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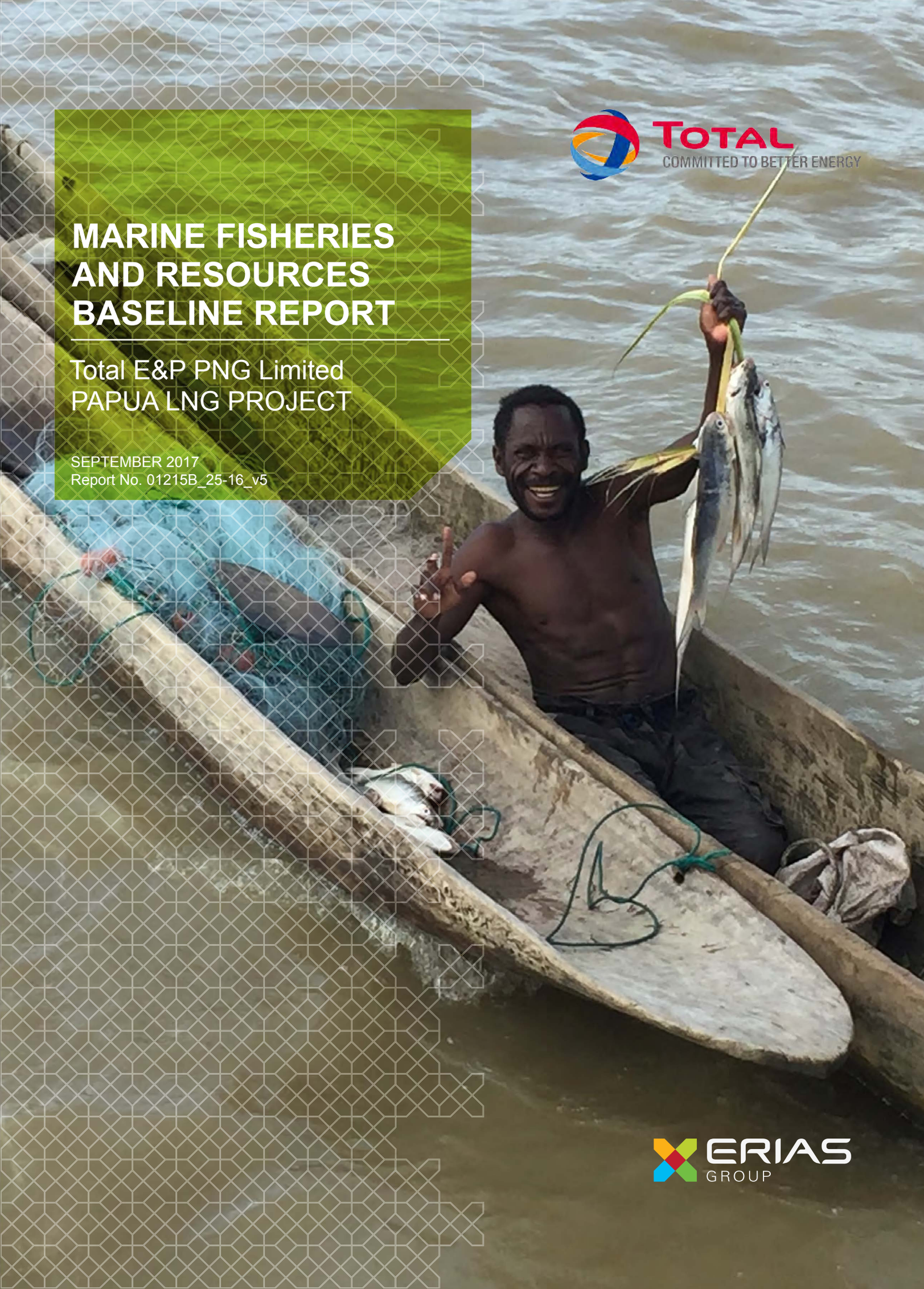
PAPUA LNG

Upstream Environmental Impact Statement

Volume 2: Environmental and Social Baseline

Part 13
Marine Fisheries and Resources Baseline Report

TOTAL
TOTAL E&P PNG LIMITED



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COMMITTED TO BETTER ENERGY

MARINE FISHERIES AND RESOURCES BASELINE REPORT

Total E&P PNG Limited
PAPUA LNG PROJECT

SEPTEMBER 2017
Report No. 01215B_25-16_v5

ERIAS GROUP

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Total E&P PNG Limited

Papua LNG Project

Marine Fisheries and Resources Baseline Report

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Executive Summary

Background

Total E&P PNG Limited (TEP PNG), a wholly owned subsidiary of TOTAL S.A. (TOTAL) is the largest partner in a joint venture to develop the Elk-Antelope gas field, located in Petroleum Retention License 15 (PRL-15) in Gulf Province, Papua New Guinea. This development, known as the Papua LNG Project (the Project), will comprise upstream production well development and associated infrastructure at the gas field within PRL-15, construction of an upstream central processing facility (CPF) and delivery of gas and condensate via onshore and offshore export pipelines to a LNG plant site at Caution Bay, Central Province, 20 km northwest of Port Moresby.

This technical report provides the findings of a baseline characterization of the marine fisheries and resources in the study area. This technical report forms part of the Environmental and Social Baseline Study (ESBS) for the Project environmental impact statement, and the environmental, social and health impact assessment (EIS/ESHIA). This report draws upon information from a broader area than the Project area of influence (PAOI) and includes: (1) Orokolo Bay and the Purari and Kikori river deltas, (2) the nominal offshore export pipeline corridor (offshore export pipeline corridor) including the surrounds of Kerema, Yule Island and Cape Suckling, (3) the offshore open ocean environment of the Gulf of Papua, (4) Caution Bay, (5) the Fly River and coastal environment of Western Province, and (6) Torres Strait.

Objectives

The aim of this study is to characterize the commercial and artisanal marine fisheries and customary usage of marine and estuarine resources in the study area. The study makes use of existing information and new data generated from related ESBS studies.

Findings

The Gulf of Papua Prawn Fishery is the second largest commercial fishery in Papua New Guinea and is the most significant commercial fishery activity in the Gulf of Papua. Prawn trawling occurs in a band throughout the northern gulf, but is most intensive in areas offshore of Kerema (Freshwater Bay and Kerema Bay) and offshore of the Purari and Kikori rivers. The Project's offshore export pipeline corridor intersects two prawn fishery reporting areas: Orokolo Bay and West Kerema Bay. Re-analysis of trawler vessel monitoring system position data, that was used as a proxy for prawn productivity, and catch data from stock assessment surveys, indicated that: (a) trawling intensity in these two regions, as a whole, is lower than in neighboring areas, and (b) the offshore export pipeline corridor traverses relatively low-activity sectors of the Orokolo Bay and West Kerema Bay fishery areas. Marine transport routes to the Purari River delta will also traverse areas of the Gulf of Papua Prawn Fishery (GOPPF) potentially including the Cape Blackwood, Purari and Orokolo Bay reporting areas. The Gulf of Papua Prawn Fishery Management Plan stipulates trawling only outside the 3 nM zone. However, there are opportunities for fishing enterprises to enter into profit-sharing arrangements with landowners to access the 'coastal zone' that extends 3 nM from shore. This option is seemingly taken by at least

some cooperatives, as there is substantial trawler activity within the 3 nM zone. Coastal villagers also reportedly interact with the commercial prawn fishery via the trade of trawl by-catch (notably elasmobranchs).

Historically, there was small-scale commercial barramundi fishing in the Purari River and surrounds. Today, commercial barramundi fishery activity in the Gulf of Papua occurs only in Western Province. However, barramundi remains an important species in artisanal fisheries of the Purari River delta and adjacent coastal zone.

Subsistence reliance on marine and estuarine fisheries is expected to be secondary to gardening and terrestrial resource use throughout the study area. However, marine and estuarine fisheries are central to the health, livelihoods and cultural identity of all people with access to the Purari River delta, estuaries and coastal marine environment. Waterways are typically accessed by un-motorized canoes and the predominant fishing methods are gillnetting and hook-and-line fishing. In the Purari and Orokolo Bay areas, the collection of prawns and small fishes using hand-operated scoop nets is also a common fishing method. Artisanal fishing activity is tuned to the habitats and species available. Thus, in Caution Bay, coral reefs and seagrass beds (that do not occur in the Purari-Orokolo Bay region) are targeted for marine resources while in the Purari-Orokolo Bay area, the mangrove-lined deltaic watercourses and the sediment beds of the open coast are targeted.

Seasonal wind conditions also place limitations on people's access to the marine environment. Local knowledge of the migration patterns and seasonal increases in the abundance of the following species is used to maximize subsistence and artisanal catches:

- Barramundi (*Lates calcarifer*).
- Sharks, rays and sawfishes.
- Palaemonid and penaeid prawns.
- Threadfin salmon (family Polynemidae).
- Jewfish (family Scaenidae).
- Ornate rock lobster (*Panulirus ornatus*) at Yule Island and surrounds.
- Reef fishes in Caution Bay.

Generally, localized increases in the abundance of these species are related to spawning events that may be seasonally defined (e.g., barramundi and ornate rock lobster) or cued to other environmental factors such as moon phase and temperature (e.g., coral reef fishes). In several instances, such migrations and spawning activities are associated with particular habitat types and locations. For example, mangrove systems are known to be important nursery areas for a range of coastal fish species and the connectivity between mangroves and the coastal environment is key to prawn production in the Gulf of Papua. Similarly, reef features at Yule Island are key to successful lobster spawning and coral reef fishes tend to aggregate around

particular reef features. Where details are available, the relevant migrations and seasonal increases in the abundance of these species are discussed herein.

Maintenance of the ecosystem processes associated with the migrations and other life history traits of these species is therefore considered key to the maintenance of artisanal fisheries. Artisanal fisheries are almost exclusively within the 3 nM coastal zone and the offshore export pipeline corridor intersects this zone in three locations: at the upstream coastal extent of the corridor (Gulf Province), adjacent to Cape Suckling (Central Province) and at the downstream coastal extent of the corridor (Central Province). Artisanal fishing practices at Cape Suckling are not well characterized at this time due to a lack of information.

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1. Introduction

1.1 Project Overview

The following Project description is focused on the upstream components of the Papua LNG Project and aims at providing minimal but appropriate context for the baseline reports.

Joint venture partners are currently planning the development of the Elk-Antelope gas field, which is located within Petroleum Retention License 15 (PRL-15) in the Gulf Province, Papua New Guinea. Total E&P PNG Limited (TEP PNG), a wholly owned subsidiary of TOTAL S.A (TOTAL) has the largest interest in the Elk-Antelope gas field and is the operator of the Papua LNG Project (the Project) on behalf of the other joint venture partners.

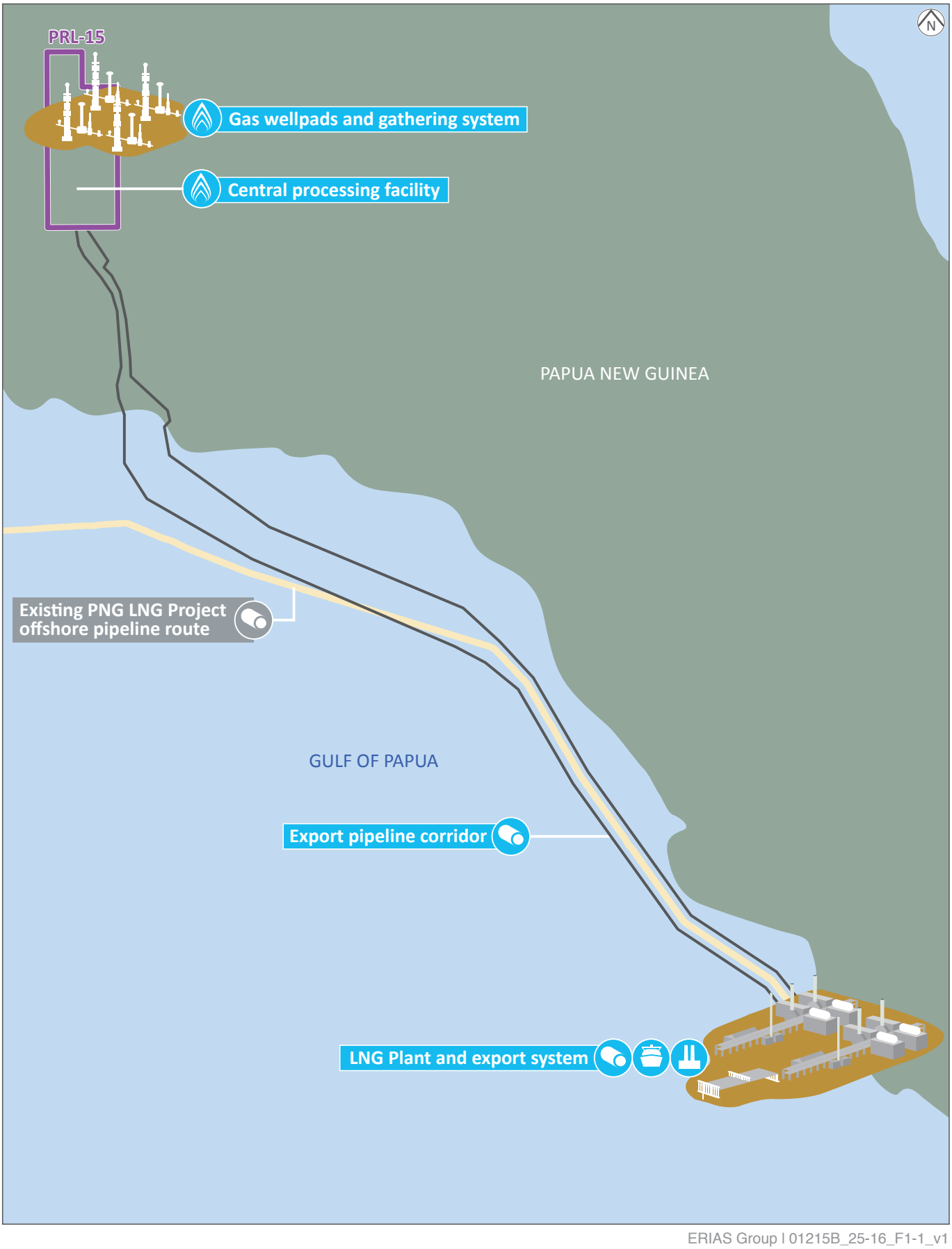
The Elk-Antelope gas field is a significant gas discovery in Papua New Guinea consisting of a gas reservoir with several trillion cubic feet of gas reserves located approximately 120 km inland from the township of Kerema, and 340 km northwest of Port Moresby (Figure 1.1).

The Project will comprise upstream production well development and associated infrastructure at the gas field within PRL-15, construction of an upstream central processing facility (CPF) and delivery of gas and condensate via onshore and offshore export pipelines to a LNG Plant site at Caution Bay, Central Province, 20 km northwest of Port Moresby. The design life for the Project will be 25 years.

The Project area comprises the physical footprint of the various Project components and associated infrastructure as detailed below.

- Production, processing and related facilities (within PRL-15):
  - Wellpads and the associated gathering system (including flowlines and trunkline).
  - An upstream central processing facility (CPF) to separate condition gas and condensate streams, including an acid gas removal unit (AGRU).
  - Logistics base and river offloading facilities, accommodation camps, airstrip, roads and bridges.
  - Quarries and communications infrastructure.
- Onshore pipeline (outside PRL-15):
  - Onshore export pipeline system comprising separate single gas and condensate pipelines, from the CPF to landfall on the gulf coast including valve stations.
  - Temporary laydown areas and camps.
  - Quarries and communications infrastructure.

FIGURE 1.1



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- Transport (river) corridor:
  - River transport routes — the Purari, Urika-Ivo and Wame-Varoi rivers.
- Offshore pipeline:
  - Offshore section of the export pipeline system from landfall on the northern coast of the Gulf of Papua in Orokolo Bay, to landfall at a LNG plant site in Caution Bay.

1.2 Objectives

The aim of this study is to characterize the commercial and artisanal fisheries and usage of marine and estuarine resources in the study area. This study adopts the definition of artisanal fisheries provided by the Food and Agriculture Organization of the United Nations:

> *Traditional fisheries involving fishing households (as opposed to commercial companies), using relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption. In practice, definition varies between countries, e.g. from gleaning or a one-man canoe in poor developing countries, to more than 20 m trawlers, seiners, or long-liners in developed ones. Artisanal fisheries can be subsistence or commercial fisheries, providing for local consumption or export. Sometimes referred to as small-scale fisheries*[1].

Translating this definition to the current study, artisanal fisheries in the Gulf of Papua can be described as small-scale fisheries activities that are for subsistence use, or localized market sale and that use traditional fishing techniques. Artisanal fishing activities in Papua New Guinea are not regulated by government agencies, although traditional resource owners implement closed areas, closed seasons or other forms of resource management. This contrasts with commercial fisheries that are based on fishing companies and cooperatives that process a product for commercial sale and export, the activities of which are regulated by government agencies.

This study aims to document the current state of artisanal and commercial fisheries resource use, but also to document the historical activities and relevant changes that have occurred so that relevant trends and factors that impinge on people's access to resource can be described. By characterizing the spatiotemporal extent of resource use, the practices, and the species and habitats of importance, this study feeds into an assessment of the social and environmental impacts associated with the Project.

[1] http://www.fao.org/docrep/003/X2465E/x2465e0h.htm

2. Regulatory Framework and Standards

The Project is regulated primarily under the *Environment Act 2000* and the *Oil and Gas Act 1998* together with aspects of the suite of recently introduced Marine Pollution Acts. TEP PNG will also be guided by company environmental performance standards and international guidelines for the purposes of the EIS/ESHIA. Therefore, the three sets of performance standards applicable to the EIS/ESHIA are:

- Papua New Guinean Legislation, including Conservation and Environmental Protection Authority (CEPA) operational procedures and codes of practice under the *Environment Act 2000*.
- International environmental guidelines, including the IFC performance standards.
- TOTAL company standards and commitments.

2.1 Papua New Guinean Authorities and Legislation

Commercial fisheries in Papua New Guinea are regulated and licensed by the National Fisheries Authority (NFA), a statutory authority that operates under the *Fisheries Management Act 1998*. Fishing activity is regulated via the *Fisheries Management Regulation 2000* and the *Fisheries Management (Amendment) Regulation 2016*. Commercial fisheries are managed under separate 'sectors', most of which are defined by a fishery management plans that set out total allowable catch, fishing areas and other arrangements. The management plans of relevance to the Project are the:

- Gulf of Papua Prawn Fishery Management Plan.
- Torres Strait and Western Province Tropical Rock Lobster Fishery Management Plan.
- National Bêche-de-mer Fisheries Management Plan.
- Barramundi Fishery Management Plan.

The management plans are supported by stock assessment research and are subject to revision on the basis of fishery performance. NFA is also responsible for compliance monitoring of commercial fishing activity. Commercial fishing is generally beyond 3 nautical miles (nM) from shore, with the coastal zone from the shore to the 3 nM limit generally reserved for artisanal fisheries. For the Gulf of Papua Prawn Fishery, there are cases of commercial operators negotiating access rights with landowners to establish joint fishing ventures and profit sharing.

Papua New Guinea is signatory to the Torres Strait Treaty (1985) which establishes the Torres Strait Protected Zone. Under the treaty, Papua New Guinean and Australian vessels are entitled to take a share of total allowable catch from the protected zone, under the management of the Protected Zone Joint Authority (PZJA).

The artisanal and recreational fishing sectors are not formally regulated by the NFA. There are a number of marine protected areas or 'reserves' in Papua New Guinea. With respect to the Project, the only marine reserve of potential relevance is located some 15 km southwest of Port Moresby. Although the current status of these protected areas is unclear (Peterson, 2014, cited in CEPA, 2015; UNEP-WCMC, 2015), CEPA has commenced conservation planning and the conceptualization of marine protected areas (CEPA, 2015). In that planning, priority areas for potential marine reserves have apparently been identified in locations southwest of Port Moresby, in the western Gulf of Papua and at Cape Suckling (CEPA, 2015).

Most attention from the NFA and other agencies in the area of marine artisanal fisheries has been targeted towards opportunities to increase or improve the utilization and associated income and health benefits from sustainable harvesting of marine resources. As such, various collaborative programs are implemented by NFA to investigate fisheries infrastructure development, fisheries resource types and current levels of utilization and management needs. Community-based fisheries management, including potential facilitation of local-level implementation of marine reserves, seasonal closures and other conservation tools, is contemplated for some coastal fisheries.

2.2 International Standards and Guidelines

The International Finance Corporation (IFC) performance standards (PS) most relevant to the marine fisheries and resources baseline study are:

- PS 3: Resource Efficiency and Pollution Prevention – This PS outlines a project-level approach to resource efficiency and pollution prevention and control in line with internationally disseminated technologies and practices. It recognizes that increased economic activity and urbanization often generate increased levels of pollution to air, water, and land, and consume finite resources in a manner that may threaten people and the environment at the local, regional, and global levels (IFC, 2012a).
- PS 4: Community Health, Safety and Security – This PS addresses the proponent's responsibility to avoid or minimize the risks and impacts to community health and safety that may arise from project related-activities (IFC, 2012b).
- PS 6: Biodiversity Conservation and Sustainable Management of Living Resources – This PS recognizes that protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development. Those ecosystem services relevant to the marine fisheries and resources baseline study are provisioning services, which are the products people obtain from ecosystems (IFC, 2012c).

2.3 TOTAL Company Standards and Commitments

TOTAL has developed the following general specifications for the purpose of environmental impact assessment that are relevant to the Project EIS/ESHIA:

- GS EP SDV 101: Social Baseline Study.
- GS EP SDV 102: Social Impact Assessment.

- CR EP HSE 130: Societal Requirements in E&P Activities.
- GS EP ENV 120: Environmental Impact Assessment of E&P Activities.
- GS EP ENV 111: Environmental Baseline and Monitoring Studies: Onshore Sites.
- GS EP ENV 112: Environmental Baseline and Monitoring Studies: Offshore Sites.

GS EP ENV 120 provides details on the process for undertaking an environmental impact assessment and preparing an environmental management plan. The instrument adopts the ISO14001 approach for impact assessment and management. Some relevant specific requirements of the specification include:

- Identification of the physical, biological and socio-economic context of a project, including sensitivities of the environment.
- Assessment of impacts within an 'area of influence'.
- Use of a modelling study (if relevant) to assess liquid effluent discharges dispersion.

The specifications also identify a method for impact assessment and contents of an environmental management plan (including oil spill contingency plan).

3. Study Area

3.1 Study Area

The study area for the marine fisheries and resources baseline study corresponds with the expected Project area of influence (PAOI) in the marine environment described in the Upstream ESBS Report, but expanded to incorporate the following areas:

- Nearshore coastal marine areas – environments within a distance of 3 nM from shore in the region of Orokolo Bay and the Purari River delta (Gulf Province), Daru and the Fly River (Western Province) and in the region of Cape Suckling and Caution Bay (Central Province). Relevant information is sourced from analogous habitats in the Kikori-Omati river systems, Kerema, Yule Island and other provinces of Papua New Guinea where appropriate.
- Offshore marine areas – environments within the Gulf of Papua beyond 3 nM from shore where commercial fishing activity is focused and that are relevant to the life history of species of interest to this study.
- Torres Strait and far Northern Australia – environments between Papua New Guinea and Australia and on the Australian north coast that are beyond the potential area of influence of the Project but are relevant to contextualizing fisheries in the Gulf of Papua.
- Estuarine areas – river mouths, estuaries, mangrove systems and deltas are inextricably linked to life histories, ecosystem processes and fisheries in the marine environment of the Gulf of Papua. The lower Purari River delta distributaries, including the Purari, