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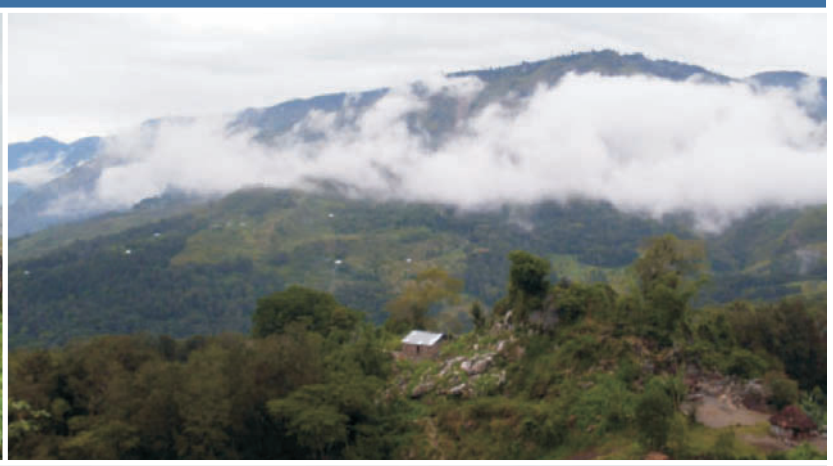
Tasi Mane Project - Betano Petroleum Refinery and Beaco LNG Plant

Strategic Environmental Impact Statement

Final Report

June 2012

Volume 4 - Attachments



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The Tasi Mane Project – Betano Petroleum Refinery and Beaco LNG Plant Strategic Environmental Impact Assessment (Final Report) is made up of four separate volumes:

VOLUME 1 of 4: Betano Petroleum Refinery and Beaco LNG Plant Strategic Environmental Impact Assessment Main Report Part A (Chapters 1 to 6)

VOLUME 2 of 4: Betano Petroleum Refinery and Beaco LNG Plant Strategic Environmental Impact Assessment Main Report Part B (Chapters 7 to 10)

VOLUME 3 of 4: Betano Petroleum Refinery and Beaco LNG Plant Strategic Environmental Impact Assessment Main Report Part C (Appendices)

VOLUME 4 of 4: Betano Petroleum Refinery and Beaco LNG Plant Strategic Environmental Impact Assessment (Attachments)

Terrestrial Flora and Fauna Final Technical Report
Marine Environment Final Technical Report

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STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Tasi Mane Project – Betano Petroleum Refinery and Beaco LNG Plant

VOLUME 1 of 4 Main Report Part A

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STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT
Tasi Mane Project – Betano Petroleum Refinery and Beaco LNG Plant
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STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Tasi Mane Project – Betano Petroleum Refinery and Beaco LNG Plant

VOLUME 3 of 4: Main Report Part C (Appendices)

DESCRIPTION

APPENDICES

STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Tasi Mane Project – Betano Petroleum Refinery and Beaco LNG Plant

VOLUME 4 of 4: Attachments

Attachment 1:
Terrestrial Flora and Fauna Technical Report

STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Tasi Mane Project – Betano Petroleum Refinery and Beaco LNG Plant

VOLUME 4 of 4: Attachments

Attachment 2:
Marine Environment Technical Report

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Tasi Mane Project – Betano Petroleum Refinery and Beaço LNG Plant

Terrestrial Flora and Fauna Technical Report

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ATTACHMENT 1

Tasi Mane – Betano and Beaço Development Areas SEIA

Terrestrial Flora and Fauna Technical Report

FINAL

June 2012

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PROJECT 301012-01504 - TASI MANE PROJECT –BETANO AND BEAÇO DEVELOPMENT AREAS SEIA

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for internal review	M Love	S Hudson	A Faulkner	19 Apr 12	N/A	
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REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

EXECUTIVE SUMMARY

301012-01504-EN-REP-0006
June 2012

EXECUTIVE SUMMARY

WorleyParsons was commissioned by the Secretaria De Estado Dos Recursos Naturais, on behalf of the Government of Timor-Leste, in December 2011 to undertake a flora and vertebrate fauna assessment for the Tasi Mane Project, specifically the Betano Refinery and Petrochemical Industries and the Beaço LNG Plant. WorleyParsons has been engaged to prepare a Strategic Environmental Impact Assessment to describe the likely environmental and social impacts associated with the proposed development including an understanding on the study areas' terrestrial flora and fauna species.

The two sites within the project area are located on the south coast on the island nation of Timor-Leste. Timor-Leste is part of the Lesser Sunda Archipelago, an assemblage of islands composed of a northern, volcanogenic arc (the Inner Banda Arc, with main islands Bali, Lombok, Sumbawa, Flores, and Wetar) and a southern, orogenic arc (the Outer Banda Arc, with main islands Sumba, Roti, and Timor). The Betano site is 70 km south of the capital city of Dili and the Beaço site is 100 km south east of Dili.

The flora assessment and the vertebrate fauna assessment for the project occurred from the 14 to 22 December 2011 and from the 9 to 15 February 2012.

The objectives of the flora assessment were to:

- Validate the accuracy of the desktop reviews;
- Describe broad vegetation units and agricultural areas;
- Identify remnant areas of primary and secondary forest, coastal forest and mangroves;
- Identify species of potential conservation significance (IUCN Red List);
- Identify species of economic importance (Teak, Rosewood, Sandalwood, food crops); and
- Determine any significant impacts to species or vegetation communities of conservation significance.

The objectives of the vertebrate fauna assessment were to:

- Validate the accuracy of the desktop reviews;
- Ground-truth the extent and condition of fauna habitat types present;
- Identify species of potential conservation significance (IUCN Red List);
- Further delineate and characterise the species and fauna habitat types present and potentially present at each site;
- Provide additional information for any subsequent clearing requirements; and
- Determine any significant impacts to species of conservation significance.

The two geographical areas covered by the Tasi Mane – Beaço LNG Plant and Betano Refinery project are termed (i) the Beaço development area, and its four components: the Beaço LNG plant and jetty, Nova Beaço, Nova Viqueque and the Viqueque airport, and (ii) the Betano development area and its two components: the Betano Refinery and Petrochemical Industries and Nova Betano.

Dominant and common species were the main focus of the flora and vegetation survey due to time constraints. In the desktop survey, 36 flora species were listed as being of 'Least Concern' by the IUCN Red List for Timor-Leste, and one of these was recorded during the field survey, *Acanthus ilicifolius* (Holly Leaf Mangrove). No further flora species were listed by the IUCN Red List specifically for Timor-Leste, however, Sandalwood (*Santalum album*) and Rosewood (*Pterocarpus indicus*), both of which are 'Vulnerable' species listed for Indonesia, were recorded in the Beaço and Betano development areas.

Mangroves, which are considered to be of conservation significance, were recorded in the Beaço development area, specifically the Beaço LNG Plant area. Mangroves stabilise the soils, reducing the amount of soil erosion that would otherwise occur.

Vegetation communities recorded in the Beaço and Betano development areas include: Coastal Forest (Pes-caprae Formation, Riparian and Mangroves), and Lowland Moist Deciduous Forest.

Four fauna habitats were recorded across both development areas, including Moist Deciduous Woodland/Forest, Coastal, Riparian and Swidden Agriculture. Generally the intact vegetation was found in the Deciduous Woodland/Forest and Coastal habitat types whereas the Riparian and Swidden Agriculture had largely been degraded and impacted by man. Often, the greater impact from agricultural practises the reduced availability of micro-niches occurs, for example, sheltering, foraging and nesting potential for fauna species.

A total of 98 species of vertebrate fauna were recorded in the project study areas, consisting of 2 species of amphibians, 11 species of reptiles, 70 species of birds and 15 species of mammals. Sixty species of vertebrate fauna were recorded from the Betano development area, consisting of 7 species of reptiles, 40 species of birds and 13 species of mammals. Eighty species of vertebrate fauna were recorded from the Beaço development area, consisting of 2 species of amphibians, 9 species of reptiles, 59 species of birds and 10 species of mammals. Due to a lack of baseline knowledge and regional context, it is difficult to gauge the adequacy of survey effort and therefore the extent of expected faunal assemblages for the area.

Species listed as Critically Endangered, Endangered, Vulnerable and Near Threatened under the IUCN Red List constitutes species having conservation significance. Seven species of conservation significance were recorded in the study area: the Canut's Horseshoe Bat (*Rhinolophus canuti timoriensis*), Great Knot (*Calidris tenuirostris*), Slaty Cuckoo Dove (*Turacoena modesta*), Pink-headed Imperial Pigeon (*Ducula rosacea*), Olive-shouldered Parrot (*Aprosmictus jonquillaceus*) Cinnamon-Banded Kingfisher (*Todiramphus australasia*), and Timor Bush-chat (*Saxicola gutturalis*). Lack of baseline data of Timor-Leste's fauna means that conservation significant species which were not recorded may still be present.

Canut's Horseshoe Bat and Great Knot are listed as Vulnerable on the IUCN Red List. Canut's Horseshoe Bat was recorded at both Betano and Beaço development areas. This species was commonly encountered in the acoustic and trapping surveys of Pavey and Milne (2004) and Armstrong (2007), but there is no information on how widespread this species is outside of the most forested areas in the east of Timor-Leste. Ten individuals of the Great Knot were recorded foraging on a reef platform within the Beaço development area. This species' migratory pattern allows it to avoid impact from the proposed development and migrate to forage and roost in similar locations within the region and local vicinity.

Environmental impacts associated with flora and vegetation include (but are not limited to); the loss of valuable timber species and mangroves, the spread of weeds and the destabilisation of soils. Fauna environmental impacts include; the potential depletion/degradation of the habitat associated with supporting seven conservation significant species found in both Betano and Beaço development areas, two of which are listed as Vulnerable on the IUCN Red List.

Limitations existed for both the flora and vegetation and fauna surveys, notably the length of study and seasonality. Further survey effort to achieve optimum results should be undertaken throughout the year and for longer periods of time, enabling the identification of a broader range of species.

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CHAPTER 1

INTRODUCTION

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June 2012

1 INTRODUCTION

WorleyParsons was commissioned by the Secretaria de Estado dos Recursos Naturais (SERN), on behalf of the Government of Timor-Leste (GoTL), in November 2011 to undertake a flora and vegetation and vertebrate fauna assessment of the Tasi Mane Project (herein referred to as the project). The project involves the development of two sites on the south coast of Timor-Leste specifically the Betano Refinery and Petrochemical Industries and the Beaço LNG Plant. WorleyParsons has been engaged to prepare a Strategic Environmental Impact Assessment (SEIA) to describe the likely environmental and social impacts associated with the proposed development including an understanding of the project's terrestrial flora and fauna species.

The project comprises the following components:

- Betano Refinery and Petrochemical Industries.
  - Refinery and Petrochemical complex.
  - Petroleum City (Nova Betano).
- Beaço LNG Plant
  - LNG Plant.
  - Nova Beaço.
  - Nova Viqueque.
  - Viqueque airstrip.

1.1 Location

The two sites within the project area are located on the south coast on the island nation of Timor-Leste. Timor-Leste is part of the Lesser Sunda Archipelago, an assemblage of islands composed of a northern, volcanogenic arc (the Inner Banda Arc, with main islands Bali, Lombok, Sumbawa, Flores, and Wetar) and a southern, orogenic arc (the Outer Banda Arc, with main islands Sumba, Roti, and Timor). The Betano site is 70 km south of the capital city of Dili and the Beaço site is 100 km south east of Dili.

1.2 Project Brief/Scope

The proposed project developments are likely to have adverse impacts on the terrestrial flora and vegetation and vertebrate fauna species that currently exist at each site largely due to the clearance of native vegetation. WorleyParsons' ecological team surveyed and described terrestrial flora and vertebrate fauna species at each site in accordance with the terms of reference in order to provide sufficient information to address both biodiversity conservation and ecological function values, and meet the GoTL objectives for the protection of the environment.

The two geographical areas covered by the Tasi Mane – Beaço LNG Plant and Betano Refinery project are termed (i) the Beaço development area, and its four components: the Beaço LNG plant and jetty, Nova Beaço, Nova Viqueque and the Viqueque airport, and (ii) the Betano development area and its two components: the Betano Refinery and Petrochemical Industries and Nova Betano.

A broad focus approach was taken to flora and vegetation surveys in order to obtain information on species and areas of conservation and economic importance.

Given time constraints and limited knowledge of the flora and vegetation in the Beaço and Betano development areas, the survey focused on potential matters of environmental and economic importance to the people of Timor-Leste and GoTL.

A stronger emphasis was given to the flora survey rather than the vegetation survey due to time constraints. This allowed for the collection of preliminary baseline information in the absence of a baseline survey. Adequate baseline flora data is a prerequisite to completing meaningful vegetation survey work. This also provided more time to focus on the assessment of threatened species and economically important species.

Broad objectives for the assessment included:

- Review existing knowledge on the flora, vegetation and fauna of Timor-Leste through a desktop study.
- Conduct a database search to identify species of potential conservation significance on the IUCN Red List.
- Describe, analyse and report on the project's terrestrial flora and vertebrate fauna species present.
- Describe the conservation significant species present in and within the vicinity of the project.
- Provide baseline ecological knowledge for the project.

1.3 Regulatory Context

The Democratic Republic of Timor Leste (RDTL) became party 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 (UNTAET and Indonesian) that address 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.
- United Nations Transitional Administration in East Timor (UNTAET) Regulation No. 2000/17.
- United Nations Transitional Administration in East Timor (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 East Timor. 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.

Of particular relevance to this survey is:

- Section 5 – Wetlands and Mangroves, which states that wetlands and mangrove areas shall be protected. Cutting, damaging or removing of a mangrove shall be prohibited.
- Section 3 – Endangered Species – which states that endangered species and their habitats shall be protected throughout the terrestrial territory of East Timor.

The State Secretariat for the Environment (SEMA), under the Ministry of Economy and Development, and the Ministry of Agriculture and Fisheries (MAF) 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. The laws and regulations from previous administrations listed above are not necessarily recognised.

The Convention on International Trade in Endangered Species (CITES) is an international agreement that aims to ensure that international trade in fauna and flora does not threaten their survival. The Convention controls international trade in fauna but does not necessarily reflect conservation status in a particular country. Appendix I lists species that are considered the most endangered among CITES-listed animals and plants, while Appendix II lists species that are not necessarily currently threatened with extinction but that may become so unless trade is closely controlled. Consequently, CITES can be used to provide some indication of the relative global conservation status of species listed under CITES but not on the IUCN Red List (e.g., pythons, monitor lizards, birds of prey).

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CHAPTER 2

EXISTING ENVIRONMENT

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2 EXISTING ENVIRONMENT

2.1 Climate

Little climate information is available for the south-coast of Timor-Leste. Trainor *et al*. (2008) identified Timor-Leste as having a highly seasonal, dry tropical climate which is geographically variable depending on the elevation and aspect of the location. The south coast is known to receive the highest rainfall, falling in the wet season which occurs mainly between November and April and extending sometimes to June (Trainor 2010)**.** The annual precipitation for Timor-Leste is approximately 1,500 to 4,000 mm of rain per year (Trainor et al. 2008). Coastal towns are typically hot during the day (31°C to 33°C) and warm at night (20°C to 25°C); however, the dry season is cooler (18°C to 20°C at night compared to 25°C to 28°C by day) and less humid (Trainor 2010).

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.

Timor-Leste is located in the Central Melesia (Wallacea) region and its flora is considered to be transitional between the main rainforest blocks of the Sunda (Peninsula Malaysia, Sumatra, Borneo, West Java) and Sahul (New Guinea) shelves (van Welszen et al. 2005).

Few publications document the flora and vegetation of Timor-Leste; however, some information can be gained from studies undertaken in the bordering Indonesian province of East Nusa Tenggara (West Timor) and surrounding islands. A review of literature by Monk *et al.* (1997) concludes that Nusa Tenggara has a mixture of Indo-Malay and Australian elements.

A total of 407 endemic species and five genera of plants are known from Nusa Tengarra and Maluku, of which only eight species are shared between each location (Rhee *et al.* 2004). Nusa Tengarra and the Maluku groups of islands have differing geological origins, ranging from young, active volcanic islands, to limestone with karst formations. The plant genera endemic to Timor are *Sautiera* and *Sinthraoblastes*. Timor was identified as having the highest number of endemic species recorded in Indonesia, at approximately 10.3% (Rhee et al. 2004).

Both Indo-west Malaysian (rainforest plants) and eastern genera species (mix of rainforest and seasonal) are moderately represented in Nusa Tenggara. Wallace's line has no significance for plants between Bali and Lombok Islands and both western and eastern floral elements are present. Wallace's Line was not the most significant biogeographic boundary for plant species in the study (Rhee *et al.* 2004).

The following broad vegetation types have been described within Nusa Tenggara:

- Lowland Evergreen Rainforests are common, generally on the drier slopes.
- Semi-Evergreen Rainforest is structurally complex vegetation which is transitional between Lowland Evergreen Rainforest and Monsoon Forest.
- Montane Forest – little seasonal Montane Forest survives in Nusa Tenggara.
- Seasonal Montane Forest occurs above Monsoon Forest, and would have originally covered mountainous areas in Nusa Tenggara.
- Heath Forests are rare with small patches in Timor-Leste.
- Forests on ultra-basic rocks occur on Timor island.
- Forests on limestone rocks in Nusa Tenggara occur in both ever wet and aseasonal areas.
- Mangroves – small areas.

Existing forest cover in Timor-Leste occurs in scattered areas along the south coast with smaller remnants elsewhere. The former closed forest areas of Timor-Leste currently consist of a mosaic of secondary forest and grassland possibly with primary forest fragments. In 1991, approximately one quarter of forested area was primary forest and three quarters was secondary forest (Oxfam 2003).

The rate of deforestation in Timor-Leste from 1972 to 1999 has been estimated at 1.1% per year, which is four times higher than the global average of 0.3%. The direct results have been severe soil erosion, reduced forest productivity and loss of biodiversity (Alves 2007).

Alves (2007) identified that there are six major ecosystem types recognised within Timor-Leste and the status of biological diversity was assessed for each:

- Marine and Coastal Zone,
- Arid Lowland Areas,
- Moist Lowland Areas,
- Mountainous Areas,
- Highland Plains, and
- Wetlands.

Two of the ecosystem types were relevant to the project and are described in Table 2-1.

Table 2-1 Ecosystem Types

Ecosystem Type	Description	Efforts to Manage Biological Diversity
Marine and Coastal Zone	Includes specialised coastal vegetation like mangroves, shallow seas adjacent to land, coral reefs and sea grass beds.	Mangroves and coral reefs are protected by (UNTAET) Regulation No. 2000/19.
Moist Lowland Areas	Include those roughly between the altitudes of 0 and 600 m, where the temperatures are above 24°C, there is a heavier rainfall and the dry season lasts three months. The original vegetation was mainly moist deciduous forest, semi-evergreen forests or rain forests. Present vegetation includes cultivated lands, plantations, secondary vegetation and some badlands. Includes the coastal plain and steep hillsides.	BirdLife International has identified nine Important Bird Areas in closed forest canopy vegetation. Identification of two endangered tree species, conservation and restoration activities including provision of seedlings (government initiated reforestation).

2.3 Flora and Vegetation

2.3.1 Previous Surveys

Recent documented flora and vegetation knowledge has been confined to the far east of Timor-Leste. Since Timor-Leste independence, several flora and vegetation surveys have been undertaken in the proposed Jaco-Tutuala-Lore National Park (Cowie 2006, 2007). The proposed park contains the largest remaining area of natural closed forest vegetation on the island of Timor-Leste. Several flora and vegetation surveys have also been completed for proposed infrastructure projects such as the Iralalaro Hydropower Project (Cowie 2007). The flora of Timor-Leste is estimated at 2,500 species and 22 new plant species were recorded during preliminary findings by Cowie (2006).

Cowie (2006) provides an account of the previous botanical exploration of Timor-Leste and states that there are limited recent flora checklists for Timor-Leste. Flora collections have been intermittent and were often conducted for specific purposes such as ethnobotanical study or taxonomic studies relating to specific groups. A recent checklist of Timor-Leste orchids comprised 66 species, including 32 new species records for the island, and four newly described species (Silveira et al. 2008). At least

10 orchid species are considered endemic to Timor-Leste. This list is likely to increase as further plant material is identified and further botanical research is undertaken.

Primary forests are closed communities including ever-wet, semi evergreen and moist deciduous. These feature an abundance and dominance of tree species with relatively large fleshy fruits (bird attractive fruits). These trees may be dependent on larger fruit pigeons and flying foxes for dispersal of seed.

The large fruited trees are absent from the secondary dry deciduous forest and thorn forest typical in most parts of Timor-Leste.

2.4 Fauna

2.4.1 Previous Surveys

Current vertebrate fauna knowledge of Timor-Leste is limited, especially for the south coast. The few biological surveys that have been undertaken within the past ten years include Rapid Biodiversity Surveys in Jaco Island and Lake Iralalaru areas, which were conducted by conservation organisations such as BirdLife International in conjunction with NDCF.

Historically, the vertebrate fauna of Timor-Leste has been poorly documented; however, some studies have been conducted on herpetofauna, birds and mammals. Kaiser et al. (2011) conducted fieldwork throughout Timor-Leste resulting in the identification of seven species of amphibians and 30 species of reptiles. Among the amphibians the most frequently encountered were toads, rice paddy frogs and rhacophorid treefrogs (Kaiser et al. 2011). Common skinks included the four fingered skinks (Carlia spp.), wedge skinks (Sphenomorphus spp.) and night skinks (Eremiascincus spp.). Of the snakes recorded, pit vipers such as Cryptelytrops insularis amounted to 25% of all the snakes found.

Trainor et al. (2008) noted that 262 bird species are known for Timor-Leste, and of these, 169 are considered resident, 76 regular migrants and 17 vagrants. Up to 1980, 24 ornithological surveys or reports are listed for Timor Island (White and Bruce 1986). Recent studies by Richard Noske (Noske 1994, 1996, 1997, Noske and Saleh 1996) have added many new birds to the expected species list. Extensive tropical forests in Lautem district have been the prime target of recent fieldwork Trainor et al. (2008).

The mammal fauna of Timor-Leste is dominated by Asian families with at least 52 mammalian species potentially occurring, of which about one-third are introduced (Trainor et al. 2008). Remarkably, only four native terrestrial mammals have been recorded including the Timor Shrew (Crocidura tenuis) Sunda Shrew (Crocidura maxi), Timor Rat (Rattus timoriensis) and Ricefield Rat (Rattus argentiventer) Trainor et al. (2008). Timor once had a native rat fauna including giant rats, but these may have become extinct after the introduction of mammals associated with human settlement during the last 1,000 to 7,000 years (Glover 1986).

There have been relatively few bat surveys on the island of Timor, and the fauna is not yet completely described. The earliest and still the most comprehensive summary of the bats of Timor is that of Goodwin (1979), who conducted field surveys, an extensive examination of museum collections and a review of the literature to derive a list of taxa with their current taxonomy. Based on Goodwin's field surveys and taxonomic examinations, there are 22 species known from Timor, 11 of which he added (Goodwin 1979).

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CHAPTER 3

METHOD

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3 METHOD

3.1 Survey Areas

An investigation of flora, vegetation and fauna was completed at the following sites for the project on the south coast of Timor Leste:

- Betano development area: Refinery and Petrochemical Industries, Nova Betano; and
- Beaço development area: LNG plant complex and jetty, Nova Beaço, Nova Viqueque and Viqueque Airstrip.

3.2 Timing of Surveys

A nine day field survey was conducted from 14 to 22 December, 2011, and a second seven day field survey from 9 to 15 February, 2012.

3.3 Flora and Vegetation

3.3.1 Desktop Review – IUCN

Before fieldwork was undertaken, data from a detailed desktop review of historical information and past surveys undertaken near the study area was compiled into a list of flora, vegetation and fauna species present.

The International Union for Conservation of Nature (IUCN) Red List of Threatened Species was used for this desktop review, identifying the conservation status of known species in Timor Leste.

The IUCN Red List is recognised globally as being the most comprehensive tool for evaluating the conservation status of plant and animal species, not only allocating a category (out of nine) for relative risk of extinction but also their distribution. Conservation can then be targeted towards those species at higher risk of extinction. A full description and list of IUCN categories is available in Appendix 1.

The flora and vegetation assessment comprised a desktop review to collate historical data and/or knowledge, previous opportunistic flora collections and delineation and characterisation of the known range of vegetation communities present in the study area. The flora and vegetation desktop assessment included:

- Review of all available and current information; and
- IUCN Red List search.

3.3.2 Vegetation Survey

A broad assessment of plant communities and their distribution, floristic composition and structure was undertaken. Vegetation communities were sampled opportunistically within each study area at observation points. Information regarding dominant species present and the physical characteristics at each site was recorded. It was not possible to complete a quadrat sampling design in the time available for surveys.

Vegetation descriptions used for the Beaço and Betano development areas were adapted from those developed by Cowie (2006, 2007) in the Lautem district on the east coast of Timor-Leste, approximately 100 to 200 km from the study area. Descriptions were based on vegetation structure and dominant species composition.

3.3.3 Flora Survey

The objectives of the flora and vegetation assessment within the Beaço and Betano development areas include:

- Identify species of potential conservation significance (IUCN Red List);
- Identify commercial timber and food crops (Teak, coconuts, bananas, Sandalwood);
- Collect and photograph dominant species;
- Describe broad vegetation units – remnant areas of primary and secondary forest, coastal, mangroves, agricultural, riparian; and
- Determine any significant impacts to species or vegetation communities of conservation significance.

Within the Beaço and Betano development areas more emphasis was given to the flora survey than the vegetation survey. This approach was adopted by Cowie (2006, 2007) for the east coast of Timor-Leste and allowed for the collection of preliminary baseline information for the project in the absence of a baseline survey. Adequate baseline flora data is a prerequisite to completing meaningful vegetation survey work. This also provided more time to focus on the assessment of threatened species and economically important species.

The flora survey aimed to record the diversity in flora species in the Beaço and Betano development areas with a focus on the common and dominant species and on species of conservation and economic importance. There was no emphasis placed on quantitative sampling or recording structural attributes. Where known, the threatened status or weed status was recorded, as well as local names in Tetum.

Specimens were collected from various plant life forms, including trees, shrubs, herbaceous species, vines, grasses and sedges, ferns, and epiphytes (non-ferns). Photographs were taken where possible of live specimens in the field or of fresh, pressed specimens.

All collected plant specimens were pressed for several days in field presses and then preserved for the short term using a technique described by Forman and Bridson (1989) to suit the wet tropical conditions experienced at the time of survey. This technique involved pressing specimens between folds of newspaper which were then tied in bundles with string and placed in heavy duty plastic bags to which sufficient 70% ethanol was added to wet newspaper. The top of the bag was folded over and sealed with adhesive tape, and then placed in a second bag to reduce drying. On return to Australia the plant specimens were submitted for Gamma irradiation to meet Australian Quarantine Inspection Services (AQIS) regulations. This process took approximately four weeks for the first collection of plants (December 23, 2011 to January 23, 2012) and three weeks for the second collection (February 16, 2012 to March 8, 2012). On completion of treatment plant specimens were submitted to the Northern Territory herbarium where they were returned to normal plant presses and dried at 50^{o}C.

Flora identifications were completed by Ian Cowie of the Northern Territory (NT) Herbarium who has considerable expertise with the flora of east Timor-Leste and Northern Australia. The NT Herbarium houses a reference collection of Timor-Leste flora collected by Cowie (2006, 2007)[1].

3.4 Fauna

3.4.1 Desktop Review

The terrestrial vertebrate fauna assessment also comprised a desktop review to collate historical knowledge on fauna species and fauna habitat present. A comprehensive inventory of relevant fauna was compiled, using as many sources as possible. The fauna desktop assessment included the following:

- Review of all available and current information; and
- IUCN Red List search.

Additional locally relevant information was sourced from relevant reference texts and important key stakeholders.

The purpose of the desktop review was to gather background information on the study area and the fauna that it may support. This involved a search of the following sources:

- Birdlife International database search;
- IUCN Red List expected species search tool; and
- Previous vertebrate fauna surveys (e.g., previous biological surveys/research).

Collectively, these sources were used to compile a list of species that have been previously recorded in the region and specifically within the vicinity of the study area. This list will invariably include some species that do not occur in the study area, because some fauna have a limited or patchy distribution,

[1] A number of the flora collected also occurs in Northern Australia.

high level of habitat specificity, are locally extinct or were erroneously identified in previous surveys. Some records were excluded from this list, such as extinct species.

3.4.2 Field Survey

The primary objective of the terrestrial fauna assessment was to:

- Validate the accuracy of the desktop reviews;
- Ground-truth the extent and condition of fauna habitat types present;
- Further delineate and characterise the species and fauna habitat types present and potentially present at each site; and
- Provide additional information for any subsequent clearing requirements.

The fauna field study method comprised the following:

- Selection of field sites from aerial photography;
- A description of fauna habitat at each site;
- Map the extents of each fauna habitat type;
- Conduct anabat microbat recordings;
- Opportunistic observations of vertebrate fauna species present; and
- Assessment of the site's potential to house species of conservation significance.

Broad fauna habitats were identified based on vegetation associations and known landforms. These fauna habitats were then assessed for their potential to support fauna, in particular species of conservation significance. Habitats were assessed on the basis of their complexity, the presence of microhabitats (including significant trees with hollows, loose bark, fallen hollow logs and leaf litter) and other habitat features likely to provide foraging opportunities and/or shelter for fauna, such as water bodies and rocky outcrops.

Acoustic ultrahigh frequency equipment (Anabat) was used to record the presence of microbats. Acoustic Anabat recording equipment was placed in the study area to achieve a broad coverage but also designed to target potential maternal and breeding roosts. The analysis of ultrasonic echolocation calls of bat species with bat recording or other acoustic equipment is a very convenient way to determine the presence of bat species at a particular site. Often many more species can be identified at a greater number of sites using passive acoustic recording equipment than by trapping alone such as harp traps and mist nets.

A significant effort in diurnal searching was undertaken in the study area. Active searching for ground-dwelling reptiles and mammals usually involves searching the particular microhabitats present and includes the following:

- Searching and recording scats, tracks and other traces;

- Digging up burrows;
- Turning over rock and logs;
- Splitting fallen timber;
- Raking soil and leaf litter;
- Peeling off bark; and
- Searching rocky habitats, in cracks and caves, around water bodies and holes in fence posts.

In addition, call play back was undertaken for avian species which are known to respond to species-specific calls for active identification in the study area. This technique is often used to allow positive identification of species that can be overlooked during surveys or have cryptic behavior.

3.4.3 Nomenclature

Naming conventions for amphibians and reptiles are based on the paper by Kaiser et al. (2011). For bird species, BirdLife International (2012) is used, with the following exceptions: the distinctive capistratus race of Rainbow Lorikeet Trichoglossus haematodus is recognised as a full species, as is the Marigold Lorikeet (*T. capistratus*) and the distinctive Timor race of Pheasant Coucal is recognised as a full species, Timor Coucal (*Centropus mui*). The nomenclature for mammals follows the adopted taxonomy contained in the IUCN Red List. Local Tetum names were included where known.

3.5 Limitations

3.5.1 Flora and Vegetation

A broad approach was taken to assess flora and vegetation within the Betano and Beaço development areas to accommodate the limited time frame available for field survey. Flora and vegetation were assessed together to maximise available time at each site. An emphasis was placed on vegetation structure and dominant species composition.

Mapping of vegetation types was not undertaken during these surveys. Extensive ground-truthing, detailed inventories from plots/quadrats and detailed high-resolution aerial photography is required for vegetation mapping. It has previously been documented that the classification and field recognition of closed canopy forest formations (rainforest and monsoon) is problematic (Cowie 2006).

There was no attempt to make an exhaustive species inventory of each site, and a concentrated effort was placed on recording dominant species and plants of interest. Less emphasis was placed on ferns, herbs and other non-dominant flora. Lichens, bryophytes (mosses, liverworts), epiphytes and parasitic plants occurring high up in the tree canopy were not included in survey.

Flora surveys are ideally undertaken at the best time of year for detecting the most plant species. In areas with highly seasonal rainfall distribution this is at the end of the wet season. Field work at other

times of the year is also needed to detect the full range of species. By conducting the survey during the wet season, limitations existed for plant identifications.

3.5.2 Fauna

The lack of fauna baseline data for Timor-Leste is significant and makes the assessment of project impacts on population, distribution and ecological occurrences of fauna problematic. For this project, an holistic broad approach was taken given the lack of background information, utilising the best possible information available.

Fauna surveys are ideally undertaken throughout the year, across seasonal variability, to be able to identify a full range of species. Conducting a study in the wet season may have impacted on the completeness of results.

The length of survey may also impact results, with 16 days being insufficient to extensively survey the project area and accurately identify all species that potentially occur.

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CHAPTER 4

RESULTS

301012-01504-EN-REP-0006
June 2012

4 RESULTS

4.1 Flora and Vegetation

4.1.1 Vegetation Communities

General Overview

A Global Forest Resources Assessment was completed for Timor-Leste in 2010 by the Forestry Department of the Food and Agriculture Organization (FAO) of the United Nations (FRA 2010). This report states that no consistent and agreed land and vegetation classification system had been developed for the country, and therefore a set of classifications and definitions were created (Table 4-1).

Cowie (2006) noted that there is no structural/ floristic classification derived from vegetation data collected in any region of Timor-Leste. Plant communities recognised by Cowie (2006) within the Jaco-Tutuala-Lore National Park were regarded as preliminary and were based on field observations and limited quadrat data from few locations without classification or ordination of quadrat data. Importantly, Cowie (2006) notes that many plant communities intergrade floristically and structurally and the boundaries and distinctions between these are arbitrary and difficult to determine in the field.

The south coast of Timor-Leste features a broad coastal plain with hills that extend to the coastline at intervals. Rivers are numerous and mainly without water, and there are large drainage areas between rivers. Soil erosion is high, especially within drainage basins.

The coastal plain of southern Timor-Leste has largely been cleared in association with swidden agriculture, sandalwood harvesting, plantation estates and timber plantations. Remnant vegetation exists as highly fragmented and secondary communities. Most of the understory within remnant vegetation and agricultural land is dominated by invasive weeds, particularly Siam weed *(Chromolaena odorata)* and Cogon Grass (*Imperata cylindrica*). Grasses are extensively grazed by cattle, water buffalo, pigs and goats.

4.1.2 Betano Development Area

The Betano Refinery site is hilly with a medium to steep incline and flat foothills extending to the coast. Soil appears to be limestone based, with some outcropping present. The refinery site is mostly vegetated and natural vegetation can be described as moist deciduous forest on the hills and secondary coastal vegetation on the foothills and coastal plain, with small areas of riparian vegetation on drainage lines.

Table 4-1 Vegetation classifications and definitions developed for Timor Leste

National Class	Definition		Size of Area (ha) Data Collected (2000)
Lowland Forest <1,000 m asl	Forest defined as trees and shrubs > 30% tree canopy cover Occurs below 1,000 m asl	Moist lowland forest - dense	261,694
		Moist lowland forest - sparse	174,992
		Dry lowland forest - mainly one species	135,720
		Dry lowland forest - mixed composition	189,080
Highland Forest 1,000-2,000 m asl		Moist mixed forest	65,103
		Single species forest	2,356
Montane Forest	The Montane forests are found at levels > 2,000 m asl	Montane forest	2,611
Wetland Forest	Wetland forests are identified with drainage and slope. Normally flat poorly drained wetland areas or basin type features will contain wetland vegetation and/or related land uses.	Swamp forest	269
		Palm forest	NA
Coastal Forest	Includes three subclasses (i) Mangrove forest; (ii) Dune forests – mixed species; (iii) Coastal forest – single species	Mangrove forest	19,709
		Dune forests – mixed species	NA
		Coastal forest – single species	NA
Man-made Forest		Teak Other commercial plantings woodlots	918

Source: FRA (2010)

Nova Betano is located within an extensive area of secondary moist deciduous forest on the hills located 5 to 6 km north west of the coastline. Soils in the Nova Betano site are limestone based soils. A proportion of the western area of the Nova Betano site is relatively undisturbed dense moist deciduous forest, although the majority of the central and eastern area is open secondary moist deciduous forest.

Tracks and small areas of land have been cleared in associated with power line construction within the Betano Refinery and Nova Betano sites. Vegetation near the beach in the Betano Refinery site is highly disturbed and predominantly made up of invasive shrubby weeds including Crown Flower (*Calotropis gigantea*) and Bellyache Bush (*Jatropha gossypifolia*).

Vegetation communities were broadly mapped for the Betano development area (Figure 4-1).

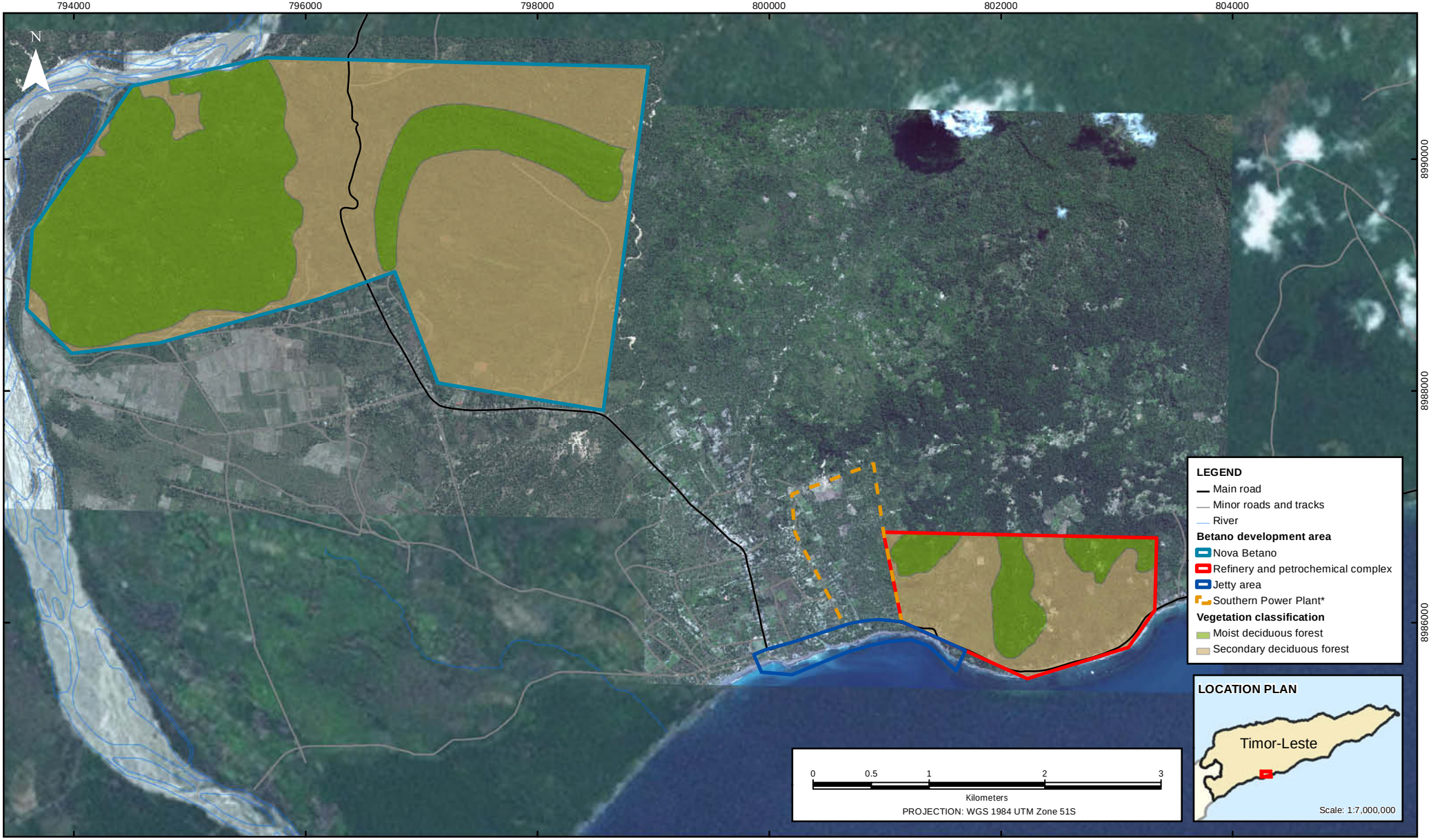
Moist Deciduous Forest

As defined by Monk *et al.* (1997), moist deciduous forest occurs where the climate seasonally dry for four to six months and the monsoon produces 1500-4,000 mm rainfall. The majority of trees appear to lose their leaves at the end of the wet season.

Within the Betano Refinery site the hills are vegetated with secondary moist deciduous forest with a canopy height of around 20 to 25 m. The overstorey and mid storey species included *Pterocarpus indicus*, *Tamarindus indica*, *Schleichera oleosa*, *Grewia* sp., *Ziziphus timoriensis*, *Z. mauritiana, Strychnos lucida* and *Mallotus philippensis*. The ground layer included a variety of shrubs and vines and a few understorey herbs and ferns in undisturbed patches of forest where limestone outcropping was present. There were fewer weeds on the densely vegetated hilltops and hill slopes than in open vegetation of the foothills. Vegetation in the shadow of the hills appeared drier and was dominated by *Schleichera oleosa* and *Senna timorensis* and the invasive weeds Siam weed and Coffee Bush (*Leucaena leucocephala*).

Within the Nova Betano site, dense forest is characterised by a canopy height of 20 to 25 m, with an understory of shrubs, vines, herbs and epiphytic ferns. Open forest is characterised by scattered trees and palms over a weed understory and species diversity is low. Within the disturbed areas the hills are covered with Siam weed, Lantana (*Lantana camara*), grasses, *Passiflora foetida* and snakeweed (*Stachytarpheta cayennensis*). Small areas of vegetation have been cleared and burnt for teak and corn gardens.

Dominant trees within the Nova Betano site are *Schleichera oleosa*, *Pterocarpus indicus, Acacia nilotica* subsp. *indica*, *Tectona grandis, Casuarina* sp. *Ziziphus mauritiana* and scattered *Corypha utan* and *Borassus flabellifer* palms. *Bamboo blumeana* is associated with drainage lines on hill slopes.



NOTES:
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2. Rivers: Geographic Information Group TimorLeste (2010)
3. Roads: DivaGIS (2010)
4. Vegetation communities: WorleyParsons (2012)

*Not part of this scope

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Figure 4-1
Betano study area vegetation mapping

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The north-west section of Nova Betano is adjacent to a government operated irrigation channel and is a hilly site. Within this area is undisturbed forest in good condition and according to local guides this area is 'lulik' or sacred. Timber has not been taken. The undisturbed site had a canopy cover of 50% and a well-developed understory, and species diversity appears to be high. Orchids and stag horns (*Platycerium* sp.) were observed high in the canopy. The soil appears to have high organic matter and leaf litter is dense.

Coastal Vegetation

Three main types of coastal vegetation are commonly recognised by (Whistler 1987) in the Melesian regions; Pes-caprae formation, Barringtonia formation and vegetation of rocky shores. Monk et al. (1997) regard coastal vegetation as open forest and don't define coastal forest. Cowie (2006) interprets coastal vegetation on the east coast of Timor-Leste as strand vegetation and the associated non closed forest formations, excluding mangroves.

Barringtonia formation occurs on sandy soils and is the common beach forest/mangrove along the south Timor coastline; and while Barringtonia vegetation was observed to the west of the Betano Refinery site, none was recorded in the Betano development area. No rocky shore vegetation occurred at any of the study areas.

Pes-caprae formation occurs along sandy foreshores where sand is actively deposited or eroded, and is typical near lagoons and in areas of low nutrients and high salt (Monk et al. 1997). Pes-caprae is described as an open community of low sand-binding herbs, trailing vines, grasses and sedges including *Ipomoea pes-caprae* and *Spinifex longifolius* or *S. littoreus.* Within the Betano development area, a small area of highly degraded Pes-caprae formation was observed at the proposed jetty site. *Spinifex littoreus* grasses were present on the beach within the proposed jetty area. The weeds *Calotropis gigantea* and *Jatropha gossypifolia* were prevalent.

Coastal vegetation within the Betano development area is secondary vegetation and occurs on the foothills and lowland towards the beach. It comprises open forest dominated by tree species *Borassus flabellifer, Schleichera oleosa, Senna timorensis,* teak (*Tectona grandis*), *Pterocarpus indicus,* and *Peltophorum pterocarpum.* Other common species were *Broussonetia papyrifera* and *Lepisanthes rubiginosa.* The understory was dominated by Siam weed and Bellyache bush. The majority of trees appear to be deciduous in the dry season, apart from palms. Vegetation was interrupted from meeting the beach and was largely cleared for a road and village running alongside the shoreline. A narrow strip of roadside plantings was present between the beach and road including trees such as *Vitex pinnata, Vitex trifolia* and *Delonix regia* (Poinciana).

There are small areas of swidden agriculture on the foothills with corn, peanut and cassava crops and banana and coconut trees. Disturbance to the understory appears to be from wild pigs and cattle grazing.

Riparian Vegetation

Riparian vegetation was present on several drainage lines flowing towards the ocean within the Betano Refinery Site. Several representatives of mangrove community species including *Excoecaria agallocha* and *Lumnitzera racemosa* were recorded occurring on drainage lines that formed inlets or small lagoons. Tamarind (*Tamarindus indica*), *Pterocarpus indicus* and *Jatropha curcas* were common species on dry river beds.

4.1.3 Beaço Development Area

The Beaço LNG plant area lies on a coastal plain largely cleared for grazing, agriculture, teak and coconut plantations. The low-lying coastal plain area is often inundated during the wet season. Remnant vegetation in this area exists as a narrow strip of coastal vegetation and small areas of coastal mangroves, riparian mangroves and remnant moist deciduous forest along the eastern boundary. Remnant moist deciduous forest comprises the western portion of the Nova Beaço site.

Nova Viqueque is situated on rolling hills with some limestone outcropping visible. Vegetation is largely cleared for agriculture and water buffalo and cattle grazing. Remnant vegetation exists as patches of very open secondary vegetation or scattered trees on hill tops and in minor drainage lines.

Viqueque Airstrip exists as an old grass airfield adjacent to a village and is currently used for cattle and water buffalo grazing.

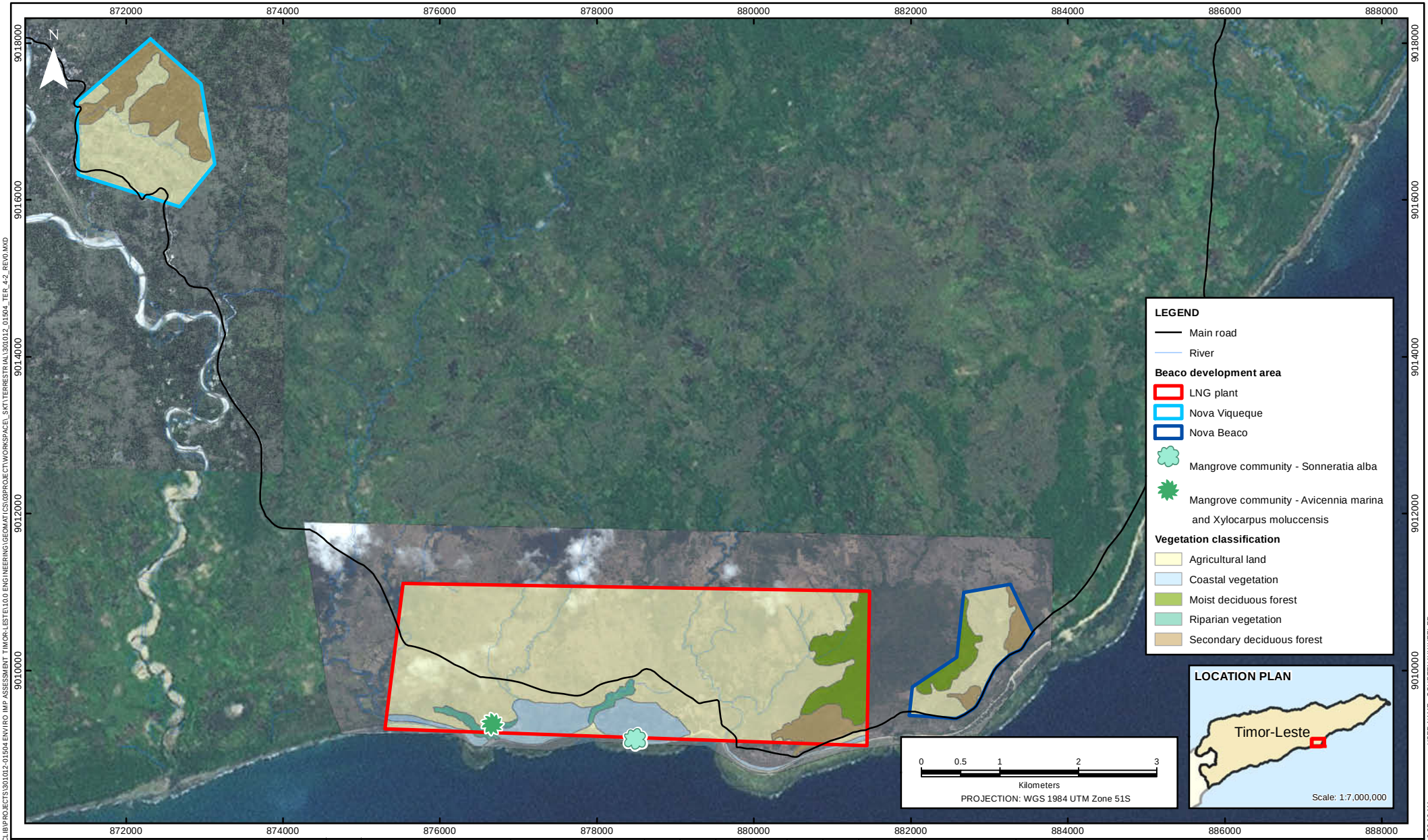
Vegetation communities were broadly mapped for the Beaço development area (Figure 4-2).

Coastal Vegetation

In the Beaço LNG Plant area there are narrow strips of coastal vegetation on the beach shore that are less disturbed by grazing. Vegetation is characterised by several species of large trees including *Calophyllum inophyllum* and *Nauclea orientalis.* Smaller tree species include *Schleichera oleosa, Cerbera manghas, Cordia dichotoma, Pandanus* sp., *Maytenus marginata, Bridelia ovata* and *Elattostachys verrucosa.* Common shrub species include *Scaevola taccada, Cordia subcordata,* Siam weed and Crown Flower. Vines include *Ryssopterys timoriensis* and *Smilax zeylanica.*

Limited areas of Pes-caprae Formation (*Ipomoea pes-caprae* and *Spinifex littoreus*) occur on beach sand Plate 4-1.

In some low-lying areas there are areas of dense forest which is characterised by a canopy height of 20 to 25 m and includes the tree and shrub species *Dolichandrone spathaceae, Litsea glutinosa* and *Tabernaemontana pandacaqui*. There are patches of *Saccharum spontaneum,* a tall grass up to 3 m in height, and other grasses including *Chloris truncata, Cyrtococcum trigonum* and the invasive weed Cogon Grass.



NOTES:

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Figure 4-2

Beaco study area vegetation mapping

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Plate 4-1 Pescaprae formation

Plate 4-2 Coastal mangrove

Mangroves

In the Beaço LNG Plant area a single coastal mangrove community was recorded as well as two areas of riparian mangrove communities on estuarine rivers (locations shown in Figure 4-2 and Figure 4-3).

Coastal Mangroves were represented by a tall stand of *Sonneratia alba* (white-flowered apple mangrove) trees that recorded on a rock substrate on the seaward edge to the west of Ponta Beaço Plate 4-2 (52L: 218599.90mE, 9009913.57mS). Trees were up to 15 m in height and were surrounded by elongated pneumatophores to 0.3 m in height. Although this mangrove species is widely distributed in the tropics, there appears to be little representation on the south coast of Timor-Leste. This stand of mangroves is likely to represent an important marine and faunal habitat.

Riparian mangrove communities were recorded along estuarine rivers or landward inlets within the Beaço LNG Plant area. Dominant species include *Acanthus ilicifolius* shrubs to 1 m in height, *Excoecaria agallocha, Heritiera littoralis* and *Hibiscus tiliaceus* trees to 10 to 15 m in height and sedges *Cyperus javanicus*. These mangrove communities are adjacent to coastal forest dominated by *Borassus flabellifer* and Siam weed.

Acanthus illicifolius is a spreading and sprawling shrub found as an undercanopy plant beneath closed canopy. This species is listed on the IUCN Red List as being of Least Concern. *Heritiera littoralis* is a columnar tree growing to 25 m with large spreading buttress roots. *Excoecaria agallocha* is a multi-stemmed tree or shrub growing to 15 m in height and is characterised by exposed cable roots and leaves which turn red and orange before falling in the dry season.

A large riparian mangrove forest community was recorded on a narrow estuarine river within the Beaço LNG Plant, at an area known locally as ‘Belalut’ (Figure 4-2). Belalut is considered to be an important crocodile habitat by local people (Plate 4-3). This community is characterised by tall trees with a closed canopy and includes *Avicennia marina* and *Xylocarpus moluccensis. Avicennia marina* is a spreading tree up to 25 m in height, with pencil-like pneumatophores and *Xylocarpus moluccensis* is a columnar tree growing to 15 m with conical woody pneumatophores.

Secondary Vegetation

In the Beaço LNG Plant area secondary vegetation is characterised by very open forest over grassland and introduced weed communities. This community is common in the area and results from repeated cycles of ‘slash and burn’ or swidden agriculture. Most trees are deciduous at the end of the wet season. Dominant trees include *Borassus flabellifer*, *Corypha utan, Schleichera oleosa* and *Ziziphus mauritiana.* Other common species include *Pterocarpus indicus,* teak (*Tectona grandis*), *Tamarindus indica, Hibiscus tiliaceus, Albizia lebbeckoides, Glochidion xerocarpum, Melia azedarach* and *Gmelina arborea.* The occasional cashew, sandalwood or breadfruit tree was observed. Invasive weeds comprise the understory and cattle and water buffalo graze on grasslands. There is also some ground disturbance by wild deer and wild pigs.

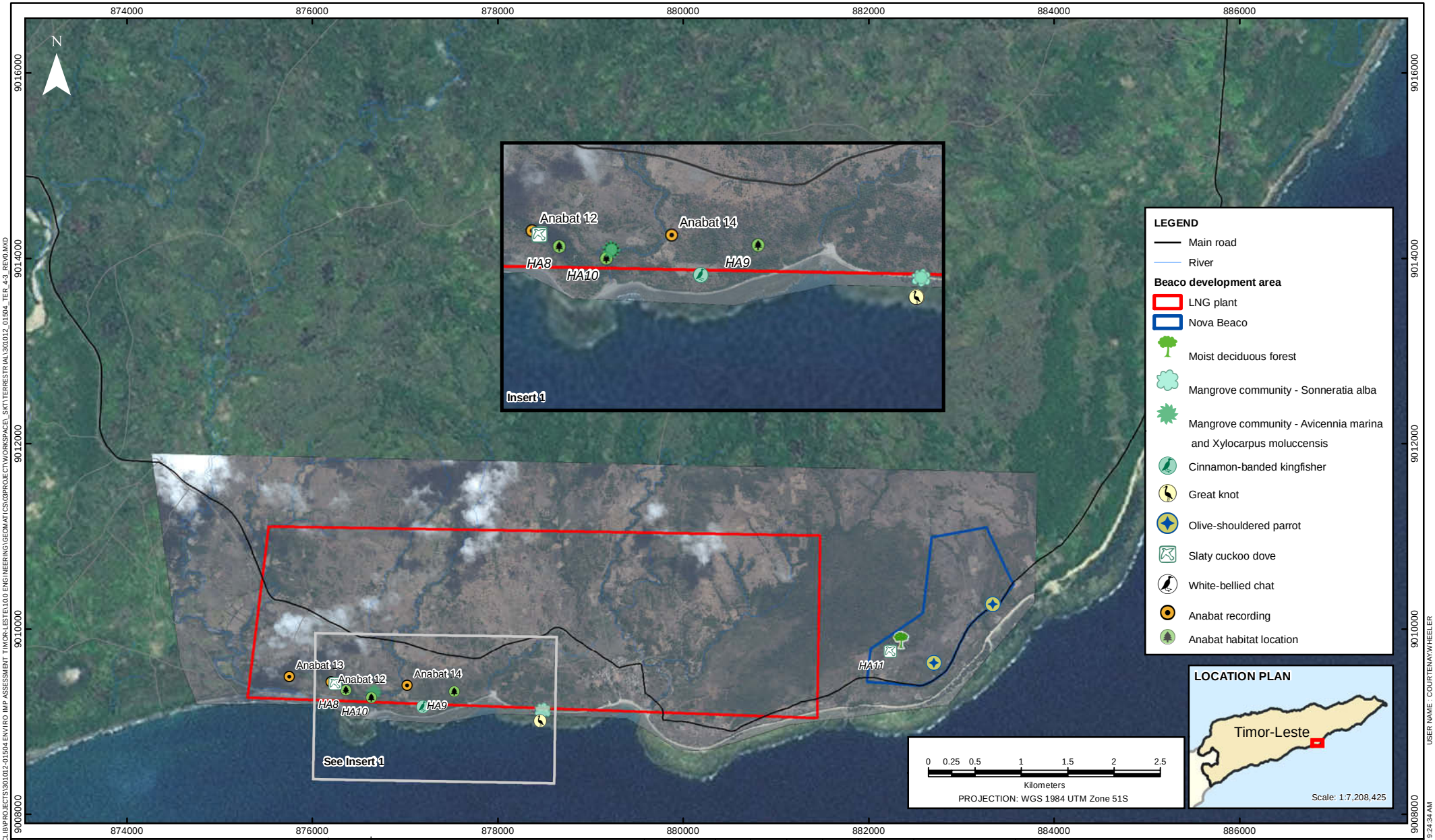

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Figure 4-3
Beaco study area biodiversity key sites

Plate 4-3 Riparian mangrove

Plate 4-4 Secondary vegetation at Nova Viqueque

In the Nova Viqueque area, vegetation exists as patches of very open forest or scattered trees over grassland and introduced weed communities Plate 4-4. Tree species recorded include *Borassus flabellifer*, *Schleichera oleosa, Pterocarpus indicus, Dichrostachys cinerea, Acacia nilotica* subsp. *indica*, *Cassia javanica* ssp. *nodosa*, *Timonius timon*, *Glochidion xerocarpum*, *Ziziphus timoriensis*, and *Casuarina* sp. affin. *junghuhniana*. Coconut, mango and teak trees are common. Siam weed, Coffee bush, Crown flower and Golden false beardgrass (*Chrysopogon aciculatus*) are prevalent.

Vegetation in the Viqueque Airstrip area exists as scattered trees and shrubs including *Borassus flabellifer* and *Ziziphus mauritiana* over Siam weed, Bellyache bush, Golden false beardgrass and other grasses. Vegetable gardens and groves of breadfruit, teak and coconut are present within the airport boundary.

Moist Deciduous Forest

On the eastern edge of the Beaço LNG site and western edge of the Nova Beaço site, large areas of remnant secondary moist deciduous forest are present. These areas are interspersed with heavily grazed grasslands with sedges and herbs on gentle hill slopes with limestone outcropping.

The forest has a canopy height of around 20 to 25 m. The overstorey and mid storey species included *Borassus flabellifer*, *Corypha utan*, *Schleichera oleosa*, *Ziziphus mauritiana*, *Dolichandrone spathacea*, teak, *Gmelina arborea,* sandalwood, *Pterocarpus indicus* and *Ficus* spp. The ground layer included a variety of shrubs and vines and a few understorey herbs and ferns in undisturbed patches of forest where limestone outcropping was present. Siam weed was prevalent in disturbed areas with an open canopy (Plate 4-5).

The vegetation communities recorded in the Beaço and Betano development areas are presented below in Table 4-2.

Plate 4-5 Moist deciduous forest

Table 4-2 Vegetation types recorded in the Beaço and Betano development areas

Vegetation Formation (Monk *et al*. 1997)	Vegetation Formation (Cowie 2006)	Presence in project areas	Biological Features	Inferred Distribution	Current Threats to Vegetation
Moist Deciduous Forest	*Canarium* – *Calophyllum* forest (putative moist deciduous forest)	Nova Beaço and Nova, Betano, Betano Refinery	Dominants >50% deciduous species, canopy >25 m, rarely dense and even; large woody climbers, bamboos in undergrowth; sub dominants and understorey evergreen	On coastal plain	Active, ongoing conversion for agriculture, logging
Coastal Forest	Coastal and strand vegetation	Nova Beaço, Beaço LNG, Nova, Betano, Betano Refinery		On coastal plain	Intensive grazing by cattle, conversion for agriculture, weed invasion
Tidal Forest	Mangroves	Beaço LNG Plant	Refers to the habitat rather than a single entity, include trees, shrubs, palm or ground fern	Small scattered areas	Fire wood harvesting
N/A		Betano Refinery Site	Riparian	Major rivers	Potentially conversion for rice, cattle grazing, weeds

Source: Descriptions adapted from Monk et al. 1997 and Cowie 2006.

4.1.4 Agriculture

The traditional slash and burn or swidden system of agriculture is used in Timor-Leste. Forest is cleared for cultivation, cropped for several years and then followed by fallow periods to allow for natural regeneration. Boundary markers are used around plots of land to indicate land ownership.

Cultivated soils appear to be nutrient poor with little remaining topsoil. Runoff of topsoil into rivers and the ocean is high. The soil is generally shallow and susceptible to landslides and flooding (Oxfam 2003). The vulnerability to erosion is enhanced by highly uneven and erratic rainfall. Large river systems flow onto the coastal plain.

The majority of area at the Beaço LNG plant area comprised agricultural land used for subsistence farming. Few marketable cash crops were encountered. Gardens appeared to be in fallow over the wet season. The primary crops grown are corn/ maize, cassava, sweet potato, peanuts, long beans, papaya, watermelon and bananas. Gardens in the study areas supported weeds and secondary species.

Grazing by water buffalo, cattle, goats and pigs is widespread in the Beaço and Betano development areas.

Small plantations or estates of coconuts, bananas, mango and occasionally cashew or candlenut trees were present in the Beaço and Betano development areas.

Teak Plantations/Woodlots

Small plantations or woodlots of teak were observed in the Beaço and Betano development areas.

4.1.5 Vegetation of Conservation Interest

Beaço Development Area

Mangroves are of particular conservation interest in the Beaço development area for their economic and conservation benefits; however, they are subject to felling for timber. Mangroves stabilize soils, primarily in coastal and estuarine communities and reduce the amount of soil erosion occurring. Loss of mangrove habitat affects the conservation status of Timor-Leste and also the economic gain by reducing land available for agriculture and forestry.

Mangrove areas are protected under the UNTAET Regulation No. 2000/19, section 5 ‘Wetlands and Mangroves’, prohibiting any destruction of this vegetation type. Nevertheless, exploitation still occurs. Locations of mangroves are show in Figure 4-3 and Figure 4-2 and include:

- Tall stand of *Sonneratia alba* on the seaward edge to the west of Ponta Beaço;

- Riparian mangrove communities along estuarine rivers or landward inlets within the Beaço LNG Plant area, including *Acanthus ilicifolius* (listed on the IUCN Red List as of Least Concern); and
- A large riparian mangrove forest community on a narrow estuarine river in an area known locally as 'Belalut' within the Beaço LNG Plant area. This community is characterised by tall trees with a closed canopy and includes *Avicennia marina* and *Xylocarpus moluccensis*.

Remnant areas of moist deciduous forest are of conservation interest as they are poorly known and warrant further study. On the eastern edge of the Beaço LNG site and western edge of the Nova Beaço site large areas of remnant secondary moist deciduous forest are present.

Betano Development Area

Remnant areas of moist deciduous forest are of conservation interest as they are poorly known and warrant further study. Within Nova Betano there is a large area of undisturbed forest with little disturbance and according to local guides this area is 'lulik' or sacred (Figure 4-1 and Figure 4-4). Orchids and stag horns (*Platycerium* sp.) were observed high in the canopy.

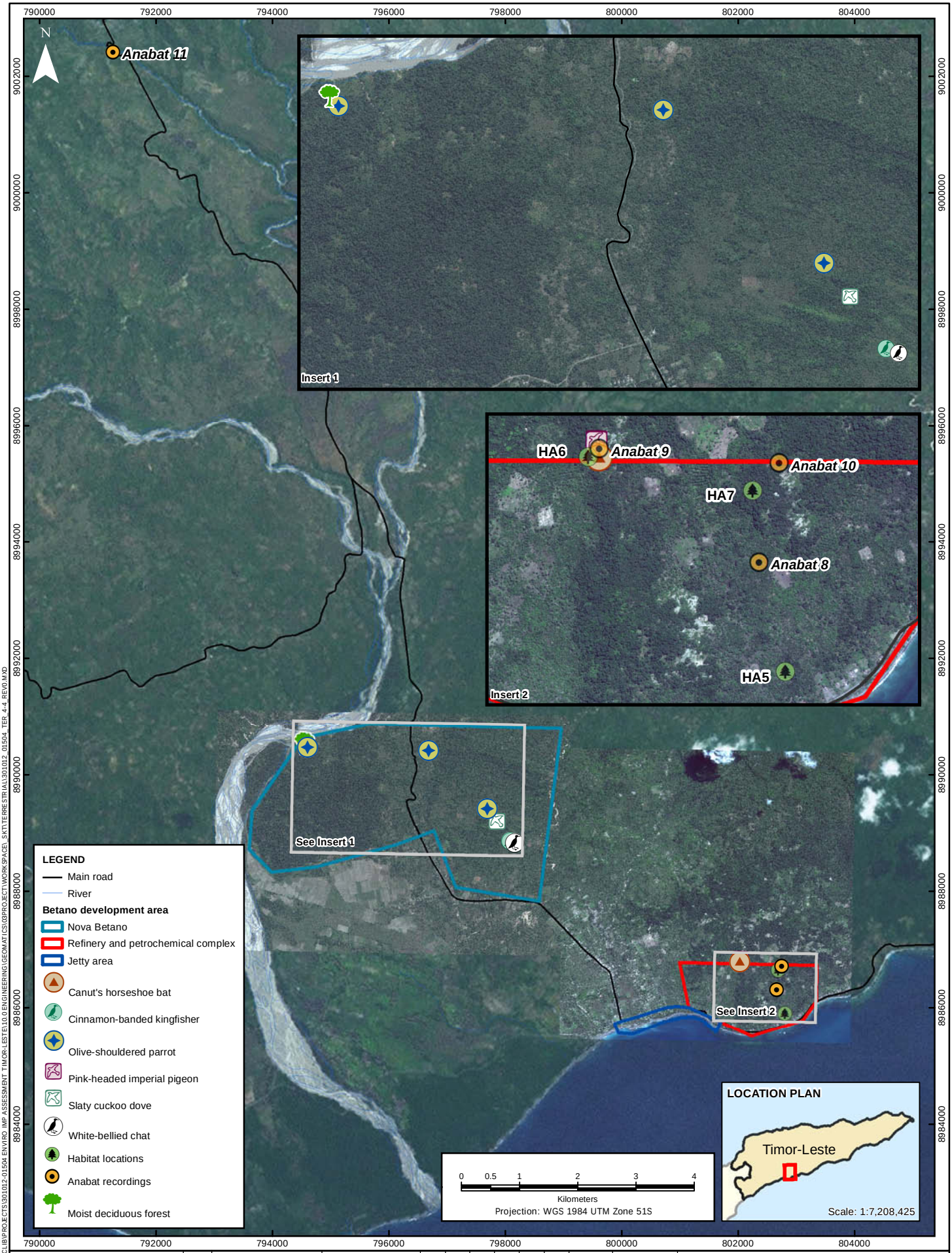
4.1.6 Flora

These results focus on the dominant flora species, conservation significant flora, economically important flora species and weed species. Local Tetum names were recorded where possible, and this list of names is considered indicative only as there were several inconsistences. In some cases the usage of the same name varied between local guides and regions, and several species or plant forms were grouped together under one name.

A total of 201 species were identified from collected material and photographs and a species list for the Beaço and Betano development areas is presented in Appendix 2.

A large number of species recorded in the Beaço and Betano development areas have a widespread distribution in the tropics. Several of these are weed species and several are considered to be naturalized species. Two species listed on the IUCN Red List as Vulnerable were recorded; *Pterocarpus indicus* and *Santalum album.* A large number of species recorded are common to both Northern Australia and Timor-Leste.

Some large fruited species that are bird and bat attracting were recorded; including *Cerbera manghas*, *Ficus variegata* and *Ficus* spp.



NOTES:
This map consists of:
1. Imagery: Digital Globe (2008-2011)
2. Rivers: Geographic Information Group TimorLeste (2010)
3. Roads: DivaGIS (2010)
4. Vegetation communities: WorleyParsons (2012)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
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PROJECT No: 301012-001504

TASI MANE PROJECT - BETANO AND BEACO TERRESTRIAL ENVIRONMENT TECHNICAL REPORT

WorleyParsons resources & energy

TIMOR GAP, E.P. Timor Gas & Petroleo

REPUBLICA DEMOCRATICA DE TIMOR-LESTE SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Figure 4-4

Betano study area biodiversity key sites

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USER NAME : COURTENAY.WHEELER

4.1.8 Species of Conservation Interest

The IUCN Red List of Threatened Species does not list any Critically Endangered, Endangered or Vulnerable plant species specifically for the region of Timor-Leste (IUCN 2011). However, there are records of three Vulnerable species from the east coast of Timor-Leste; *Intsia bijuga*, *Pterocarpus indicus* and *Santalum album* (Cowie 2006, 2007). Two of these were recorded in the Betano and Beaço development areas during the field surveys, *Pterocarpus indicus* and *Santalum album.* There are 36 plant species listed on the IUCN Red List as being of Least Concern for Timor-Leste, and these are considered to have a low risk of extinction (Appendix 3). One of these species was recorded during the field survey in both the Beaço and Betano development areas, *Acanthus ilicifolius* (Holly Leaf Mangrove). The low number of plant species listed for Timor-Leste as Least Concern on the Red List (compared to the number of plant species occurring in Timor-Leste) is likely to be a reflection of the limited assessment carried out on plants in the area.

Within the broad region of Indonesia the following numbers of plant species are listed on the IUCN Red List: 207 Vulnerable, 86 Near Threatened, 78 Endangered and 115 Critically Endangered. It is likely that as more surveys are undertaken within Timor-Leste that more plant species will be listed specifically for the country.

Sandalwood (*Santalum album)* was present in very low numbers in both the Beaço and Betano development areas as young trees only and not at the harvestable stage. Sandalwood is a highly sought after timber which has been overexploited for several centuries. By the beginning of the 1900s Sandalwood was brought close to extinction by Chinese and European traders (Sandlund et al. 2001). Further overexploitation occurred during Indonesian occupation during 1975 to 1999.

Pterocarpus indicus (Tetum ai-na) was present within the Beaço and Betano development areas on the banks of rivers and on hills slopes. It is a tall timber species, reaching 25 to 35 m, is a briefly deciduous tree and can be useful for soil stabilization and adding nitrogen to soil. It is a highly sought after timber and is listed on the IUCN Red-list as Vulnerable. Described as a widespread tree found in lowland primary and some secondary forest, native subpopulations have declined because of overexploitation of the timber and increasing general habitat loss. Cultivated subpopulations are widely distributed throughout the tropics.

Intsia bijuga is a reasonably common tree of primary semi-evergreen rain forest, moist deciduous forest, and coastal forest. This species was not recorded from the Beaço and Betano development areas.

Cowie (2006) also lists a further four species recorded on the east coast that may be considered threatened in Timor-Leste: Antiaris toxicaria, Neoalsomitra podagrica, Carallia brachiate and Cycas rumphii. The forest communities in which these species occur are under threat: deciduous forest, thorn forest and coastal forest. None of these four species were recorded from the Betano and Beaço development areas.

4.1.9 Species of Economic Importance

Within the Beaço and Betano development areas the species listed in Table 4-3 are considered to have economic or local importance either as timber or food crops. Two of these species, *Pterocarpus indicus* and *Santalum album,* have been discussed in Section 4.1.6.

Small plantations or estates of coconuts, bananas, and occasionally mango were present in the Betano and Beaço development areas. The tenureship of trees within estates may be external to local villages. Occasional breadfruit, jackfruit, cashew, cinnamon trees were encountered, and appear to be individually owned and marked accordingly.

Table 4-3 Species of local importance and/or economic interest recorded in the Beaço and Betano development areas

Common Name	Scientific Name	Tetum Name	Use
Coconut	*Cocus nucifera*	nú	Food
Cashew	*Anacardium occidentale*	caijus	Food
Banana	*Musa spp.*	hudi	Food
Breadfruit	*Artocarpus altilis*	kulu modo	Food
Mango	*Mangifera* spp.	has	Food
Candlenut	*Aleurites moluccana*	Kemiri or cami	Food
Cinnamon	*Cinnamomum* sp.	ai-canela	Spice
Teak	*Tectonia grandis*	ai-teka	Timber
Gmelina	*Gmelina arborea*	Gmelina, ai-teka Malaysia	Timber
Cassod tree	*Senna siamea*	ai-johar	Timber
Sandalwood	*Santalum album*	ai-cameli	Timber
Narra	*Pterocarpus indicus*	ai-na	Timber
Mangrove trumpet tree	*Dolichandrone spathacea*	ai-sirian	Timber

4.1.10 Weeds/Invasive Species

The major weed species recorded in the Beaço and Betano development areas are listed in Table 4-4. Siam weed (*Chromolaena odorata*), Cogon Grass (*Imperata cylindrica*) and Coffee Bush (*Leucaena leucocephala*) are listed on the IUCN's Global Invasive Species Database (GISD) of the 100 worst invasive species.

Table 4-4 Major weed species identified in the Betano and Beaço development areas

Weed Species	Common Name	Tetum Name
Chromolaena odorata	Siam weed	ai-funanmutik
Imperata cylindrica	Cogon Grass	pae
Leucaena leucocephala	Coffee Bush	ai-café
Lantana camara	Lantana	ai-funan meak
Acacia nilotica	Prickly Acacia	bakuro malae, ai-tarak
Chrysopogon aciculatus	Golden False Beardgrass	du'ut
Jatropha gossypifolia	Bellyache Bush	miro
Calotropis gigantea	Crown Flower	fuka
Stachytarpheta cayennensis	Snakeweed	-

Siam weed is a perennial shrub in the Asteraceae family which forms dense tangled thickets up to 2 m tall. It has an extremely fast growth rate and prolific seed production (CRC Weed Management 2003). Siam weed was the most widespread weed throughout the Beaço and Betano development areas. Originally native to Central and South America, it is highly invasive and is considered to be one of the world's worst tropical weeds. It is estimated that Siam weed covers more land than any other plant species in Timor-Leste (Cowie 2007), and affects about one-fifth of all cropland (World Bank 2009). Siam weed invades secondary vegetation and agricultural land and its spread may be facilitated by fire.

Cogon Grass is considered to be one of the top ten worst weeds in the world. This species is of concern as it displaces native plant and animal species. It has an extensive rhizome system and adapts to poor soils.

Coffee Bush is a fast growing tree that was widely introduced as a fodder plant and has become an aggressive invader of agricultural and disturbed areas, often coastal and riverine habitats, in many tropical locations (GISD 2012). It can form dense thickets and may threaten endemic species of conservation concern in some areas (Smith 1995). It was originally native to Central America.

Bellyache Bush was widespread throughout all development areas and a second weed species in the same genus, Jatropha curcas, was recorded infrequently in the Beaço and Betano development areas. Jatropha spp. form erect perennial shrubs with thick stems and have small red flowers clustered on stalks, oblong fruit capsules and toxic seeds. Shrubs form dense thickets which out compete other species (Smith 1995).

Crown Flower is a shrub growing to 4 m in the Asclepiadaceae family which has clusters of waxy white or mauve coloured flowers; it is a common weed of roadsides, disturbed areas, sandy beaches,

water courses and river flats and thrives on poor soils. It is particularly widespread in coastal vegetation.

Prickly Acacia is a fast growing species that forms thickets and may displace native species (Smith 1995).

Golden False Beardgrass is a rhizomatous perennial grass growing to 0.4 m in height. This grass was widespread.

Lantana is a sprawling thicket-forming shrub growing to 5 m in height. This plant is considered a major invasive weed in many habitats, although within the Beaço and Betano development area Lantana is not widespread. In Timor-Leste this species appears to be outcompeted by Siam weed.

Snakeweed is an erect herb or shrub growing to 1.2 m in height with blue flowers in a terminal spike. Snakeweed forms dense stands and is a common weed of disturbed areas and invades forests and pastures.

Several introduced flora species are now considered naturalized as they are widespread and not considered invasive weeds. *Passiflora foetida,* part of the Passifloraceae family, is a woody climber with cream-white-blue flowers and occurs in coastal areas and rivers. Tamarind (*Tamarindus indica*) is a common tree species in secondary forest.

4.2 Fauna

4.2.1 Fauna Habitat

Currently the knowledge on the habitat requirements of Timor-Leste vertebrate fauna is lacking and most studies conducted have largely been focused on bird species. The level of knowledge on ground-dwelling species such as reptiles and mammals is minimal and therefore conducting an assessment of habitat requirements for such species is difficult. There are no baseline data to compare against and develop an understanding of regional representation. This therefore makes deducing possible impacts from development to population occurrences, distribution and ecological diversity problematic. For this project a holistic broad approach was taken, given the lack of background information utilising the best possible information available.

An important information source was the Global Forest Resources Assessment for Timor-Leste in 2010 by the Forestry Department of the Food and Agriculture Organisation (FAO) of the United Nations (FRA 2010). Six vegetation classifications were recognised and can be used as analogues for vertebrate fauna habitats. This report stated that no consistent and agreed land and vegetation classification system had previously been developed for the country, and therefore a set of classifications and definitions were created (Table 4-1).

Other significant vertebrate fauna work included Trainor et al. (2007). Although largely confined to avian species diversity and distribution, this study provided a detailed account of habitat types. Their

classification included tall evergreen forest (tree height up to 40 m), semi-deciduous and tropical dry forest types (tree height up to 20 m), a patchy tropical montane forest (elevations > 1,000 m), beach forest and coastal scrub, savanna woodland, open eucalyptus forest, shaded coffee plantations (> 600 m), swamps and swamp forests, rice paddies, and village land.

A compilation of previously identified vertebrate fauna habitats, plus those described for the project during the field survey was developed for the current assessment. This process also took into consideration the study areas' location on the south coast of Timor-Leste and was correspondingly revised. Table 4-5 describes the four categories of vertebrate fauna habitats were present within the project's study areas and immediate vicinity.

Ten vertebrate fauna habitat assessments were conducted across the project study areas and included: five in the Betano Refinery and Petrochemical Industries area and five in in Beaço LNG Plant (including Nova Viqueque) area (Appendix 4). Locations in the Betano development area are shown in Figure 4-4 and locations in the Beaço development area are shown in Figure 4-3.

Table 4-5 Vertebrate fauna habitat types developed for the Tasi Mane Timor-Leste project, relevant to the Betano and Beaço project areas.

Fauna Habitat Type	Vegetation	Study Area
Deciduous Woodland /Forest	Woodland defined as trees and shrubs < 30% tree canopy cover	Betano Beaço Viqueque
Coastal	Includes three subclasses (i) Mangrove forest; (ii) Dune forests – mixed species; (iii) Coastal dunes and reef platforms	Betano Beaço
Riparian	Includes drainage lines (major and minor), drainage basins, creek lines and water catchments; includes associated vegetated banks.	Betano Beaço
Swidden Agriculture	Includes 'man made' plantations and associated fringing vegetation and habitat opportunities	Betano Beaço Viqueque

Four fauna habitats were recorded across both development areas, including Moist Deciduous Woodland/Forest, Coastal, Riparian and Swidden Agriculture. Generally the intact vegetation was found in the Deciduous Woodland/Forest and Coastal habitat types whereas the Riparian and Swidden Agriculture had largely been degraded and impacted by man. Often, the greater impact from agricultural practises the reduced availability of micro-niches occurs, for example, sheltering, foraging and nesting potential for fauna species.

Remnant areas of moist deciduous forest are of conservation interest as they are poorly known and warrant further study. Generally the area is devoid of remnant vegetation as swidden agricultural practices have cleared large swaths of land. On the eastern edge of the Beaço LNG site and western edge of the Nova Beaço site large areas of remnant secondary moist deciduous forest are present. In addition this habitat type is found in Nova Betano within the Betano development area. These areas provide significant foraging and nesting potential for vertebrate fauna species and in particular species of conservation significance. Birds such as the Slaty Cuckoo Dove (*Turacoena modesta*), Pink-headed Imperial Pigeon (*Ducula rosacea*), Olive-shouldered Parrot (*Aprosmictus jonquillaceus*) were recorded perched in these 'intact' vegetation communities. The micro-niche availability of this habitat type is comparably better than degraded areas that have been cleared for farming.

As previously mentioned in Section 4.1.5 mangroves are of particular conservation interest in the Beaço development area for their economic and conservation benefits; however they are subject to felling for timber. Coastal habitats inclusive of mangroves provide a habitat for a range of fauna vertebrate species and often species that are habitat specific. Species like migratory waders and conservation significant bird species like the Cinnamon-Banded Kingfisher (*Todiramphus australasia*) can be found foraging and nesting in such habitats. Loss of mangrove habitat affects the conservation status of Timor-Leste and also the economic gain by reducing land available for agriculture and forestry. In addition mangrove and coastal habitats are generically underrepresented in the area placing added pressure on availability for species only reliant on coastal habitats to find suitable foraging and nesting potential.

4.2.2 Fauna Assemblages

General

Fauna assemblages were collated from the desktop review. Many of the species identified from the desktop assessment are unlikely to occur in the study areas on a regular basis since from the desktop addressed a large area encompassing a wide range of habitats (Appendix 5).

A total of 98 species of vertebrate fauna were recorded in the project study areas, consisting of two species of amphibians, 11 species of reptiles, 70 species of birds and 15 species of mammals (Table 4-6).

Table 4-6 Number of Species recorded for the Betano/Beaço development areas

Assemblage	Tasi Mane Project (Betano and Beaço)
Amphibians	2
Reptiles	11
Birds	70
Mammals	15
Total	**98**

The Betano development area recorded 60 species of vertebrate fauna, consisting of seven species of reptiles, 40 species of birds and 13 species of mammals. The Beaço development area recorded 80 species of vertebrate fauna, consisting of two species of amphibians, nine species of reptiles, 59 species of birds and 10 species of mammals (Table 4-7).

Table 4-7 Number of Species recorded for the Tasi Mane Project per site

Assemblage	Betano	Beaço
Amphibians	0	2
Reptiles	7	9
Birds	40	59
Mammals	13	10
Total	**60**	**80**

Previous study results can be found in Appendix 5.

Amphibians

The two amphibians were identified within the Betano and Beaço development area the Common Indian Toad (*Duttaphrynus melanostictus*) and the Common Tree Frog (*Polypedates* cf. *leucomystax*).

Reptiles

Reptiles identified in the Betano and Beaço development area comprised 11 species from seven families including: Tokay (*Gekko gecko*), Asian House Gecko (*Hemidactylus frenatus*), Fat-tailed House Gecko (*Hemidactylus platyurus*), Common Wolf Snake (*Lycodon capucinus*), Indonesian Water Python (*Liasis macklotti macklotti*) and Saltwater Crocodile (*Crocodylus porosus*).

Birds

A large number of birds were identified within the Betano and Beaço development area, consisting of 70 species. The most common species included the Spotted Dove (*Streptopelia chinensis*), the Barred Dove (*Geopelia maugei*) and the Streak-breasted Honeyeater (*Meliphaga reticulata*). The two most common families were the Columbidae (pigeons and doves) and the Meliphagidae (honeyeaters).

Mammals

Mammal species recorded in the Betano and Beaço development area consisted of 11 families and 15 different species, and included the Indonesian Short-nosed Fruit Bat (*Cynopterus titthaecheilus*), Domestic Dog/Dingo (*Canis familiaris*), Domestic Pig (*Sus scrofa*), Bali Cattle (*Bos javanicus*), Domestic Cattle (*Bos taurus*) and the Domestic Goat (*Capra hircus*).

Bats

Within the Betano and Beaço development are five species of known bats were recorded, including the Canut's Horseshoe Bat (*Rhinolophus canuti)* which is listed as Vulnerable on the IUCN Red List, Sulawesi Horseshoe Bat (*Rhinolophus celebensis parvus*), Timorese Horseshoe Bat (*Rhinolophus montanus*), Diadem Leaf-nosed Bat (*Hipposideros diadema diadema*) and the Little Long-fingered Bat (*Miniopterus australis)*. A full report on survey results for bats is included in Appendix 6.

4.2.3 Conservation Significant Fauna

Species listed as Critically Endangered, Endangered, Vulnerable and Near Threatened on the IUCN Red List constitutes species of conservation significance (Table 2-1). The lack of baseline data regarding the fauna of Timor-Leste suggests that additional conservation significant species which have not been recorded may potentially be present. The full extent of results including all categorised species is described in Appendix 7.

Section three of the UNTAET Regulation No. 2000/19, states that 'All animals and plant species listed in Appendix I or Appendix II of the Convention on the International Trade in Endangered Species' (CITES) 'shall mean a species of animal or plant at risk of extinction within East Timor'.

The desktop review identified 35 species of conservation significance that potentially occur or have been previously recorded for Timor-Leste (Table 4-8).

Seven species of conservation significance were recorded in the study area: the Canut's Horseshoe Bat (*Rhinolophus canuti timoriensis*), Great Knot (*Calidris tenuirostris*), Slaty Cuckoo Dove (*Turacoena modesta*), Pink-headed Imperial Pigeon (*Ducula rosacea*), Olive-shouldered Parrot (*Aprosmictus jonquillaceus*), Cinnamon-Banded Kingfisher (*Todiramphus australasia*), and Timor Bush-chat (*Saxicola gutturalis*). Locations of conservation significant fauna in the Betano development area are shown in Figure 4-1 and locations in the Beaço development area are shown in Figure 4-2.

Table 4-8 Conservation significant species and their likelihood of occurring in the Betano and Beaço development area

Species	Conservation Significance				Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced	
Mauremys reevesii Reeves' Turtle	EN			x	Unlikely
Fregata andrewsi Christmas Island Frigatebird	CR		App I		Possible
Esacus magnirostris Beach Thick-knee	NT				Likely
Charadrius peronii Malaysian Plover	NT				Possible
Charadrius javanicus Javan Plover	NT				Possible
Numenius madagascariensis Far Eastern Curlew	VU				Likely
Numenius arquata Eurasian Curlew	VU				Likely
Limosa limosa Black-tailed Godwit	NT				Likely
Calidris tenuirostris Great Knot	VU				Recorded
Limnodromus semipalmatus Asian Dowitcher	NT				Likely

Species	Conservation Significance				Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced	
Turacoena modesta Slaty Cuckoo-Dove	NT				Recorded
Gallicolumba hoedtii Wetar Ground-Dove	EN				Possible
Treron psittaceus Timor Green-Pigeon	EN				Likely
Ducula rosacea Pink-headed Imperial-Pigeon	NT				Recorded
Ducula cineracea Timor Imperial-Pigeon	EN				Unlikely
Cacatua sulphurea Yellow-crested Cockatoo	CR		App I		Likely
Psitteuteles iris Iris Lorikeet	NT				Likely
Aprosmictus jonquillaceus Olive-shouldered Parrot	NT				Recorded
Todiramphus australasia Cinnamon-banded Kingfisher	NT				Recorded
Bradypterus timoriensis Timor Bush-Warbler	NT				Unlikely

Species	Conservation Significance				Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced	
Heleia muelleri Timor White-eye	NT	x			Possible
Ficedula timorensis Black-banded Flycatcher	NT	x			Possible
Saxicola gutturalis Timor Bushchat	NT				Recorded
Zoothera dohertyi Chestnut-backed Thrush	NT				Unlikely
Zoothera peronii Orange-banded Thrush	NT				Likely
Lonchura fuscata Timor Sparrow	NT				Possible
Acerodon mackloti Sunda Fruit bat	VU				Possible
Nyctimene keasti Keast's Tube Nosed Fruit Bat	VU				Unlikely
Pteropus temminckii Temminick's Flying-fox	VU		App II		Unlikely
Pteropus vampyrus Large Flying-fox	NT		App II		Possible
Rhinolophus canuti timoriensis Canut's Horseshoe Bat	VU				Recorded

The conservation significant IUCN Red Listed species recorded during this survey, including their locations, are detailed in Table 4-9. Conservation significant fauna, listed in Appendix 7 includes species' distribution and ecology, their regional context and their likelihood of occurring in the Timor-Leste study areas.

The Great Knot is listed as Vulnerable under the IUCN Red List. This species was recorded foraging on a reef platform within the Beaço development area. Ten individuals were recorded foraging on the reef platform at Beaço. Suitable foraging/sheltering habitat is present in the project area and within this species distribution and migratory pathways. This species may be expected to be found foraging and sheltering during its annual migration. This species' migratory pattern allows it to avoid impact from the proposed development and migrate to forage and roost in similar locations within the region and local vicinity.

One individual of the Slaty Cuckoo-dove was recorded at Betano and three individuals were recorded at Beaço on two occasions. This species is expected to be found foraging and nesting within suitable habitat of the development area.

Two individuals of the Pink-headed Imperial Pigeon were recorded perched at Betano. This species is expected to occur at all sites in habitats that provide foraging, sheltering and nesting potential

Four individuals of the Olive-shouldered Parrot were recorded on three occasions were recorded at Betano and four individuals on two occasions were recorded at Beaço. This species of parrot occurs over a wide range of mostly lowland habitats, and appears to be commonest in *Eucalyptus* woodlands, open forests and coastal environments typical of the project area.

The Cinnamon Banded Kingfisher was recorded both at Betano and Beaço development areas; two individuals at Betano and one individual at Beaço. It is expected that this species will be found in suitable habitats across all project areas.

Five individuals were recorded at Betano, one male and four females. Two males were recorded at Beaço development area, specifically Nova Viqueque. The disparity of records for this species might be a reflection of little survey work conducting for this species. It is expected that this species may occur broadly across suitable habitat types for the south-coast of Timor-Leste.

Bats identified as species of conservation interest include two cave roosting Horseshoe Bats; the Timorese Horseshoe Bat (*Rhinolophus montanus*) and the Canut's Horseshoe Bat (*R. canuti timoriensis*). The Timorese Horseshoe Bat is listed as Data Deficient and the Canut's Horseshoe-bat is listed as Vulnerable on the IUCN Red List. In addition to these species, the possibility of some of the undescribed taxa that were discovered on recent surveys by Pavey and Milne (2004) and Armstrong (2007), namely Pipistrellus sp. may occur in the Betano and Beaço development area.

The Timorese Horseshoe Bat is listed as being Data Deficient, and the recording of this species is significant as it has only been recorded on two previous occasions; the site of the first collection near Lequi Mia, south of Ermera (7 to 8 individuals), and calls from the Ira Chaupiti watercourse on the

southern side of the Paitchau Range. The Canut's Horseshoe Bat (*R. canuti*) was commonly encountered in the acoustic and trapping surveys of Pavey and Milne (2004) and Armstrong (2007), but there is no information on how widespread this species is outside of the most forested areas in the east of Timor-Leste.

Table 4-9 Conservation significant fauna recorded during survey work in the Betano and Beaço development areas

Common Name	Conservation Status	Location
Great Knot	VU	Beaço
Slaty Cuckoo-dove	NT	Betano Beaço
Pink-headed Imperial Pigeon	NT	Betano
Olive-shouldered Parrot	NT	Betano Beaço
Cinnamon-banded Kingfisher	NT	Betano Beaço
Timor Bushchat	NT	Betano Beaço
Canut's Horseshoe Bat	VU	Betano Beaço

4.2.4 Endemic Fauna

Timor-Leste lies in a biogeographic region known as Wallacea, which is predominately colonised with plants and animals from Asia and Australia. Due to the island's long isolation, endemism has reached exceptional levels (Trainor et al. 2008), with Timor having the highest rates of endemism recorded in Indonesia, at 10.3 % (Rhee et al. 2004). Endemism occurs especially for frogs (about 50% Timor-endemic), skinks (25%) and geckos (25%). Remarkably, only four native terrestrial mammals have been recorded including the Timor Shrew (*Crocidura tenuis*) Sunda Shrew (*Crocidura maxi*), Timor Rat (*Rattus timoriensis*) and Ricefield Rat (*Rattus argentiventer*) Trainor et al. (2008).

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REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

CHAPTER 5

DISCUSSION

301012-01504-EN-REP-0006
June 2012

5. DISCUSSION

5.1 Summary

A flora and vertebrate fauna assessment for the Tasi Mane Project - Betano Refinery and Petrochemical Industries and the Beaço LNG Plant was undertaken in December 2011 and February 2012. A total of 201 species of flora were recorded. A total of 98 species of vertebrate fauna were recorded in the project study areas, consisting of 2 species of amphibians, 11 species of reptiles, 70 species of birds and 15 species of mammals. Sixty species of vertebrate fauna were recorded in the Betano development area, consisting of 7 species of reptiles, 40 species of birds and 13 species of mammals. Eighty species of vertebrate fauna were recorded in the Beaço development area, consisting of 2 species of amphibians, 9 species of reptiles, 59 species of birds and 10 species of mammals

Species listed as Critically Endangered, Endangered, Vulnerable and Near Threatened under the IUCN Red List constitute species of conservation significance. A lack of baseline data of Timor-Leste's flora and fauna indicates that not all occurrences of conservation significant species have been assessed by the IUCN. There is a possibility that additional species of conservation significance may occur within the Betano and Beaço development areas.

Two Vulnerable listed flora species were recorded in the Betano and Beaço development areas, *Pterocarpus indicus* and *Santalum album,* which are both valuable timber species. Seven species of conservation significance were recorded in the study area: Canut's Horseshoe Bat (*Rhinolophus canuti timoriensis*), Great Knot (*Calidris tenuirostris*), Slaty Cuckoo Dove (*Turacoena modesta*), Pink-headed Imperial Pigeon (*Ducula rosacea*), Olive-shouldered Parrot (*Aprosmictus jonquillaceus*) Cinnamon-Banded Kingfisher (*Todiramphus australasia*), and Timor Bush-chat (*Saxicola gutturalis*).

Mangrove communities in the Beaço LNG Plant area represent some of the only remnant vegetation in good condition and are considered to have conservation significance. A stand of *Sonneratia alba* trees recorded on the seaward edge to the west of Ponta Beaço is likely to represent an important marine and faunal habitat. The largest riparian mangrove community occurred at the area known as 'Belalut', and dominant tree species were *Avicennia marina* and *Xylocarpus moluccens.* Coastal habitats inclusive of mangroves provide a habitat for a range of fauna vertebrate species and often species that are habitat specific. Species like migratory waders and conservation significant bird species like the Cinnamon-Banded Kingfisher (*Todiramphus australasia*) can be found foraging and nesting in such habitats.

Four fauna habitats were recorded across both development areas, including Moist Deciduous Woodland/Forest, Coastal, Riparian and Swidden Agriculture. Generally the intact vegetation was found in the Deciduous Woodland/Forest and Coastal habitat types where as the Riparian and Swidden Agriculture had largely been degraded and impacted by man. Often, the greater impact from agricultural practises the reduced availability of micro-niches occurs, for example, sheltering, foraging and nesting potential for fauna species.

5.2 Environmental Impacts/Issues

Flora and Fauna

The construction and operation of the Betano and Beaço development areas is likely to have adverse effects on the terrestrial environment. This strategic level assessment is focused on the identification of existing ecological values at the proposed Betano development site. Whilst the area to be cleared for the proposed infrastructure is not known, it is desirable that the areas of conservation significance and habitat value identified through detailed baseline assessment, could be avoided during the infrastructure design stage.

Potential environmental impacts for flora, vegetation communities and fauna as a result of construction and operations, include, but are not limited to:

- Loss of individuals of IUCN listed species; *Santalum album* (sandalwood) *Pterocarpus indicus* (rosewood), both valuable timber trees;
- Loss of floristic biodiversity that has not been documented;
- Secondary weed invasion after clearing, particularly Siam weed and Cogon Grass;
- Loss of forest and tree cover;
- Loss of important mangrove habitat;
- Loss of agricultural land and subsistence gardens;
- Loss of food crops and estates e.g., coconuts, bananas;
- Loss of timber for fuel source;
- Loss of cash crops e.g., Teak, Rosewood and Sandalwood; and
- Loss of fauna habitat, specifically important habitat for species of conservation significance.
- Increased potential of vehicle strike upon vertebrate fauna species;
- Increased potential of noise disturbance to vertebrate fauna species, particular nesting and roosting individuals; and
- Increased potential of vertebrate fauna habitat fragmentation.

The removal of vegetation cover will result in the destabilization of soils and an increased rate of erosion and sedimentation.

5.3 Avoidance, Management and Mitigation Measures

Flora and Fauna

The loss of vegetation within the Betano and Beaço development areas is a likely and unavoidable consequence of the construction process. The potential impact of these alterations can be reduced by avoiding sensitive and high-conservation value habitats when selecting the development location.

Mitigations measures should be developed for construction works to reduce vegetation clearance. These may be incorporated into an environmental management system for the Betano Refinery and Beaço LNG Plant. Detailed vegetation mapping and a vegetation management plan prepared in advance of vegetation clearance can help to ensure that high-quality vegetation is protected and clearing activities are controlled and monitored.

The impact of remnant vegetation clearance may be reduced by avoiding impacts to the high conservation value remnant vegetation.

It is recommended that riparian vegetation be preserved and rehabilitated to reduce erosion and maintain current flow patterns of rivers. To reduce soil erosion, those river bank areas not in use within the Betano and Beaço development area can be rehabilitated and revegetated.

Mangroves

Construction will unavoidably remove some areas of mangrove habitat and the faunal communities they contain. Further impacts on mangroves can be limited through the control of vegetation clearance and detailed design to avoid or minimise clearance.

Wastewater or desalination outlet should be located away from remnant mangrove vegetation.

Invasive Plant Species

The removal of the canopy layer in coastal forest is likely to result in the spread of invasive weeds, in particular Siam weed, Cogon Grass and Coffee Bush. A weed management plan should be prepared incorporating weed hygiene practices to reduce spread of weed propagules and weed control measures to reduce the colonisation of weed species within the development area.

Protocols will be developed into an invasive weed management plan and incorporated as part of the environmental management system for the Betano Refinery and Beaço LNG Plant.

Vertebrate Fauna

The removal of remnant moist deciduous woodland/forests and coastal habitats places further pressure on the species that are reliant on these areas for sheltering, foraging and nesting. Specifically, the species of conservation significance that were recorded or may potentially be found in the future.

The Riparian and Swidden Agriculture habitats in the Betano and Beaço development areas are already fragmented and degraded and do not constitute environmentally sensitive areas. However, without adequate baseline data for comparison, the level of ecological linkage with surrounding vegetation in the vicinity is unknown. In addition, the proposed potential impacts from increase vehicle traffic and noise disturbance is difficult to gauge considering the lack of knowledge.

5.4 Monitoring and Reporting

Flora and Fauna

The monitoring and reporting measures for flora and fauna during construction and operations include:

- A multiple season baseline flora, vegetation and fauna assessment of the remnant vegetation is recommended.
- Surveys undertaken at different seasons during the year to record different fauna species assemblages and to capture fruiting and flowering patterns.
- A monitoring program for remnant vegetation may be designed and implemented at the completion of a baseline assessment. Including independent expert advice on the potential sites ability to house displaced individuals.
- A mangrove health monitoring program should be established within the remnant mangrove communities to document the health of mangrove species during the construction and operation phase of the project.

5.5 Further Work

Flora and Vegetation

It is recommended that additional baseline flora and vegetation assessment are undertaken at the proposed Beaço and Betano development areas, including:

- Quadrats to define floristic composition and structural form of each vegetation community, particularly in mangrove and moist forest vegetation.
- A checklist of flora species including annual herbs, ferns, epiphytes, mosses, bryophytes, parasitic plants to record floristic diversity.
- Vegetation mapping at a scale of 1:10,000.
- Undertaking field work at other times of the year to detect a full range of species.

Fauna

It is recommended that additional fauna surveys are undertaken across several seasons. It is also recommended that the duration of field trips are extended to ensure a more thorough survey. This will increase the likelihood that potentially critically endangered species are recorded.

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CHAPTER 6

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APPENDIX 1

IUCN Red List

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The IUCN Red List of Threatened Species™ is widely recognized as the most comprehensive, objective global approach for evaluating the conservation status of plant and animal species (IUCN 2012). It provides taxonomic, conservation status and distribution information on plants and animals that have been globally evaluated using the IUCN Red List Categories and Criteria (IUCN 2012). The IUCN red List describes nine categories that which a species of flora and fauna can be assessed as. Table 1 details the nine categories in which species can be determined as. This system is designed to determine the relative risk of extinction, and the main purpose of the IUCN Red List is to catalogue and highlight those plants and animals that are facing a higher risk of global extinction (i.e. those listed as Critically Endangered, Endangered and Vulnerable). The IUCN Red List also includes information on plants and animals that are categorized as Extinct or Extinct in the Wild; on taxa that cannot be evaluated because of insufficient information (i.e., are Data Deficient); and on plants and animals that are either close to meeting the threatened thresholds or that would be threatened were it not for an ongoing taxon-specific conservation programme (i.e., are Near Threatened) (IUCN 2012).

Table 1 The detailed criteria and categories of the IUCN Red List

Criteria		Description
EX	Extinct	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
EW	Extinct in the Wild	A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
CR	Critically Endangered	A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Section V), and it is therefore considered to be facing an extremely high risk of extinction in the wild.
EN	Endangered	A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.
VU	Vulnerable	A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable, and it is therefore considered to be facing a high

Criteria		Description
		risk of extinction in the wild.
NT	Near Threatened	A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.
LC	Least Concern	A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.
DD	Data Deficient	A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.
NE	Not Evaluated	A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.

Source: http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria

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APPENDIX 2

Flora Species List

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Vascular flora species recorded in the Tasi Mane project area

Life Form Key: Tree (T), Shrub (S), Vine (V), Herb (H)

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
ACANTHACEAE	*Acanthus ilicifolius*		holly leaf mangrove	S		
ACANTHACEAE	*Avicennia marina*	ate-dara		T		
ACANTHACEAE	Indeterminate		pea herb	H		
ACANTHACEAE	*Lepidagathis eucephala*		herb	H		
ACANTHACEAE	*Ruellia tuberosa*		Petunia	H		
AMARANTHACEAE	*Aerva sanguinolenta*			H		
AMARYLLIDACEAE	*Crinum* affin. *stuhlmannii*			H		
ANACARDIACEAE	*Anacardium occidentale*	caijus	cashew	T		
ANACARDIACEAE	*Mangifera indica*	has	mango	T		
ANACARDIACEAE	*Mangifera timorensis*	has fuik	wild mango	T		
ANNONACEAE	*Annona squamosa*	ayata		T		
ANNONACEAE	*Uvaria rufa*	hudi-clar	vine	V		
APOCYNACEAE	*Alstonia scholaris*	ai-roti		T		
APOCYNACEAE	*Alstonia spectabilis*	ate-rutik	native frangipani	T		
APOCYNACEAE	*Amphineurion marginatum*		vine	V		
APOCYNACEAE	*Asclepias curassavica*		herb	H		
APOCYNACEAE	*Cascabela thevetia*	ai-askabit		S		
APOCYNACEAE	*Cerbera manghas*	ai-odi	native frangipani	T		
APOCYNACEAE	*Dischidia major*	tatalik	vine	V		
APOCYNACEAE	*Tabernaemontana pandacaqui*	ai-kahoruk		S		
APOCYNACEAE	*Wrightia pubescens* subsp. *pubescens*	ai-lele fuik		T		
APOCYNACEAE	*Wrightia* sp.	ai-lele fuik		V		
ARACEAE	*Amorphophallus paeonifolius*	maek		H		
ARECACEAE	*Borassus flabellifer*	tali	palm	T		

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
ARECACEAE	*Cocus nucifera*	nú	coconut	T		
ARECACEAE	*Corypha utan*	tuatali metan	palm	T		
ARECACEAE	*Nypa fruiticans*	ai-tasi	mangrove palm	T		
ARECACEAE	*Salacca edulis*	ai-rota		T		
ASCLEPIDIACEAE	*Calotropis gigantea*	fuka	Crown flower	S	*	
ASPARAGACEAE	*Asparagus racemosus*	hatikibi		V		
ASPARAGACEAE	*Pleomele flexuosa*			S		
ASTERACEAE	*Chromolaena odorata*	ai-funanmutik	Siam weed	S	*	
ASTERACEAE	*Pluchea indica*			S		
ASTERACEAE	*Tridax procumbens*			H		
BIGNONIACEAE	*Dolichandrone spathacea*	ai-sirian		T		
BORAGINACEAE	*Cordia dichotoma*	ai-nunak, ai-bokelili, ai-nonawae		T		
BORAGINACEAE	*Cordia subcordata*	ate-biamete		S		
BORAGINACEAE	*Tournefortia sarmentosa*	vine		S		
CACTACEAE	*Opuntia ficus-indica*		cactus	S		
CARICACEAE	*Carica papaya*	aidila	papaya	S		
CASUARINACEAE	*Casuarina* sp. affin. *junghuhniana*	ai-kakeu	she-oak	T		
CELASTRACEAE	*Maytenus marginata*	ai-luruka		T		
CLEOMACEAE	*Cleome viscosa*			H		
CLUSIACEAE	*Calophyllum inophyllum*	ai-toh		T		
COLCHICACEAE	*Gloriosa superba*	tatalik	vine	H		
COMBRETACEAE	*Lumnitzera racemosa*	ai-biku	mangrove	T		Timor, Alor
COMBRETACEAE	*Terminalia catappa*	ai-lesse		T		
CONVOLVULACEAE	*Ipomoea aquatica*	kanko (Kangkung, Indonesia)		H		
CONVOLVULACEAE	*Ipomoea batatas*	fehuk midar	sweet potato	H		
CONVOLVULACEAE	*Ipomoea pes-caprae*			V		
CONVOLVULACEAE	*Ipomoea* sp.			V		

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
CONVOLVULACEAE	*Ipomoea triloba*	tatalik		V		
CONVOLVULACEAE	*Merremia emarginata*	tatalik		V		
CUCURBITACEAE	*Citrullus lanatus*	pateka	watermelon	V		
CUCURBITACEAE	*Cucumis sativus*	pipinu	cucumber	V		
CUCURBITACEAE	*Cucumis sp.*	melansia	melon	V		
CUCURBITACEAE	*Cucurbita sp.*	lakeru	pumpkin	V		
CYPERACEAE	*Cyperus javanicus*	du'ut	sedge	H		
CYPERACEAE	*Fimbristylis cymosa*	du'ut	sedge	H		
CYPERACEAE	*Fimbristylis ferruginea*	du'ut		H		
CYPERACEAE	*Schoenus falcatus*			H		
EBENACEAE	*Diospyros littorea*	ai-metan		T		
EBENACEAE	*Diospyros montana*	ai-metan	caraumatan fuan	T		Philippines, Celebes, E Java, LSI (Lombok, Sumba, Flores, Timor);
EUPHORBIACEAE	*Aleurites moluccana*	cami	candlenut	T		India to Pacific Is; t/o Malesia; (pres Timor), cult
EUPHORBIACEAE	*Euphorbia tithymaloides*	ai-tatalik tasi		H		
EUPHORBIACEAE	*Excoecaria agallocha*	ai-tano	mangrove	T		
EUPHORBIACEAE	*Excoecaria agallocha*	ai-tano	mangrove	T		
EUPHORBIACEAE	*Jatropha curcas*	banut-mutin		S	*	
EUPHORBIACEAE	*Jatropha curcas*	banut-mutin		S		
EUPHORBIACEAE	*Jatropha gossypiifolia*	miro		S	*	introduced Timor
EUPHORBIACEAE	*Mallotus philippensis*	ai-sablama, ai-dikin meak		T		
EUPHORBIACEAE	*Mallotus tiliifolius*	ai-besi tahan bo'ot				Taiwan to N Aust; LSI (Ba, Ti)
EUPHORBIACEAE	*Manihot esculenta*	aiferina	cassava	H		
FABACEAE	*Abrus prectatorius*	olonanawa		V		
FABACEAE	*Acacia nilotica* subsp. *indica*	roat, ai-bakuro malae, ai-tarak	acacia	T		

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
FABACEAE	*Albizia lebbeckoides*	ai-samtuku, ai-martuku		T		China to NG; LSI (Bali, Kisar, Sumba, Sumbawa, Komodo, Flores, Timor)
FABACEAE	*Albizia saman*	ai-matan dukur	sleeping tree	T		Native to S Am; intro in LSI; scarcely naturalised Timor
FABACEAE	*Albizia tomentella* subsp. *rotundata*	ai-cachote fuik		T		
FABACEAE	*Arachis hypogaea*	forai	peanut	H		
FABACEAE	*Bauhinia cunninghamii*			S		
FABACEAE	*Cassia javanica* subsp. *nodosa*	ai-mutin				Thailand to LSI (pres Timor, Flores)
FABACEAE	*Cathormion umbellatum*	ai-lulun		T		
FABACEAE	*Centrosema molle*	tatalik		V		
FABACEAE	*Delonix regia*		poinciana	T		
FABACEAE	*Desmanthus virgatus*			S		
FABACEAE	*Dichrostachys cinerea* subsp. *malesiana*	ai-adelae		T		
FABACEAE	*Leucaena leucocephala*	ai-café	coffee tree	T	*	Pantropical; t/o Malesia (intro) Timor
FABACEAE	*Peltophorum pterocarpum*	ai-máme, bak-mur		T		Sri Lanka to N Aust; t/o Malesia, pres Timor
FABACEAE	*Pterocarpus indicus*	ai-na		T		
FABACEAE	*Senna timorensis*	ai-cachote		S		
FABACEAE	*Tamarindus indica*	sukaer	tamarind	T	*	
FABACEAE	*Teramnus labialis*			V		
FABACEAE	*Uraria lagopodioides*	Ervilha	pea	H		all LSI
FABACEAE	*Vachellia nilotica*	ai-bakuro malae, ai-tarak		T	*	
FABACEAE	*Vigna unguiculata* subsp. *sesquipedalis*	fore	beans	H		
FLAGELLARIACEAE	*Flagellaria indica*	tatalik tirilolo		V		

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
GOODENIACEAE	*Scaevola taccada*	ai- tasi	scaevola	S		
Indet	Indet	ai-feu				
LAMIACEAE	*Callicarpa candicans*	sapateri	vine	S		
LAMIACEAE	*Gmelina arborea*	ai-teka	teak	T		
LAMIACEAE	*Gmelina elliptica*	ai-lok fuk		V		
LAMIACEAE	*Ocimum tenuiflorum*			H		
LAMIACEAE	*Premna serratifolia*	tatalik, ai-tasi	vine	S		
LAMIACEAE	*Premna* sp. (IDC11096)	ai-manas fuik		T		
LAMIACEAE	*Vitex pinnata*	ai-tahan tolu		T		
LAMIACEAE	*Vitex trifolia*	ai-tasi		S		
LAURACEAE	*Cinnamomum* sp.	ai-canela	cinnamon tree	T		
LAURACEAE	*Litsea glutinosa*			T		
LECYTHIDACEAE	*Barringtonia racemosa*	ai-baknas, ai-baganasa	mangrove	T		
LILIACEAE	*Gloriosa superba*	tatalik	vine	V		
LOGANIACEAE	*Strychnos lucida*	bakmur lotuk		T		IndoAustralia, E Java, LSI (Bali, Flores, Sumbawa, Timor, Wetar, Babar)
LOMARIOPSIDACEAE	*Nephrolepis sp.*		fern	F		
LYGODIACEAE	*Lygodium circinnatum*	ai-tatalik lutu	fern	F		
LYTHRACEAE	*Sonneratia alba*	ate-kesu, ai-tano	red mangrove	T		
MALPIGHIACEAE	*Hiptage benghalensis*	tatalik	vine	V		India to Taiwan to LSI (Bali, Alor, Timor) vine, mericarp1, 3-winged
MALPIGHIACEAE	*Ryssopterys timoriensis*	tatalik	vine	V		
MALVACEAE	*Ceiba petandra*	cabas katal - Timor	wild cotton	T		
MALVACEAE	*Gossypium arboreum*		wild cotton	S		
MALVACEAE	*Grewia sp.*	ai-semen		T		
MALVACEAE	*Helicteres isora*	oel		S		FS

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
MALVACEAE	*Heritiera littoralis*	ai-kebo	mangrove	T		
MALVACEAE	*Hibiscus tiliaceus*	ai-fau, ai-araleu, ai-katar		T		
MALVACEAE	*Sida.* sp.			H		
MALVACEAE	*Stercula foetida*	ai-bano		S		
MELIACEAE	*Aglaia elaeagnoidea*	ai-mean		T		
MELIACEAE	*Aphanamixis polystachya*			T		
MELIACEAE	*Dysoxylum gaudichaudianum*	ai-corneta	vine	T		Philip. to Samoa, Aust (Q); LSI (Sumbawa, Flores, Timor)
MELIACEAE	*Melia azedarach*	ai-betukate		T		
MELIACEAE	*Xylocarpus moluccensis*	ate-sabrika	mangrove	T		India to N Aust.; t/o Malesia, pres Timor
MORACEAE	*Artocarpus altilis*	kulu modo	breadfruit	T		
MORACEAE	*Artocarpus heterophyllus*	kulu jaka	jackfruit			
MORACEAE	*Broussonetia papyrifera*	ai-bau		T		India to NG; LSI(Fl,Ti,Al,We)
MORACEAE	*Fatoua pilosa*		herb	H		Philippines, Celebes, Java, all LSI, Moluccas, Melanesia
MORACEAE	*Ficus ?benjamina* or *microcarpa*		fig			
MORACEAE	*Ficus hispida*	ai-kapkou		T		
MORACEAE	*Ficus racemosa* var. *racemosa*	ai-catimu-fuik	fig	T		
MORACEAE	*Ficus* sp.	ai-hale	fig	T		
MORACEAE	*Ficus variegata*	ai-kun	fig	T		
MORACEAE	*Ficus virens, drupacea* or *superba*	hale	fig	T		
MORACEAE	*Streblus taxoides*		vine	S		India to LSI (Fl,Ti)
MUNTINGIACEAE	*Muntingia calabura*	cerejes	Timor cherry	T		
MUSCACEAE	*Musa* sp.	hudi	banana	T		
MYRTACEAE	*Psidium guajava*	goyava	guava	T		
NYCTAGINACEAE	*Boerhavia errecta*	marlale		H		

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
ORCHIDACEAE	*Tropidia curculigoides*	trilolo	vine	H		
OXALIDACEAE	*Averrhoa bilimbi*	belimbe		S		
PANDANACEAE	*Pandanus* sp.	ai-hedan	Pandanus	T		
PANDANACEAE	*Pandanus tectorius*		Pandanus	T		
PASSIFLORACEAE	*Passiflora foetida*	marquisas	wild passionfruit	V		
PHYLLANTHACEAE	*Bridelia ovata*	ate-siki		T		LSI (Ba, Sw, Su, Fl, Ti, Al)
PHYLLANTHACEAE	*Bridelia tomentosa*	ate-kai lakudiri		T		
PHYLLANTHACEAE	*Flueggea virosa*		vine	S		Af to N Aust; LSI (Fl, Sw, Ti)
PHYLLANTHACEAE	*Glochidion xerocarpum*	metikai-kobi, ai-nabu		T		
PIPERACEAE	*Piper sulcatum*	ai-manas aileten	vine	V		
POACEAE	*Bambusa blumeana*	au	bamboo	H		D.Franklin (pers.comm.); Apparently native, possibly naturalised from historical introductions
POACEAE	*Chloris truncata*		grass	H		
POACEAE	*Chrysopogon aciculatus*	du'ut	grass	H	*	
POACEAE	*Cyrtococcum trigonum*		grass	H		
POACEAE	*Imperata cylindrica*	pae	grass	H	*	
POACEAE	*Saccharum spontaneum*	du'ut bobok	grass		*	
POACEAE	*Spinifex littoreus*		beach spinifex	H		
POACEAE	*Zea mays*	batar	corn	S		
POLYPODIACEAE	*Drynaria quercifolia*	kluku	basket fern	F		
POLYPODIACEAE	*Platycerium* sp.	pakis (indonesian)	stag horn	F		
POLYPODIACEAE	*Pyrrosia longifolia*		fern	F		
PRIMULACEAE	*Maesa* sp. affin. *integrifolia*	ai-lenuk, ai-tasi		S		
PTERIDACEAE	*Adiantum caudatum*		fern	F		
PTERIDACEAE	*Doryopteris concolor*		fern	F		
PTERIDACEAE	*Pteris ensiformis*		fern	F		

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
RHAMNACEAE	*Ziziphus celtidifolia*	ai-meda-odan		T		
RHAMNACEAE	*Ziziphus mauritiana*	ai-lok		T	*	
RHAMNACEAE	*Ziziphus timoriensis*	ai-metan bo'ot, lerhula ki'ik		T		
RHIZOPHORACEAE	*Rhizophora stylosa*		mangrove	T		
RUBIACEAE	*Hedyotis biflora*			H		
RUBIACEAE	*Morinda citrifolia*	mengkudu or ai-lenuk		T		
RUBIACEAE	*Nauclea orientalis*	ai-kafira, sawa		T		
RUBIACEAE	*Timonius timon*	kiar, ai-catimu		T		Australia, NG, Moluccas, Celebes, Lesser Sunda lslands (Bali, Sumba, Sumbawa, Flores, Timor).
RUTACEAE	*Aegle marmelos*	aidila fatuk	wild papaya	T		
RUTACEAE	*Fimbristylis ferruginea*			H		
RUTACEAE	*Harrisonia brownii*	ate-gaba		S		
RUTACEAE	*Luvunga monophylla*			V		
RUTACEAE	*Triphasia trifolia*	derok fuik		S		
SANTALACEAE	*Exocarpos latifolius*	ai-cacasa, tatalik metan		T		
SANTALACEAE	*Santalum album*	ai-cameli	sandalwood	T		Australia (N Territory), S NG, S Celebes, LSI (Timor, Flores);
SAPINDACEAE	*Allophylus cobbe*	ai-menas-fuik	vine	S		Pantropical; all Malesia (pres Timor)
SAPINDACEAE	*Elattostachys verrucosa*	ai-baknas, ate-asaulalai		T		Java to Philip & Moluccas, LSI (Bali, Lombok, Sumba, Sumbawa, Flores, Timor, Wetar)
SAPINDACEAE	*Lepisanthes rubiginosa*			S		N India to NW Aust (WA); common Malesia (Timor)
SAPINDACEAE	*Schleichera oleosa*	ai-dak		T		Sri Lanka to China & Moluccas; LSI (Bali Sumba,

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
						Sumbawa, Flores, Timor, Alor)
SCROPHULARIACEAE	*Myoporum montanum*	ai-kahoruk ki'ik		S		
SMILACACEAE	*Smilax zeylanica*	tatalik siapa	vine	V		
SOLANACEAE	*Capsicum annuum*	ai-manas		H		
STERCULIACEAE	*Helicteres isora*	oel				
THELYPTERIDACEAE	*Christella arida*	pakis (Indonesian)	fern	F		
THYMELAEACEAE	*Phaleria octandra*	ai-laliti		S		Australia, Thursday Island, SE Moluccas (Tenimber Islands), all LSI, Java;
VERBENACEAE	*Lantana camara*	ai-funan meak	lantana	V	*	
VERBENACEAE	*Stachytarpheta cayennensis*		herb	H	*	
VERBENACEAE	*Tectona grandis*	ai-teka	teak	T		
VIOLACEAE	*Hybanthus enneaspermus*	fore tali	pea	H		Philippines, E Java, all LSI, Moluccas, NG. Once in N Borneo
VITACEAE	*Ampelocissus arachnoideus*		vine	V		
VITACEAE	*Cayratia trifolia*	tatalik	vine	V		
VITACEAE	*Leea aequata*	ai-manek	climber	H		Nepal to Moluccas; LSI (Sumba, Timor, Wetar)

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APPENDIX 3

IUCN Listed Flora

301012-01504-EN-REP-0006
June 2012

Family	Species	Status
Acanthaceae	*Acanthus ilicifolius* (Holy Mangrove)	Least Concern
Burmanniaceae	*Burmannia disticha*	Least Concern
Ceratophyllaceae	*Ceratophyllum muricatum*	Least Concern
Cyperaceae	*Carex baccans* (Crimson Seeded Sedge)	Least Concern
Cyperaceae	*Cyperus compactus*	Least Concern
Cyperaceae	*Diplacrum caricinum*	Least Concern
Cyperaceae	*Echinochloa picta*	Least Concern
Cyperaceae	*Eleocharis geniculata* (Canada Spikesedge)	Least Concern
Cyperaceae	*Eleocharis retroflexa*	Least Concern
Cyperaceae	*Fimbristylis argentea*	Least Concern
Cyperaceae	*Fimbristylis bisumbellata* (Fimbristylis à Deux Ombelles)	Least Concern
Cyperaceae	*Fimbristylis consanguinea*	Least Concern
Cyperaceae	*Fimbristylis dipsacea* (Harper's Fimbristylis)	Least Concern
Cyperaceae	*Fimbristylis nutans*	Least Concern

Family	Species	Status
Cyperaceae	*Fimbristylis ovata*	Least Concern
Cyperaceae	*Fuirena pubescens* (Fuirène Pubescent)	Least Concern
Cyperaceae	*Lipocarpha gracilis*	Least Concern
Cyperaceae	*Pycreus macrostachyos*	Least Concern
Cyperaceae	*Pycreus sanguinolentus*	Least Concern
Cyperaceae	*Schoenoplectiella lateriflora*	Least Concern
Cyperaceae	*Scleria mikawana*	Least Concern
Cyperaceae	*Scleria terrestris*	Least Concern
Fabaceae	*Parochetus communis* (Blue Oxalis)	Least Concern
Halagoraceae	*Myriophyllum tuberculatum*	Least Concern
Leguminosae	*Sesbania javanica*	Least Concern
Lemnaceae	*Lemna minor* (Common Duckweed)	Least Concern
Lygodiaceae	*Lygodium microphyllum*	Least Concern
Poaceae	*Brachiaria eruciformis*	Least Concern

Family	Species	Status
Poaceae	*Eriochloa procera* (Spring Grass)	Least Concern
Poaceae	*Leptochloa fusca*	Least Concern
Poaceae	*Leptochloa obtusiflora*	Least Concern
Poaceae	*Leptochloa panicea* (Mucronate Sprangletop)	Least Concern
Podocarpaceae	*Podocarpus rubens*	Lower Risk/least concern
Podocarpaceae	*Sundacarpus amarus*	Lower Risk/least concern
Podostemaceae	*Cladopus nymanii*	Least Concern
Scrophulariaceae	*Lindernia antipoda*	Least Concern

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APPENDIX 4

Fauna Habitat Assessments

301012-01504-EN-REP-0006
June 2012

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Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	14 December 2011	ML
Site Number – HA5 [Betano]			
Habitat	Riparian		
UTM Coordinates	Zone 51L Easting 802800 Northing 8985912		

Stratum	Species	Cover (%)	Height (m)
Over-story	[ai-bakmur], *Schleichera oleosa* [ai-dak]	<20%	< 25 m
Mid-story	Pandanus spp. [ai-hedan], Palmyra Palm *Borassus* spp. [tali], *Acacia* spp. [ai-tarak]	>20%	~4 m
Under-story	Siam Weed *Chromolaena odorata* [ai-funanmutik], deciduous herbs and grasses	>20%	< 0.5 m

Litter cover	Logs (%) <1%		Twigs (%) <5%		Leaves (%) >5%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Cracks / crevices	nil					
Soils	Brown sand					
Tree Hollows	Large	nil	Medium	Present	Small	Present
Water Bodies	Dry creek bed potential for pooling					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Small dry creek. Dense understory promotes high micro-niche diversity and abundance.					

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Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	14 December 2011	ML
Site Number – HA6 [Betano]			
Habitat	Deciduous Woodland / Forest		
UTM Coordinates	Zone 51L Easting 802019 Northing 8986794		

Stratum	Species	Cover (%)	Height (m)
Over-story	*Schleichera oleosa* [ai-dak], [ai-tahantolu]	10-30%	< 20 m
Mid-story	[lerhula ki'ik]	>50%	1-5 m
Under-story	Deciduous herbs and grasses	>40%	< 0.4 m

Litter cover	Logs (%) <1%		Twigs (%) >5%		Leaves (%) >10%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Cracks / crevices	nil					
Soils	Reddish Brown soil with white limestone rocks cobbles and pebbles					
Tree Hollows	Large	nil	Medium	Present	Small	Present
Water Bodies	nil					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Dense understory with complex leaf litter high micro-niche diversity potential.					

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Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	15 December 2011	ML
Site Number – HA7 [Betano]			
Habitat	Deciduous Woodland / Forest		
UTM Coordinates	Zone 51L Easting 802681 Northing 8986647		

Stratum	Species	Cover (%)	Height (m)
Over-story	Gebang Palm *Chorypha utan* [tuatali metan], Pandanus spp. [ai-hedan], Palmyra Palm *Borassus* spp. [tali]	10-20%	<20 m
Mid-story	nil	nil	nil
Under-story	Siam Weed *Chromolaena odorata* [ai-funanmutik]	>50%	<1 m

Litter cover	Logs (%) nil Twigs (%) <5% Leaves (%) 20%					
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Cracks / crevices	nil					
Soils	Reddish brown sand					
Tree Hollows	Large	nil	Medium	nil	Small	Present
Water Bodies	nil					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Lack of complex understory species / stratum reduced micro-niche potential; area subject to repeatable fire events and swidden agriculture.					

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Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	18 December 2011	ML
Site Number – HA8 [Beaço]			
Habitat	Deciduous Woodland / Forest		
UTM Coordinates	Zone 52L Easting 216473 Northing 9010093		

Stratum	Species	Cover (%)	Height (m)
Over-story	Gebang Palm *Chorypha utan* [tuatali metan], Palmyra Palm *Borassus* spp. [tali], [sawa], *Ziziphus mauritiana* [ai-lok], [ai-martuku]	10-20%	<20 m
Mid-story	*Acacia* spp. [ai-tarak]	>40%	1-4 m
Under-story	Siam Weed *Chromolaena odorata* [ai-funanmutik], Sedge [du'ut], Herb [marlale]	>50%	< 0.5 m

Litter cover	Logs (%) <1%		Twigs (%) <5%		Leaves (%) 10-20%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Cracks / crevices	nil					
Soils	Brown sand /mud complex					
Tree Hollows	Large	nil	Medium	nil	Small	Present
Water Bodies	nil					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Possible inundation on really high tide events					

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Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	19 December 2011	ML
Site Number – HA9 [Beaço]			
Habitat	Deciduous Woodland / Forest		
UTM Coordinates	Zone 52L Easting 217643 Northing 9010102		

Stratum	Species	Cover (%)	Height (m)
Over-story	Gebang Palm *Chorypha utan* [tuatali metan], Palmyra Palm *Borassus* spp. [tali], [sawa], *Ziziphus mauritiana* [ai-lok], [ai-martuku], *Ficus variegata* [ai-kun], Ficus spp. [hali], [ai-catimu]	10-20%	<20 m
Mid-story	*Acacia* spp. [ai-tarak]	>40%	1-4 m
Under-story	Siam Weed *Chromolaena odorata* [ai-funanmutik], Sedge [du'ut], Herb [marlale]	>50%	< 0.5 m

Litter cover	Logs (%) <1%		Twigs (%) <10%		Leaves (%) >20%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Cracks / crevices	nil					
Soils	Brown sand					
Tree Hollows	Large	nil	Medium	Present	Small	Present
Water Bodies	nil					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Lack of complex understory species / stratum reduced micro-niche potential; area subject to repeatable fire events and swidden agriculture. Fruiting trees *Ficus variegata* [ai-kun] present provide foraging sources for bats and fruit eating birds (Doves & Pigeons)					

Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	20 December 2011	ML
Site Number – HA10 [Beaço]			
Habitat	Riparian		
UTM Coordinates	Zone 52L Easting 216750 Northing 9010025		

Stratum	Species	Cover (%)	Height (m)
Over-story	*Schleichera oleosa* [ai-dak], [ate-dara], [betu kate]	<20%	< 25 m
Mid-story	Pandanus spp. [ai-hedan]	>20%	~4 m
Under-story	Holly Mangrove *Acanthus ilicifolius*	< 10%	<1 m

Litter cover	Logs (%) <1%		Twigs (%) <5%		Leaves (%) >20%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Cracks / crevices	nil					
Soils	Brown sand /mud complex					
Tree Hollows	Large	nil	Medium	nil	Small	Present
Water Bodies	4 m wide estuarine tributary					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Large trees deciduous species, little mid-story or understory structure. Small creekline 4 m wide estuarine tributary. 'Holly' mangrove species present					

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Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	21 December 2011	ML
Site Number – HA11 [Beaço]			
Habitat	Deciduous Woodland / Forest		
UTM Coordinates	Zone 52L Easting 222341 Northing 9010610		

Stratum	Species	Cover (%)	Height (m)
Over-story	*Schleichera oleosa* [ai-dak], [sawa], *Ziziphus mauritiana* [ai-lok], [ai-martuku], *Ficus variegata* [ai-kun], Ficus spp. [hali], [ai-catimu]	10-20%	<20 m
Mid-story	*Acacia* spp. [ai-tarak]	>40%	1-4 m
Under-story	Vine species [sapateri, tatalik tirilolo, ate-gabo], Sedge [du'ut], Herb [marlale]	>50%	< 0.5 m

Litter cover	Logs (%) <1%		Twigs (%) <5%		Leaves (%) >10%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Cracks / crevices	nil					
Soils	Brown sand					
Tree Hollows	Large	nil	Medium	Present	Small	Present
Water Bodies	nil					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Vine thicket, large trees in complex vegetation stratum. High micro-niche biodiversity.					

WorleyParsons resources & energy

EcoNomics

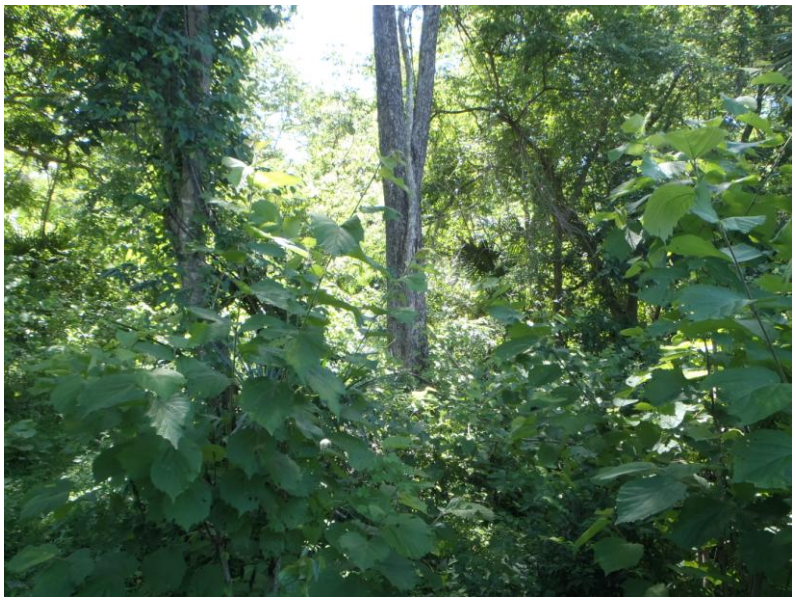
Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	10 February 2012	ML
Site Number – HA15 [Betano]			
Habitat	Deciduous Woodland / Forest		
UTM Coordinates	Zone 51L Easting 796661 Northing 8990460		

Stratum	Species	Cover (%)	Height (m)
Over-story	Palmyra Palm *Borassus* spp. [tali], *Schleichera oleosa* [ai-dak], [sawa], *Ziziphus mauritiana* [ai-lok], [ai-martuku], *Ficus variegata* [ai-kun], Ficus spp. [hali], [ai-catimu], Bamboo	<35%	20-25 m
Mid-story	nil	Nil	nil
Under-story	Siam Weed *Chromolaena odorata* [ai-funanmutik], Vine species [sapateri, tatalik tirilolo, ate-gabo],	>50%	<1 m

Litter cover	Logs (%) <5%		Twigs (%) <10%		Leaves (%) >15%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Cracks / crevices	nil					
Soils	Brown mud/clay					
Tree Hollows	Large	nil	Medium	Present	Small	Present
Water Bodies	nil					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	High micro-niche biodiversity from dense leaf litter, weed species such as the Siam Weed in ‘open’ areas					

WorleyParsons resources & energy

EcoNomics

Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	11 February 2012	ML
Site Number – HA16 [Betano]			
Habitat	Deciduous Woodland / Forest		
UTM Coordinates	Zone 51L Easting 794385 Northing 8990318		

Stratum	Species	Cover (%)	Height (m)
Over-story	*Schleichera oleosa* [ai-dak], [sawa], *Ziziphus mauritiana* [ai-lok], [ai-martuku], *Ficus variegata* [ai-kun], Ficus spp. [hali], [ai-catimu]	10-20%	<20 m
Mid-story	*Acacia* spp. [ai-tarak]	>40%	1-4 m
Under-story	Vine species [sapateri, tatalik tirilolo, ate-gabo], Sedge [du'ut], Herb [marlale]	>50%	< 0.5 m

Litter cover	Logs (%) <5%		Twigs (%) <10%		Leaves (%) >20%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Soils	Brown sand					
Tree Hollows	Large	nil	Medium	Present	Small	Present
Water Bodies	nil					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	High micro-niche biodiversity; good burrowing potential for ground dwelling reptiles and mammals; good nesting and roosting potential for aerial species such as birds and fruit and micro-bats. Fruiting trees [ai-kun] present provide foraging sources for bats and fruit eating birds (Doves & Pigeons)					

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resources & energy

EcoNomics

Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	13 February 2012	ML
Site Number – HA17 [Viqueque]			
Habitat	Deciduous Woodland / Forest		
UTM Coordinates	Zone 52L Easting 212347 Northing 9017858		

Stratum	Species	Cover (%)	Height (m)
Over-story	[ai-lele fuik], [ai-catimu fuik], [ai-kakau]	>25%	~ 20 m
Mid-story	[ai-bokelili], [ai-manas fuik]	<5%	1-3 m
Under-story	[du'ut bobok], Siam Weed *Chromolaena odorata* [ai-funanmutik],	>50%	<1 m

Litter cover	Logs (%)	<1%	Twigs (%)	<5%	Leaves (%)	>10%
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	Present
Cracks / crevices	nil					
Soils	Limestone					
Tree Hollows	Large	nil	Medium	nil	Small	Present
Water Bodies	nil					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Lack of mid and under-story species restricts leaf litter and micro-niche diversity					

WorleyParsons
resources & energy

TIMOR GAP, E.P.
TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

APPENDIX 5

Timor-Leste Vertebrate Fauna List

301012-01504-EN-REP-0006
June 2012

Scientific Name	Common Name	Conservation Codes				A	B	C
		IUCN	CITES	Endemic	Introduced			
Anatidae								
Dendrocygna arcuata	Wandering Whistling-Duck	LC				x	x	
Tadorna radjah	Radjah Shelduck	LC				x	x	
Nettapus pulchellus	Green Pygmy-Goose	LC				x	x	
Anas superciliosa	Pacific Black Duck	LC				x	x	
Anas querquedula	Garganey	LC				x	x	
Anas gibberifrons	Sunda Teal	LC				x	x	
Aythya australis	White-eyed Duck	LC				x	x	
Megapodiidae								
Megapodius reinwardt	Orange-footed Scrubfowl	LC				x	x	
Phasianidae								
Coturnix ypsilophora	Brown Quail	LC				x	x	x
Coturnix chinensis	Blue-breasted Quail	LC				x	x	
Gallus gallus	Red Junglefowl	LC			x	x	x	
Podicipedidae								
Tachybaptus ruficollis	Little Grebe	LC				x	x	
Tachybaptus novaehollandiae	Australasian Grebe	LC				x	x	
Procellariidae								
Calonectris leucomelas	Streaked Shearwater	LC				x	x	
Puffinus pacificus	Wedge-tailed Shearwater	LC				x	x	
Hydrobatidae								
Oceanodroma matsudairae	Matsudaira's Storm-Petrel	DD				x	x	
Phaethontidae								
Phaethon lepturus	White-tailed Tropicbird	LC				x	x	
Phaethon rubricauda	Red-tailed Tropicbird	LC				x	x	
Fregatidae								
Fregata andrewsi	Christmas Island Frigatebird	CR	App I			x	x	
Fregata minor	Great Frigatebird	LC				x	x	
Fregata ariel	Lesser Frigatebird	LC				x	x	
Sulidae								
Sula dactylatra	Masked Booby	LC				x	x	
Sula leucogaster	Brown Booby	LC				x	x	
Sula sula	Red-footed Booby	LC				x	x	
Phalacrocoracidae								
Phalacrocorax sulcirostris	Little Black Cormorant	LC				x	x	
Phalacrocorax melanoleucos	Little Pied Cormorant	LC				x	x	
Anhingidae								
Anhinga novaehollandiae	Australasian Darter	LC				x	x	
Pelecanidae								
Pelecanus conspicillatus	Australian Pelican	LC				x	x	
Ardeidae								
Ixobrychus sinensis	Yellow Bittern	LC				x	x	

Scientific Name	Common Name	Conservation Codes				A	B	C
		IUCN	CITES	Endemic	Introduced			
Ixobrychus eurhythmus	Von Schrenk's Bittern	LC				x		
Ixobrychus cinnamomeus	Cinnamon Bittern	LC				x	x	
Ixobrychus flavicollis	Black Bittern	LC				x	x	
Ardea purpurea	Purple Heron	LC				x		
Ardea sumatrana	Great-billed Heron	LC				x	x	
Ardea alba	Great Egret	LC				x	x	
Mesophoyx intermedia	Intermediate Egret	LC				x	x	
Egretta novaehollandiae	White-faced Heron	LC				x	x	
Egretta garzetta	Little Egret	LC				x	x	
Egretta sacra	Pacific Reef-Heron	LC				x	x	x
Egretta picata	Pied Heron	LC				x	x	
Bubulcus ibis	Cattle Egret	LC				x	x	
Ardeola speciosa	Javan Pond-Heron	LC				x	x	
Butorides striata	Striated Heron	LC				x	x	x
Nycticorax nycticorax	Black-crowned Night-Heron	LC				x	x	
Nycticorax caledonicus	Rufous Night-Heron	LC				x	x	
Threskiornithidae								
Plegadis falcinellus	Glossy Ibis	LC				x	x	
Threskiornis molucca	Australian Ibis	LC				x	x	
Platalea regia	Royal Spoonbill	LC				x	x	
Pandionidae								
Pandion haliaetus	Osprey	LC				x	x	x
Accipitridae								
Aviceda subcristata	Pacific Baza	LC	App II			x	x	
Pernis ptilorhynchus	Oriental Honey-buzzard	LC	App II			x	x	
Elanus caeruleus	Black-shouldered Kite	LC	App II			x	x	x
Milvus migrans	Black Kite	LC	App II			x	x	
Haliastur indus	Brahminy Kite	LC	App II			x	x	x
Haliaeetus leucogaster	White-bellied Sea-Eagle	LC	App II			x	x	x
Circaetus gallicus	Short-toed Eagle	LC	App II			x	x	
Circus assimilis	Spotted Harrier	LC	App II			x	x	
Accipiter fasciatus	Brown Goshawk	LC	App II			x	x	x
Accipiter gularis	Japanese Sparrowhawk	LC	App II			x	x	
Butastur indicus	Gray-faced Buzzard	LC	App II			x	x	
Aquila fasciata	Bonelli's Eagle	LC	App II			x	x	
Falconidae								
Falco moluccensis	Spotted Kestrel	LC	App II			x	x	
Falco cenchroides	Australian Kestrel	LC	App II			x	x	
Falco subbuteo	Eurasian Hobby	LC	App II			x	x	
Falco longipennis	Australian Hobby	LC	App II			x	x	x
Falco peregrinus	Peregrine Falcon	LC	App I			x	x	x
Rallidae								
Gallirallus philippensis	Buff-banded Rail	LC				x	x	
Gallirallus striatus	Slaty-breasted Rail	LC				x	x	

Scientific Name	Common Name	Conservation Codes				A	B	C
		IUCN	CITES	Endemic	Introduced			
Amaurornis phoenicurus	White-breasted Waterhen	LC				x	x	
Porzana pusilla	Baillon's Crake	LC				x	x	
Porzana fusca	Ruddy-breasted Crake	LC				x	x	
Porzana tabuensis	Spotless Crake	LC				x	x	
Porzana cinerea	White-browed Crake	LC				x	x	
Porphyrio porphyrio	Purple Swamphen	LC				x	x	
Gallinula tenebrosa	Dusky Moorhen	LC				x	x	
Fulica atra	Eurasian Coot	LC				x	x	
Burhinidae								
Esacus magnirostris	Beach Thick-knee	NT				x	x	
Charadriidae								
Vanellus miles	Masked Lapwing	LC				x	x	
Pluvialis squatarola	Grey Plover	LC				x	x	
Pluvialis fulva	Pacific Golden-Plover	LC				x	x	
Charadrius mongolus	Lesser Sand-Plover	LC				x	x	x
Charadrius leschenaultii	Greater Sand-Plover	LC				x	x	
Charadrius ruficapillus	Red-capped Plover	LC				x	x	
Charadrius peronii	Malaysian Plover	NT				x	x	
Charadrius alexandrinus	Kentish Plover	LC				x	x	
Charadrius javanicus	Javan Plover	NT				x	x	
Charadrius dubius	Little Ringed Plover	LC				x	x	
Charadrius veredus	Oriental Plover	LC				x	x	
Recurvirostridae								
Himantopus himantopus	Black-winged Stilt	LC				x	x	
Jacanidae								
Irediparra gallinacea	Comb-crested Jacana	LC				x	x	
Scolopacidae								
Xenus cinereus	Terek Sandpiper	LC				x	x	
Actitis hypoleucos	Common Sandpiper	LC				x	x	x
Tringa brevipes	Gray-tailed Tattler	LC				x	x	
Tringa nebularia	Common Greenshank	LC				x	x	
Tringa stagnatilis	Marsh Sandpiper	LC				x	x	
Tringa glareola	Wood Sandpiper	LC				x	x	
Tringa totanus	Common Redshank	LC				x	x	
Numenius minutus	Little Curlew	LC				x	x	
Numenius phaeopus	Whimbrel	LC				x	x	x
Numenius madagascariensis	Far Eastern Curlew	VU				x	x	
Numenius arquata	Eurasian Curlew	NT				x	x	
Limosa limosa	Black-tailed Godwit	NT				x	x	
Limosa lapponica	Bar-tailed Godwit	LC				x	x	
Arenaria interpres	Ruddy Turnstone	LC				x	x	
Calidris tenuirostris	Great Knot	VU				x	x	x
Calidris canutus	Red Knot	LC				x	x	
Calidris alba	Sanderling	LC				x	x	

Scientific Name	Common Name	Conservation Codes				A	B	C
		IUCN	CITES	Endemic	Introduced			
Calidris ruficollis	Red-necked Stint	LC				x	x	
Calidris subminuta	Long-toed Stint	LC				x	x	
Calidris acuminata	Sharp-tailed Sandpiper	LC				x	x	
Calidris ferruginea	Curlew Sandpiper	LC				x	x	
Limicola falcinellus	Broad-billed Sandpiper	LC				x	x	
Philomachus pugnax	Ruff	LC				x	x	
Limnodromus semipalmatus	Asian Dowitcher	NT				x	x	
Gallinago gallinago	Common Snipe	LC				x	x	
Gallinago stenura	Pin-tailed Snipe	LC				x	x	
Gallinago megala	Swinhoe's Snipe	LC				x	x	
Phalaropus lobatus	Red-necked Phalarope	LC				x	x	
Turnicidae								
Turnix maculosus	Red-backed Buttonquail	LC				x	x	
Glareolidae								
Stiltia isabella	Australian Pratincole	LC				x	x	
Glareola maldivarum	Oriental Pratincole	LC				x	x	
Rostratulidae								
Rostratula benghalensis	Greater Painted-snipe	LC				x	x	
Laridae								
Anous stolidus	Brown Noddy	LC				x	x	
Sterna fuscata	Sooty Tern	LC				x	x	
Sterna anaethetus	Bridled Tern	LC				x	x	
Sternula albifrons	Little Tern	LC				x	x	
Gelochelidon nilotica	Gull-billed Tern	LC				x	x	
Hydroprogne caspia	Caspian Tern	LC				x	x	
Chlidonias leucopterus	White-winged Tern	LC				x	x	
Chlidonias hybrida	Whiskered Tern	LC				x	x	
Sterna sumatrana	Black-naped Tern	LC				x	x	
Thalasseus bergii	Great Crested Tern	LC				x	x	
Thalasseus bengalensis	Lesser Crested Tern	LC				x	x	
Columbidae								
Columba livia	Rock Pigeon	LC			x	x	x	x
Columba vitiensis	Metallic Pigeon	LC				x	x	x
Streptopelia bitorquata	Island Collared-dove	LC				x	x	
Streptopelia chinensis	Spotted Dove	LC				x	x	x
Macropygia ruficeps	Little Cuckoo-dove	LC				x	x	
Turacoena modesta	Slaty Cuckoo-dove	NT				x	x	x
Chalcophaps indica	Emerald Dove	LC				x	x	x
Geopelia maugei	Barred Dove	LC				x	x	x
Gallicolumba hoedtii	Wetar Ground-dove	EN				x	x	
Treron psittaceus	Timor Green Pigeon	EN				x	x	
Ptilinopus cinctus	Black-backed Fruit-dove	LC				x	x	x
Ptilinopus regina	Rose-crowned Fruit-dove	LC				x	x	
Ducula rosacea	Pink-headed Imperial Pigeon	NT				x	x	x

Scientific Name	Common Name	Conservation Codes				A	B	C
		IUCN	CITES	Endemic	Introduced			
Ducula cineracea	Timor Imperial Pigeon	EN				x	x	
Cacatuidae								
Cacatua sulphurea	Yellow-crested Cockatoo	CR	App I	x		x	x	
Psittacidae								
Trichoglossus euteles	Olive-headed Lorikeet	LC				x	x	
Psitteuteles iris	Iris Lorikeet	NT				x	x	
Geoffroyus geoffroyi	Red-cheeked Parrot	LC				x	x	x
Tanygnathus megalorynchos	Great-billed Parrot	LC				x	x	
Aprosmictus jonquillaceus	Olive-shouldered Parrot	NT				x	x	x
Cuculidae								
Cuculus saturatus	Oriental Cuckoo	LC				x	x	x
Cacomantis pallidus	Pallid Cuckoo	LC				x	x	
Cacomantis variolosus	Brush Cuckoo	LC				x	x	
Chrysococcyx basalis	Horsfield's Bronze-Cuckoo	LC				x	x	
Chrysococcyx lucidus	Shining Bronze-Cuckoo	LC				x	x	
Chrysococcyx minutillus	Little Bronze-Cuckoo	LC				x	x	
Chrysococcyx russatus	Gould's Bronze-Cuckoo	LC				x		x
Eudynamys scolopaceus	Asian Koel	LC				x	x	
Eudynamys cyanocephalus	Australian Koel	LC				x	x	
Scythrops novaehollandiae	Channel-billed Cuckoo	LC				x	x	x
Centropus phasianinus	Pheasant Coucal	LC				x	x	
Centropus mui	Timor Coucal			x			x	
Centropus bengalensis	Lesser Coucal	LC				x	x	x
Tytonidae								
Tyto alba	Barn Owl	LC	App II			x	x	
Caprimulgidae								
Caprimulgus macrurus	Large-tailed Nightjar	LC				x	x	x
Caprimulgus affinis	Savanna Nightjar	LC				x	x	
Apodidae								
Hirundapus caudacutus	White-throated Needletail	LC				x	x	
Collocalia esculenta	Glossy Swiftlet	LC				x	x	
Aerodramus fuciphagus	Edible-nest Swiftlet	LC				x	x	
Apus pacificus	Fork-tailed Swift	LC				x	x	
Alcedinidae								
Alcedo atthis	Common Kingfisher	LC				x	x	
Todiramphus australasia	Cinnamon-banded Kingfisher	NT				x	x	x
Todiramphus chloris	Collared Kingfisher	LC				x		x
Todiramphus sanctus	Sacred Kingfisher	LC				x		
Meropidae								
Merops philippinus	Blue-tailed Bee-eater	LC				x	x	
Merops ornatus	Rainbow Bee-eater	LC				x	x	x
Coraciidae								
Eurystomus orientalis	Dollarbird	LC				x	x	x
Pittidae								

Scientific Name	Common Name	Conservation Codes				A	B	C
		IUCN	CITES	Endemic	Introduced			
Pitta elegans	Elegant Pitta	LC				x	x	
Meliphagidae								
Meliphaga reticulata	Streak-breasted Honeyeater	LC		x		x	x	x
Myzomela vulnerata	Black-breasted Myzomela	LC		x		x	x	x
Lichmera indistincta	Brown Honeyeater	LC				x		
Lichmera flavicans	Yellow-eared Honeyeater	LC				x	x	
Philemon inornatus	Timor Friarbird	LC		x		x	x	x
Philemon buceroides	Helmeted Friarbird	LC		x		x	x	x
Acanthizidae								
Gerygone inornata	Plain Gerygone	LC				x	x	x
Artamidae								
Artamus leucorynchus	White-breasted Woodswallow	LC				x	x	x
Artamus cinereus	Black-faced Woodswallow	LC				x	x	x
Campephagidae								
Coracina personata	Wallacean Cuckoo-shrike	LC				x	x	x
Coracina novaehollandiae	Black-faced Cuckoo-shrike	LC				x	x	x
Coracina tenuirostris	Cicadabird	LC				x	x	
Lalage sueurii	White-winged Triller	LC				x	x	x
Pachycephalidae								
Pachycephala orpheus	Fawn-breasted Whistler	LC				x	x	x
Pachycephala pectoralis	Golden Whistler	LC				x	x	x
Laniidae								
Lanius schach	Long-tailed Shrike	LC				x	x	x
Oriolidae								
Oriolus melanotis	Timor Oriole	LC				x	x	x
Sphecotheres viridis	Timor Figbird	LC				x	x	x
Dicruridae								
Dicrurus densus	Wallacean Drongo	LC				x	x	x
Rhipiduridae								
Rhipidura rufiventris	Northern Fantail	LC				x	x	x
Rhipidura rufifrons	Rufous Fantail	LC					x	x
Monarchidae								
Monarcha cinerascens	Island Monarch	LC				x	x	x
Symposiachrus trivirgatus	Spectacled Monarch	LC				x	x	x
Grallina cyanoleuca	Magpie-lark	LC				x	x	
Myiagra ruficollis	Broad-billed Flycatcher	LC				x	x	x
Corvidae								
Corvus macrorhynchos	Large-billed Crow	LC				x	x	x
Alaudidae								
Mirafra javanica	Australasian Bushlark	LC				x	x	x
Hirundinidae								
Hirundo rustica	Barn Swallow	LC				x	x	x
Hirundo tahitica	Pacific Swallow	LC				x	x	
Cecropis striolata	Striated Swallow						x	

Scientific Name	Common Name	Conservation Codes				A	B	C
		IUCN	CITES	Endemic	Introduced			
Petrochelidon ariel	Fairy Martin	LC				x	x	
Petrochelidon nigricans	Tree Martin	LC				x	x	x
Paridae								
Parus major	Great Tit	LC				x	x	
Pycnonotidae								
Pycnonotus aurigaster	Sooty-headed Bulbul	LC				x	x	
Pnoepygidae								
Pnoepyga pusilla	Pygmy Cupwing	LC				x	x	
Cettiidae								
Urosphena subulata	Timor Stubtail	LC				x	x	
Cettia vulcania	Sunda Bush-Warbler	LC				x	x	
Phylloscopidae								
Phylloscopus borealis	Arctic Warbler	LC				x	x	
Phylloscopus presbytes	Timor Leaf-Warbler	LC				x	x	
Seicercus montis	Yellow-breasted Warbler	LC				x	x	
Acrocephalidae								
Acrocephalus orientalis	Oriental Reed-Warbler						x	
Acrocephalus stentoreus	Clamorous Reed-Warbler	LC				x	x	
Locustellidae								
Bradypterus timoriensis	Timor Bush-Warbler	NT		x		x	x	
Megalurus timoriensis	Tawny Grassbird	LC				x	x	x
Buettikoferella bivittata	Buff-banded Bushbird	LC		x		x	x	
Cisticolidae								
Cisticola juncidis	Zitting Cisticola	LC				x	x	
Cisticola exilis	Golden-headed Cisticola	LC				x	x	x
Zosteropidae								
Heleia muelleri	Timor White-eye	NT		x		x	x	
Zosterops montanus	Mountain White-eye	LC				x	x	
Zosterops citrinella	Ashy-bellied White-eye	LC				x	x	
Muscicapidae								

Scientific Name	Common Name	Conservation Codes				A	B	C
		IUCN	CITES	Endemic	Introduced			
Cyornis hyacinthinus	Timor Blue-Flycatcher	LC				x	x	
Brachypteryx leucophrys	Lesser Shortwing	LC				x	x	
Ficedula westermanni	Little Pied Flycatcher	LC				x	x	
Ficedula timorensis	Black-banded Flycatcher	NT		x		x	x	
Ficedula hyperythra	Snowy-browed Flycatcher	LC				x	x	
Saxicola caprata	Pied Bushchat	LC				x	x	x
Saxicola gutturalis	Timor Bushchat	NT				x	x	x
Turdidae								
Zoothera dohertyi	Chestnut-backed Thrush	NT				x	x	
Zoothera peronii	Orange-banded Thrush	NT				x	x	
Zoothera andromedae	Sunda Thrush	LC				x	x	
Turdus poliocephalus	Island Thrush	LC				x	x	
Sturnidae								
Aplonis minor	Short-tailed Starling	LC				x	x	
Dicaeidae								
Dicaeum agile	Thick-billed Flowerpecker	LC				x	x	
Dicaeum maugei	Red-chested Flowerpecker	LC				x	x	x
Dicaeum sanguinolentum	Blood-breasted Flowerpecker	LC				x	x	
Nectariniidae								
Cinnyris solaris	Flame-breasted Sunbird	LC				x	x	x
Motacillidae								
Motacilla flava	Western Yellow Wagtail	LC				x	x	
Motacilla cinerea	Grey Wagtail	LC				x	x	
Anthus novaeseelandiae	Richard's Pipit	LC				x	x	x
Anthus gustavi	Pechora Pipit	LC				x	x	
Passeridae								
Passer montanus	Eurasian Tree Sparrow	LC				x	x	x
Estrildidae								
Amandava amandava	Red Avadavat	LC			x	x	x	
Taeniopygia guttata	Zebra Finch	LC				x	x	x
Erythrura tricolor	Tricolored Parrotfinch	LC				x	x	
Lonchura molucca	Black-faced Munia	LC				x	x	x
Lonchura punctulata	Nutmeg Mannikin	LC				x	x	x
Lonchura quinticolor	Five-colored Munia	LC				x	x	x
Lonchura pallida	Pale-headed Munia	LC				x	x	
Lonchura fuscata	Timor Sparrow	NT				x	x	

Key: A = Listed under IUCN Red List; B = Recorded in previous survey; C = Recorded in current assessment

(CR, EN, VU, NT, LC, DD) denotes Critically Endangered, Endangered, Vulnerable, Near Threatened, Least Concern and Data Deficient under the IUCN Red List; (x) denotes recorded during the survey or database search

WorleyParsons
resources & energy

TIMOR GAP, E.P.
TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

APPENDIX 6

Bat Call Analysis

301012-01504-EN-REP-0006
June 2012

Specialised Zoological

Bat call identification

from the south coast of Timor-Leste

Type:	Bat Call Analysis
Prepared for:	WorleyParsons Services Pty Ltd
Date:	16 May 2012
Job No.:	SZ240
Prepared by:	Dr Kyle Armstrong and Ms Yuki Konishi Specialised Zoological ABN 92 265 437 422 + 61 (0) 404 423 264 kyle.n.armstrong@gmail.com http://www.szool.com.au

Contents Page

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Date	Type
16 February 2012	First incomplete draft submitted to WorleyParsons
6 March 2012	Full draft submitted to WorleyParsons
16 May 2012	Final version submitted to WorleyParsons

1.0 INTRODUCTION

Bat species were identified on the basis of echolocation call recordings made with electronic bat detectors, as part of the flora and fauna survey for the Timor-Leste South Coast Environmental Impact Assessment, prepared by WorleyParsons Services Pty Ltd for the proposed Tasi-Mane petrochemical project. Further context details of the project can be found in the main flora and fauna report. This report by Specialised Zoological includes details related to the chiropteran mammals only, with some reiteration included in the main report. Specialised Zoological contributed electronic bat detectors, undertook analysis of echolocation recordings, provided background information (some of it the subject of private unpublished research in progress) and interpretation of the results. Apart from taxonomic comments on the Pteropodidae, the majority of this report concerns echolocating species in the remaining five chiropteran families present on Timor. For a summary of findings, please refer to section *5.0 Conclusions*.

2.0 BAT BIODIVERSITY IN TIMOR

Timor is part of the non-volcanic southern archipelago of the Lesser Sunda islands (also known as Nusa Tenggara), which forms part of the Indo-Australian tectonic plate. It can be further classified into the Moluccan Division, and the western part of the Wallacea ecoregion that contains biota of mixed Asian and Australasian origin, but with the predominance of the former. This Moluccan Division is characterised by "very impoverished faunas" according to Corbet and Hill (1992:6), being characteristic of islands east of Lombok with low endemism, and was considered to be very poorly known even as recently as this publication.

There have been relatively few bat surveys on the island of Timor, and the fauna is not yet completely described. The earliest and still the most comprehensive published summary of the bats of Timor is that of Goodwin (1979), who conducted field surveys, an extensive examination of museum collections and a review of the literature to derive a list of taxa with their current taxonomy. Based on Goodwin's field surveys and taxonomic examinations, there were 22 species known from Timor, 11 of which he added from identifications of previously described taxa or descriptions of new ones.

Further attention was given to the taxonomy of the Timorese bat fauna by Kitchener and colleagues from the Western Australian Museum and the Indonesian Institute of Sciences (LIPI), who collected from West Timor, and included these representatives in taxonomic revisions of several bat groups in Nusa Tenggara (e.g. review in Kitchener and Suyanto 1996).

More recently, systematic bat surveys were conducted as part of an environmental impact assessment for a hydropower scheme involving power generation infrastructure in the vicinity of the Ira Lalaro polje and the Paitchau Range. The first survey in March 2004 near the village of Malahara recorded 16 species, of which up to four taxa were new records for the island and possibly species new to science (Pavey and Milne 2004). A second survey in October 2006 north and south of the Paitchau Range recorded 15 species, at least one of which was a new record for the island and also possibly new to science (Armstrong 2007). Voucher specimens, reference echolocation calls and tissue biopsies were collected on both surveys, and follow up taxonomic work involving comparisons with other museum specimens,

micro-CT scanning of skulls, analysis of reference calls and DNA sequencing of tissue biopsies has been conducted as part of a manuscript in preparation (Armstrong et al., ms in prep.). Much of the unpublished information used for identifications in the present report is derived from this resource.

These unpublished reports have provided updates to Goodwin's (1979) species list for the island of Timor, in conjunction with another brief informal survey conducted by Helgen (2004). Based on the capture of a species of long-eared bat *Nyctophilus* sp. and the examination of museum skins, most notably of one resembling *Dobsonia moluccensis*, Helgen (2004) compiled from various sources a list of 27 (with a minimum of 25) bat species thought to be on Timor.

Armstrong (2007) provided a further update based on his own survey, museum records (most notably based on the many collections made by Kitchener et al. from the Western Australian Museum), that of Pavey and Milne (2004), and based on the taxonomic treatments of Simmons (2005), which brought the total for the island of Timor to 31 species. Of those, 28 were confirmed from within the boundaries of the nation of Timor-Leste. The work conducted for the manuscript in preparation (Armstrong et al. ms in prep.) has revised the list produced by Armstrong (2007), and is reproduced here in Table 1. Excluding doubtful records or species that may now be extinct on the island (*Dobsonia moluccensis, Nyctimene keasti, Pteropus temminckii*), there are 32 species currently likely to be extant on Timor, of which 29 are known from Timor-Leste, and of which six are currently the subject of active taxonomic studies and are potentially species or subspecies new to science. Of the 32 extant species of bat on Timor, one is endemic, an additional three have recognised endemic subspecies, and there are seven taxa that might be endemic at either species or subspecies level, pending further taxonomic investigation (Table 1). The endemics are in the families Hipposideridae, Rhinolophidae and Vespertilionidae.

Many of the bat species on Timor have an IUCN conservation status listing of Least Concern (20 species). However this means that just over a third of bats are, or could be, of conservation significance. If the three doubtful species records are excluded, two species are listed as Vulnerable, and one species is listed as Near Threatened. For the remainder, there is insufficient information on their distribution to allocate them to a category: four species are listed as Data Deficient; there are a further five taxa first recorded by Helgen (2004), Pavey and Milne (2004) and Armstrong (2007) on Timor that are not currently listed because of their uncertain taxonomic status, or because they are new and have yet to be described and evaluated; and there is one species thought previously to be widespread and listed as Least Concern, but which might actually be an undescribed endemic taxon based on recent genetic work (*Pipistrellus* aff*. tenuis*; Armstrong et al. ms in prep.). Given that there are only three other extant, non-introduced and non-commensal species of mammal on Timor (*Crocidura maxi* [widespread in Indonesia], *Crocidura tenuis* [endemic to Timor] and *Rattus timoriensis* [endemic to Timor]; Kitchener et al. 1991; Ruedi 1995; Aplin and Helgen 2010), bats represent around 90% of the known, non-commensal, native and extant Timorese mammal assemblage, and this is a significant proportion that needs consideration in the context of development proposals.

3.0 METHODS

3.1 Acoustic Recordings

The ultrasonic echolocation calls of bats, which are produced for spatial orientation and prey detection in flight, are useful for species identification because each produces a unique and distinguishable (in many cases) signal type. Analysis of the recordings made using electronic 'bat detectors' can reveal echolocating bat diversity at sampling sites with minimal effort as part of a comprehensive approach to surveying bats. On the present survey, acoustic recordings were made with AnaBat SD1 and SD2 bat detectors (Titley Scientific, Brisbane), which were chosen for their ease of use and deployment, and the efficiency of data storage[1]. Data was available from two field survey periods: 10 – 19 December 2011 and 7 – 13 February 2012, and equipment was deployed by staff of WorleyParsons.

Bat detectors were waterproofed in plastic boxes, and microphones (both HiMic/green and ST1) on a 1 m extension lead were placed in a funnel made from a plastic drink bottle to reduce the chance of water exposure. The use of funnels reduces slightly the zone of signal detection, but was unavoidable as sites received rain frequently. The detectors were employed as passive stationary data recorders, being set in position prior to dusk and collected after dawn, and placed off the ground (1 m or more) with the microphone capsule tied to trees. The equipment was placed in a variety of habitats to maximise the potential to encounter all species present. A GPS position was recorded at each recording site and associated with the serial number of the recording unit and deployment date.

Echolocation signals were divided by a factor of 8 by AnaBat detectors, and stored automatically on a Compact Flash card, with each sequence of calls receiving a time and date stamp. The recording effort is summarised for each sampling locality in Table 2. The total recording effort was seven full night AnaBat recording sessions in December 2011 and six sessions in February 2012. Further deployments of AnaBat detectors were made, but recordings were not recovered because of issues with equipment.

3.2 Analysis of Acoustic Recordings

AnaBat recordings were downloaded using CFC Read 4.3s software. The output consisted of two sets of data: 1. the individual sequence files produced during interpretation by CFC Read software, which are organised into folders representing a single night's recording; and 2. the continuous representation of the AnaBat recordings in ZCA and MAP files, which show all of the signals detected by the AnaBat microphone but which have not been parsed into individual sequence files according to default interpretation parameters. The signals in both parsed sequence files and the ZCA and MAP files were examined in AnalookW 3.8s software.

Bat echolocation calls recorded with 'passively' deployed bat detectors at stationary sites over a full night are referred to here as 'anonymous' because there is no *a priori* knowledge of the number and identity of contributing bats. The first step in any analysis of acoustic recordings

[1] SM2BAT detectors (Wildlife Acoustics, Massachusetts) were available for December 2011 but could not be deployed.

of bats is attributing these anonymously recorded call types to a single species. This is usually done with the help of a reference library of good quality calls recorded from confidently identified bats. Given that trapping for bats was beyond the scope of the present survey, precluding the opportunity to collect reference calls from the local bat assemblage, identifications were made by comparing pulse shapes and measured variables with those from reference calls collected by Armstrong (2007; summarised in Armstrong et al. ms in prep.). Three call variables were measured on good quality search phase pulses in representative call sequences: pulse duration (milliseconds), maximum frequency (kHz) and characteristic frequency (the point at the end of the flattest portion of a pulse before any terminal secondary frequency sweep; kHz). A fourth variable was measured on Constant Frequency calls: the frequency with the greatest number of cycles (the flattest part of the call, designated as Fpz in AnalookW software). Summaries of pulse variables (Table 3) and representative sequence traces (Figure 1) are presented in support of the analysis and identifications, as recommended by the Australasian Bat Society (ABS 2006).

Call types that could not be identified based on the limited reference call material available were allocated a descriptive name according to a new nomenclatural scheme (Armstrong and Aplin ms in prep.) that defines the pulse in terms of its characteristic frequency and shape (Table 4). The scheme was modified from de Oliveira (1998a,b) and Corben and O'Farrell (1999), and has been used previously for surveys in Papua New Guinea (Armstrong and Aplin 2011; other unpublished confidential reports by K.P. Aplin and K.N. Armstrong) where the echolocation calls of many bat species have yet to be recorded and described. Fourteen call types, each likely representing a single species, could be recognised based on both the call type classification scheme and the reference calls. Notes on each call type and a justification for the identifications are provided, and where call types could not be attributed to a single species, candidates were noted for later verification (Table 5).

3.3 Interpreting echolocation calls – limitations and considerations

Several caveats and considerations of relevance to this survey are noted with regard to the identification of bat species based on recordings of their echolocation calls:

- Two or more bat species may produce calls that are so similar that they cannot be distinguished reliably using the available methods or reference recordings (examples from Australia in McKenzie and Muir 2000; Milne 2002).

- A single bat species may produce more than one call type (e.g. search phase calls, approach phase calls, clutter calls) that might suggest the presence of more than one species. With sufficient experience of related species, it is generally possible for a bat echolocation specialist to take this into account, and to base identifications on the typically more diagnostic search phase calls. The development of an adequate call reference library will diminish this limitation.

- While the most recent bat surveys in Timor (Helgen 2004; Pavey and Milne 2004; Armstrong 2007) have together discovered up to six species new to Timor (some possibly new to science), the majority of the unidentified call types will likely belong to described or these previously encountered species for which there are no verified

echolocation reference calls, rather than additional new forms. As further reference calls become available, it will be possible to identify retrospectively many of the unallocated calls. Moreover, it should be noted that taxonomically unallocated call types are still useful for comparing trends in bat richness, relative abundance and community composition across sites and habitats. By using the call type as the unit of presentation and analysis, retrospective identifications can be applied through all analyses, site and habitat summaries; and knowledge of bat community structure and ecological function based on the echolocation call structure will allow predictions of changes within the bat assemblage in response to habitat modification.

- In the process of making identifications, the practice of identifying call types on the basis of general correlations between physical characteristics (e.g. forearm length, body weight) and echolocation call frequency (e.g. based on Jones 1996; Robinson 1996; Bogdanowicz *et al.* 1999; Zhang *et al.* 2000; Feng *et al.* 2000) (see Richards 2005, 2008 as an example) was avoided. Although this inferential method has merit in some circumstances, a more cautious, evidentiary approach that minimises the chance of calls being misidentified was preferred in the present survey.

- Absolute abundance of each species or call type at a site cannot be estimated from bat detector recordings because it is not possible to distinguish between relatively few bats passing the detector but contributing many calls, and a larger number of individuals passing the detector with each contributing relatively few calls. If sufficient site replication (multiple nightly sessions) in each locality is available, a measure of relative abundance of each call type can be derived. This value represents the proportional occurrence of each species / call type across replicate recording sessions, and gives a rough indication of 'commonness'.

- Finally, it should be noted that in all acoustic surveys (regardless of bat detector brand and model) the detectability of each species is determined to some extent by characteristics of their echolocation calls. In particular, species that produce ultra-high frequency (> 100 kHz) calls or those that produce calls with low amplitude (e.g. long-eared bats *Nyctophilus* spp.) will have relatively short detection distances, which will lead to their being under-represented or even missed altogether in an acoustic survey. The detectability of different call types is also influenced by atmospheric conditions, most notably relative humidity and temperature that act together to attenuate ultrasound, the effects of which are dramatic at higher frequencies (e.g. Armstrong and Kerry 2011). Thus, acoustic detection represents only one component of a comprehensive survey approach for bats, and targeted effort is required for species with lower acoustic detectability.

4.0 RESULTS AND DISCUSSION

A total of 13 informative AnaBat sessions was made on the two field surveys. All represent a full night of passive stationary recording at one of the survey localities. A total of 14 different call types (=species) was distinguished, and six of these call types could be allocated to species level through comparison with available reference calls (Tables 2 and 6). The remaining eight call types could not be assigned to either species or genus level, though possibilities are given in Table 5.

The replication of passive recording sites in the locality of Suai allowed for the calculation of a species accumulation curve and the relative abundance of each species in that locality. Similar patterns could not be derived for the other sites because only one or two nights were available for each. The accumulation curve was calculated on the basis of the number of recording sites rather than survey nights to make it easier to display the pattern taken over two separate survey periods that were separated by around one month (Figure 2). Where several recordings (=sites) were made on the same night, those with cumulatively additional species were plotted first. Relative abundance of each species / call type is calculated as the proportion of nightly recordings that contain signals of that taxon (Table 6).

The accumulation curve reached eight species / call types after four bat detector nights in December 2011, and the addition of a further six survey nights in February 2012 added five species. While the curve appears to be approaching an asymptote, the plot also suggests that further taxa might still be added with additional survey nights. Obviously effort to detect non-echolocating fruit bats will likely add more chiropteran species, but further survey work (including trapping) will also help determine firstly whether there are additional echolocating bat species present and secondly what the unidentified call types may be attributed to if they can be captured.

At Suai, there were seven of 13 species with relatively high abundance (values of 0.8 and above). These included two species that forage widely in the open spaces above treetops (*21 sh.cFM, 25 cFM*; attributable to species of *Saccolaimus* and *Taphozous*, see Table 5); four species that forage in gaps and open spaces around stands of vegetation (*37 st.cFM, 41 st.cFM, 54 st.cFM, 63 st.cFM Miniopterus australis*) and one species that forages within and among stands of vegetation (*72 lCF Rhinolophus canuti timoriensis*). Most of these species roost in trees, suggesting that this resource is well supported in the locality, and also that caves are nearby for at least one of the species (*72 lCF Rhinolophus canuti timoriensis*). The other species present at lower abundance all roost in caves: *28 lCF Rhinolophus* aff. *philippinensis, 47 st.cFM, 55 sCF Hipposideros diadema, 86 lCF Rhinilophus celebensis parvus*; the latter has reduced detection potential because of its relatively high frequency. Thus, the values of relative abundance at Suai also reflect the more minor but important contribution of nearby cave habitats.

Species of conservation significance include two cave roosting species of horseshoe bat (Canut's horseshoe bat *Rhinolophus canuti timoriensis;* Timorese horseshoe bat *Rhinolophus montanus*). The recording of *R. montanus* is significant since it has only been recorded on two previous occasions: the site of first collection near Lequi Mia, south of Ermera (7-8 individuals; by Goodwin 1979), and calls from the Ira Chaupiti watercourse on the southern side of the Paitchau Range (Armstrong 2007). Canut's horseshoe bat *R. canuti* was

encountered commonly in the acoustic and trapping surveys of Pavey and Milne (2004) and Armstrong (2007), but there is no information on how widespread this species is outside of the most forested areas in the east of Timor-Leste. It roosts in caves during the day, and will be dependent on them for persistence in a local area. Both this and other species of horseshoe bat are likely to be sensitive to human disturbance of colonies in caves.

The presence of *Rhinolophus* species plus the Diadem leaf-nosed bat *Hipposideros diadema* also suggests that other cave roosting bat species are present at Suai. While no calls of the other two *Hipposideros* were recorded, the survey effort to date is probably insufficient to rule out their presence, and their apparent absence may also be partly a function of their ultra-high frequency calls (over 100 kHz in both cases) that cannot be detected at the same distance as the lower frequency calls of other species. There is also a possibility of the presence of one or more species of bent-winged bat *Miniopterus* sp. and some of the unallocated call types are almost certainly attributable to this genus. Bent-winged bats tend to have large home ranges and are known to migrate in other countries (e.g. Dwyer 1969; Cardinal and Christidis 2000; Rodrigues et al. 2010), so the roost site of any *Miniopterus* identified in the project area could be a reasonable distance away. Conversely, the presence of *Hipposideros* or *Rhinolophus* would suggest that caves are relatively close by, given their flight morphology that is typical of agile fliers that do not travel large distances nightly (e.g. Norberg and Rayner 1987; Kingston et al. 2003).

There was a general paucity of species that forage within stands of vegetation, with the exception of the species of horseshoe bat *Rhinolophus* spp. encountered. Calls of relatively short duration and large bandwidth (calls types *bFM*, *st.sFM.d*) suitable for foraging in this structural habitat (e.g. Denzinger et al. 2004) and that could be attributable to taxonomically unresolved species of *Harpiocephalus, Kerivoula, Murina* and *Nyctophilus* were not detected, possibly because the habitats surveyed were not suitable for these species, but it could also reflect the level of survey effort or call detectability. Such call types are typically emitted at relatively low amplitude, and are thus less detectable (have a shorter detection range) than other call types, requiring greater effort to encounter them.

The low frequency calls (< 30 kHz) attributed to species of sheath-tailed bats *Saccolaimus saccolaimus* and tomb bats *Taphozous achates* and *T. melanopogon* were difficult to distinguish because of the variability in call structure and characteristic frequency. It is likely that all three species were present, though better quality anonymous recordings and reference calls would help with identification in the future. While there were only three candidate species for the three unallocated low frequency call types, the characteristic frequency of *T. achates* is not known, and *S. saccolaimus* produces calls with a characteristic frequency ranging by 5 kHz or more across its range throughout South East Asia and Australasia (Milne et al. 2009; Corben 2010), overlapping with one of the two *Taphozous* species in this case. All three species were recorded commonly foraging in the open spaces above the sites, though roost sites might be some distance away given their good capacity for relatively long distance flight.

The calls of many vespertilionids and miniopterids are often difficult to distinguish because of their similar structure (*st.cFM*), undocumented characteristic frequencies and geographic variation preventing direct comparison with the same species on other islands. It is possible that several species attributable to *Miniopterus, Pipistrellus, Scotophilus* and *Scotorepens*

were present based on the observation of the six *st.cFM* call types. Further good quality recordings and capture effort will likely help with the attribution of species names to some of the call types documented in the survey. While all species to which this general call type are attributable are not listed in a Threatened conservation category, several of them (*Miniopterus* spp.) form large colonies in caves and will be vulnerable to disturbance if this habitat is removed or modified, or if an increase in human presence because of the project activities leads to increased cave visitation and thus colony disturbance.

5.0 CONCLUSIONS

1. At least 14 echolocating bat species are present at the survey sites (6 – 13 species depending on the site and taking into account survey effort), representing six species that were able to be identified, and eight species that need some additional follow up capture work to confirm their identity. The latter could be identified retrospectively at each site based on the call classification system used, given new reference call information.

2. One of the detected species is listed in a Threatened category: Canut's horseshoe bat *Rhinolophus canuti timoriensis* (Vulnerable B1ab(iii)), which is also represented as an endemic taxon (at subspecies level) on Timor. It had high relative abundance at Suai, suggesting the presence of nearby caves containing colonies of reasonable size, and was also present at Betano and Viqueque.

3. Four species that are not currently listed by the IUCN for lack of information were either confirmed as being present—*Rhinolophus montanus* (DD)—or considered likely to be present pending further confirmation by fieldwork and attribution of echolocation call types—*Taphozous achates* (DD); *Rhinolophus* aff. *philippinensis* (NE); *Pipistrellus* sp. aff. *tenuis* (NE). While these species are not currently listed, they may represent endemics, have limited distribution on the island and be subject to threatening processes that have not yet been identified formally.

4. The number of endemic species or subspecies confirmed from the project area was three—*Rhinolophus canuti timoriensis, Rhinolophus montanus, Rhinolophus celebensis parvus*; while a further two might be endemic if their identification from echolocation calls and taxonomy can be confirmed—*Rhinolophus* aff. *philippinensis*; *Pipistrellus* sp. aff. *tenuis.* The list of other endemics that might also be present pending further survey (and taxonomic) effort includes: cave roosting species *Hipposideros bicolor hilli* and *Hipposideros sumbae rotiensis*; and forest roosting species *Harpiocephalus* aff. *harpia, Kerivoula* sp., *Murina* aff. *florium,* and *Nyctophilus* sp.

5. The diversity of echolocating bat species in the project was relatively high and indicative of reasonably intact habitats, though species that prefer primary undisturbed forest or thicker stands of vegetation were absent. To some degree this might be a function of their detectability (because of their low amplitude calls), but further survey effort would provide better evidence of their apparent absence.

6. At least six species of cave roosting bat were recorded and identified to species (species of *Rhinolophus; Hipposideros diadema*, *Miniopterus australis*), with several others likely (other *Miniopterus* spp.; *Taphozous* spp.). Thus, at least half of the 14 echolocating bat species recorded on the survey use caves for daytime roosting. Careful management of cave habitat will be an important consideration in the proposed project because of the presence of endemics, Threatened species, taxonomically unresolved forms with undefined conservation status, large aggregations (bat colonies) with high vulnerability to a single event of human disturbance, and the long term importance of such structures for animal populations in a landscape that may have limited replication (i.e. alternative habitat) elsewhere.

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Table 1. Summary of bat species known from the island of Timor, with notes on their identification and IUCN conservation status.

Species[1]	**Comment on taxonomy, identification and presence on Timor**	**IUCN status**[2]
Family Pteropodidae (Fruit bats and flying-foxes)		
Sunda fruit bat *Acerodon mackloti*	Confirmed, recently collected by Helgen (2004) near Lospalos.	Vulnerable A3cd
Indonesian short-nosed fruit bat *Cynopterus titthaecheilus*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor.	LC
Moluccan naked-backed fruit bat *Dobsonia moluccensis*	Unpublished observations on a single museum specimen by Helgen (2004), no published accounts, record doubtful. Closest record is Roti Island (Corbet and Hill 1992).	LC
Western naked-backed fruit bat *Dobsonia peronii peronii*	Observed at Lenahara cave by Pavey and Milne (2004), accepted to be on Timor.	LC
Lesser dawn bat *Eonycteris spelaea*	Captured by Pavey and Milne (2004), accepted to be on Timor.	LC
Dagger-toothed long-nosed fruit bat *Macroglossus minimus*	Captured by Armstrong (2007), accepted to be on Timor.	LC
Keast's tube-nosed fruit bat *Nyctimene keasti*	No records on Timor since Andersen (1912 cited in Goodwin 1979). See Simmons (2005) for taxonomy cf. *N. cephalotes.*	Vulnerable B1ab(ii,iii)
Gray flying-fox *Pteropus griseus*	Records accepted (Goodwin 1979, Corbet and Hill 1992, Simmons 2005). Collected by Pavey and Milne (2004).	DD
Lombok flying-fox *Pteropus lombocensis*	Not included by Corbet and Hill (1992) but present according to Kitchener and Suyanto (1996), review of Simmons (2005).	DD
Temminck's flying-fox *Pteropus temminckii*	Record doubtful (Simmons 2005).	Vulnerable A2c
Large flying-fox *Pteropus vampyrus*	Records accepted (Goodwin 1979, Corbet and Hill 1992).	NT
Geoffroy's rousette *Rousettus amplexicaudatus*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor.	LC

Continued next page ...

Table 1. Summary of bat species known from the island of Timor, *continued*.

Species[1]	Comment on taxonomy, identification and presence on Timor	IUCN status[2]
Family Emballonuridae (Sheath-tailed bats)		
Bare-rumped sheath-tailed bat *Saccolaimus saccolaimus*	Accepted to be on Timor (Simmons 2005)	LC
Indonesian tomb bat *Taphozous achates*	Collected from West Timor (Kitchener and Suyanto 1995). Nominate subspecies on other islands in Nusa Tenggara.	DD
Black-bearded tomb bat *Taphozous melanopogon*	Accepted to be on Timor (Simmons 2005).	LC
Family Rhinolophidae (Horseshoe bats)		
Canut's horseshoe bat *Rhinolophus canuti timoriensis*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor. Taxonomy follows Csorba et al. (2003).	Vulnerable B1ab(iii) *E
Sulawesi horseshoe bat *Rhinolophus celebensis parvus*	Captured by Pavey and Milne (2004) and echolocation calls recorded by Armstrong (2007), accepted to be on Timor. Taxonomy follows Csorba et al. (2003).	LC *E
Timorese horseshoe bat *Rhinolophus montanus*	Described by Goodwin (1979) as a taxon distinct from *R. philippinensis*, elevated to species status by Csorba (2002) and Csorba et al. (2003). Echolocation calls recorded by Armstrong (2007), endemic to Timor.	DD *E
Unidentified Large-eared horseshoe bat *Rhinolophus* aff. *philippinensis*	Captured, and echolocation calls recorded by Armstrong (2007), currently under taxonomic investigation (Armstrong et al. ms in prep.). Calls distinct from *R. montanus*. Might be referrable to either *R. p. achilles*, *R. p. maros* or a new taxon.	NE *E?
Family Hipposideridae (Leaf-nosed bats)		
Bicoloured leaf-nosed bat *Hipposideros bicolor hilli*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor (Goodwin 1979; Kitchener et al. 1996).	LC *E
Diadem leaf-nosed bat *Hipposideros diadema diadema*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor (Simmons 2005). Timor is the type locality of this species.	LC
Sumban leaf-nosed bat *Hipposideros sumbae* aff. *rotiensis*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor. Kitchener and Maryanto (1993) examined a single specimen from Campalong in West Timor and referred it to the subspecies *rotienesis*, pending further collection.	LC *E?

Continued next page ...

Table 1. Summary of bat species known from the island of Timor, *continued*. *See over for footnotes ...*

Species[1]	Comment on taxonomy, identification and presence on Timor	IUCN status[2]
Family Vespertilionidae (Evening bats)		
Unidentified Hairy-winged bat *Harpiocephalus* aff. *harpia*	Captured by both Pavey and Milne (2004) and Armstrong (2007) and designated as *Murina* aff. *cyclotis*. Subsequent examination shows this to be either *Harpiocephalus harpia* or a related new species on the basis of skull features (Armstrong et al. ms in prep.).	NE *[E?]
Unidentified woolly bat *Kerivoula* sp.	Captured by both Pavey and Milne (2004) and Armstrong (2007). Species status still under investigation (Armstrong et al. ms in prep.).	NE *[E?]
Unidentified tube-nosed bat *Murina* aff. *florium*	First captured by Pavey and Milne (2004), specimens undergoing further examination (Armstrong et al. ms in prep.).	NE *[E?]
Large-footed myotis *Myotis adversus adversus*	Recorded to date from West Timor only (Kitchener et al. 1995).	LC
Unidentified long-eared bat *Nyctophilus* sp.	Specimens collected from near Maubisse (Helgen 2004) are possibly *Nyctophilus heran* which is on Lembata Island (Kitchener et al. 1991b), unlikely to be the same species as in Australasia, which was until recently (Parnaby 2009) known as *N. timoriensis*.	NE *[E?]
Unidentified pipistrelle *Pipistrellus sp.*	Widespread, occurs around villages, see comments in Goodwin (1979), Simmons (2005). Genetic studies recently suggested that the form resembling *P. tenuis* captured by Armstrong (2007) is not this taxon, and taxonomic status is undergoing further examination (Armstrong et al. ms in prep.).	NE *[E?]
Sody's yellow house bat *Scotophilus collinus*	See Simmons (2005) for taxonomic summary – *S. kuhlii* not on Timor. Captured by Pavey and Milne (2004) but misidentified as a possible new species of *Taphozous*.	LC
Northern broad-nosed bat *Scotorepens sanborni*	Collected from West Timor only (Kitchener et al. 1994). Present in New Guinea (Bonaccorso 1998) and northern Australia (Churchill 2008), likely to be found across Timor.	LC
Greater bamboo bat *Tylonycteris robustula*	Present on basis of two historical specimens in the BMNH (London) labelled as being from Timor (Goodwin 1979). No other records.	LC
Family Miniopteridae (Bent-winged bats)		
Little bent-winged bat *Miniopterus australis*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor.	LC
Large bent-winged bat *Miniopterus magnater*	Present according to Simmons (2005).	LC
Australasian bent-winged bat *Miniopterus oceanensis*	Captured by both Pavey and Milne (2004) and Armstrong (2007). Previously referred to as *M. schreibersii*, updated according to Appleton et al. (2004) and Tian et al. (2004).	LC
Small bent-winged bat *Miniopterus pusillus*	Captured by Pavey and Milne (2004), distinct subspecies on Timor (Kitchener and Suyanto 2002; Simmons 2005).	LC

[1] Nomenclature follows IUCN (2012) preferentially, then Simmons (2005). [2] IUCN (International Union for Conservation of Nature) conservation status (IUCN 2012). DD: Data Deficient; LC: Least Concern; NT: Near Threatened; NE: Not Evaluated, no conservation status yet available. Taxa that are potentially new to science are given a status of NE. *^{E} denotes endemic species or subspecies on Timor island, and *$^{E?}$ denotes possible endemic taxon, pending further taxonomic study (e.g. Armstrong et al ms in prep.).

Table 2. Species identified at each site from overnight recordings made with AnaBat detectors (raw results; NC: needs confirmation).

Date	Serial	Site	Site code	Habitat	UTM	*18 sh.cFM*	*21 sh.cFM*	*25 cFM*	*32 st.cFM*	*37 st.cFM*	*28 ICF R. aff. philippinensis*	*38 ICF Rhinolophus montanus*	*41 st.cFM*	*47 st.cFM*	*54 st.cFM*	*55 sCF Hipposideros diadema*	*63 st.cFM Miniopterus australis*	*72 ICF Rhinolophus canuti*	*86 ICF Rhinolophus celebensis*
10/12/2011	5334	Suai	—	—	—	◆	◆	◆	—	◆		—	◆		—	—	—	—	—
11/12/2011	80095	Suai	—	—	—	—	◆	◆	—	—		—	◆		◆	—	◆	◆	—
12/12/2011	5334	Suai	—	—	—	◆	◆	◆	—	◆		—	◆		◆	—	◆	—	—
12/12/2011	80095	Suai	—	—	—	◆	◆	◆	—	◆		—	◆		◆	—	◆	◆	—
16/12/2011	80095	Betano	AN9	Hilltop / woodland	51L 802026 8986789	◆	◆	◆	◆	◆		◆	◆		◆	◆	◆	◆	◆
16/12/2011	81220	Betano	AN8	Woodland	51L 802663 8986322	—	◆	◆	—	◆		—	◆		◆	—	◆	—	◆
19/12/2011	5334	Beacu	AN14	Near coastal scrub	51L 217134 9010159	◆	◆	◆	—	—		—	◆		◆	—	◆	—	—
7/02/2012	5334	Suai	AN15	Woodland	51L 752256 8971670	—	◆	◆	◆	◆	—	—	◆	—	◆	—	◆	◆	◆
7/02/2012	80095	Suai	AN16	Woodland	51L 753670 8972774	—	◆	◆	◆	◆	—	—	◆	◆	◆	◆	◆	◆	◆
8/02/2012	5334	Suai	AN15	Woodland	51L 752256 8971670	—	◆	◆	—	◆	—	—	◆	—	◆	—	◆	◆	—
8/02/2012	80100	Suai	AN17	Open water / dam	51L 755080 8971473	—	◆	—	◆	◆	—	—	◆	◆	◆	◆	◆	◆	◆
8/02/2012	81220	Suai	AN18	Large fig trees	51L 754700 8972975	—	◆	◆	◆	—	NC	—	◆	—	◆	—	◆	◆	◆
13/02/2012	80100	Viqueque	AN23	Low hill / grassland	52L 211964 9018060	—	◆	◆	◆	◆	—	—	◆	◆	◆	◆	◆	◆	◆

Table 3. Summary of variables from representative call sequences of the species identified and the call types recognised.

Species (FM body type)	**s,p[1]**	**Duration (msec)[2]**	**Max Frequency (kHz)[2]**	**Char frequency (kHz)[2]**
18 sh.cFM	7,30	11.3 ± 3.3 7.1 – 20.6	18.8 ± 1.7 16.3 – 21.0	17.9 ± 1.4 15.8 – 19.9
21 sh.cFM	4,17	10.1 ± 2.1 7.1 – 14.3	22.9 ± 1.0 21.4 – 25.1	21.5 ± 0.4 20.6 – 22.1
25 cFM	3,13	8.2 ± 2.2 4.7 – 12.3	27.7 ± 2.1 26.0 – 32.4	24.8 ± 0.8 23.7 – 26.3
32 st.cFM	4,84	5.8 ± 1.6 3.0 – 10.3	40.4 ± 7.8 31.1 – 60.2	31.8 ± 0.8 29.5 – 33.5
37 st.cFM	4,35	4.9 ± 1.3 3.2 – 8.1	41.6 ± 3.6 37.0 – 51.6	37.3 ± 0.7 36.4 – 39.2
41 st.cFM	9,82	6.5 ± 2.3 3.1 – 14.0	46.4 ± 6.0 41.0 – 64.0	41.5 ± 1.0 39.0 – 44.4
47 st.cFM	3,39	5.0 ± 1.1 3.0 – 7.1	50.0 ± 3.8 44.9 – 59.3	46.5 ± 1.7 44.0 – 49.7
54 st.cFM	7,50	3.4 ± 0.6 2.0 – 5.4	65.2 ± 6.0 54.1 – 80.0	54.0 ± 0.9 51.3 – 55.9
63 st.cFM Little long-fingered bat *Miniopterus australis*	9,50	4.8 ± 1.4 3.1 – 9.8	70.5 ± 5.1 62.5 – 82.5	62.7 ± 1.1 60.6 – 65.0
Species (CF body type)	**s,p[1]**	**Duration (msec)[3]**		**Char frequency (kHz)[4]**
28 lCF Large-eared Horseshoe bat *Rhinolophus* aff. *philippinensis*	1,1	50+	—	27.8
38 lCF Timorese horseshoe bat *Rhinolophus montanus*	4,10	69+	—	38.1 ± 0.8 36.4 – 39.8
55 sCF Diadem leaf-nosed bat *Hipposideros diadema diadema*	5,24	13.5 ± 2.2 10.4 – 18.2	—	54.6 ± 0.4 53.7 – 55.2
72 lCF Canut's horseshoe bat *Rhinolophus canuti timoriensis*	5,58	9.2 ± 17.1 0.2 – 65.2	—	71.1 ± 0.8 69.6 – 72.7
86 lCF Sulawesi horseshoe bat *Rhinolophus celebensis parvus*	1,3	36+	—	86.0 ± 0.6 85.1 – 87.9

[1] s,p: number of sequences measured, combined total number of pulses measured; [2] Mean ± SD; range; [3] Mean ± SD; range; partial calls only were available for some species; [4] The frequency with the greatest or peak number of cycles, designated as 'Fpz' in AnalookW; Mean ± SD; range.

Table 4. Echolocation call categories based on the morphology of the dominant type of search-phase pulses in high quality sequences (adapted from de Oliveira (1998a,b) and Corben and O'Farrell (1999); examples are not scaled equally). Pulses generally consist of three main sections: an initial frequency sweep (IFS), followed by the main body (BST: Body Sub Type), and ending in a terminating frequency sweep (TFS). The shape of the pulse is represented by the codes in the form '*IFS.BST.TFS*', prefixed by a value representing the mean characteristic frequency in kHz. Note that most CF pulses have a recognisable initial upward frequency sweep, and all have a terminating frequency sweep, so the IFS and TFS descriptors are not used for this Body Sub Type.

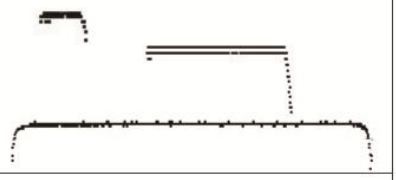
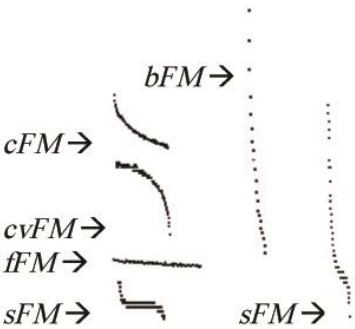
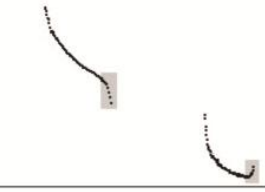
Code	Description	Example
CF	**Constant Frequency main Body Sub Type (BST)**	
sCF	Short duration (<15 ms)	
mCF	Medium duration (15 – 30 ms)	
lCF	Long duration (>30 ms)	
FM	**Frequency Modulated main Body Sub Type (BST)**	
bFM	Broadband, slightest degree of curvature only, no significant development of serpentine component (*sFM*)	*bFM*→
cFM	Curved, simple or curvilinear trace	*cFM*→
cvFM	Convex curved, essentially cFM rotated 180°	*cvFM*→
fFM	Flat or with a very slight curve, narrowband, not *CF*	*fFM*→
sFM	Serpentine, generally S-shaped	*sFM*→ *sFM*→
	Initial Frequency Sweep (IFS)	
i.	Inclined, a narrowband increasing frequency sweep	
sh.	Short, shallow or narrowband frequency sweep	
st.	Steeply decreasing, broadband frequency sweep	
	Terminating Frequency Sweep (TFS)	
.d	Drooped, decreasing frequency sweep following the characteristic frequency in the main body of the call	
.h	Hooked, increasing in frequency following the characteristic frequency	

Table 5. Comments on the taxonomic identification of the bat call types defined in this survey.

18 sh.cFM	Most likely attributable to the bare-rumped sheath-tailed bat *Saccolaimus saccolaimus* on the basis of call frequency, and also the commonly observed pattern of alternating the characteristic frequency in successive pulses (e.g. Milne et al. 2009). Capture or observation of bats in flight in a spotlight would be required for confirmation.
21 sh.cFM	Attributable to one of the sheath-tailed bats on Timor: either the Indonesian tomb bat *Taphozous achates*, the call of which has not yet been characterised; or the bare-rumped sheath-tailed bat *Saccolaimus saccolaimus*, which produces a variety of call types. One or both of these species might produce this call type. Capture or observation of bats in flight in a spotlight would be required for confirmation.
25 cFM	Most likely attributable to the black-bearded tomb bat *Taphozous melanopogon* based on reference calls described in Pottie et al. (2005) and other unpublished information, however reference calls are not available from Timor, and have not been compared with those from *T. achates*. The call type designation should be used until further information is available for a confident retrospective identification, since there may be geographic variation in characteristic call frequency and/or taxonomic issues that will have a bearing on this identification.
32 st.cFM	Possibly attributable to a large vespertilionid such as Sody's yellow house bat *Scotophilus collinus* (cf. the calls of *S. kuhlii* in Pottie et al. 2005). Capture would be required for identification.
37 st.cFM	Most likely attributable to a large species of miniopterine bat such as the western long-fingered bat *Miniopterus magnater*, based on the similarity of the characteristic frequency with calls of this species in New Guinea (K.P. Aplin and K.N. Armstrong unpublished data), or one of the larger vespertilionids such as *Scotophilus collinus* (cf. the calls of *S. kuhlii* in Pottie et al. 2005). Capture, and possibly DNA barcoding if the bat was a *Miniopterus*, would be required for identification.
28 lCF Rhinolophus* aff. *philippinensis	One very poor quality call sequence had signals with characteristics indicating the possible presence of a previously unrecognised species of *Rhinolophus* in the *philippinensis* group, as first discovered by Armstrong (2007). The taxonomic affiliation of this form has yet to be established, and it may be referrable to *R. philippinensis achilles*, *R. p. maros*, or a taxon new to science.
38 lCF Rhinolophus montanus	Attributable with high confidence to the Timorese horseshoe bat *Rhinolophus montanus* based on the remarkably low characteristic frequency and long duration of calls. While reference calls are not available for *R. montanus*, this species belongs to the *philippinensis* group of *Rhinolophus* that typically produce calls with a characteristic frequency somewhere below 45 kHz. The other undescribed *philippinensis*-group *Rhinolophus* also present on Timor is larger and produces calls with a characteristic frequency of c. 27 kHz (Armstrong et al. ms in prep.), allowing *R. montanus* to be identified through a process of elimination.

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Table 5. Comments on the taxonomic identification of the bat call types, *continued*.

41 st.cFM	One of several candidate species in the Miniopteridae or Vespertilionidae. Capture, and possibly DNA barcoding if the bat was a *Miniopterus*, would be required for identification.
47 st.cFM	One of several candidate species in the Miniopteridae or Vespertilionidae. Some echolocation calls had a body type of *sFM*, typical of *Miniopterus*. Capture, and possibly DNA barcoding if the bat was a *Miniopterus*, would be required for identification.
54 st.cFM	One of several candidate species in the Miniopteridae or Vespertilionidae. Capture, and possibly DNA barcoding if the bat was a *Miniopterus*, would be required for identification.
63 st.cFM Miniopterus australis	One of several candidate species in the Miniopteridae or Vespertilionidae. Based on reference calls collected by Armstrong (2007), this call could be attributable to the little long-fingered bat *Miniopterus australis*. Capture, and possibly DNA barcoding if the bat was indeed a *Miniopterus*, would be required for identification.
55 sCF Hipposideros diadema diadema	Attributable based on reference calls collected by Armstrong (2007) and elsewhere such as in Papua New Guinea (Leary and Pennay 2011).
72 lCF Rhinolophus canuti timoriensis	Attributable based on reference calls collected by Armstrong (2007).
86 lCF Rhinolophus celebensis parvus	Attributable based on calls collected by Pavey and Milne (2004) and Armstrong (2007).

Table 6. Summary of species identified at each locality from overnight recordings made with AnaBat detectors (NC: needs confirmation). The relative abundance (RA) of each species is given for Suai, based on the proportion of observations over 9 AnaBat recording nights.

	Beacu	**Betano**	**Suai**	**(RA)**	**Viqueque**
18 sh.cFM	◆	◆	◆	0.3	—
21 sh.cFM	◆	◆	◆	1	◆
25 cFM	◆	◆	◆	0.9	◆
32 st.cFM	—	◆	◆	0.4	◆
37 st.cFM	—	◆	◆	0.8	◆
28 lCF R. aff. *philippinensis*	—	—	NC	0.1	—
38 lCF Rhinolophus montanus	—	◆	—	0	—
41 st.cFM	◆	◆	◆	1	◆
47 st.cFM	—	—	◆	0.2	◆
54 st.cFM	◆	◆	◆	0.9	◆
55 sCF Hipposideros diadema	—	◆	◆	0.2	◆
63 st.cFM Miniopterus australis	◆	◆	◆	0.9	◆
72 lCF Rhinolophus canuti	—	◆	◆	0.8	◆
86 lCF Rhinolophus celebensis	—	◆	◆	0.4	◆
No. AnaBat nights	1	2	9		1
Total richness	6	12	13		11

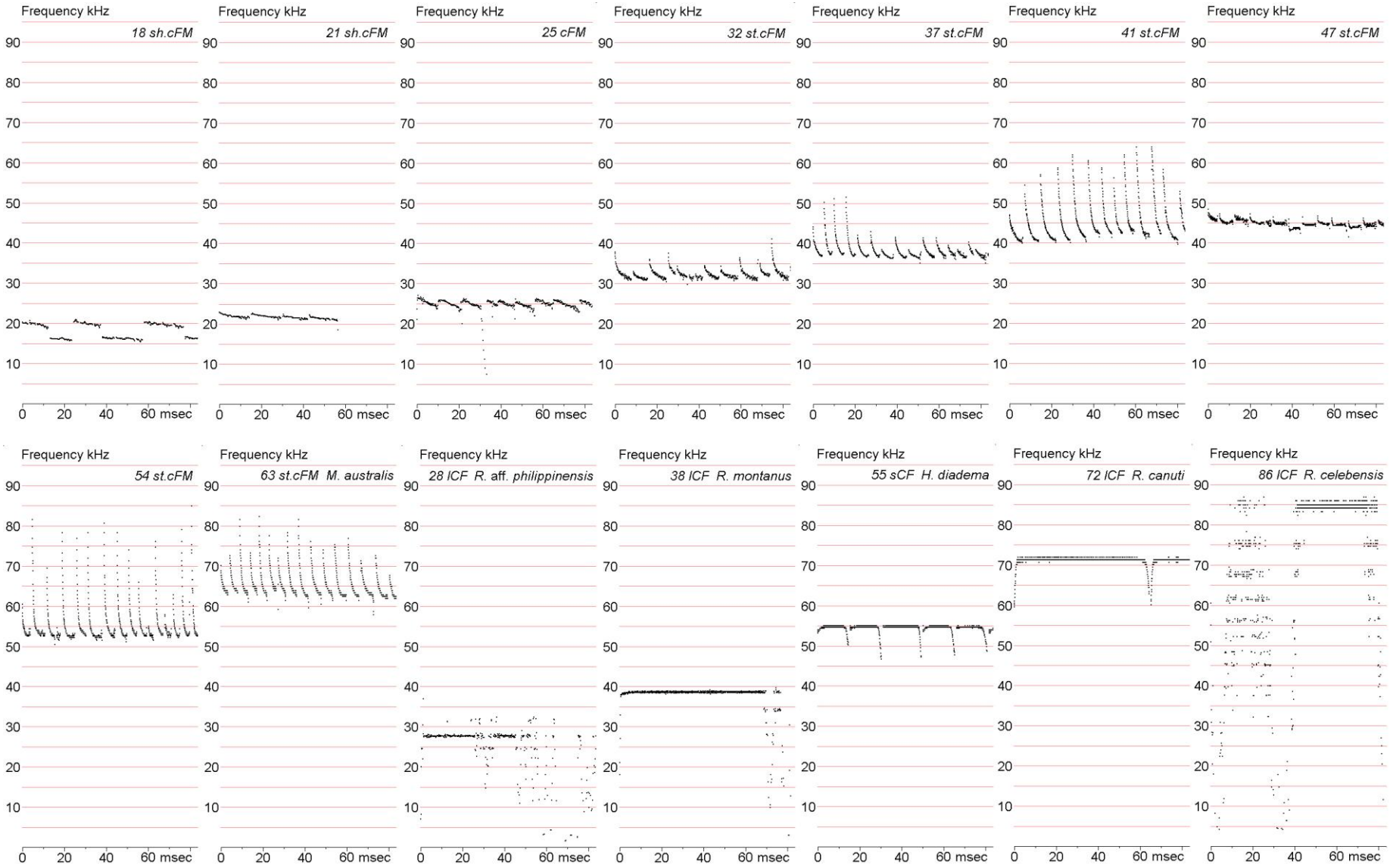

Figure 1. Representative call sequences of the species identified (time is compressed between pulses).

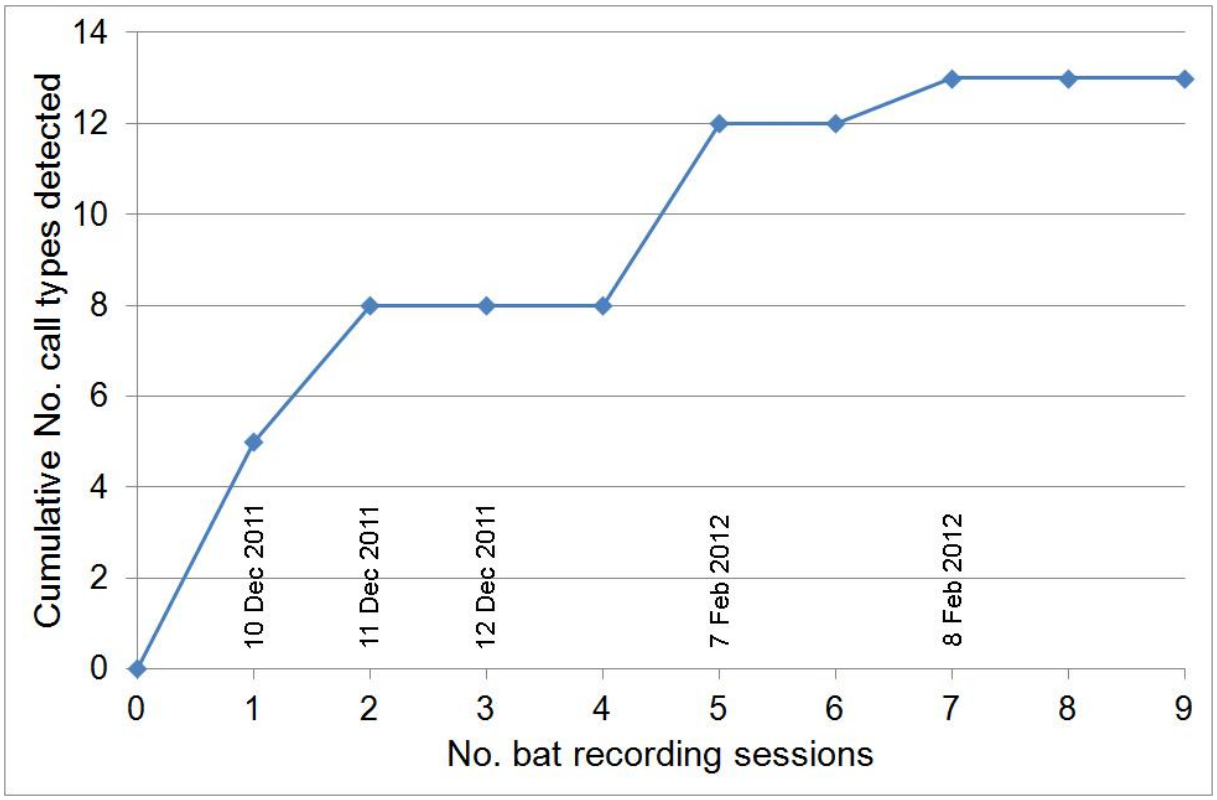

Figure 2. Species accumulation curve for Suai, based on surveys in December 2011 and February 2012. Multiple deployments were in different habitats at Suai on 12 Dec 2011, 7 Feb 2012 and 8 Feb 2012.

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REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

APPENDIX 7

Potential Likelihood of Occurrence of Conservation Significant Species

301012-01504-EN-REP-0006
June 2012

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
Mauremys reevesii Reeves' Turtle	EN			x	*Mauremys reevesii* is native to most of temperate and subtropical China, North Korea and South Korea; populations also occur in Taiwan, Hong Kong and Japan, though these may be historic introductions by humans (Fong and Chen 2010). Populations recorded from Timor (Indonesia), Timor-Leste and Palau certainly originated from human introductions. Historically a common and widespread species, *Mauremys reevesii* is now a rare species in the wild. This species natural habitat includes shallow wetlands and the land that immediately surrounds them.	This species presence in Timor-Leste is due to historic human introduction and is far outside its nominal distribution. No wetland habitat type exists in the project area suitable for this species to become resident.	Unlikely
Fregata andrewsi Christmas Island Frigatebird	CR		App I		The Christmas Island Frigatebird *Fregata andrewsi* is the rarest of the five species of the family Fregatidae and breeds only on Christmas Island. When not breeding, Christmas Island Frigatebirds range widely around South-east Asia and the Indian Ocean, and are occasional visitors to the shores of Java, Sumatra, Bali, Borneo, the Andaman Is, Darwin and the Cocos (Keeling) Islands (Gore 1968, Marchant and Higgins 1990). It is possible the young birds are nomadic and wander widely until they reach breeding age; however, adults have also been seen far away from the island. It has been speculated they may breed somewhere in the Anamba-Natuna islands (Chasen 1933, Gibson-Hill 1947), but this was based only on sightings in the vicinity of these islands.	An uncommon vagrant to Timor-Leste. There have been two recent records for Timor-Leste: a male at Cristo Rei 1 March 2003 and a female at Comoro River on 11 March 2006.	Possible
Esacus magnirostris Beach Thick-knee	NT				The Beach Thick-knee is widespread around coasts from the Andaman Islands, India, Mergui Archipelago, Myanmar, islands off peninsular Thailand, and Peninsular Malaysia through Indonesia, Brunei, the Philippines, Papua New	The Beach Thick-knee is expected to be found within the marine coastal environments /	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					Guinea, the Solomon Islands, Vanuatu, New Caledonia (to France) and Australia. Pairs may be found on most beaches within its range; including short stretches of muddy sand among mangroves, coralline sands on atolls and prime surf beaches (Garnett and Crowley 2000). Beaches associated with estuaries and mangroves are particularly favoured. Adults are sedentary, although the species has a tendency for wide-ranging vagrancy. It lays a single egg in a scrape in the sand at the landward edge of the beach, often using the same area repeatedly. It forages mainly in the intertidal zone on crustaceans and other invertebrates (Garnett and Crowley 2000). This species qualifies as Near Threatened because it has a small population. If the population is found to be in decline it might qualify for up listing to a higher threat category.	habitats of the project area.	
Charadrius peronii Malaysian Plover	NT				The Malaysian Plover is a breeding resident in Vietnam (scarce in Cochinchina), Cambodia (rare), peninsular Thailand (local and uncommon), Peninsular Malaysia (scarce to locally common), East Malaysia, Singapore (rare), Brunei (apparently declining), Philippines (widespread but uncommon) and Indonesia (local around coasts and offshore islands of Sumatra, uncommon on and around Borneo and Bali, very rare on mainland Java; uncommon and sparsely distributed in the Lesser Sundas and the Sulawesi subregion). It frequents quiet sandy bays, coral sand beaches, open dunes and artificial sand-fills, where it lives in pairs, generally not mixing with other waders. This species is classified as Near Threatened because it	This species typical distribution and migratory pathways are outside the project area and its general vicinity. Potential to be an uncommon vagrant.	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					is likely to have a moderately small population which, owing to the development pressures on the coastal areas it inhabits, is likely to be undergoing a decline.		
Charadrius javanicus Javan Plover	NT				The Javan Plover is typically restricted to Java and the Kangean Islands in Indonesia; this species may be found as a vagrant in Timor Leste. The taxonomic status of this species is extremely unclear and records attributable to it are therefore sparse; nevertheless, it was recently found common in southern Madura. Whilst it may prove widespread, its population is likely to be small and declining. It occurs on sandy beaches, mudflats and adjacent open areas around the coasts. This species has a narrow range in which development and recreation are putting pressure on critical breeding habitats. It is likely to have a moderately small population, and this is thought to be declining; it is consequently classified as Near Threatened.	This species may be an uncommon vagrant to Timor Leste. Suitable marine coastal foraging habitat is present	Possible
Numenius madagascariensis Far Eastern Curlew	VU				The Far Eastern Curlew breeds in eastern Russia, from the upper reaches of the Nizhnyaya Tunguska river east though the Verkhoyarsk mountains to Kamchatka, and south to Primorye and north-eastern Mongolia. It has been recorded as a non-breeding visitor to Japan, North Korea, South Korea, mainland China, Hong Kong (China), Brunei, Bangladesh, Thailand, Vietnam, Philippines, Malaysia, Singapore, with most birds wintering in Australia, but also in Taiwan, Indonesia, Papua New Guinea, and New Zealand (del Hoyo *et al.* 1996). The species breeds on open mossy or transitional bogs, moss-lichen bogs and wet meadows, and on the swampy shores of small	Suitable foraging / sheltering habitat is present in the project area and within this species distribution and migratory pathways. This species may be expected to be found foraging and sheltering during its annual migration.	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					lakes; in the non-breeding season it is essentially coastal, occurring at estuaries, mangrove swamps, saltmarshes and intertidal flats, particularly those with extensive seagrass (Zosteraceae) meadows. It often roosts in salt-marshes, behind mangroves, or on sandy beaches (del Hoyo *et al.* 1996). This species has been up listed to Vulnerable owing to a rapid population decline which is suspected to have been primarily driven by habitat loss and deterioration. Further proposed reclamation projects are predicted to cause additional declines in the future.		
Numenius arquata Eurasian Curlew	VU				Eurasian Curlew is widely distributed breeding across Europe from the British Isles, through north-western Europe and Scandinavia into Russia extending east into Siberia, east of Lake Baikal. It winters around the coasts of north-west Europe, the Mediterranean, Africa, the Middle East, the Indian Subcontinent, South-East Asia, Japan and the Sundas. The species breeds on upland moors, peat bogs, swampy and dry heathlands, fens, open grassy or boggy areas in forests, damp grasslands, meadows (del Hoyo et al. 1996), non-intensive farmland in river valleys (Hayman et al. 1986), dune valleys and coastal marshlands (del Hoyo et al. 1996). Non-breeding During the winter the species frequents muddy coasts, bays and estuaries (del Hoyo et al. 1996) with tidal mudflats and sandflats (Snow and Perrins 1998), rocky and sandy beaches with many pools (Johnsgard 1981, Snow and Perrins 1998), mangroves, saltmarshes (Snow and Perrins 1998), coastal meadows (Johnsgard 1981)and muddy shores of coastal lagoons8, inland	Suitable foraging / sheltering habitat is present in the project area and within this species distribution and migratory pathways. This species may be expected to be found foraging and sheltering during its annual migration.	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					lakes and rivers (del Hoyo et al. 1996). This widespread species remains common in many parts of its range, and determining population trends is problematic. Nevertheless, declines have been recorded in several key populations and overall a moderately rapid global decline is estimated. As a result, the species has been uplisted to Near Threatened.		
Limosa limosa Black-tailed Godwit	NT				The Black-tailed Godwit has a large discontinuous breeding range extending from Iceland to the Russian far east, with wintering populations in Europe, Africa, the Middle East and Australasia (del Hoyo *et al*. (1996). The species migrates southwards between late-June and October Australasia (del Hoyo *et al*. (1996). In its breeding range it mostly inhabits areas with high grass and soft soil (del Hoyo *et al*. 1996, Johnsgard 1981), occasionally using sandy areas (Johnsgard 1981). This species tends to winter in freshwater habitats (del Hoyo *et al*. (1996), including swampy lake shores, pools, flooded grassland and irrigated rice fields (del Hoyo *et al*. (1996). Subspecies *islandica* and *melanuroides*, however, often winter in brackish habitats (del Hoyo *et al*. (1996) such as sheltered estuaries and lagoons with large intertidal mudflats (Johnsgard 1981), sandy beaches, salt-marshes and salt-flats (del Hoyo *et al*. 1996). Although this species is widespread and has a large global population, its numbers have declined rapidly in parts of its range owing to changes in agricultural practices. Overall, the global population is estimated to be declining at such a rate that the species qualifies as Near Threatened.	Suitable foraging / sheltering habitat is present in the project area and within this species distribution and migratory pathways. This species may be expected to be found foraging and sheltering during its annual migration.	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
Calidris tenuirostris Great Knot	VU				The Great Knot breeds in north-east Siberia, Russia, wintering throughout the coastline of South-East Asia, and also on the coasts of Australia, India, Bangladesh, Pakistan, and the eastern coast of the Arabian Peninsula (del Hoyo *et al*. 1996). The species breeds on gravelly areas covered with lichen and patches of herbs, heather (del Hoyo *et al*. 1996), *Empetrum* spp., *Dryas* spp. and *Vaccinium* spp. (Johnsgard 1981), or alternatively on areas with a continuous layer of lichen and scattered stunted larch *Larix* spp. or dwarf pine *Pinus pumila* (del Hoyo *et al*. 1996). In its wintering range the species occurs in sheltered coastal habitats such as inlets, bays, harbours, estuaries and lagoons with large intertidal mud and sandflats, oceanic sandy beaches with nearby mudflats (del Hoyo *et al*. 1996, Higgins and Davies 1996), sandy spits and islets, muddy shorelines with mangroves and occasionally exposed reefs or rock platforms (Higgins and Davies 1996). This species has been uplisted to Vulnerable owing to a rapid population decline caused by the reclamation of non-breeding stopover grounds, and under the assumption that further proposed reclamation projects will cause additional declines in the future.	Ten individuals were recorded foraging on the reef platform at Beaco. Suitable foraging / sheltering habitat is present in the project area and within this species distribution and migratory pathways. This species may be expected to be found foraging and sheltering during its annual migration.	Recorded
Limnodromus semipalmatus Asian Dowitcher	NT				Asian Dowitcher has a disjunct breeding range in the steppe regions that extend from west to east Siberia, Russia, and south into Mongolia and Heilongjiang in north-east China. It has been recorded as a non-breeding visitor to Japan, North Korea, South Korea, mainland China, Hong Kong (China), Taiwan (China), Kazakhstan, Uzbekistan, India, Bangladesh, Sri Lanka, Myanmar, Thailand,	Suitable foraging / sheltering habitat is present in the project area and within this species distribution and migratory pathways. This species may be	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					Vietnam, Philippines, Malaysia, Singapore, Brunei, Indonesia, Papua New Guinea, Australia and New Zealand. It breeds in extensive freshwater wetlands in the steppe and forest steppe zones. Suitable habitats include lake shores, river deltas, flooded meadows and grassy bogs along rivers with short grass and sedge vegetation (del Hoyo *et al*. 1996), and areas of bare mud (Johnsgard 1981). During the non-breeding season it occurs in sheltered coastal environments, primarily estuarine and intertidal mudflats, lagoons, creeks and saltworks (del Hoyo *et al*. 1996). It will also roost on sandy beaches or in shallow lagoons during this season (del Hoyo *et al*. 1996). This species is classified as Near Threatened because, although it is quite widespread, it has a moderately small population overall and this is thought to be in decline, owing primarily to destruction of its wintering grounds. An even more rapid population decline may take place in the future owing to climate change.	expected to be found foraging and sheltering during its annual migration.	
Turacoena modesta Slaty Cuckoo-Dove	NT				The Slaty Cuckoo-dove is restricted to Timor-Leste, West Timor and Wetar, Nusa Tenggara, Indonesia, where it is generally uncommon or rare. Historical records indicate that it was once fairly common, at least locally on Wetar and in West Timor, even near settlements. A paucity of recent records, despite extensive searching, suggests that a marked decline has occurred in West Timor. However, recent survey work in Timor-Leste revealed it to be frequent in a wide range of habitats (Trainor *et al*. (2004). It inhabits primary and tall secondary monsoon-forest, often where this habitat is drier or more open, and also vine thickets, thickly vegetated	One individual was recorded at Betano and three individuals were recorded at Beaco on two occasions. This species is expected to be found foraging and nesting within suitable habitat of the development area.	Recorded

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					gullies and eucalyptus woodland with dense understorey, from sea-level to 1,770 m (Trainor *et al*. 2007a, Mauro 2003). As it has been found in "more or less open areas near villages", it probably has a degree of tolerance to habitat degradation, and in Timor-Leste appears to be more common in patchy landscapes (forest edge, secondary forest, woodland with scattered figs, Eucalyptus savanna or non-Eucalyptus woodlands with tropical forest trees in gullies or on scattered rock outcrops) (Trainor *et al*. 2007a). This species is classified as Near Threatened because recent surveys in Timor-Leste have shown it to be more abundant than once feared, and to inhabit a wider range of habitats. However, it is still suspected to be declining moderately rapidly owing to the levels of hunting and rates of habitat loss, and it is therefore classified as Near Threatened.		
Gallicolumba hoedtii Wetar Ground-Dove	EN				The Wetar Ground Dove occurs in West Timor and Wetar, Nusa Tenggara, Indonesia, and Timor-Leste. This species is one of the rarest pigeons in the world (Timor and Wetar) and may have specialised habitat requirements. In Timor-Leste, it was found in 2005 in spring forest at Foho Lulik, on the south coast near the Indonesian border (Lambert *et al.* 2006). No other regular sites are known anywhere, but traders in Dili indicated that captured birds were obtained from the Natarbora area, which includes a wild area of swamp forests, secondary forests and wetlands in the Sungai Clere region of Manufahi (Same) and Manatuto districts. Birds seen appeared to have a strong association with the spring habitat, but more survey work is	This highly rare pigeon was recorded 20 km to the west of the Suai development area. Suitable habitat is present in the project area and despite being extremely rare this species can be expected to occur. Considering the rare appearance of this species in the wild	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					needed on the broad coastal plain on Timor-Leste's south coast. It is believed to be absent from Nino Konis Santana National Park in the far-east (Lambert *et al.* 2006). It inhabits lowland monsoon-forest, and possibly woodland, up to 950 m. In West Timor two of the three records have been from "forest near a clearing" and "fairly undisturbed hill forest". Its habitat receives highly seasonal rainfall, but it is not known whether it makes any dispersive movements, e.g. in response to bamboo seeding events, as in several of its congeners (Trainor *et al.* 2007b). It is possible that this species is associated with bamboo, and thus partly nomadic (Lambert *et al.* 2006). Birds found recently in Timor-Leste were only found within gallery forest and remnant trees bordering a wide stream, suggesting wet forest - possibly even only that associated with flowing water - is important breeding habitat (Lambert *et al.* 2006). It has been presumed to be largely solitary and to forage on the ground like its congeners but it appears to call from, and nest in, the canopy (Lambert *et al.* 2006). It appears to be a dry-season breeder. This species qualifies as Endangered because it has suffered a very rapid population decline which is expected to continue as a result of severe lowland habitat loss and hunting. A healthy population may survive on Wetar, but further surveys are required to establish its current status.	determines that it may 'possibly' occur as opposed to 'likely'.	
Treron psittaceus Timor Green-Pigeon	EN				The Timor Green-pigeon is endemic to Timor-Leste, West Timor and its satellite islands, Semau (though there is no recent data) and Roti, Nusa Tenggara, Indonesia, where it appears to be uncommon or rare, and apparently very local. It has been	This species is typical localised in their distribution and may be nomadic in response to the	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					infrequently recorded during recent fieldwork, although it is perhaps overlooked owing to its inconspicuous and very wary disposition. It inhabits primary and tall secondary, lowland dry and monsoon-forest, mostly in the extreme lowlands, straggling up to 1,000 m (Mauro 2003, Trainor and Soares 2004 and Trainor *et al.* 2007a). It may be nomadic in response to the fruiting cycle of figs, and is usually encountered in small flocks containing tens of birds, exceptionally up to 140 individuals (Trainor *et al.* 2007a). It is thought to have declined recently throughout West Timor, but is more common in Timor-Leste (Trainor *et al*. 2004). The population of this species is suspected to be declining very rapidly, concurrent with the rapid reduction in its lowland forest habitat. As a result, it is classified as Endangered.	fruiting cycle of Fig trees. Suitable habitat is present in the project area and general vicinity, it is expected that this species may occur.	
Ducula rosacea Pink-headed Imperial-Pigeon	NT				The Pink-headed Imperial Pigeon is restricted to Indonesia and Timor-Leste, where it occurs in four Endemic Bird Areas (Northern Nusa Tenggara; Timor and Wetar; Banda Sea Islands; Northern Maluku) and five Secondary Areas (Seribu Islands; Masalembu; Kangean; Salayar and Bonerate Islands; Tukangbesi Islands). It inhabits forest, scrub and farmland up to 600 m. Despite this wide range, the species appears to have become very rare at least in some areas, and rather uncommon elsewhere. Although it has quite wide range, this species is uncommon and probably has a moderately small population, hence its classification as Near Threatened. It is much sought after by hunters and suffers from the effects of habitat degradation and is therefore thought to be	Two individuals were recorded perched at Betano. This species is expected to occur at all three sites in habitats that provide foraging, sheltering and nesting potential.	Recorded

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					declining.		
Ducula cineracea Timor Imperial-Pigeon	EN				The Timor Imperial-pigeon is endemic to the mountains of Timor-Leste, and West Timor and Wetar, Nusa Tenggara, Indonesia, with recent reports from only three localities. It is locally common, but presumed to be declining as available habitat continues to shrink. It is presumably resident, perhaps making local altitudinal movements, in Montane forest and monsoon woodland between 600 m and 2,200 m. It is reportedly common in native eucalyptus forest. This pigeon qualifies as Endangered because it has a small population within a very small range (with only four recent locations), and this is suffering severe habitat loss, degradation and fragmentation, such that continuing population declines are likely.	This species is a highland specialist (Montane Forest) and is not expected to occur in the coastal environments of the project area	Unlikely
Cacatua sulphurea Yellow-crested Cockatoo	CR				The Yellow-crested Cockatoo is endemic to Timor-Leste and Indonesia, where it was formerly common throughout Nusa Tenggara (from Bali to Timor), on Sulawesi and its satellite islands, and the Masalembu Islands (in the Java Sea). It has undergone a dramatic decline, particularly in the last quarter of the 20th century, such that it is now extinct on many islands and close to extinction on most others. It inhabits forest (including evergreen, moist deciduous, monsoon and semi-evergreen), forest edge, scrub and agriculture up to 500 m on Sulawesi, and 800 m (sometimes 1,500 m) in Nusa Tenggara. On at least some islands (e.g. Sumba), it appears heavily dependent on closed-canopy primary forest. On others, it survives despite the total clearance of original vegetation, indicating that its habitat requirements are somewhat flexible.	Suitable habitat occurs within the Betano and Beaco development area and within this species distribution. The depurate number of records reflects the conservation status of this species. However recent recordings made at Suai suggest that similar habitat at Beaco and Betano would support	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					Breeding takes place from September to May on Sumba (Walker *et al*. 2005). It nests in tree cavities with specific requirements, tending use chink in the trunk or branch, or a pre-existing nest-hole made by another species, often in dead, snagged or rotting trees (Walker *et al*. 2005). This species of cockatoo has suffered (and may continue to suffer) an extremely rapid population decline, owing to unsustainable trapping for the cagebird trade. It therefore qualifies as Critically Endangered.	foraging and nesting opportunities for this species.	
Psitteuteles iris Iris Lorikeet	NT				Iris Lorikeet is restricted to Timor and Wetar, Indonesia and Timor-Leste. This species is reported to be not uncommon on Timor-Leste, it still survives in reasonable numbers in West Timor and it is, or at least once was, locally not uncommon on Wetar. It occurs in monsoon forest up to 1,500 m, and also in open eucalypt savannah. This poorly known species has a moderately small population, and it is likely to be declining owing to trapping and habitat loss; it therefore qualifies as Near Threatened.	Suitable foraging, sheltering and nesting habitat exist in the project area for this species, as well as being in the typical distribution boundary and is therefore expected to occur.	Likely
Aprosmictus jonquillaceus Olive-shouldered Parrot	NT				The Olive-shouldered Parrot is restricted to Timor and Wetar, Indonesia and Timor-Leste, where it occurs on Timor, Wetar and Roti. The species is found up to 2,600 m in monsoon forest, acacia savanna, lightly wooded cultivation and scrubby second growth. This species is listed as Near Threatened because it is believed to have a moderately small, fragmented population, and to be undergoing a continuing decline owing possibly to trapping and forest loss. However, little is currently known about the population size and structure of, and threats to, this species. Further information may indicate it is more threatened.	Four individuals on three occasions were recorded at Betano and Four individuals on two occasions were recorded at Beaco. This species of parrot occurs over a wide range of mostly lowland habitats, and appears to be commonest in	Recorded

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
						Eucalyptus woodlands, open forests and coastal environments typical of the project area.	
Todiramphus australasia Cinnamon-banded Kingfisher	NT				The Cinnamon Banded-kingfisher is restricted to four Endemic Bird Areas (Northern Nusa Tenggara; Sumba; Timor and Wetar; and the Banda Sea Islands, the first three with nominate *australasia*, the last one with races *dammeriana* and *odites*), in Indonesia and Timor-Leste. Its distribution within this fairly wide area is, however, very patchy, and it is generally uncommon. This species is a closed-canopy specialist, occurring in monsoon forest at 0-700 m. It is also found in secondary habitats such as gardens and cultivated areas, provided that sufficient canopy cover remains. This species is listed as Near Threatened as it has a moderately small and fragmented population which is likely to be declining owing to habitat loss.	This species was recorded both at Betano and Beaco development areas; two individuals at Betano and one individual at Beaco. It is expected that this species will be found in suitable habitats across all project areas.	Recorded
Bradypterus timoriensis Timor Bush-Warbler	NT				The Timor Bush-warbler is endemic to the island of Timor, Lesser Sundas, and is only known from two specimens collected at 1,800 m on Gunung Mutis, West Timor, in 1932, and a sight record (August 1972) from forest at 1,800 m near to Same, Timor-Leste (Dickinson *et al*. 2001). There have been a number of searches by competent observers, although it is likely to be very skulking and easily overlooked (Trainor *et al*. 2007a, Lambert *et al*. 2006). This very poorly known species has been classified as Near Threatened owing to concerns that burning and grazing may be causing a moderately rapid decline in the area of habitat	The project area does not contain any Montane Forest type habitat; given the study areas' proximity in the landscape specifically coastal and near coastal, it is highly unlikely this highly cryptic and poorly documented species occurs.	Unlikely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					suitable for it. However, rediscovery and subsequent fieldwork may provide data which lead to this threat status being amended.		
Heleia muelleri Timor White-eye	NT	x			The Timor White-eye is restricted to Timor, Indonesia and Timor-Leste, where it is generally uncommon and local, although it can be moderately common in ideal habitat. This species occurs up to 1,300 m in monsoon forest. It appears to favour lower-lying areas with closed-canopy forest, and may not persist in secondary habitats. This species is scarce and local within its restricted range, and is likely to have a small global population size. It is suspected to be declining moderately rapidly owing to ongoing habitat loss. It is currently considered Near Threatened, and further studies are urgently required in order to clarify the magnitude of threats facing it.	Suitable habitat does occur in the project study areas and despite this species being highly cryptic and difficult to identify it is expected this species should occur	Possible
Ficedula timorensis Black-banded Flycatcher	NT	x			The Black-banded Flycatcher is restricted to Timor, Indonesia and Timor-Leste where it appears to be uncommon or locally common, but may be frequently overlooked. It occurs up to 1,200 m in the dense undergrowth of monsoon forest, apparently preferring areas with limestone boulders and rocky scree slopes. Although it has been found in degraded forest patches, it shows a preference for primary habitats. It typically forages alone or in pairs, within 2 m of the ground in dense undergrowth, gleaning insects or making short sallying flights. This species has a moderately small range within which moderately rapid declines are owing to ongoing loss and clearance of lowland forest. As a result it is classified as Near Threatened.	This species shows a preference for primary forests but has also been recorded in degraded habitat types. Generally speaking the project area contains very little primary forest but does contain secondary forests and plantation / agriculture habitat opportunities. It is expected that this	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
						species may occur in low abundance.	
Saxicola gutturalis Timor Bushchat	NT				Timor Bushchat is restricted to the island of Timor (Indonesia and Timor-Leste) and its satellite islands of Roti and Semau (nominate *gutturalis* on Timor and Roti, race *luctuosa* on Semau). Given its restricted range the total population is not thought to be large. It occurs up to 1,200 m in monsoon forest and scrubby savanna. In West Timor it is present even in very small remnant pockets of woodland but is largely excluded from savanna and open scrub by the Pied Bushchat *S. caprata*. It forages on insects by gleaning and sallying in the canopy and in tall shrubbery beneath. It nests mainly October-November, but also May-June. This species is listed as Near Threatened because it may have a moderately small, fragmented population that is undergoing a continuing decline owing to extensive forest loss within its restricted range. However, little is currently known about its population size; further information may indicate its status warrants evaluation.	Five individuals were recorded at Betano, one male and four females. Two males were recorded at Beaco development area, specifically Nova Viqueque. The disparity of records for this species might be a reflection of little survey work conducting for this species and for avian species as a whole. It is expected that this species may occur broadly across suitable habitat types for the south-coast of Timor-Leste.	Recorded
Zoothera dohertyi Chestnut-backed Thrush	NT				Chestnut-backed Thrush is restricted to three Endemic Bird Areas (Northern Nusa Tenggara; Sumba; Timor and Wetar) in Indonesia and Timor-Leste. It is considered generally uncommon to rare, only locally common at higher elevations, and is probably already extinct on Lombok and close to extinction on Sumbawa. It occurs at 400-1,700 m in semi-evergreen, lower Montane and Montane	The project area does not contain habitat suitable for this species specifically a lack of Montane Forest. This elusive bird is generally found at	Unlikely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					forest, occurring at highest densities within primary forest. It is usually solitary but may assemble when at a food source. It has been recorded associating with Chestnut-capped Thrush *Z. interpres*. It is generally less shy and retiring than other *Zoothera* thrushes in the region. It typically forages on the ground. Juveniles have been recorded from July-September but singing within this period suggests an extended breeding season. This species is listed as Near Threatened because there are some indications that its population is fragmented and undergoing a continuing moderately rapid decline owing to trapping. However, little is currently known about the population size and structure of, and threats to, this species. Further information may indicate it is more threatened.	an altitude above 1,100 m and given the project area is coastal and near coastal in origin suggests this species is highly unlikely to occur.	
Zoothera peronii Orange-banded Thrush	NT				The Orange-banded Thrush is restricted to the Banda Sea Islands, Indonesia and Timor-Leste, where it is generally common on Roti and West Timor (race *peronii*), Timor-Leste, Wetar and Romang, Babar and Damar (race *audacis*). It occurs up to 1,200 m in forest (including monsoon forest). Although it has been found in degraded patches, it appears to favour areas with closed-canopy forest, which are constantly diminishing. It is largely terrestrial and solitary but will aggregate in small numbers if feeding in fruiting trees. Seen in the mid and upper canopies as well as on the ground. This species is listed as Near Threatened because there are some indications that its population is fragmented and undergoing a continuing moderately rapid decline owing to trapping and loss of lowland forest. However, little is	This species of thrush occurs in a wide variety of forest types including secondary forests and occasionally regenerating swidden fields suggests this species is likely to occur.	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					currently known about the population size of and the threats to this species. Further information may indicate it is more threatened.		
Lonchura fuscata Timor Sparrow	NT				The Timor Sparrow is restricted to Timor-Leste, West Timor, and its outlying islands, Semau and Roti, Indonesia, where it is widespread, but generally sparsely and patchily distributed. It is locally moderately common, being described as uncommon to abundant in Timor-Leste (Trainor *et al*. 2004) where recent surveys at two sites along the Laivai River located several groups of 30-50 birds within a few hectares in a short period at both sites, suggesting a likely population total in the thousands for the entire river region (Trainor *et al*. 2004). It mainly frequents the extreme lowlands, sometimes ascending hills to around 700 m, where it regularly occurs as individuals or in small groups of three to five birds, occasionally mixed with other granivorous birds, and can form larger flocks with groups of 30-50 recently recorded (Trainor *et al*. 2004). It forages on or near the ground in grassland, lightly wooded cattle-pasture, scrub, overgrown gardens, deciduous or degraded monsoon-forest and the margins of cultivation, and in Timor-Leste was found in *Eucalyptus alba* savanna, ricefields, severely degraded coastal shrublands and riparian woodland dominated by *Casuarina* (Trainor *et al*. 2004). This species is listed as Near Threatened because recent assessments suggest that the population may experience a moderately rapid decline as a result of habitat loss and increasing exploitation for the cagebird trade.	This species have been found in substantial populations in dry degraded savanna-woodland landscapes (especially river valleys associated with irrigated ricefields) specifically on the north coast of Timor Leste but is not restricted to this location. Further survey effort and research into this species will give a greater understanding of its ecological requirements.	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
Acerodon mackloti Sunda Fruit bat	VU				A coastal species occurring from sea level up to 450 m asl, and roosts in colonies of 300-500 individuals in secondary forest and gardens.	Distributed throughout the large islands of Nusa Tenggara, its presence on Timor has been confirmed recently (Helgen 2004). Large colonies of this species would be significant if present in the project area.	Possible
Nyctimene keasti Keast's Tube Nosed Fruit Bat	VU				Roosts and forages in tall vegetation, gardens, feeding on fruit; very little information is available for this species.	No records on Timor since Andersen (1912 cited in Goodwin 1979). Found elsewhere in Indonesia, but the poorly known taxonomic relationships in this genus limit knowledge of distributions and conservation advice.	Unlikely
Pteropus temminckii Temminick's Flying-fox	VU		App II		Reported from tropical moist forest, not likely to occur in large colonies.	Found in the central Moluccan islands, Simmons (2005) regards its distribution on Timor-Leste as doubtful.	Unlikely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
Pteropus vampyrus Large Flying-fox	NT		App II		This species generally ranges through much of continental and insular Southeast Asia. On the mainland, it has been reported from southern Myanmar, southern Vietnam (possibly southern Cambodia), through much of Peninsular Malaysia to Singapore. The species is found over much of Indonesia, being recorded from the islands of Sumatra, Bangka, the Mentawi Islands (Sipura, North Pagai and South Pagai), the Krakatau Islands, Java, Bali, Lombok, Sumbawa, Sumba, Savu, the Anamba Islands, the Natuna Islands (Bunguran Besar) and Siantan. It is present on the island of Timor (Timor-Leste and Indonesia), and on Borneo (Brunei, Indonesia and Malaysia). This tree roosting species is tolerant to some habitat disturbance; it occurs in primary and secondary forest and uses adjacent agricultural areas for feeding (Bates *et al*. 2008). In view of the species wide range, it seems probable that it is present in many protected areas. There is a need to protect important roosting sites for this species, and to regulate any hunting pressure.	This species occurs in primary and secondary forests and thus should be expected to occur in such habitat types of the project area.	Possible
Rhinolophus canuti timoriensis Canut's Horseshoe Bat	VU				Roosts in caves, and has been recorded foraging in a variety of habitats including intact primary forest, riparian zones and over grasslands adjacent to rocky outcrop (Armstrong 2007).	Distinct subspecies found on Timor, other distributional records in Java, Nusa Barong and Bali, where it is apparently uncommon. Possibility of occurrence if rocky outcrop and caves	Recorded

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
						are nearby, records in the project area are significant. This species was recorded at Suai and Betano.	
Sus celebensis Sulawesi Warty Pig	NT			x	The Sulawesi Warty-pig is found in the lower east portion of the oriental region and the upper west portion of the Australian region. *Sus celebensis* is common in the northern, central and eastern Sulawesi Island. Available evidence supports that this species formerly occurred throughout Sulawesi, as well as the neighboring islands of Selayer, Muna, Buton, Peleng, Lembeh and the Togain Islands. The species is now scarce in Southern Sulawesi and may also be extinct on the nearby Selayar due to the virtual deforestation of these areas. Wild pigs referred to as feral *S. celebensis* have been extensively introduced in Indonesia on the islands of Halmahera, Flores, Timor, Lendu, Simeuleu, and Nias Islands, and the domesticated forms of *S. celebensis* can be seen on the islands of Roti and Savur. (Macdonald 1993). Celebes wild boars are reported to occur in a wide variety of habitats on the Indonesian Islands, including rainforests, swamps, high grassland terrains, and agricultural areas. They are found at altitudes up to moss forest at about 2300 m, but they prefer valleys. (Huffman, 1999, Parker, 1990).	This species may have been introduced to Timor-Leste and may possibly be expected to occur as a domestic animal in subsistence agriculture.	Possible
Rusa timorensis Javan Rusa	VU			x	The Javan Rusa is believed to be native only to Java and Bali in Indonesia. It has been introduced to many other islands of the Indo-Pacific region. Some introductions apparently took place in	Despite being listed as Vulnerable upon the IUCN Red List, this species is	Recorded

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					antiquity within present-day Indonesia, to the Lesser Sunda islands, Maluku (= Molucca) islands (including Buru and Seram), Sulawesi, and Timor. This species is essentially a tropical and subtropical grassland species but is highly flexible, with successful populations in forests, mountains, shrublands and marshes.	historically an introduced species from neighbouring Indonesia. Introduced populations are not assessed as being conservation significant.	
Bos javanicus Banteng	EN			x	The Banteng (*Bos javanicus*), also known as tembadau, is a species of wild cattle found in Southeast Asia. Banteng have been domesticated in several places in Southeast Asia, and there are around 1.5 million domestic Banteng, which are called Bali cattle. These animals are used as working animals and for their meat. Bali has been introduced to Timor-Leste, where they have established stable feral populations.	This species was intermittently recorded across the south coast region of Timor-Leste. Despite being listed as Endangered upon the IUCN Red List, this species is historically an introduced species from neighbouring Indonesia. Introduced populations are not assessed as being conservation significant.	Likely

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REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

Tasi Mane Project – Betano Petroleum Refinery and Beaço LNG Plant

Marine Environment Technical Report

301012-01504-EN-REP-0007
June 2012

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GOVERNMENT OF TIMOR-LESTE, THROUGH THE SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

ATTACHMENT 2

Tasi-Mane Project – Betano Refinery and Petrochemical Complex, and Beaço LNG Plant Complex

Marine Environment Technical Report

FINAL

June 2012

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PROJECT 301012-01504-EN-REP-0007 – TASI-MANE PROJECT – MARINE ENVIRONMENT TECHNICAL REPORT

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for Review	E McGinty	H Houridis	N/A	19-04-12	N/A	
B	Issued for client review	E McGinty	H Houridis	A Faulkner	19-04-12	N/A	
0	Issued for use	E McGinty	H Houridis	A Faulkner	31-05-12	N/A	

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REPUBLICA DEMOCRATICA DE TIMOR-LESTE
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CHAPTER 1
INTRODUCTION

301012-01504-EN-REP-0007
June 2012

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 Cluster, and the Beaço LNG Plant Complex (Figure 1-1).

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 Betano and Beaço development areas. Data from the Suai development area has been presented in a separate report.

1.1 Project Setting

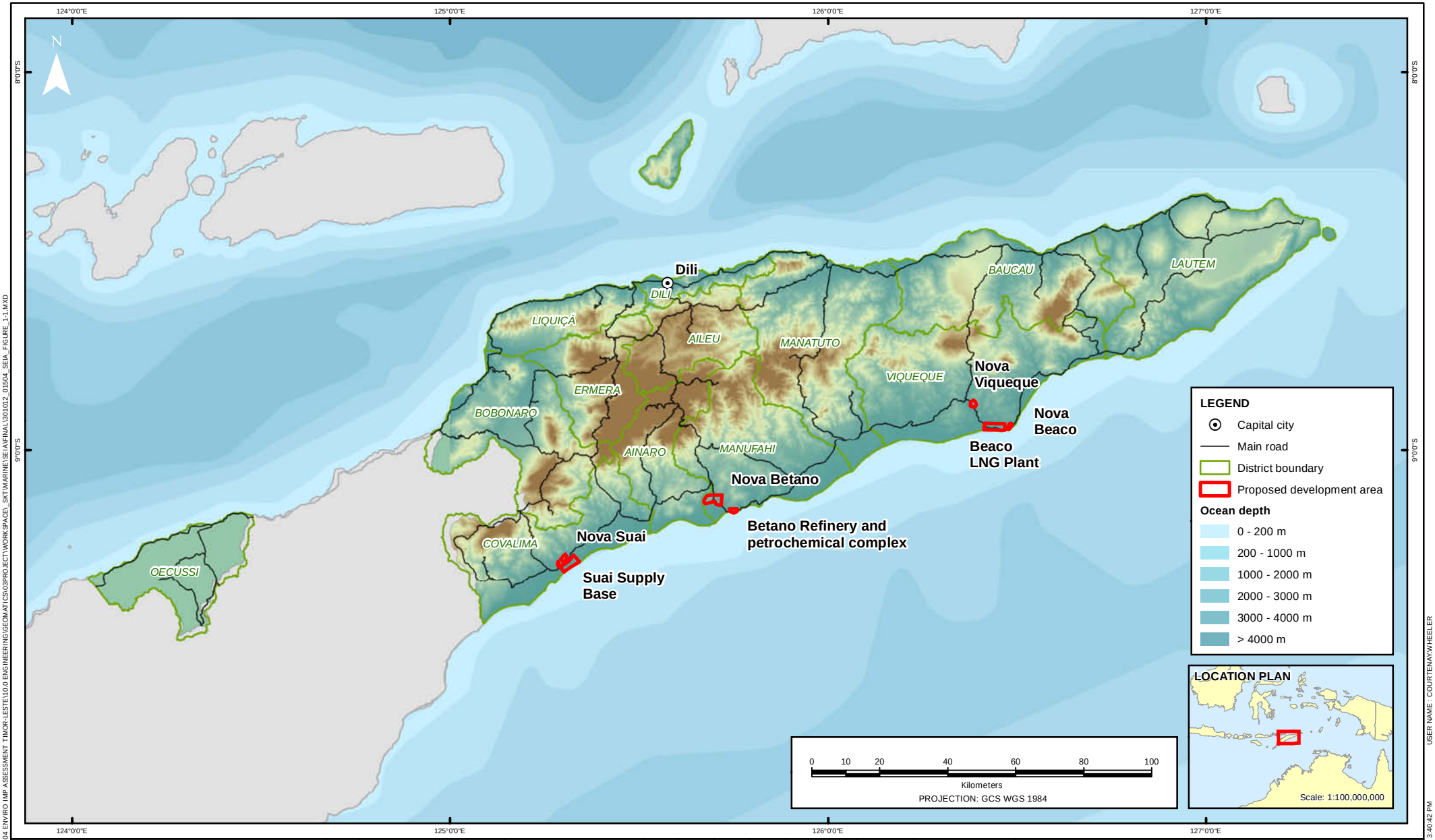
The scope for this study is the Tasi Mane – Betano Refinery and Petrochemical Complex, and Beaço LNG Plant, herein referred to as 'the project'.

The Betano and Beaço development areas comprise the following components:

- Betano Refinery and Petrochemical Development Area.
  - Refinery and petrochemical complex.
  - Petroleum City (Nova Betano).
- Beaço LNG Plant Development Area.
  - LNG Plant.
  - Nova Beaço.
  - Nova Viqueque upgrade to the Viqueque Airstrip.

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



NOTES:
This map consists of:
1. Digital Elevation Model: SRTM (2011)
2. District boundary's: Geographic Information GroupTimorLeste (2010)
3. Rivers: Grographic Information Group TimorLeste (2010)
4. Roads: DivaGIS (2101)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST	PROJECT No: 301012-001504
0	30/05/2012	FINAL FOR ISSUE	CW	MW	CW	-	GH	-	A4 SHEET SCALE 1:1,500,000

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TASI MANE PROJECT - BETANO AND BEACO MARINE ENVIRONMENT TECHNICAL REPORT

Figure 1-1
Tasi Mane Project overview

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The scope of work included 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 physicochemical 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.
- 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 (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.
- United Nations Transitional Administration in East Timor (UNTAET) Regulation No. 2000/17
- United Nations Transitional Administration in East Timor (UNTAET) Regulation No. 2000/19.

UNTAET Regulation No. 2000/19 on protected places (30 June 2000) was established 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 East Timor. 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 and Fisheries (MAF) 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.

The RDTL Government Decree Law 5/2011 on environmental licensing (environmental licensing law) establishes the licensing procedures to be followed to prevent negative impacts on the environment. The decree is administered by the Direcção Nacional dos Serviços do Meio Ambiente or National Directorate of Environmental Service (DNSMA). Further information relating to legislative and policy requirements is provided in Chapter 2 (Regulatory Context) of this SEIA.

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CHAPTER 2
REGIONAL PERSPECTIVE

301012-01504-EN-REP-0007
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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 taken directly from (Eni 2007, 2010a; 2010b). These environmental reports are based on data compiled as part of oil and gas approvals documentation for areas located in the southern section of Timor-Leste territorial waters.

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 1,770 mm (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 100 km/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 and is characteristically limestone with karst formations. The terrain in Timor-Leste is frequently 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 rivers are 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 that the seabed slopes 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 200 m can be found less than 1 km 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 rotate anti-clockwise, 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 Beaço 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 (20 to 30 m) reefs.
- 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 to 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 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 and 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 study areas. 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*) also 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 10 m) and are relatively protected (Marsh and Lawler 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 known to occur in the Timor Sea region, with as many as 15 species recorded in northern Australian waters (Storr et al. 1986).

FishBase (FishBase 2006) lists 144 marine fish species in 38 families for Timor-Leste waters, with 1 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 and Stevens 1994). The most prolific of the shark species in the Timor Sea region are the whalers, represented by at least 12 species.

2.7.5 Marine Protected Areas

The nearest currently declared marine conservation zone or marine protected area to the proposed development area is the Jaco Island Marine Park, at the eastern end of Timor- Leste. The park is located more than 100 km to the east of Beaço.

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CHAPTER 3
FIELD METHODS

301012-01504-EN-REP-0007
June 2012

3. FIELD METHODS

Water quality, sediment quality, benthic infauna and plankton samples were collected at both nearshore (250 m from shore) and offshore (750 m from shore) sites over a 10 day period between the 10 and 20 December 2011. Video footage was collected over a 5 day period between 18 and 22 February 2012 at Betano and over a three day period between 10 and 12 December 2011 at Beaço. 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.

3.1 Sampling Locations

3.1.1 Betano

A total of three inshore and three offshore sediment and water quality samples were collected at sites adjacent to the proposed Refinery and Petrochemical complex at Betano (Figure 3-1). Water and sediment quality samples were collected over one day on the 19 December 2011. Inshore sites were located between 8 to 10m depth. Offshore sites were between 20 to 35 m depth.

Video footage was collected over a three day period between the 20 and 22 February 2012. Towed video footage was used to obtain information on the marine benthic habitat present at the study site. Video transects between 250 and 600 m in length were run perpendicular to the shoreline (Figure 3-1). Each transect at the Betano study site commenced in a depth of approximately 7 m and extended seaward to the 34 m depth contour. A total of eight towed video transects and three intertidal transects were completed at the Betano study site which were approximately 600 m apart. GPS co-ordinates were collected at each sampling site (using a handheld Garmin GPS) and are presented in Table 3-1.

Table 3-1 Table showing GPS coordinates of sample sites adjacent to the Betano footprint area

Scope	Name	Start_Lat	Start_Long	Finish_Lat	Finish_Long
Benthic Habitat Intertidal Survey	IT1	125.756719	-9.165183	125.757071	-9.166056
	IT2	125.759151	-9.163375	125.759612	-9.163875
	IT3	125.749278	-9.167091	125.749205	-9.167875
Benthic Habitat Subtidal Survey	T21	125.759698	-9.165492	125.760820	-9.166645
	T22	125.756333	-9.167482	125.757965	-9.169097
	T23	125.751937	-9.168275	125.752500	-9.169317
	T24	125.746792	-9.168670	125.747279	-9.170316

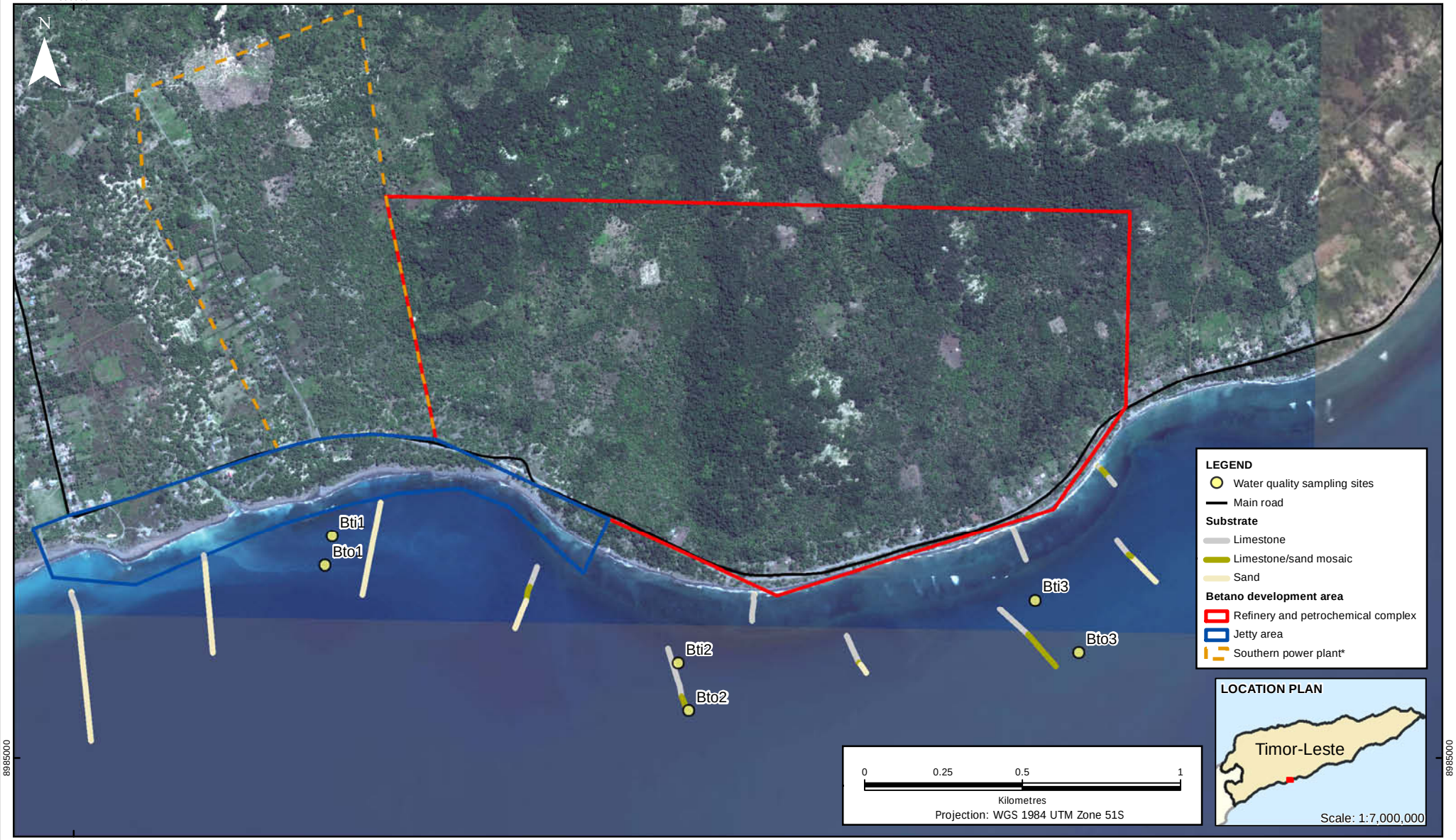
Table 3-1 Table showing GPS coordinates of sample sites adjacent to the Betano footprint area

Scope	Name	Start_Lat	Start_Long	Finish_Lat	Finish_Long
	T25	125.743013	-9.166377	125.742398	-9.168125
	T26	125.738497	-9.164552	125.737998	-9.167195
	T27	125.733423	-9.166105	125.733703	-9.168883
	T28	125.729623	-9.167172	125.730208	-9.171437
Water and Sediment Quality, Benthic Infauna, Fisheries	Bti1	125.737117	-9.165535		
	Bti2	125.747103	-9.169084		
	Bti3	125.757362	-9.167209		
	Bto1	125.736917	-9.166367		
	Bto2	125.747414	-9.170463		
	Bto3	125.758624	-9.168698		

3.1.2 Beaço

A total of three inshore and three offshore sediment and water quality samples were collected at sites adjacent to the proposed LNG plant complex at Beaço (Figure 3-2). Water and sediment quality samples were collected on the 12 December 2011. Inshore sites were located between 8 to 10 m depth. Offshore sites were in between 20 to 35 m depth.

Video footage for Beaço was collected over a 2 day period between the 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 between 250 and 600 m in length were run perpendicular to the shoreline (Figure 3-2). Each transect at the Beaço study site commenced in a depth of approximately 2.5 m and extended seaward to the 30 m depth contour. A total of eight transects were completed at the Beaço study site which were approximately 600 m apart. Only half of the Beaço footprint area was covered by video transects due to a significant sediment plume from the river to the west of the study area reducing visibility and affecting video capture. GPS co-ordinates were collected at each sampling site (using a handheld Garmin GPS) and are presented in Table 3-2.



NOTES:
This map contains:
1. Imagery: Digital Globe (2008-2011)
2. Imagery: Google Earth (2010)
3. Roads: DivaGIS (2010)
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Figure 3-1
Betano water quality and marine tow locations

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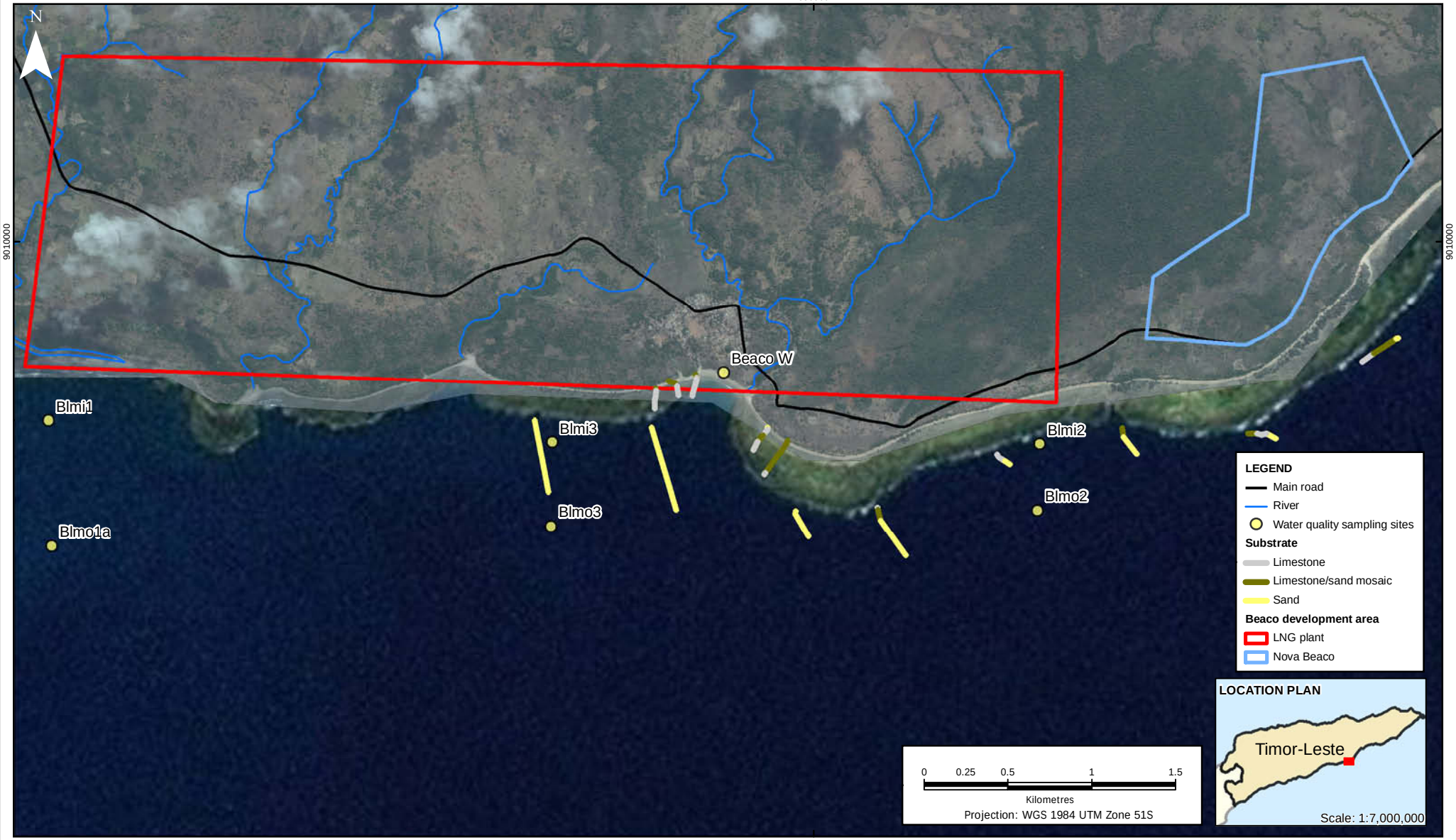

NOTES:
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1. Imagery: Digital Globe (2008-2011)
2. Rivers: GIGTimorLeste (2010)
3. Roads: DivaGIS (2010)
4. Substrate: WorleyParsons (2012)

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Figure 3-2
Beaco water quality and marine tow locations

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Table 3-2 Table showing GPS coordinates of sample sites adjacent to the Beaço footprint area

Scope	Name	Start_Lat	Start_Long	Finish_Lat	Finish_Long
Benthic Habitat Intertidal Survey	IT1	126.448343	-8.947209	126.448167	-8.948381
	IT2	126.446864	-8.947593	126.447405	-8.948361
	IT3	126.446182	-8.947994	126.446135	-8.949079
	IT4	126.453335	-8.950730	126.452089	-8.952548
	IT5	126.452260	-8.950031	126.451499	-8.951223
Benthic Habitat Subtidal Survey	T1	126.439660	-8.949767	126.440422	-8.953573
	T2	126.445967	-8.950077	126.447355	-8.954482
	T3	126.453812	-8.954493	126.454510	-8.955860
	T4	126.458233	-8.954255	126.459795	-8.956838
	T5	126.464672	-8.951352	126.465367	-8.951893
	T6	126.471442	-8.949863	126.472225	-8.951267
	T7	126.484397	-8.946185	126.486328	-8.944907
	T8	126.478247	-8.950093	126.479760	-8.950355
Water and Sediment Quality, Benthic Infauna, Fisheries	Blmi1	126.413355	-8.950021		
	Blmi2	126.467000	-8.950769		
	Blmi3	126.440612	-8.950924		
	Blmo1	126.413589	-8.956759		
	Blmo2	126.466908	-8.954337		
	Blmo3	126.440581	-8.955442		

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 1 m 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).
- Turbidity (nephelometric turbidity units [NTU]).

3.2.2 Chemical Sampling

At each sampling site, a mid-water column sample was collected using a 1 L 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),
- 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 0.45 µm 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 to 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).
- Particle Size Distribution (PSD).

3.3.3 Sediment Quality Criteria

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 concentrations were compared against relevant published literature, with no comparable benchmarks within the ANZECC/ARMCANZ (2000) guidelines. PSD is a measure of the relative proportion of size classes within a given sediment sample.

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 video transects were completed at each of the study sites, Betano and Beaço. Transects were approximately 600 m apart covering approximately a 6 km section of coastline at both Betano and Beaço. Three intertidal transects were also complete along the reef flat at Betano and five at Beaço.

The benthic habitat was recorded using an underwater video camera (Splash Cam). 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. Coordinates 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.

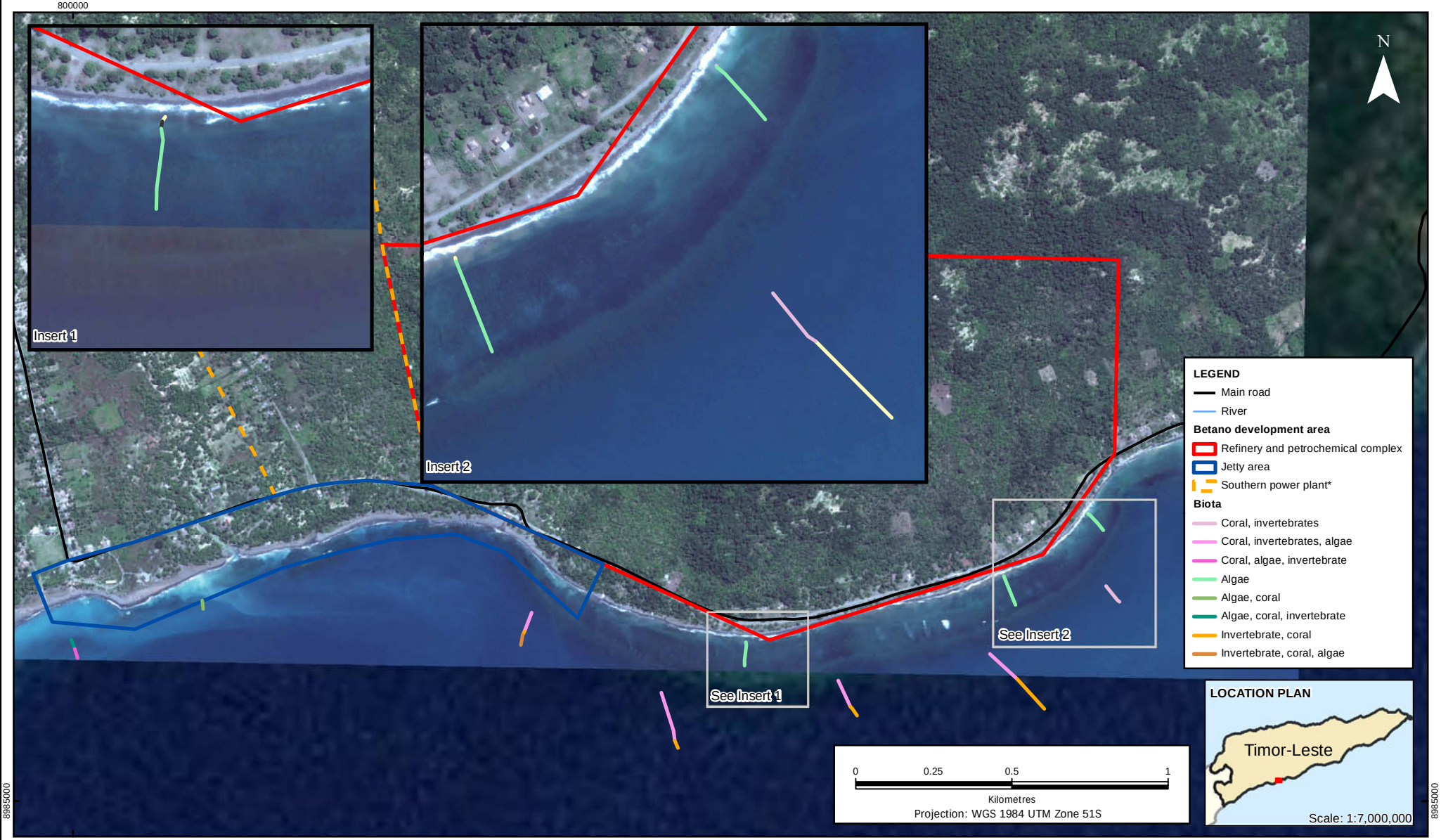
The video footage was analysed by marine scientists experienced in classifying benthic habitats. Maps displaying the distribution of habitats, including substrate and biota were then produced across the study area (Betano in Figure 3-3 and Beaço in Figure 3-4).

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.
- 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 to 75%) or sparse (0 to 25%). Substrate type was defined using the Wentworth grade scale of particle sizes (Wentworth 1922).



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NOTES:
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2. Rivers: Geographic Information Group TimorLeste (2010)
3. Roads: DivaGIS (2010)
4. Biota: WorleyParsons (2011)

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Figure 3-3
Betano marine habitat

NOTES:
This map contains:
1. Imagery: Digital Globe (2008-2011)
2. Imagery: Google Earth (2010)
3. Rivers: GIGTimorLeste (2010)
4. Roads: DivaGIS (2010)
5. Biota: WorleyParsons (2012)

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Figure 3-4
Beaco marine habitat

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3.5 Plankton

3.5.1 Sample Collection

A plankton net was towed behind a vessel travelling at <1 knot over a 100 m 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 125 µm 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 a 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 method adopted did not follow 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.
- >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 to 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 125 µm 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 125 µm 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 engine discharges 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 manufacturer specifications and using standardised solutions in the 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.

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.

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CHAPTER 4
BETANO

301012-01504-EN-REP-0007
June 2012

4. BETANO

The following sections describe results obtained at Betano for water quality, sediment quality, benthic habitat, plankton, and benthic infauna.

4.1 Water Quality

4.1.1 Physicochemical Water Quality

Physicochemical water quality profiles at each of the Betano inshore and offshore sites are presented as a series of graphs (Figure 4-1 to Figure 4-5). A summary of the data collected is also presented in Table 4-1. Relevant trends in the dataset have been identified, including any differences observed between nearshore and offshore sites.

Temperature

Water temperature profiles across all sites were within similar ranges of between 29.4°C and 31.9°C. Maximum inshore and offshore temperatures were observed at the surface waters of BTI3 and BTO3 respectively.

Vertical profiles of the mean water temperature values for the three inshore and three offshore sites are shown in Figure MBF004. Inshore and offshore sites displayed a decrease in mean temperature with increasing depth. Water temperature at the inshore sites ranged between 31.8 °C (surface) and 30.7 °C (-9 m), and 31.9 °C (surface) and 29.4 °C (-36 m) for the offshore sites.

pH

Inshore sites ranged between 7.9 and 8.1 pH while offshore sites were slightly less variable, ranging between 8.0 and 8.1 pH. Maximum inshore and offshore pH values were observed at BTI3 and BTO3 respectively. While pH ranges for both inshore and offshore (Figure 4-2) locations were outside the ANZECC lower and upper limit of 8.0- 8.4, the mean pH of 8.0 for both inshore and offshore sites does fall within this range.

Salinity

There was little variability in salinity between inshore and offshore sites (Table 4-1), with mean salinity values being close to the global seawater average of 35 ppt. Figure 4-3 shows a gradual increase in salinity with increasing depth at inshore and offshore sites. Similar salinity levels were observed between inshore and offshore sites (35 ppt) (Table 4-1).

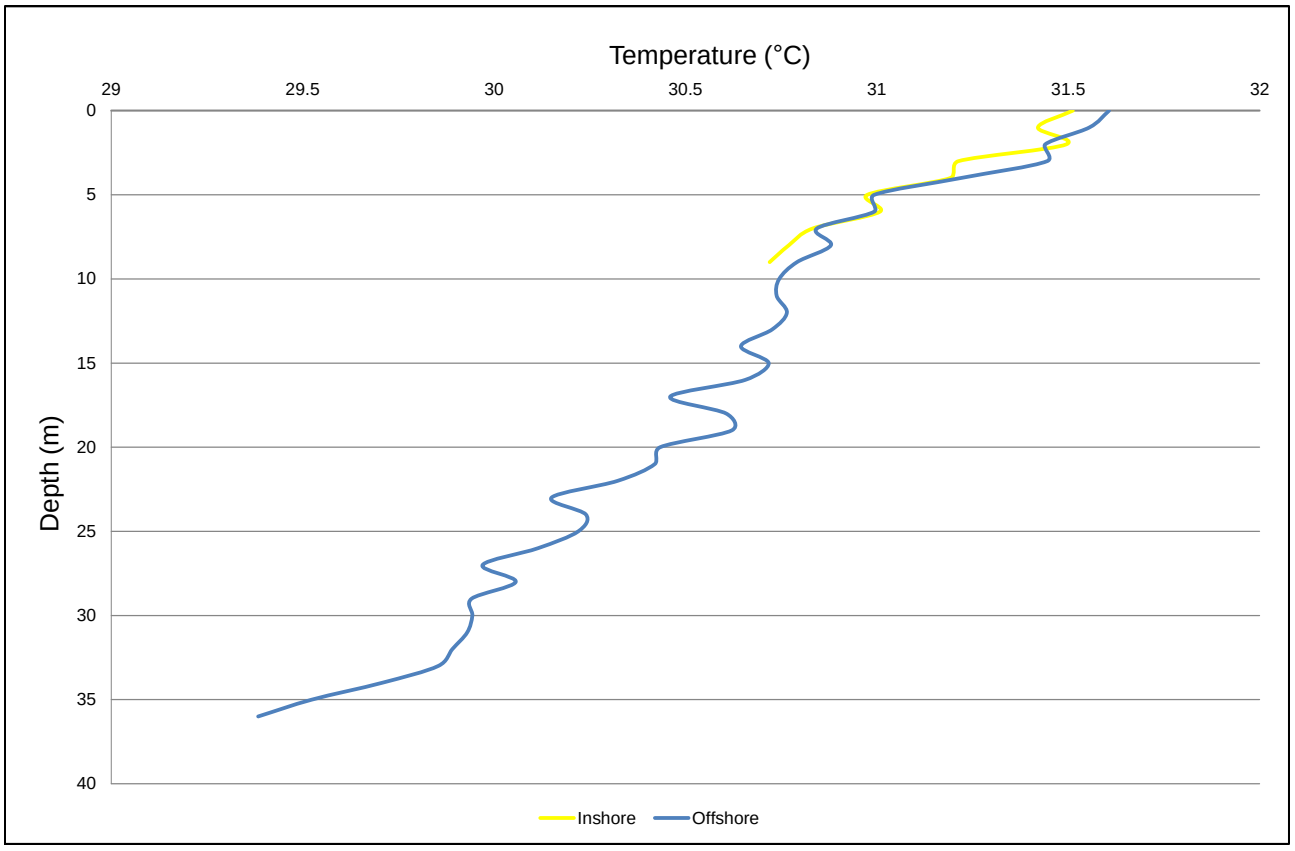

Figure 4-1 Mean water temperature at Betano inshore and offshore sites

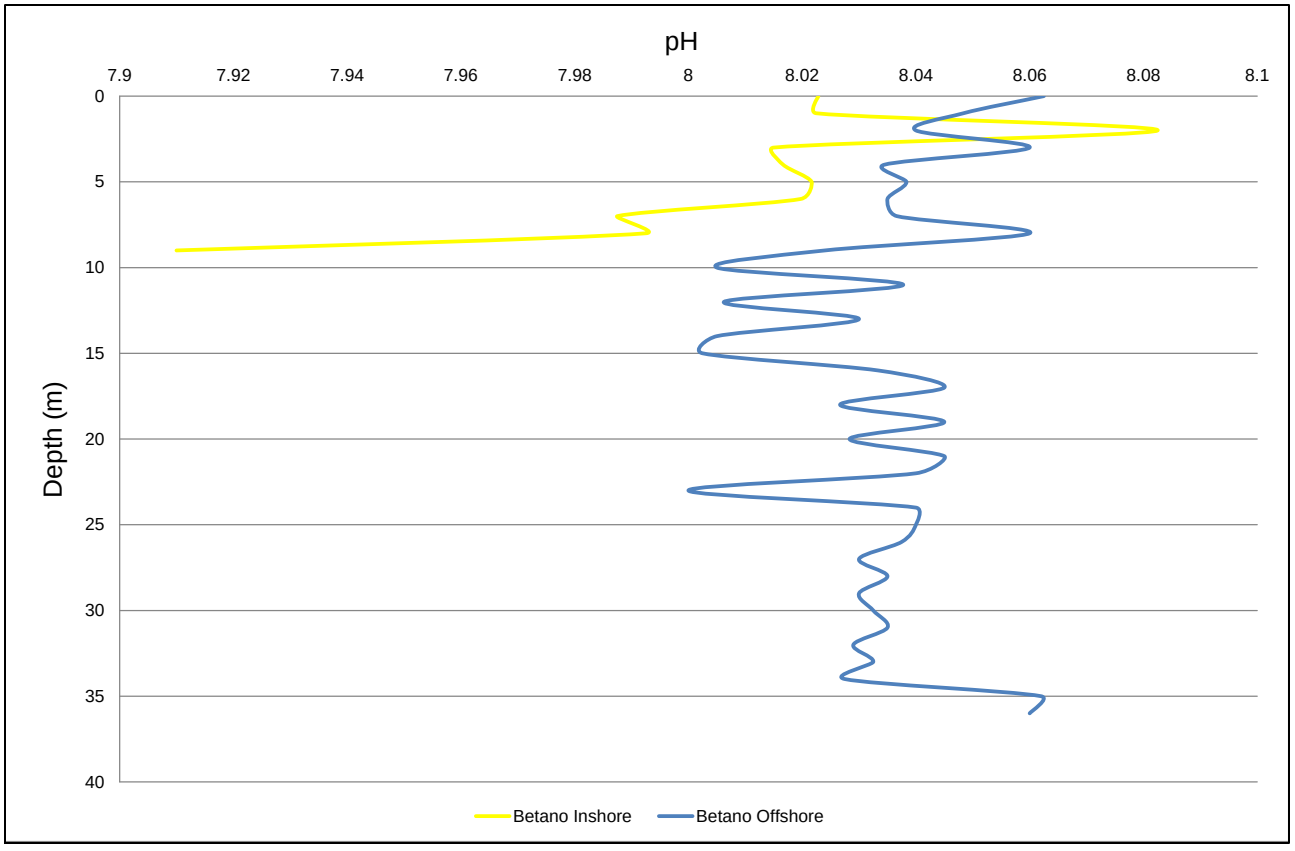

Figure 4-2 Mean pH at Betano inshore and offshore sites

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Figure 4-1
Figure 4-2

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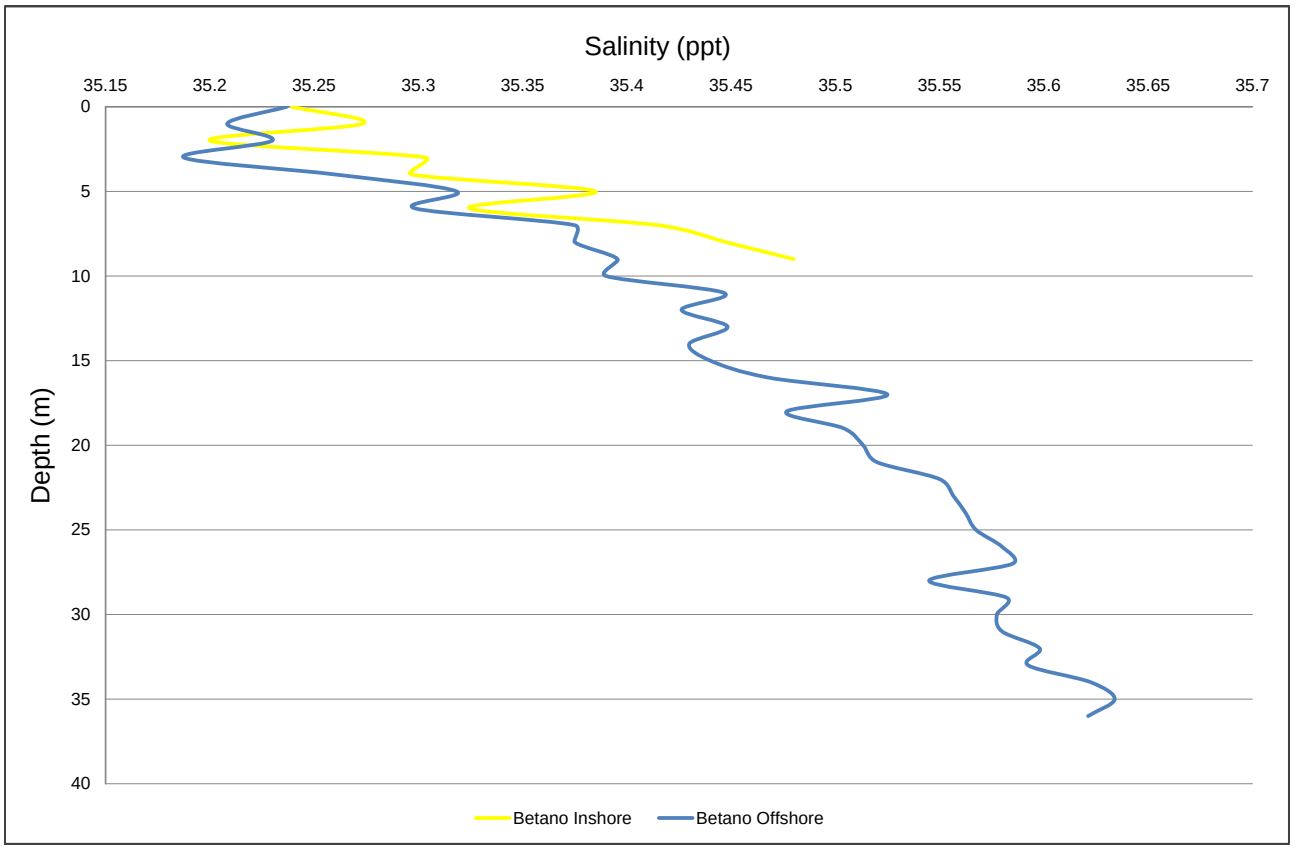

Figure 4-3 Average salinity (ppt) levels for nearshore and offshore sites

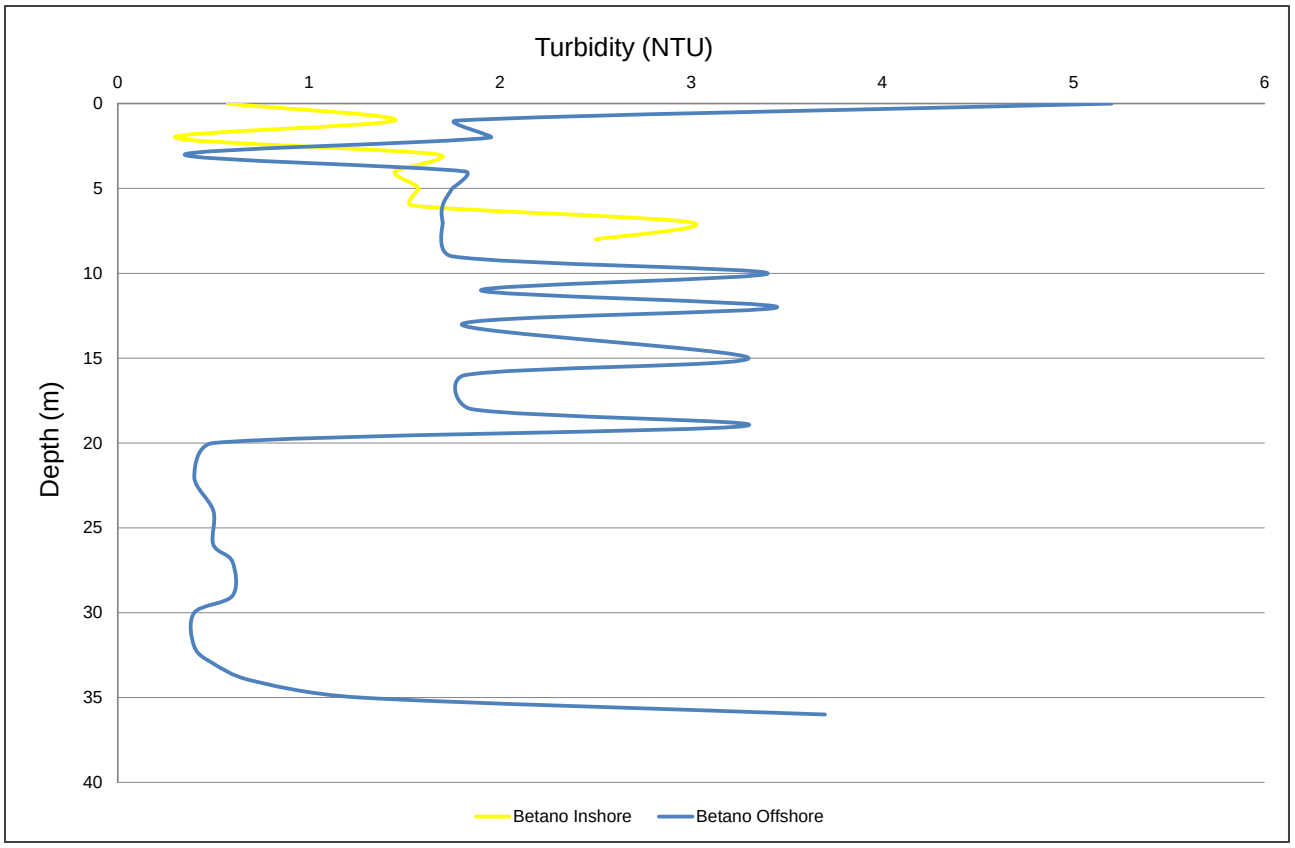

Figure 4-4 Mean turbidity (NTU) levels for nearshore and offshore sites

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Figure 4-3
Figure 4-4

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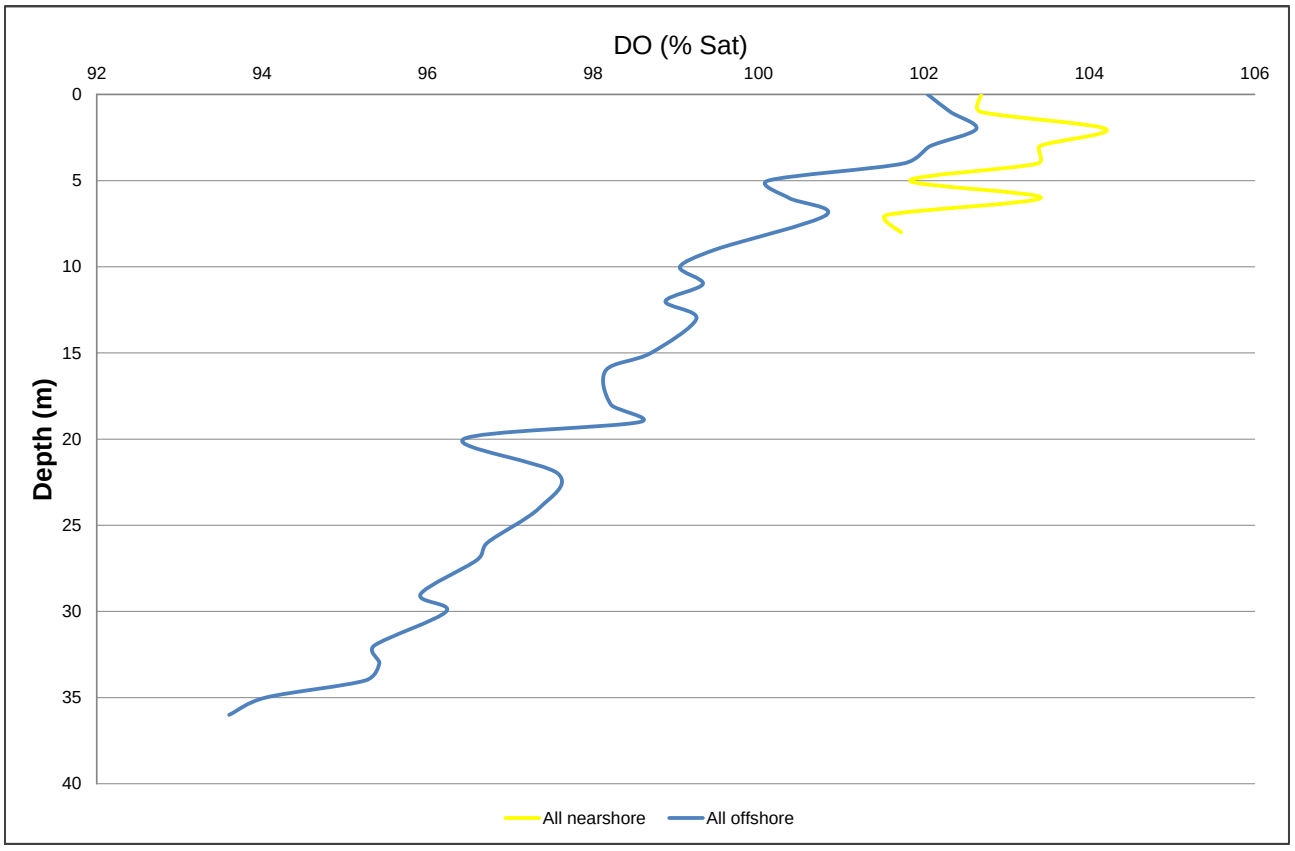

Figure 4-5 Mean dissolved oxygen (DO) levels for nearshore and offshore sites

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Figure 4-5

Turbidity

Turbidity results were not obtained at BTI3 and BTO3 due to equipment malfunction. Of the results obtained, some variability was recorded between inshore and offshore sites. Inshore sites varied between 0.1 NTU and 3.0 NTU while offshore sites ranged between 0.2 NTU and 7.9 NTU. All sites were within the ANZECC/ARMCANZ (2000) guidelines of 1-20 NTU (Table 4-1).

The turbidity profile of BTO3 displayed maximum turbidity at the surface (7.9 NTU) before dropping away sharply after 1 m of depth to below 1 NTU. Turbidity then rises abruptly again near the sea bed (36 m depth) to 3.7 NTU (Figure 4-4).

Dissolved Oxygen

Dissolved oxygen levels recorded from nearshore sites ranged between 98.6% and 107.5% saturation while offshore sites displayed slightly more variability ranging between 93.6% and 104.3% saturation. Dissolved oxygen levels tended to decrease with increasing depth at offshore sites, although this trend was not so apparent at inshore sites (Figure 4-5) due to the lesser range of depths profiled. Mean dissolved oxygen values were 102.8% saturation for the inshore sites, compared with 98.7% saturation at the offshore sites (Table 4-1).

Table 4-1 Physiochemical water quality parameters for nearshore and offshore sites, Betano, December 2011

Parameter	ANZECC Guidelines	Site	Min	Max	Median	Mean	20th percentile	80th percentile	Standard Deviation
Temperature (°C)	N/A	Nearshore	30.7	31.8	31.2	31.2	30.8	31.5	0.1
		Offshore	29.4	31.9	30.6	30.6	29.9	31.0	0.2
pH	8.0- lower limit 8.4- upper limit	Nearshore	7.9	8.1	8.1	8.0	8.0	8.1	0.0
		Offshore	8.0	8.1	8.0	8.0	8.0	8.1	0.0
Conductivity (mS/cm)	n/a	Nearshore	53.2	53.6	53.2	53.4	53.2	53.5	0.0
		Offshore	53.2	53.8	53.5	53.5	53.4	53.8	0.0
Salinity (ppt)	35 ppt*	Nearshore	35.2	35.5	35.2	35.3	35.2	35.4	0.0
		Offshore	35.2	35.6	35.4	35.4	35.3	35.6	0.0
Turbidity (NTU)	1-20 NTU	Nearshore	0.1	3.0	1.5	1.4	0.6	2.5	0.2
		Offshore	0.2	7.9	1.9	2.0	0.9	2.8	0.7
Dissolved Oxygen (% Sat)	90- lower limit	Nearshore	98.6	107.5	104.3	102.8	100.5	105.5	0.4
		Offshore	93.6	104.3	98.7	98.7	96.4	101.7	0.6
Dissolved Oxygen (mg/L)	n/a	Nearshore	6.11	6.62	6.41	6.33	6.19	6.5	0.0
		Offshore	5.87	6.64	6.13	6.13	6.02	6.2	0.0

*The average global salinity concentration of seawater (inclusive of open ocean and nearshore saline environments) is around 35 ppt.

4.1.2 Chemical Water Quality

Summaries of the laboratory results are presented below under nutrients, metals and hydrocarbons respectively.

Nutrients

A summary of results describing nutrient water quality parameters for inshore and offshore sites is presented in Table 4-2.

All inshore sites recorded ammonia concentrations of 0.05 mg/L, while offshore sites displayed more variability ranging between 0.03 mg/L and 0.1 mg/L. Maximum offshore ammonia concentrations were observed at BTO1 (0.1 mg/L). All sites exceeded the ANZECC/ARMCANZ (2000) guideline value of 10 µg/L.

Nitrite and nitrate (NO_x) concentrations were less than the limit of reporting (LOR) of 0.01 mg/L and less than the ANZECC/ARMCANZ (2000) guideline value at all inshore and offshore sites. Only one inshore site, BTI3, displayed total nitrogen concentrations above the LOR (<0.1 mg/L) at 0.5 mg/L. Offshore sites ranged between 0.5 mg/L and 0.7 mg/L, with one site (BTO2) below the LOR. As the LOR for total nitrogen was equal to the ANZECC/ARMCANZ (2000) guideline value of 0.1 mg/L, the guideline was exceeded at three of the six sites tested.

Given that nitrate and nitrite levels were below the LOR, total nitrogen (TN) concentrations were comprised entirely of the organic Total Kjeldahl Nitrogen (TKN) for samples. Consequently, the summary statistics calculated for TN were identical to those concentrations calculated for TKN. Two sites, BTI3 and BTO1, had recordable TKN and TN concentrations of 0.5 mg/L while BTO3 had slightly higher concentrations at 0.7 mg/L. All other sites were below the LOR.

Total phosphorus (TP) and reactive phosphorous (RP) were below the LOR (0.01 mg/L) at all sites.

Table 4-2 Nutrient water quality parameters for nearshore and offshore sites, Betano, December 2011

	Site	Ammonia	NO_x	TKN	TN	TP	RP
Nutrients		(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	n/a	0.1	0.015	0.5
Nearshore	BTI1	**0.05**	<0.01	<0.5	<0.1	<0.05	<0.01
	BTI2	**0.05**	<0.01	<0.5	<0.1	<0.05	<0.01
	BTI3	**0.05**	<0.01	**0.5**	**0.5**	<0.05	<0.01
Offshore	BT01	**0.1**	<0.01	**0.5**	**0.5**	<0.05	<0.01
	BT02	**0.04**	<0.01	<0.5	<0.1	<0.05	<0.01
	BT03	**0.03**	<0.01	**0.7**	**0.7**	<0.05	<0.01

Chlorophyll a and BOD

Both nearshore and offshore chlorophyll *a* concentrations were negligible, with all results less than the LOR of 1 mg/m³ and below the ANZECC/ARMCANZ (2000) guideline level of 1.4 mg/m³ (Table 4-3).

Biochemical Oxygen Demand (BOD) levels were below the LOR at all sites with the exception of one offshore site (BTO3) where a value of 4 mg/L was recorded. All other sites were below the LOR of <2 mg/L.

Table 4-3 Biological water quality parameters of near shore and offshore sites, Betano, December 2011

	Site	Chlorophyll a	BOD
Nutrients		mg/m^3	mg/L
	LOR *	**1**	**2**
	ANZECC	1.40	n/a
Nearshore	BTI1	<1	<2
	BTI2	<1	<2
	BTI3	<1	<2
Offshore	BT01	<1	<2
	BT02	<1	<2
	BT03	<1	**4**

Metals

Dissolved and total metal concentrations recorded from nearshore and offshore sampling sites are presented in Table 4-4 and Table 4-5 respectively. The LORs and ANZECC/ARMCANZ (2000) guideline values are also provided for comparative purposes.

Dissolved and total mercury, cadmium, and zinc concentrations were below their respective LORs at all sites. Dissolved and total chromium was also below the LOR at all sites except for BTO2, an offshore site where a total metal concentration value of 0.60 µg/L (just above the LOR of 0.50 µg/L) was recorded. Dissolved and total lead concentrations were below their respective LORs for all sites with the exception of BTO1 where a total metal concentration of 0.20 µg/L was recorded. Dissolved and total nickel concentrations were below the LOR at all sites except for BTI3 (0.60 µg/L- dissolved) and BTO1 (0.60 µg/L- total). All sites complied with the ANZECC/ARMCANZ (2000) guideline values for mercury, cadmium, chromium, lead and nickel (Table 4-4; Table 4-5).

Dissolved copper concentrations exceeded the ANZECC/ARMCANZ (2000) guideline value of 0.3 µg/L at both inshore (1.40 µg/L) and offshore (1.00 µg/L) sites (Table 4-4). All other sites were below the LOR. Total copper concentrations also exceeded the adopted ANZECC/ARMCANZ (2000) guideline value at both inshore (1.4 µg/L) and offshore (2.13 µg/L) sites (Table 4-5).

Table 4-4 Dissolved metal concentrations for nearshore and offshore sites, Betano, December 2011

	Site	Mercury	Cadmium	Chromium	Copper	Lead	Nickel	Zinc
Dissolved Metals		(mg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
	LOR*	**0.0001**	**0.20**	**0.50**	**1.0**	**0.20**	**0.50**	**5**
	ANZECC	0.10	0.70	7.70	0.30	2.20	7.00	7.00
Nearshore	BTI1	<0.0001	<0.20	<0.5	<1.0	<0.2	<0.5	<5
	BTI2	<0.0001	<0.20	<0.5	**1.40**	<0.2	<0.5	<5
	BTI3	<0.0001	<0.20	<0.5	<1.0	<0.2	**0.60**	<5
Offshore	BT01	<0.0001	<0.20	<0.5	<1.0	<0.2	<0.5	<5
	BT02	<0.0001	<0.20	<0.5	**1.00**	<0.2	<0.5	<5
	BT03	<0.0001	<0.20	<0.5	<1.0	<0.2	<0.5	<5

* Limit of reporting

Bold indicates values above the LOR, **Red** indicates values above ANZECC/ARMCANZ (2000)

Table 4-5 Total metal concentrations for nearshore and offshore sites, Betano, December 2011

	Site	Mercury	Cadmium	Chromium	Copper	Lead	Nickel	Zinc
Total Metals		mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
	LOR*	**0.0001**	**0.20**	**0.50**	**1.0**	**0.20**	**0.50**	**5**
	ANZECC	0.1	0.7	7.7	0.3	2.2	7	7
Nearshore	BTI1	<0.0001	<0.20	<0.5	<1.0	<0.2	<0.5	<5
	BTI2	<0.0001	<0.20	<0.5	**1.80**	<0.2	<0.5	<5
	BTI3	<0.0001	<0.20	<0.5	1.00	<0.2	<0.5	<5
Offshore	BT01	<0.0001	<0.20	<0.5	**3.80**	0.20	**0.60**	<5
	BT02	<0.0001	<0.20	**0.60**	**1.20**	<0.2	<0.5	<5
	BT03	<0.0001	<0.20	<0.5	**1.40**	<0.2	<0.5	<5

* Limit of Reporting

Bold indicates values above the LOR, **Red** indicates values above ANZECC/ARMCANZ (2000)

Hydrocarbons

Total petroleum hydrocarbons (TPH), total recoverable hydrocarbons (TRH) and Polycyclic Aromatic Hydrocarbons (PAH) were analysed at all nearshore and offshore sites. No sites recorded hydrocarbon concentrations above the LOR for each of the parameters (Table 4-6).

Table 4-6 Hydrocarbon concentrations in water for nearshore and offshore sites, Betano, December 2011

Hydrocarbons	Site	Total TPH µg/L	Total TRH µg/L	Total PAH µg/L
LOR*		50	100	0.5
Nearshore	BTI1	<50	<100	<0.5
	BTI2	<50	<100	<0.5
	BTI3	<50	<100	<0.5
Offshore	BTO1	<50	<100	<0.5
	BT02	<50	<100	<0.5
	BT03	<50	<100	<0.5

* Limit of reporting

4.2 Sediment Quality

Sediment samples were collected at the nearshore site BTI1 and its corresponding offshore site BTO1. At all other sites, hard substrate was encountered on the seabed surface preventing the sampling of sediment.

4.2.1 Chemical Sediment Quality

Nutrients

A summary of sediment nutrient parameter results collected from BTI1 (nearshore) and BTO1 (offshore) at Betano is presented in Table 4-7. Ammonia and Nitrite + Nitrate (NO_x) concentrations were below the LOR. TKN and TN samples were 50 mg/kg and 160 mg/kg for BTI1 and BT01, respectively. Total concentration of phosphorous at the inshore site BTI1 was 283 mg/kg, while the offshore site BTO1 recorded a value of 353 mg/kg. Both TN and TP values were proportionally higher in the offshore site than the nearshore site (110 mg/kg and 70 mg/kg respectively).

Table 4-7 Nutrient sediment quality parameters for nearshore and offshore sites, Betano, December 2011

Nutrients	Site	Ammonia	NO_x	TKN	TN	TP
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
	LOR*	**20**	**0.1**	**20**	**20**	**2**
Nearshore	BTI1	<20	<0.1	**50**	**50**	**283**
Offshore	BT01	<20	<0.1	**160**	**160**	**353**

* Limit of reporting

Bold indicates values above the LOR

Metals

Concentrations of metals recorded within the sediment at BTI1 (nearshore) and BTO1 (offshore) sites are presented in Table 4-8. The LOR is presented, along with a comparison to the ANZECC/ARMCANZ (2000) guideline values.

Cadmium, lead and mercury concentrations were all below their respective LOR. Chromium concentrations were slightly higher at the inshore site BTI1 (14.8 mg/kg) than the offshore site BTO1 (8.5 mg/kg), although both were well below the ANZECC/ARMCANZ (2000) guideline value of 80 mg/kg. There was less variation between nearshore and offshore sites for copper, with values of 11.6 mg/kg and 12.3 mg/kg, respectively. Nickel and zinc concentrations similarly also showed little variation between nearshore and offshore sites. All concentrations were less than the corresponding ANZECC/ARMCANZ (2000) sediment quality guidelines.

Table 4-8 Metal sediment quality parameters for nearshore and offshore sites, Betano

Total 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	BTI1	<0.1	**14.8**	**11.6**	<1.0	**8**	**15.2**	<0.01
Offshore	BT01	<0.1	**8.5**	**12.3**	<1.0	**7.4**	**14.1**	0.01

* Limit of reporting

Bold indicates values above the LOR

Hydrocarbons

A summary of hydrocarbon (TPH, TRH and PAH) concentrations collected from sediment samples at Betano is presented in Table 4-9. Hydrocarbon concentrations were below the LOR at both sites.

Table 4-9 Hydrocarbon sediment quality parameter results for Betano

Hydrocarbons	Site	Total TPH (mg/kg)	Total TRH (mg/kg)	Total PAH (mg/kg)
LOR*		**50**	**50**	**0.5**
Nearshore	BTI1	<50	<50	<0.5
Offshore	BTO1	<50	<50	<0.5

* Limit of reporting

4.2.2 Particle Size Distribution

Sediment at BTI1 was composed mostly of sand (83%), with some gravel (16%) and fines (1%) while sediment from BTO1 had a higher proportion of fines (17%), 82% sand and no gravel (Figure 4-6).

4.3 Benthic Habitat

4.3.1 Substrate

The substrate recorded in the study area comprised of conglomerated coastal limestone, a mosaic of weathered limestone and sand, and sand (Figure 3-1). Conglomerated limestone was found as a large inshore reef flat adjacent to the Betano footprint area.

From the reef flat, the substrate graded into a limestone/sand mosaic and then into unconsolidated sand with increasing distance from the shoreline (Figure 3-1). The profile of the substratum offshore from the reef flat was relatively steep, with a depth of 30 m found 200 m offshore. There was a uniformly general occurrence of sediment substrate at a depth of 25 m at all surveyed transects beyond the reef flat.

Seaward of the 25 m depth contour, the substrate type was 100% sand.

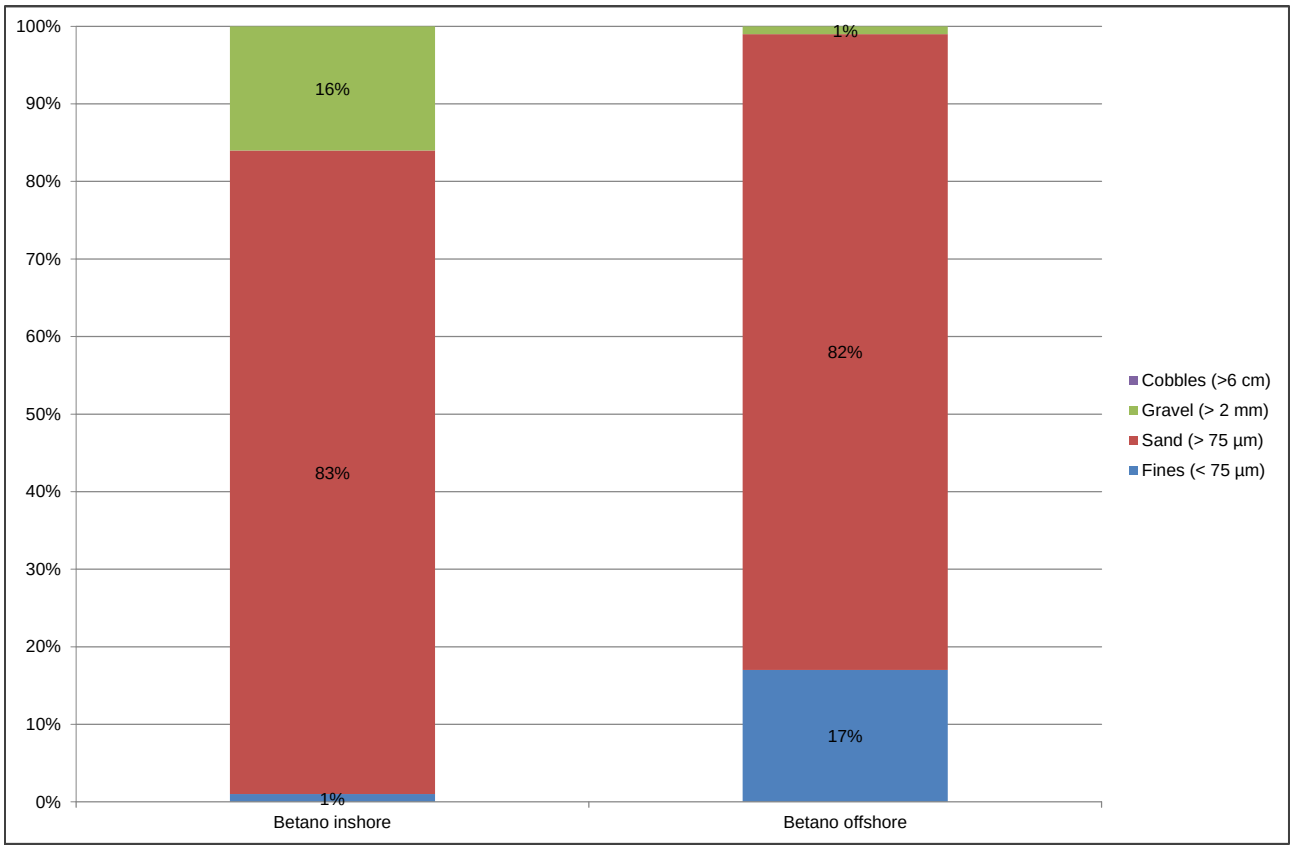

Figure 4-6 Particle size distribution (PSD) at Betano onshore and offshore sites

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Figure 4-6

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4.3.2 Biota

Three biota classes were identified in the study area, including coral, algae and invertebrates (Figure 3-3). Five coral families were found within the study area, consisting of Acroporidae, Favviidae, Poritidae, Fungiidae and Dendrophyllidae. A wide variety of algae types occur in the study area including turfing, brown, red, green and coralline species. Gorgonians, sea whips, sponges and crinoids were the dominant invertebrates present. The observed distribution of each of the biota classes along the surveyed transects is provided in Figure 3-3. This map in combination with the substrate distribution map (Figure 3-1) demonstrates good correlation between the biota types and the occurrence of hard substrate.

The reef flat at Betano was low in diversity and dominated by algae (Figure 3-3). The primary algae type was turf algae with moderate patches of brown algae and sparse patches of green algae towards the reef crest.

The reef flat drops steeply into deep water (1 to 25 m). The greatest coral diversity was generally found within 3 to 8 m of the surface and then gradually declined below 8 m. The band of rich coral growth is very narrow, being approximately 150 m wide (Plate 4-1). The dominant families present were Acroporidae, Favviidae, Poritidae, Fungiidae and Dendrophyllidae.

The dense coral cover gradually changes into a mix of algae and invertebrates found growing on a mosaic of weathered limestone and sand from approximately 8 to 25 m (Figure 3-3). Coralline and turf algae were the main types of algae present with the invertebrates mainly consisting of sea whips, sponges, crinoids and gorgonians.

Generally, no epibenthic species were present on the sediment dominated substrate beyond a depth of 25 m.

4.4 Plankton

A total of 1,249 planktonic fauna from 17 taxonomic groups were collected during the Betano baseline survey from both inshore and offshore sites. The most abundant fauna were the siphonophores, followed by crustacean and fish eggs (Figure 4-7).

A total of one fish larvae and 269 fish eggs were collected in the Betano plankton trawls. Identification of larval fish is extremely difficult; however, the fish collected had the following characteristics (Leis and Carson-Ewart, 2004):

- Body depth moderate (body depth 20 - 40% of body length); and
- Gut coiled and compacted early in larval development (<3 mm BL).

The fish larvae were tentatively identified as belonging to the Family Terapontidae. This was based on the myomere count (Myomeres are the ‘V’ shaped muscles visible along the flanks of the fish, Plate 4-2 after Leis and Carson-Ewart (2004)).

Plate 4-1 Coral reef adjacent to the Betano footprint area

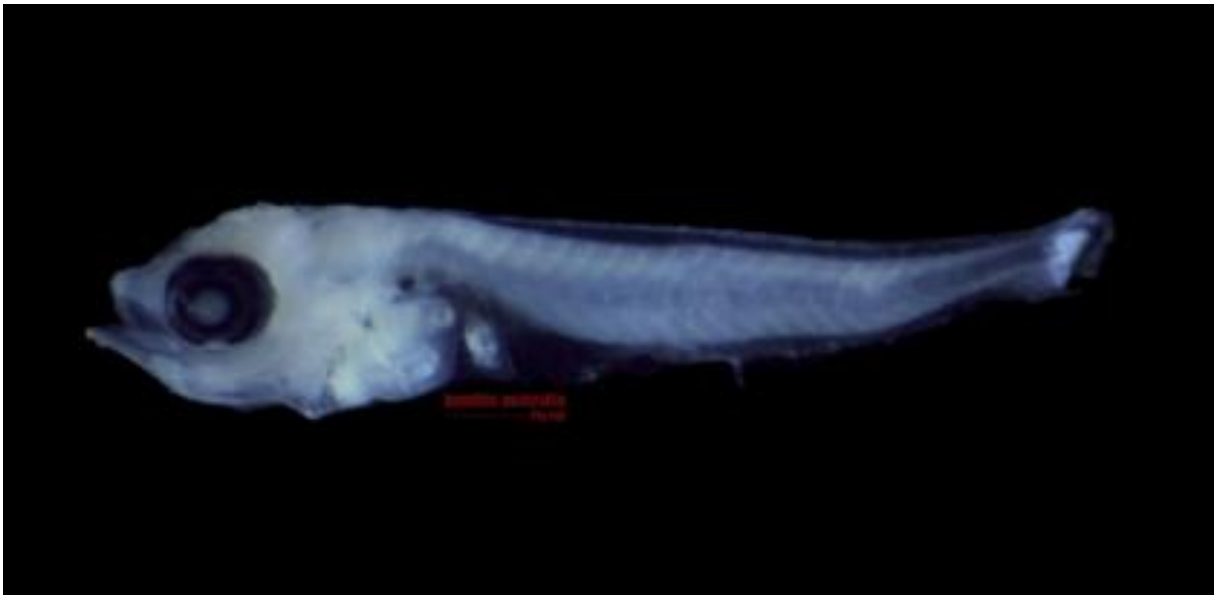

Plate 4-2 Fish larvae from the family Terapontidae (Body length 2.82 mm)

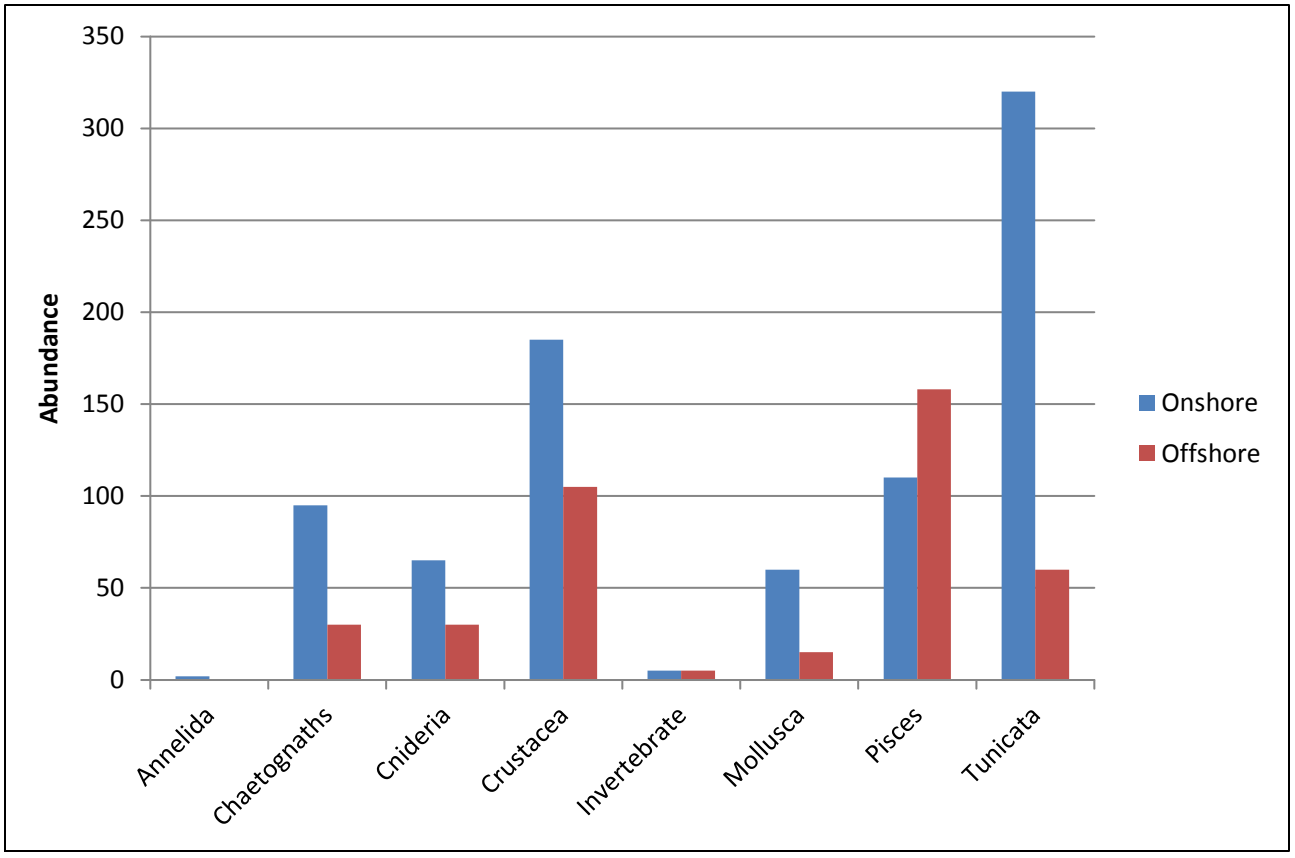

Figure 4-7 Abundance of plankton classes found inshore and offshore at Betano

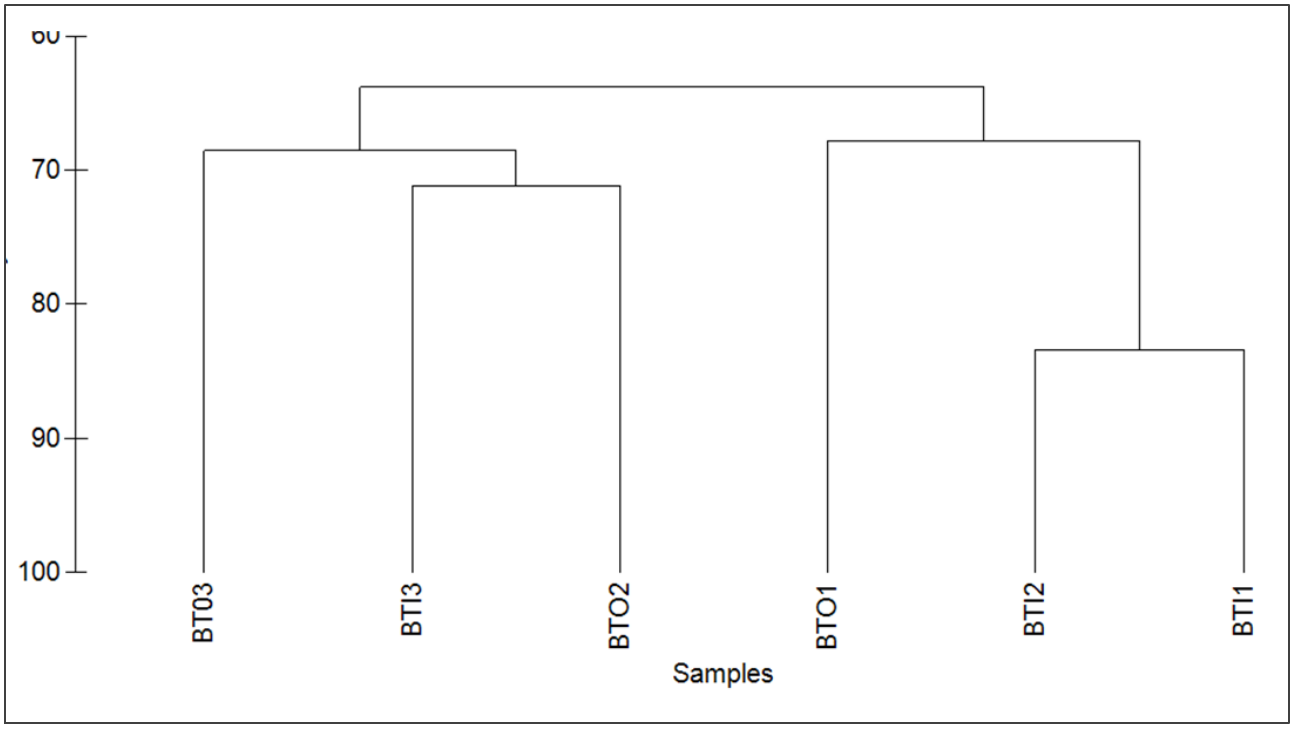

Figure 4-8 Cluster plot showing the similarity of plankton from the Betano survey sites

The cluster plot and MDS ordination showed no groupings of sampling sites (Figure 4-8 and Figure 4-9). The overlay, of the cluster plot onto the MDS ordination showed the majority of sites have a 60% similarity grouping (green circles, Figure 4-9). 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, prior-grouping of the samples by location (BTO and BTI sites) enabled a one-way ANOSIM to be conducted. This showed no significant difference between these groups (Global R = -0.07; p=0.5).

A SIMPER analysis showed that the fauna contributed to the differences between sites. The fish egg and siphonophores contributed the highest to the similarity between sites (Table 4-10).

Table 4-10 SIMPER analysis results for plankton fauna contributing to similarities in the Betano sites.

Species	Average Abundance	Contribution (%)	Cumulative (%)
Fish eggs	5.38	23.82	23.82
Siphonophores	4.91	23.8	47.63
Calanoid	3.6	15.49	63.12
Chaetognaths	2.52	10.31	73.43
Pteropoda	1.94	8.9	82.34
Cnidaria - jellies	2.4	8.55	90.88

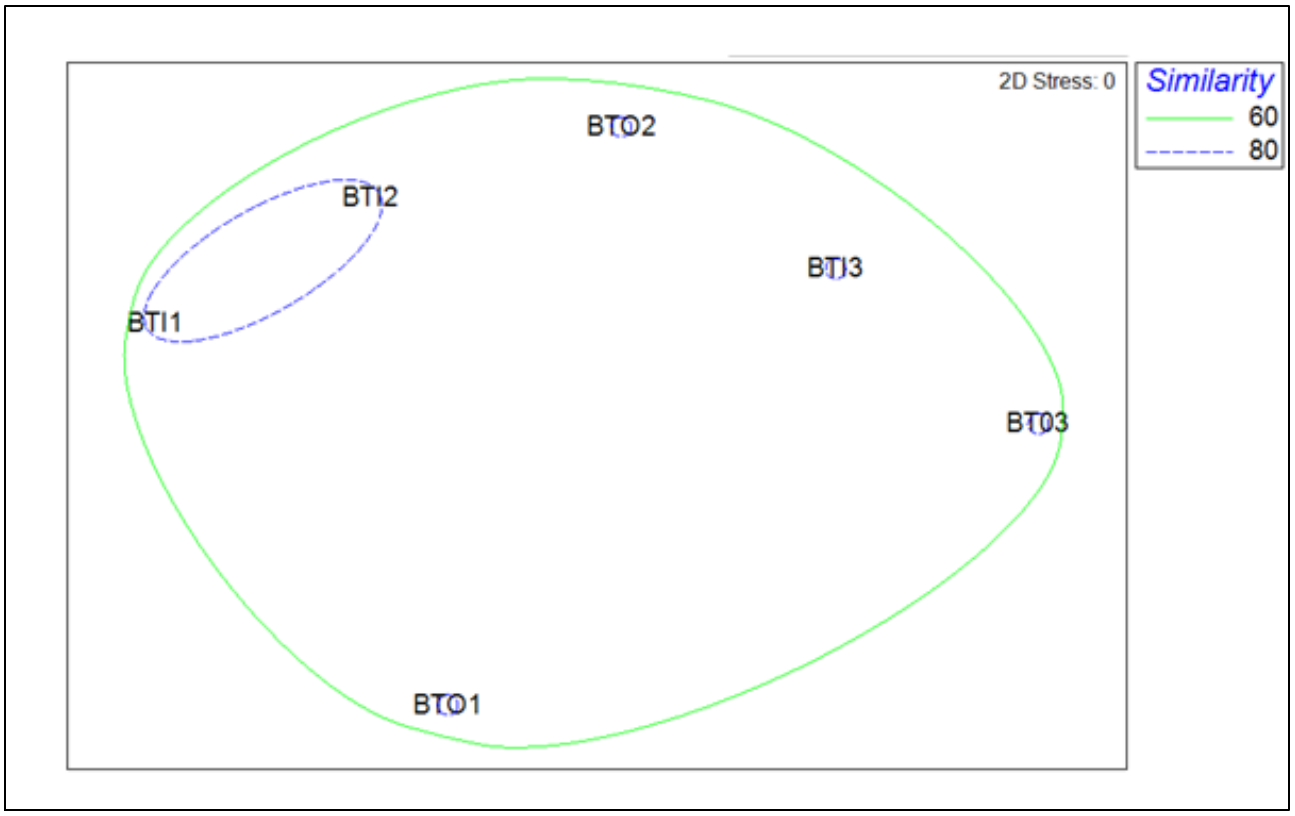

Figure 4-9 MDS ordination of plankton from the Betano samples. Circles show similarity groupings from the Cluster analysis

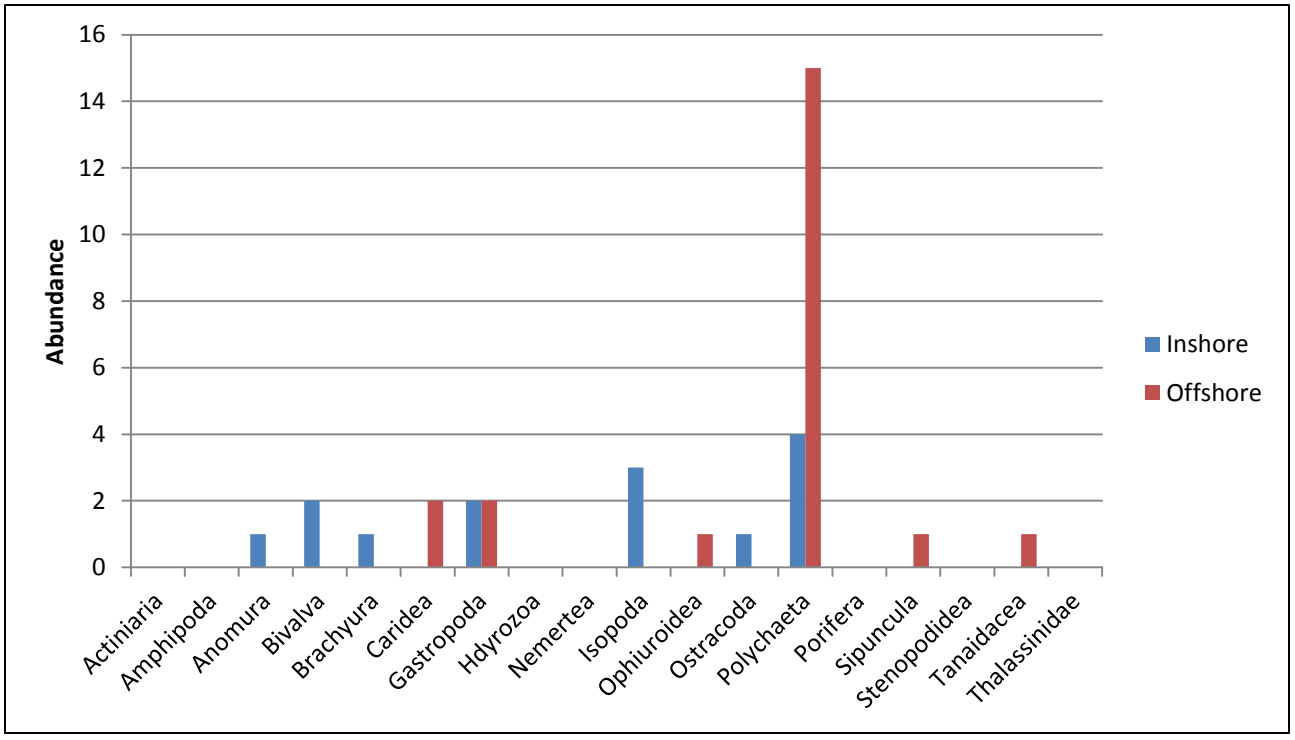

Figure 4-10 Abundance of benthic infauna classes found inshore and offshore at Betano

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Figure 4-9
Figure 4-10

4.5 Infauna

Infauna numbers were very low. A total of 36 macroinvertebrates from 24 taxonomic groups were collected during this baseline survey. The most abundant families was the eunicid worms (n=6), followed by the spionid worms (n=3) and isopod sea lice (n=3) (Figure 4-10).

The cluster plot showed no strong groupings of sampling site or replicates (Figure 4-11). 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 20% similarity grouping. That is, the sites grouped within the boundaries of the circles share a 20% similarity in faunal composition and abundance, and so on sites grouped in a 40% similarity circle share a 40% similarity in their faunal composition. These circles are bound by the similarity divisions of the cluster plot (see y-axis of cluster plot, Figure 4-12). A one-way ANOSIM comparing all sites, supports the findings that there is no significant difference between the sites, with a global R=0.259 (p=0.2).

A SIMPER analysis showed that the spionid polychaetes contributed the highest to the similarity between sites having a 33.1% contribution and was also one of the most dominant fauna (Table 4-11).

Table 4-11 SIMPER analysis results for infauna contributing to Betano site similarities.

Species	Average Abundance	Contribution (%)	Cumulative (%)
Spionidae	1.7	33.1	33.1
Eunicidae	1.9	20.0	53.2
Isopoda	1.6	19.1	72.3
Alphiidae	1.5	17.2	89.5
Sigalionidae	1.2	10.6	100

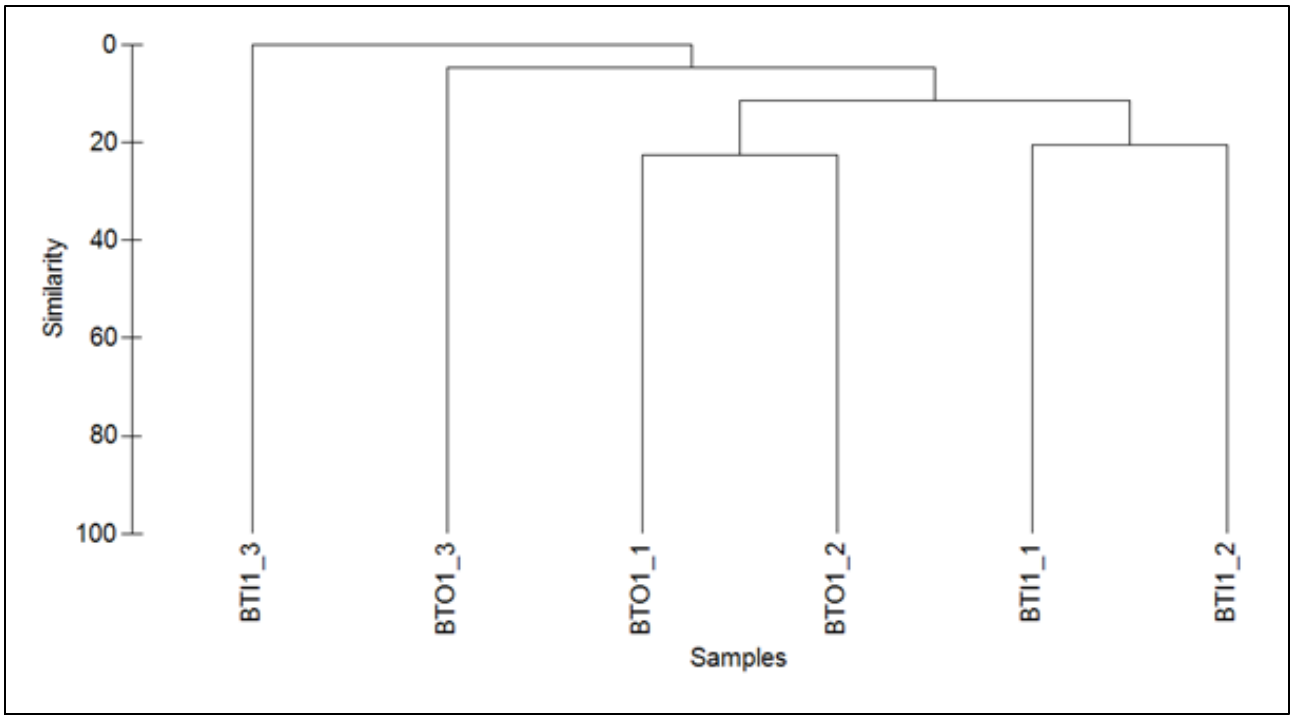

Figure 4-11 Cluster plot showing the similarity of macro-invertebrates at Betano survey sites

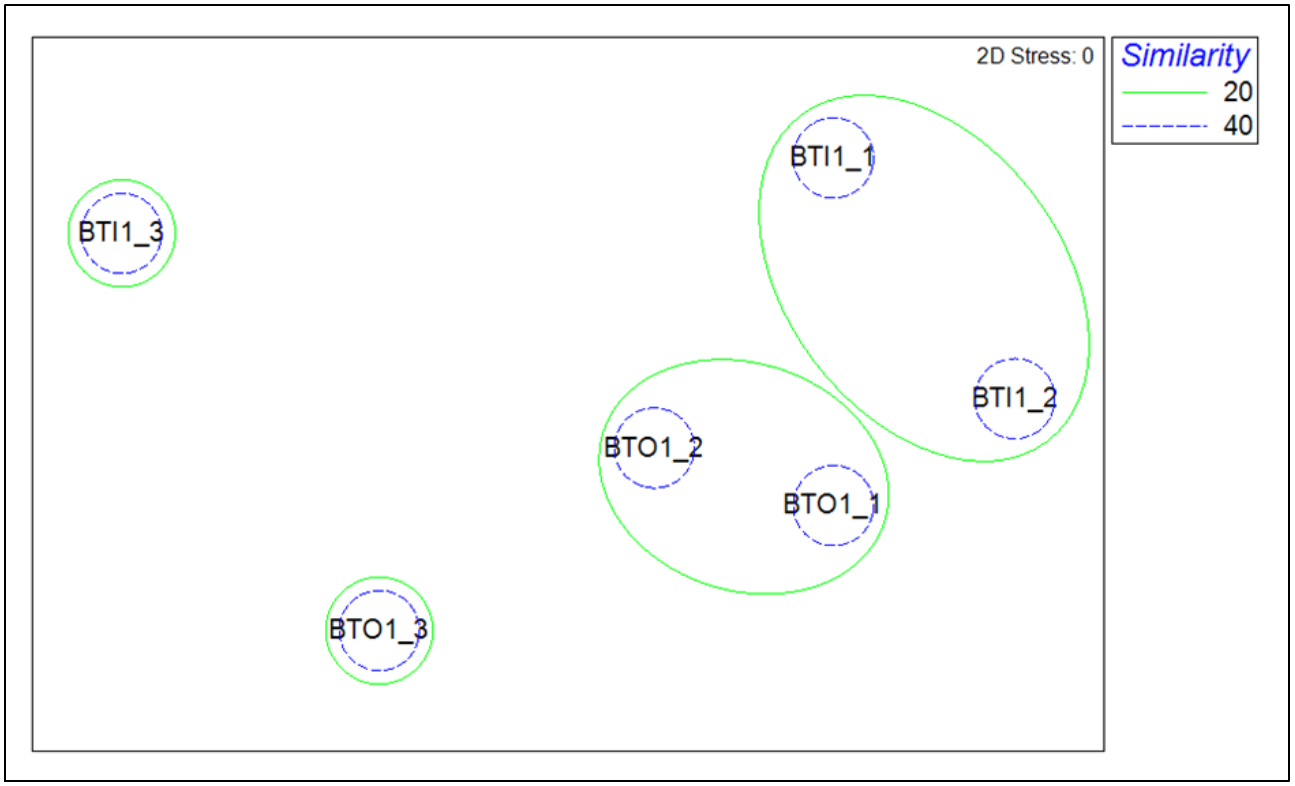

Figure 4-12 MDS ordination of macro-invertebrate at Betano site. Circles show similarity groupings from the Cluster analysis.

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Figure 4-11
Figure 4-12

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CHAPTER 5
BEAÇO

301012-01504-EN-REP-0007
June 2012

5. BEAÇO

The following sections describe results obtained at Beaço for water quality, sediment quality, benthic habitat, plankton, and benthic infauna.

5.1 Water Quality

5.1.1 Physicochemical Water Quality

Physicochemical water quality profiles for Beaço nearshore and offshore sites are presented as a series of graphs (Figure 5-1 to Figure 5-5). A summary of data is also presented in Table 5-1. Relevant trends in the dataset have been identified, including any differences observed between nearshore and offshore sites.

Temperature

Water temperatures recorded at all inshore and offshore sites were within a similar range of 30.6 to 32.0°C (Figure 5-1; Table 5-1). Vertical profiles of water temperature displayed a slight decrease in mean temperature with increasing depth (Figure 5-1).

pH

Mean pH was 8.1 for inshore and offshore sites (Figure 5-2). Little variation was evident in pH across sites, with levels ranging between 8 and 8.1 (Table 5-1).

Salinity

Salinity remained relatively stable at inshore and offshore sites and changed little with depth, ranging between 35.4 and 35.6 ppt respectively (Figure 5-3; Table 5-1). No freshwater influence was apparent and the lack of stratification in salinity suggests waters are well mixed.

Turbidity

Mean turbidity was relatively low at inshore and offshore sites, ranging between 1.2 and 5 NTU (Figure 5-4; Table 5-1), and well within the ANZECC/ARMCANZ (2000) guideline value of 1 to 20 NTU. The nearshore site BLMI1 displayed the greatest turbidity reading of 6.4 NTU close to the seabed at 7 m depth.

Dissolved Oxygen

Mean DO % saturation at inshore and offshore sites ranged between 97.5% and 101.5% saturation, indicating well mixed waters. DO decreased with increasing depth at both inshore and offshore sites (Figure 5-5; Table 5-1).

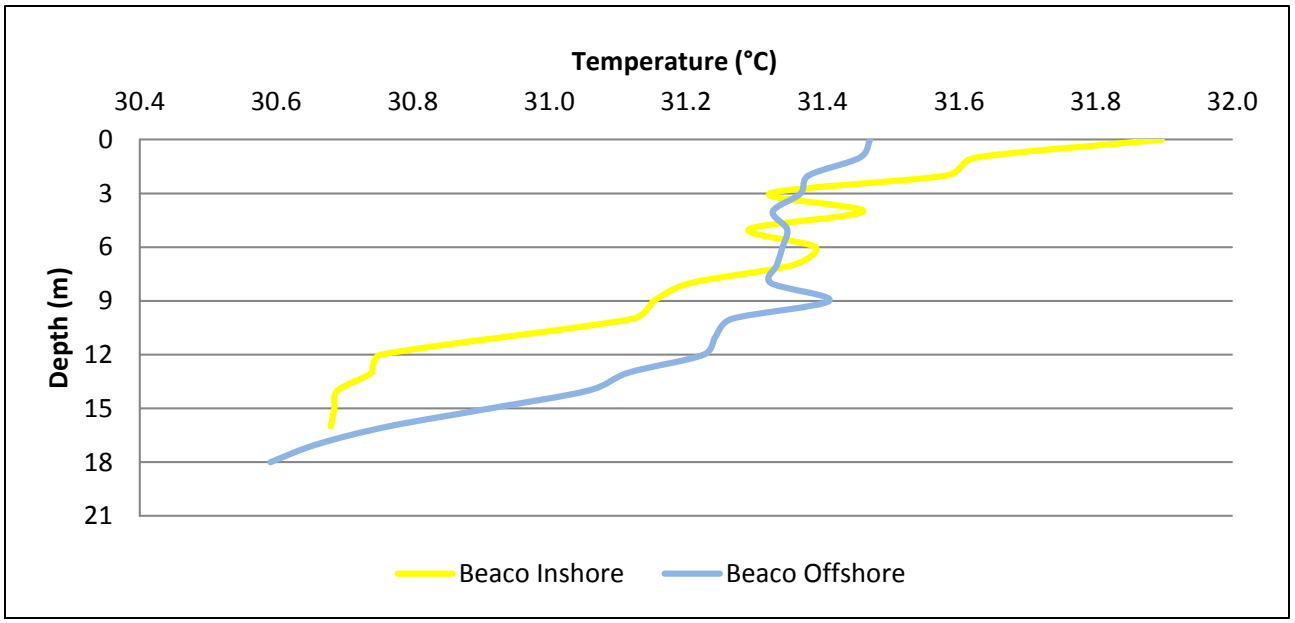

Figure 5-1 Mean water temperature at Beaco Inshore and Offshore sites

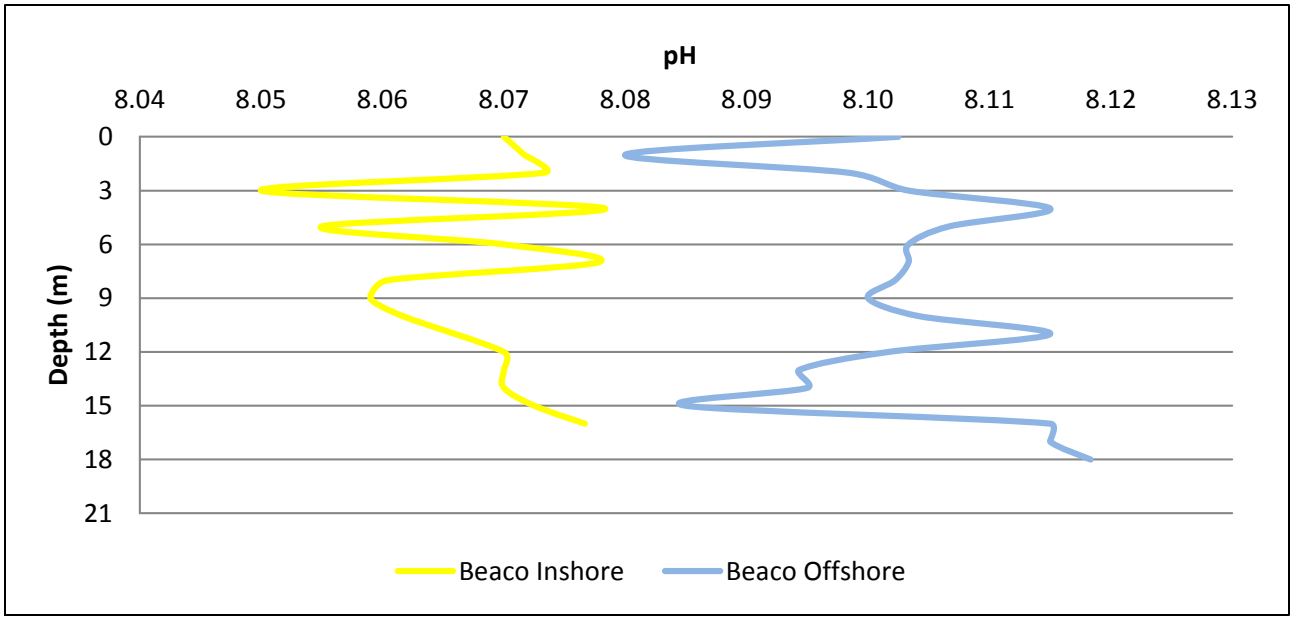

Figure 5-2 Mean pH at Beaco Inshore and Offshore sites

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Figure 5-1
Figure 5-2

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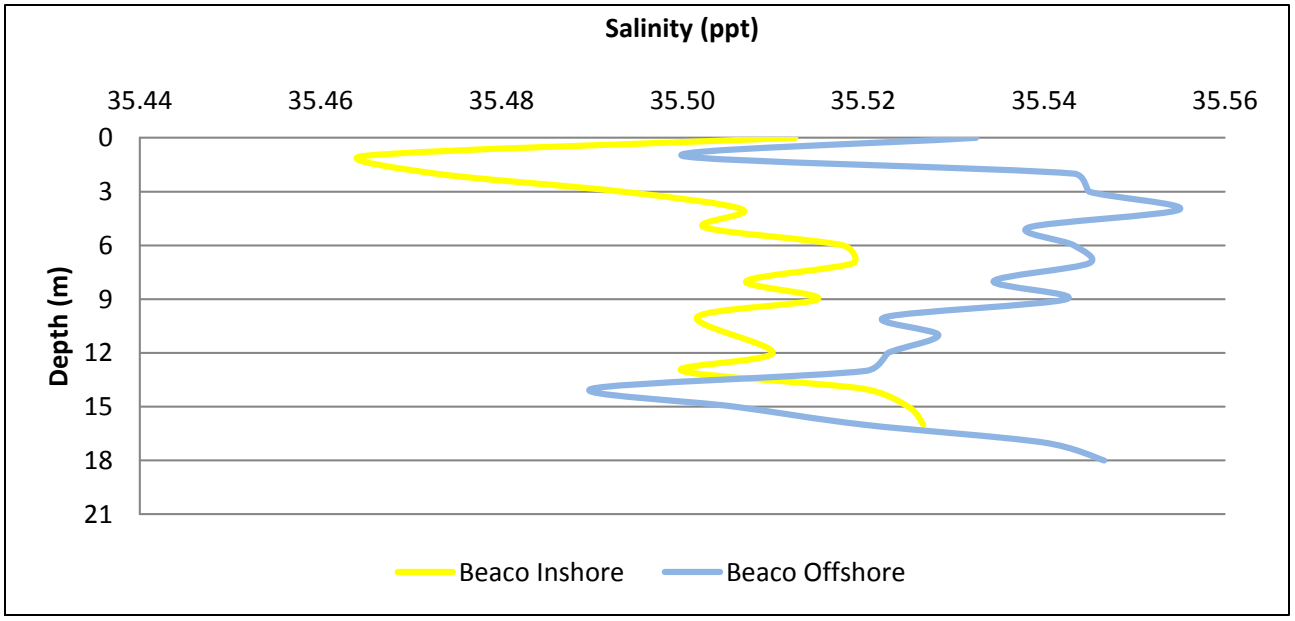

Figure 5-3 Mean salinity at Beaco inshore and offshore sites

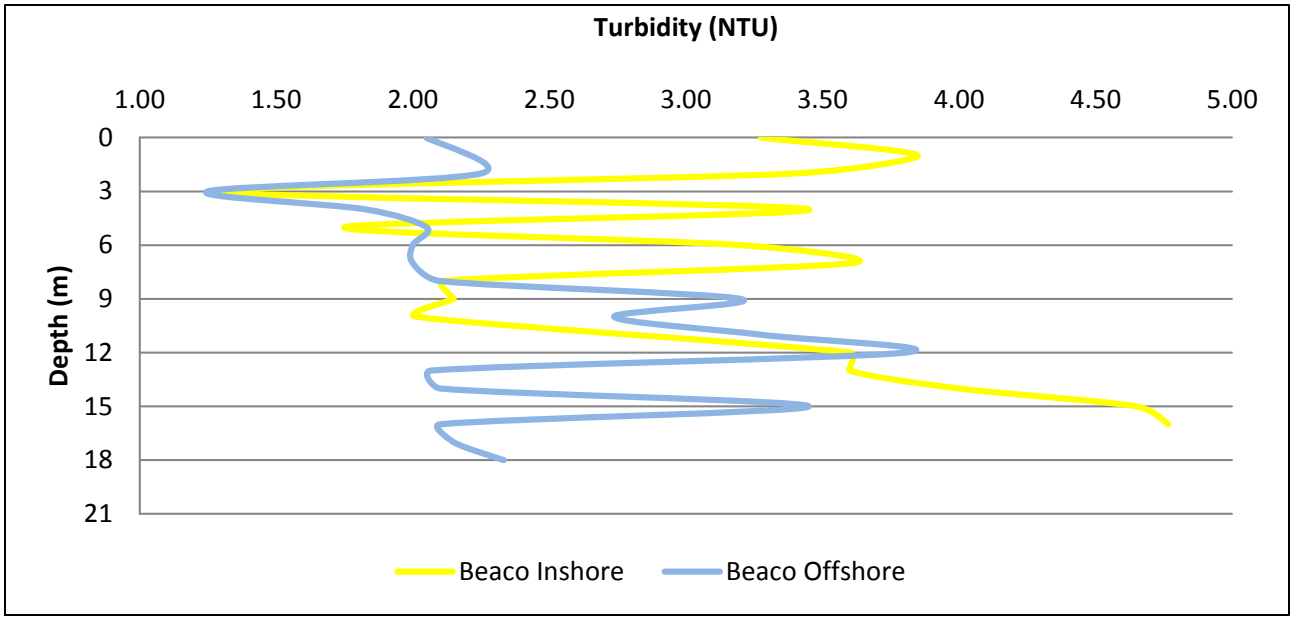

Figure 5-4 Mean turbidity at Beaco inshore and offshore sites

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Figure 5-3
Figure 5-4

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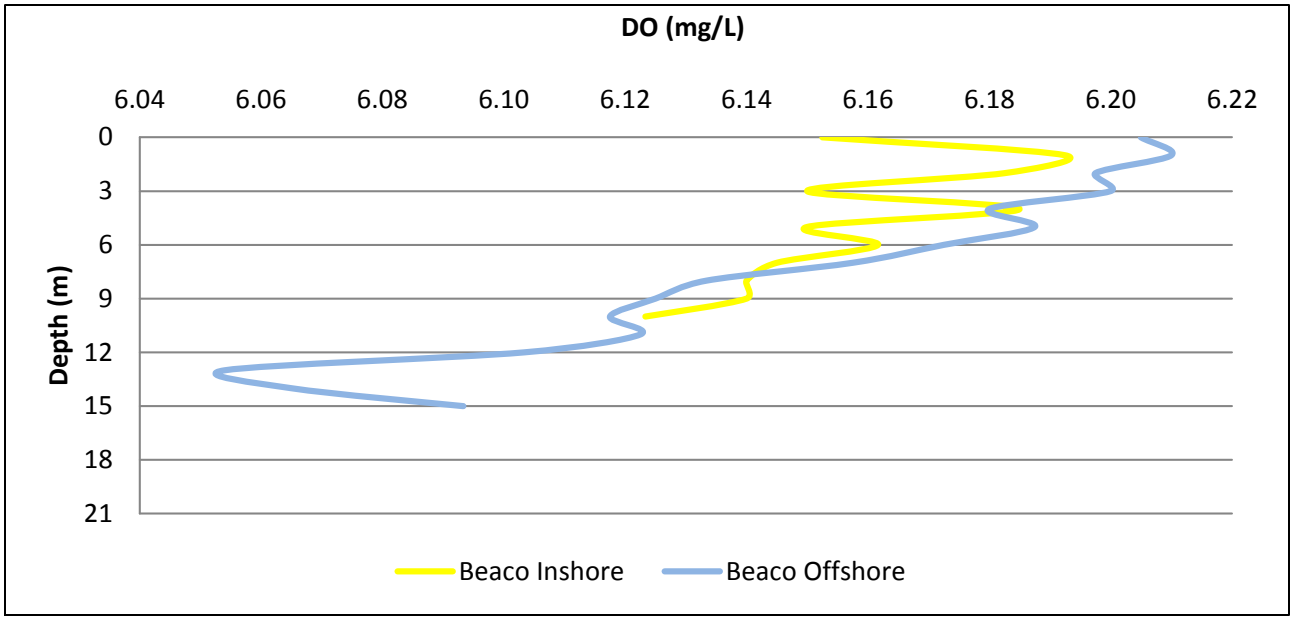

Figure 5-5 Mean Dissolved oxygen at Beaco inshore and offshore sites

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Figure 5-5

Table 5-1 Physicochemical water quality data for inshore and offshore sites, Beaço, December 2011

Parameter		ANZECC Guidelines*	Minimum	Maximum	Median	Mean	20th Percentile	80th Percentile	Standard Deviation
Temperature	Inshore	N/A	30.7	32.0	31.6	31.5	31.0	31.9	0.1
	Offshore		30.6	31.5	31.4	31.3	31.0	31.4	0.1
pH	Inshore	8.0- lower limit 8.4- upper limit	8.0	8.1	8.1	8.1	8.0	8.1	0.0
	Offshore		8.1	8.1	8.1	8.1	8.1	8.1	0.0
Conductivity (mS/cm)	Inshore	n/a	53.5	53.7	53.6	52.9	53.5	53.7	2.8
	Offshore		53.6	53.7	53.7	53.7	53.6	53.7	0.0
Salinity (ppt)	Inshore	35**	35.4	35.5	35.5	35.5	35.5	35.5	0.0
	Offshore		35.5	35.6	35.5	35.5	35.5	35.6	0.0
Turbidity (NTU)	Inshore	1-20 NTU	0.1	6.4	3.5	3.5	1.5	5.4	0.2
	Offshore		0.2	5.6	2.1	2.4	1.7	3.4	0.2
Dissolved Oxygen (% Sat)	Inshore	90- lower limit	97.6	102.2	100.7	100.5	99.3	101.7	0.2
	Offshore		97.8	101.6	100.2	100.0	98.8	101.3	0.3

Parameter		ANZECC Guidelines*	Minimum	Maximum	Median	Mean	20th Percentile	80th Percentile	Standard Deviation
Dissolved Oxygen (mg/L)	Inshore	n/a	6.1	6.2	6.2	6.2	6.1	6.2	0.0
	Offshore		6.0	6.2	6.1	6.1	6.1	6.2	0.0

* Limit of reporting

Bold indicates values above the LOR

5.1.2 Chemical Water Quality

Nutrients

A summary of results describing nutrient water quality parameters for inshore and offshore sites is presented in Table 5-2.

Ammonia concentrations varied between 0.02 mg/L (BLMI2 and BLMI3) and 0.12 mg/L (BLMO3). Offshore sites displayed marginally higher concentrations than inshore sites, ranging between 0.6 and 0.12 mg/L and between 0.02 to 0.04 mg/L, respectively. All sites exceeded the ANZECC/ARMCANZ (2000) guideline level of 0.01 mg/L for ammonia (Table MAR015).

Nitrite and nitrate (NO_x) concentrations were below the LOR at all nearshore and offshore sites except for BLMI1 where a value of 0.05 mg/L was recorded.

Only one inshore site, BLMI2, displayed TKN and TN concentrations above the LOR (0.10 mg/L) at 0.5 mg/L. which also exceeded the ANZECC/ARMCANZ (2000) guideline value of 0.1 mg/L (Table 5-2).

Total phosphorus (TP) and reactive phosphorous (RP) were below the LOR (0.01 mg/L) at all sites except for BLMI2, where a TP value of 0.23 mg/L was recorded. All sites, except for BLMI2, were below the ANZECC/ARMCANZ (2000) values for TP (0.015 mg/L) (Table 5-2).

Table 5-2 A summary of results describing nutrient water quality parameters for inshore and offshore sites at Beaço

	Site	Ammonia	NO_x	TKN	TN	TP	RP
		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Nutrients	**LOR***	**0.01**	**0.10**	**0.10**	**0.10**	**0.01**	**0.01**
	ANZECC	0.01	0.008	N/a	0.1	0.015	0.5
Inshore	BLMI1	**0.04**	**0.05**	<0.5	<0.1	<0.05	<0.01
	BLMI2	**0.02**	<0.01	**0.5**	**0.5**	**0.23**	<0.01
	BLMI3	**0.02**	<0.01	<0.5	<0.1	<0.05	<0.01
Offshore	BLM01	**0.11**	<0.01	<0.5	<0.1	<0.05	<0.01
	BLM02	**0.06**	<0.01	<0.5	<0.1	<0.05	<0.01
	BLM03	**0.12**	<0.01	<0.5	<0.1	<0.05	<0.01

* Limit of Reporting

Bold indicates values above the LOR

Chlorophyll a and BOD

Both inshore and offshore chlorophyll a concentrations were negligible, with results from all sites less than the LOR of 1 mg/m³ and below the ANZECC/ARMCANZ (2000) guideline of 1.40 mg/m³ (Table 5-3).

Biochemical Oxygen Demand (BOD) levels were below the LOR at all sites with the exception of BLMI2 and BLM01 where values of 6 mg/L and 15 mg/L respectively were recorded (Table 5-3).

Table 5-3 Summary of results for biological water quality parameters of near shore and offshore sites at Beaço

Sites		Chlorophyll a (mg/m$^{3)}$	BOD (mg/L)
LOR*		**1**	**2**
ANZECC		1.40	n/a
Inshore	BLMI1	<1	<2
	BLMI2	<1	**6**
	BLMI3	<1	<2
Offshore	BLM01	<1	**15**
	BLM02	<1	<2
	BLM03	<1	<2

*Limit of reporting

Bold indicates values above the LOR

Metals

Dissolved and total metal concentrations recorded from inshore and offshore sampling sites are presented in tables Table 5-4 and Table 5-5 respectively. The LORs and ANZECC/ARMCANZ (2000) guideline values are also provided for comparative purposes.

Dissolved and total mercury, chromium, and nickel were below their respective LORs at all sites. Dissolved and total cadmium was also below the LOR at all sites except for BLMI2, a nearshore site where a dissolved metal concentration value of 0.26 µg/L was recorded. Dissolved and total lead concentrations were below their respective LORs for all sites with the exceptions of BLMO2 (dissolved concentration of 0.9 µg/L and a total concentration of 0.4 µg/L) and BLMI1 (total concentration of 0.2 µg/L). Dissolved and total zinc concentrations were below the LOR for all sites apart from BLMI2 where a value of 6 µg/L was recorded. All sites complied with the adopted ANZECC/ARMCANZ (2000) guideline values for cadmium, chromium, lead, nickel and zinc.

Dissolved copper concentrations exceeded the ANZECC guidelines for 99% protection of species (0.3 µg/L) at two sites, BLMO1 (1 µg/L) and BLMO3 (1.6 µg/L). Total copper concentrations exceeded the ANZECC guidelines at all sites apart from BLMI2. Total copper concentrations ranged between 1.2 µg/L (BLMI3 and BLM01) and 2.2 µg/L (BLMI1).

Table 5-4 Dissolved metal concentrations for near shore and offshore sites at Beaço.

	Site	Mercury	Cadmium	Chromium	Copper	Lead	Nickel	Zinc
		(mg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
	LOR*	0.0001	0.20	0.50	1.0	0.20	0.50	5
Dissolved Metals	ANZECC	0.10	0.70	7.70	0.30	2.20	7.00	7.00
Inshore	BLMI1	<0.0001	<0.20	<0.5	<1.0	<0.2	<0.5	<5
	BLMI2	<0.0001	**0.26**	<0.5	<1.0	<0.2	<0.5	**6**
	BLMI3	<0.0001	<0.20	<0.5	<1.0	<0.2	<0.5	<5
Offshore	BLM01	<0.0001	<0.20	<0.5	**1**	<0.2	<0.5	<5
	BLM02	<0.0001	<0.20	<0.5	<1.0	**0.9**	<0.5	<5
	BLM03	<0.0001	<0.20	<0.5	**1.6**	<0.2	<0.5	<5

*Limit of reporting

Bold indicates values above the LOR, **Red** indicates values above ANZECC/ARMCANZ (2000)

Table 5-5 Total metal concentrations for near shore and offshore sites at Betano

	Site	Mercury	Cadmium	Chromium	Copper	Lead	Nickel	Zinc
		mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
	LOR*	0.0001	0.20	0.50	1.0	0.20	0.50	5
Total Metals	ANZECC	0.1	0.7	7.7	0.3	2.2	7	7
Inshore	BLMI1	<0.0001	<0.20	<0.5	**2.2**	**0.2**	<0.5	<5
	BLMI2	<0.0001	<0.20	<0.5	<1.0	<0.2	<0.5	<5
	BLMI3	<0.0001	<0.20	<0.5	**1.2**	<0.2	<0.5	<5
Offshore	BLM01	<0.0001	<0.20	<0.5	**1.2**	<0.2	<0.5	<5
	BLM02	<0.0001	<0.20	<0.5	**1.5**	**0.4**	<0.5	<5
	BLM03	<0.0001	<0.20	<0.5	**1.3**	<0.2	<0.5	<5

*Limit of reporting

Bold indicates values above the LOR, **Red** indicates values above ANZECC/ARMCANZ (2000)

Hydrocarbons

Total petroleum hydrocarbons (TPH) total recoverable hydrocarbons (TRH) and Polycyclic Aromatic Hydrocarbons (PAH) were analysed at all inshore and offshore sites. No sites recorded hydrocarbon concentrations above the LOR for any of the parameters analysed (Table 5-6).

Table 5-6 Hydrocarbon sediment quality parameter results for Beaço

Hydrocarbons	Site	Total TPH (µg/L)	Total TRH (µg/L)	Total PAH (µg/L)
LOR*		50	100	0.5
Nearshore	BLMI1	<50	<100	<0.5
	BLMI2	<50	<100	<0.5
	BLMI3	<50	<100	<0.5
Offshore	BLM01	<50	<100	<0.5
	BLM02	<50	<100	<0.5
	BLM03	<50	<100	<0.5

5.2 Sediment Quality

5.2.1 Chemical Sediment Quality

Nutrients

A summary of sediment nutrient parameter results collected from inshore and offshore sites at Beaço is presented in Table 5-7. The LOR is specified and results are compared with the ISQG ANZECC/ARMCANZ (2000) guideline values.

Ammonia and nitrite + nitrate (NO_x) concentrations were below the LOR at all sites apart from BLMI2, where an ammonia concentration of 30 mg/kg was recorded. TKN and TN samples ranged between 260 to 320 mg/kg at nearshore sites with a mean of 290 mg/kg, while offshore sites displayed higher overall values ranging between 380 to 720 mg/kg with a mean of 526.6 mg/kg. TP concentrations at inshore sites ranged between 278 to 420 mg/kg, with a mean of 349.3 mg/kg. Offshore sites displayed higher overall phosphorous values, ranging between 444 to 486 mg/kg with a mean of 459.6 mg/kg. (Table 5-7).

Table 5-7 Nutrient sediment quality parameters for inshore and offshore sites at Beaço.

	Site	Ammonia	NOx	TKN	TN	TP
Nutrients		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
	LOR*	**20**	**0.1**	**20**	**20**	**2**
Inshore	BLMI1	<20	0.1	**260**	**260**	**420**
	BLMI2	30	0.1	**290**	**290**	**278**
	BLMI3	<20	<0.1	**320**	**320**	**350**
Offshore	BLM01	<20	<0.1	**480**	**480**	**449**
	BLM02	20	<0.1	**720**	**720**	**486**
	BLM03	<20	<0.1	**380**	**380**	**444**

* Limit of reporting

Bold indicates values above the LOR

Metals

Concentrations of metals within the sediment at Beaço sites are presented in Table 5-8. The LOR is presented, along with a comparison to ANZECC/ARMCANZ (2000) guideline values.

Cadmium results were below the LOR for data analysis across all sites. Chromium concentrations were slightly higher at offshore sites (mean of 14.03 mg/kg) than inshore sites (10.93 mg/kg), although both were well below the ANZECC/ARMCANZ (2000) guideline value of 80 mg/kg. Copper concentrations were also higher at offshore sites, with a mean of 21.56 mg/kg compared to 9.9 mg/kg at inshore sites. Lead was below the LOR at all sites apart from BLMO1, where a value of 2.4 mg/kg was recorded. Nickel concentrations at offshore sites were all marginally above the ANZECC/ARMCANZ (2000) limit of 21 mg/kg, with a mean of 22.4 mg/kg. Inshore sites were lower with a mean of 14.16 mg/kg. Zinc levels were also higher at offshore sites with a mean of 36.06 mg/kg when compared to inshore sites (mean of 19.43 mg/kg). All sites were well below the ANZECC/ARMCANZ (2000) guideline zinc value of 200 mg/kg. Mercury levels were very low at all sites apart from BLMI3 where a value of 0.16 mg/kg was recorded, just above the ANZECC/ARMCANZ (2000) limit of 0.15 mg/kg (Table 5-8).

Table 5-8 Metal sediment quality parameters for inshore and offshore sites at Beaço

	Site	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Mercury
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Metals	**LOR***	**0.1**	**1**	**1**	**1**	**1**	**1**	**0.01**
	ANZECC	1.5	80	65	50	21	200	0.15
Inshore	BLMI1	<0.1	**13.5**	**13.2**	<1.0	**19.7**	**28.5**	**0.02**
	BLMI2	<0.1	**5.4**	**5.8**	<1.0	**4**	**4.7**	**0.01**
	BLMI3	<0.1	**13.9**	**10.7**	<1.0	**18.8**	**25.1**	**0.16**
Offshore	BLM01	<0.1	**13.5**	**25.2**	**2.4**	24.7	**38.9**	**0.03**
	BLM02	<0.1	**13.8**	**24.1**	<1.0	21.3	**38.1**	**0.04**
	BLM03	<0.1	**14.8**	**15.4**	<1.0	21.2	**31.2**	**0.03**

* Limit of reporting

Bold indicates values above the LOR, **Red** indicates values above ANZECC/ARMCANZ (2000)

Hydrocarbons

A summary of hydrocarbon (TPH, TRH and PAH) concentrations collected from sediment samples from inshore and offshore environments at Beaço are presented in Table 5-9. Hydrocarbon concentrations were below the LOR for all sites.

Table MAR022: summary of hydrocarbon (TPH, TRH and PAH) concentrations collected from sediment samples from inshore and offshore environments at Beaço.

Table 5-9 Hydrocarbon (TPH, TRH and PAH) concentrations collected from sediment samples from inshore and offshore environments at Beaço

Hydrocarbons		**Total TPH** (mg/kg)	**Total TRH** (mg/kg)	**Total PAH** (mg/kg)
Inshore	BLMI1	<50	<50	<0.5
	BLMI2	<50	<50	<0.5
	BLMI3	<50	<50	<0.5
Offshore	BLM01	<50	<50	<0.5
	BLM02	<50	<50	<0.5
	BLM03	<50	<50	<0.5

5.2.2 Particle Size Distribution

Sediment at Beaço inshore sites (BLMO 1–3) was predominantly sand (mean = 74%, *n* =3), with some fines (mean = 23%, *n* = 3) and gravel (mean = 3%, *n* = 3). The Beaço offshore sites were dominated by fines (mean = 70%, *n* = 3), with some sand (mean = 30%, *n* = 3) and gravel (mean = 0.3%, *n* = 3) (Figure 5-6).

5.3 Benthic Habitat

5.3.1 Substrate

The study area adjacent to the development footprint at Beaço was dominated by conglomerated coastal limestone in the form of reef flats, a mosaic of weathered limestone and sand, and unconsolidated sand (Figure 3-4). Reef flats dominated the coastline adjacent to the footprint area at Beaço. The reef flat changed into a limestone/sand mosaic which graded into sand with increasing distance from the shoreline. The profile of the substratum offshore from the reef flat was relatively steep, with a depth of 30 m found 500 m offshore. Sediment substrate was recorded at a depth of 15 m at all surveyed transects beyond the reef flat. Beyond the 15 m depth contour, the substrate type was exclusively sand.

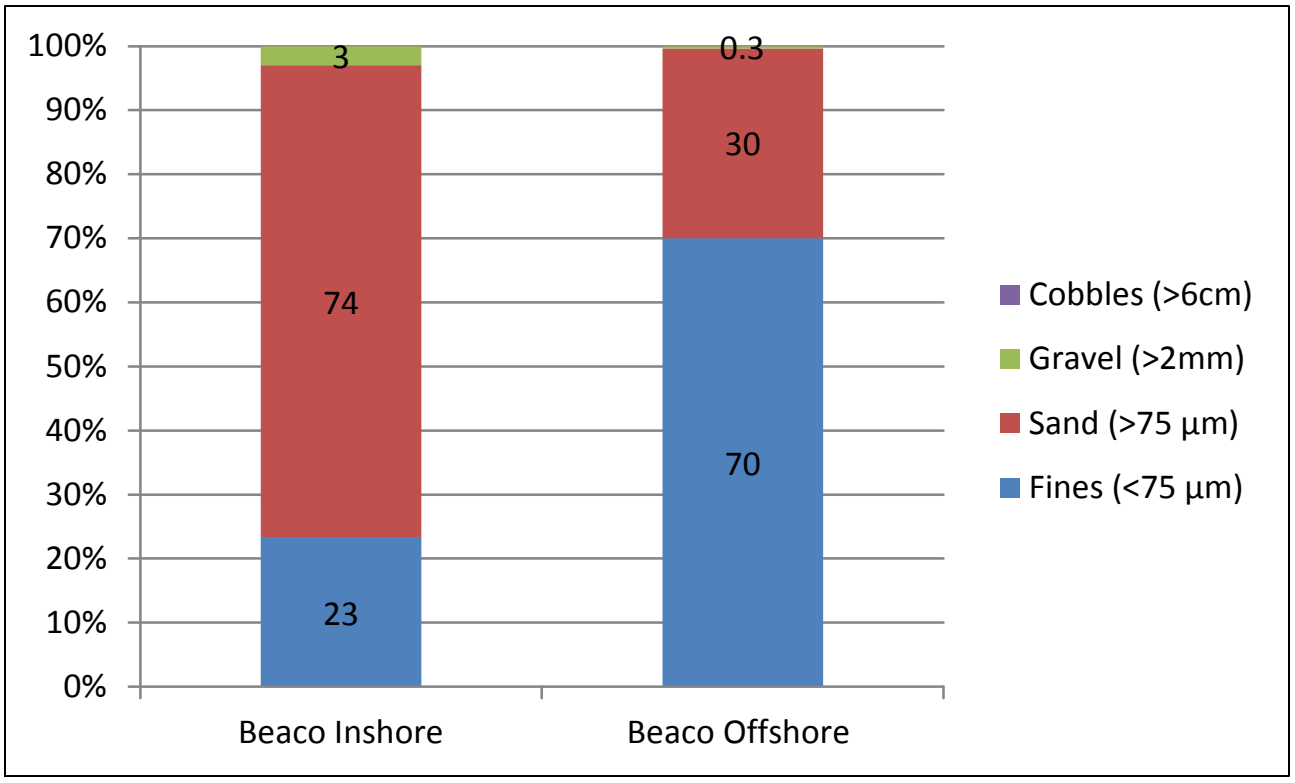

Figure 5-6 Mean PSD at Beaco inshore and Beacu offshore sites

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Figure 5-6

5.3.2 Biota

Four biota classes were identified in the study area, including coral, algae and invertebrates (Figure 3-4). Three coral families were found within the study area, consisting of Acroporidae, Faviidae and Poritidae. A wide variety of algal species are found in the study area including turf, brown, red, green and species from the *Padina* genus. Gorgonians, sea whips, sponges, ascidians and soft corals were the dominate invertebrates present. The observed distribution of each of the biota classes along the surveyed transects is provided in Figure 3-4. This map in combination with the substrate distribution map (Figure 3-4) demonstrates that most of the biota distribution was correlated with the presence of hard substrate.

The reef flat at Beaço was quite diverse (Figure 3-4). Generally the reef flat was dominated by algae, with corals and invertebrates found closer to the reef crest. Dense seagrass meadows were found along the reef flats. The primary algae type was turf algae with moderate patches of brown and green algae including sparse patches of *Padina* algae. Numerous favid corals were found close to the reef crest along with sparse acroporids and soft corals.

The reef drops steeply into deep water, offshore from the reef crest (1 to 15 m). The greatest coral diversity was generally found within 5 to 8 m of the surface which then gradually declined below 8 m. The band of rich coral growth is very narrow, being approximately 100 m wide (Plate 5-1). The dominant families found were Acroporidae, Faviidae and Poritidae.

The dense coral cover gradually changes into a mix of algae and invertebrates found growing on a mosaic of weathered limestone and sand from approximately 8 to 15 m (Brown, red, green and turf algae were the main types of algae present with the invertebrates mainly consisting of sea whips, sponges, soft corals, ascidians and gorgonians.

Generally no epibiota was present where sediment dominated the substratum beyond a depth of 15 m.

5.3.3 Plankton

A total of 400 planktonic fauna from 15 taxonomic groups were collected during the Beaço baseline survey. The most abundant fauna were the calanoids (n=97), followed by fish eggs (n=73) and isopod larvae (n=55) (Figure 5-7).

A total of five fish larvae and 73 fish eggs were collected in the Beaço plankton trawls for this survey event. The larvae were found to be from three different taxa. The fish collected, were tentatively described as belonging to the family Aploactinidae and Terapontidae (Plate 5-2), (Leis and Carson-Ewart 2004). The third fish taxa recorded was unidentifiable due to damage to the gut region of the specimen (Plate 5-3).

Plate 5-1 Photograph showing some of the corals and sponges present along the benthic habitat transects adjacent to the Beaco footprint area

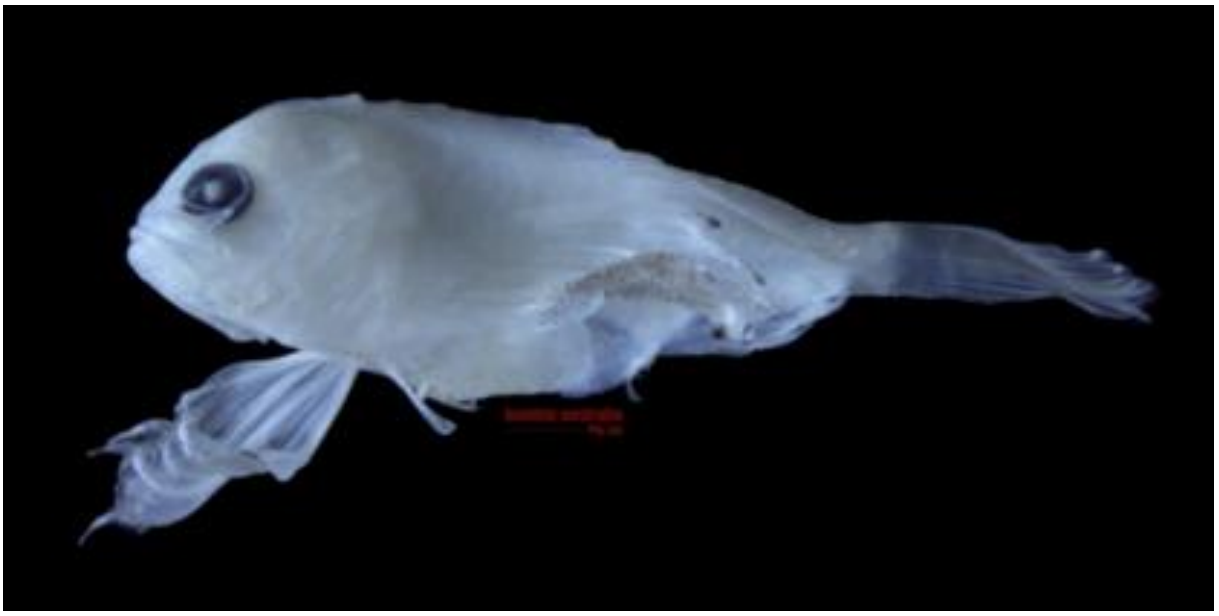

Plate 5-2 Fish larvae from the family Aploactinidae (Body length 4.5 mm)

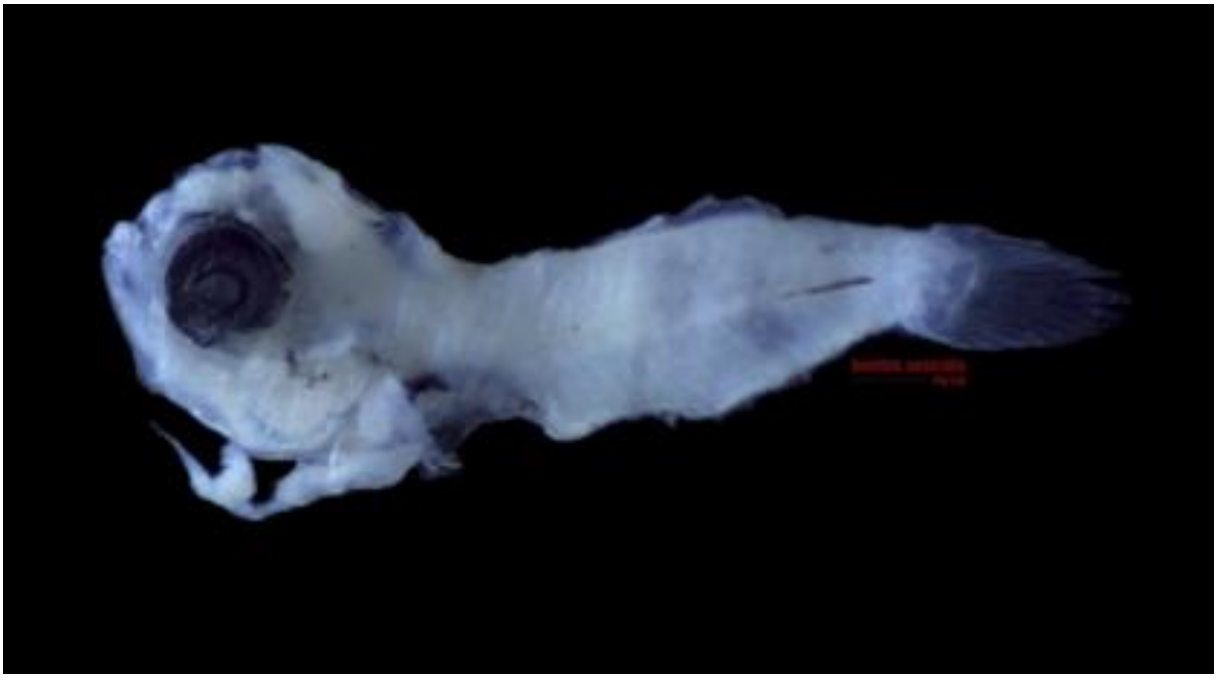

Plate 5-3 Fish larvae from an unidentified family (Body length 2.75 mm)

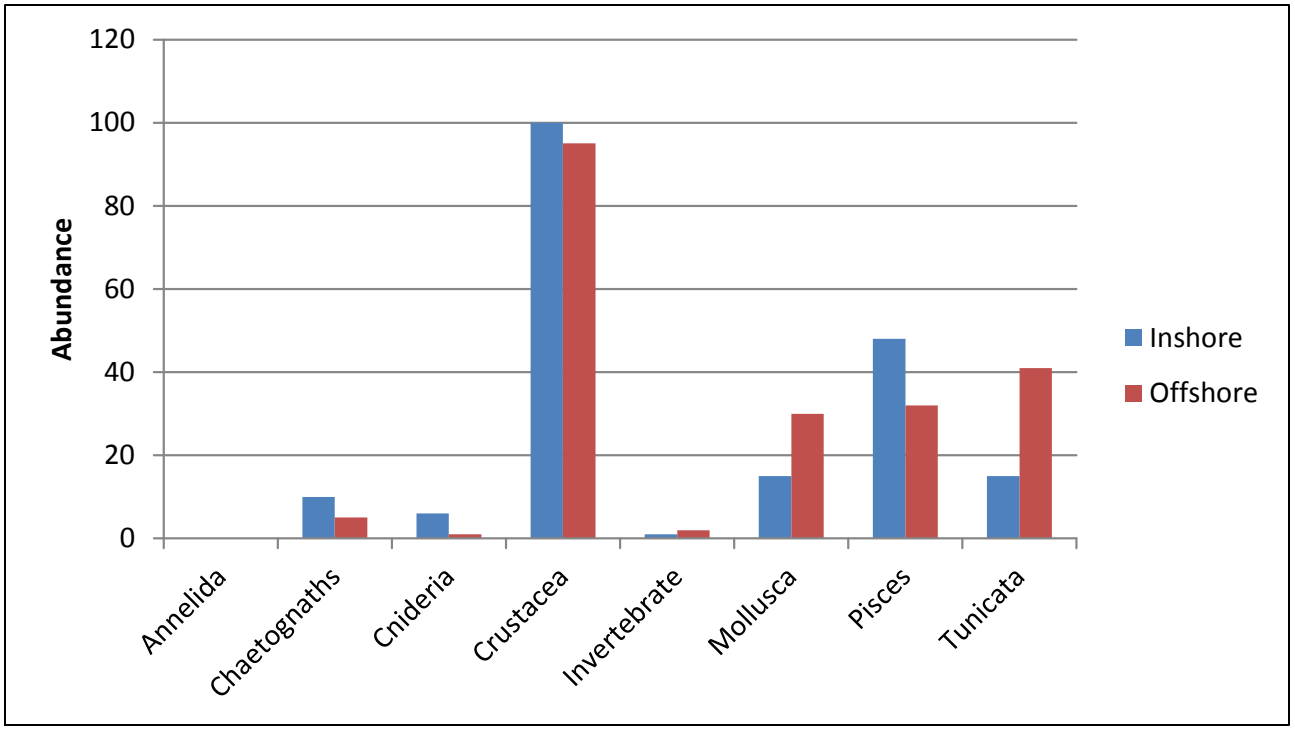

Figure 5-7 Abundance of plankton classes found inshore and offshore at Beaco

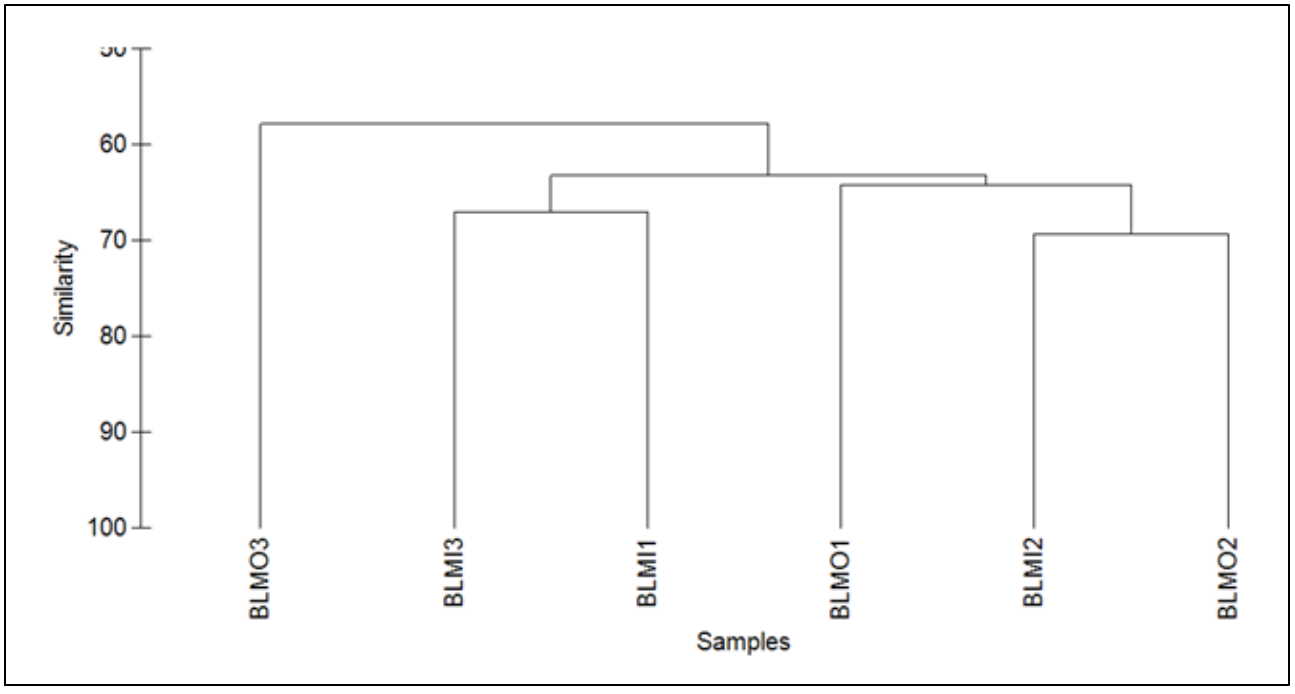

Figure 5-8 Cluster plot showing the similarity of plankton in the Beaco survey sites

The cluster plot (Figure 5-8) and MDS ordination (Figure 5-9) showed no groupings of sampling sites. The overlay, of the cluster plot onto the MDS ordination showed the majority of sites have a 40% similarity grouping (green circles, Figure 5-9). 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, prior-grouping of the samples by location (BLMO and BLMI sites), enabled a one-way ANOSIM to be undertaken. This showed no significant difference between these groups (Global R= -0.14; p=0.7).

A SIMPER analysis showed that the fauna contributing the highest to the differences between sites was also the most dominant fauna Calanoid, having 18.54% contribution to the similarity between sites (Table 5-10).

Table 5-10 SIMPER analysis results for plankton fauna contributing to the similarities in the Beaço sites.

Species	Average Abundance	Contribution (%)	Cumulative (%)
Calanoid	4.6	18.54	18.54
Fish eggs	3.82	16.66	35.21
Gastropoda	3.1	14.72	49.93
Siphonophores	3.1	12.48	62.41
Crab Zoea	2.38	10.95	73.35
Prawn Larvae	2.06	8.16	81.51
Isopoda Larvae	2.26	5.41	86.92
Larvaceans	1.62	5.11	92.03

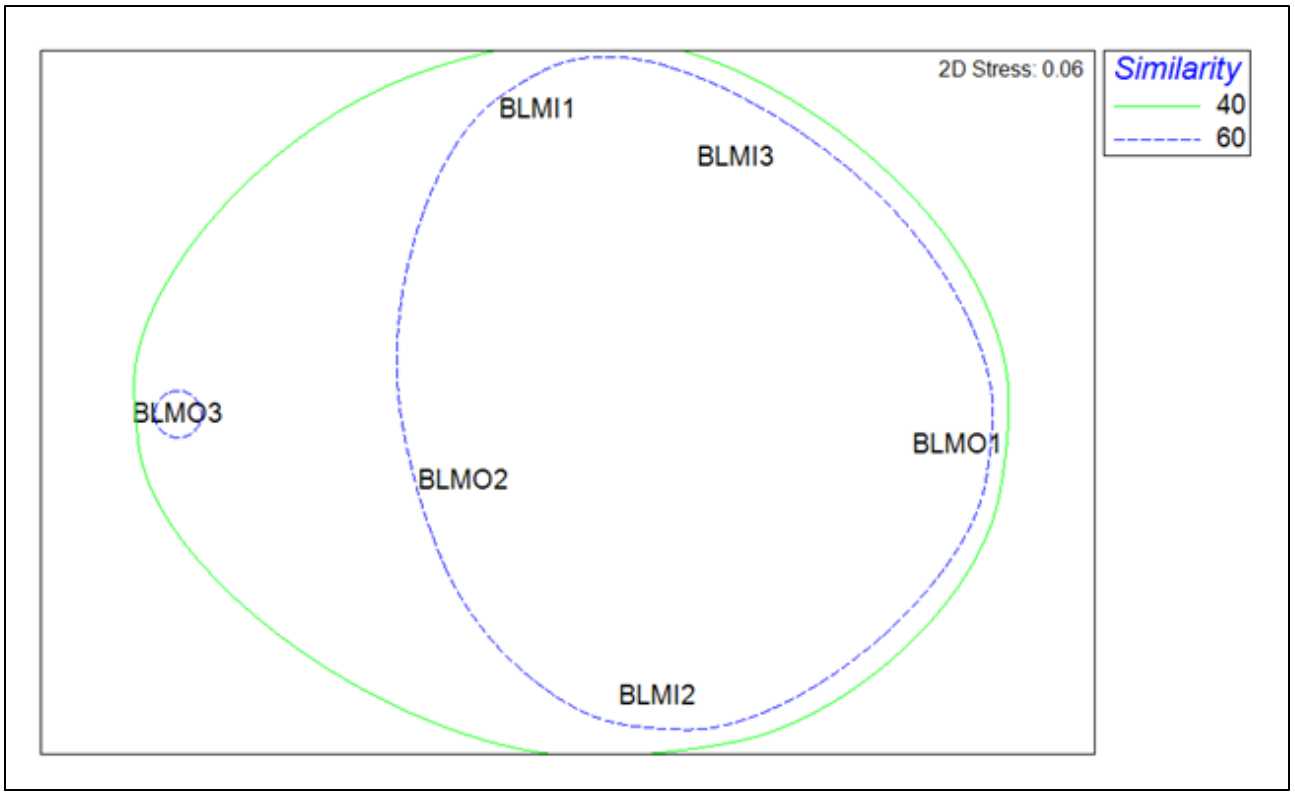

Figure 5-9 MDS ordination of plankton from the Beaco samples. Circles show similarity groupings from the cluster analysis.

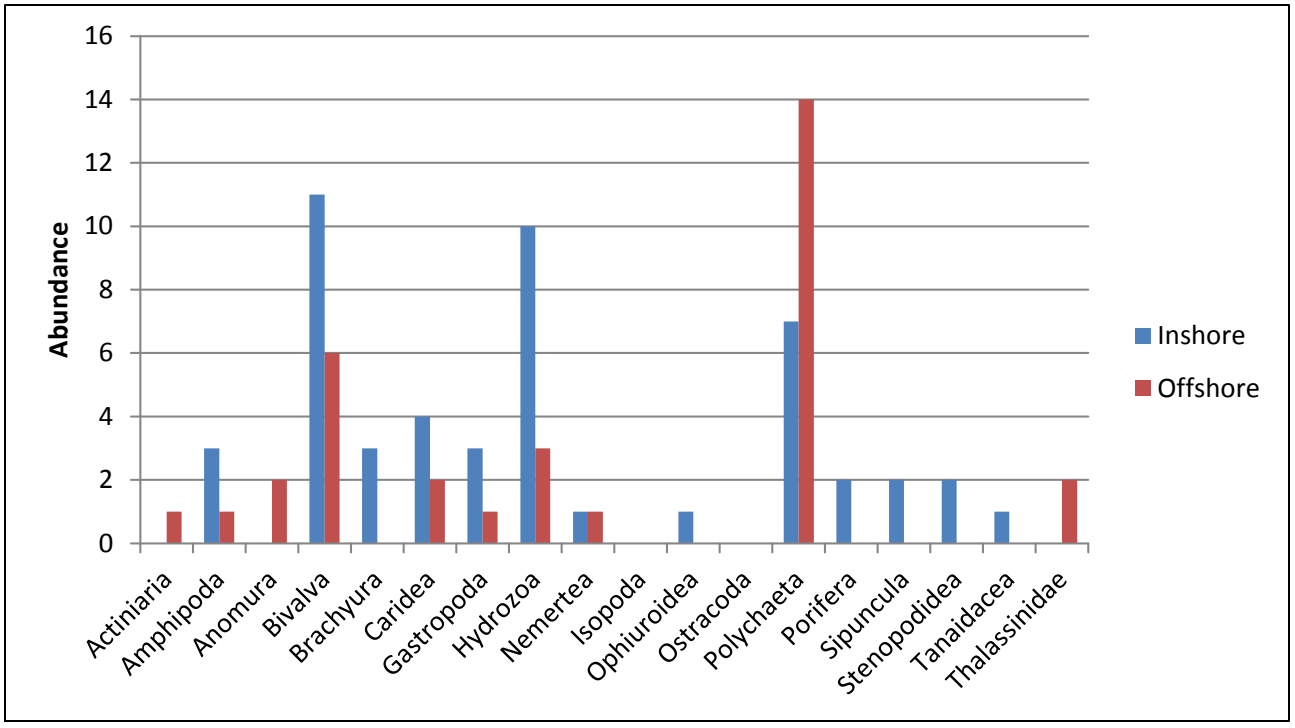

Figure 5-10 Abundance of benthic infauna classes found inshore and offshore at Beaco

5.3.4 Infauna

At total of 81 macroinvertebrates from 34 taxonomic groups were collected during this baseline survey. The most abundant families was a hydrozoan (n=13), followed by the terebellid worms (n=7) and the prawn ogyridid shrimp (n=6) (Figure 5-10).

The cluster plot showed no visual groupings of sampling site or replicates (Figure 5-11). 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 20% similarity grouping (green circles, Figure 5-12). A one-way ANOSIM comparing each community, indicated that there was no significant difference between Beaço sites, with a global R=0.271 (p=0.05). A pairwise comparison showed no significant difference between sites (Table 5-11).

A SIMPER analysis showed that the fauna contributing the highest to the similarity between sites was also the most dominant fauna hydrozoan, having 23.9% contribution to the similarity between sites (Table 5-12).

Table 5-11 One-way ANOSIM pairwise results for Beaço sites

	BLMI3	BLMI1	BLMI2	BLMO1	BLMO2	BLMO3
BLMI3						
BLMI1	0.3					
BLMI2	0.1	0.1				
BLMO1	0.1	0.1	0.1			
BLMO2	0.2	0.1	0.4	0.8		
BLMO3	0.1	0.2	0.2	0.5	0.7	

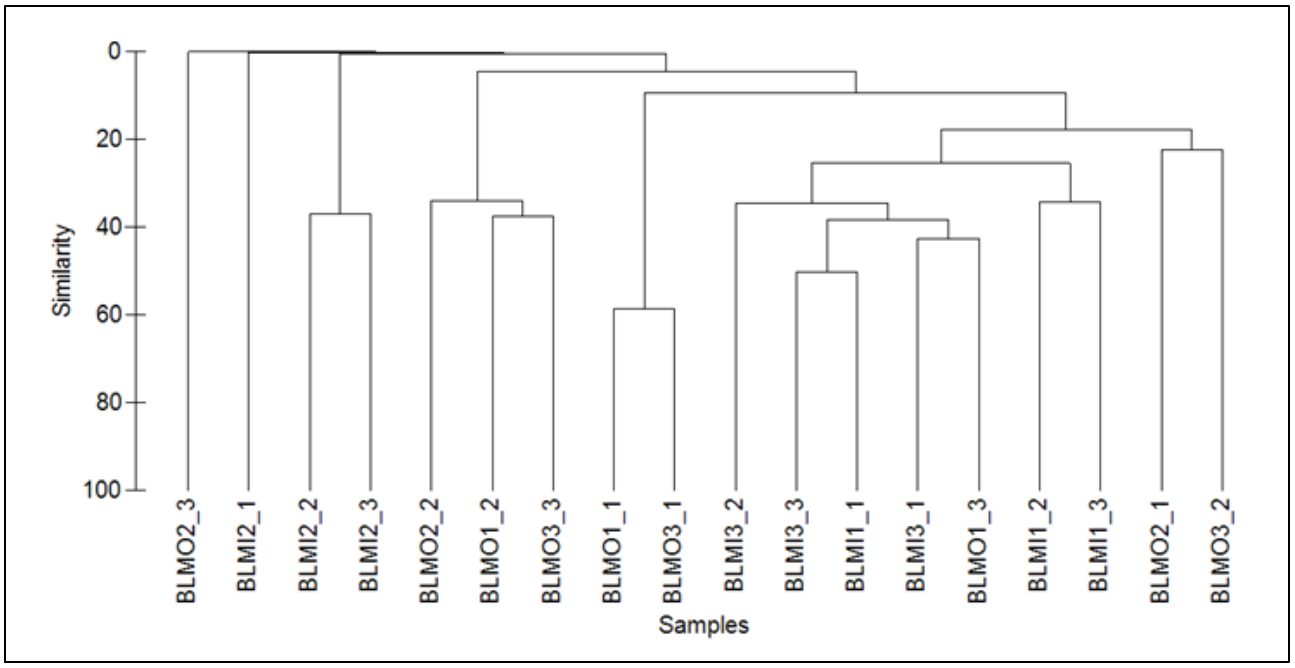

Figure 5-11 Cluster plot showing the similarity of macro-invertebrate at Beaco survey sites

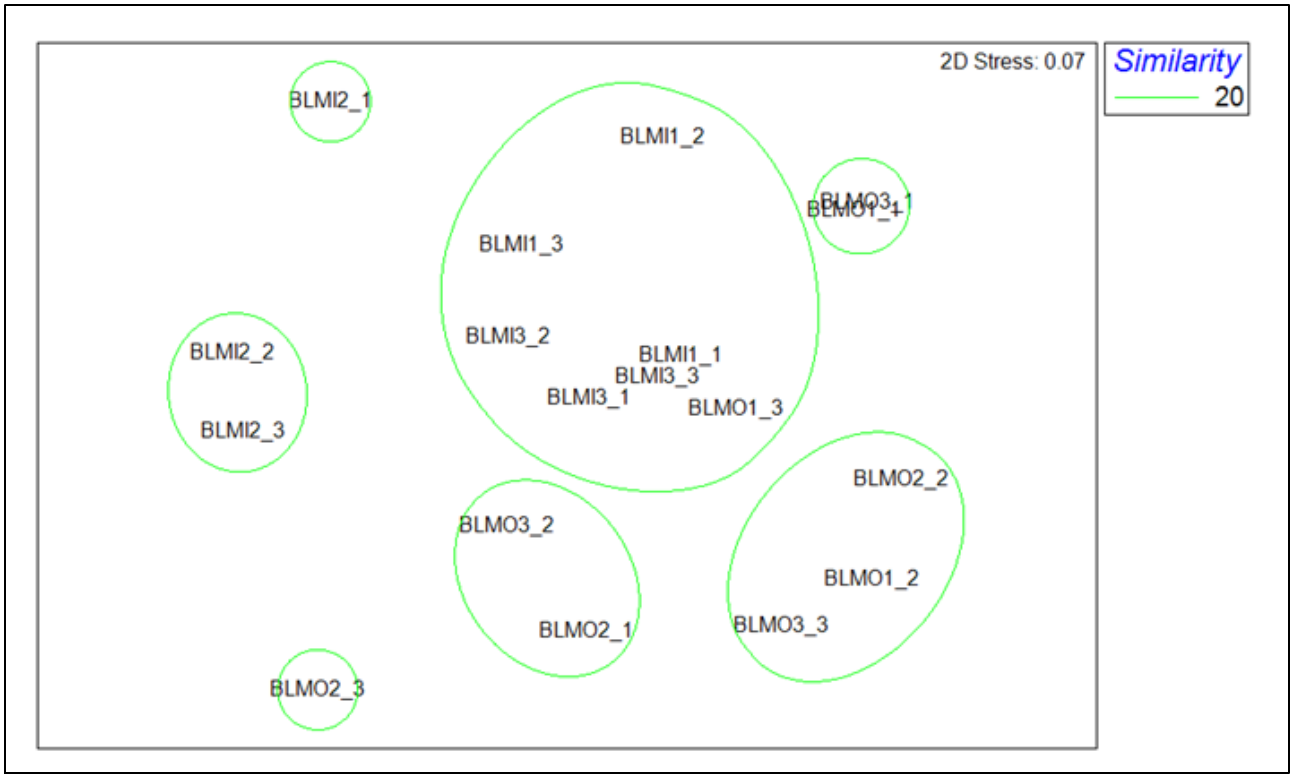

Figure 5-12 MDS ordination of macro-invertebrate at Beaco site. Circles show similarity groupings from the cluster analysis.

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OneWay to zero harm

Figure 5-11
Figure 5-12

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PLOT DATE AND TIME: 30 May 2012, 4:49 PM Creator: Courtenay Wheeler

Table 5-12 SIMPER analysis results for fauna contributing to Beaço site differences

Species	Average Abundance	Contribution (%)	Cumulative (%)
Hydrozoan	2.0	23.9	23.9
Tellinidae	1.9	22.3	46.2
Terebellidae	1.5	13.7	59.8
Ogyrididae	1.2	11.1	70.9
Nuculidae	0.8	4.6	75.6
Porifera	0.9	3.1	78.7
Diogenidae	0.7	2.2	80.9
Spionidae	0.7	2.1	82.9
Nephtyidae	0.6	1.8	84.8
Pectinariidae	0.5	1.7	86.5
Callianassidae	0.6	1.6	88.1
Ampeliscidae	0.6	1.5	89.6
Nemertea	0.5	1.5	91.1

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CHAPTER 6
DISCUSSION

301012-01504-EN-REP-0007
June 2012

6. DISCUSSION

6.1 Betano

6.1.1 Water Quality

Physicochemical Water Quality

Physicochemical water quality at Betano from the limited spatial and temporal data collected was characteristic of a tropical marine ecosystem at the start of the wet season, prior to large sediment plumes and freshwater influx from river systems (Kirono, 2010). Few trends were apparent across sites or between offshore and inshore sites. This is indicative of well-mixed waters where the predominant longshore currents are effective at maintaining relatively constant water quality.

Temperature was found to generally decrease linearly with depth and is generally attributable to reduced thermal radiation caused by less sunlight penetrating the water column with increasing depth. There was no significant difference in temperature between offshore and inshore sites.

The inshore site BTI1 was more acidic than other inshore and offshore sites with a minimum pH of 7.89, just below the ANZECC/ARMCANZ (2000) guidelines for the lower limit of pH (8.0). However, no inferences can be drawn from this result given the small spatial and temporal dataset obtained, and there were no apparent trends in pH between inshore and offshore sites overall.

A slight increase in salinity was apparent for inshore and offshore sites as depth increased. Surface waters from offshore sites were marginally less saline than surface waters from inshore sites with a mean difference of 0.8 ppt. This is most likely due to the diluting influence of freshwater input from riverine systems surrounding Betano such as the Caraulun River. However, no significant pycnocline (density gradient) was evident indicating that coastal waters are well mixed.

Turbidity results were not obtained at BTI3 and BTO3 due to equipment malfunction, and results obtained from the other 4 sites show no apparent trends with all values falling within the ANZECC/ARMCANZ (2000) guidelines for turbidity (1-20 NTU).

Dissolved oxygen decreased with increasing depth in both offshore and inshore sites. Near the surface, oceanic water is well oxygenated by entrainment of air through wave action.

Chemical Water Quality

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

Chlorophyll *a* was below the LOR and ANZECC/ARMCANZ (2000) guideline value.

Concentrations of total and dissolved metals were generally low for most parameters across all sites and were mostly less than the limits of reporting, with the exception of total and dissolved copper concentrations which exceeded the ANZECC/ARMCANZ (2000) guidelines in a number of instances.

Copper is an essential micronutrient for both plants and animals and is found in the marine environment in varying concentrations. It is derived from both anthropogenic (e.g., copper used in the construction of materials and equipment) and natural (e.g., copper within rock layers) sources. The vast majority of copper input into the marine environment is sourced from riverine particulate matter (Blossom, 2003) where minerals in terrestrial soil and weathered rock bind to sediments and are transported by processes such as sheet flow and leachate to streams and rivers. Particulate matter is subsequently washed out to sea, and copper is either dissolved within the water column or deposited via the process of marine sedimentation. It is important to note that anthropogenic activities such as land clearance, deforestation and land use change that exacerbate runoff and subsequent relative volumes of riverine particulate matter, can add to the total copper loads entering the marine environment. Such terrestrial activities are apparent in the catchments of Timor-Leste, including those of the Caraulun River catchment which is the major riverine system in the Betano region; however without further temporal and spatial investigations no inference can be made as to the relative contribution of anthropogenic sources to naturally derived copper concentrations within marine waters.

Hydrocarbons within the water column were recorded at levels less than the LOR at both sites, and this is in indicative of an environment largely free from human induced hydrocarbon sources such as oil spillages (boats, tankers) or land based runoff from built infrastructure.

6.1.2 Sediment Quality

Nitrogen concentrations from all sampling sites (inshore and offshore) were comprised entirely of organic nitrogen (TKN), indicating that nitrogen found in sedimentary material is derived from organic sources. TN and TP sedimentary levels were within the same relative ranges as recorded in previous studies (e.g. Prasad, 2008). However, without ascertaining data from suitable reference sites to use as a comparative analysis of relative levels of nitrogen and phosphorous and without sampling across a more complete spatial and temporal range at Betano, no inferences on the significance of relative levels of sedimentary TN and TP can reliably be made.

Proportionally higher concentrations of both TN and TP were found in the offshore site BTO1 than the inshore site BTI1. Nutrient levels within marine sediments at Betano are largely influenced by the accumulation of organic matter on the seabed, and this is most likely derived from particulate matter transported via riverine inputs as sediments fall out of suspension in the water column. Nutrient concentrations in sediment also tend to *increase* with *decreasing* grain size as the proportional surface area of finer sediments is greater and organic matter is more readily absorbable onto mineral surfaces. Finer sediments remain in suspension within the water column longer and travel further distances than coarser material, which is why the offshore site BTO1 has relatively higher concentrations of both TN and TP than BTI1.

All sedimentary metal concentrations were below the ANZECC/ARMCANZ (2000) sediment quality guidelines with cadmium, lead and mercury also below the LOR. No distinct trends were apparent between offshore and inshore sites.

Sedimentary hydrocarbons were recorded at levels less than the LOR at both sites.

Particle size distribution of the sediments at Betano followed general expectations, with shallower inshore sites dominated by sand granules and deeper offshore sites containing a greater relative proportion of fines. Fine sediments are likely sourced from riverine inputs, with fines being transported further out to sea than coarser material and eventually settling in deeper areas offshore. The presence of gravel, particularly at inshore sites, suggests that these sites are located in close proximity to rock or reef systems.

6.1.3 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 200 m can be found less than 1 km offshore. 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 Betano area show turbid plumes moving from east to west along the coastline.

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 Betano footprint area was weathered coastal limestone which formed inshore reef flats.

Offshore from the reef flats within the study area, the dominant substrate type was 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 enhance sediment supply.

Within the study area, algae, coral and invertebrates made up the biotic benthic community, which were primarily associated with hard substrate. The fringing reef identified adjacent to the Betano 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 3 to 8 m of the surface which then gradually declines below 8 m as depth increases and light diminishes. According to Burke et al (2002), a high diversity of coral reefs exist in southern Timor-Leste with 301-500 species identified. In the present study, five families of corals were identified; however, corals couldn't be identified to species level due to video imagery affected by poor water clarity.

6.1.4 Plankton

Siphonophores were the most abundant taxa at the Betano sites; however, it was the fish eggs and the siphonophores that contributed equally to the similarity between sites (23.8%). A total of one fish larvae from the family Terapontidae and 269 fish eggs were found in the samples. The invertebrate community composition at Betano showed no significant differences across sites.

6.1.5 Infauna

Eunicid worms were the most abundant family at the Betano sites; however it was the spionid worms that contributed the highest to the similarity between sites (33.1%). The invertebrate community at Betano showed no significant differences across sites.

6.2 Beaço

6.2.1 Water Quality

Physicochemical water quality

Physicochemical water quality at Beaço from the limited temporal data collected was generally typical of a tropical marine ecosystem at the start of the wet season (Kirono, 2010), with few distinct trends apparent across sites or between offshore and inshore sites. This is indicative of well mixed waters where predominant longshore currents are effective at maintaining relatively stable water quality.

Temperature was found to generally decrease linearly with depth and is generally attributable to reduced thermal radiation caused by less sunlight penetrating the water column with increasing depth. There was no significant difference in temperature between offshore and inshore sites.

Offshore sites were marginally less saline than inshore sites, with a mean difference of 0.2 ppt. This is most likely due to the diluting influence of freshwater input from riverine systems surrounding Beaço. However, no significant pycnocline (density gradient) was evident indicating that coastal waters are well mixed.

Turbidity results show no apparent trends with all values falling within the ANZECC/ARMCANZ (2000) guidelines for turbidity (1-20 NTU).

Dissolved oxygen decreased with increasing depth in both offshore and inshore sites. Near the surface, oceanic water is oxygenated with atmospheric oxygen through wave action. DO is absorbed with increasing depth through biological respiration, while the influence of wave action is also negated reducing turbulence and subsequent oxygen dissolution.

Chemical Water Quality

Concentrations of nutrients were generally below the laboratory LOR for all nearshore and offshore sites, with the exception of ammonia. Ammonia levels exceeded the recommended ANZECC/ARMCANZ (2000) trigger level at all sites. Ammonia is a source constituent of nitrogen in marine waters and is resultant from microbiological activity.

Concentrations of other nutrients (NO_x, TKN, TN and TP) were generally low and often below the laboratories LOR for all sites, except at the inshore site, BLMI2 where all parameters tested exceeded the ANZECC/ARMCANZ (2000) guidelines.

Chlorophyll a and BOD were below the LOR, and for chlorophyll a, the applicable ANZECC/ARMCANZ (2000) guideline value.

Concentrations of total and dissolved metals were generally low for most parameters across all sites and did not register above the LOR. However, much like Betano (and Suai) total and dissolved copper concentrations at most Beaço sites exceed the ANZECC/ARMCANZ (2000) guidelines value for the 99% protection of marine species. The significance of copper in the marine environment has been discussed previously.

Hydrocarbons within the water column at Beaço were recorded at levels less than the LOR at both sites.

6.2.2 Sediment Quality

Nitrogen concentrations from all sampling sites (inshore and offshore) at Beaço were comprised entirely of organic nitrogen (TKN), indicating that nitrogen found in sedimentary material is derived from organic sources. TN and TP sedimentary levels were within the same relative ranges as recorded in previous studies (e.g., (Prasad and Ramanathan 2008) although further assessment is required to account for the elevated levels of ammonia in the coastal waters at all three project areas.

Nutrient levels within marine sediments at Beaço are largely influenced by the accumulation of organic matter on the seabed, and this is most likely derived from particulate matter transported via the numerous stream and rivers of the region as sediments fall out of suspension in the water column.

Sedimentary metal concentrations were generally above the LOR but below the ANZECC/ARMCANZ (2000) sediment quality guidelines. Offshore sites displayed marginally higher concentrations overall for chromium, copper, lead, nickel, zinc and mercury (cadmium was below the LOR at all offshore and inshore sites). This is likely attributable to the predominantly finer grained sediments that occur at offshore sites which display a higher affinity for binding metals, minerals and nutrients. Nickel concentrations at all offshore sites were also just above the ANZECC/ARMCANZ (2000) guideline value of 21 mg/kg.

Hydrocarbon levels in sediments were also very low and less than the LOR at both sites.

Particle size distribution of the sediments at Beaço followed general expectations, with shallower inshore sites dominated by coarser sand granules (74%) and deeper offshore sites containing a much greater proportion of fines (70%). Fine fractions within sediment compositions are likely sourced from riverine systems in the region, with fines being transported further out to sea than coarser material and eventually settling in deeper areas offshore.

6.2.3 Benthic Habitat

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 Beaço footprint area was weathered coastal limestone which formed inshore reef flats.

Offshore from the reef flats within the study area, the dominate substrate type was sediment. Given the high elevation and seasonal rainfall in catchments draining to the south coast of Timor-Leste, 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 into the coastal environment.

Within the study area, algae, coral and invertebrates made up the biotic benthic community, which were primarily associated with hard substrate. The fringing reef identified adjacent to the Beaço 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 8 m of the surface which then gradually declines below 8 m as depth increases and light diminishes. According to Burke et al (2002), a high diversity of coral reefs exist in southern Timor-Leste with 301 to 500 species identified. In the present study; however, only a low diversity of corals was found within the study area. The structure of the reef was quite immature, consisting of a thin layer of predominately plated corals growing on dead coral rubble or weathered limestone. Reef blasting using grenades, was a common fishing method found on the Southern Timor-Leste coast after the Indonesian invasion. This blasting method could be an explanation as for the low diversity of corals observed at Beaço. At a depth of 8 to 15 m, invertebrates were the dominant biota present, with generally no epibiota present at depths greater than 15 m.

Seagrass communities have previously been identified in northern parts of Timor-Leste. Dense seagrass meadows were found along the reef flats adjacent to the Beaço 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.

6.2.4 Plankton

Calanoid copepods were the most abundant taxa at the Beaço sites and contributed the highest to the similarity between sites (18.54%). A total of five fish larvae from three taxonomic groups (Aploactinidae, Terapontidae and unknown family) and 13 fish eggs were found in the samples. The invertebrate community composition at Beaço showed no significant difference across all sites.

6.2.5 Infauna

Hydrozoans were the most abundant family at the Beaço sites; and this taxon also contributed the highest to the similarity between sites (23.9%). The invertebrate community at Beaço showed no significant difference across sites.

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CHAPTER 7
CONCLUSION

301012-01504-EN-REP-0007
June 2012

7. 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. Although differences noted in this survey were minor, larger fluctuations in parameters are likely following high rainfall events.

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.

A comparison of infauna, plankton and benthic communities between the three study areas has shown that faunal composition is fairly similar.

The macroinvertebrate communities during the baseline sampling event were species rich in polychaetes and crustaceans. Generally speaking, finer sediments are usually dominated by polychaetes whereas sandier sediments are usually crustacean dominated (Long & Poiner, 1994; Currie & Small, 2005). The invertebrate community at Suai, Betano and Beaço showed no significant difference in invertebrate community composition.

Plankton species richness and abundance reflected a day time community composition. There was no difference in plankton community composition across the sites at Suai, Betano and Beaço. In total four families of fish larvae were collected, including a Blennidae from Suai; Terapontidae from Betano and Aploactinidae, Terapontidae and an unknown family from Beaço. Fish eggs were common at all locations.

Overall the marine communities both benthic and pelagic during the baseline survey showed no significant difference in faunal composition.

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. 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. The reef flats located in the Betano and Beaço footprint region consisted of a low diversity limestone reef flat which dropped steeply into deep water. A thin band of rich corals generally occurred from the 3 to 8 m depth contour which grades into an algae and invertebrate dominated habitat from 8 to 15 m at Beaço and 8 to 25 m at Betano. Beyond the 12 m depth at Beaço and the 25 m depth at Betano, the habitat is sand, on which very little epibiota was present.

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SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

CHAPTER 8
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