SERN

## ATTACHMENT 2

# Tasi Mane - Suai Supply Base EIA

## Marine Environment Technical Report

## DRAFT

301012-01504-EN-REP-0002

23 March 2012

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resources & energy

EcoNomics

**SERN**
**TIMOR LESTE SOUTH COAST EIA**
**MARINE ENVIRONMENT SUAI TECHNICAL REPORT**

## Disclaimer

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**PROJECT 301012-01406-EN-R – TIMOR LESTE SOUTH COAST EIA**

| REV | DESCRIPTION | ORIG | REVIEW | WORLEY-PARSONS APPROVAL | DATE | CLIENT APPROVAL | DATE |
|---|---|---|---|---|---|---|---|
| A | Issued for internal review | E McGinty | H Houridis | N/A | 12-03-12 | N/A | |
| B | Issued for client review | | | | 23 Mar 12 | | |
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# 1. INTRODUCTION

The Tasi Mane Project is a multi-year development of three industrial clusters on the south coast of Timor. The project will involve development of a coastal zone from Suai to Beaço providing the infrastructure required to support a growing domestic petroleum industry. Tasi Mane will include the Suai Supply Base cluster, the Betano Refinery and Petrochemical Industry cluster, and the Beaço LNG-Plant cluster (SDP 2011) (Figure MAR001).

WorleyParsons was commissioned by the Secretaria de Estado dos Recursos Naturais (SERN), on behalf of the Government of Timor-Leste (GoTL), on December 2011, to prepare an Environmental Impact Assessment (EIA) to describe the likely environmental and social impacts associated with the proposed development.

As part of the EIA, WorleyParsons undertook marine environmental surveys at each of the three development sites. This report presents data for the Suai development area. Data from the Betano and Beaco development areas will be presented in a separate report.

## 1.1 Project Setting

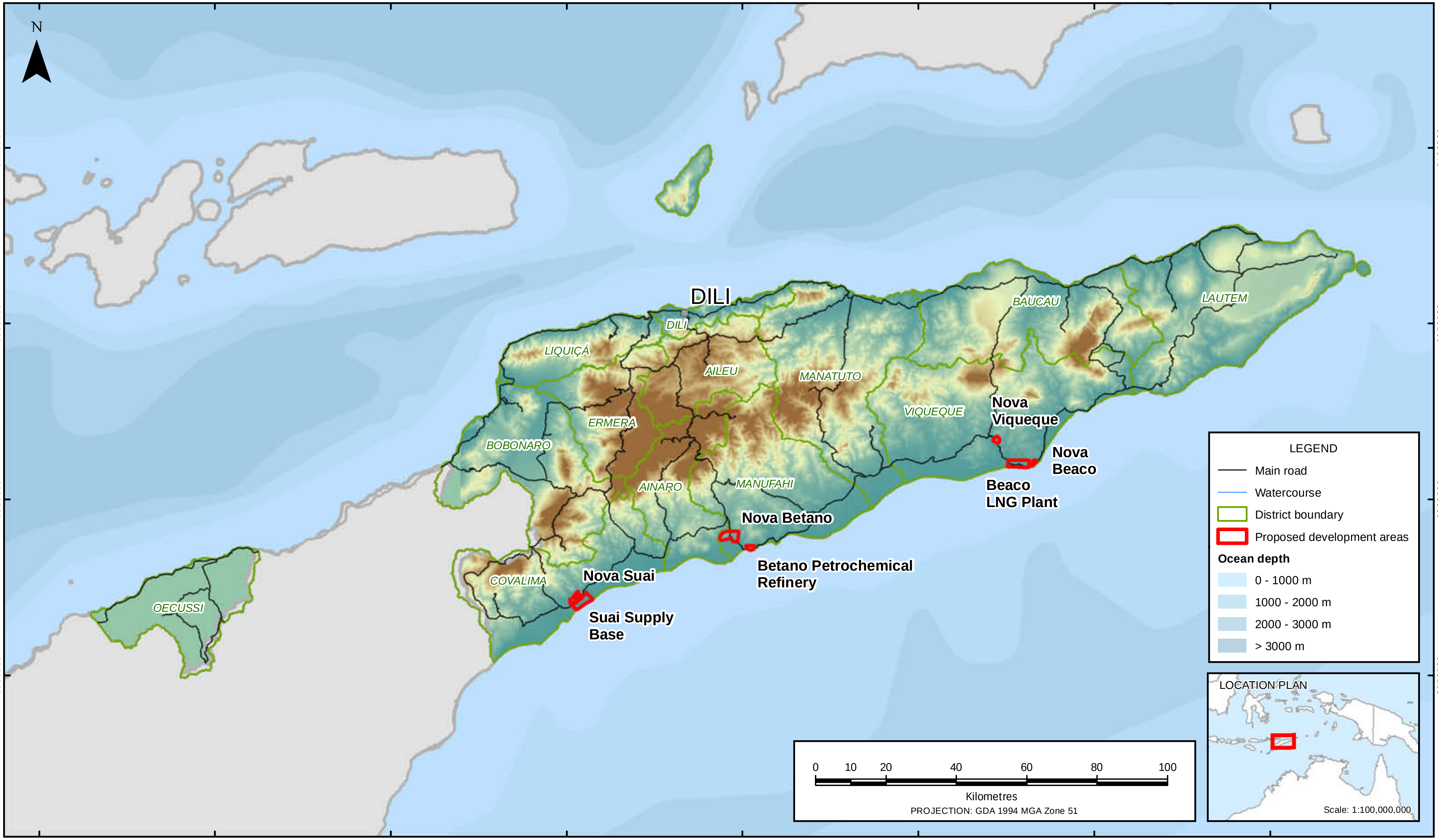
The scope for this study is the supply base component of the Tasi Mane project, herein referred to as the Tasi Mane – Suai Supply Base Project ('the project').

The project comprises the following components:

- Supply base area;
- Industrial estate;
- A new town, Nova Suai;
- Upgrade to the existing Suai Airport; and
- Two crocodile reserves.

## 1.2 Study Objectives

This study was undertaken to provide a baseline description of the marine environment within and adjacent to the proposed development at Suai. The collection of baseline data was undertaken to address the paucity of existing knowledge from the southern coastline of Timor-Leste and also forms the basis for assessment of impacts associated with the project.




NOTES:

This map consists of:
1. Digital Elevation Model: SRTM (2011)
2. District boundary's: GIGTimorLeste (2010)
3. Rivers: GIGTimorLeste (2010)
4. Roads: DivaGIS (2101)

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PROJECT No: 301012-001504

TASI MANE PROJECT
ENVIRONMENTAL IMPACT ASSESSMENT

Figure MAR001
Tasi Mane Project overview

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REPUBLICA DEMOCRATICA DE TIMOR-LESTE
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OneWay to zero harm



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In addition, the assessment was undertaken to provide sufficient information to meet the GoTL objectives for the protection of the environment.

The scope of work included undertaking the following tasks:

- Describing the condition and extent of benthic marine habitats that occur within the vicinity of the study area;
- Describing ambient marine water quality, including both physiochemical and chemical properties from the coastal waters within the study area;
- Describing sediment quality of surface sediments from within the study area;
- Describing the abundance and diversity of benthic infauna from within the study area; and
- Describing the marine fish larvae, eggs and plankton present within the study area.

## 1.3 Regulatory Context

The Democratic Republic of Timor-Leste (RDTL) became a signatory to the United Nations Convention on Biological Diversity (UNCBD) in 2007. A thematic assessment report of Timor-Leste was prepared for the UNCBD by Alves (2007). Under this Convention, countries are obliged to develop a National Biodiversity Strategy and Action Plan (NBSAP) which involves identifying actions and measures for conservation of biodiversity. Timor-Leste is yet to develop regulations and policy documents specifically addressing biodiversity conservation.

There are several laws and regulations from previous administrations (United Nations Transitional Administration in East Timor (UNTAET) and Indonesian) that concern environmental protection and biodiversity conservation in Timor-Leste:

- Law No. 5, 1990 on Conservation of Biological Resources and their Ecosystems;
- Law No. 5, 1994 Concerning Biodiversity;
- Government Regulation No. 28, 1985 on Forest Protection;
- Government Regulation No. 51, 1993 on Environmental Impact Analysis;
- UNTAET Regulation No. 2000/17; and
- UNTAET Regulation No. 2000/19.

UNTAET Regulation No. 2000/19 on protected places (30 June 2000) was in place for the purpose of protecting designated areas, endangered species, wetlands, mangrove areas, historic, cultural and artistic sites, conservation of biodiversity and protection of the biological resources of Timor-Leste. Fifteen natural areas were protected under this regulation and have been designated as Protected

Natural Areas (PNAs). The majority comprise primary forest areas, coral reefs, mangroves, wetland habitat and mountain summits above 2,000 m.

The State Secretariat for the Environment (SEMA), under the Ministry of Economy and Development, and the Ministry of Agriculture, Forestry and Fisheries (MAFF) are the two government agencies with primary responsibilities for the environment. SEMA deals with the environmental issues in the sectors, and MAF deals with resource management, including; forests, fisheries, and biodiversity conservation.

With the change in government administration from the United Nations (UN) to Timor-Leste, there is no environmental legislation currently in place in Timor-Leste. The aforementioned legislation from the previous administration, however, will provide some guidance as to the expected legislation that will be developed for GoTL.

# 2. REGIONAL PERSPECTIVE

Physical, biological and environmental data for the marine and coastal environment in Timor-Leste is very scarce (Sandlund et al., 2001). The information presented within this section provides regional context to the project area and is primarily based on data compiled as part of oil and gas approvals documentation for areas located in the southern section of Timor-Leste territorial waters (Eni 2007, 20010a, 2010b).

## 2.1 Climate

Timor-Leste has two annual seasons and three climatic zones which are the result of monsoon activity. The two distinct seasons are the Northwest Monsoon (wet season) from November to May and the Southeast Monsoon (dry season) from April to September with brief transitional periods in between (Timor-Leste, 2006).

High rainfall is associated with the Northwest Monsoon and low rainfall with the Southeast Monsoon. Heavy rainfalls are also associated with tropical cyclones and thunderstorm activity. Mean annual rainfall for the Timor Sea region is 1,770mm (Heyward et al., 1997).

The majority of cyclones occur in the region between January and March, with the most severe cyclones most often occurring in the months December to April (SKM, 2001). Most (75%) of these cyclones are not fully mature, having an estimated wind speed of less than 80 km/h. Severe cyclones, with wind speeds exceeding 100km/h occur, on average, once every 2.6 years (Heyward et al., 1997).

## 2.2 Biogeography

The island of Timor-Leste is part of the Malay Archipelago, representing the largest and easternmost of the Lesser Sunda Islands (World Bank, 2009). The island is non-volcanic, part of the Outer Banda Arc, derived from the basement of rocks of the Australian continental margin (Audley Charles, 1993 in Rhee et al. 2004) and is characteristically limestone with karst formations. The terrain in Timor-Leste is almost consistently steep and as a result has a number of large fast flowing rivers running to the sea. Rainfall is fairly uniform throughout the year over the mountain range that runs through the middle of the country.

Keefer (2000) reported that rainfall intensity is usually greatest during the North West Monsoon (December-March) period, particularly those in northern locations, while in the southern sites many of the high daily rain totals were recorded in the May-August period. Rivers originating in the mountains and flowing into the sea on the southern side of Timor-Leste, therefore, have consistent flow for the majority of the year.

The rates of fluvial sediment flux on the island and the broader region are naturally high as a result of the mountainous terrain, highly erodible strata and the high seasonal rainfall. The lack of estuaries, along with the narrow width of coastal shelf along East Timor's south coast implies that river discharge is likely to discharge sediment directly to the slope and deeper offshore waters (Milliman et al., 1999).

## 2.3 Bathymetry

Only limited bathymetrical information of the Timor-Leste coastline is available.

A review of the *Australia – East Timor, Timor Sea, Dillon Shoal to East Timor* chart (AUS charts 902 and 903 produced by RAN), navigation chart shows the seabed to slope rapidly from the shoreline to deep water. This steep slope was also confirmed during the field surveys within the project footprint. In some places water depths of 200m can be found less than 1km offshore (*Australia – East Timor, Timor Sea, Dillon Shoal to East Timor* chart).

## 2.4 Tides

The Timor Sea region is influenced by the Pacific-Indian Ocean Throughflow. This produces a current moving at a rate of between 0.1 and 0.4 m/s throughout the year in the Timor Sea between Timor-Leste and northern Australia (Molcard et al., 1996).

Tidal currents in the region are anti-clockwise rotational, commencing flood towards the NE and ebb towards the SW. Speeds will range from about 0.02 m/s on neap tides to 0.1 m/s on springs.

Surface currents are expected to reflect seasonal wind regimes. Local wind-driven surface currents may attain maximum speeds of 0.7 ms-1 during extreme wind surges. More typically speeds would be in the range of 0.2 ms-1 to 0.4 ms-1.

## 2.5 Water Temperature

Seawater temperatures in the Timor Sea region range from 25ºC to 31ºC at the surface and 22ºC to 25ºC below 150 m (OMV, 2003) and down to 10ºC at the seafloor (Heyward et al., 1997).

## 2.6 Coastal Processes

There is little known about the coastal processes along the Timor-Leste coastline. Ocean currents have been found to flow from east to west through the Timor Trench and Timor Sea up to a maximum of 0.7 m/s (MetOcean Engineers, 2004). The predominant wave direction for Timor-Leste is from the East (MetOcean Engineers, 2004) which is most likely to create net littoral movement of material from east to west.

The recent field surveys confirmed that sections of coastline inspected between Suai, Betano and Beaco consist of a combination of sandy beaches and limestone rock ledges which extend from the shoreline as intertidal reef flats and slope down steeply towards the seabed. The sandy beaches consist of medium to fine sand with silt. Heavy rains produce significant runoff from the large rivers generating extensive turbid plumes in the coastal environment.

## 2.7 Biological Environment

Habitats vary along the coastline because of the local influences of seasonal rainfall, local geology and topography, river discharges, and regional offshore oceanographic features, as well as the impact of human occupation. This results in spatial differences in marine habitats, with the north coast being different from the south coast and with the eastern edge of the island having attributes that differ from those to the west (GoTL 2006d).

Timor-Leste has been identified as part of the Wallacea region in Southeast Asia which has been identified as a biodiversity 'hotspot' (CI, 2007). The most ecologically important marine habitats in the Timor Sea region, in terms of biodiversity and productivity can be grouped into:

- The various submerged banks or shoals on the northern Australian continental shelf and shelf slope;
- The coastal intertidal coral reefs and shallow (20m to 30 m) reefs; and
- The mangrove and seagrass areas located along the Timor and northern Australian coast and islands (Sandlund et al. 2001; SKM 2001).

### 2.7.1 Mangroves

Mangroves occupy approximately 7,500 acres along the coastline of Timor-Leste. On the south coast, they tend to form small communities at the mouths of streams and in marshy or swampy terrain (timorNET, 2007). The mangroves species that occur along the coast of Timor-Leste include, *Bruguiera parvifolia, Sonneratia alba, Rhizophora conjugata, Excoecaria agallocha, Avicennia marina, Aegiceras corniculatum, Acanthus ilicifolius, Lumnitzera racemosa, Heritiera litoralis, Acanthus ilicifolius, Achrosticum aureum, Xylocarpus granatum, Corypha utan, Pandanus odoratissimus, Cycas circinalis, Dolichandrone spathacea* and *Melaleuca leucadendron* (timorNET, 2007).

### 2.7.2 Intertidal

Wyatt (2004) surveyed a small area of the nearshore coastal marine environment on the south coast of Timor-Leste. Brittle stars (*ophiuroids*) and other mobile organisms as well as a total of 27 taxa, mostly sessile species, were identified as inhabiting the reef platform. The main taxa present were algae, sponges (*poriferans*), corals (*scleractinians*), ascidians, anemones and forams.

### 2.7.3 Coral Reefs

Timor-Leste is near the centre of the global region with the highest coral species diversity (the Wallacea region). A high diversity of coral reefs exist in southern Timor-Leste with 301-500 species identified (Burke et al., 2002).

A series of surveys conducted in Indonesian waters between 1990 and 1998 (Burke et al., 2002) determined that the percentage of coral reefs in good or excellent condition (live coral cover of more than 50%) in eastern Indonesia were 45% compared to only 23% in western Indonesia. Burke et al. (2002) also identified a number of coral reefs along the Timor-Leste coast, including five distinct communities along the south coast of Timor-Leste, that were considered to be at Medium to High risk of impact from the combined effects of coastal development, marine-based pollution, sedimentation, overfishing and destructive fishing.

### 2.7.4 Offshore Benthic Habitats

Heyward et al. (1997) identified four broad benthic communities for the Big Bank Shoals area, encompassing the shallow banks to the deep water: Halimeda (shallow waters); encrusting sponges (shallow waters); coral filter-feeders (shallow waters); and continental shelf communities (deep water).

With little sea floor topography and hard substrate, such areas offered minimal habitat diversity or niches for animals to occupy. Detritus-feeding crustaceans, holothurians and echinoderms tend to be the dominant epibenthic organisms of these habitats, however, where an area of hard substrate is available filter-feeding heterotrophs, such as sponges, soft corals and gorgonians may occur (Heyward et al., 1997).

### 2.7.5 Marine Fauna

The marine fauna of the Timor Sea is part of the Indo-West Pacific biogeographical Province. The majority of species are widely distributed in this region (Wilson & Allen, 1987).

A number of whale, dolphin and porpoise species have broad distributions (including the Timor Sea). Of these, a number of whale species are considered endangered, vulnerable or might be encountered due to their migratory habit. These include the Blue whale, Humpback whale, Sperm whale, Bryde's whale, Antarctic Minke whale and Killer whale. Some are very rare (blue whale), or usually restricted to deep or cool waters (Sperm whale), and are very unlikely to be encountered in this region (Bannister et al., 1996). Humpback whales (*Megaptera novaeangliae*), which are seasonally the most abundant whale along the Western Australian coast, complete their northern migration in the Camden Sound area of the West Kimberley (reported in Woodside, 2000).

A number of dolphins may occur within the project area. These species include the Irrawaddy dolphin, the Australian snubfin dolphin, the long snouted spinner dolphin, the spotted bottlenose dolphin, Risso's dolphin, the Indo-Pacific humpback dolphin and the pantropical spotted dolphin.

Dugongs (*Dugong dugon*) occur within Timor-Leste waters. Major concentrations of dugongs tend to occur in areas coinciding with sizeable seagrass beds. These areas are typically in shallow water (depths less than 10m) and are relatively protected (Marsh, 2006).

There are six turtle species that may be encountered, including the Flatback, Olive, Hawksbill, Leatherback and particularly the Loggerhead turtle and the Green turtle. Jaco Island and Tutuala beach have been identified as turtle nesting sites (Nunes, 2001) and other breeding sites may exist on the south coast of Timor-Leste where the appropriate conditions exist.

The distribution of the saltwater crocodile, *Crocodylus porosus*, encompasses Timor-Leste and the islands and coasts surrounding the Timor Sea. The animals usually inhabit territories within tidal river systems and estuaries, sometimes around coastal areas and in freshwater rivers or water bodies and are sometimes found long distances from shore (Ross, 1998). The saltwater crocodile is listed as Low Risk, Least Concern in the International Union for Conservation of Nature (IUCN) Red List.

Sea snakes are expected in the Timor Sea region, with as many as 15 species known to occur in northern Australian waters (Storr et al., 1986).

FishBase (2006) lists 144 marine fish species in 38 families for Timor-Leste waters, with one species, the bigeye tuna (*Thunnus obesus*) listed as Threatened, 18 of the species as being pelagic and 10 of the species as being deep water. Many of the species listed for Timor-Leste are found throughout the tropics and are important commercial species, such as the tunas, mackerels and snappers.

The whale shark (*Rhincodon typus*) is listed in FishBase (2006) as occurring within Timor- Leste waters and is considered threatened. The Great White Shark (*Carcharodon carcharias*) may transit the region (Environment Australia, 2002) and is considered to be vulnerable. There are at least 49 species of sharks identified as occurring within an area which encompasses Australian territorial waters within the Timor Sea (Last & Stevens, 1994). The most prolific of the shark species in the Timor Sea region are the whalers, represented by at least 12 species.

### 2.7.6 Marine Protected Areas

The nearest currently declared marine conservation zones or marine protected areas to the project area is the Jaco Island Marine Park, at the eastern end of Timor-Leste.

# 3. FIELD METHODS

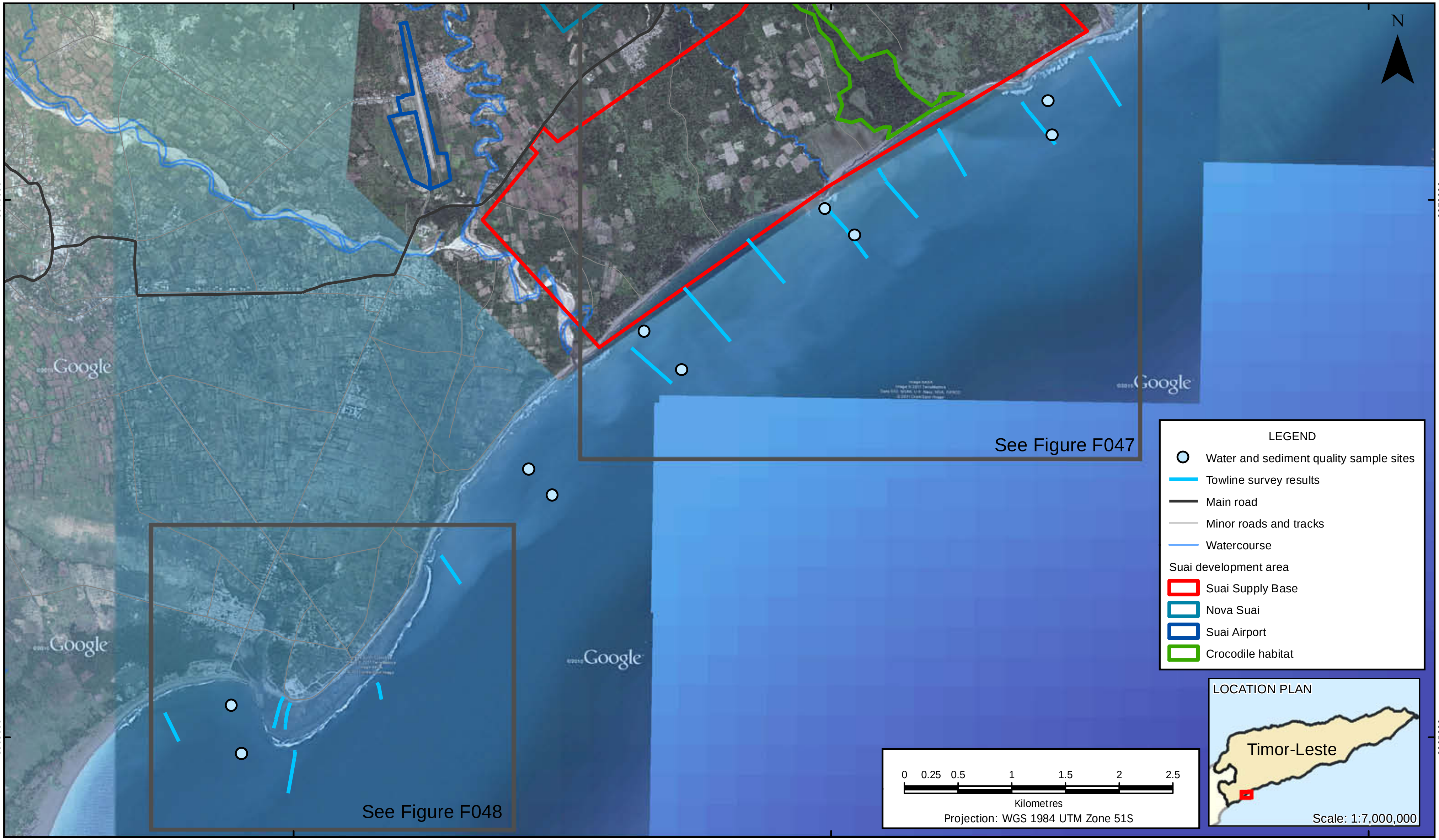
## 3.1 Sampling Locations

Water quality, sediment quality, benthic infauna and plankton samples were collected at both nearshore (250 m from shore) and offshore (750 m from shore) over a 10 day period between 10 and 20 December 2011 and over a five day period between 18-22nd February 2012. During this period, the sea conditions were calm with 5 to 10 knot winds and 0 to 0.2 m swell. The average temperature was 34°C with rainfall most afternoons. A total of five inshore and five offshore samples were collected at sites adjacent to the proposed supply base at Suai (Figure MAR002). Inshore sites were located between 4 to 8m depth. Offshore sites were in up to 20 m depth.

Video footage was collected over a two day period between 10 and 20 December 2011. Towed video footage was used to obtain information on the marine benthic habitat present at the study site. Video transects ranging between 300 to 500 m extended vertically from the shoreline (Figure MAR002). Each transect commenced in a depth of approximately 2.5 m extending out to the 10m depth contour. A total of eight transects were completed at the Suai study site distanced approximately 600 m apart. GPS co-ordinates were collected at each sampling site (using a handheld Garmin GPS) and are presented in Table MAR001.

**Table MAR001 Table showing GPS coordinates**

| Scope | Name | Start_ Latitude | Start_ Longitude | Finish_ Latitude | Finish_ Longitude |
|---|---|---|---|---|---|
| **Benthic Habitat** | T13 | -9.322910 | 125.304583 | -9.325875 | 125.308027 |
| | T14 | -9.317825 | 125.308985 | -9.322340 | 125.312975 |
| | T15 | -9.313723 | 125.314310 | -9.317388 | 125.317523 |
| | T16 | -9.311017 | 125.321140 | -9.315273 | 125.324497 |
| | T17 | -9.307683 | 125.325358 | -9.311818 | 125.328720 |
| | T18 | -9.304322 | 125.330383 | -9.308332 | 125.332778 |
| | T19 | -9.302047 | 125.337477 | -9.305573 | 125.340358 |
| | T20 | -9.298175 | 125.343183 | -9.302352 | 125.345827 |
| **Water and Sediment Quality, Benthic Infauna, Fisheries** | SBMI1 | -9.321541 | 125.305665 | | |
| | SBMO1 | -9.324749 | 125.308861 | | |
| | SBMI2 | -9.311132 | 125.320884 | | |
| | SBM02 | -9.313338 | 125.323397 | | |
| | SBMI3 | -9.301943 | 125.339699 | | |
| | SBMO3 | -9.304842 | 125.340077 | | |




NOTES:

This map contains:
1. Imagery Suai: SRTM (2011)
2. Imagery: DigitalGlobe (2008 - 2010)
3. Rivers: GIGTimorLeste (2010)
4. Roads: DivaGIS (2010)

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TASI MANE PROJECT
ENVIRONMENTAL IMPACT ASSESSMENT

Figure MAR002
Suai marine study area and sampling sites

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## 3.2 Water Quality

### 3.2.1 Physicochemical Profiling

A calibrated multi parameter water quality logger (Hydrolab Mulitparameter DSX5) was used to measure physicochemical properties. A physicochemical water quality profile was obtained by recording measurements at 1m intervals from the water surface to the seabed at each of the sampling sites. The water quality logger was lowered and raised at a speed of approximately one meter per five seconds. Two depth profiles were recorded at each sampling site.

The following parameters were measured:

- Temperature (°C);
- Salinity (parts per thousand (ppt));
- pH;
- Conductivity (µS.cm-1);
- Dissolved Oxygen (DO; % Saturation and mg.L-1); and
- Turbidity (nephelometric turbidity units [NTU]).

### 3.2.2 Chemical Sampling

At each sampling site, a mid-water column sample was collected using a 1L Van Dorn sampler. Each sample was transferred into parameter specific sample bottles and placed on ice.

- Total Metals (Cd, Cr, Cu, Hg, Pb, Ni, Zn); and
- Dissolved Metals (Cd, Cr, Cu, Hg, Pb, Ni, Zn), Ammonia, Total Nitrogen, Total Phosphorus, TPH, PAH, BOD, TSS, E.coli, Chlorophyll, Nitrate, Nitrite, TKN, Reactive phosphorus.

Dissolved metal samples were filtered in the field through a 0.45µm filter.

### 3.2.3 Water Quality Criteria

As no water quality guidelines exist for Timor-Leste, ANZECC/ARMCANZ guidelines (2000) for marine environments (Tropical Australia) were adopted for water quality monitoring, analysis and reporting. All toxicants were compared to the 99% species protection trigger levels.

### 3.2.4 Data Analysis

Physicochemical data collected was analysed by calculating descriptive statistics for each parameter. Chemical data was tabulated and compared to adopted guideline levels.

## 3.3 Sediment Quality

### 3.3.1 Sample Collection

Surface sediment samples (0-0.3 m) were collected using a Van Veen grab sampler. The Van Veen sampler was lowered to the seabed before being retrieved with a grab sample. Sediment samples were then geophysically logged. The sample was then homogenised in a stainless steel mixing bowl before being transferred into a sterilised 250 mL glass jar and a 250 ml plastic bag. Each sample was then stored at 4°C and couriered to a NATA accredited laboratory for analysis.

### 3.3.2 Chemical Testing

Parameters identified for laboratory analysis were developed based on likely contaminants to be encountered during construction and operation of a port and associated facilities. Sediment samples were analysed for the following parameters:

- Metals (Al, As, Cd, Cr, Cu, Fe, Pb, Hg, Ni and Zn);
- Nutrients (Nitrate, Nitrite, Total Nitrogen, Total Phosphorus and Sulphate); and
- Particle Size Distribution (PSD).

### 3.3.3 Sediment Quality Criteria

As no sediment quality guidelines exist for Timor-Leste, the interim sediment quality guideline (ISQG) found in ANZECC/ARMCANZ (2000) were used as a basis for comparing relative metal concentrations. Sediment nutrient concentration results from Suai were compared against relevant published literature as there are no comparable benchmarks within the ANZECC/ARMCANZ (2000) guidelines.

PSD is a measure of the relative proportion of particle size classes within a given sediment sample. Results have been presented based on the classifications displayed in Figure Mar 011.

### 3.3.4 Data Analysis

Laboratory results were collated, concentrations were tabulated and any spatial trends identified. All values were then compared with relevant sediment quality criteria.

## 3.4 Benthic Habitat

### 3.4.1 Data Collection and Mapping

A total of eight transects were completed at the Suai study site. Transects were approximately 600m apart covering a 5 km section of coastline.

The benthic habitat was recorded using an underwater video camera (Splash Cam) (Plate MP001). The remotely operated video camera was towed behind a vessel travelling at a speed of 1 knot or less. The camera was attached to a swimming device, permitting the camera to face forward and travel in a straight direction. High definition video footage was taken approximately 50 cm above the substratum and recorded to a hard drive. Co-ordinates of the video transects were tracked using a GPS (Starfish) and overlayed onto the video along with time and date information to allow geo-referencing of the processed habitat data.

The video footage was analysed by marine scientists experienced in classifying benthic habitats. Maps displaying the distribution of habitats, including substrate and biota were then produced across the study area.

### 3.4.2 Data Analysis

A customised WorleyParsons system for benthic habitat classification was adapted from the national intertidal and subtidal benthic habitat classification scheme (Mount et al., 2007) and used to classify the observed habitats. The level of taxonomic detail that can be classified was restricted by environmental condition such as water visibility, sea state and tide. For the purpose of generating a habitat map, biota was defined as:

- Hard coral;
- Invertebrates;
- Algae;
- Seagrass; and
- Substrate was classified as sediment (soft) or reef (hard).

A qualitative classification method was applied to define the cover (density) of specific biota and substrata types as dense (>75%), medium (25-75%) or sparse (0-25%). Substrate type was defined using the Wentworth grade scale of particle sizes (Wentworth, 1922).

Source:

Plate MP001 Picture showing the video camera being deployed for the benthic habitat video tows

Source:


Plate MP002 Photograph showing small sea ripples in the sediment

## 3.5 Plankton

### 3.5.1 Sample Collection

A plankton net was towed behind a vessel travelling at <1 knot over a 100m transect at each site. The plankton net comprised of a 0.8 m diameter with 800 µm mesh sieve. Once the sample had been collected in the sieve, the contents were then transferred to a sample vial. Ethanol (100%) was added to the vial to preserve the sampled larvae.

### 3.5.2 Laboratory Analysis

The plankton fauna was removed from the plastic sampling vial and placed in a 125µm sieve. The excess ethanol used for preservation of the samples was then captured in a storage container for chemical disposal. Water was then flushed over the sample, to remove any remaining ethanol. The entire sample was placed in Ward Counting Wheel, with the corresponding site label. The Ward Counting Wheel was placed under a Stereo-Microscope (Olympus SZ61 Microscope) and slowly turned under the microscope allowing the fauna to be counted and identified. Taxonomy identification was conducted using the most up to date references available for the geographic region. Taxonomic names and abundances were recorded on laboratory sheets for each site. After taxonomy identification was completed the fauna was returned to the vial with 70% ethanol for long term storage.

As plankton samples collected presented with very low abundance, the sorting methodology adopted did not following the standard plankton sub-sampling methods. Instead 100% of the sample volume was sorted for plankton, fish eggs and fish larvae.

### 3.5.3 Statistical Analysis

Statistical analysis of the plankton was conducted using Primer ver.6 (Clarke, 2001). Cluster and multidimensional scaling (MDS) analyses were performed to represent groupings of samples with a similar faunal and community composition.

Both the cluster and MDS were based on a similarity matrix produced using the Bray-Curtis similarity co-efficient, with standardisation and square-root transformation. Standardisation is essential for sampling techniques where exact sampling volumes are unknown and sampling bias can occur between replicates.

