13. RECEIVING MARINE ENVIRONMENT: MARINE FACILITIES

13.1 Introduction

This chapter summarises the physical (Section 13.2), biological (Section 13.3) and resource utilisation (Section 13.4) characteristics of the nearshore marine environment traversed by the LNG Project Gas Pipeline, shipping access channel and marine facilities (i.e., LNG Jetty / Materials Offloading Facility) in Caution Bay (see Figure 4.1).

Caution Bay is located between Porebada and Boera villages, about 20 km to the northwest of Port Moresby. The marine habitats within Caution Bay include coral reefs, seagrass beds, mangroves, subtidal and intertidal sandy substrates. The nearshore marine components of the project that are proposed for construction in Caution Bay include the pipeline installation and shore crossing, the LNG Jetty / Materials Offloading Facility, and the shipping access channel and turning circle. The pipeline approach route enters Caution Bay via a relatively deep channel in the northern part of Caution Bay, traverses the nearshore reef, mangrove and mud flat habitats and terminates at the LNG Facilities site. The pipeline landfall is approximately 1.5 km to the north of the combined LNG Jetty / Materials Offloading Facility, which also traverses the same nearshore fringing reef, mangrove and mud flat habitats. Descriptions and further details about the siting of these facilities are detailed in Section 4.3, Description of the LNG Jetty and Materials Offloading Facility, and Section 3.3.2.2, Offshore Section (LNG Pipeline).

Information presented in this chapter is sourced from the following studies:

- A nearshore marine impact assessment (Appendix 23, Nearshore Marine Impact Assessment), which characterises the biological communities, habitats, water quality and sediment characteristics within Caution Bay, (based on three field surveys), and identifies the main issues and provides the pre-mitigation impact assessment.
- A geophysical and bathymetric study (EGS, 2008), which allowed identification of offshore coral bommies and rocky outcrops in Caution Bay.
- Oceanographic studies and dredging program simulations (Appendix 22, Hydrodynamic Modelling), which modelled the oceanographic conditions (i.e., current movements, wind, waves, sediment transport and coastal processes) in Caution Bay.
- A resource use survey (Appendix 24, Resource Use Survey of Caution Bay), which examined how marine resources are used in the Caution Bay area.
- An aquatic fauna impact assessment (Appendix 13, Aquatic Fauna Impact Assessment), which includes characterisation of aquatic fauna in the mangrove areas along the coast of Caution Bay.
- BBC Weather (BBC Weather, 2006; BBC, undated), which provided detailed meteorological conditions for Port Moresby.

13.2 Physical Environment

13.2.1 Physiography

Caution Bay (Figure 13.1) is a shallow coastal basin, situated approximately 20 km northwest of Port Moresby. Within the area of nearshore marine components of the project, the majority of the seafloor is characterised by terrigenous silt and clay sediments with evidence of epibenthic faunal activity in the form of mounds and burrows, which range in size and abundance across the seafloor. The deeper waters (i.e., 30 m to 50 m water depth) have a predominately muddy seafloor and a generally sparse distribution of visible biota. The shallow areas of seabed (i.e., less than 30 m water depth) closer to the coast are characterised by coarser coral sands and coral rubble.

An outer barrier reef forms the southwestern (offshore) boundary of the bay and provides protection from ocean swells. There are natural openings in the reef to the north of Idihi Island, which effectively marks the northwestern extent of the barrier reef, and to the south (Liljeblad Passage), which are used by small vessels to move in and out of the reef. The proposed access for LNG carriers is via the entrance to the north of Idihi Island, south of Redscar Head, and along a natural channel of at least 14 m depth that is devoid of shoals or bommies running south as far as the LNG Jetty (Figure 13.2).

There are a number of coral bommies within Caution Bay, rising from the seafloor to a depth of approximately 5 m below the water surface. Most are located in the southern part of the bay, which is characterised by more extensive shallow areas, as can be seen in Figure 13.1. Two island groups are located on the boundary of Caution Bay: Vari Vari Island situated to the north, which is a remnant of the mainland, and Idihi Island to the south (located on the northwest limit of the barrier reef), which is a coral cay (see Figure 13.1). The nearshore fringing reef is a continuous feature that runs approximately 200 to 500 m beyond the mangrove fringe, and is exposed at low tide in parts.

13.2.2 Climate

An automatic weather station (AWS) was deployed on land near the coast of Caution Bay in February 2008 (Plate 13.1). The location on land may reflect some influence of land–sea effects (of cliffs and hilly topography) and cause some local differences with respect to offshore winds. Notwithstanding, the climate of the region is dominated by two main seasons. The northwest monsoon season extends from December to March, and the southeast trade winds extend from May to October; November and April are transitional months.

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Caution Bay

Figure No: **13.1**

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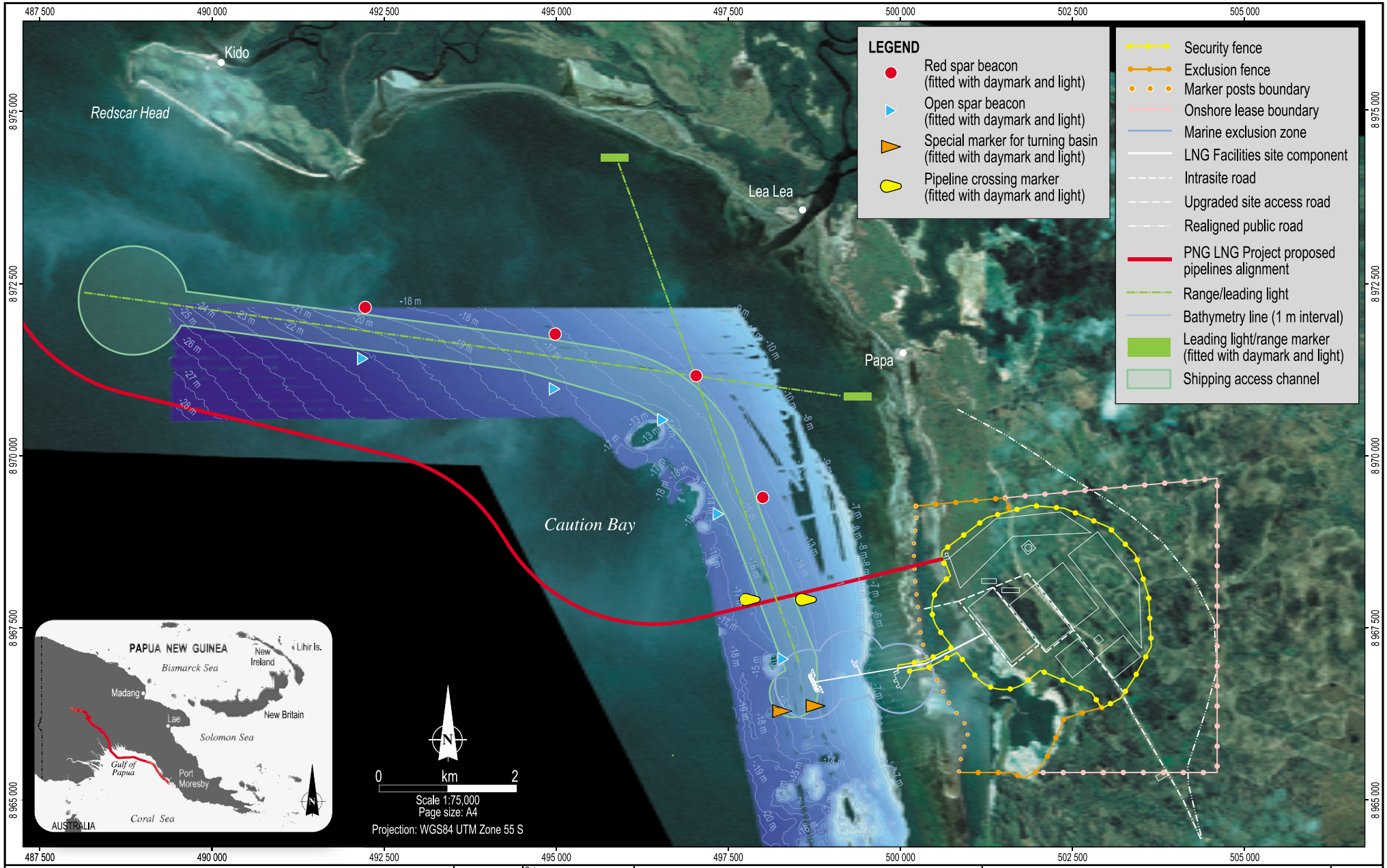

Note:
Layout is indicative only.
Final placement of all components are contingent upon pending soil and geological data.
Pipelines approximate the proposed alignment based on engineering data provided up to 1 October 2008.

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Detailed bathymetry of Caution Bay

Figure No: 13.2

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Plate 13.1
Automatic weather station near Caution Bay coast

Plate 13.2
Dominant fringing-coast mangrove *(Rhizophora stylosa)*

Plate 13.3
Aerial roots of a grey mangrove patch *(Avicennia marina)*

13.2.2.1 Winds

Wind patterns in the Caution Bay area are described in Section 12.2.6.4, Winds, and are not repeated here.

13.2.2.2 Temperature and Rainfall

Details of temperature and rainfall patterns in the Caution Bay area are given in Section 12.2.6.2, Rainfall and Humidity, and are not repeated here.

13.2.3 Oceanography

13.2.3.1 Bathymetry

The bathymetry of Caution Bay is complex with the existence of coral reefs and channels. Caution Bay has a wide, westerly facing entrance between Redscar Head and Idihi Island, inshore of which the bathymetry gradually shelves from around 50 m to less than 5 m at the nearshore fringing reef (see Figure 13.2). Within the bay, average depths are around 25 m, with many shallower coral bommies, mostly in the southern part of the bay. To the south and east of Idihi Island, the outer barrier reef forms the southern boundary of Caution Bay, beyond which, the seafloor depth drops rapidly off the continental slope to depths below 1,000 m about 3 km offshore of the barrier reef (see Figure 13.1).

Within Caution Bay, a natural channel of at least 14 m depth and free from coral bommies runs between Redscar Head and Idihi Island and generally follows the alignment of the coast until reaching the area adjacent to the proposed LNG Jetty. This provides adequate access and depth for the LNG carriers without need for dredging along the shipping access channel. However, some dredging may be required to provide even depth of 14 m within the turning circle – see Section 4.6.1.10, Dredging for the Marine Facilities); and dredging will be required to provide adequate depth access to the Materials Offloading Facility. Further to the south, numerous shoals and bommies rise to about 5 m below the water surface (see Figures 13.1 and 13.2). In the 20-km-long segment of the offshore pipeline route that runs through Caution Bay, the seafloor depth reaches 47 m at the seaward margin.

13.2.3.2 Tides

Port Moresby has semi-diurnal tidal cycles, with two high and low tides per day. Mean spring tidal height in Caution Bay is less than 3 m. Tidal data available for hydrodynamic modelling of sea surface heights was taken from the data obtained from two acoustic Doppler current profilers (ADCPs) placed in Caution Bay and in the Western Gulf of Papua that (to date) were available from a 5-month period (December 2007 to May 2008) (Appendix 22, Hydrodynamic Modelling). Global tidal data from the Australian region, including the Gulf of Papua, was used to compare predicted with observed sea surface heights, and showed that longer time predictions could be made with confidence. Overall sea tidal ranges were between 1.5 m below and 1.5 m above mean sea level (see Figure 3.5 in Appendix 22).

13.2.3.3 Currents

Oceanic circulation in the Gulf of Papua is described in Section 11.2.4.2, Currents, and shown in Figure 11.2. Data on currents within Caution Bay obtained were from the ADCP deployed at the

proposed LNG Jetty location, with the first five months data used to model a 12-month period (Appendix 22). The mean hourly current speed in Caution Bay is 0.07 m/s with a maximum mean speed of 0.32 m/s (calculated as an average of the top 100 current speed records in the bay). Figure 13.3 provides an indication of the dominant patterns of tidal and wind driven currents within Caution Bay. These currents have been used to develop a hydrological model for the bay (Appendix 22) to assess the impacts of the marine structures on coastal currents and sediment transportation processes. This impact assessment is provided in Chapter 21, Environmental Impacts and Mitigation Measures: Marine Facilities.

