning bulk carriers to service the Gladstone trade, plus a range of spot-chartered Panamax carriers for overseas exports (Neill *et al* 2005). Lorim Point wharf is thus primarily an export point for bauxite, although fuel imports are also offloaded here. Humbug wharf (~260m long) is the second largest wharf and is primarily a cargo wharf. It is used for imports of general cargo and heavy equipment and can handle vessels up to 114 m long and ~8 m draft (Neill *et al* 2005). Evan's Landing (~100m long) is a multi-purpose wharf and base for import of petroleum products, small vessel refuelling, and seafood offloading (Hilliard *et al.* 1997), it also includes a pilot boat facility.

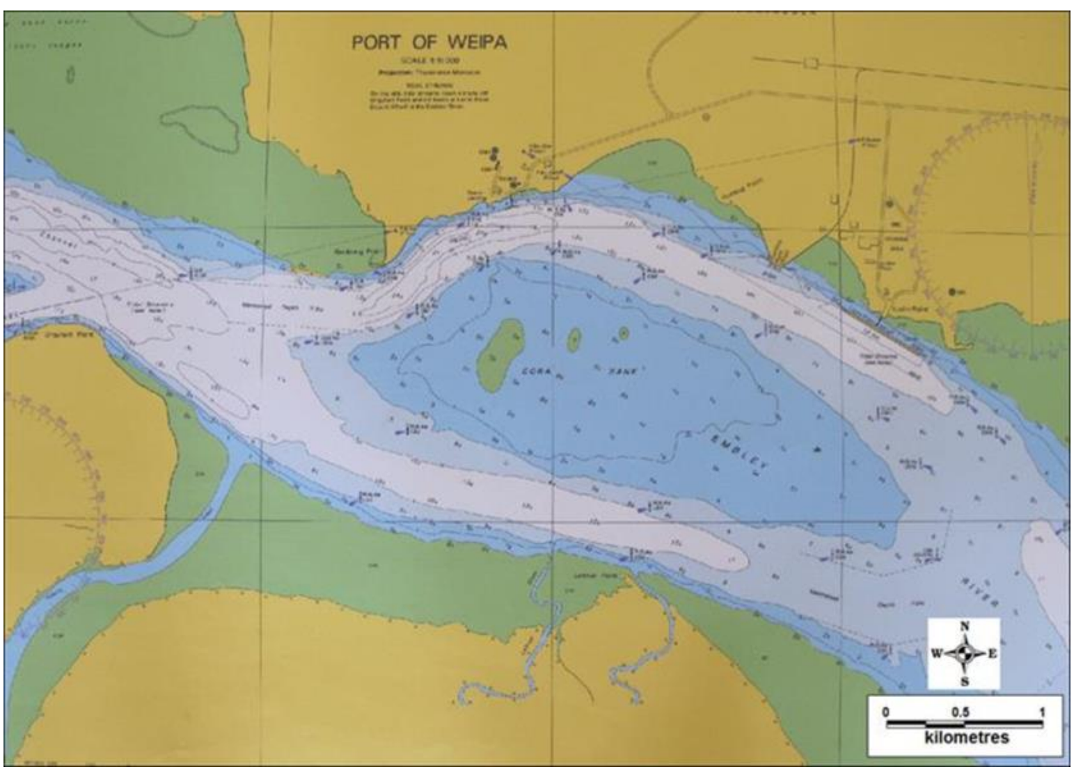

Figure 2. Port of Weipa

A public boat ramp is situated adjacent to Evans Landing Wharf, although this ramp was closed to the public in December 2015. Simultaneously a new public ramp with a walkway and floating pontoon (to facilitate safe launching, retrieval and boarding of recreational boats and charter vessels) was opened approximately 250m east of Evans Landing. This facility was developed to avoid potential associated with recreational vessel traffic and fuel unloading at Evans Landing.

Artificial structures are particularly significant for the establishment of marine pests (e.g. Connell and Glasby 1999, Glasby et al 2007). In Weipa Port they include the three wharves previously mentioned, as well as channel markers and rocky break-walls. In the vicinity of the port facilities there are high intertidal saltmarsh flats, mid-high intertidal sand beaches and dunes, mid-tidal mangrove forests and rocky shorelines in addition to lower-intertidal sand and mudflats (Hilliard *et al.* 1997). Extensive mangrove forests comprised of 37 species of mangrove fringe all rivers in the Weipa and Amrun Port areas. The mangrove estuaries support a diverse assemblage of marine flora and fauna. Lower intertidal sand and mudflats support seagrass and macroalgae are found between the shallow subtidal zone to 1m depth. These habitats constitute nursery areas for fish and prawns.

Additional infrastructure associated with the Amrun project will be constructed in Weipa Port and is summarised in Section 1.1 above. Briefly it includes:

1. A roll on/roll off (RORO) barge facility at Humbug Point,
2. A new barge/ferry terminal on the western bank of the Hey River.
3. Modification of the east wharf at Lorim point to provide protected tug moorings.

The majority of the Weipa Port area is less than 15m deep (see Figure 2), with the deepest section of the shipping channel near Gonbung Point reaching approximately 25m. Water depth alongside the three main wharves ranges from 9.6m to 12.5m. Sampling effort was focused on the Port of Weipa due to the increased likelihood of marine pests being present in the area.

3. Amrun Port

In December 2015 no substantial artificial structures were installed in the Amrun Port area (see **Figure 3**). The Amrun Port area is therefore loosely defined in this context to include the proposed ship loading jetty for bulk carriers (and associated dredged channel), and temporary passenger jetty artificial structures to be established at Boyd Bay (~2.5 km to the North East). A temporary artificial barge landing structure was planned at Pera Head (~3.5 km to the South West)[2] see Figure 3, and was used to inform the sampling design. However this will no longer be established. At the time of sampling the broader Amrun Port Area was a relatively undisturbed marine environment.

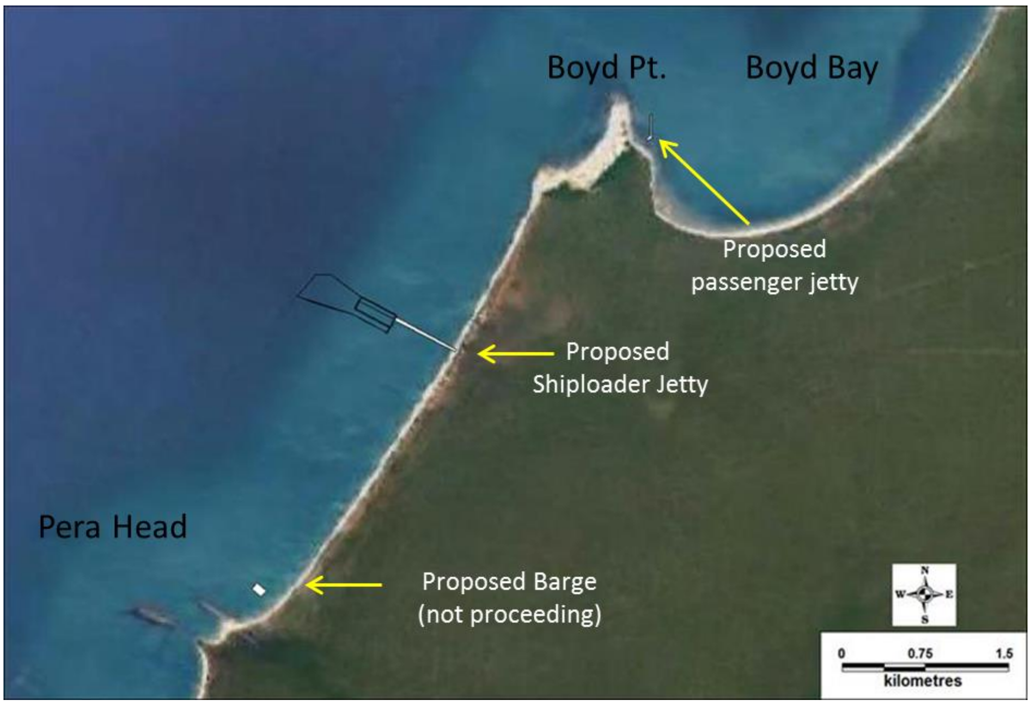

Figure 3. Amrun Port with planned infrastructure marked

The Amrun Port Area is situated on an exposed coastline facing predominantly northwest. Intertidal areas include sandy beaches and dunes with rocky reef headlands and rocky outcrops. Subtidal habitats are predominantly gently sloping, muddy and sandy sediments. However near shore fringing reef communities exist in the vicinity of the proposed port area. They occur at Boyd Point, Pera Head and between Pera Head and Thud Point (5 km further south west). These comprise both reefs containing hard corals and low profile reefs containing soft coral-sponge assemblages. The importance of these reef systems (Boyd Point to Thud Point) in a regional context is considered to be high as they support resources that are of conservation, cultural, commercial and recreational importance. In particular, the near shore sponge and coral reefs provide a food resource for a range of turtle species in the area (Environmental Impact Assessment 2011).

[2] Confirmation the proposed barge terminal would not be completed was not provided until mid-February 2016.

4. Background Environmental Data

4.1 Climate

Weipa has a tropical monsoonal climate with distinct wet and dry seasons. The wet season occurs between October and April and tropical cyclones regularly cross the Gulf of Carpentaria during this period. South-easterly winds dominate in the dry season and lighter, northerly and westerly winds are predominant in the wet season. The monsoonal climate gives hot, wet summers and mild, dry winters. Ninety-five percent of rainfall occurs between November and April.

4.2 Temperature

Annual water temperatures at Weipa were sourced from the Australian Institute of Marine Science (AIMS) in November 2015. A sea water temperature data logger was deployed at Weipa (Lorim Point) from 11 May 1998 to 02 Nov 2006. This data indicated seasonal maximum of 31.5^{0}C and a minimum of 24.6^{0}C. Hoedt *et al* (2001) reported that water temperatures in Albatross Bay (including the Amrun Port region) range from 24.8^{0}C to 31.8^{0}C.

4.3 Salinity

Salinity at Weipa Port changes seasonally from the wet season (high rainfall and relatively low salinity) to the dry season (low rainfall and higher salinity values.). Specific data for the Port is currently lacking and will vary considerably between years depending on the extent of the wet season rains. The Royal Australian Navy´s Navy METOC (Meteorology and Oceanography) section has developed a generalised model of sea surface salinity around Australia (see http://www.metoc.gov.au/products/data/aussss.php). It predicts the mean monthly surface water salinities (in psu) for 'Weipa' as follows: Jan= 34.1, Feb =34.0, Mar=33.1, Apr= 33.5, May=34.1, Jun=34.3, Jul=34.9, Aug=34.7, Sept=34.9. Oct= 34.6, Nov=34.6, Dec =35.4. However these model outputs likely reflect predictions for Albatross Bay, and are most relevant for the Amrun port area which is not directly associated with substantial estuaries.

Lower salinity values are expected in the Weipa Port than are predicted by the METOC model due to influence of plumes of freshwater from the Hey and Embley Rivers. Salinity also changes considerably through the water column; on the surface (particularly in estuaries during the wet season) the salinity will be lower. Hoedt *et al* 2001 reported that salinities in the Gulf of Carpentaria are normally in the range of 34 in winter to 33 in summer, although surface salinities drop to 27 to 28 in the peak of the rainy season. Salinities near the Weipa port facilities, were reported by Hoedt *et al* 2001 as ranging from 35.5 to 37.5 (in October 1993 near the end of the dry season) and 29.6 to 33.9 (in January 1995 during the wet season). It is unclear how broadly representative of other years/ seasons these values are.

4.4 Tides and Sea Conditions

Tides in the Weipa region vary from semi-diurnal (2 tides per day) neap tides, to diurnal (1 tide per day) spring tides. Wave heights in exposed port waters can exceed 1.5 m and can exceed 2.0m in open waters of Albatross Bay and the Amrun Port area.

5. Baseline Marine Pest Survey Methods

5.1 Refined Target Species List

The baseline sampling design and effort was focused on the detection of marine pests on the refined NMTSL in a pragmatic survey consistent with the principles of the Department of Agriculture Forestry and Fisheries (DAFF) Australian Marine Pest Monitoring Manual and Guidelines. The NMTSL includes 55 species that pose a risk to marine environments, social, cultural and economic values and could (or already have) established invasive populations around Australia. The NMTSL was refined to those 22 species that could potentially survive in the Weipa and Amrun Port areas, based on abiotic tolerances. It was not possible to further refine the target species list on the basis of vessel connectivity with areas infested with marine pests. Insufficient detail on domestic and international vessel connectivity was available for both historical vessel movement patterns, and planned construction activities. Once the refined target species list was established the selection of sampling methods and distribution of sampling effort was designed to maximise chances of detecting these targeted marine pests within operational and financial constraints.

5.2 Selection of sampling techniques.

A wide variety of proven, cost effective and practical sampling techniques exist for obtaining marine pest samples to facilitate identification. The sampling techniques chosen were consistent with those identified in the Australian Marine Pest Monitoring Manual and have been widely applied in port surveys in Australia and New Zealand. Sampling techniques outlined in the Australian Marine Pest Monitoring Manual were broadly based on protocols developed by CSIRO's Centre for Research on Introduced Marine Pests (CRIMP) and described by Hewitt and Martin (2001). The sampling methods outlined in the Australian Marine Pest Monitoring Manual are somewhat generic and require modifications to local conditions as implemented for New Zealand Ports (Gust *et al.* 2001) and tropical applications (Hoedt *et al.* 2001b). Sampling techniques were chosen to target the refined target list.

Sampling techniques were determined on the basis of life stages being targeted, habitat preferences, constraining factors and cost-effectiveness considerations. Decisions about suitable sampling techniques for each target species were informed by extensive practical research experience in port surveys for marine pests. A summary of sampling techniques for each species is provided in **Table 1** below. Descriptions of each sampling technique are subsequently provided, and preservation techniques are summarised for the targeted taxa in Section 6.4.

Table 1. Baseline sampling techniques for refined Target Species List.

Species Name	Common name	Benthic Cores	Benthic Sled Tow	Crab Box Trap	Intertidal Visual Search	Pile Scrapes
Alexandrium monilatum	Toxic dinoflagellate	☑				
Balanus eburneus	Ivory barnacle				☑	☑
Bonnemaisonia hamifera	Red macroalga		☑		☑	☑
Callinectes sapidus	Blue crab			☑	☑	
Caulerpa racemosa [3]	Green macroalga		☑		☑	☑
Caulerpa taxifolia (exotic strains only)	Green macroalga		☑		☑	☑
Chaetoceros concavicornis	Centric diatom	☑				
Chaetoceros convolutus	Centric diatom	☑				
Codium fragile spp. fragile	Green macroalga		☑		☑	☑
Crassostrea gigas	Pacific oyster				☑	☑
Crepidula fornicata	American slipper limpet				☑	☑
Didemnum spp. (exotic invasive species only)	Tunicate – sea squirt				☑	☑
Ensis directus	Jack-knife clam		☑		☑	
Grateloupia turuturu	Red macroalga		☑		☑	☑
Hemigrapsus sanguineus	Japanese shore crab			☑	☑	
Hemigrapsus takanoi / penicillatus	Pacific crab			☑	☑	
Hydroides dianthus	Tube worm				☑	☑
Mytilopsis sallei	Black-striped mussel				☑	☑
Perna viridis	Asian green mussel				☑	☑
Pseudo-nitzschia seriata	Pennate diatom	☑				
Rapana venosa	Asian/veined rapa whelk				☑	☑
Rhithropanopeus harrisii	Harris mud crab			☑	☑	

Note: Phytoplankton tows were also conducted in both Ports, along with opportunistic visual assessments of artificial structures (pier piles and channel markers) in the Port of Weipa using an underwater video and light system mounted on an extendable pole.