Transformations are required for datasets where more common fauna could potentially outweigh the rarer fauna when determining similarity between samples. Applying a transformation will define a balance between the contribution of common and rarer fauna (Clarke, 2001).

The adequacy of an MDS plot is represented by a stress value, in the range of 0.0 to >0.3. Interpretation of the stress value was as follows:

- <0.05 gives an excellent representation of sites;
- <0.1 is a good ordination with no real prospect of misleading interpretation;
- <0.2 still gives a potentially useful ordination, although values at the upper end of this scale should not be relied upon in great detail; and
- >0.3 indicates that the points are close to being arbitrary and placement of sites within the ordination are completely random (Clarke, 2001).

An Analysis of Similarities (ANOSIM) is used in conjunction with a cluster and MDS to provide a significant value (p=0.05) for differences between samples and grouping seen in the MDS ordination. SIMPER analysis is used to determine which species contribute the most to the differences between sites and the construction of the MDS ordination.

## 3.6 Infauna

### 3.6.1 Sample Collection

Surface sediment samples (0-0.3 m) were collected using a Van Veen grab. A total of three replicates were collected per sample location. Upon collection of each replicate sample, the samples were combined and sieved through a 1 mm mesh sieve. All samples were transferred to a sample container and preserved in 100% ethanol.

### 3.6.2 Laboratory Method

Macroinvertebrate samples were processed and fauna identified at Benthic Australia laboratories. The sediment and fauna were placed in a 125µm sieve. The excess ethanol used for preservation of the samples was captured in a storage container for chemical disposal. Water was flushed through the sediment in the 125µm sieve, to remove any remaining ethanol from the sample. The entire sample was placed in a large petri-dish with the corresponding site label. The petri-dish was placed under a Stereo-Microscope (Olympus SZ61 Microscope). A level 5 grade forceps was used to systematically sort through the sediment and remove all fauna that was found. Fauna were placed in a vial with 70% ethanol, and a label with the corresponding site information. Once all the sediment from the site was sorted, the vial of fauna was placed to one side awaiting taxonomic identification.

The specimens were then placed into a small petri-dish for taxonomic identification under a stereo-microscope, (Olympus SZ61 Microscope). Taxonomy was conducted using the most up to date references available for the geographic region. Taxonomic names and abundances were recorded on laboratory sheets for each site. After taxonomy was completed the fauna was returned to the vial with 70% ethanol for long term storage.

### 3.6.3 Statistical Analysis

Statistical analysis of the marine benthic fauna was conducted using the same methods as plankton (see Section 3.5.3).

## 3.7 Quality Control and Assurance

All sampling equipment was deployed from the side of the vessel, to ensure the risk of contamination from the engine, discharge was reduced. Engines were also switched off where practicable to minimize further risk of contamination. Personnel undertaking water and sediment collection for sampling wore latex gloves at all times to prevent cross-contamination, all sampling equipment was cleaned with Decon90 prior to use and rinsed with seawater between samples.

The multi-parameter water quality logger was calibrated to manufacture specifications and using standardised solutions in field. A minimum of two depth profiles were recorded at each site to improve data accuracy. The water quality logger and Van Dorn sampler were weighted down to counteract the effects of the currents pulling the equipment horizontally through the water column.

Water and sediment quality samples were analysed by ALS Group. ALS has NATA certification for all analyses requested and QA/QC plans and protocols to support this certification. The integrity of the samples was assured by the use of Chain of Custody (CoC) documentation, which accompanied the samples from the time of collection until receipt by ALS. Samples were chilled on collection and dispatched to the laboratory frozen in chilled containers.

As part of the NATA requirements, the laboratory analyses for water and sediment quality included quality control testing of samples, including duplicate samples (the same sample analysed more than once), blanks (containing no levels of the analytes to be analysed), spiked samples (containing known additions of the analytes to appropriate matrices) and standard samples (samples containing known concentrations of the analytes - also known as reference standards). All samples were analysed within laboratory holding times.

QA/QC was conducted on five benthic infauna samples. This method requires five samples to be sorted twice. On the second sort any missed fauna are collected in a separate vial. The total missed fauna is divided by the total collected in the first sort and a percentage error calculated. The error is expected to be below 10%. If the sorting error is above 10% then each additional samples is checked until the percentage error is below 10%. QA\QC was not used on the plankton samples due to insufficient sample numbers.

# 4. RESULTS

## 4.1 Water Quality

Vertical profiles of physicochemical water quality recorded at each sampling site have been graphically presented in in the sections below. Laboratory data for chemical water quality, including nutrients, metals and hydrocarbons were also analysed, with a summary of results presented separately below. Comparisons of results with ANZECC/ARMCANZ (2000) are based on default trigger values provided for Tropical Australia (Inshore Waters).

### 4.1.1 Physicochemical Water Quality

A summary of the physicochemical water quality data collected at each site is presented in Table MAR002. Sites have been classified according to nearshore or offshore locations. Trends in the data set have been provided where relevant and differences in data between nearshore and offshore sites identified.

#### *Temperature*

Temperatures recorded at nearshore and offshore sites were similar, ranging between 30.2°C and 31.6°C. Maximum nearshore and offshore temperatures were observed at SMBI2 and S2O respectively (Table MAR002; Figure MAR003).

Vertical profiles of the mean temperature values for nearshore and offshore sites are shown in Figure MAR003. Both nearshore and offshore areas experienced a slight decrease in mean temperature with an increase in depth. Surface temperatures for the nearshore sites ranged between 31.3 °C (surface) and 31°C (seabed), and 31.1 °C (surface) and 30.5 (near seabed) for the offshore sites. Slight variation in temperature was identified at offshore sites between 16m and 18m.

#### *pH*

A mean pH of 8.1 was observed at both the nearshore and offshore sites. Inshore sites ranged between 8.0 and 8.2 while offshore sites showed less variability, ranging between 8.0 and 8.1. (Table MAR002; Figure MAR004).

A higher variation in pH was observed at nearshore sites compared with offshore sites. Low variation was generally observed at all offshore sites (Figure MAR005).

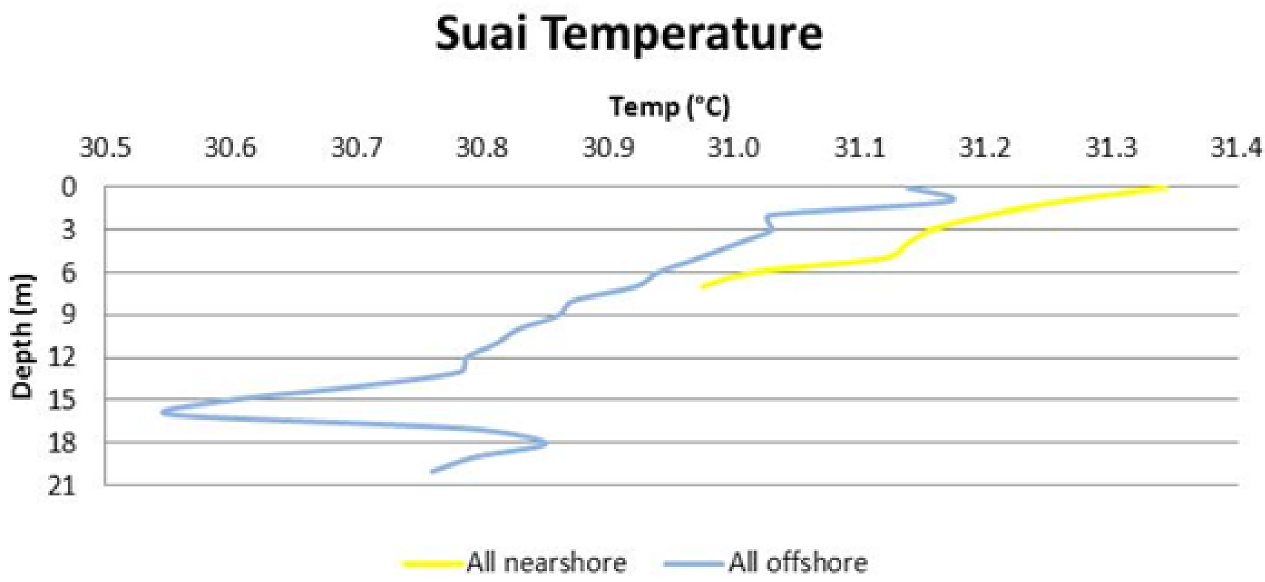


Figure MAR003 Mean temperature (°C) levels for nearshore and offshore sites

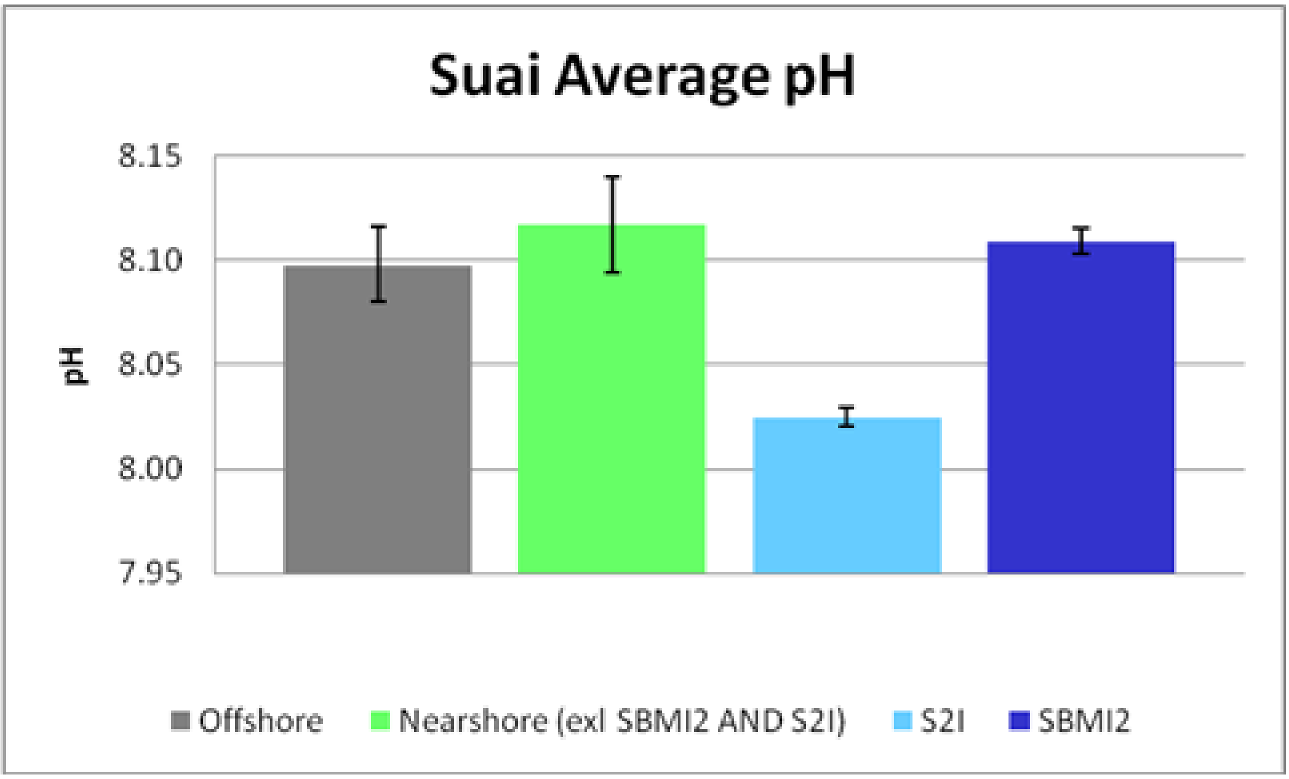


Figure MAR004 Comparison of average pH levels for offshore sites, outliers from nearshore sites as well as the average nearshore levels

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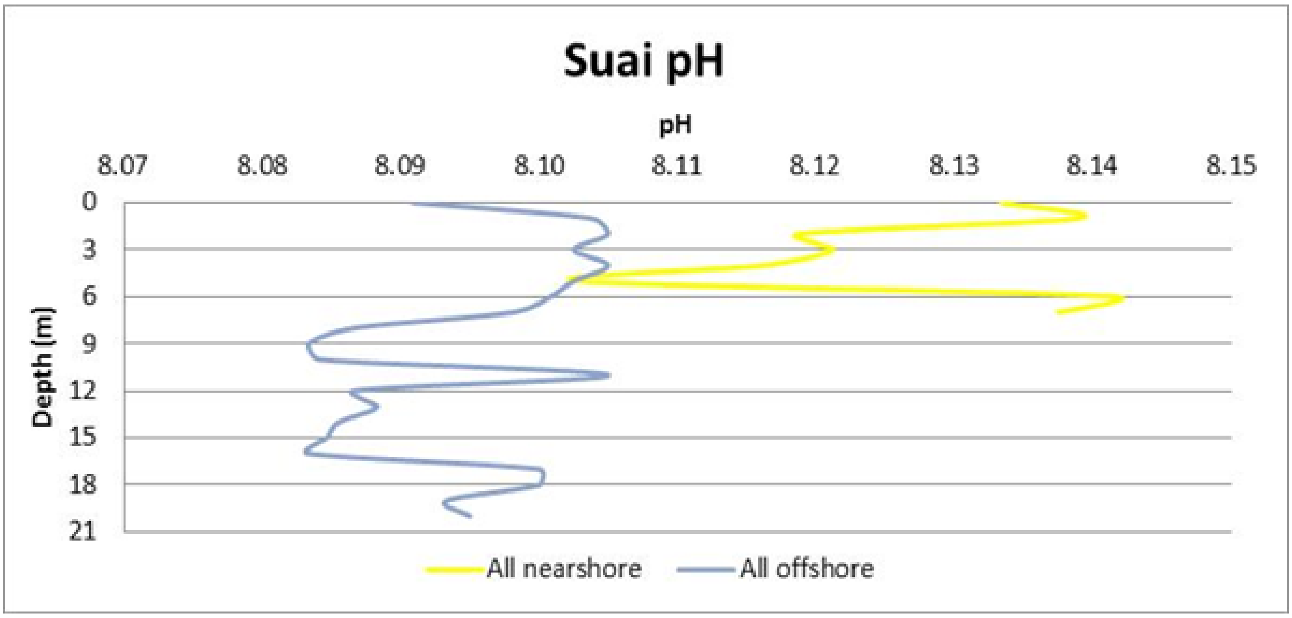


Figure MAR005 Mean pH levels for nearshore and offshore sites

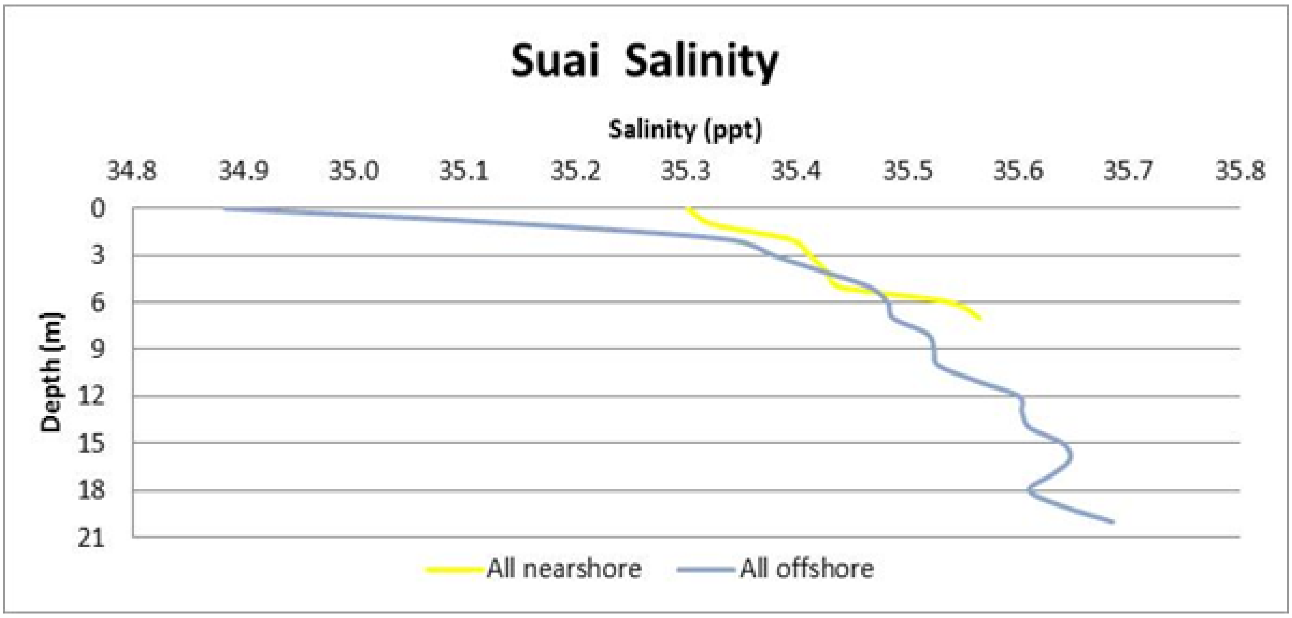


Figure MAR006 Average salinity (ppt) levels for nearshore and offshore sites

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### *Salinity*

Variations in salinity levels were observed spatially between the nearshore and offshore sites, and by depth (Table MAR002). Figure MAR006 shows a gradual increase in salinity with increase in depth for both nearshore and offshore sites. Salinity recorded at nearshore sites varied between 35.1 ppt and 35.6 ppt while offshore sites displayed greater variability ranging between 34.8 ppt and 35.7 ppt (Table MAR002). Maximum nearshore and offshore salinity was observed at SMBI3 and SBMO3 sites respectively. No variation was found in mean salinity at nearshore and offshore sites (35.4 ppt) (Table MAR002) Salinity recorded at SBMI2 was considerably lower than mean salinity at nearshore and offshore sites ranging between 35.0 ppt and 35.2 ppt (Figure MAR006).