Upwelling

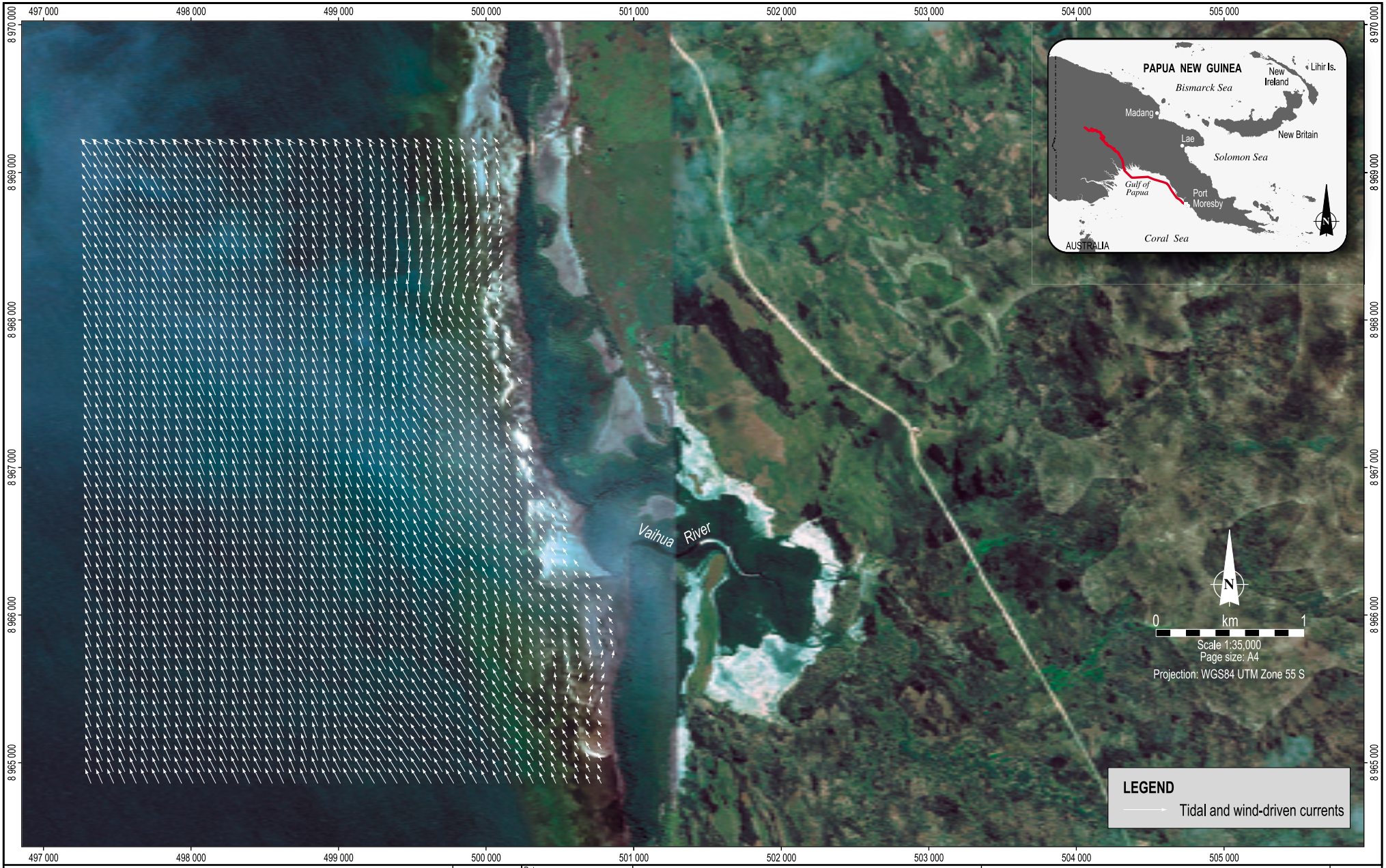
Interpretation of satellite imagery of sea surface temperature along the south coast of Papua New Guinea by the Commonwealth Scientific and Industrial Research Organisation (Cresswell, pers. com., 2008) shows some indications of upwelling, as indicated by cooler water, which correlates with periods of prolonged southeast trade winds. This is centred along the coast mainly to the east of Port Moresby, and weakens and moves further offshore to the west. Figure 13.4 shows upwelling in May 2008, indicated by the areas of low sea surface temperatures off the coast, mainly to the southeast of Port Moresby. There is a correlation between upwelling and the prolonged periods southeast trade winds; with upwelling evident following several consecutive days of southeast winds (indicated by along-shore wind stress), and absence in June when these wind conditions had subsided. This was considered in the selection and modelling of potential locations for the disposal of dredge spoil (see Appendix 22).

13.2.3.4 Waves

Within Caution Bay, the severity of waves is somewhat mitigated by the barrier reef. Data modelled over 12 months at the proposed LNG Jetty site (using the data collected from the ADCP) indicated a mean wave height of 0.42 m and a maximum wave height of 1.9 m. Wave height only exceeded 1 m for 10% of the time over the 12-month period (Appendix 22).

Tropical cyclones represent the extreme oceanographic conditions likely to be experienced in Caution Bay. However, the project area is north of the main cyclone belt and occurrences of such extremes are rare, with only five named cyclones in 15 years entering the Gulf of Papua, all situated well to the south of Caution Bay. Of these Cyclone Guba is the most relevant as it entered the Gulf of Papua from the southeast as a Category One cyclone and passed to the south of Port Moresby (see Figure 5.1 in Appendix 22, Hydrodynamic Modelling). Wave recording instruments were recording during this period and the peak significant wave heights at the Caution Bay jetty site were just over 1 m, while there was only a small storm surge and peak currents reached 0.2 m/s. A search of the tropical cyclone data base, to as far back in time as the 1950s, before satellite observations were available did not reveal any incident of cyclone genesis in the northern part of the Gulf of Papua.

Simulation of an extreme upper bound on sea conditions at the jetty site (see Appendix 22) has been used to predict the peak wind, wave, sea level and current conditions generated in Caution Bay by the passage of a 990 hectopascal (hPa) tropical storm, as might occur by the near-approach of cyclones such as Tropical Cyclone Guba. It should be noted, however, that this storm is purely theoretical and stronger than any event found in the meteorological database.



Source:
Current data from GEMS, 2008.

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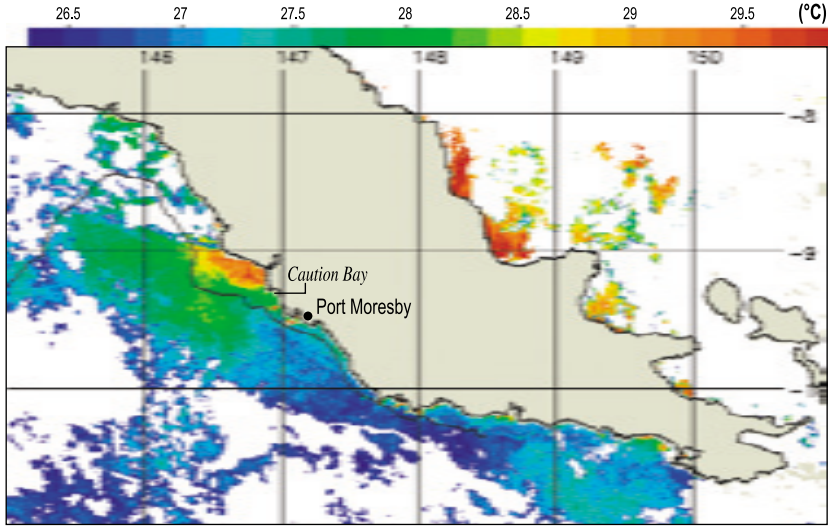
Tidal and wind-driven currents

Figure No: **13.3**

A

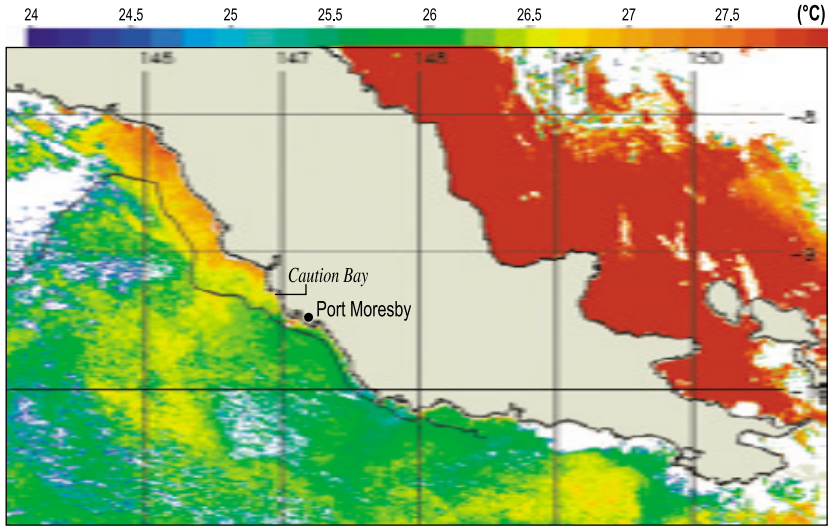
Satellite image of sea surface temperature in May 2008, indicating upwelling mainly to the east of Port Moresby (blue colour)



NOAA18 SST 15 May 2008 0322

B

Satellite image of sea surface temperature in June 2008, showing no upwelling

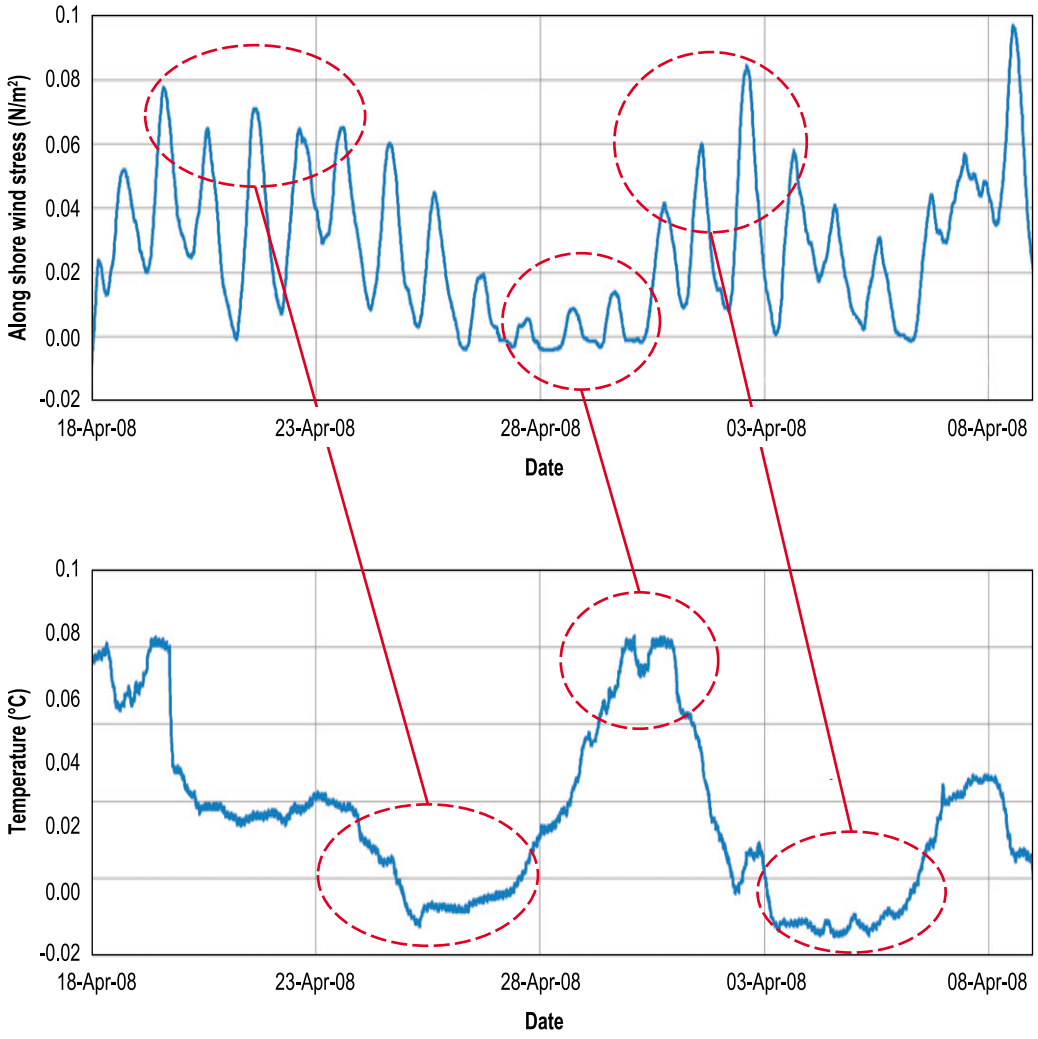


NOAA18 SST 11 Jun 2008 0342

C

Correlation between periods of extended southeast trade winds (high alongshore wind stress; upper graph) and upwelling (low sea surface temperature; lower graph)

Note: Time lag of 1 to 2 days.



Source:
Creswell, pers.com., 2008.

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Incidence of upwelling and correlation with southeast trade winds

Figure No: **13.4**

Table 13.1 shows the output from the model of the theoretical storm travelling from the northwest to southeast past Caution Bay, at a distance such that the strongest winds would impact near the coastline (i.e., comparable to Tropical Cyclone Guba in November 2007). Table 13.1 also summarises the data collected by the one of the ADCPs during Tropical Cyclone Guba. The results described for both current and waves reflect the extreme conditions within Caution Bay.

Table 13.1 Summary of the peak wind, wave, sea level and current conditions generated in Caution Bay by the passage of a theoretical 990 hPa tropical storm and Tropical Cyclone Guba

Parameter	Theoretical Tropical Storm	Tropical Cyclone Guba
Maximum wind speed	25 m/s (90.0 km/h)	12 m/s (43.2 km/h)
Maximum sea level	0.25 m	0.10 m
Maximum current speed	0.40 m/s	0.21 m/s
Maximum significant wave height	3.2 m	1.0 m

13.2.4 Water and Sediment Quality

13.2.4.1 Water Quality

PNG environmental water quality guidelines are provided in Schedule 1 of the Environment (Water Quality Criteria) Regulation 2002 and outline the water quality criteria for protection of marine aquatic life. Any discharges to water associated with the project will be regulated under the PNG *Environment Act 2000* and require an Environment (Waste Discharge) Permit.

The enforceable PNG water quality standards do not include some quality measures, therefore, results were also compared against the Australian and New Zealand Guideline for Fresh and Marine Water Quality, for a range of environmental values were published (ANZECC/ARMCANZ, 2000).

General Parameters

The results summarised in the following sections are taken from Appendix 23, Nearshore Marine Impact Assessment. Locations of all sampling sites are given in Figure 13.5.

Results for general water quality parameters, including conductivity, salinity, temperature, pH and nutrients, are summarised in Table 13.2. Water pH values sampled from the nearshore marine environment are within the expected pH range for seawater of 7.5 to 8.5. Conductivity and salinity ranges were also typical of nearshore waters with some freshwater influence. Concentrations of total suspended solids were higher in April than December, contrary to the higher visibility in April noted by divers undertaking coral and fish surveys (see Section 13.3, Biological Environment). The reason for this is not evident; however, further baseline TSS sampling (for ongoing monitoring) will be completed prior to commencement of the project.

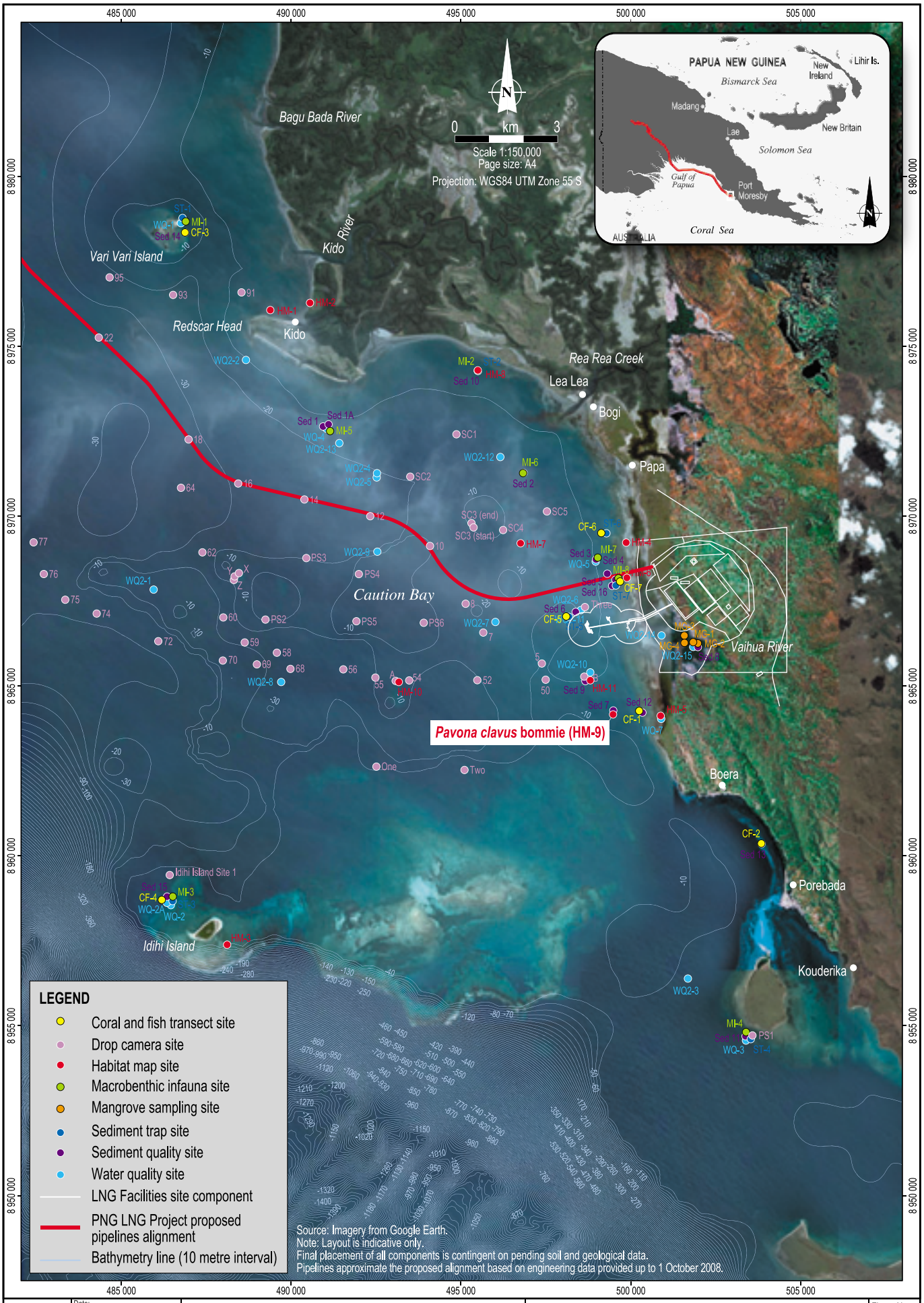

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Table 13.2 Summary of general water quality results

Parameter	Value
Conductivity	43.4 to 57.8 mS/cm
Salinity	27,880 mg/L to 34,500 mg/L
pH	7.94 to 8.24
Total suspended solids	2 to 17 mg/L (December 2007) 26 to 68 mg/L (April 2008)
Nutrients (such as total Kjeldahl nitrogen, total nitrogen, total phosphorus and ammonia)	Within typical concentration range

Sedimentation rates were recorded in settlement tubes located on the reefs for periods from December 2007 to February 2008 and February 2008 to April 2008 (Table 13.3). These results show a range of sedimentation rates, possibly reflecting localised conditions where sedimentation on the reef can be high (e.g., at ST-6), but no overall consistency across all sites over the sampling periods.

Table 13.3 Sedimentation rates within Caution Bay

Site	Sedimentation Rate* (mg/cm^2/day)	
	December 2007 to February 2008	February 2008 to April 2008
ST-1	2.79	5.52
ST-2	4.91	5.69
ST-3	1.03	0.86
ST-4	3.92	0.10
ST-5	1.51	1.08
ST-6	29.17	4.40
ST-7	14.74	** see note

Projection: WGS84 (Zone 55).

* Sedimentation rate excludes the settlement of calcium carbonate.

**Note: Sedimentation results were disregarded for site ST-7 during the February to April 2008 sampling period due to the high variability obtained from the four individual traps.

Metal Concentrations

Concentrations of cobalt, chromium, copper, nickel, lead, selenium and zinc in most samples were below the analytical detection limits (which were less than 0.001 mg/L for copper, less than 0.002 mg/L for cobalt, lead and selenium and less than 0.005 mg/L for chromium, nickel and zinc).

Concentrations of aluminium, iron, arsenic, cadmium, manganese and silver were above the detection limits, but below the guidelines (i.e., Schedule 1 of the Environment (Water Quality Criteria) Regulation 2002 and ANZECC/ARMCANZ, 2000), indicating uncontaminated waters.

The above summary relates to results for total metal concentrations (see Appendix 23, Nearshore Marine Impact Assessment). Although there are no guidelines for total metal concentrations, comparisons are made against the guidelines for filterable metal concentrations. Using total metal

values therefore adds a level of conservatism in this assessment. As expected, the results indicate good marine water quality and give no indication of contamination.

13.2.4.2 Sediment Quality

PNG regulatory authorities have not established sediment quality guidelines. The Australian and New Zealand Guideline for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000) describes interim sediment quality guidelines (ISQG), and therefore these have been used as a comparison with the results obtained from the sediment analyses. These guidelines contain two values, ISQG-low and ISQG-high, which delineate three biological effects ranges:

- Concentrations below the ISQG-low guideline represent a range where adverse biological effects on benthic biota will rarely be observed.
- Concentrations between the ISQG-low and ISQG-high guidelines represent a range where adverse biological effects on benthic biota will occasionally be observed.
- Concentrations above the ISQG-high guideline represent a range where adverse biological effects on benthic biota frequently occur.

These results are summarised from Appendix 23, Nearshore Marine Impact Assessment. Metal concentrations were analysed from the sub 2,000-µm fraction at all sites. Concentrations of arsenic, chromium, copper, nickel, lead and zinc were above the detection limit but below ISQG-low guidelines. Silver and cadmium concentrations in sediment samples were below the detection limit, but in the case of these two elements, the laboratory detection limit was higher than the ISQG-low guideline, so it was not possible to determine if the concentrations of these metals were below this guideline. Single samples (at locations Sed 7 and Sed 8 – see Figure 13.5) exceeded the ISQG-low guideline for silver and nickel respectively. Otherwise, sediment metal levels are below the detection limit and ISQG-low guidelines and within ranges of background crustal levels (Berkman, 1989). It is unlikely that there is any significant source of contamination of the sediments within Caution Bay; however, further baseline sampling is planned prior to the commencement of construction.

Sediment samples collected from the proposed shipping access channel in Caution Bay, at Idihi Island and in the mangrove communities of the Vaihua River were dominated by particle sizes below the 63-µm fraction, and between the 63-µm and 2,000-µm sediment fraction.

Sediments between 63 µm and 2,000 µm represented the majority of the sediment samples collected from other sites in Caution Bay. In samples obtained from areas dominated by coral reefs, which are areas that consist mainly of coral rubble and shell debris, approximately one-third of particle size distributions were in the greater than 2,000-µm sediment fraction. This is typical of coral reef lagoon sediments.

13.3 Biological Environment

During December 2007 and April 2008, Coffey Natural Systems conducted two surveys of the nearshore marine environment in Caution Bay (Appendix 23, Nearshore Marine Impact Assessment). The aim of the study was to identify marine habitats, assess their current general condition and identify the potential impacts posed by the project. A third survey in June 2008 focused on specific coral bommies that were identified from bathymetric data that became

available after the second survey. This section describes the results of the surveys and characterises the current condition of the nearshore biological environments in Caution Bay. Results of studies of the estuarine fauna of the mangroves are provided in Appendix 13, Aquatic Fauna Impact Assessment.

13.3.1 Nearshore Habitats Including Intertidal Mangroves

The four main marine habitats along the nearshore marine environment of Caution Bay adjacent to the proposed nearshore marine components of the project are coral reef, mangrove, seagrass and sandy seafloor (submerged and intertidal). Some areas of supratidal saltflats also occur to the landward side of the mangroves. These only receive tidal inundation during extreme spring high tides and are predominantly dry during the dry season and are mainly bare of vegetation. A map of these habitats is provided as Figure 13.6[1].