[3] Previously detected in the Port of Weipa by Hoedt *et al* 2001, but considered not to pose an invasive threat at the time. The endemic range of this species is debated and it is possibly not introduced to Australian waters.

5.2.1 Benthic Cores

Benthic cores were used to sample for dinoflagellate cysts and the resting stages of diatoms identified in **Table 1**. A specialised cyst coring device (a Craib Corer: see **Figure 4**) was deployed to capture dinoflagellate cysts and diatoms in the surface layers of sediment. The Craib corer was made of stainless steel with a lead weighted base. A gravity trigger releases a pin and a clear perspex tube was driven into the sediment. A spring activated stopper prevented sediment loss on retrieval of the corer. The sediment cores were retained in the perspex tube within the device as the corer was brought to the surface. In muddy or fine sandy sediments, the corer effectively preserved the vertical structure of the sediments and fine flocculent material on the sediment surface where dinoflagellate cysts are most likely to be found.

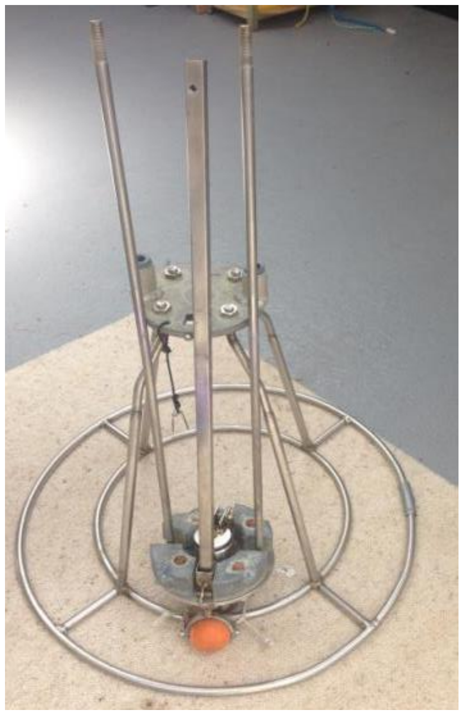

Figure 4. Craib corer.

Dinoflagellate cyst sampling was limited to sites where there was a high probability of occurrence. Dinoflagellate cysts are not deposited evenly across open areas of sediment within port environments, rather they are only reliably detected in depositional environments characterised by depressions in fine sediments. Accordingly, cost efficient searches for these cysts using coring techniques are best achieved by initially identifying local gyres, local bathymetric depressions in the seabed and high sedimentation locations. We identified such locations from existing bathymetry data in the Port of Weipa to improve probability of detecting these cysts. The vessel's depth sounder was used to confirm appropriate previously identified sampling locations within the ports. This approach minimises the expenses of excessive sampling across broad areas of relatively cyst-free benthos, and reduces safety concerns associated with deploying divers to obtain benthic cores in potentially high risk areas.

The samples were labelled and kept in cool, dark conditions before delivery to a globally recognised expert in the taxonomy of these organisms (Professor Gustaaff Hallegraeff, University of Tasmania). Samples were subsequently stored in a refrigerator before being transported to the University of Tasmania's laboratories for processing and identification of dinoflagellate cysts. The top 60 mm of each core sample was then extruded and subsamples sonicated and sieved to remove sediment grains and large detritus particles. Subsamples were then examined on wet-mount slides and cysts were identified and counted under a compound light microscope.

It should be noted that the sampling design did not include dedicated sampling of phytoplankton and zooplankton marine pests. These communities are extremely variable in both space and time, and extreme variability is likely to exist in plankton community composition, species richness, relative abundance and trophic structure within ports and through the year. Furthermore changes in composition occur rapidly within a matter of days. As such, plankton tows and drop net deployments taken at one point in time (as proposed by the Australian Marine Pest Monitoring Manual) provide inadequate and potentially misleading characterisation of this component of the marine flora and fauna of ports. We feel that substantial plankton net sampling effort was unjustified and unlikely to prove a useful means of surveillance for invasive marine planktonic organisms since very little confidence could be attached to findings from sampling limited to a single week of the year. In contrast, surveys of cysts and resting stages in sediment cores provide an integrated history of plankton communities and have been used previously to demonstrate historical species introductions via by ballast water (Hallegraeff 1998). Nevertheless, Professor Hallegraeff suggested that "a small number" of vertical plankton net samples would assist his characterisation and identification of potentially toxic phytoplankton species within the region. Accordingly we collected four plankton net samples for the baseline survey, two within the Weipa Port and two at Amrun Port. These plankton samples were taken using a 20micron sampling net (**Figure 5**) retrieved vertically through the water column from 8m to the surface. Samples were placed in labelled jars, and preserved in Lugols solution prior to delivery to University of Tasmania and Prof. Gustaaf Hallegraeff for identification using light microscopy.

Figure 5. Plankton net.

5.2.2 Benthic Sled Tows

Large benthic organisms and macroalgae, living at the water/seafloor interface ('epibenthos'), were sampled using an Ocklemann benthic sled. The sled consisted of a metal frame 0.75 m length, 0.5 m width and 0.15 m depth, with an outer mesh size of 7.5 cm and an additional inner mesh size of 1.2 cm. A short yoke of heavy chain connected the sled to a towing line (see **Figure 6**). Depending on the benthic sediments, the mouth of the sled either skimmed along the surface or partially dug into the sediment to collect epibenthic organisms on the surface/ and or to a depth of a few centimetres. Runners on each side of the sled prevented it from sinking into the sediment so that shallow burrowing organisms and small, epibenthic fauna pass into the exposed mouth.

Sleds were towed for a standard time of 2 minutes at approximately 2 knots. During this time, the sled typically traversed between 75 – 100 m of seafloor before being retrieved. Benthic sleds were effectively deployed in water less than 15 m deep. Sediment and other material that entered the sled passed through a mesh basket that retains organisms larger than ~5 mm. Samples were emptied into individually labelled nally bins and sorted on board the research vessel *Raptor*. Samples were photographed and any suspected marine pests on the revised target list were placed in labelled jars, retained on ice for further inspection and preservation that night back at the temporary laboratory on land.

Figure 6. Ocklemann bethic sled.

5.2.3 Crab Box Traps

Collapsible light weight box traps (85 cm x 60 cm x 25 cm) were baited and suspended in triplicate from a rope backbone. At each sample location three baited traps were deployed, spaced 3 – 5 m apart on a single anchored and buoyed trap line. The commercially available traps required modification since their mesh size of approximately 10cm is too large for the target species (see Table 4). Accordingly they were modified by lining the outside of traps with 1cm black mesh as indicated in **Figure 7**. A single dive weight was attached to the bottom centre of each trap to ensure they remained on the benthos in order to sample mobile crabs and other small epibenthic scavengers.

Figure 7. Collapsible box trap

A central bait (a can of fish flavoured cat food, with the can punctured in a number of places) was cable-tied to the inside middle base of the trap. Previous work has shown this to be one of the most successful bait types when targeting crab species in tropical ports. Organisms attracted to the bait entered the traps through slits in inward sloping panels at each end. The traps were deployed in the late afternoon and recovered early the following morning, and soak times were recorded. Trap lines were deployed overnight in both major survey areas (Weipa Port and Amrun Port). Crab trap contents were sorted on board, photographed and specimens of interest, including suspected marine pests on the revised target list were placed in labelled jars and retained on ice for further inspection and preservation that night back at the temporary laboratory on land.

5.2.4 Beach Wrack Surveys

Visual searches for the target species were made along sloping sandy shorelines, accessible intertidal rocky reef areas and pontoons, piles and other structures. Wherever possible, the searches were made at low tide. Suspected marine pests on the revised target list were photographed, collected, and placed in labelled jars for further preservation and identification as necessary.

5.2.5 Pile Scrapes

Biofouling assemblages on hard substrata (wharf piles predominantly, but potentially channel markers or other artificial structures) were sampled by scraping. Pile scrapes target a wide variety of biofouling species (see Table 4) on the refined NMTSL. Scrapes were undertaken from the research vessel using a scraping device ('remote scraper') illustrated in Figure 8. This device was tailor-made for sampling biofouling organisms for marine pests on submerged artificial structures in North Queensland where diving was not feasible. The remote scraper consists of a stainless steel frame 30 cm x 25 cm with inwards-facing blade to allow scraping of surfaces, and a 4 mm mesh net to collect dislodged material. It also included a 50 cm long curved handle and a longer handle attachment to facilitate deeper sampling. At each jetty, three to five vertical transects were sampled, from a maximum reach of the "remote scrape" of approximately 2 m depth up to the surface. Once scraping was completed, the sample bag was emptied, the contents examined and suspected marine pests on the revised target list or specimens of interest were photographed, labelled and retained on ice for further inspection and preservation that night back at the temporary laboratory.

Figure 8. Remote pile scraper

5.2.6 Underwater Video Searches

Additional visual searches of artificial structures were conducted within Weipa Port on the final day of the survey (21 December 2015). These searches used an underwater video camera and lighting system mounted on an extendable pole (**Figure 9**), to inspect anthropogenic structures in and around the Weipa port including pier pilings and navigational markers. It provides a qualitative visual record of the predominant biofouling assemblages on artificial structures within Weipa Port at this time. Video surveys were conducted at low tide and the unit recorded biofouling assemblages from a depth of approximately 2.5 m up to the surface. Videos were subsequently reviewed for evidence of marine pests on the restricted NMTSL. Footage was suitable for identification.

Figure 9. Underwater video and lighting equipment

5.3 Preservation techniques for target marine pests

Samples collected in the field were labelled, jarred and kept on ice. Each night after field sampling the samples were then preserved according to the protocols summarised in **Table 2**.

Table 2. Sample preservation protocols.

Taxon	Narcotisation	Fixing	Preservation	Comments
Ascidian	MC	4% formalin	70% ethanol	-
Crustacea	F	4% formalin	70% ethanol	-
Macroalgae		4% formalin	70% ethanol	Preservation may also be achieved by air-drying
Mollusca	No or F or M	4% formalin	70% ethanol	-
Phytoplankton	No	1% Lugol's solution	1% Lugol's solution	Cyst samples to remain cool and dark for transport, no preservatives
Polychaetes		4% formalin	70% ethanol	"default method"
All others		4% formalin	70% ethanol	"default method"

* Where M = $MgSO_4$ or $MgCl_2$, MC = menthol crystals, F = freezing and No = narcotisation not needed, source: Hewitt and Martin (2001)

5.4 Locations and habitats at risk of potential marine pest invasion.

The locations of sampling sites were determined on the basis of vector nodes, habitats present, habitat preferences of species, hazards and constraining factors, and suitability for application of the chosen sampling methods. Sampling location in both Weipa Port and Amrun Port were largely associated with existing or proposed artificial structures (or nearby habitats) where marine pests are most likely to establish and be detectable with the chosen sampling techniques. In the Amrun Port area where infrastructure was not yet built, sampling focused around the footprints of future construction sites. Broader sampling of albatross bay was beyond the scope of the current survey. Spoil grounds were not selected as sampling sites for the refined target species list since a limited number of targeted species could potentially be present and more cost-effective sampling at higher risk sites was prioritised.

6. Baseline Marine Pest Survey Implementation

The marine pest baseline survey was conducted over a six day period (16-21 December 2015) during a period of neap tides in the wet season. The field team consisted of two marine scientists (Dr Nick Gust and Dr Joe Valentine), the vessel skipper (David Donald), and a traditional owner/ observer (Peter Cevanthen). All operations were conducted from the 10m vessel *Raptor*. Four days of sampling were conducted at Weipa Port (16, 19, 20 and 21 December) and two days of sampling were conducted at Amrun Port (17 and 18 December). Sampling effort exceeded the sampling design expectations. Notably a larger number and distribution of crab traps and benthic sled replicates were achieved and additional underwater video searches of channel markers and pier piles were conducted.

A summary of the sampling effort achieved is provided in **Table 3**:

Table 3. Sampling effort achieved.

Port	Technique	Sites	Replicates (per Site)	Total Replicates
Weipa	Benthic Cores	4	3	12
Weipa	Benthic Sled Tows	5	4 x 5 and 1 x 3	23
Weipa	Crab Traps	7	3	21
Weipa	Pile Scrapes	3	5	15
Weipa	Plankton Tows	1	2	2
Weipa	Underwater Video: Wharf Piles	3	10, 4, 5	19
Weipa	Underwater Video: Channel Markers	6	1	6
Weipa	Beach Wrack Surveys	3	1	3
Amrun	Benthic Cores	3	3	9
Amrun	Benthic Sled Tows	3	5	15
Amrun	Crab Traps	4	3	12
Amrun	Plankton Tows	1	2	2
Amrun	Beach Wrack Surveys	1	1	1

Table 4. Labelling protocols and abbreviations.

<table>
<tr><th>Port</th><th>Method</th><th>Sites</th><th>Replicates</th></tr>
<tr><td rowspan="5">Weipa Port (W)</td><td>Pile Scrapes (PSC)</td><td>Evans Landing (EL)
Humbug Point (HP)
Lorim Point (LP)</td><td>1-5</td></tr>
<tr><td>Cyst Cores (CORE)</td><td>A, B, C</td><td>1-3</td></tr>
<tr><td>Benthic Sled (BSLD)</td><td>D, E, F, G, H</td><td>1-3</td></tr>
<tr><td>Crab Traps (CBTP)</td><td>Evans Landing (EL)
Humbug Point (HP)
Lorim Point (LP)
Hey River Terminal (HRT)</td><td>1-3</td></tr>
<tr><td>Intertidal Visual Search (INTV)</td><td>Sections from Gonbung point to Hornibrook</td><td>1-3</td></tr>
<tr><td rowspan="5">Amrun Port (B)</td><td>Pile Scrapes (PSC)</td><td>N/A</td><td>1-3</td></tr>
<tr><td>Cyst Cores (CORE)</td><td>Amrun Jetty (BJ)[4]
Boyd Bay (BB)</td><td>1-3</td></tr>
<tr><td>Benthic Sled (BSLD)</td><td>Pera Head (PH)
Amrun Jetty (BJ)
Boyd Bay (BB)</td><td>1-3</td></tr>
<tr><td>Crab Traps (CBTP)</td><td>Pera Head (PH)
Amrun Jetty (BJ)
Boyd Bay (BB)</td><td>1-3</td></tr>
<tr><td>Intertidal Visual Search (INTV)</td><td>Pera Head (PH)
Amrun Jetty (BJ)
Boyd Bay (BB)</td><td>1</td></tr>
</table>

The format of each label was: Port / Method / Site / Replicate**.**
For example **W CORE A 1** is a sample taken in Weipa Port, using a Craib Corer at site A replicate 1.
Date and time were also recorded for each sample on the field data sheets.

The spatial distribution of sampling achieved in Weipa Port is indicated in **Figure 10** to **Figure 20** below. In each case yellow polygons indicate the intended sampling areas during the design phase, and points indicate the actual sampling areas during the baseline survey.

[4] Note that the Amrun Jetty was referred to as Boyd Jetty during the sampling and labelling protocols accepted prior to the sampling survey.