### *Turbidity*

Turbidity recorded at nearshore and offshore sites displayed large variability. Nearshore sites varied between 0.6 NTU and 47.4 NTU while offshore sites ranged between 3.1 NTU to 20.0 NTU. Maximum turbidity displayed at nearshore and offshore sites were observed at SMBI3 and SBMO3 respectively. These levels were substantially higher than other nearshore and offshore sites which displayed maximum turbidity levels ranging between 7.1 NTU to 14.0 NTU respectively (Table MAR002).

Higher turbidity was recorded at site SBMI3 compared with all other nearshore sites, ranging between 10 to 40 NTU (Figure MAR007). Generally, nearshore turbidity levels ranged between 1 and 7 NTU. Turbidity levels offshore were found to increase with depth, increasing from around 4 NTU near the surface to 12 NTU near the seabed.

Turbidity values were generally less than the ANZECC/ARMCANZ (2000) guideline of 1-20 NTU (Table MAR002). Higher values were most likely associated with high rainfall events and associated run-off.

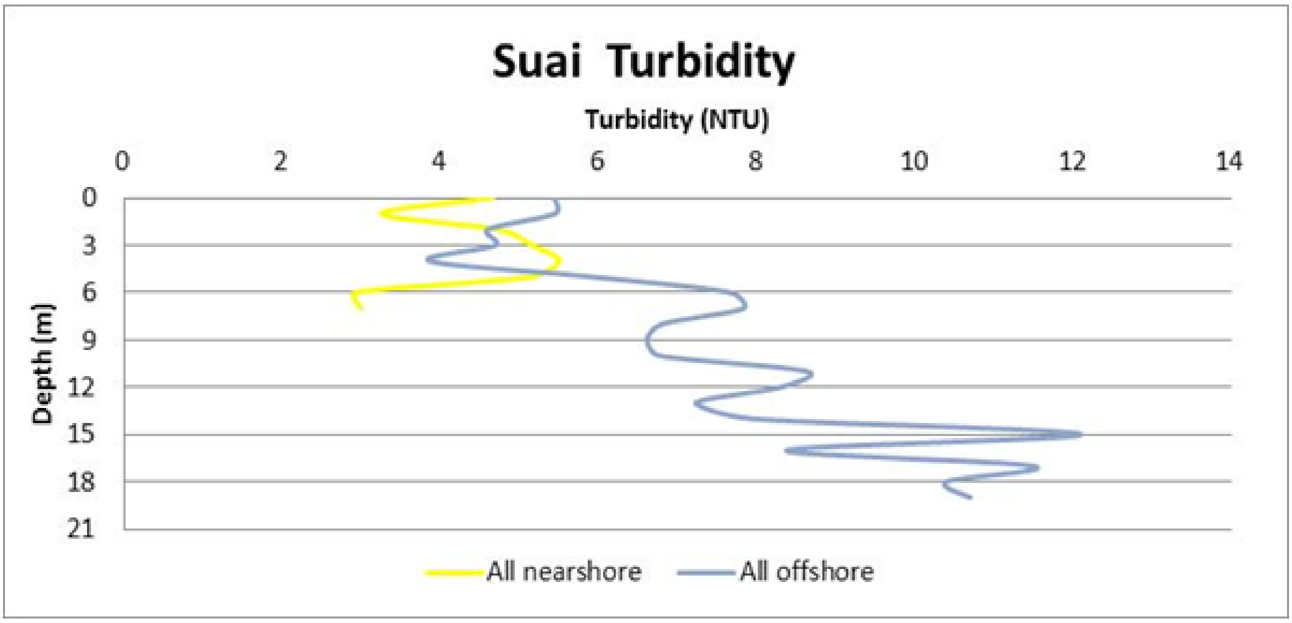


Figure MAR007 Turbidity (NTU) levels for nearshore sites (A); Mean turbidity (NTU) levels for inshore and offshore sites (B)

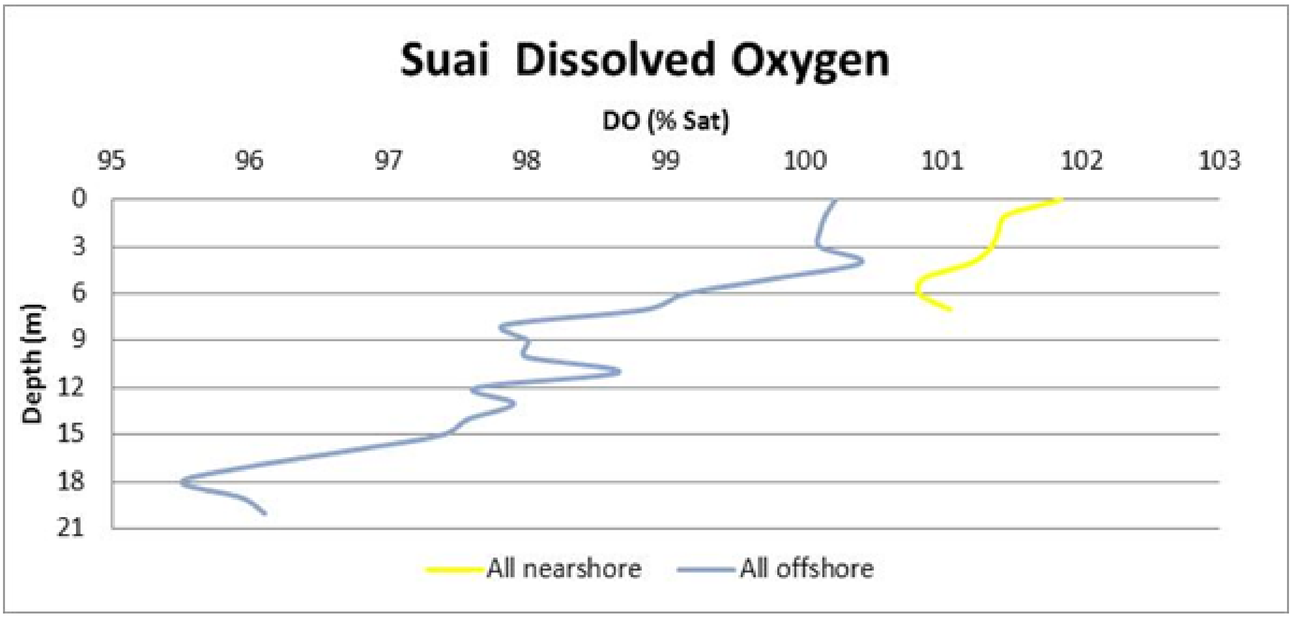


Figure MAR008 Mean dissolved oxygen (% sat) for nearshore and offshore sites

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### *Dissolved Oxygen*

Dissolved oxygen levels recorded at nearshore sites ranged between 99.0% and 103.07% saturation while offshore sites displayed slightly more variability ranging between 95.3% and 101.5% saturation. Maximum nearshore and offshore dissolved oxygen levels were observed at SI1 and SBMO3 respectively.

Dissolved oxygen levels decreased with increasing depth at both nearshore and offshore sites. Figure MAR08 shows dissolved oxygen levels (% saturation) to be lower at offshore sites compared to nearshore sites. Mean dissolved oxygen values were 101.3% saturation for the nearshore sites, compared with 98.2% saturation at the offshore sites (Table MAR002).

**Table MAR002 Physiochemical water quality parameters for nearshore and offshore sites at Suai, 17 December 2011**

| | | Minimum Value | Maximum Value | Median | Mean | 20th Percentile | 80th Percentile | Standard Deviation |
|---|---|---|---|---|---|---|---|---|
| **Temperature (°C)** | Nearshore | 30.78 | 31.59 | 31.21 | 31.24 | 30.96 | 31.52 | 0.04 |
| | Offshore | 30.20 | 31.47 | 30.89 | 30.92 | 30.73 | 31.05 | 0.08 |
| **pH** | Nearshore | 8.02 | 8.17 | 8.12 | 8.10 | 8.05 | 8.13 | 0.01 |
| | Offshore | 8.04 | 8.14 | 8.11 | 8.10 | 8.07 | 8.13 | 0.00 |
| **Conductivity (mS/cm)** | Nearshore | 53.05 | 53.80 | 53.60 | 53.49 | 53.32 | 53.70 | 0.05 |
| | Offshore | 52.63 | 53.93 | 53.60 | 53.54 | 53.35 | 53.84 | 0.05 |
| **Salinity (ppt)** | Nearshore | 35.08 | 35.60 | 35.47 | 35.40 | 35.28 | 35.53 | 0.04 |
| | Offshore | 34.76 | 35.73 | 35.48 | 35.43 | 35.28 | 35.63 | 0.03 |
| **Turbidity (NTU)** | Nearshore | 0.60 | 47.37 | 5.90 | 9.00 | 3.67 | 12.50 | 5.88 |
| | Offshore | 3.10 | 20.00 | 6.22 | 6.95 | 4.10 | 10.18 | 1.64 |
| **Dissolved Oxygen (% Sat)** | Nearshore | 99.03 | 103.07 | 101.13 | 101.22 | 100.28 | 101.81 | 0.30 |
| | Offshore | 95.25 | 101.50 | 98.04 | 98.80 | 96.25 | 100.56 | 0.61 |
| **Dissolved Oxygen (mg/L)** | Nearshore | 6.12 | 6.33 | 6.20 | 6.22 | 6.16 | 6.24 | 0.02 |
| | Offshore | 5.91 | 6.73 | 6.10 | 6.14 | 6.01 | 6.21 | 0.02 |

### *Suspended Solids*

Suspended solids (TSS) at nearshore sites had an average concentration of 32.6 mg/L while offshore sites displayed a higher average concentration 35.8 mg/L. These TSS values are consistent with turbidity results from both inshore and offshore sites and confirm that ambient turbidity is relatively high, although within the range expected for coastal areas receiving high rainfall runoff. Maximum nearshore and offshore suspended solids were observed at SBMI3 and SO1 respectively (Table MAR003). There are no default trigger values for TSS in ANZECC/ARMCANZ (2000).

**Table MAR003 Summary of Total Suspended Solids (TSS) for nearshore and offshore sites, Suai**

| | Site | TSS (mg/L) |
|---|---|---|
| | **LOR *** | **5** |
| **Nearshore** | SBMI1 | 17 |
| | SBMI2 | 30 |
| | SBMI3 | 54 |
| | SI1 | 41 |
| | SI2 | 21 |
| **Offshore** | SBM01 | 22 |
| | SBM02 | 30 |
| | SBM03 | 27 |
| | S01 | 55 |
| | S02 | 45 |

*Limit of Reporting

## 4.1.2 Chemical Water Quality

### *Nutrients*

A summary of results describing nutrient water quality parameters for nearshore and offshore sites are presented in Table MAR004.

Ammonia recorded at nearshore sites varied between 0.02 mg/L and 0.03 mg/L while offshore sites displayed more variability ranging between <0.02 mg/L and 0.1 mg/L. Maximum nearshore ammonia concentrations were observed at SI1 and SBMI1 while maximum ammonia concentrations offshore was recorded at SO1. All sites exceeded the ANZECC/ARMCANZ (2000) guideline value of 10µg/L.

Nitrite and Nitrate ($NO_x$) concentrations were below the LOR (0.01 mg/L) at all sites both nearshore and offshore sites. The ANZECC/ARMCANZ (2000) guideline value for $NO_x$ is 0.008 mg/L (8µg/L).

Total nitrogen (TN) concentrations recorded at nearshore sites were similar to TN concentrations recorded offshore. Nearshore TN concentrations ranged between <0.1 mg/L and 1.1 mg/L while offshore sites ranged between <0.1 mg/L and 0.9 mg/L. Maximum nearshore and offshore total nitrogen was observed at SBMI2 and SO1 respectively. Five of the ten sites exceeded the ANZECC/ARMCANZ (2000) guideline value of 0.1 mg/L (100µg/L).

Given that nitrate and nitrite levels were below the LOR, total nitrogen concentrations were comprised entirely of the organic nitrogen TKN for samples. Consequently, the summary statistics calculated for TN were identical to those concentrations calculated for TKN. Generally TN and TKBN concentrations were similar across all sites both nearshore and offshore.

Total phosphorus recorded sites varied between <0.05 mg/L and 0.05 mg/L. No variability was observed between nearshore and offshore sites. Maximum total phosphorus concentrations were observed at near shore site SBMI3 and offshore site SO1. All concentrations were equal to or less than the limit of reporting of 0.05 mg/L. The LOR is higher than the ANZECC/ARMCANZ (2000) guideline value of 0.015 mg/L (or 15µg/L).

Reactive phosphorus concentrations recorded at both the nearshore and offshore sites measured below the LOR of 0.01 mg/L. The LOR is higher than the ANZECC/ARMCANZ (2000) guideline value of 0.005 mg/L (or 5µg/L).

### *Chlorophyll a and Biochemical Oxygen Demand*

Both nearshore and offshore chlorophyll a concentrations were negligible, all reporting less than the LOR of 1 mg/m$^3$ and below the ANZECC/ARMCANZ (2000) guideline level of 1.4 mg/m$^3$ Table MAR005.

**Table MAR004** **Nutrient water quality parameters for nearshore and offshore sites, Suai.**

| Nutrients | Site | Ammonia | Nox | TKN | TN | TP | RP |
|---|---|---|---|---|---|---|---|
| | | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L |
| | **LOR *** | **0.01** | **0.10** | **0.10** | **0.10** | **0.01** | **0.01** |
| | ANZECC | 0.01 | 0.008 | - | 0.1 | 0.015 | 0.5 |
| **Nearshore** | SBMI1 | **0.03** | <0.01 | 0.5 | **0.5** | <0.05 | <0.01 |
| | SBMI2 | **0.02** | <0.01 | 1.1 | **1.1** | <0.05 | <0.01 |
| | SBMI3 | **0.02** | <0.01 | <0.5 | <0.1 | **0.05** | <0.01 |
| | SI1 | **0.03** | <0.01 | 0.5 | **0.5** | <0.05 | <0.01 |
| | SI2 | **0.02** | <0.01 | <0.5 | <0.1 | <0.05 | <0.01 |
| **Offshore** | SBM01 | **0.07** | <0.01 | <0.5 | <0.1 | <0.05 | <0.01 |
| | SBM02 | **0.04** | <0.01 | <0.5 | <0.1 | <0.05 | <0.01 |
| | SBM03 | **0.05** | <0.01 | 0.7 | **0.7** | <0.05 | <0.01 |
| | S01 | **0.1** | <0.01 | 0.9 | **0.9** | **0.05** | <0.01 |
| | S02 | **0.02** | <0.01 | <0.5 | <0.1 | <0.05 | <0.01 |

* Limit of Reporting
**Bold** indicates values above the ANZECC limit

Biochemical Oxygen Demand (BOD) is used as an indicator of organic loading based on the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material within a body of water. BOD levels were below the LOR at all sites with the exception of one offshore site (SO2) where a value of 21 mg/L was recorded. All other sites measured BOD levels <2 mg/L.

**Table MAR005** **Chlorophyll a and BOD values, Nearshore and offshore sites, Suai**

| | Site | Chl a | BOD |
|---|---|---|---|
| | | mg/m$^3$ | mg/L |
| | **LOR *** | **1** | **2** |
| | **ANZECC** | **1.40** | **n/a** |
| **Nearshore** | SBMI1 | <1 | <2 |
| | SBMI2 | - | <2 |
| | SBMI3 | <1 | <2 |
| | SI1 | <1 | <2 |
| | SI2 | <1 | <2 |
| **Offshore** | SBM01 | <1 | <2 |
| | SBM02 | <1 | <2 |
| | SBM03 | <1 | <2 |
| | S01 | <1 | <2 |
| | S02 | <1 | 21 |

* Limit of Reporting
**Bold** indicates values above ANZECC

### ***Metals***

Total and dissolved metal concentrations recorded from the near shore and offshore sampling sites are presented in Table MAR006 and Table MAR007, respectively. All data was then compared with the ANZECC/ARMCANZ (2000) guideline values. Results were also averaged for nearshore and offshore sites with mean values presented below.