13.3.1.1 Mangroves, Saltflats and Beaches

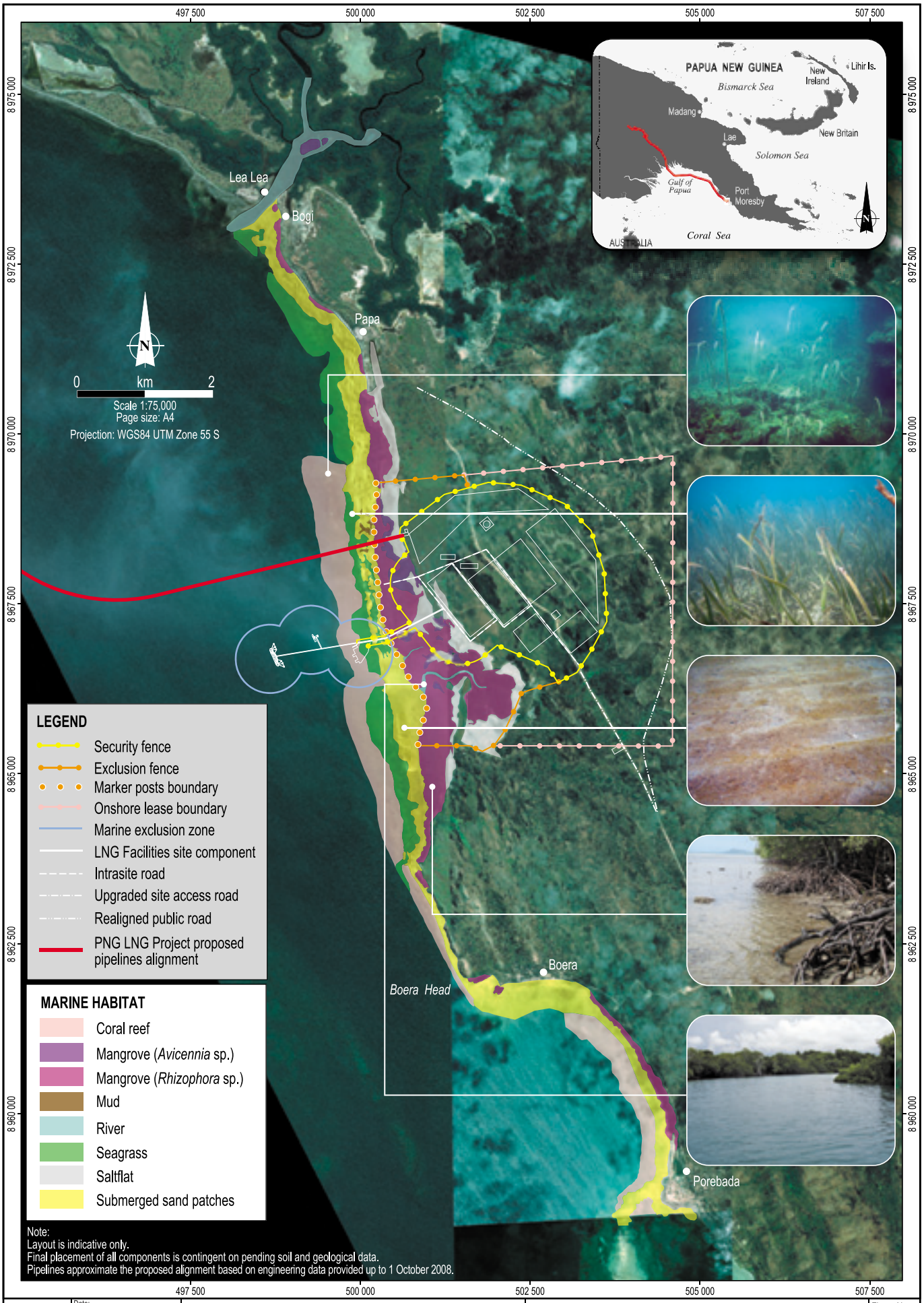
Mangroves extend along much of the coast of Caution Bay (see Figure 13.6), and are dominated by the spotted-leaved red mangrove (*Rhizophora stylosa*) (Plate 13.2), which represents more than 90% of all mangrove individuals present in the area. This species extends from the seaward margin to the start of the saltflats; a distance of approximately 300 to 900 m. Trees were typically 4 to 5 m high with a maximum height of approximately 10 m. High in the intertidal zone (on the landward margin), patches of smaller grey mangrove (*Avicennia marina*) occur (Plate 13.3). Apart from these two species, only a few individuals of other species were observed, including club mangrove (*Aegialitis annulata*) and yellow mangrove (*Ceriops* sp.). Given the spatial dominance of *Rhizophora*, the other species occur in scattered and discrete patches so there are no well-defined zones from low to high tide areas.

The mangroves and their root systems provide important ecological functions, such as nursery habitat for many juvenile fish species and marine invertebrates. They also act as buffers against erosion during severe weather and act as a natural nutrient filtration system.

The mangrove areas are extensively utilised by local people on a subsistence basis for fishing (spear fishing and netting), for collecting crustaceans and molluscs for food. Where there is easy access from tidal channels, mangrove trees also provide a source of timber for building materials or for firewood. Further discussion on the use of mangroves for subsistence is provided in Section 13.4.3, Mangrove Resource Use.

Sandy beaches occur in small patches along the southern coast of Caution Bay in regions not supporting mangroves. An extensive sandy beach occurs in northern Caution Bay, and a wide beach is also present north of the Kido River (Plate 13.4).

[1] While the habitat descriptions are accurate, it is important to note that the areas have not been extensively ground truthed and may not accurately delineate exact boundaries of the habitats identified.



Note:
Layout is indicative only.
Final placement of all components is contingent on pending soil and geological data.
Pipelines approximate the proposed alignment based on engineering data provided up to 1 October 2008.

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Plate 13.4
Small patches of sandy beach along the southern coast of Caution Bay

Plate 13.5
Supratidal mudflats / saltflats

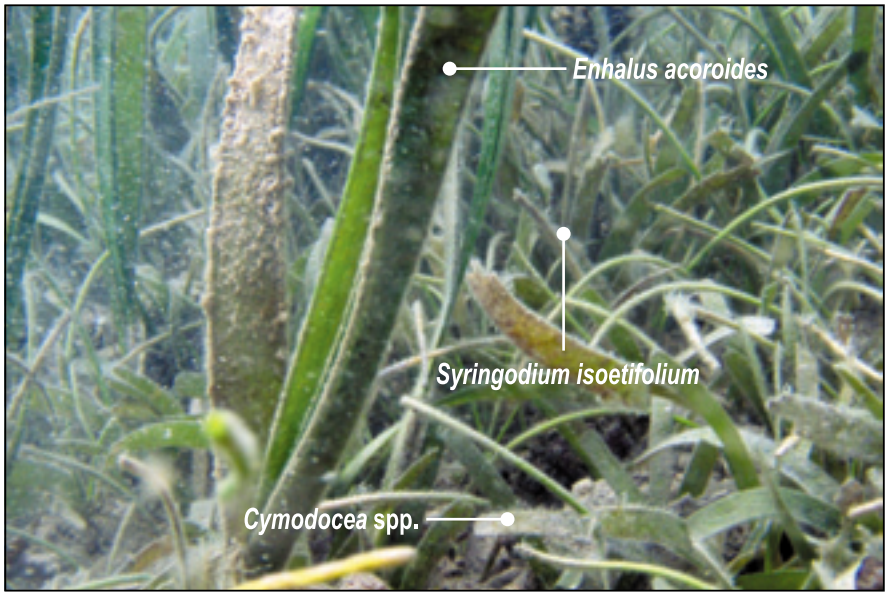


Plate 13.6
Enhalus acoroides, *Syringodium isoetifolium*, and *Cymodocea* spp. seagrass

Supratidal mudflats and saltflats are located behind the mangroves along the Vaihua River (Plate 13.5). These areas are barren of vegetation as they are only inundated infrequently. Further information about this habitat is provided in Section 12.4.2.2, Hypersaline Wetland (Saltflat) Habitats.

13.3.1.2 Seagrass

Large areas of seagrass occur in Caution Bay (see Figure 13.6), generally on the flat, sandy seafloor between the mangroves and the fringing reef. The seagrass communities consist of three species: *Enhalus acoroides*, *Syringodium isoetifolium*, and *Cymodocea* spp. (Plate 13.6). These three seagrass species form dense seagrass meadows located between the mangrove-lined shore and the fringing reef but did not extend deeper into the lagoon, seaward of the base of the fringing reef. Seagrass communities can be of ecological significance as nursery or feeding habitats for prawns, lobsters, crabs, fish and turtles, as well as an aid in stabilising the substrate. While locally dense, the overall area of seagrass is not extensive. No dugong feeding trails were observed in the seagrass beds, which is consistent with discussions with local people who stated that dugongs do not occur in Caution Bay.

13.3.2 Coral Reefs and Seafloor Characteristics

Visual assessment of the seafloor of Caution Bay by divers and by the use of drop camera enabled description of the benthic habitat in the vicinity of the nearshore marine facilities and shipping access channel. The main expanse of Caution Bay, seaward of the fringing reef and between the bommies and shoals, includes areas of homogeneous fine sand and silty substrate, with generally sparse visible biota. However, there is much bioturbation (burrows and pits) from biological activity of benthic infauna that occur in these sediments.

The majority of nearshore coral reefs within Caution Bay appear degraded, with very low coral and fish abundance, and a veneer of sediment. Abiotic substrate accounted for over 55% of the total substrate composition at five of the seven coral reef sampling sites. The degradation has most likely been caused by heavy fishing use and resuspension of sedimentation during periods of strong winds and waves (Plates 13.7 and 13.8). Despite the protection from ocean swells provided by the outer barrier reef, the fetch within Caution Bay is sufficient for wave action and sediment resuspension on the fringing reef, particularly during the season of the southeast trade winds. In places, it is possible that dynamite fishing may have exacerbated the degradation. Discussions with local fishers indicated that this practice has occurred in Caution Bay in recent times (see Section 13.4.1, Subsistence Fisheries). However, no fresh evidence of dynamite fishing was apparent during the surveys.

In comparison, the offshore islands and outer barrier reef support higher coral cover. The coral at both Vari Vari Island and Idihi Island had high coral cover and diversity, no veneer of sediment and few signs of disturbance from anthropogenic or natural sources.

13.3.2.1 Fringing Reef

The condition of the majority of the fringing reef in Caution Bay is poor, with generally low coral cover, extensive areas of abiotic substrate and visible veneers of sediment. Much of the reef is dominated by brown algae (*Sargassum* spp.) (Plate 13.9). Although *Sargassum* is a common algal component of tropical reefs and lagoons (Womersley, 1987; Cribb, 1990; Vuki & Price,

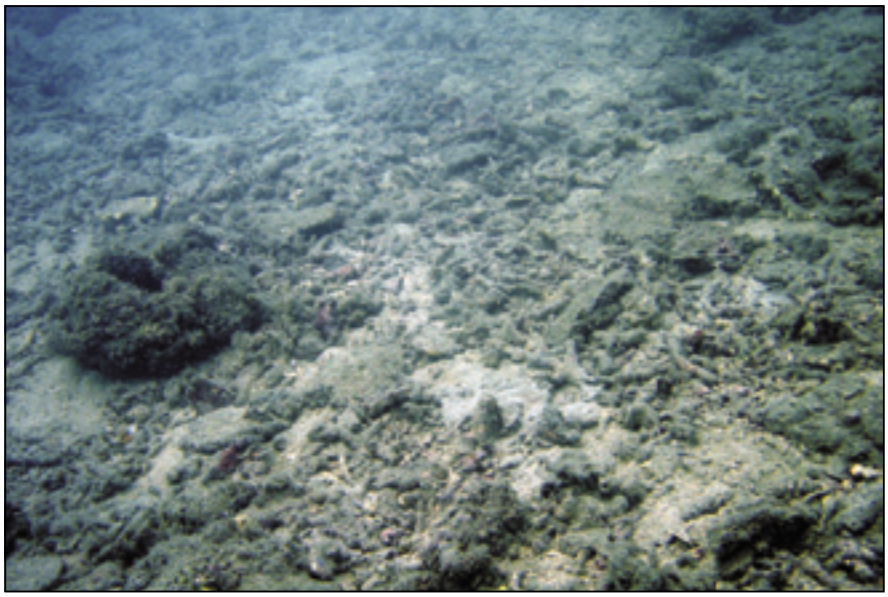


Plate 13.7
Coral rubble on an offshore bommie in Caution Bay

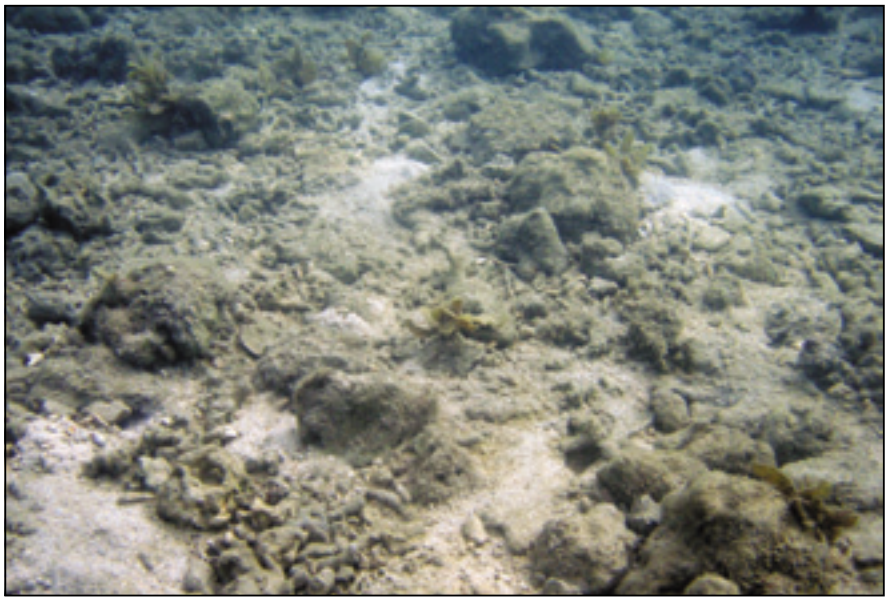


Plate 13.8
Dead coral and rubble

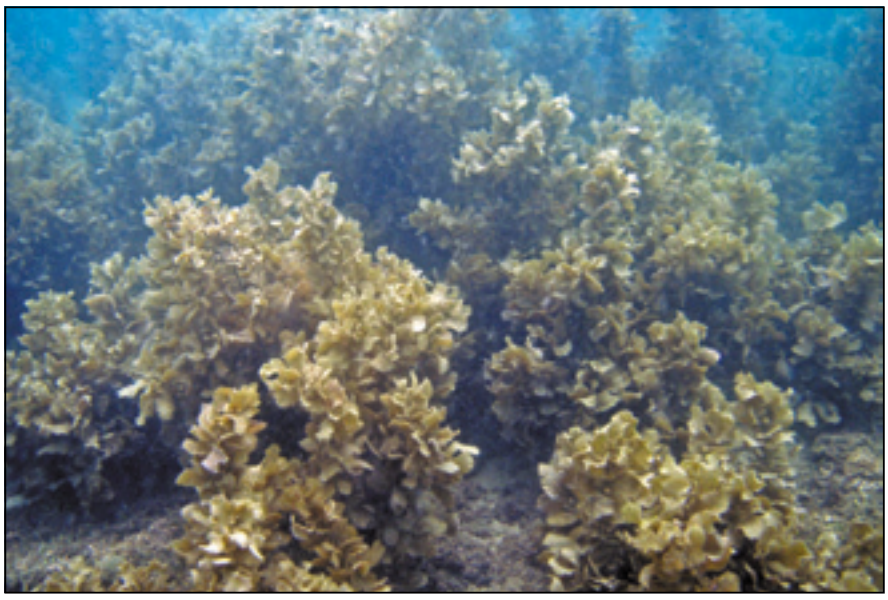


Plate 13.9
Reef top dominated by brown algae *(Sargassum spp.)*

1994), it now occupies extensive areas around the crest of the fringing reef. It is not clear whether the *Sargassum* has increased by gradual replacement of degraded coral on the fringing reefs of Caution Bay or whether this is a natural condition. Nutrient levels were within typical ranges (see Section 13.2.4.1, Water Quality) and not suggestive of a possible cause.