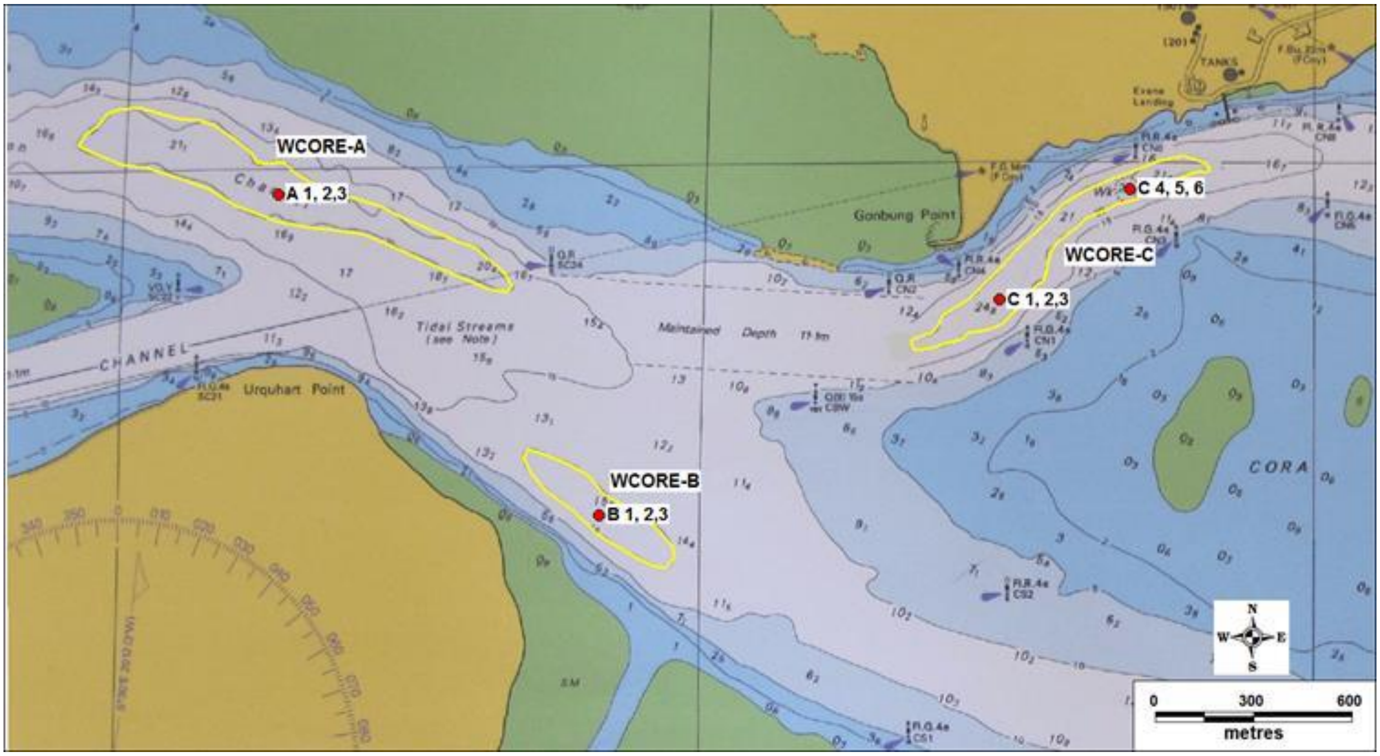

Figure 10. Cyst core sampling sites within the Port of Weipa.