**Table MAR006** **Total metal concentrations for near shore and offshore sites, Suai**

| | Site | Mercury | Cadmium | Chromium | Copper | Lead | Nickel | Zinc |
|---|---|---|---|---|---|---|---|---|
| **Metals** | | mg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L |
| | LOR* | 0.0001 | 0.2 | 0.5 | 1.0 | 0.2 | 0.5 | 5 |
| | ANZECC | 0.1 | 0.7 | 7.7 | 0.3 | 2.2 | 7 | 7 |
| **Nearshore** | SBMI1 | <0.0001 | <0.20 | <0.5 | **2** | <0.2 | <0.5 | <5 |
| | SBMI2 | <0.0001 | <0.20 | <0.5 | **2.1** | 0.3 | <0.5 | <5 |
| | SBMI3 | <0.0001 | <0.20 | 0.6 | **1.6** | 0.2 | 0.8 | <5 |
| | SI1 | <0.0001 | <0.20 | 0.5 | **6.4** | <0.2 | <0.5 | **8** |
| | SI2 | <0.0001 | <0.20 | 0.8 | <1.0 | <0.2 | 0.6 | <5 |
| **Offshore** | SBM01 | <0.0001 | <0.20 | 0.6 | **1.6** | 0.2 | <0.5 | <5 |
| | SBM02 | <0.0001 | <0.20 | <0.5 | **1.1** | <0.2 | <0.5 | <5 |
| | SBM03 | <0.0001 | <0.20 | <0.5 | **1.2** | 0.3 | 0.6 | **10** |
| | S01 | <0.0001 | <0.20 | 0.5 | **1.4** | <0.2 | <0.5 | <5 |
| | S02 | <0.0001 | <0.20 | 0.7 | **4.5** | 0.8 | 0.8 | <5 |

* Limit of Reporting
**Bold** indicates values above ANZECC

**Table MAR007 Dissolved metal concentrations for nearshore and offshore sites, Suai**

| | Site | Mercury | Cadmium | Chromium | Copper | Lead | Nickel | Zinc |
|---|---|---|---|---|---|---|---|---|
| **Metals** | | mg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L |
| | LOR* | 0.0001 | 0.2 | 0.5 | 1.0 | 0.2 | 0.5 | 5 |
| | ANZECC | 0.1 | 0.7 | 7.7 | 0.3 | 2.2 | 7 | 7 |
| **Nearshore** | SBMI1 | <0.0001 | <0.20 | <0.5 | <1.0 | 0.20 | 0.60 | <5 |
| | SBMI2 | <0.0001 | <0.20 | <0.5 | <1.0 | 0.30 | 0.50 | 5 |
| | SBMI3 | <0.0001 | <0.20 | 0.50 | **1.10** | <0.2 | <0.5 | <5 |
| | SI1 | <0.0001 | <0.20 | 0.50 | **3.60** | <0.2 | <0.5 | <5 |
| | SI2 | <0.0001 | <0.20 | 0.50 | <1.0 | <0.2 | <0.5 | <5 |
| **Offshore** | SBM01 | <0.0001 | <0.20 | <0.5 | **2.60** | <0.2 | 0.50 | <5 |
| | SBM02 | <0.0001 | <0.20 | <0.5 | <1.0 | <0.2 | <0.5 | <5 |
| | SBM03 | <0.0001 | <0.20 | 0.60 | <1.0 | <0.2 | 0.50 | <5 |
| | S01 | <0.0001 | <0.20 | 0.50 | **2.00** | <0.2 | 0.60 | <5 |
| | S02 | 0.0001 | <0.20 | 0.50 | **1.80** | 0.40 | 0.50 | <5 |

* Limit of Reporting

**Bold** indicates values above ANZECC

Dissolved and total mercury concentrations were below the LOR of 0.0001 mg/L at all sites. One offshore site displayed a mercury concentration of 0.0001 mg/L identical to the ANZECC/ARMCANZ (2000) trigger level.

Dissolved and total concentrations of cadmium were <0.20µg/L at both nearshore and offshore sites, and therefore less than the ANZECC/ARMCANZ (2000) trigger value of 0.7µg/L.

Dissolved chromium concentrations collected from nearshore samples were similar to concentrations displayed from offshore sites. Maximum nearshore dissolved chromium concentrations were observed at SBMI3, SI1 and SI2, while maximum offshore concentrations were recorded at SMB03. All sites were less than the ANZECC/ARMCANZ (2000) trigger value of 7.7µg/L.

Dissolved copper concentrations collected from nearshore samples varied between <1.0µg/L and 3.6µg/L while offshore sites displayed less variability ranging between <1.0µg/L and 2.6µg/L. Maximum nearshore and offshore dissolved copper concentrations were observed at SI1 and SBM01 respectively. SBMI2, SBMO2, SBMI3 AND SBMO3 all exceeded the ANZECC/ARMCANZ (2000) trigger value of 0.3µg/L.

Total copper concentrations collected from nearshore samples varied between <1.0µg/L and 6.4µg/L while offshore sites displayed less variability ranging between <1.0µg/L and 4.5µg/L. Maximum nearshore and offshore total copper concentrations were observed at SI1 and S02 respectively. Results confirm that most of the copper present in water is attached to particulates.

Dissolved lead concentrations were above the LOR of 0.1µg/L at two nearshore sites (SMBI1 and SMBI2) and one offshore site (S2O). Total lead concentrations comparable between sites ranging between 0.2µg/L and 0.3µg/L nearshore and <0.2µg/L to 0.4µg/L for offshore sites. All sites were below the ANZECC/ARMCANZ (2000) trigger value of 2.2µg/L (Table MAR007).

Dissolved nickel concentrations were above the LOR at two sites nearshore (SMBI1 and SMBI2) and four sites offshore (SMB01, SMB03, S1O and S2O), while all remaining sites recorded concentrations below the LOR of 0.5µg/L. Total nickel concentrations were above the LOR at nearshore sites SMBI2 and SMBI3 and at offshore sites SBM03 and S2O (Table MAR007).

Mean total nickel concentrations were similar for nearshore and offshore sites while dissolved nickel concentrations were slightly higher nearshore when compared to offshore. All sites were below the ANZECC/ARMCANZ (2000) trigger value of 7µg/L.

Dissolved zinc concentrations were generally below the LOR of 1µg/L, however a value of 5µg/L was observed at the nearshore site SMBI2, which is above the LOR, but below the ANZECC/ARMCANZ (2000) trigger value of 7µg/L. Concentrations of total zinc however were above the LOR but below the trigger except for SI1 which recorded a total zinc concentration of 8µg/L and offshore site SBM03 which displayed a concentration of 10µg/L (Table MAR007).

### *Hydrocarbons*

Total Petroleum Hydrocarbons (TPH; C10 to C36 Fraction), Total Recoverable Hydrocarbons (TRH; >C10 to C40 Fraction) and Polynuclear Aromatic Hydrocarbons (PAH) were measured at all sites nearshore and offshore. All hydrocarbon concentrations were less than the LOR (Table MAR008).

**Table MAR008** **Hydrocarbon concentrations for nearshore and offshore sites at Suai**

| Hydrocarbons | Site | Total TPH | Total TRH | Total PAH |
|---|---|---|---|---|
| | | µg/L | µg/L | µg/L |
| **LOR*** | | **50** | **100** | **0.5** |
| **Nearshore** | SBMI1 | <50 | <100 | <0.5 |
| | SBMI2 | <50 | <100 | <0.5 |
| | SBMI3 | <50 | <100 | <0.5 |
| | SI1 | <50 | <100 | <0.5 |
| | SI2 | <50 | <100 | <0.5 |
| **Offshore** | SBM01 | <50 | <100 | <0.5 |
| | SBM02 | <50 | <100 | <0.5 |
| | SBM03 | <50 | <100 | <0.5 |
| | S01 | <50 | <100 | <0.5 |
| | S02 | <50 | <100 | <0.5 |

* Limit of Reporting

## 4.2 Sediment Quality

### 4.2.1 Chemical Sediment Quality

Laboratory data for chemical sediment quality including; nutrients, metals and hydrocarbons, was analysed, with a summary of the results presented below.

#### *Nutrients*

A summary of sediment nutrient parameter results collected from nearshore and offshore sites are presented in Table MAR009. There are no sediment quality criteria for nutrients.

**Table MAR009** **Nutrient sediment quality parameters for nearshore and offshore sites, Suai**

| Nutrients | Site | Ammonia | NOx | TKN | TN | TP |
|---|---|---|---|---|---|---|
| | | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg |
| | LOR* | 20 | 0.1 | 20 | 20 | 2 |
| **Nearshore** | SBMI1 | <20 | 0.8 | 170 | 170 | 499 |
| | SBMI2 | - | - | - | - | - |
| | SBMI3 | <20 | <0.1 | 340 | 340 | 403 |
| | SI1 | <20 | <0.1 | 100 | 100 | 602 |
| | SI2 | <20 | <0.1 | 210 | 210 | 542 |
| **Offshore** | SBM01 | <20 | <0.1 | 290 | 290 | 513 |
| | SBM02 | <20 | <0.1 | 260 | 260 | 509 |
| | SBM03 | <20 | <0.1 | 380 | 380 | 431 |
| | S01 | <20 | <0.1 | 620 | 620 | 516 |
| | S02 | 20 | <0.1 | 840 | 840 | 485 |

* Limit of Reporting
- No Sample Result

Nitrogen concentrations collected from nearshore samples ranged between 100 mg/kg and 340 mg/kg while offshore sites displayed more variability ranging between 260 mg/kg and 840 mg/kg. Maximum nearshore and offshore nitrogen concentrations were observed at 340 mg/kg and 840 mg/kg respectively.

Total phosphorus concentrations for nearshore and offshore sites are presented in MAR011. Phosphorus concentrations collected from nearshore samples varied between 403 mg/kg and 602 mg/kg while offshore sites displayed less variability ranging between 431 mg/kg and 516 mg/kg. Maximum nearshore and offshore phosphorus concentrations were observed at SI1 and SO1 respectively.

### *Metals*

Metal levels identified within the sediment at nearshore and offshore sites are presented in Table MAR010. All data was compared with ANZECC/ARMCANZ (2000) guideline values. Results that were above the ANZECC guidelines were averaged for nearshore and offshore sites and graphically displayed for comparison.

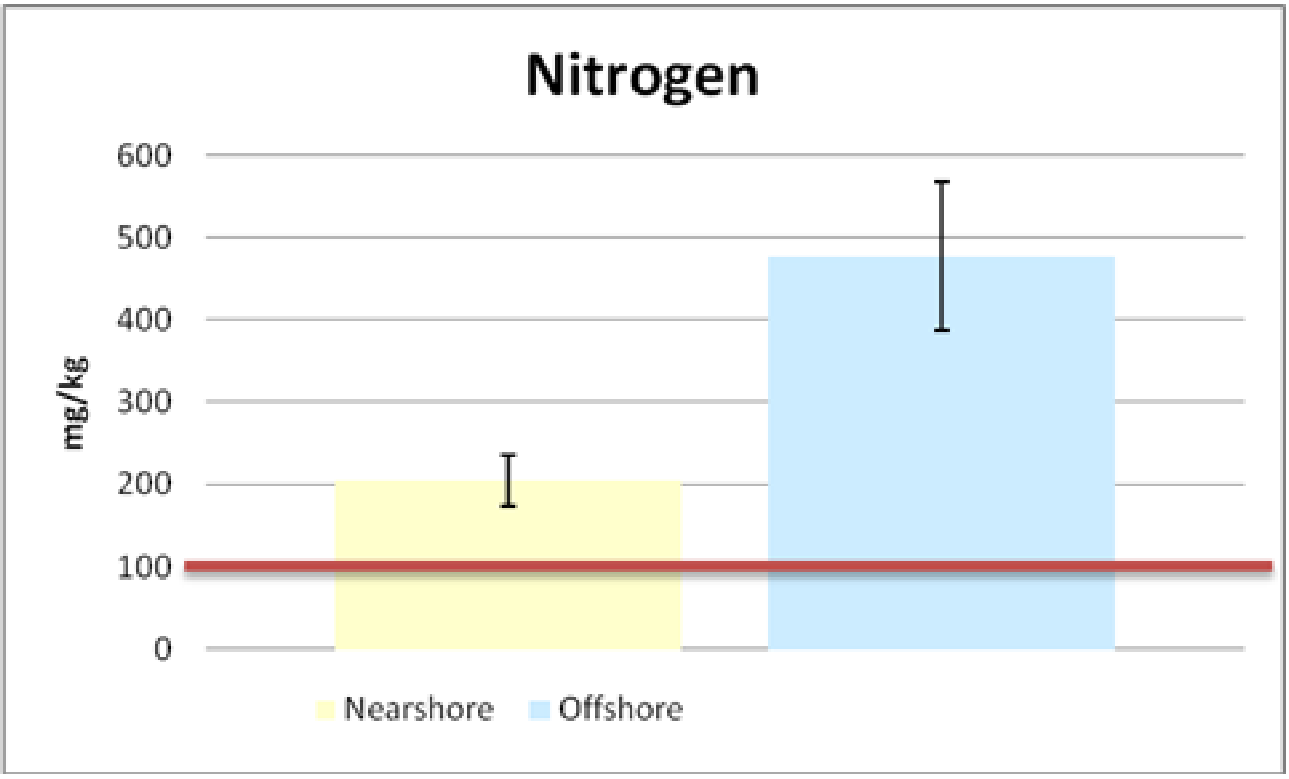


Figure MAR009 Mean nitrogen values for nearshore and offshore sediment, with the ANZECC guideline value shown in red

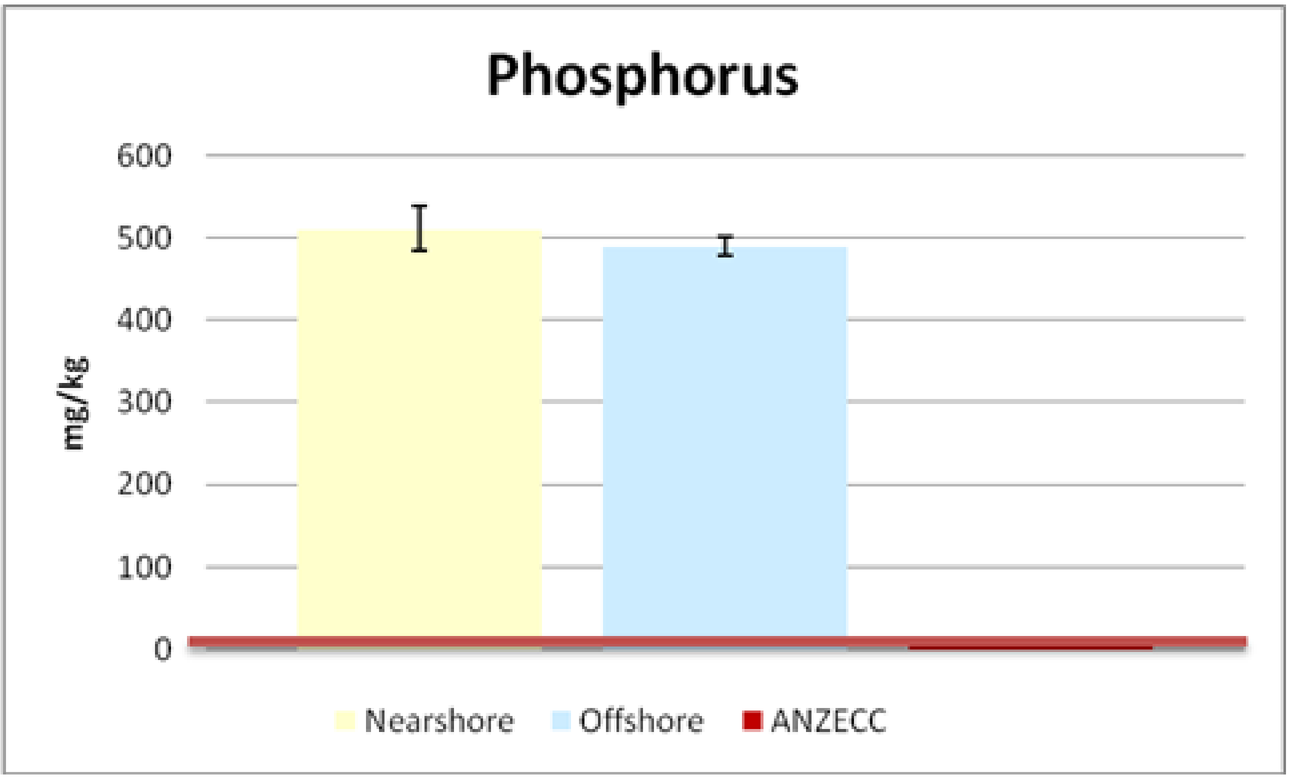


Figure MAR010 Mean values of phosphorus for nearshore and offshore, with the ANZECC guideline value shown in red

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Creator: Courtenay Wheeler

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**Table MAR010** **Metal sediment quality parameters for nearshore and offshore sites at Suai**

| Metals | Site | Cadmium | Chromium | Copper | Lead | Nickel | Zinc | Mercury |
|---|---|---|---|---|---|---|---|---|
| | | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg |
| | **LOR*** | **0.1** | **1** | **1** | **1** | **1** | **1** | **0.01** |
| | ANZECC | 1.5 | 80 | 65 | 50 | 21 | 200 | 0.15 |
| **Nearshore** | SBMI1 | <0.1 | 16 | 18 | <1.0 | **24.4** | 32.3 | 0.01 |
| | SBMI2 | - | - | - | - | - | - | - |
| | SBMI3 | <0.1 | 14.2 | 29.6 | **2.7** | **28.1** | 46.5 | 0.03 |
| | SI1 | <0.1 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | 0.02 |
| | SI2 | <0.1 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | 0.01 |
| **Offshore** | SBM01 | <0.1 | 14.9 | 16.5 | <1.0 | **24.6** | 32.2 | 0.02 |
| | SBM02 | <0.1 | 17.8 | 17.8 | <1.0 | **28.9** | 38 | 0.02 |
| | SBM03 | <0.1 | 15.8 | 28 | **1.2** | **27.5** | 45.3 | 0.12 |
| | S01 | <0.1 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | 0.05 |
| | S02 | <0.1 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | 0.04 |

* Limit of Reporting
**-** No Sample Result
**Bold** indicates values above ANZECC

Nickel concentrations collected from nearshore samples and offshore displayed similar variation ranging varied between <1.0 mg/kg and 28.9 mg/kg. Maximum nearshore and offshore nickel concentrations were observed at SBMI3 and SBMO2 respectively. All sites located between the Karoulun and Raiketan Rivers exceeded the adopted ANZECC (2000) guideline value of 21 mg/kg. The remaining sites to the south of these rivers were found at levels less than 1.0 mg/kg (Table MAR010).