The inshore fringing reefs also have high densities of the sea urchins (*Diadema* spp.) (Plate 13.10), which is often indicative of the lack (most likely through high fishing pressure – see Section 13.4.1, Subsistence Fisheries) of higher-order predatory species, such as predatory fish and octopus (Steiner & Williams, 2006). The grazing by *Diadema* spp. in turn adds to the reduction of coral settlement and recovery.

Hard coral cover in the nearshore marine areas adjacent the proposed marine facilities, shipping access channel and offshore pipeline route ranged between 21% and 61% across all survey sites (Table 13.4). However, the transect locations (see Figure 13.5) were selected to include areas where there was a reasonably extensive cover of coral, as well as poor areas, in order to extend comparisons into the future. Hence, these figures provide the range of cover but not necessarily the average conditions over the entirety of the fringing reef. The major substrate type across all sampling sites combined was abiotic lifeforms such as dead coral, rubble and sand. Abiotic surfaces accounted for over 55% of total substrate composition at five of the seven sampling sites. Site CF-7, located adjacent the proposed offshore pipeline approach and approximately 1 km north of the proposed LNG Jetty, was typical of poor quality fringing reef with percentage cover only (21%) and this area generally consisted of large areas of coral rubble and bare substrate. However, CF-7 had the second highest diversity of corals, with nine categories recorded (see Table 13.4). This site also had the highest cover of calcareous green alga (*Halimeda* spp.), which is common in tropical habitats.

Table 13.4 Coral reef community composition based on the 6-m coral visual census[1,2]

Lifeform Category	Sampling Site						
	CF-1	CF-2	CF-3	CF-4	CF-5	CF-6	CF-7
Hard Coral							
Acropora (branching)	0	4	0	0	0	0	0
Acropora a (digitate)	1.5	16.1	8.2	0	0	0	2.4
Acropora (submassive)	0	0	0	7.3	0	0	0
Acropora (corymbose)	0	8.9	1.2	2.9	0	1.6	2.4
Acropora (encrusting)	0	0.8	0	6.5	1.4	0	0
Acropora (tabulate)	0	0	2.9	0	0	0	0
Porites (massive)	30.9	15.4	12.4	10.9	42.9	46.1	1.6
Porites (encrusting)	0	0	2.9	0	0	0	0
Dendrophyllia	0	0	0	0	0	0	3.2
Faviid (encrusting)	0	0	2.5	0	0	0	0.8
Faviid (massive)	0	0	6.4	4.3	5.7	0	3.2
Pectiniidae (foliose)	0	0	0	0	0	3.9	1.6
Mussidae (massive)	0	0	0	0	0	0	3.2
Oculinidae	0	0	0	0	0	1.6	0

Table 13.4 Coral reef community composition based on the 6-m coral visual census[1,2] (cont'd)

Lifeform Category	Sampling Site						
	CF-1	CF-2	CF-3	CF-4	CF-5	CF-6	CF-7
Hard Coral							
Pocillopora	2.9	0	0	0	0	7.7	2.4
Total	**35.3**	**45.2**	**36.5**	**31.9**	**50**	**60.9**	**20.8**
Other Biota							
Coralline algae	0	0	0	3.6	0	0	0
Encrusting sponge	0	0	0	0	0	0	0.8
Soft coral	0	0	0	0	0	0	1.6
Sponge	0	0	0	0	14.3	0	0
Halimeda	0	0	0	0	0	18	20
Total	**0**	**0**	**0**	**3.6**	**14.3**	**18**	**22.4**
Abiotic							
Dead coral	47.1	13.7	54.7	25.4	27.1	10.2	31.2
Rubble	13.2	14.5	7.6	21.7	8.6	0	0
Sand	4.4	26.6	1.2	17.4	0	10.9	25.6
Total	64.7	54.8	63.5	64.5	35.7	21.1	56.8
Total Lifeforms	***100***	***100***	***100***	***100***	***100***	***100***	***100***
H' – Diversity[1, 3]	1.29	1.87	1.57	1.95	1.43	1.60	1.91

[1] Coral censuses were done to characterise the species, structure and cover of corals. These censuses were done by taking a photographic record of the coral transect using a high-definition digital camera in an underwater housing. The diver first photographed the swing tag to provide a reference at the start of each transect and then took photographs at approximately 0.6-m intervals along the 6-m transect with the camera held 1 to 2 m perpendicularly above the substrate, with the measuring tape framed in the centre of each photograph. Mosaics of each transect were constructed by stitching individual photographs together to provide a general overview of the structure of the coral reef community within the sampling site.

[2] Where H' is the value of the Shannon-Weiner diversity index.

Massive corals, particularly *Porites* spp. dominate the reefs in the region, as typically observed in areas of sedimentation, although a greater diversity (but lower cover) of *Acropora* spp. coral also occurs (see Table 13.4). *Porites* spp. accounted for between 8% and 88% of hard corals at all sampling locations in Caution Bay. Branching *Acropora* spp. coral, although usually dominant on typical tropical coral reefs, occurs infrequently.

Little evidence of anchor scars or domestic rubbish was apparent on the coral reefs at any of the survey sites.

13.3.2.2 Offshore Reefs

The bathymetry of the northern end of the bay is comparatively simple, with fewer shallow shoals, compared with the southern end of the bay, which is dominated by extensive shallow reef areas inshore of the barrier reef. The area of most offshore shoals and coral bommies commences approximately 2 km west of the edge of the fringing reef in the central / southern region of Caution Bay and extends westwards. Most of the shoals and bommies have been investigated by divers

Plate 13.10
Sea urchins (*Diadema* spp.) in Caution Bay

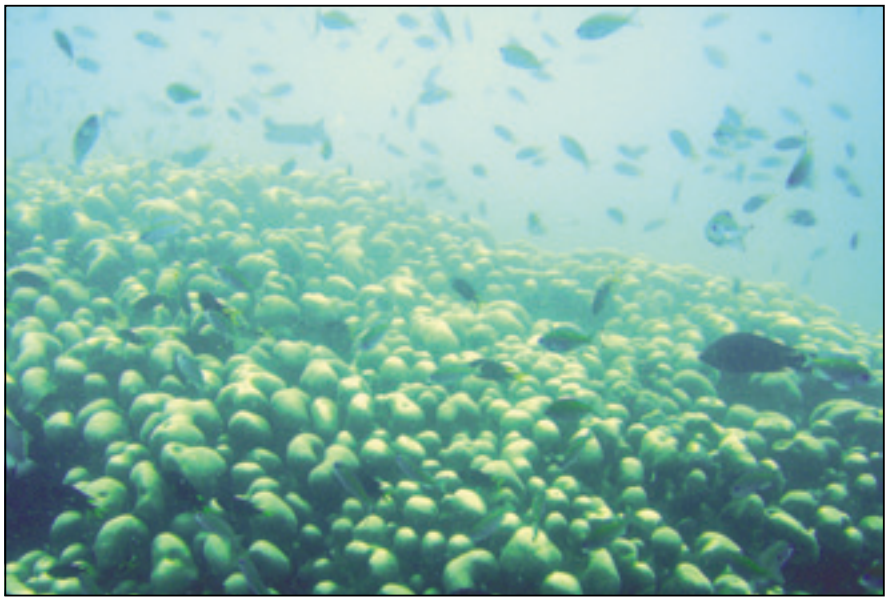


Plate 13.11
Fish abundance on *Pavona clavus* bommie

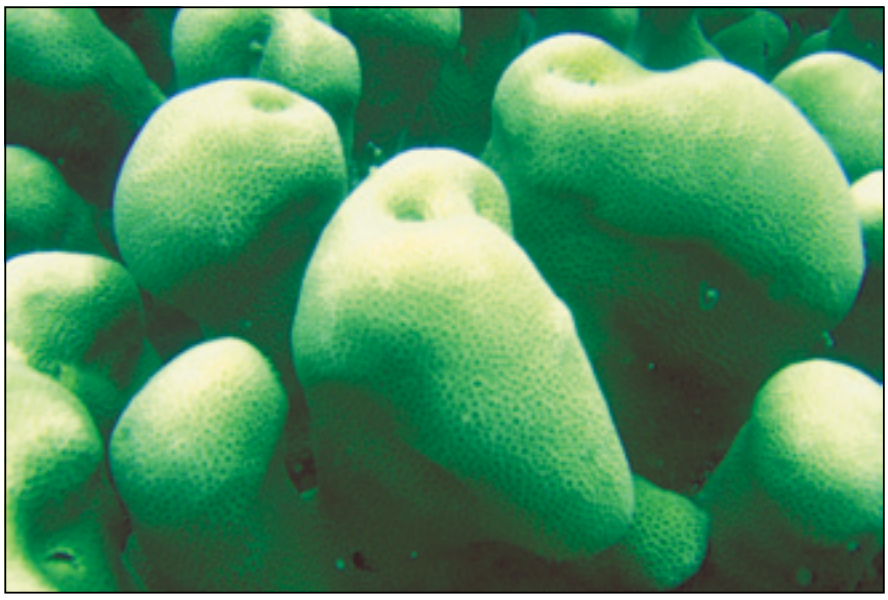


Plate 13.12
Coral structure of *Pavona clavus* bommie

and also by drop camera survey (see sample sites in Figure 13.5 and Appendix 23, Nearshore Marine Impact Assessment). One survey site corresponded with site CF-5, a coral and fish site established on one bommie offshore the proposed jetty location. As was observed on the fringing reef, these offshore coral shoals and bommies were all generally very similar, consisting of large amounts of broken coral heads and coral rubble to depths of approximately 15 m. Live coral occurred in sporadic patches, but the overall cover and abundance was low.

A single bommie of unusual appearance (on sidescan sonar) was first observed during a geotechnical survey and subsequently investigated by divers. This bommie consisted of a single large *Pavona clavus* coral colony (see Figure 13.5) and was in excellent condition despite being located in only 8 m of water in an area of sandy seabed, away from other coral bommies. Its condition is in such contrast to the corals in other areas that it may not be well known to fishermen.

The *P. clavus* bommie (Plates 13.11 and 13.12) is 16.75 m in diameter and approximately 3 m high. *P. clavus* is a common coral with a wide distribution across the Indo-Pacific region. This species is known to grow very large, several metres in diameter, and form large mono-specific stands or reefs. Other examples of very large individuals (larger than 15 m in diameter) of this species have been recorded in the literature, such as a colony from Urvina Bay, Galápagos (Benway, undated); but specimens of this size are not common.

The species has been studied extensively by paleoclimatologists, and linear growth rates of 5 to 20 mm/yr are recorded in the literature (Cronin, 1999). This suggests that the *P. clavus* coral in Caution Bay could be 150 to more than 300 years old, based on its height above the surrounding seabed.

Unlike most other nearshore coral reef areas of Caution Bay, the proportion of live coral cover across the *P. clavus* bommie is very high (up to 100%), and the coral is in a healthy condition (see Plates 13.11 and 13.12). The bommie supports high fish densities, including large numbers of Lutjanidae (snapper), which are not as commonly sighted at other sites in Caution Bay.

As discussed in Section 13.2.1, Physiography, the two main offshore islands located within Caution Bay are Idihi Island and Vari Vari Island (see Figure 13.1). Vari Vari Island is situated to the north and is a remnant of the mainland, supporting an extensive fringing reef. Idihi Island is a coral cay, and is located to the south on the barrier reef. The coral at both Vari Vari Island and Idihi Island appear to be in good condition with high coral cover and diversity observed and no veneer of sediment. The offshore islands have a greater diversity and abundance of hard corals and fewer abiotic features than all other sites sampled in Caution Bay, although the results in terms of percentage cover of coral appeared to underestimate the overall visual impression at these locations (possibly due to the lack of sediment veneer). Both site CF-3 at Vari Vari Island (Plate 13.13) and site CF-4 at Idihi Island (Plate 13.14) show hard coral cover of 37% and 32% respectively. There are no signs of anthropogenic disturbance or disturbance from natural sources at these two sites, which would suggest that dynamite has not been used there for fishing.

Plate 13.13
High coral diversity and cover at Vari Vari Island

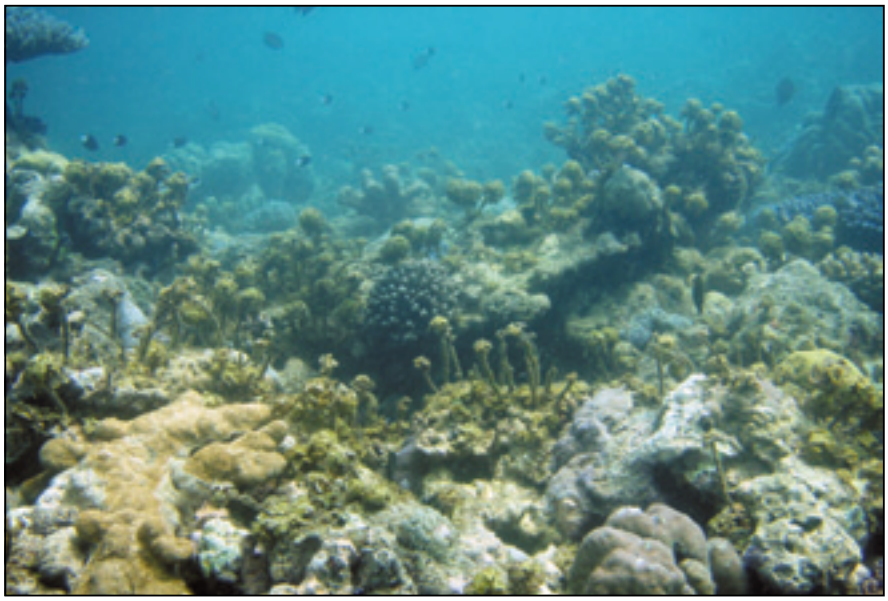


Plate 13.14
Schooling damselfish at Idihi Island

Plate 13.15
Cryptic damselfish on a digitate *Acropora* coral

13.3.3 Fish and Other Marine Fauna

13.3.3.1 Fish

A total of 1,280 and 1,825 fish were recorded across seven sites in Caution Bay during December 2007 and April 2008 respectively. The difference in fish abundance is mainly due the clearer water conditions encountered during April, particularly inshore, enabling divers to observe fish more effectively. Such marked temporal variation is less likely to represent seasonal movements, as most of the species are resident on the reef. Timing of future monitoring should preferably be outside the wet season and before onset of the southeast trade winds to coincide with most favourable conditions of visibility.

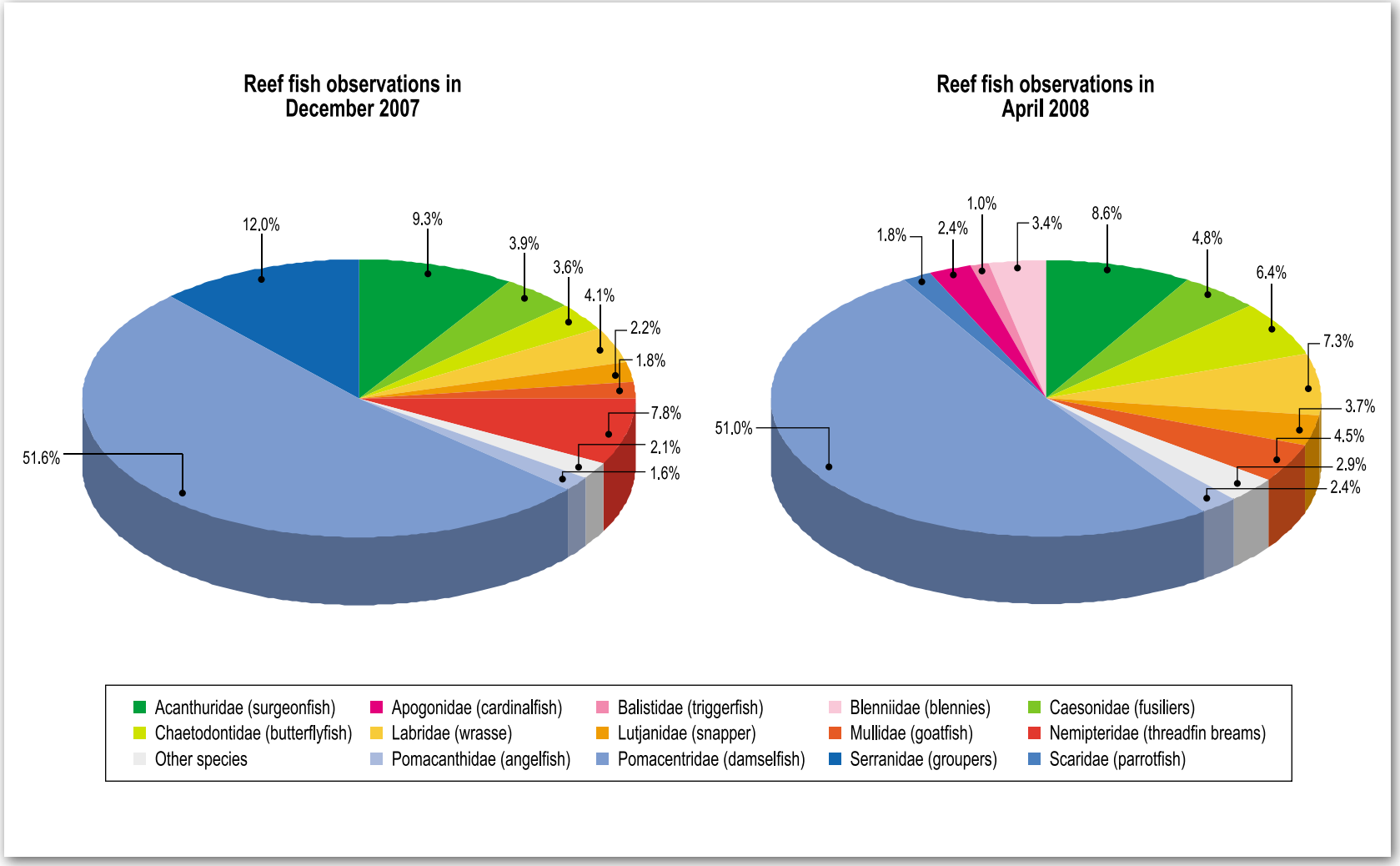
Figure 13.7 presents the percentage composition of reef fish observed across all sites. Although identification of fish was to the family level, most of the species of fish typically inhabiting coral reefs of Papua New Guinea are widely distributed throughout the tropical Indo-Pacific (Allen & Steene, 1998), and not restricted to Caution Bay. Reef fish from the families Chaetodontidae (butterflyfish) and Pomacentridae (damselfish) were the only groups observed at all sampling sites during both field studies. The larger fish, such as snappers, emperors, groupers and sharks, were absent or very rarely seen. This is consistent with the heavy reef usage determined in the survey of resource utilisation within Caution Bay (see Appendix 24, Resource Use Survey of Caution Bay).

Mean density and biomass[2] estimates for families at each site are shown in Figures 13.8 and 13.9 for December 2007 and April 2008 surveys respectively. The lowest density and biomass of reef fish of all the sampling sites was observed at site CF-7 (Table 13.5 and see Figure 13.5). This site also had the lowest abundance of hard coral, suggesting a direct correlation between fish abundance and coral cover. Sites CF-6 and CF-7, situated closest to the proposed marine facilities (see Figure 13.5), had the lowest combined biomass across all sampling sites, although from the limited survey data to date, differences between the inshore reef sites would not be significant. In contrast, Site CF-4 at Idihi Island (see Figure 13.5) had the highest combined biomass (10.7 g/m^2 and 29.9 g/m^2 during December 2007 and April 2008 respectively) across all sampling locations (see Table 13.5). This is not unexpected as the higher structural complexity of coral forms at Idihi Island provides shelter, food and refuge for reef fish. Larger reef fish were also present at Idihi Island.

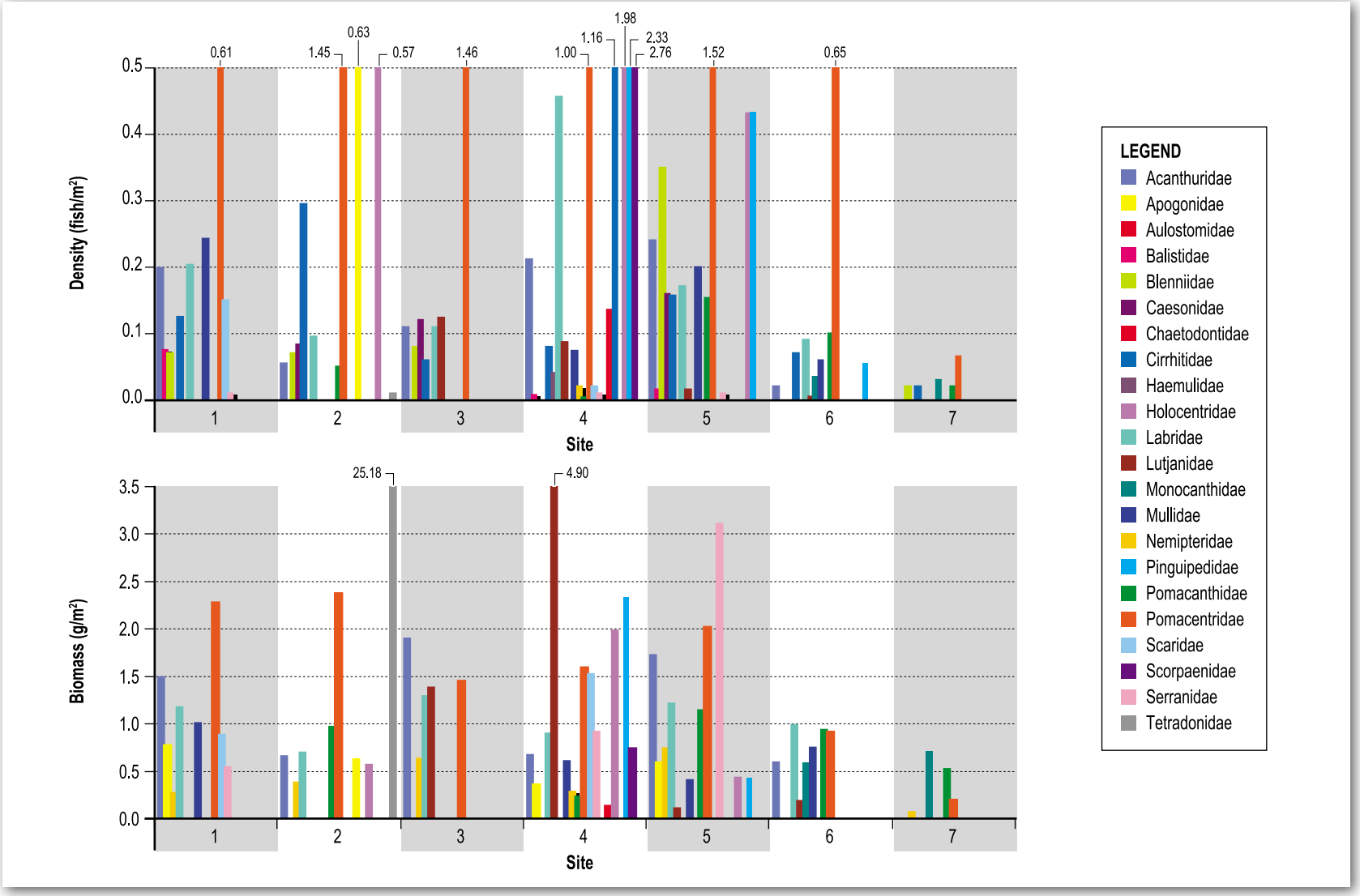
Table 13.5 Fish density and biomass estimates

Parameter	December 2007							April 2008						
	Site CF-							Site CF-						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Density (fish/m^2)	0.1	1.3	1.3	1.3	0.3	1.4	0.03	1.7	3.2	2.1	2.3	3.2	1.1	0.2
Biomass (g/m^2)	3.0	4.8	3.6	10.7	5.4	5.6	1.0	10.0	9.7	7.4	29.9	14.5	5.5	2.0

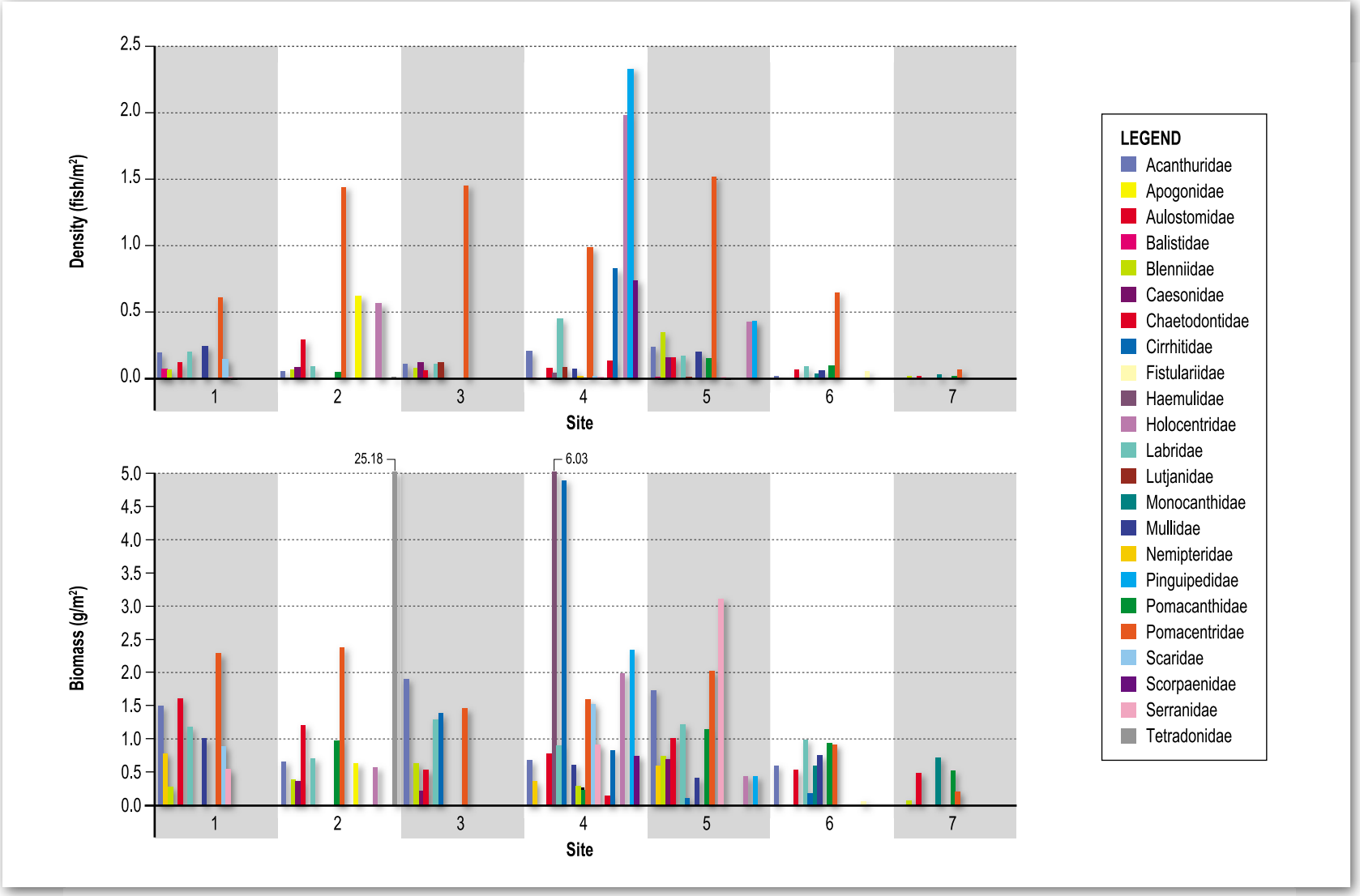
[2] Biomass is the mass of living biological organisms in a given area at a given time and is a relative measure that is used to make comparisons between sites, which precludes the underestimation of the abundance of small fish.



	PNG LNG	Job No: 1284	Esso Highlands Limited	Figure No: 13.7
		File Name: 1284_09_F13.07 _HB	PNG LNG Project	Percentage of coral reef fish observations



PNG LNG	Job No: 1284	Esso Highlands Limited	Density and biomass of coral reef fish families in December 2007	Figure No: 13.8
	File Name: 1284_09_F13.08 _HB	PNG LNG Project		



PNG LNG

Job No: 1284	Esso Highlands Limited	Density and biomass of coral reef fish families in April 2008	Figure No: 13.9
File Name: 1284_09_F13.09 _HB	PNG LNG Project		

Damselfish (family Pomacentridae) were the most abundant group across all sites (52% and 51% of total observations recorded in surveys conducted in December 2007 and April 2008 respectively – see Figure 13.7). Damselfish are one of the most diverse groups of coral reef fish, with approximately 100 species occurring in Papua New Guinea (Allen & Swainston, 1993). The humbug dascyllus (*Dascyllus aruanua*) was frequently observed in groups above hard *Acropora* spp. coral, in which it seeks shelter and protection from predators (Plate 13.15).

Butterflyfish are common and are often observed in pairs, which supports scientific studies that they have permanent lifetime bonds (Allen & Steene, 1998). Plate 13.16 shows a pair of butterfly fish feeding on encrusting algae on an offshore coral bommie within Caution Bay. These fish represented 4% and 6% of the total reef fish observed in the December 2007 and April 2008 field studies respectively (see Figure 13.7).

Surgeonfish (family Acanthuridae) are frequently observed in schools of 3 to 12 individuals. These fish graze on filamentous algae that grow on the surface of the coral colonies, and were observed at all sites. Surgeonfish are quite abundant at coral reef sites, comprising 9% of all fish observed in both the December 2007 and April 2008 field studies (see Figure 13.7). A number of other species from this family occur in Caution Bay, including the Indo-Pacific bluetang (*Paracanthurus hepatus*), white-cheeked surgeonfish (*Acanthurus nigricans*) and pale-lipped surgeonfish (*Acanthurus leucoheilus*).

Wrasse (family Labridae) are conspicuous rainbow-coloured fishes and inhabit all coral reefs surveyed in Caution Bay. Of the estimated 500 species of this family that occur worldwide, the most common observed in Caution Bay were moon wrasse (*Thalassoma lunare*) and cleaner wrasse (*Labroides dimidiatus*). The family Labridae represented 4% of all fish observations in December 2007 and 7% in April 2008 (see Figure 13.7).

Damselfish, butterflyfish, surgeonfish and wrasse are all common families that are resident on fringing reefs, and these would be expected to be present, as observed. Reef predators, such as groupers (Serranidae), snappers (Lutjanidae) and jacks (Carangidae) appeared to be in low abundance across all sampling sites, possibly due to high fishing pressure (see Section 13.4, Resource and Shipping Use).

The majority of observations within Caution Bay were of small-sized reef fish (i.e., less than 10 cm), with smaller numbers of medium (i.e., 10 to 20 cm) and large (i.e., greater than 20 cm) sized reef fish. The reefs within Caution Bay are commonly referred to as the ‘nursery reefs’ by people from local communities inhabiting the coastal regions of Caution Bay. Juvenile red emperor (*Lutjanus sebae*) about 20 cm in length, are often caught along the coastal reefs at depths of 10 to 15 m (Seeto, pers. com., 2008; Yip, pers. com., 2008), although none were observed by the divers. Spawning grounds for coral trout, hammerhead sharks and finger mark bream are thought (by local people) to occur within five coastal reefs between Boera and Papa, as they claim to catch juveniles regularly along this region of the coast (Seeto, pers. com., 2008). However, the divers did not observe any of these species during the two surveys.

Plate 13.16
Butterflyfish feeding on encrusting algae

Plate 13.17
Dolphins in Caution Bay

Plate 13.18
Fresh catch of tuna in Boera village

13.3.3.2 Marine Fauna

No turtles, sharks or large pelagic marine mammals were observed during the nearshore marine surveys. It is known from discussions with people from the coastal villages of Caution Bay that turtles such as green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) occur, and these species are listed on the International Union for the Conservation of Nature (IUCN) Red List of threatened species (IUCN, 2007). It would also be expected that a number of reef sharks (*Carcharhinus* spp.) would have been observed during the study, as they are apex predators of coral reef ecosystems. The lack of observations of sharks in the present surveys is consistent with the high fishing pressure, as shark fins were observed drying in the sun on Idihi Island. Local people noted that whale sharks are observed from time to time beyond the fringing reef (approximately once every two years).

Dolphins (Plate 13.17) were sighted in Caution Bay during the marine pipeline survey in March and April 2008 (see Section 11.3.1, Habitats and Seafloor Characteristics). Although it is unlikely that larger marine mammals occur in Caution Bay frequently enough to be seen during construction activities, their possible presence cannot be discounted.

13.3.3.3 Macrobenthic Infauna

A total of 725 individuals from 68 different taxa (see Annex J of Appendix 23, Nearshore Marine Impact Assessment) were collected in Caution Bay across eight sampling locations (Figure 13.10). Of these, the majority were crustaceans (28 taxa) followed by polychaetes (23 taxa) with lesser numbers of gastropods, bivalves, echinoderms, and 6 other taxa represented by one or two individuals. The identifications indicated a high diversity of macrobenthic infauna, as indicated by the numbers of taxa observed within each sample. The numbers of taxa varied between sampling locations, possibly reflecting the natural sediment characteristics (i.e., different particle size, carbonate content, organic carbon), but the polychaete worms and crustaceans were the dominant macrobenthic infaunal taxa of the sediment samples, which is typical of shallow-water sediments.

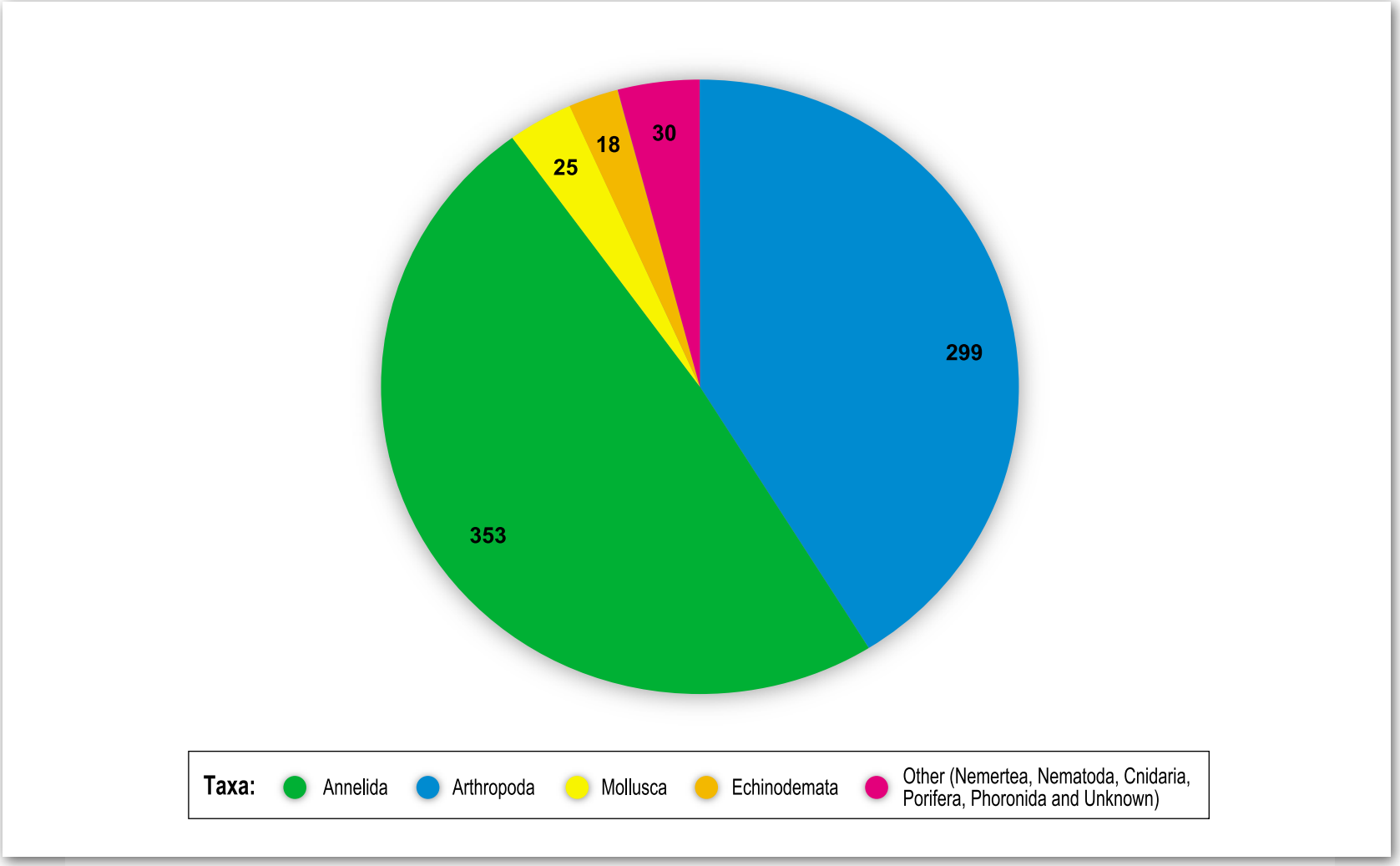
13.4 Resource and Shipping Use

Consultations with the people from villages situated along the coast of Caution Bay were conducted to determine the current status of resource utilisation within the marine environment.

- A survey of the usage of reefs and mangroves between Boera and Papa (Annex A of Appendix 24, Resource Use Survey of Caution Bay).

- A social impact assessment of the project (Appendix 26, Social Impact Assessment).