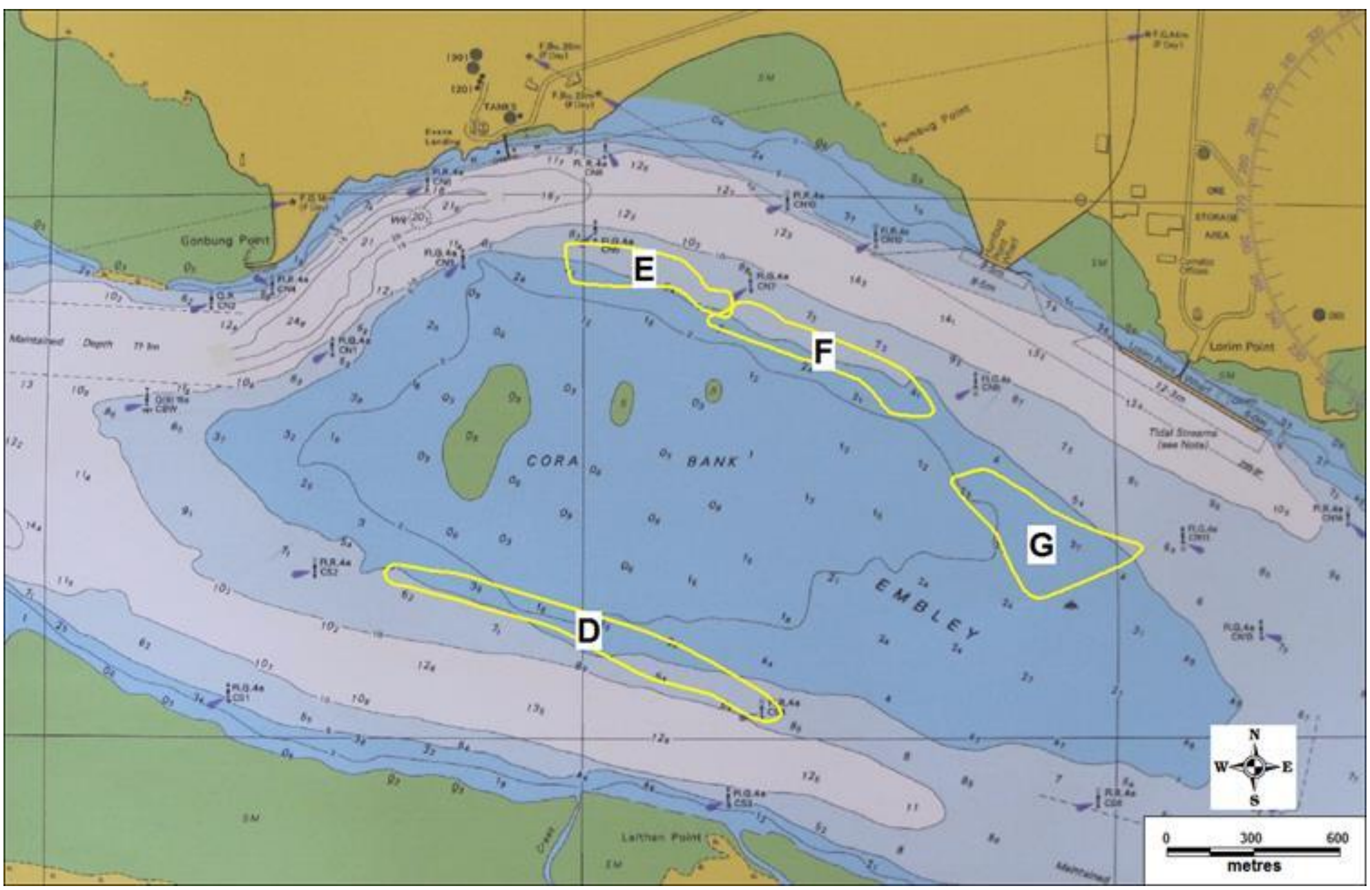

Figure 11 Overview of Benthic sled sampling sites within the Port of Weipa

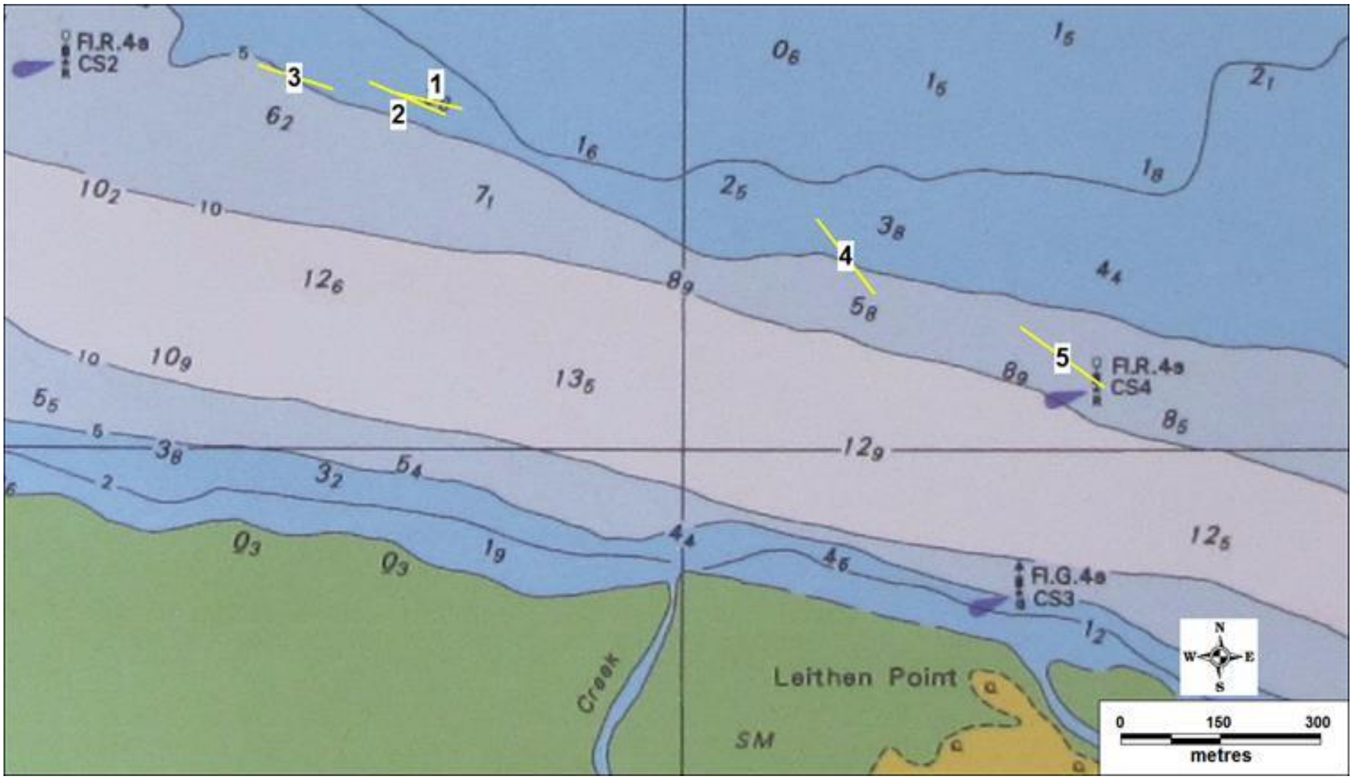

Figure 12 Benthic sled tow paths at site D within the Port of Weipa

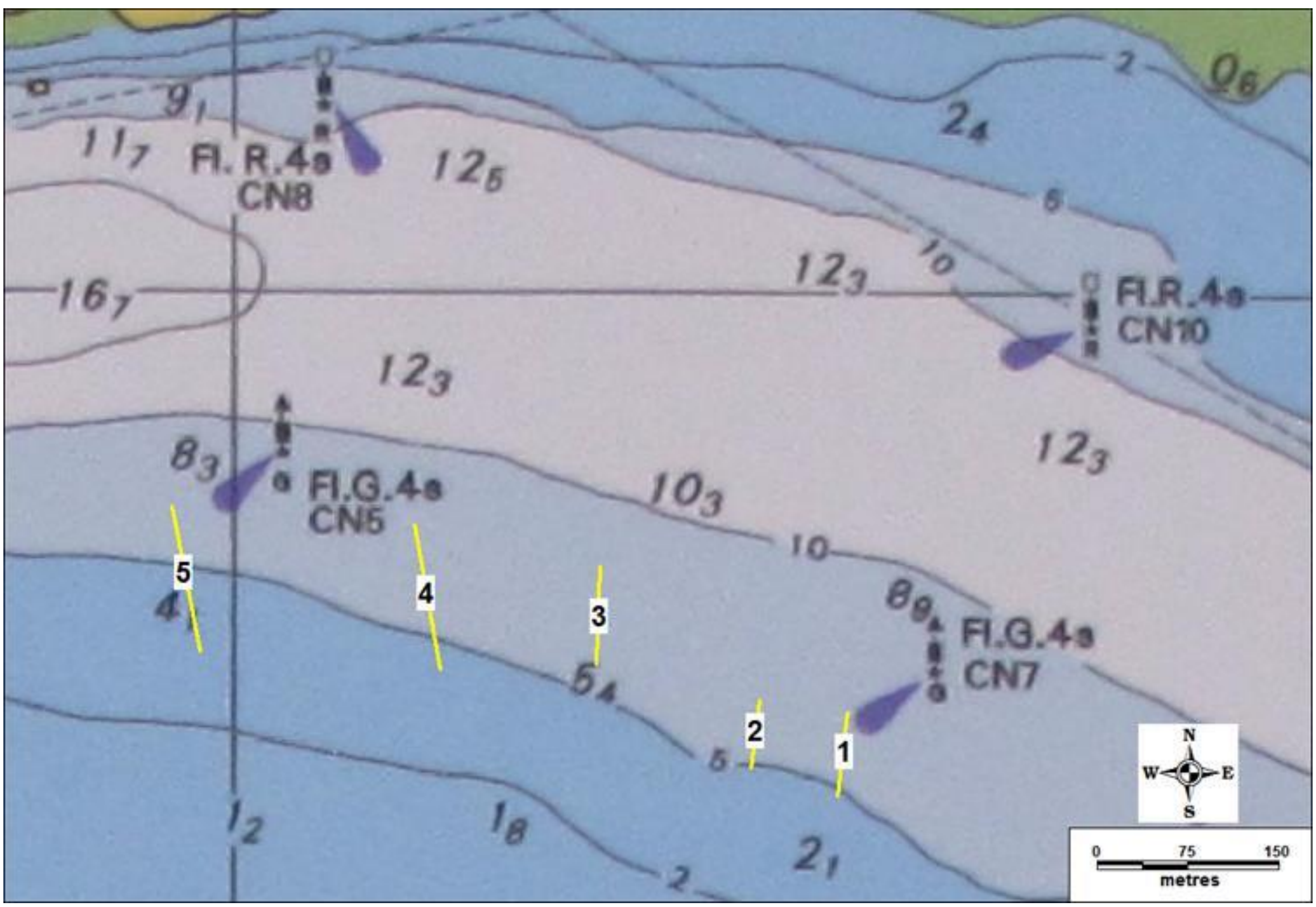

Figure 13 Benthic sled tow paths at site E within the Port of Weipa

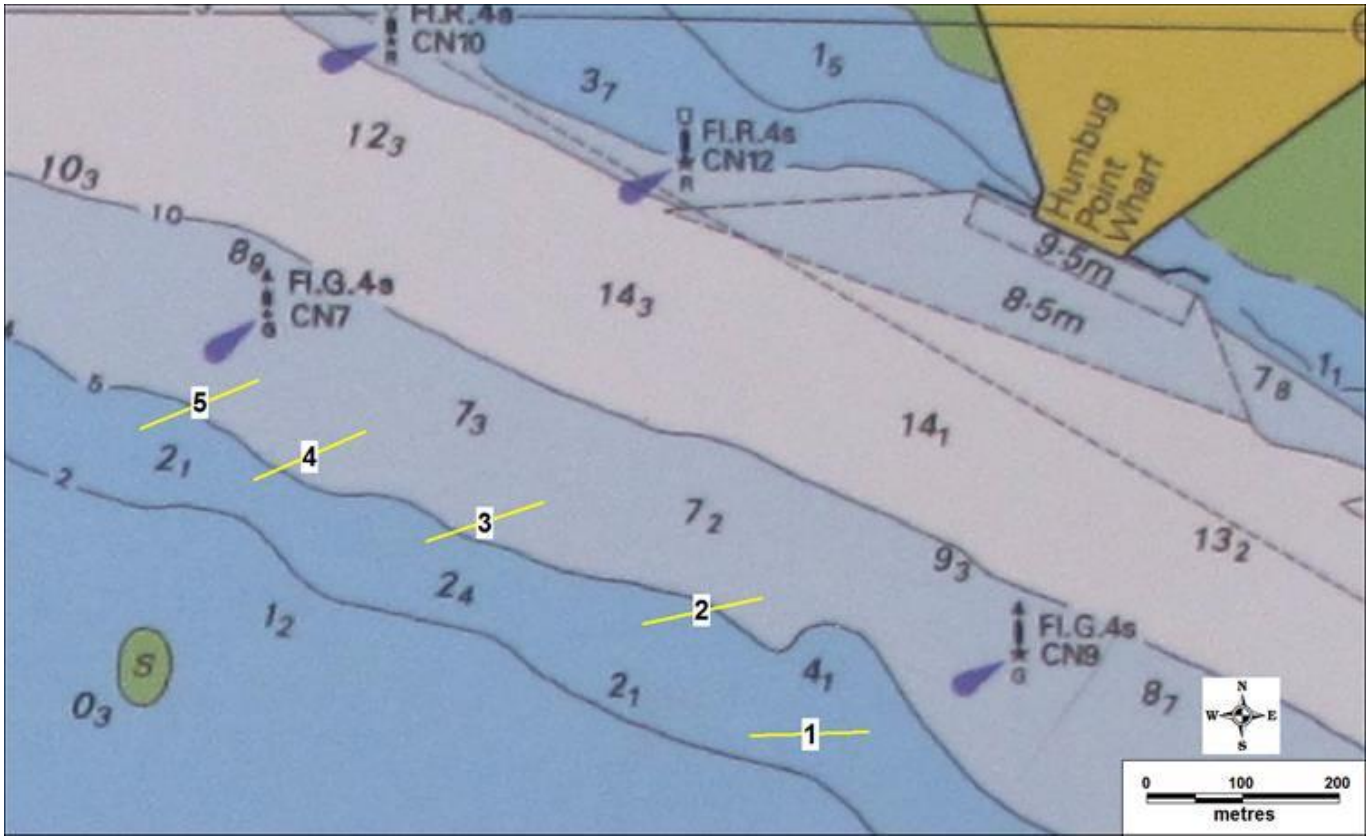

Figure 14 Benthic sled tow paths at site F within the Port of Weipa

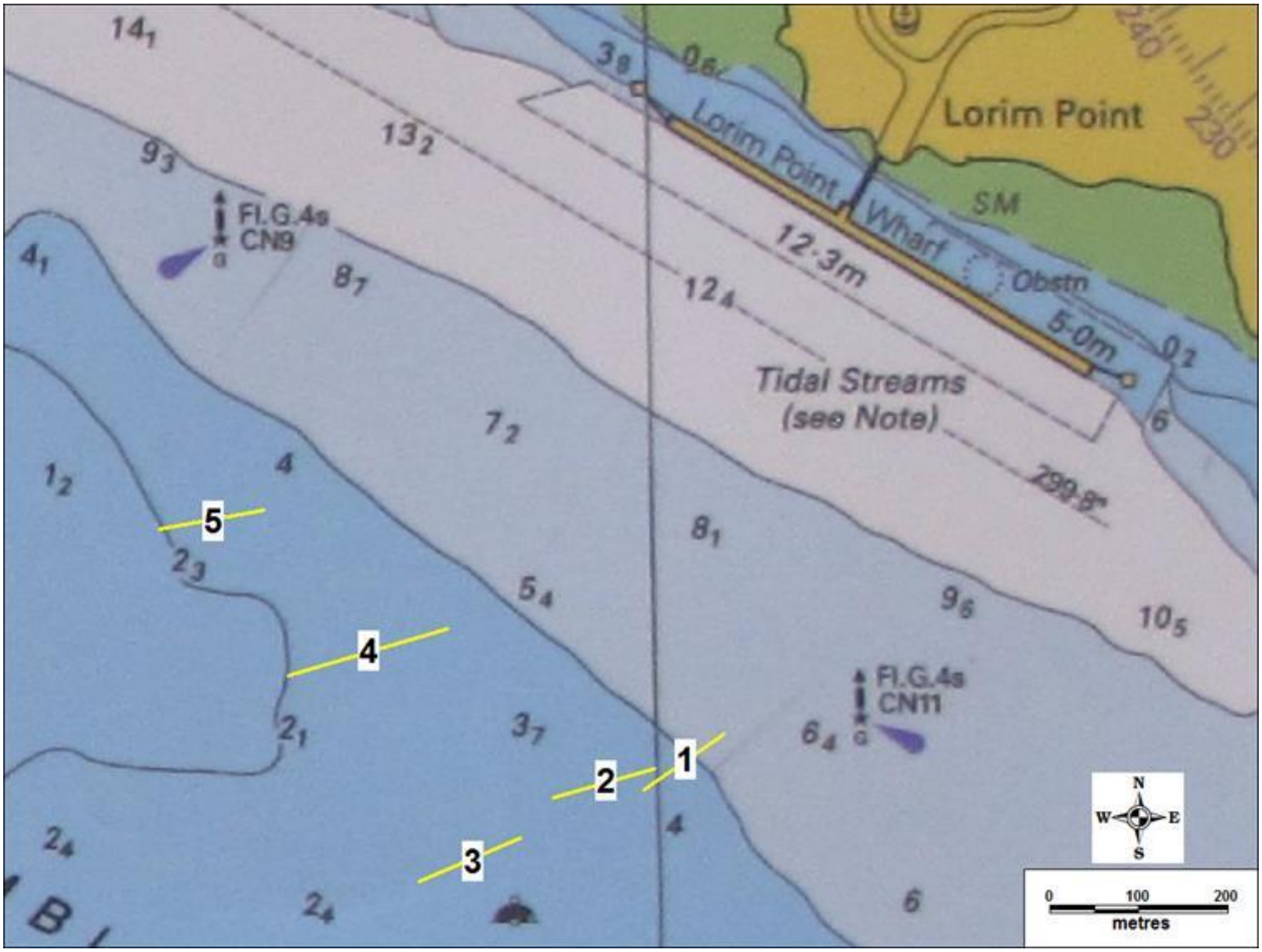

Figure 15 Benthic sled tow paths at site G within the Port of Weipa

Figure 16 Benthic sled tow paths and crab trapping sites at Hey River Terminal

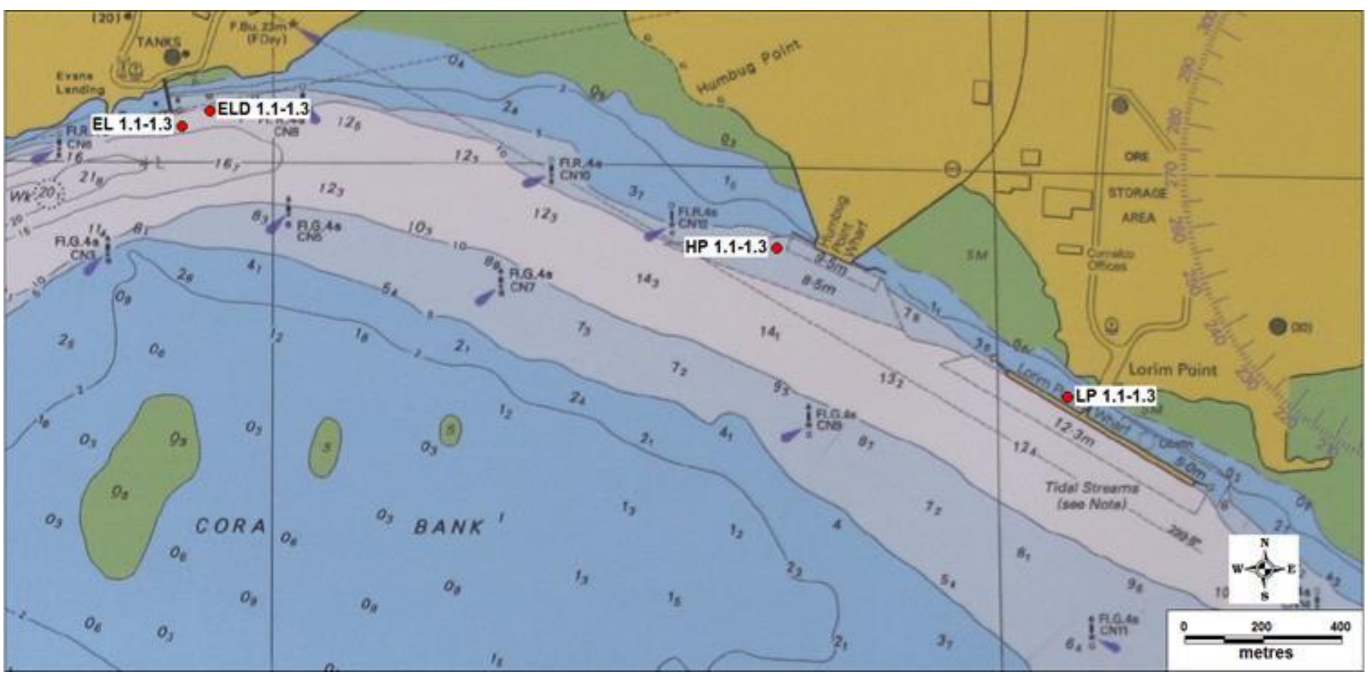

Figure 17 Crab trapping sites within the Port of Weipa

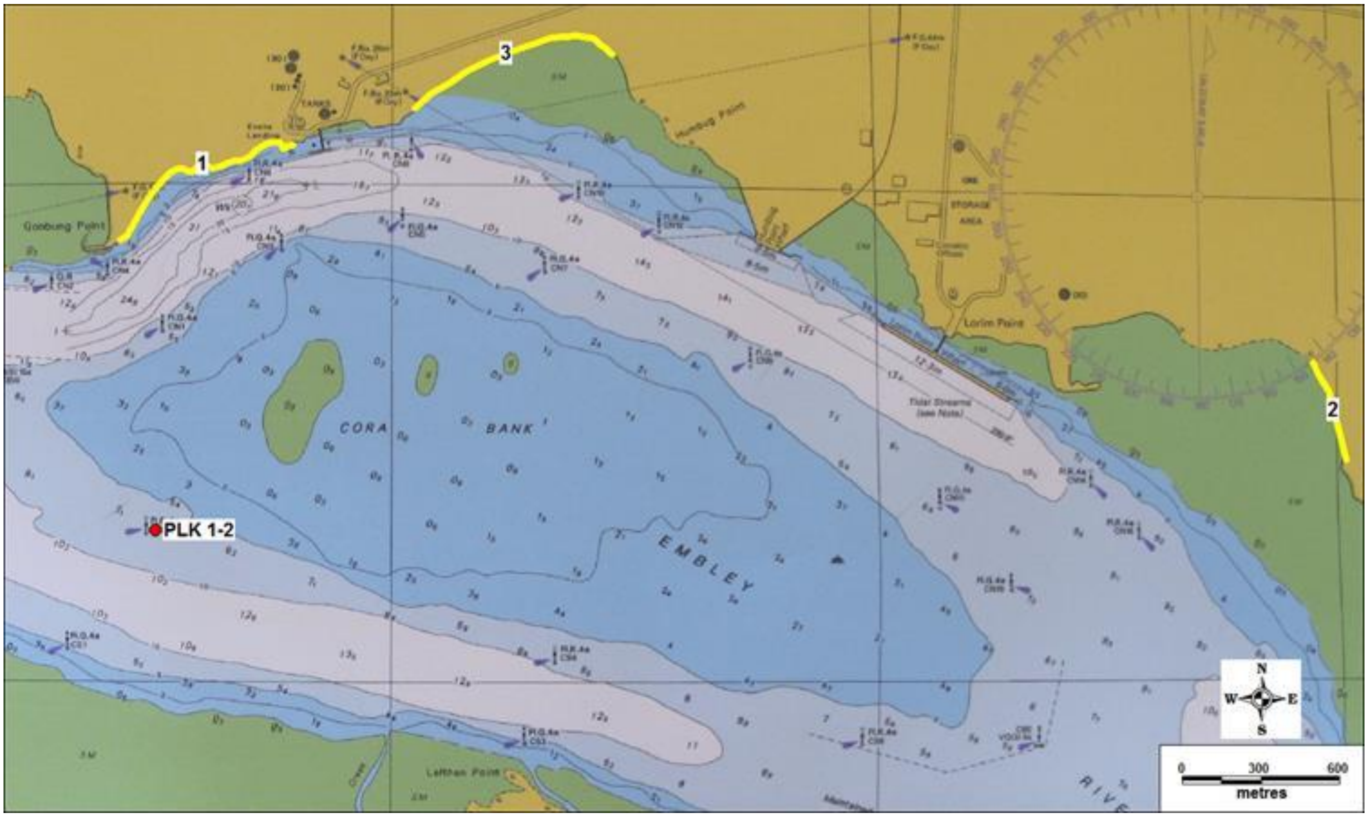

Figure 18 Intertidal visual searches and plankton sampling site within the Port of Weipa