### *Hydrocarbons*

A summary of hydrocarbon (TPH, TRH and PAH) concentrations collected from sediment samples from nearshore and offshore environments at Suai are presented in Table MAR011. Hydrocarbon concentrations were below the LOR for all nearshore and offshore sites.

**Table MAR011 Summary of hydrocarbon sediment quality parameters for nearshore and offshore sites at Suai**

| Hydrocarbons | Site | Total TPH | Total TRH | Total PAH |
|---|---|---|---|---|
| | | mg/kg | mg/kg | mg/kg |
| **LOR*** | | **50** | **50** | **0.5** |
| **Nearshore** | SBMI1 | <50 | <100 | <0.5 |
| | SBMI2 | <50 | <100 | <0.5 |
| | SBMI3 | <50 | <100 | <0.5 |
| | SI1 | <50 | <100 | <0.5 |
| | SI2 | <50 | <100 | <0.5 |
| **Offshore** | SBM01 | <50 | <100 | <0.5 |
| | SBM02 | <50 | <100 | <0.5 |
| | SBM03 | <50 | <100 | <0.5 |
| | S01 | <50 | <100 | <0.5 |
| | S02 | <50 | <100 | <0.5 |

* Limit of Reporting

## 4.2.2 Particle Size

Particle size distribution (PSD) at inshore sites was dominated by sand (mean = 71%, $n$ =4), with some fines (mean = 29%, $n$ = 4) whereas offshore sites were dominated by fines (mean = 63%, $n$ = 5), with some sand (mean = 37%, $n$ = 5) (Figure MAR011).

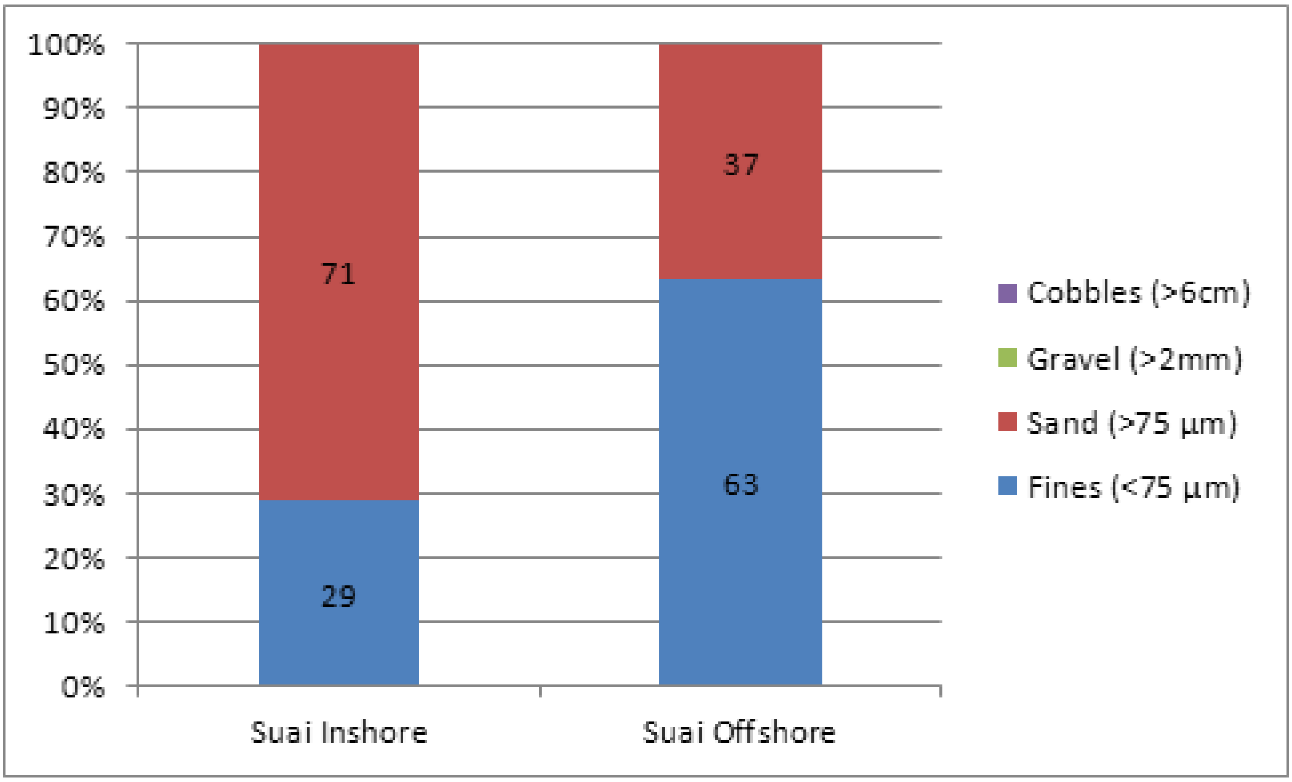


Figure MAR011 Mean PSD at Suai inshore and Suai offshore sites

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## 4.3 Benthic Habitat

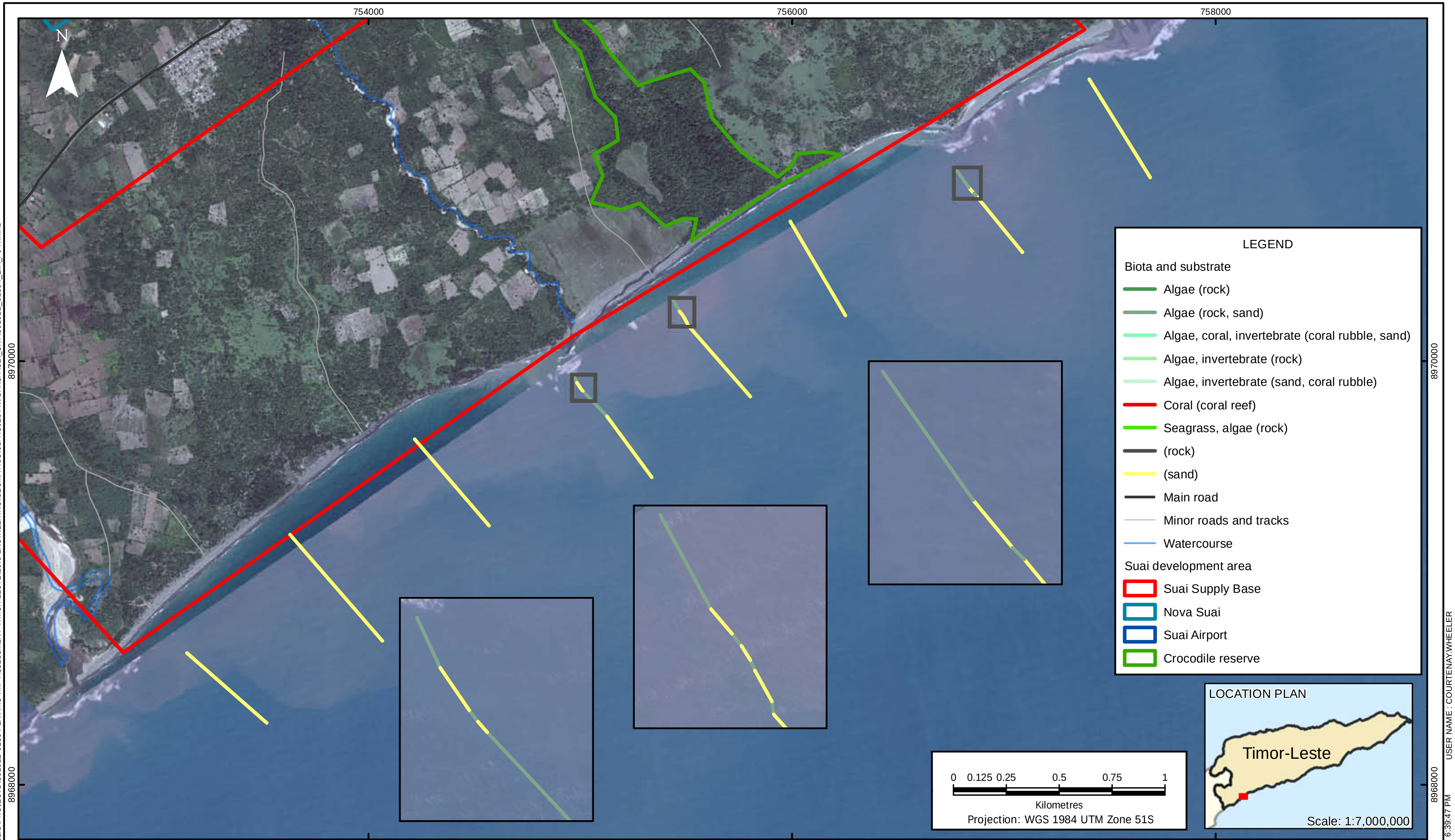
### 4.3.1 Substrate

The substrate recorded in the study area comprised of either sediment or rock. Sediment substrate was recorded across all surveyed transects, including areas where rock was present. Sediment was the dominant substrate type found within the study area comprising mainly sand and silt. The sediment profile was relatively flat with small ripples (<10 cm) in some areas (Plate MP002, in Section 3.4.2).

The only hard substrate recorded was rock in the form of cobbles (64-256 mm) and boulders (> 256 mm). Rocks comprised between 10 to 15% of the surveyed transect area and were found to be located close to the shore at a maximum distance of 450 m from the shoreline (Figure MAR012).

### 4.3.2 Biota

The presence of biota was always associated with the presence of hard substrate (Figure MAR013). The only biota found present on the rocks was turf algae. The density of turf algae covering the rock within transects ranged from sparse (<25%) to dense (>75%), but more commonly covered <25% of the substrate (Figure MAR012).




NOTES:

This map contains:
1. Imagery Suai: SRTM (2011)
2. Imagery: DigitalGlobe (2008 - 2010)
3. Rivers: GIGTimorLeste (2010)
4. Roads: DivaGIS (2010)

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Figure MAR012
Suai benthic habitat tow paths

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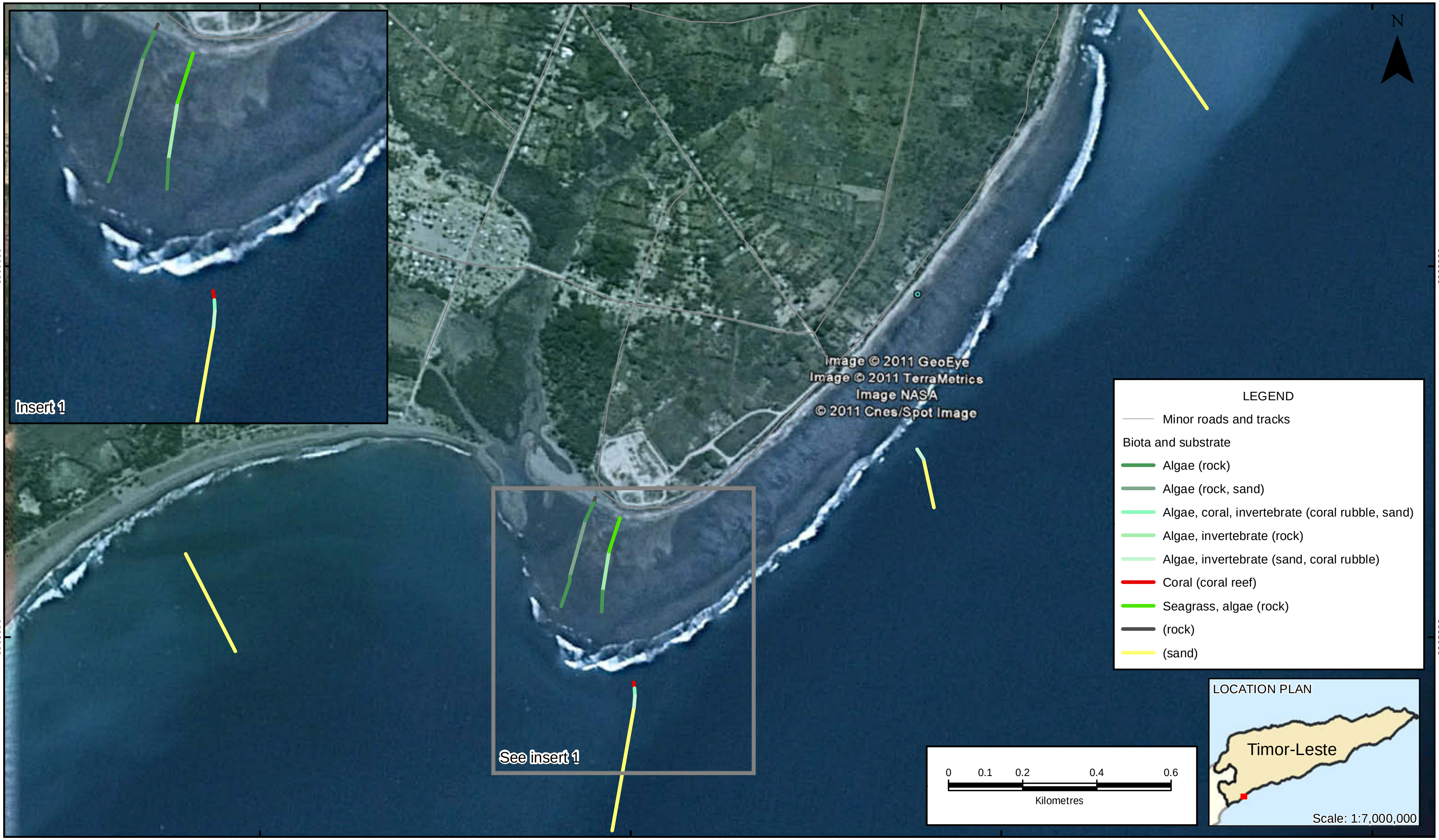


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This map contains:
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2. Imagery: DigitalGlobe (2008 - 2010)
3. Rivers: GIGTimorLeste (2010)
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# Figure MAR013
## Suai reef area benthic habitat tow paths

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### 4.3.3 Reef Adjacent to Development Area

A coral reef is located approximately 5km to the south west of the Suai development. The reef is predominantly a low diversity reef flat. Limestone rock was the primary substrate of the reef. The main biotic classes found on the reef flat were algae (turf, *Padina*, brown and green), seagrass and sparse patches of soft coral. Dense seagrass meadows were found along the reef flats but were limited in extent.

The reef flat drops steeply into deep water. The greatest coral diversity was generally found within 5 to 8m of the surface which then gradually declined below 8 m. The band of rich coral growth is very narrow, being approximately 50 m wide. The dominant species found were *Acropora* and plating *Porites*.

The dense coral cover gradually changes into a mix of algae and invertebrates found growing on a coral rubble substrate from approximately 8 to 12 m. Brown algae was the main type of algae present with the invertebrates mainly consisting of seawhips, sponges and gorgonians. The band of algae/invertebrates found growing on coral rubble was narrow, being approximately 100 m wide. Generally from a depth 10m sand was observed as part of the substrate until 12 m below surface, where it turned into 100% sand.

## 4.4 Plankton

A total of 367 planktonic fauna from 17 taxonomic groups were collected during the baseline survey. The most abundant fauna were larvaceans (n=97), followed by copepods (n=93) and pteropods (n=47). Plate MP004 shows the top three most abundant fauna.

### 4.4.1 Fish Larvae and Eggs

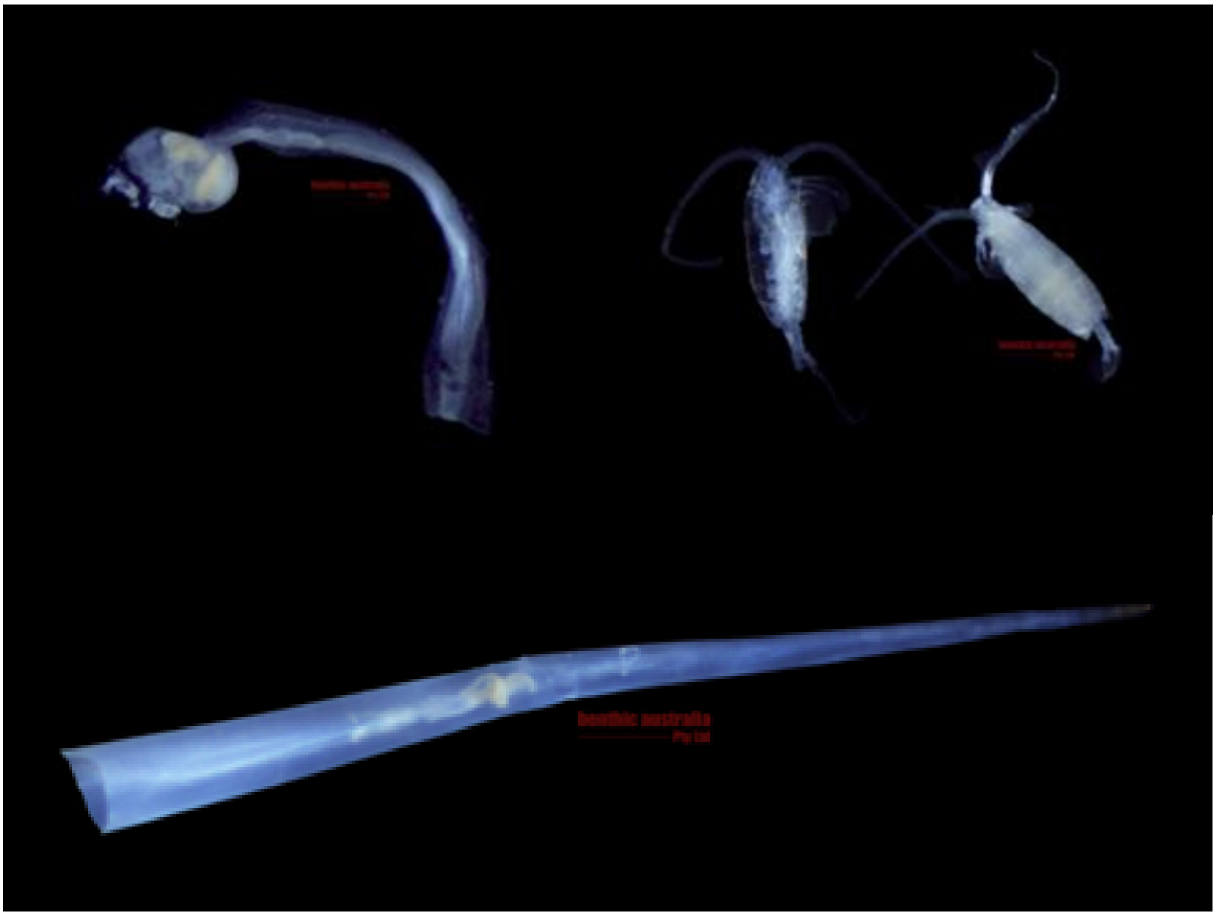
A total of 4 fish larvae and 13 fish eggs were collected in the plankton trawls (Plate MP005). The larvae collected were all of similar anatomy, possibly from the same species. Identification of larval fish is difficult; however, following the taxonomic guide of Leis and Carson-Ewart (2004), the fish collected have the following characters:

- Body is very elongated (body depth < 10% of body length); and
- Gut is short < 50% of body length.

This matches Group 3 in Leis and Carson-Ewart (2004), from this group it is most likely the fish larvae are from the family Blennidae.

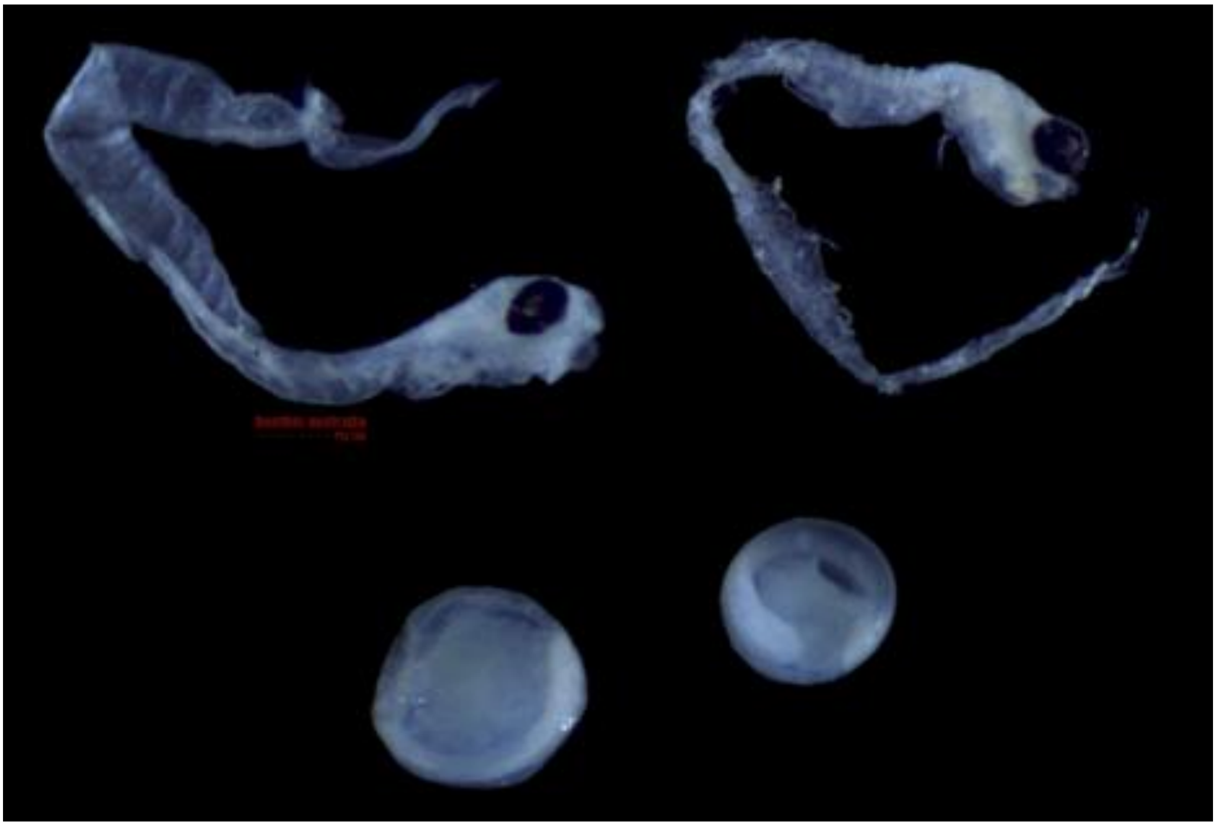

Source:

Plate MP003 Map showing turf algae present on the rocks, adjacent to the Suai footprint area



Source:

Plate MP004 Most abundant fauna collected in plankton trawls. (top left - larvaceans; top right – Calanoidea Copopods; bottom – Pteropoda)



Source:

Plate MP005 Larval fish and eggs collected in plankton trawls (Not to scale); Fish 1-2mm in length; Eggs 0.5 – 1mm in diameter

Source:

Plate MP006 Most abundant fauna collected in benthic grabs. Top left - Hydrozoan; top right – Tellinidae; bottom – Terebellidae (Terebellidae specimen only a representative photograph)

The cluster plot and MDS ordination showed three groupings of sampling sites. The overlay, of the cluster plot onto the MDS ordination showed the majority of sites have a 60% similarity grouping (green circles; Figure MAR017). A one-way ANOSIM comparing each community was not able to be conducted for each site as the survey design did not account for replicate plankton trawls. However, allocating the samples by ‘S’ location; ‘SBM’ location and ‘SMB’ location as indicated by groupings in the MDS ordination, the one-way ANOSIM showed no significant difference between these groups (Global R=0.207; p=0.139; Figure MAR015).

A SIMPER analysis determined the fauna contributing to the differences between sites. The most dominant fauna Calanoids, Pteropoda and Larvaceans had a 60% combined contribution to the difference between sites (Table MAR012).

**Table MAR012 SIMPER analysis results for plankton fauna contributing to all site differences**

| Species | Av.Abund | Contrib% | Cum.% |
|---|---|---|---|
| Calanoid | 5.19 | 39.24 | 39.24 |
| Pteropoda | 3.57 | 19.45 | 58.69 |
| Larvaceans | 2.89 | 10.32 | 69.01 |
| Gastropoda | 1.61 | 6.44 | 75.45 |
| Fish eggs | 1.22 | 5.7 | 81.16 |
| Crab Zoea | 1.27 | 4.55 | 85.71 |
| Chaetognaths | 1.64 | 4.05 | 89.76 |
| Prawn Larvae | 1.14 | 2.91 | 92.68 |

## 4.5 Infauna

A total of 238 macroinvertebrates from 61 taxonomic groups were collected during this baseline survey. The most abundant family was the Tellinidae bivalves (n=16), followed by the spaghetti worms Terebellidae (n=15) and a branching Hydrozoan (n=14). Plate MP004 shows the top three most abundant fauna. The Terebellidae specimen shown in Plate MP004 is only a representative photograph; and not a specimen collected during the survey.

The cluster plot showed no strong groupings of sampling site or replicates (Figure MAR016). This was supported in the MDS ordination which shows all sites generally grouped together. The overlay, of the cluster plot onto the MDS ordination showed the majority of sites have a 40% similarity grouping (green circles; Figure MAR017). A one-way ANOSIM comparing each community, supports the findings that there is no significant difference between the sites, with a global R=0.103 (p=0.148). A SIMPER analysis showed that the fauna contributing to the differences between sites, with the most dominant fauna Tellinidae, having 27.2% contribution to the difference between sites (Table MAR013).

**Table MAR013 SIMPER analysis results for fauna contributing to all site differences.**

| Species | Av.Abund | Contrib% | Cum.% |
|---|---|---|---|
| Tellinidae | 1.93 | 27.22 | 27.22 |
| Pasiphaeidae | 1.61 | 17.04 | 44.25 |
| Ampeliscidae | 1.29 | 8.86 | 53.12 |
| Nephtyidae | 1.11 | 8.26 | 61.38 |
| Spionidae | 1.22 | 7.41 | 68.78 |
| Veneridae | 0.95 | 5.68 | 74.46 |
| Naticidae | 0.88 | 4.62 | 79.08 |
| Terebellidae | 0.89 | 4.61 | 83.69 |
| Dentaliidae | 0.87 | 4.06 | 87.75 |
| Ogyrididae | 0.8 | 2.69 | 90.43 |
| Sternapsidae | 0.68 | 2.27 | 92.7 |
| Alphiidae | 0.65 | 1.91 | 94.62 |
| Pilumnidae | 0.55 | 1.62 | 96.24 |
| Ocypodidae | 0.49 | 0.96 | 97.2 |
| Lysianassidae | 0.36 | 0.81 | 98.01 |
| Sipuncula | 0.33 | 0.69 | 98.71 |
| Leucosiidae | 0.45 | 0.52 | 99.23 |
| Portunidae | 0.37 | 0.3 | 99.53 |
| Sigalionidae | 0.24 | 0.24 | 99.77 |
| Corbulidae | 0.23 | 0.23 | 100 |

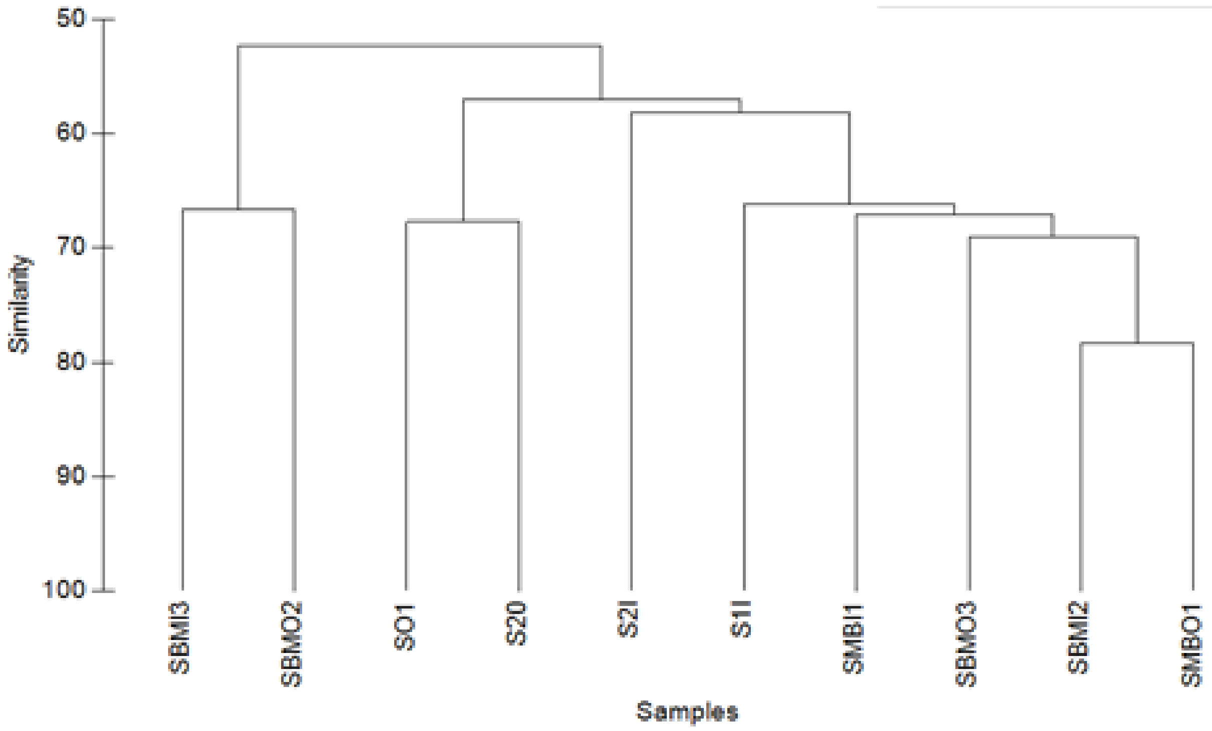



Figure MAR014 Cluster plot showing the similarity of plankton survey sites

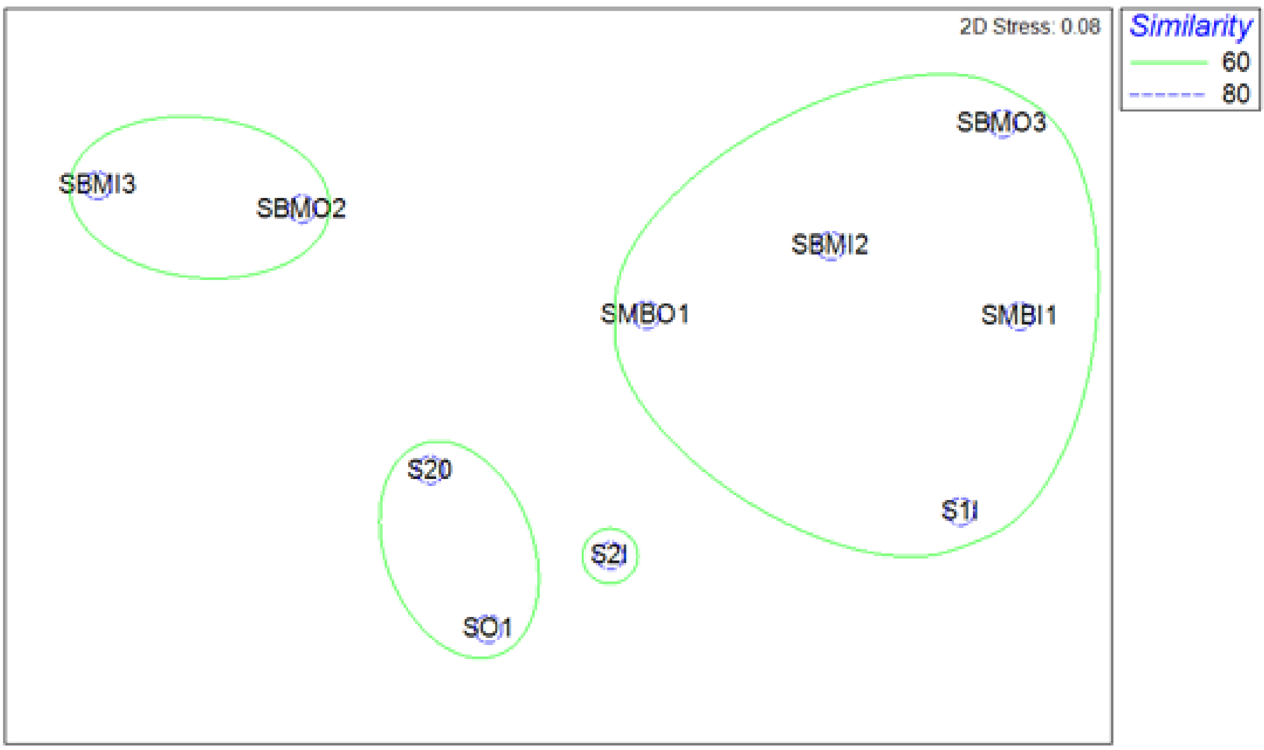



Figure MAR015 Comparison of average pH levels for offshore sites, outliers from nearshore sites as well as the average nearshore levels

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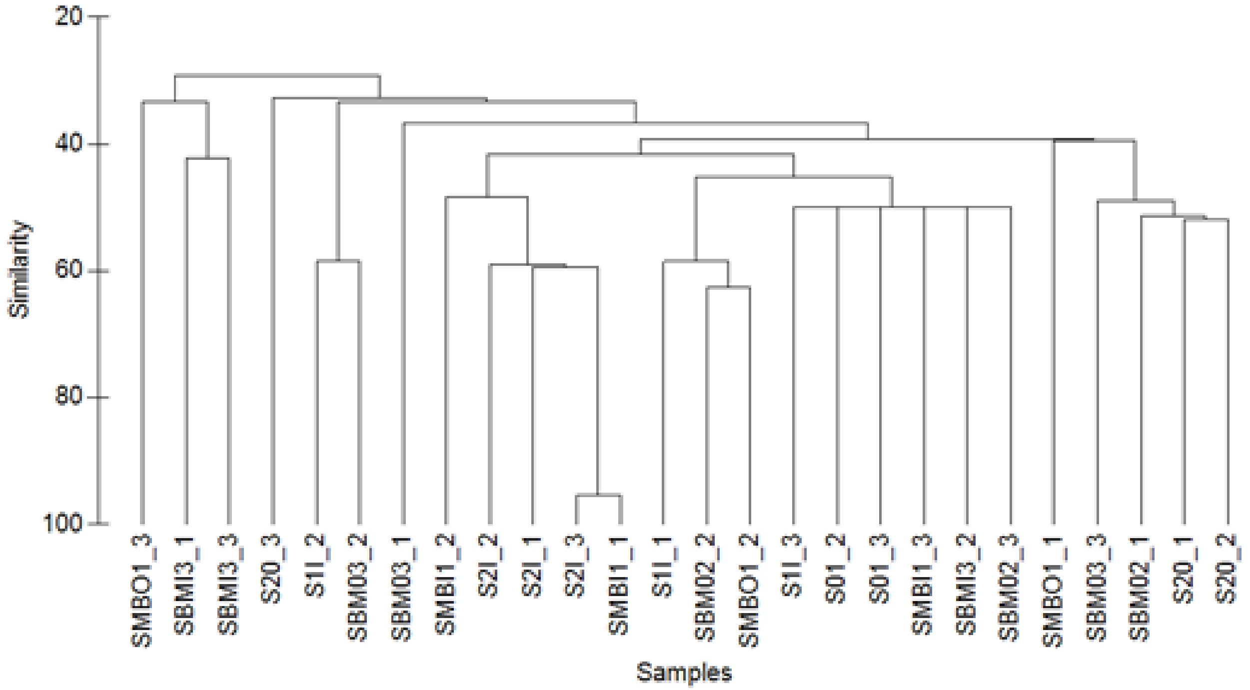


Figure MAR016 Cluster plot showing the similarity of macroinvertebrate survey sites

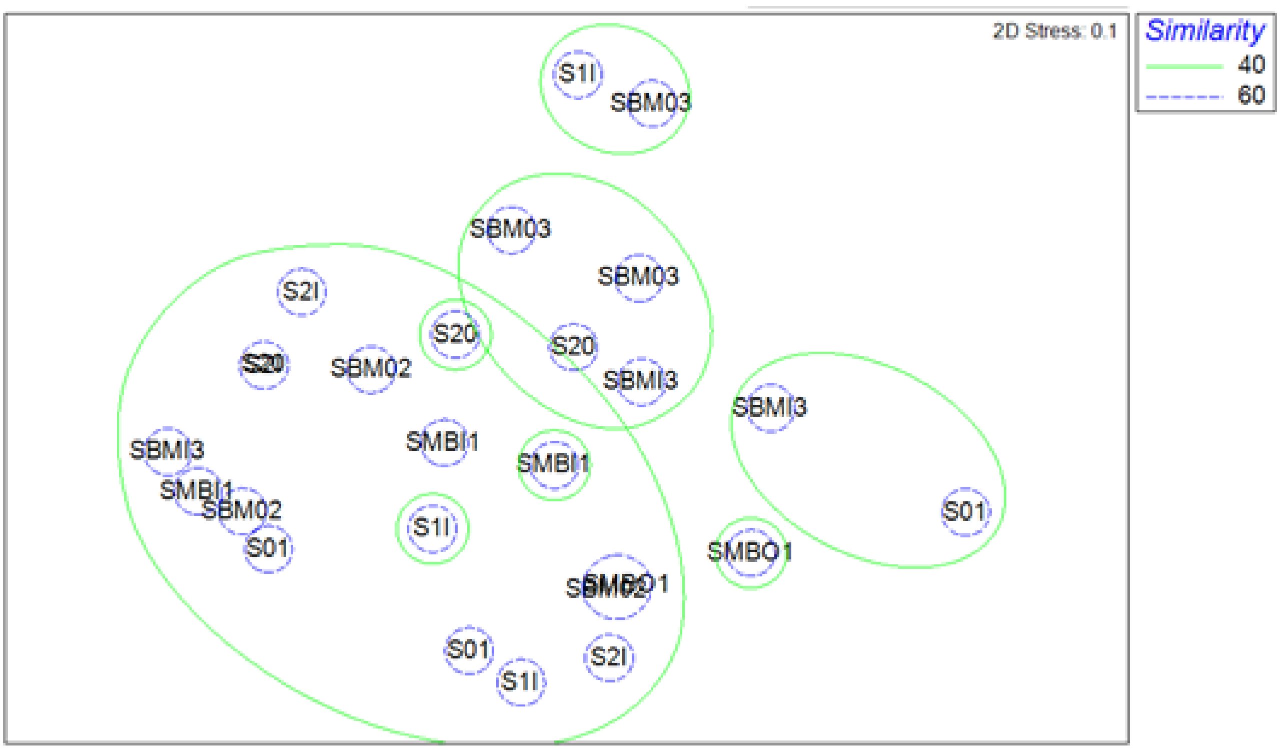


Figure MAR017 MDS ordination of macroinvertebrate samples. Circles show similarity groupings from the Cluster analysis

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Creator: Courtenay Wheeler

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# 5. DISCUSSION

## 5.1 Water Quality

### *Physicochemical water quality*

Results collected during the field investigation between 16 and 18 December 2011 indicated that marine water quality conditions at Suai are generally considered typical of a tropical marine ecosystem at the start of the wet season (Kirono, 2010). Physicochemical water quality parameters varied between nearshore and offshore sites, and are mainly related to differences in depth and their proximity to riverine discharges along the coast.

Temperature was found to generally decrease at a rate of 0.10°C per 5 m across all sites. This is most likely a consequence of the sunlights limitation in penetrating the water column with depth. Generally the offshore temperature was 0.20°C less than nearshore. This can be attributed to an influence of currents offshore and therefore an increased susceptibility to mixing, in comparison to the shallower nearshore waters (Prince et al., 1986).

An increase in salinity was noted in both nearshore and offshore sites with depth. Surface waters from the offshore sites were slightly less saline than surface waters from the nearshore sites but the difference was minor and less than 0.4 ppt. The difference in the inshore sites was in the order of 0.2 ppt. The difference noted may be due to the flow of freshwater runoff from the rivers to the west and east of the site, however no significant pycnocline (density gradient) was evident indicating that coastal waters are well mixed.

No trend in pH was apparent and the dataset too small to draw any conclusions relating to temporal or spatial variation. The pH values in the offshore sites varied between 8.09 and 8.10, while inshore sites varied between 8.11 and 8.14.

Generally turbidity gradually increased with depth at both locations. There was also significant variability noted within the inshore sites, in particular at a Site SBMI3 which had much higher turbidity than other inshore sites. This is most likely attributed to its proximity to a major riverine discharge near the northern boundary of the project site. Of the offshore sites, SBMO3 (and to a lesser extent SBM02) were also elevated compared with other sites but only beyond the 5 m water depth. It is likely that rainfall events mobilise large volumes of sediment from within the catchment discharging them into the ocean causing ambient turbidity levels in the coastal environment to become elevated.

Dissolved oxygen decreased with increasing depth in the offshore sites with a less apparent trend in the inshore sites. Near the surface, water is found to more readily mixed with the atmosphere through wave action that causes oxygen to become dissolved. With increasing depth, DO is taken up by respiration or biological oxygen demand and there is less turbulence from wave action reducing the level of atmospheric oxygen available for dissolution.

### *Chemical water quality*

Concentrations of nutrients were generally below the laboratories limit of reporting (LOR) for all nearshore and offshore sites, with the exception of ammonia and total nitrogen. Ammonia levels were found to be generally higher in the offshore sites and exceeded the recommended ANZECC/ARMCANZ (2000) trigger level at all sites. Similarly, total nitrogen exceeded recommended trigger levels at five of the ten sites sampled; however, exceedances occurred in both inshore and offshore sites. No spatial trends were apparent in the data.

Low concentrations of total and dissolved metals were observed in offshore and nearshore sites except for total and dissolved copper concentrations which exceeded the ANZECC/ARMCANZ (2000) guidelines at five sites, namely Sites SBM13, SI1, SBMO1, SO1, and SO2. Copper is considered a naturally occurring metal in the marine environment, particularly from rivers and from ocean sediments, therefore high concentrations observed may indicate copper concentrations are likely to be naturally high. Similarly, total concentrations of zinc at SBMO3 and SI1 exceeded the ANZECC/ARMCANZ (2000) trigger for zinc, however all dissolved concentrations were less than the trigger level.

## 5.2 Sediment Quality

Concentrations of total nitrogen and phosphorus were relatively high in coastal sediments. Concentrations of total nitrogen were generally higher in the offshore sites and highest at Sites S02 and S01. Concentrations of phosphorous were consistent across all sites with no trend apparent.

Total nitrogen concentrations observed at all sampling sites were comprised of 100% organic nitrogen (TKN) which indicates that nitrogen found in sediments within the study area are of organic origin. Organic sources of nitrogen found in the study area are likely derived from agriculture activities along the Karoulin and Raiketan Rivers. Organic nitrogen that form the primary constituent of natural fertilizing techniques are washed into the catchment before discharging from the river mouth into the ocean (Carpenter et al., 1998).

All metal concentrations in marine sediments were less than the ANZECC/ARMCANZ (2000) sediment quality guidelines except for nickel. Elevated concentrations were recorded from sites SBMI1, SBMI 3 as well as sites SBMO1, SBMO2 and SBMO3. Interestingly, concentrations of chromium, copper and zinc were also above the limits of reporting whereas concentrations at remaining sites were consistently less than their respective limit of reporting.

All hydrocarbons were at levels less than the limit of reporting at both nearshore and offshore sites.

Particle size distribution in sediments at Suai followed expectations, with shallower inshore sites dominated by sand, and deeper offshore sites dominated by fines. These fine fractions of sediment are likely sourced from riverine systems, becoming resuspended by currents and wave energy in the shallower areas, eventually settling in deeper areas offshore.

## 5.3 Benthic Habitat

The southern Timor-Leste coastline consists of a combination of sandy beaches and limestone rock ledges that extend from the shoreline as intertidal reef flat areas that then slope down steeply towards the seabed. In some places along the southern coastline, water depths of 200m can be found less than 1km offshore (Australia – East Timor, Timor Sea, Dillon Shoal to East Timor chart produced by RAN). The sandy beaches consist of medium to fine sand with silt. During heavy rains, sediments are mobilised from the surrounding catchment and enter the ocean causing large sediment plumes. Aerial photographs associated with the Suai area show turbid plumes moving from east to west along the Suai coastline.

The benthic habitat within the study area is dominated by sediment. Given the high elevation and seasonal rainfall in catchments draining to the south coast of East Timor, a natural high flux of fluvial sediments occurs. In addition, deforestation in the region, which is evident to varying extents in aerial photographs, is likely to have enhanced sediment supply. Hard substratum made up approximately 13% of the surveyed transects. The primary hard substrate along the south coast of Timor-Leste is highly erodible coastal limestone, formed by acidification of shell material and ocean movement along the coastline. The only hard substrate found in the Suai footprint area was weathered coastal limestone.

Within the study area, brown turf algae was the primary biotic benthic community. The turf algae was primarily associated with areas of hard substrate and generally had <25% coverage. There is a coral reef located to the south west of the main Suai footprint region.

The fringing reef identified adjacent to the Suai study area is typical of the fringing reef systems found in South East Asia (Burke et al., 2002). The reef generally consisted of a low diversity reef flat which falls steeply into deep water. The greatest coral diversity was generally found within 5 to 10m of the surface which then gradually declines below 10m as depth increases and light diminishes. A high diversity of coral reefs exist in southern Timor-Leste with 301-500 species identified (Burke et al., 2002). The band of rich coral growth is very narrow, being approximately 50m wide.

Seagrass communities have previously been identified in northern parts of Timor-Leste. Dense seagrass meadows were found along the reef flats adjacent to the Suai footprint region. Meadows identified within the study area were generally limited in extent and are not considered to provide a significant resource for grazing by dugongs and turtles.

## 5.4 Plankton

Plankton communities identified from samples collected in the study area were dominated by calanoids, pteropods and larvaceans, which also had a 60% combined contribution to the difference between sites. The planktonic communities showed potential groupings in the MDS, however, these were not supported by the ANOSIM. It is most likely that the fish larvae are from the family Blennidae. Similarly a low diversity and abundance of fish larvae and eggs were also collected in the plankton trawls.

The diversity and abundance observed in this survey event are more likely a reflection of sampling being undertaken during the day. Significantly more and larger zooplankton is caught at night and is responsible for a large proportion of zooplankton variability, due to diel (diurnal) vertical migration (Suthers et al., 2009). Migratory patterns can be variable and are known to differ with the sex and age of species, habitat type and season (Van Gool & Ringelberg, 1998). In some seasons or years there may be no difference between day and night zooplankton abundance, in other years there may be a significant difference (Suthers & Rissik, 2009).

## 5.5 Infauna

The macroinvertebrate communities during the baseline sampling event were species rich in polychaetes and crustaceans, each contributing to 29% of the community fauna. It is common for either polychaetes or crustaceans to be the dominant benthic fauna in sandy sediments from the Australasian region (Long & Poiner, 1994; Currie & Small, 2005). The most abundant family was Tellinidae (bivalves), which also had a 27.2% contribution to the difference between sites. The benthic community showed no significant differences across sites.

# 6. CONCLUSION

The marine waters on the southern coast of Timor-Leste are generally well mixed with little physical stratification. Some of the variation noted in physical and chemical parameters is most likely due to the effects of freshwater associated with the numerous rivers that discharge along this section of coastline.

Large volumes of sediment are transported into coastal areas by rivers during the rainy season. Runoff from the surrounding catchment is the most likely source of nutients and contaminants into the inshore marine environment.

Given the importance of rainfall, significant seasonal differences in water quality is likely between the wet and dry seasons.

Infaunal communities were similar across all sites and composition was typical of sand dominated sediments elsewhere in the region. Plankton species richness and abundance was low but largely reflected a day time community composition with few differences noted between the grouped sites. Fish larvae and eggs were also present in low numbers. Overall, the marine communities during the baseline survey showed no significant different in faunal composition across sites.

The benthic habitat within the study area is predominantly sediment. Hard substratum made up 13% of the surveyed transects. Within the study area, brown turf algae was the primary biotic benthic community. The turf algae was primarily associated with areas of hard substrate and generally had <25% coverage. The coral reef located on the western side of the Suai footprint region consisted of a low diversity limestone reef flat which dropped steeply into deep water. A thin band of rich corals occurs from the 5 to 8m depth contour which grades into an algae and invertebrate dominated habitat from 8 to 12m.  Beyond the 12m depth, the habitat is sand.

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