- Interviews undertaken to expand on the knowledge of the fish species caught and the spawning grounds and to gain an indication of the extent of the areas covered fished by local people (Appendix 24, Resource Use Survey of Caution Bay). The following parties were involved in these interviews:



	PNG LNG	Job No: 1284 File Name: 1284_09_F13.10 _HB	Esso Highlands Limited PNG LNG Project	Marine macrobenthic infauna abundance	Figure No: 13.10

- People from four villages situated along the coast of Caution Bay: Papa, Lea Lea, Boera and Porebada.
- PNG National Fisheries Authority (NFA).
- Expatriate residents (third generation).

Resource use is also described in Section 17.8, Agriculture, Fishing and Subsistence.

13.4.1 Subsistence Fisheries

The people from the villages situated along the coast of Caution Bay, including Papa, Lea Lea, Boera and Porebada, are heavily dependent on the sea and the mangroves for their livelihood. Fishing is a subsistence activity performed by the men of the villages on a daily basis, with only a small percentage of the men not participating. It supplements subsistence gardening, which is carried out by the women, as some areas have poor soils and/or limited freshwater during the dry season, which limits production. Catch rates are reliable, with the people interviewed from all four villages stating that fish are caught on every expedition.

Fishing methods include the use of fishing lines, fishing nets, spears and spear guns. The species caught include shallow-water reef fish (e.g., small coral trout) and large pelagic fish (e.g., tuna and mackerel) (Plate 13.18). Most fishing is during the day; occasionally at night by diving and using spear guns; but not overnight. Depending on method, between 50 and 100 fish per day can be caught, ranging in size from small reef fish to larger groupers, sometimes exceeding 1 m in length. A complete list of the species caught by fishermen, is given in Table 2 of Appendix 24, Resource Use Survey of Caution Bay. Surplus catch sold by women at local markets or in Port Moresby as a source of income. Good fishermen can catch up to K250[3] worth of fish in one day. During the social impact assessment household surveys, over 50% of respondents acknowledged that they derived an income from the sale of fish. Fishing is one of the most important economic activities in the local villages.

A quantitative survey of the local fishing effort along the coat of Caution Bay between Boera and Papa, including the numbers of boats, types of equipment, people and age groups undertaking fishing activities was conducted over a seven-day period in December 2007 and the results are given in Table 13.6 (see also Appendix 24). The numbers of people recorded participating in fishing during the survey included 179 men, 4 women and 14 children: the ages of the adults ranged from 20 to 45; and children from 6 to 14 years old.

[3] US$98.40 based on a currency conversion of 1 K = US$0.39 on 24 October 2008.

Table 13.6 Observed use of reefs and mangroves between Boera and Papa

Date	Type of Boat that Passed	Type of Boat Moored and Used for Fishing*	Males	Females	Age (Years)	Activity	Equipment Used	Mangrove Resource Use	Materials Collected or Hunted	Approximate Time Spent	All Year Round or Seasonal
7/12/07		5 BB	32		20-30	Fishing	Fishing net			4 to 5 hours	All year round
		8 ORC	8		20-30	Fishing	Fishing line			4 to 5 hours	All year round
			17		20-45	Diving	Spear gun			4 to 5 hours	All year round
8/12/07			4		20-30	Fishing	Fishing net			4 to 5 hours	All year round
		1 ORC	4		20-30	Fishing	Spear gun			4 to 5 hours	All year round
		1 D	1, 4 children	1	6-45	Fishing	Fishing net			4 to 5 hours	All year round
			4		20-30	Fishing	Hand spear	Crabs and fish	Looking for crabs and fish	4 to 5 hours	All year round
		1 HB	2	1	25-35	Research	Diving gear				
10/12/07	Cargo ship										
		4 BB	9		20-30	Fishing	Fishing net			4 to 5 hours	All year round
		8 ORC	15		20-30	Fishing	Fishing line			4 to 5 hours	All year round
			2		20-30	Diving	Spear gun			4 to 5 hours	All year round
		1 HB	2	1	25-35	Research	Diving gear				
11/12/07		4 BB, 2 D	7		20-30	Fishing	Fishing net			4 to 5 hours	All year round
		5 ORC	13, 7 children		20-30	Fishing	Fishing line			4 to 5 hours	All year round
		1 D	1, 3 children	1	5-30	Collecting		Firewood	Firewood	4 to 5 hours	All year round
			3		40-50	Cutting	Axe	Mangrove	Mangrove for house post	4 to 5 hours	All year round

Table 13.6 Observed use of reefs and mangroves between Boera and Papa (cont'd)

Date	Type of Boat that Passed	Type of Boat Moored and Used for Fishing*	Males	Females	Age (Years)	Activity	Equipment Used	Mangrove Resource Use	Materials Collected or Hunted	Approximate Time Spent	All Year Round or Seasonal
13/12/07		1 BB	5		20-30	Fishing	Fishing net			4 to 5 hours	All year round
		6 ORC	7		20-30	Fishing	Fishing line			4 to 5 hours	All year round
			4		20-30	Fishing	Spear gun			4 to 5 hours	All year round
			1	1	45 -55	Collecting		Crabs and clams	Crabs and clam shells	4 to 5 hours	All year round
14/12/07		5 BB	14		20-30	Fishing	Fishing net			4 to 5 hours	All year round
		6 ORC	10		20-30	Fishing	Fishing line			4 to 5 hours	All year round
			1		20-30	Diving	Spear gun			4 to 5 hours	All year round
			1		50-56	Collecting		Snails to use as fishing bait		45 minutes	All year round
15/12/07		1 BB	2		20-30	Fishing	Fishing net			4 to 5 hours	All year round
		5 ORC	9		20-30	Fishing	Fishing line			4 to 5 hours	All year round
			3		20-30	Diving	Spear gun			4 to 5 hours	All year round

*Key: BB – banana boat, D – dinghy, ORC – outrigger canoe, HB – hired boat.

Source: Annex A of Appendix 24, Resource Use Survey of Caution Bay.

The outer limits of the fishing areas are marked by reefs surrounding the outer islands of Daugo and Idihi are shown on Figure 13.11. Popular fishing grounds include the fringing reef, isolated coral bommies in Caution Bay and reefs that surround Vari Vari, Bavo, Daugo and Idihi islands. People from nearby villages travel to these fishing grounds by banana boats, dinghies and outrigger canoes.

People from Lea Lea reported that the region has become subject to local overfishing and that stocks have depleted (Appendix 24, Resource Use Survey of Caution Bay) since the introduction of widely available nylon mesh fishing nets and increased use of motorised boats. During the social impact assessment household surveys, 47% of respondents reported that they had to travel further to collect fish (see Section 3.5.4, Fishing, in Appendix 26, Social Impact Assessment), but still fished within the areas indicated in Figure 13.11.

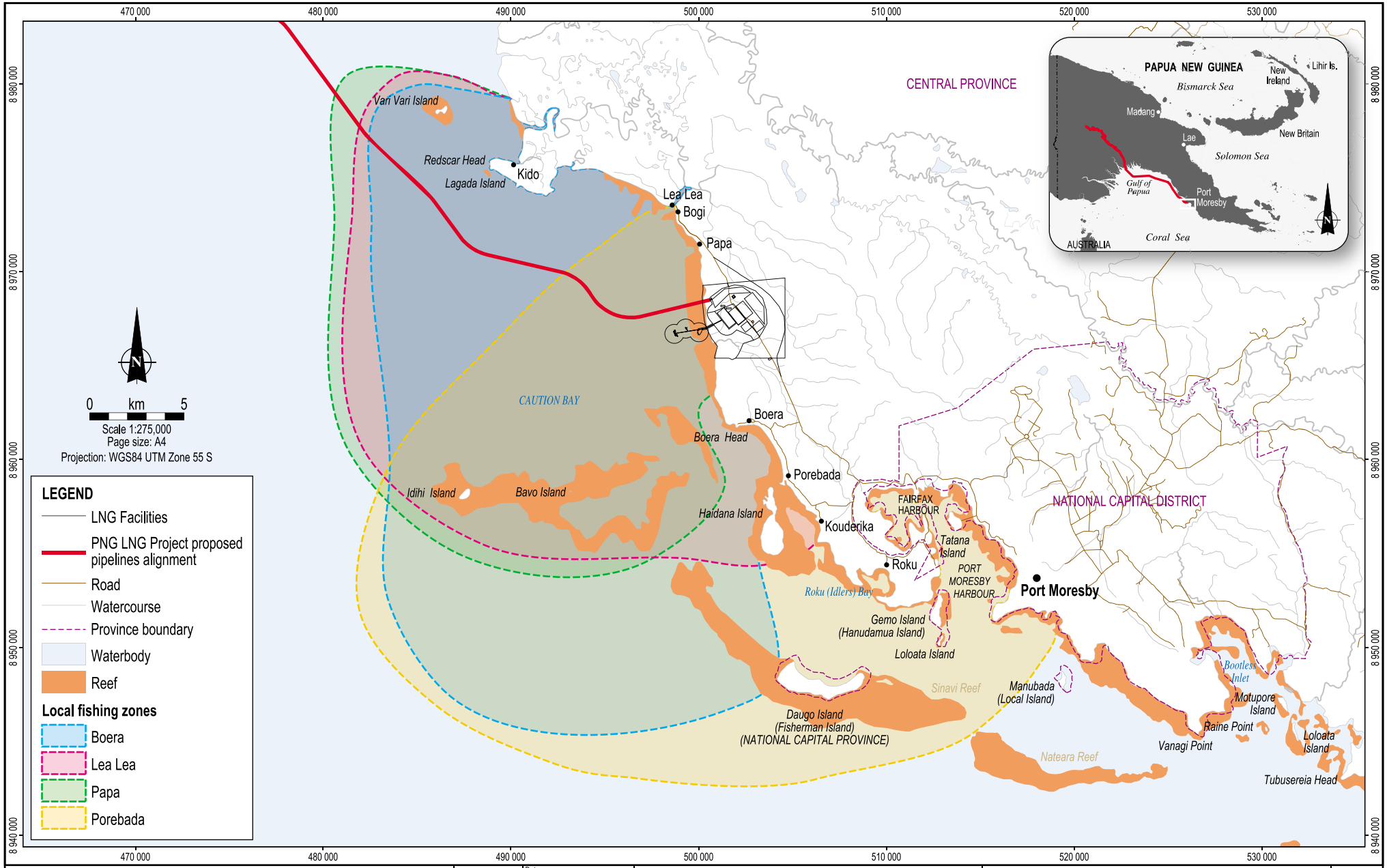
The condition of the nearshore reefs indicates that dynamite fishing is used as a method of fishing within Caution Bay. This practice is illegal under the *Fisheries Act 1994*; however, it is still undertaken, often by sourcing World War II unexploded ordnance and extracting the gunpowder to make the bombs. This technique has been known to cause injury or death.

13.4.2 Boat Traffic

A total of 63 small boats was recorded in Caution Bay during the quantitative survey (see Table 13.6 in Section 13.4.1, Subsistence Fisheries), which included 20 banana boats, 4 dinghies and 39 outrigger canoes. Commercial shipping traffic, including commercial prawn fishing vessels, cargo ships, oil and gas tankers and lumber barges, occur beyond the outer reef and generally do not transit Caution Bay. These larger vessels are generally on route to or departing from Port Moresby and servicing ports in the south and west of Papua New Guinea. Further information on shipping traffic is provided in Section 11.4.3.1, Port of Port Moresby.

13.4.3 Mangrove Resource Use

The mangrove areas of Caution Bay are an important resource for local people, as they provide sources of food and materials for shelter throughout the year. Women collect crabs (specifically coconut and mud crabs), clamshells and firewood on a daily basis from the mangroves. Most crabs and clams are consumed, with shells used for decoration, and any surplus catch is sold at markets. Snails are also collected for use as fishing bait. Fishing and collecting shellfish, firewood and building materials consume between four to five hours daily per person (Appendix 24, Resource Use Survey of Caution Bay). Men also utilise the mangrove forests as a source of building materials, in particular for the main supporting posts for houses. Evidence of wood collection at accessible areas of estuary banks is shown in Plate 3-1 of Appendix 13, Aquatic Fauna Impact Assessment. However, no extensive areas of clearing were observed in the mangroves of Caution Bay, which are predominantly intact with abundant saplings colonising available spaces.



Note:
Pipelines approximate the proposed alignment based on engineering data provided up to 1 October 2008.

PNG LNG

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Fishing zones in Caution Bay

Figure No: **13.11**

13.5 Implications for Upstream Facilities Planning, Design and Management

Caution Bay is a coastal tropical lagoon, with characteristic fringing coral reef and bommies within the lagoon. These features are the important structural elements of the lagoon ecosystem and it will be a planning priority for the incoming pipeline and the marine facilities supporting the LNG Plant to avoid them and to minimise sedimentation impacts associated with marine works and dredging. The sediments themselves are uncontaminated and the drop-off beyond the outer reef provides deep water for spoil disposal away from nearshore coral, mangrove and seagrass habitat.

Discharges to the marine environment of Caution Bay, such as pipeline integrity hydrotest water (once-off) and ongoing treated sewage effluent, wastewater and reject brine from desalination water will need to be treated so as to achieve ambient water quality objectives.