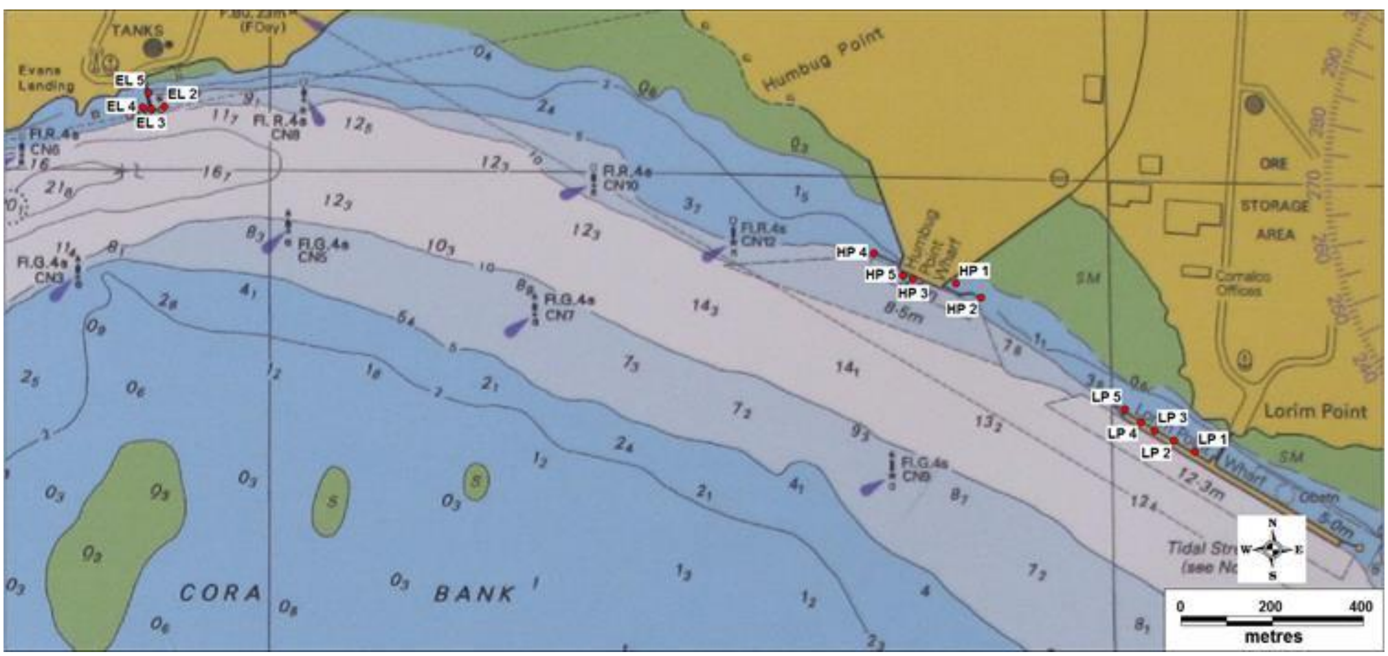

Figure 19 Pile scraping sampling sites within the Port of Weipa

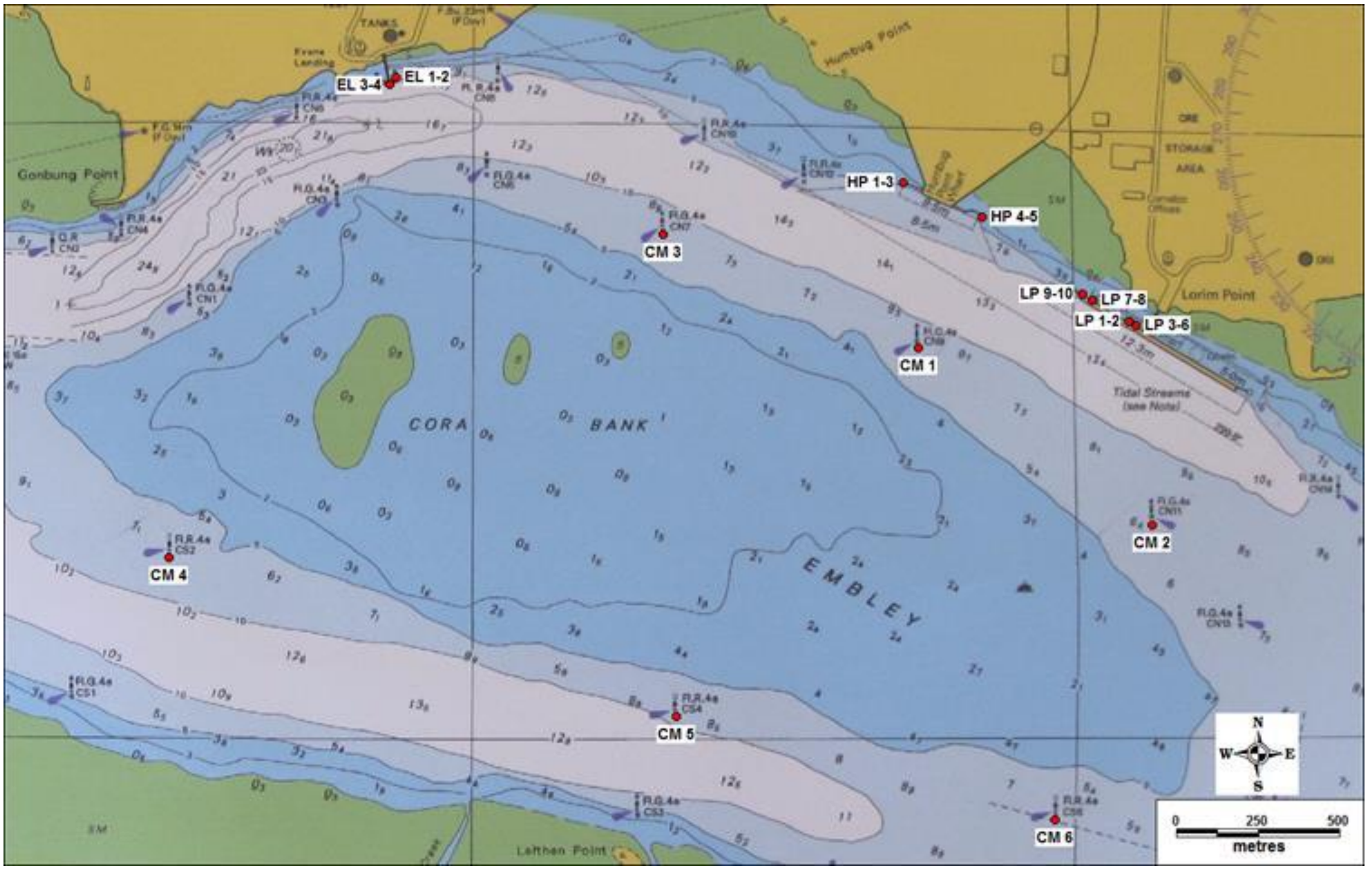

Figure 20 Underwater visual survey sites of piles and channel markers within the Port of Weipa

The spatial distribution of sampling achieved in Amrun Port is indicated in **Figure 21** to **Figure 25** below. Planned infrastructure is indicated in white, the planned dredged channel is in black. The proposed infrastructure consists of: the shiploader jetty at Amrun Port, a passenger jetty in Boyd Bay and the previously proposed barge loading facility at Pera Head.

Figure 21. Cyst core and plankton sampling sites near Amrun Port

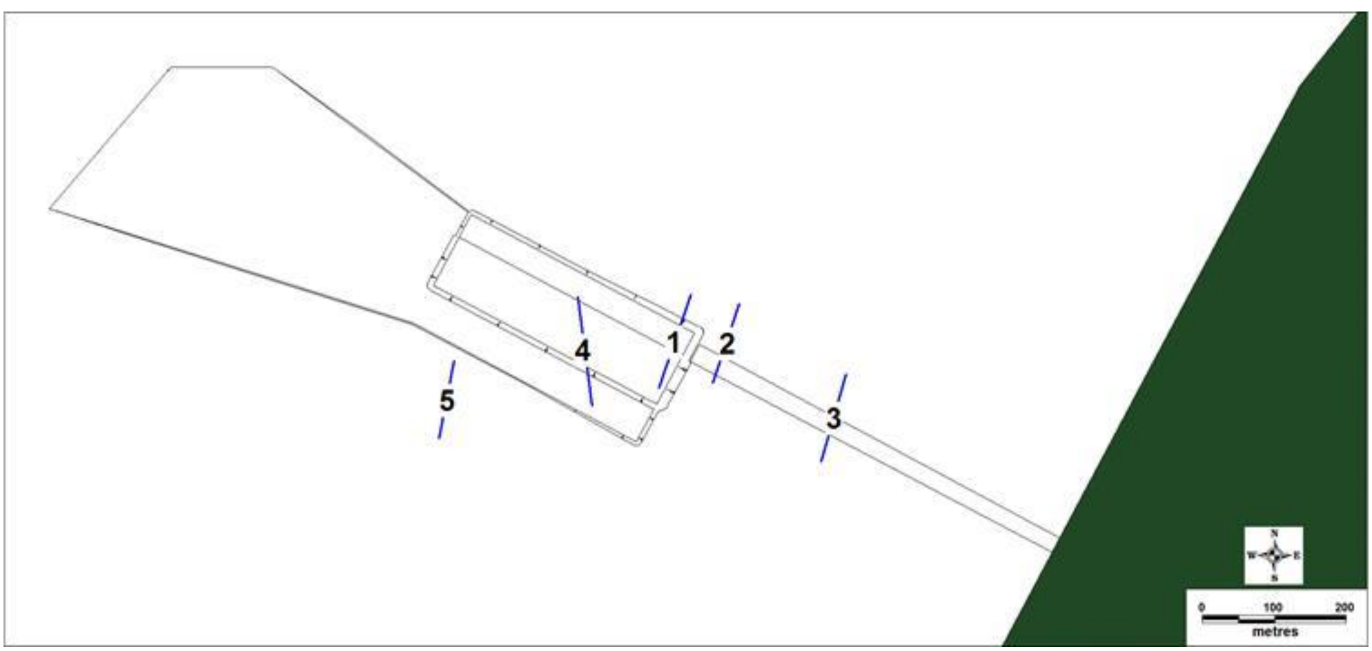

Figure 22. Benthic sled tow paths near Amrun Port and the proposed shiploader jetty.

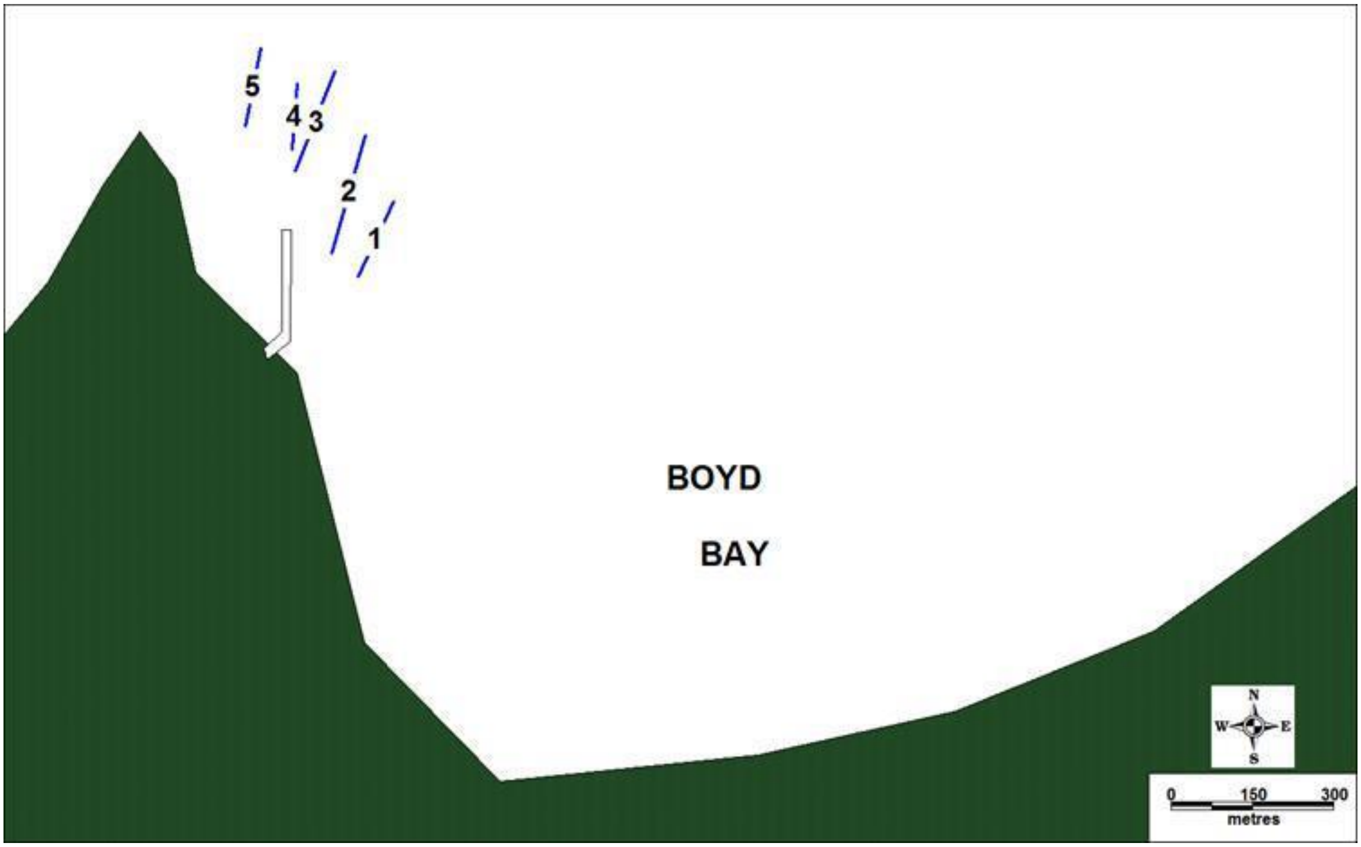

Figure 23. Benthic sled tow paths near Amrun Port and the proposed passenger jetty.

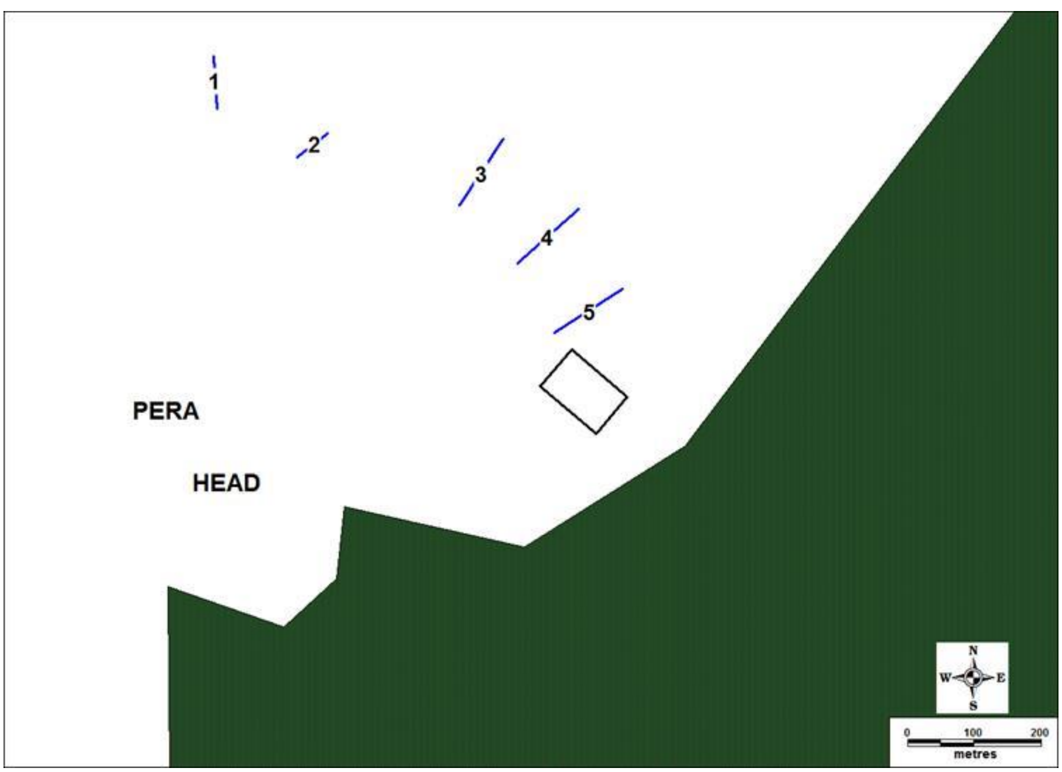

Figure 24. Benthic sled tow paths near Pera Head and the proposed landing barge.

Figure 25. Crab trapping sites and the beach wrack survey (yellow) near Amrun Port

7. RESULTS

None species on the refined NMTSL were detected during the surveys of Weipa Port and Amrun Port.

A small macroalgal fragment (a specimen of interest see **Figure 26**), was collected in benthic sled tow No.1 in Boyd Bay (see Figure 23 for precise sampling location). The small (~3cm) sample consisted of a frond and connecting rhizome which resembled *Caulerpa taxifolia* during the field collection. Since macroscopically the specimen resembled *Caulerpa taxifolia,* the field biologists preserved it for identification. Subsequent laboratory investigation indicated that the sample's morphology more closely resembled the related species *Caulerpa sertulariodies*. This conclusion was shared by the algal taxonomist Dr John Huisman, Murdoch University on the basis that ramuli (branchlets) were terete (rounded), rather than flattened or compressed as is the case in *C. taxifolia*. Nevertheless the small sample fragment precluded unambiguous identification. It should also be noted that *C. taxifolia* is a controversial inclusion on the NMTSL since native populations of this species are known throughout tropical Australia (Huisman 2000), while the invasive 'aquarium strain' tends to be found in temperate waters and is morphologically indistinguishable from the native strain.

Figure 26. *Caulerpa sertulariodies* fragment

Natural and man-made habitats were sampled during the surveys. Diverse, species rich assemblages of benthic and biofouling invertebrates (both sessile and mobile) and macroalgae were recorded at both Weipa and Amrun Ports.

The phytoplankton communities were dominated by the diatom genera *Bacteriastrum, Chaetoceros, Rhizosolenia s.l., Thalassionema*, with very sparse dinoflagellates (*Ceratium, Gonyaulax, Protoperidinium and Pyrophacus*). This compares with previous characterisation of Gulf of Carpentaria communities, including from Albatross Bay (Burford *et al*. 1995; Hallegraeff and Jeffrey 1984).

As is common for tropical locations subject to strong river discharges, dinoflagellate cysts were very sparse among a comparatively large sediment load. The dinoflagellate cyst community was dominated by *Protoperidinium* spp. in 2 size classes (small and large), while *Protoperidinium oblongum* and *Scrippsiella trochoidea* were also present. This cyst assemblage was consistent with results from surveys conducted elsewhere in tropical Australia (e.g. Darwin Harbour, Hay Point; G. Hallegraeff pers. Comm.).

Representative images of the biodiversity sampled are provided for Weipa Port and for Amrun Port (see Appendix 3, Appendix 4, and Appendix 5).

The following tables summarise the broad taxa sampled in both ports. Results are sorted by port, sampling method and individual replicates are identified.

Table 5. Weipa Port: Pile Scrapes. "X" indicates presence in sample.

Code	Algae - Phaeophyta	Algae - Chlorophyta	Bryozoa	Ascidians (colonial)	Ascidians (solitary)	Chordate - Teleost (Fish)	Cnidarian	Crustacean - cirripidea	Crustacean - crab	Crustacean - shrimp	Echninoderm - ophiuroid	Hydroids	Mollusc - bivalve	Mollusc - gastropod	Polychaete - errant	Polychaete - serpulid	Porifera	Sipunculid
WPSCEL1				X				X	X	X		X	X				X	
WPSCEL2		X		X				X	X		X	X	X		X			
WPSCEL3				X		X		X	X	X	X		X		X		X	
WPSCEL4				X				X	X				X		X		X	
WPSCEL5			X	X	X	X						X	X		X		X	
WPSCHP1				X					X		X	X	X					X
WPSCHP2													X	X				
WPSCHP3								X	X			X	X				X	
WPSCHP4				X				X	X	X			X		X		X	
WPSCHP5				X				X					X				X	
WPSCLP1	X		X		X			X	X			X			X		X	
WPSCLP2				X				X	X						X		X	
WPSCLP3			X	X				X	X				X				X	
WPSCLP4							X					X	X	X		X	X	
WPSCLP5								X	X		X	X	X	X			X	

Table 6. Weipa Port: Benthic Sled Tows. "X" indicates presence in sample.

Code	Alcyonacea (soft corals)	Algae - Phaeophyta (Brown)	Algae - Rhodophyta (Red)	Bryozoa	Ascidians (colonial)	- Ascidians (solitary)	Chordate - Teleost (Fish)	Crustacean - cirripidea	Crustacean - crab	Crustacean - isopod	Crustacean - shrimp	Crustacean - stomatopod	Echninoderm - asteroid	Echninoderm - echinoid	Echninoderm - holothurean	Echninoderm - ophiuroid	Echninoderm - crinoid	Hydroids	Mollusc - bivalve	Mollusc - gastropod	Octocorals	Polychaete - errant	Porifera	Sipunculid
WBSLDD1	X								X		X		X	X			X							
WBSLDD2	X	X					X		X					X										
WBSLDD3		X		X			X	X	X			X	X			X					X			
WBSLDD4													X				X			X				
WBSLDD5							X	X						X			X		X	X			X	
WBSLDE1			X			X	X	X	X					X	X				X		X		X	
WBSLDE2						X		X	X						X				X		X			
WBSLDE3		X					X		X		X		X						X				X	
WBSLDE4	X				X		X	X	X		X		X	X	X				X	X	X	X	X	
WBSLDE5		X											X	X			X		X		X			
WBSLDF1				X	X			X					X		X					X				
WBSLDF2	X						X								X					X	X			
WBSLDF3		X		X					X					X	X				X	X	X		X	
WBSLDF4								X	X					X	X				X				X	
WBSLDF5		X	X						X							X			X					
WBSLDG1	X													X					X				X	X
WBSLDG2	X			X					X	X	X			X			X		X	X	X			
WBSLDG3				X							X									X	X		X	
WBSLDG4	X			X			X		X					X									X	
WBSLDG5	X							X	X														X	
WBSLDH1									X					X					X	X				
WBSLDH2			X				X		X					X	X		X	X	X					
WBSLDH3									X							X		X	X		X			

Table 7. Weipa Port: Crab Traps. "X" indicates presence in sample.

Code	Chordate - Teleost (Fish)	Crustacean - crab	Echninoderm - asteroid (seastars)	Mollusc - gastropod
WCBTPEL1.1				
WCBTPEL1.2		X		
WCBTPEL1.3				
WCBTPHP1.1				
WCBTPHP1.2				
WCBTPHP1.3				
WCBTPLP1.1				X
WCBTPLP1.2				
WCBTPLP1.3	X	X		X
WCBTPHRT1.1		X		
WCBTPHRT1.2		X		
WCBTPHRT1.3	X	X		
WCBTPELD1.1	X			
WCBTPELD1.2				
WCBTPELD1.3			X	
WCBTPHRT2.1				
WCBTPHRT2.2	X			
WCBTPHRT2.3	X	X		
WCBTPHRT3.1				
WCBTPHRT3.2	X			
WCBTPHRT3.3				

Table 8. Weipa Port: Benthic Core Sampling. "XX" indicates abundant taxa in sample. "X" indicates presence in sample.

Code	Sediment type	Dinoflagellate cysts			Diatom resting stages														
		Round brown *Protoperidinium* (large 30-40 µm)	Round brown *Protoperidinium* (small 20-30 µm)	*Protoperidinium oblongum*	*Actinoptychus senarius*	*Bacteriastrum delicatulum*	*Campylodiscus* spp.	*Cymbella/Rhopalodia*	*Gyrosigma/Pleurosigma*	*Mastogloia/Lyrella*	Naviculoid	*Nitzschia* spp.	*Odontella sinensis*	*Paralia sulcata*	*Rhizosolenia/Proboscia/ Pseudosolenia* spp.	*Surirella* spp.	*Thalassiosira* spp.	*Trachyneis aspera*	*Trigonium* sp.
WCOREA1	grey silt/shell grit	XX	X						X		X								
WCOREA2	grey silt/shell grit		X						X				X	X	X	X			
WCOREA3	grey silt/shell grit	No cysts							X					X					
WCOREB1	grey silt	XX												X					
WCOREB2	grey silt	X	X		X				X	X			X	X					
WCOREB3	black silt	X							X				X	X					
WCOREC1	brown silt/shell grit		X				X							X	X		X	X	X
WCOREC2	grey silt	No cysts								X	X		X	X	X	X			
WCOREC3	grey silt	No cysts							X					X					
WCOREC4	grey silt	X												X					
WCOREC5	grey silt	X							X			X		X	X				
WCOREC6	grey silt	XX		XX		X		X				X			X		X		

Table 9. Weipa Port: Plankton Sampling. "XX" indicates abundant taxa in sample, "X" indicates presence in sample.

	Dinoflagellates			Diatoms																	
Code	*Gonyaulax polygramma*	*Protoperidinium spp.*	*Pyrophacus steinii*	*Bacillaria paradoxa*	*Bacteriastrum delicatulum*	*Chaetoceros lorenzianum*	*Chaetoceros peruvianum*	*Ditylum brightwelli*	*Guinardia* sp.	*Hemiaulus sinensis*	*Nitzschia sigmoideus*	*Odontella sinensis*	*Pleurosigma/Gyrosigma*	*Proboscia indica*	*Pseudosolenia calcar-avis*	*Rhizosolenia clevei*	*Rhizosolenia imbricata*	*Rhizosolenia setigera*	*Neostreptotheca indica*	*Thalassionema frauenfeldii*	*Trigonium* sp. (benthic)
WPLKTN1		X		X	X	X	X				X	X	X	X	X		X	X		XX	
WPLKTN2	X		X		X			X	X	X						X	X		X	X	X

For representative images of organisms detected in these samples see Appendix 5.

Table 10. Amrun Port: Benthic Sled Tows. "X" indicates presence in sample.

Code	Angiosperm (sea grass)	Algae - Chlorophyta (Green)	Chordate - Ascidians (solitary)	Crustacean - cirripidea	Crustacean – crab	Echninoderm - asteroid	Echninoderm - echinoid	Echninoderm - ophiuroid	Mollusc - bivalve	Mollusc - gastropod
BBSLDPH1				X					X	X
BBSLDPH2										
BBSLDPH3			X	X	X					X
BBSLDPH4				X	X		X			X
BBSLDPH5			X							X
BBSLDBJ21					X	X	X	X	X	X
BBSLDBJ22			X		X	X	X		X	X
BBSLDBJ23			X		X		X			X
BBSLDBJ24										
BBSLDBJ25									X	
BBSLDBB1	X	X [5]	X		X					X
BBSLDBB2	X						X			X
BBSLDBB3					X		X			X
BBSLDBB4					X		X		X	X
BBSLDBB5	X				X					X

[5] **Sample of *Caulerpa sertulariodies* detected in this replicate**

Table 11. Amrun Port: Crab Traps. “X” indicates presence in sample.

Code	Algae - Phaeophyta (Brown)	Chordate - Teleost (Fish)	Crustacean - crab	Crustacean - shrimp	Crustacean - stomatopod	Mollusc - gastropod
BCBTPPH1.1						
BCBTPPH1.2						
BCBTPPH1.3						
BCBTPBJ1.1			X			X
BCBTPBJ1.2		X			X	
BCBTPBJ1.3		X				
BCBTPBB1.1	X			X		
BCBTPBB1.2						
BCBTPBB1.3						
BCBTPBJ2.1		X	X			X
BCBTPBJ2.2						
BCBTPBJ2.3						X

Table 12. Amrun Port: Benthic Core Sampling. "XX" indicates abundant taxa in sample, "X" indicates presence in sample.

Code	Sediment type	Dinoflagellate cysts				Diatom resting stages										
		Round brown *Protoperidinium* (large 30-40 µm)	Round brown *Protoperidinium* (small 20-30 µm)	*Protoperidinium oblongum*	*Scrippsiella trochoidea*	*Actinoptychus senarius*	*Bacteriastrum delicatulum*	*Campylodiscus* spp.	*Diploneis* spp.	*Gyrosigma/Pleurosigma*	*Hyalodiscus* sp.	*Mastogloia/Lyrella*	*Odontella sinensis*	*Paralia sulcata*	*Thalassiosira* spp.	*Trigonium* sp.
BCOREBB1	coarse black sand	XX				X		X		X				X	X	X
BCOREBB2	coarse black sand		X							X		X		X	X	
BCOREBB3	coarse black sand	No cysts					X		X	X	X			X	X	
BCOREBJ1	grey silt				X					X				X	X	
BCOREBJ2	grey silt	No cysts									X			X	X	
BCOREBJ3	grey silt	No cysts												X	X	
BCOREBJ4	grey silt			X										X		X
BCOREBJ5	grey silt	No cysts												X		X
BCOREBJ6	grey silt	No cysts								X				X	X	

Table 13. Amrun Port: Plankton Sampling. "XX" indicates abundant taxa in sample, "X" indicates presence in sample.

Code	Dinoflagellates						Diatoms													
	Ceratium furca	*Ceratium fusus*	*Gonyaulax polygramma*	*Protoperidinium spp.*	*Protoperidinium cf.leonis*		*Bacteriastrum delicatulum*	*Chaetoceros lorenzianum*	*Haslea* sp.	*Hemiaulus sinensis*	*Nitzschia longissima*	*Paralia sulcata (benthic)*	*Pleurosigma/ Gyrosigma*	*Proboscia indica*	*Rhizosolenia pungens*	*Rhizosolenia imbricata*	*Rhizosolenia setigera*	*Neostreptotheca indica*	*Thalassionema frauenfeldii*	*Thalassiosira spp.*
BPLKTN1		X	X	X			XX		X		X	X	X	X	X	X			XX	
BPLKTN2	X	X			X		XX	X		X			XX				X	X	XX	X

For representative images of organisms detected in these samples see Appendix 5.

8. Discussion

No species targeted from the refined NMTSL target list were detected. Sampling focused on the marine pest species most likely to plausibly survive in the waters of Weipa and Amrun ports. Sampling strategies focused on the habitats most likely to be infected with marine pests and used reliable, proven techniques for safely sampling these areas. Replication was maximised within available field survey time, with the number of benthic sled tows exceeding the planned design and additional surveying of wharf pile surfaces achieved through remote video.

All sampling and surveying techniques sampled the targeted habitats of interest and diverse assemblages of marine and estuarine organisms were recovered during the survey. The remote pile scraping tool was poor at sampling the heavy oyster biofouling at intertidal and upper subtidal water depths on pier pilings. However, below this vertical zonation the tool worked well to sample biofouling on these artificial structures. Pile samples were augmented by video surveillance techniques.

While no species on the refined NMTSL target list were detected, it should be acknowledged that two possibilities exist. Firstly, there may indeed have been none of these targeted species present in either Weipa Port or Amrun Port at the time of sampling. The second possibility (which cannot be entirely excluded) is that the search effort was insufficient to detect marine pests if they were present particularly if they were very rare or in patchy, isolated distributions. This non-detection dilemma is universal in marine biosecurity baseline assessments since the logistics, costs and constraints of programs that can ensure high statistical detection probabilities in the event of rare, patchy or isolated invasive species are not practical to finance or implement. A trade off exists between financially/ logistically viable programs that can reliably detect marine pest populations if they are present in moderate abundance. We believe this baseline survey provided a pragmatic trade-off by focusing effort on the most appropriate species, locations and techniques to detect marine pests.

8.1 Comparison with historical marine pest surveys.

Marine pest baseline monitoring was previously completed in the Port of Weipa in October 1999 as part of the Ports Corporation of Queensland Environmental Monitoring Program (www.nqbp.com.au/wp-content/uploads/2012/05/Weipa-BaselineSurveyforMarinePests.pdf).
Hoedt *et al* 2001 reported the detection of only one recognised introduced species from this survey. The marine algae *Caulerpa racemosa* was collected from the sampling area outside the mouth of the Embley River. At the time only a single specimen was collected. The authors concluded that the species was not abundant and on this basis they suggested it was probably not having an adverse impact on native biota. No specimens of this species were detected at either Weipa or Amrun ports during the current survey, so there is no evidence to challenge their assertion.

In 2006 Asian Green Mussels (*Perna viridis*) were detected on a non-trading vessel previously operational in the Port of Weipa. The Port-of-Weipa-Environmental Management Plan states that no *P. viridis* were subsequently detected in the port, although surveillance efforts for detection are not described in the management plan. No evidence of *P. viridis* has been recorded in the Port of Weipa settlement plate monitoring which Queensland Bulk Ports has been operating since 2000. No evidence of *P. viridis* was detected during the current baseline survey. An additional monitoring settlement plate study was established in the Amrun Port area in February 2016 with the potential to detect this species.

The results of the current baseline assessment are broadly consistent with previous marine pest assessments for Australia's tropical marine communities which have shown relatively few marine pest to be present (e.g. Neill *et al*. 2005). In comparison to regions south of the Tropic of Capricorn, most of marine pest introductions recorded in Australia's tropical waters comprise widespread (cosmopolitan) and often cryptogenic species which do not appear to have caused any marked ecological or economic impact.

8.2 Additional marine pest monitoring - settlement plates

The baseline surveys provided a single 'snap-shot' of the marine organisms present in the ports and do not account for seasonal changes in the abundance of some species. Use of settlement plates was requested to provide some longer term measure of changes in the recruitment and abundance of biofouling species. Seasonal data will be collected using the settlement plate monitoring program which will be assessed for marine pests. Incorporation of a seasonal component in the settlement plate monitoring is viewed as particularly important, given the likely difference in distribution and abundance of organisms between wet and dry seasons in the tropics (Hoedt *et al.* 2001).

Accordingly we deployed settlement plates in the area of the proposed Amrun port development in February 2016.

8.3 Summary and recommendations

Overall, the baseline survey design was successfully implemented, with no detection of species on the NMTSL revised target list. Should future marine pest surveys occur, notably at the completion of the construction phase of the Amrun port, it is recommended that the same methodologies and sample sites are used. A consistent approach with respect to the sites surveyed and methodologies is viewed as a key component of on-going marine pest monitoring activities.

Consideration could be given to the benefits of a pair of surveys on completion of the construction, with both a dry season and wet season survey to detect marine pests that potentially show seasonal patterns in abundance or presence. This was initially recommended for tropical port surveys by Hoedt et al 2001. They stated that:

> *'In tropical ports, it is important to consider the impact of seasonal changes on sampling. The timing and intensity of monsoons at higher tropical latitudes influence the abundance of intertidal and shallow subtidal benthic fauna (Hilliard et al. 1997). Where a prolonged monsoon season occurs, major runoff and flushing can cause significant mortality in these habitats. Therefore, it is desirable to sample in the dry season. In areas where the monsoon is less intense, faunal densities in estuarine waters can be highest during the summer wet season (Alongi 1989). Taxa assemblages in a port may differ between the wet and dry season and ideally, surveys should be done in each season.'*

The Australian Marine Pest Monitoring Guidelines acknowledge the potential for seasonal changes in the abundance of some marine pests, however this is most likely to be relevant for annual species in temperate environments. Little evidence currently exists to justify (or dismiss) the potential for seasonal changes in abundance of the species in the refined NTMSL target list.

A final aspect of recommended ongoing monitoring is the role of locally based staff in detecting target marine pests during their normal work activities. The likelihood of early detection of a new marine pest introduction is improved if those who work regularly in the area are educated on the potential target species and are looking out for these species. Such vigilance may be particularly important in detecting marine pests in the early stages of an incursion. BFS recommend training the marine based staff in pest detection. As part of the existing marine induction relevant staff could be provided with identification materials for target species and instructions on how to monitor and report any sightings. Marine pest identification material should sensibly focus on targeting marine pest species potentially transported as vessel biofouling that can also be relatively easily identified. Of the target list used in the current survey, the two mussel species (*Mytilopsis sallei* and *Perna viridis*) are considered the most suitable candidates for such opportunistic surveillance. Given the tendency of these biofouling marine pests to colonise artificial structures, periodic inspection of artificial substrates (e.g. wharf pylons) by locally based staff is recommended as an invaluable marine pest surveillance option to complement the formal monitoring program.

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10. Appendix 1: National Monitoring Target Species

The target species that must be considered for a monitoring program for a given location in Australia are listed in this table. This list (endorsed by NIMPCG) has been compiled from a number of reports that considered the invasion potential and impact potential of a large range of species.

NO.	SPECIES NAME	COMMON NAME
1	*Acartia tonsa*	Calanoid copepod
2	*Alexandrium catenella* *	Toxic dinoflagellate
3	*Alexandrium minutum* *	Toxic dinoflagellate
4	*Alexandrium monilatum*	Toxic dinoflagellate
5	*Alexandrium tamarense*	Toxic dinoflagellate
6	*Asterias amurensis* *	Northern Pacific seastar
7	*Balanus eburneus*	Ivory barnacle
8	*Balanus improvisus* (marine/estuarine incursions only)	Bay barnacle
9	*Beroe ovata*	Comb jelly
10	*Blackfordia virginica*	Black Sea jelly
11	*Bonnemaisonia hamifera*	Red macroalga
12	*Callinectes sapidus*	Blue crab
13	*Carcinus maenas* *	European shore crab
14	*Caulerpa racemosa* (possibly an Australian native)	Green macroalga
15	*Caulerpa taxifolia* (exotic strains only)	Green macroalga
16	*Chaetoceros concavicornis*	Centric diatom
17	*Chaetoceros convolutus*	Centric diatom
18	*Charybdis japonica* * barcoded	Asian paddle/lady crab
19	*Codium fragile* spp. *fragile*[1]	Green macroalga
20	*Corbula* (Potamocorbula) amurensis	Brackish-water/Asian clam
21	*Crassostrea gigas* *	Pacific oyster

NO.	SPECIES NAME	COMMON NAME
22	*Crepidula fornicata*	American slipper limpet
23	*Didemnum* spp. (exotic invasive species only)	Tunicate – sea squirt
24	*Dinophysis norvegica*	Toxic dinoflagellate
25	*Ensis directus*	Jack-knife clam
26	*Eriocheir spp.*	Mitten crabs
27	*Grateloupia turuturu*	Red macroalga
28	*Gymnodinium catenatum* *	Toxic dinoflagellate
29	*Hemigrapsus sanguineus*	Japanese shore crab
30	*Hemigrapsus takanoi / penicillatus*	Pacific crab
31	*Hydroides dianthus*	Tube worm
32	*Limnoperna fortunei*	Golden mussel
33	*Marenzelleria* spp. (invasive species and marine/estuarine incursions only)	Red-gilled mud worm
34	*Mnemiopsis leidyi*	Comb jelly
35	*Musculista senhousia* *	Asian bag/date mussel
36	*Mya arenaria*	Soft shell clam
37	*Mytilopsis sallei*	Black-striped mussel
38	*Neogobius melanostomus* (marine/estuarine incursions only)	Round goby
39	*Perna perna*	South African brown mussel
40	*Perna viridis* *	Asian green mussel
41	*Pfiesteria piscicida* *	Dinoflagellate
42	*Pseudodiaptomus marinus*	Asian copepod
43	*Pseudo-nitzschia seriata*	Pennate diatom
44	*Rapana venosa*	Asian/veined rapa whelk
45	*Rhithropanopeus harrisii*	Harris mud crab

NO.	SPECIES NAME	COMMON NAME
46	*Sabella spallanzanii* *	European/Mediterranean fan worm
47	*Sargassum muticum*	Asian seaweed
48	*Siganus luridus*	Dusky spinefoot
49	*Siganus rivulatus*	Marbled spine foot/rabbit fish
50	*Tortanus dextrilobatus*	Asian copepod
51	*Tridentiger bifasciatus*	Shimofuri goby
52	*Tridentiger barbatus*	Shokohazi goby
53	*Undaria pinnatifida* *	Japanese seaweed
54	*Varicorbula (Corbula) gibba* *	European clam
55	*Womersleyella setacea*	Red seaweed

[1] Codium fragile spp. fragile is on the Interim CCIMPE trigger list. Noting that the CCIMPE criteria for removal requires that data indicates that impacts overseas/in Australia are likely to be less than previously thought or it becomes widely distributed in Australia, it does not seem likely at this time that justification could be provided to remove this species from the CCIMPE trigger list.
* = species with a genetic/molecular probe or barcoded (see Doblin & Bolch 2008)

11. Appendix 2: Revised CCIMPE Trigger List[6]

Phylum	Scientific Name/s	Common Name/s
Holoplankton	*Alexandrium monilatum*	Toxic dinoflagellate
Holoplankton	*Chaetoceros concavicornis*	Centric diatom
Holoplankton	*Chaetoceros convolutus*	Centric diatom
Holoplankton	*Dinophysis norvegica*	Toxic dinoflagellate
Holoplankton	*Pfiesteria piscicida*	Toxic dinoflagellate
Holoplankton	*Pseudo-nitzschia seriata*	Pennate diatom
Algae	*Caulerpa taxifolia (exotic strains only)*	Green macroalga
Algae	*Codium fragile spp. fragile*	Green macroalga
Algae	*Grateloupia turuturu*	Red macroalga
Algae	*Sargassum muticum*	Asian seaweed
Algae	*Undaria pinnatifida*	Japanese seaweed
Cnidaria	*Mnemiopsis leidyi*	Comb jelly
Annelida	*Marenzelleria spp*	Red gilled mudworm
Annelida	*Sabella spallanzanii*	European fan worm
Echinodermata	*Asterias amurensis*	Northern Pacific seastar
Mollusca	*Crepidula fornicata*	American slipper limpet
Mollusca	*Corbula (Potamocorbula) amurensis*	Asian clam
Mollusca	*Ensis directus*	Jack-knife clam
Mollusca	*Maoricolpus roseus*	New Zealand screwshell
Mollusca	*Arcuatula senhousia*	Asian bag mussel
Mollusca	*Mya arenaria*	Soft shell clam
Mollusca	*Mytilopsis sallei*	Black striped mussel
Mollusca	*Perna perna*	Brown mussel
Mollusca	*Perna viridis*	Asian green mussel
Mollusca	*Rapana venosa (syn Rapana thomasiana)*	Rapa whelk
Mollusca	*Varicorbula gibba*	European clam
Crustacea	*Amphibalanus improvisus*	Bay barnacle
Crustacea	*Carcinus maenas*	European green crab
Crustacea	*Charybdis japonica*	Lady crab
Crustacea	*Eriocheir sinensis*	Chinese mitten crab
Crustacea	*Hemigrapsus sanguineus*	Japanese/Asian shore crab
Crustacea	*Hemigrapsus takanoi/penicillatus*	Pacific crab
Ascideacea	*Didemnum spp (exotic invasive strains only)*	Colonial sea squirt
Chordata	*Neogobius melanostomus*	Round goby
Chordata	*Siganus rivulatus*	Marbled spinefoot, rabbit fish

[6] While it is acknowledged that the revised CCIMPE trigger list is no longer valid to guide emergency response actions in Australian waters, it remains the most appropriate list to use in lieu of DoAWR providing a definitive target list of marine pests of concern.

12. Appendix 3: Representative Samples Weipa Port

Photos in this appendix are representative. Further photos can be made available on request.

Plate 1 Benthic Core: WCA1

Plate 2 Benthic Core: WCA2

Plate 3 Benthic Core: WCA3

Plate 4 Benthic Core: WCB1

Plate 5 Benthic Core: WCB2

Plate 6 Benthic Core: WCB3

Plate 7 Benthic Core: WCC1

Plate 8 Benthic Core: WCC2

Plate 9 Benthic Core: WCC3

Plate 10 Benthic Core: WCC4

Plate 11 Benthic Core: WCC5

Plate 12 Benthic Core: WCC6

Plate 13 Benthic Sled: WBSLD D1

Plate 14 Benthic Sled: WBSLD D1

Plate 15 Benthic Sled: WBSLD D2

Plate 16 Benthic Sled: WBSLD D2

Plate 17 Benthic Sled: WBSLD D3

Plate 18 Benthic Sled: WBSLD D3

Plate 19 Benthic Sled: WBSLD F1

Plate 20 Benthic Sled: WBSLD F1

Plate 21 Benthic Sled: WBSLD F2

Plate 22 Benthic Sled: WBSLD F2

Plate 23 Benthic Sled: WBSLD F3

Plate 24 Benthic Sled: WBSLD F3

Plate 25 Benthic Sled: WBSLD F4

Plate 26 Benthic Sled: WBSLD F4

Plate 27 Benthic Sled: WBSLD F5

Plate 28 Benthic Sled: WBSLD F5

Plate 29 Benthic Sled: WBSLD G1

Plate 30 Benthic Sled: WBSLD G1

Plate 31 Benthic Sled: WBSLD G2

Plate 32 Benthic Sled: WBSLD G2

Plate 33 Benthic Sled: WBSLD G3

Plate 34 Benthic Sled: WBSLD G3

Plate 35 Benthic Sled: WBSLD G4

Plate 36 Benthic Sled: WBSLD G4

Plate 37 Benthic Sled: WBSLD G5

Plate 38 Benthic Sled: WBSLD G5

Plate 39 Benthic Sled: WBSLD H1

Plate 40 Benthic Sled: WBSLD H1

Plate 41 Benthic Sled: WBSLD H2

Plate 42 Benthic Sled: WBSLD H2

Plate 43 Benthic Sled: WBSLD H3

Plate 44 Benthic Sled: WBSLD H3

Plate 45 Benthic Sled: WBSLD D4

Plate 46 Benthic Sled: WBSLD D5

Plate 47 Benthic Sled: WBSLD D5

Plate 48 Benthic Sled: WBSLD D5

Plate 49 Benthic Sled: WBSLD E1

Plate 50 Benthic Sled: WBSLD E1

Plate 51 Benthic Sled: WBSLD E2

Plate 52 Benthic Sled: WBSLD E2

Plate 53 Benthic Sled: WBSLD E3

Plate 54 Benthic Sled: WBSLD E3

Plate 55 Benthic Sled: WBSLD E4

Plate 56 Benthic Sled: WBSLD E4

Plate 57 Benthic Sled: WBSLD E5

Plate 58 Benthic Sled: WBSLD E5

Plate 59 Pile Scrape: WPSC HP1

Plate 60 Pile Scrape: WPSC HP1

Plate 61 Pile Scrape: WPSC HP2

Plate 62 Pile Scrape: WPSC HP2

Plate 63 Pile Scrape: WPSC LP1

Plate 64 Pile Scrape: WPSC LP1

Plate 65 Pile Scrape: WPSC LP1

Plate 66 Pile Scrape: WPSC LP1

Plate 67 Pile Scrape: WPSC LP2

Plate 68 Pile Scrape: WPSC LP2

Plate 69 Pile Scrape: WPSC LP3

Plate 70 Pile Scrape: WPSC LP3

Plate 71 Pile Scrape: WPSC LP3

Plate 72 Pile Scrape: WPSC LP3

Plate 73 Pile Scrape: WPSC LP5

Plate 74 Pile Scrape: WPSC LP5

Plate 75 Pile Scrape: WPSC EL1

Plate 76 Pile Scrape: WPSC EL1

Plate 77 Pile Scrape: WPSC EL2

Plate 78 Pile Scrape: WPSC EL2

Plate 79 Pile Scrape: WPSC EL3

Plate 80 Pile Scrape: WPSC EL3

Plate 81 Pile Scrape: WPSC EL4

Plate 82 Pile Scrape: WPSC EL4

Plate 83 Pile Scrape: WPSC EL5

Plate 84 Pile Scrape: WPSC EL5

Plate 85 Crab trap: CBTP HRT1.1

Plate 86 Crab trap: CBTP HRT1.1

Plate 87 Crab trap: CBTP HRT1.2

Plate 88 Crab trap: CBTP HRT1.2

Plate 89 Crab trap: CBTP HRT1.3

Plate 90 Crab trap: CBTP HRT1.3

Plate 91 Crab trap: CBTP HRT2.2

Plate 92 Crab trap: CBTP HRT2.3

Plate 93 Crab trap: CBTP HRT2.3

Plate 94 Crab trap: CBTP HRT2.3

Plate 95 Crab trap: CBTP HRT2.3

Plate 96 Crab trap: CBTP HRT2.3

Plate 97 Crab trap: CBTP EL 1.1

Plate 98 Crab trap: CBTP EL 1.1

Plate 99 Crab trap: CBTP EL 1.2

Plate 100 Crab trap: CBTP EL 1.2

Plate 101 Crab trap site: CBTP ELD

Plate 102 Crab trap: CBTP ELD 1.1

Plate 103 Crab trap: CBTP ELD 1.3

Plate 104 Crab trap: CBTP ELD 1.3

Plate 105 Crab trap site: CBTP LP

Plate 106 Crab trap: CBTP LP1.1

Plate 107 Crab trap: CBTP LP1.1

Plate 108 Crab trap: CBTP LP1.1

Plate 109 Crab trap, unbaited

Plate 110 Crab traps: CBTP LP 1.2

Plate 111 Crab trap: CBTP LP 1.3

Plate 112 Crab trap: CBTP LP 1.3

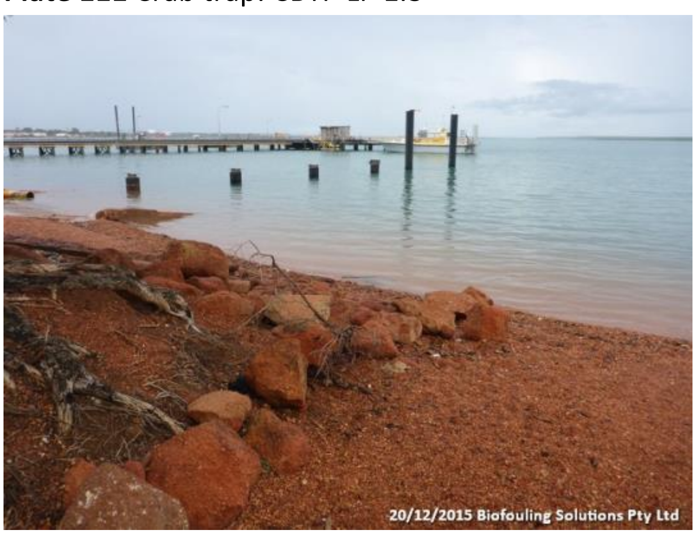


Plate 113 Beach Wrack Survey: INTV 1

Plate 114 Beach Wrack Survey: INTV 1

Plate 115 Beach Wrack Survey: INTV 1

Plate 116 Beach Wrack Survey: INTV 1

Plate 117 Beach Wrack Survey: INTV 1

Plate 118 Beach Wrack Survey: INTV 1

Plate 119 Beach Wrack Survey: INTV 1

Plate 120 Beach Wrack Survey: INTV 2

Plate 121 Beach Wrack Survey: INTV 2

Plate 122 Beach Wrack Survey: INTV 2

Plate 123 Beach Wrack Survey: INTV 2

Plate 124 Beach Wrack Survey: INTV 3

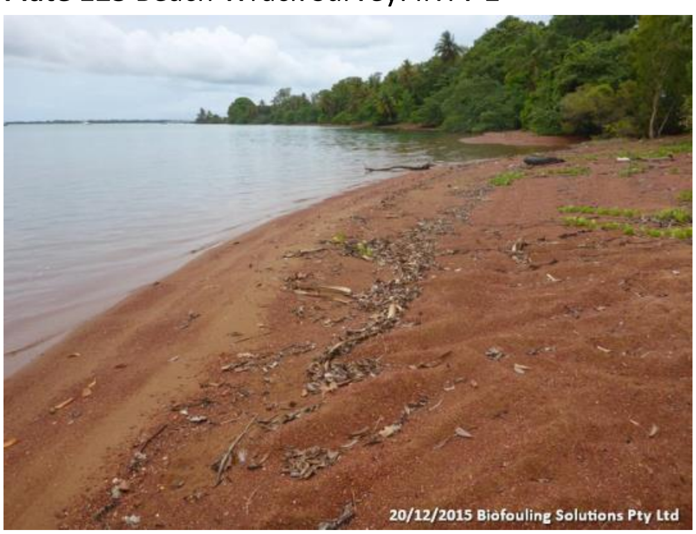


Plate 125 Beach Wrack Survey: INTV 3

Plate 126 Beach Wrack Survey: INTV 3

13. Appendix 4: Representative Samples Amrun Port

Photos in this appendix are representative. Further photos can be made available on request.

Plate 1 Benthic Core: BB1

Plate 2 Benthic Core: BB2

Plate 3 Benthic Core: BB3

Plate 4 Benthic Core: BJ1

Plate 5 Benthic Core: BJ2

Plate 6 Benthic Core: BJ3

Plate 7 Benthic Core: BJ4

Plate 8 Benthic Core: BJ5

Plate 9 Benthic Core: BJ6

Plate 10 Benthic Sled: PH1

Plate 11 Benthic Sled: PH1

Plate 12 Benthic Sled: PH1

Plate 13 Benthic Sled: PH2

Plate 14 Benthic Sled: PH2

Plate 15 Benthic Sled: PH3

Plate 16 Benthic Sled: PH3

Plate 17 Benthic Sled: PH4

Plate 18 Benthic Sled: PH4

Plate 19 Benthic Sled: PH4

Plate 20 Benthic Sled: PH4

Plate 21 Benthic Sled: PH4

Plate 22 Benthic Sled: PH4

Plate 23 Benthic Sled: BB1 (*Caulerpa sertulariodies*)

Plate 24 Benthic Sled: BB1

Plate 25 Benthic Sled: BB3

Plate 26 Benthic Sled: BB3

Plate 27 Benthic Sled: BB4

Plate 28 Benthic Sled: BB4

Plate 29 Benthic Sled: BB4

Plate 30 Benthic Sled: BJ21

Plate 31 Benthic Sled: BJ21

Plate 32 Benthic Sled: BJ21

Plate 33 Benthic Sled: BJ21

Plate 34 Benthic Sled: BJ21

Plate 35 Benthic Sled: BJ21

Plate 36 Benthic Sled: BJ22

Plate 37 Benthic Sled: BJ22

Plate 38 Benthic Sled: BJ22

Plate 39 Benthic Sled: BJ22

Plate 40 Benthic Sled: BJ22

Plate 41 Benthic Sled: BJ23

Plate 42 Benthic Sled: BJ23

Plate 43 Benthic Sled: BJ23

Plate 44 Benthic Sled: BJ25

Plate 45 Crab Trap: BB1.1

Plate 46 Crab Trap: BB1.1

Plate 47 Crab Trap: BJ1.1

Plate 48 Crab Trap: BJ1.1

Plate 49 Crab Trap: BJ1.2

Plate 50 Crab Trap: BJ1.2

Plate 51 Crab Trap: BJ1.2

Plate 52 Crab Trap: BJ1.2

Plate 53 Crab Trap: BJ1.3

Plate 54 Crab Trap: BJ2.1

Plate 55 Crab Trap: BJ2.1

Plate 56 Crab Trap: BJ2.1

Plate 57 Crab Trap: BJ2.1

Plate 58 Crab Trap: BJ2.1

Plate 59 Crab Trap: BJ2.3

Plate 60 Crab Trap: BJ2.3

Plate 61 Beach wrack survey: BB1

Plate 62 Beach wrack survey: BB1

Plate 63 Beach wrack survey: BB1

Plate 64 Beach wrack survey: BB1

Plate 65 Beach wrack survey: BB1

Plate 66 Beach wrack survey: BB1

Plate 67 Beach wrack survey: BB1

Plate 68 Beach wrack survey: BB1

Plate 69 Beach wrack survey: BB1

Plate 70 Beach wrack survey: BB1

Plate 71 Beach wrack survey: BB1

Plate 72 Beach wrack survey: BB1

Plate 73 Beach wrack survey: BB1

Plate 74 Beach wrack survey: BB1

Plate 75 Beach wrack survey: BB1

Plate 76 Beach wrack survey: BB1

Plate 77 Beach wrack survey: BB1

Plate 78 Beach wrack survey: BB1

Plate 79 Plankton sampling net

Plate 80 Plankton sampling net

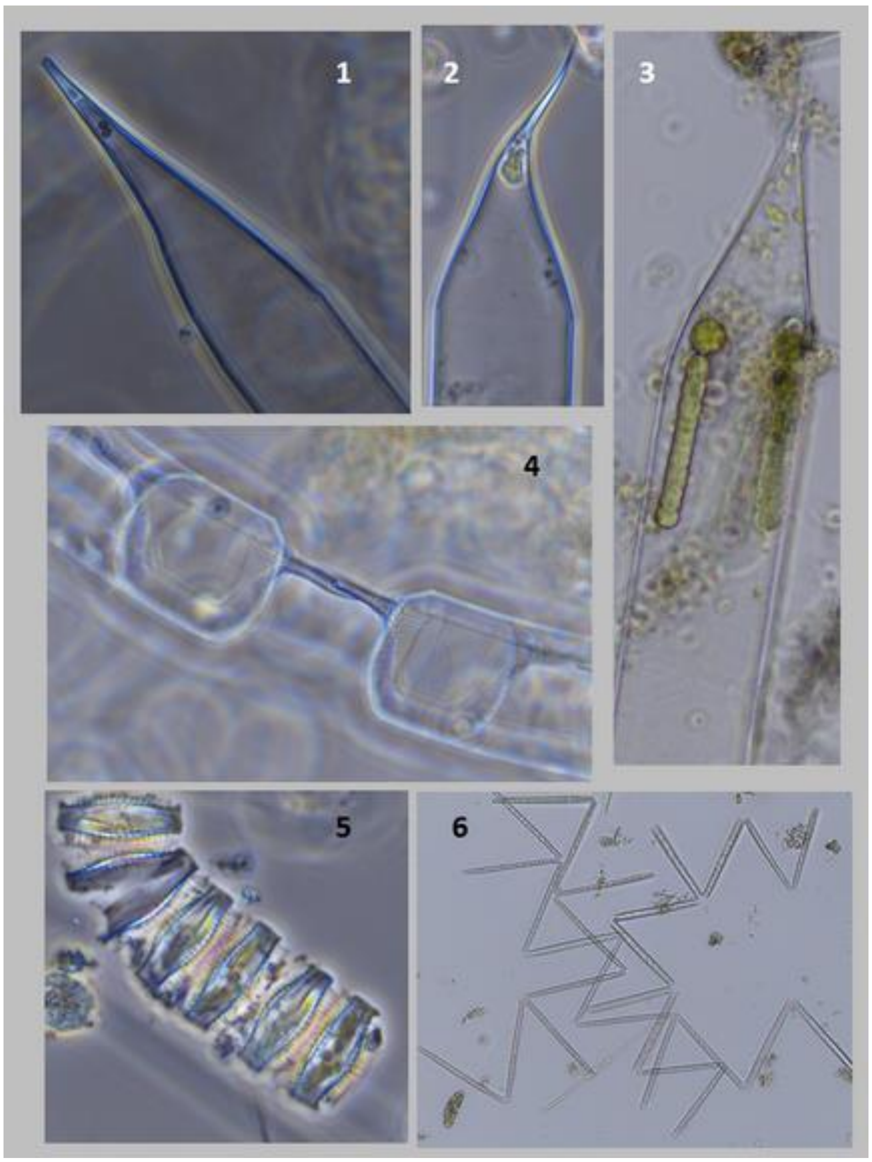
Plate 81 Plankton sample BPLKTN1

Plate 82 Returning to Weipa

14. Appendix 5: Representative Images From Benthic Core and Phytoplankton samples

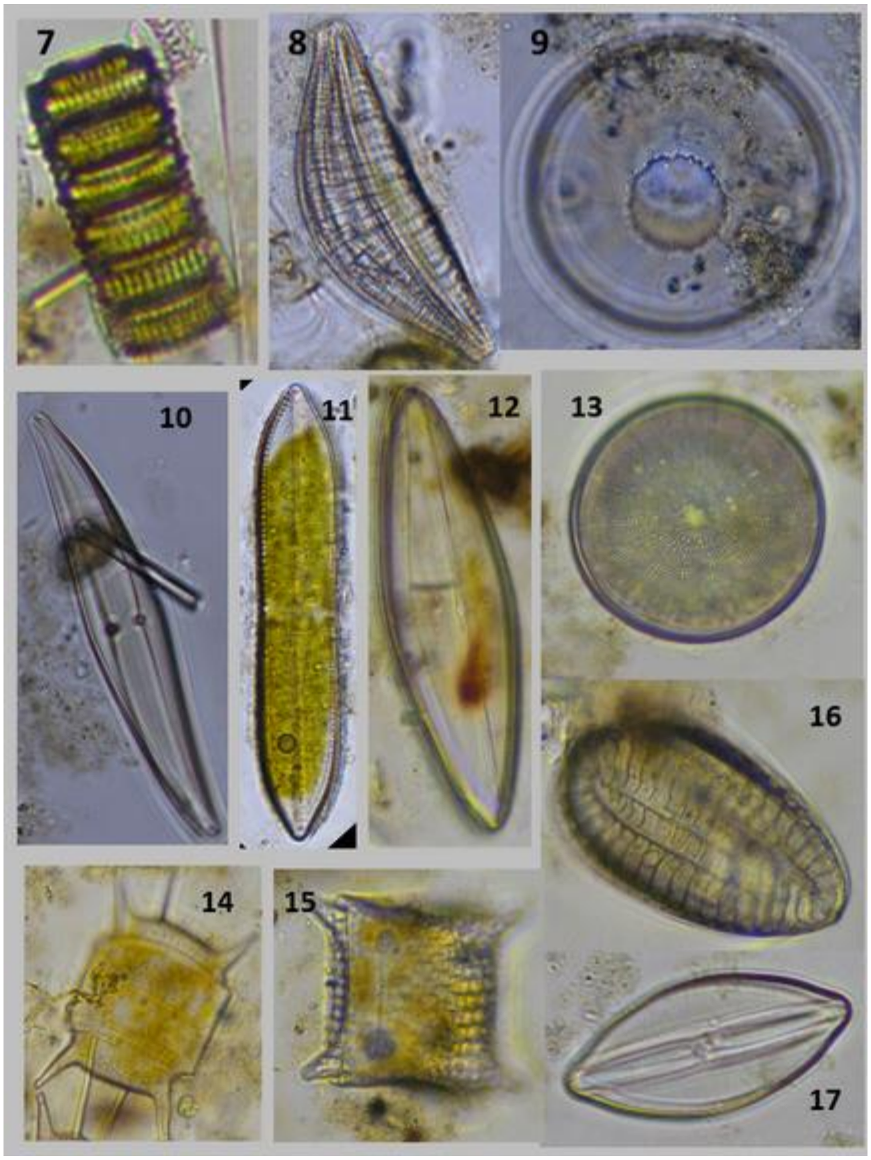
Phytoplankton

1. *Rhizosolenia* cf. *bergonii*; 2. *Pseudosolenia calcar-avis*; 3. *Rhizosolenia clevei* with *Richelia intracellularis* cyanobacterial symbiont; 4. *Hemiaulus sinensis*; 5. *Bellerochea*; 6. *Thalassionema frauenfeldii*.



Benthic diatoms

7. *Paralia*; 8. *Rhopalodia*; 9. *Hyalodiscus*; 10: *Gyrosigma*; 11. *Nitzschia* cf.*gelida*; 12. Naviculoid; 13. *Thalassiosira*; 14. *Odontella*; 15. *Trigonium*; 16. *Surirella*; 17. *Lyrella*



Dinoflagellate cysts

18, 19, 20, 21: round brown *Protoperidinium* spp., 30-50 micron; 22, 23, 24: round brown *Protoperidinium* spp., 20-30 micron; 25, 26, 27: *Protoperidinium* cf. *oblongum*; 28; *Scrippsiella trochoidea*.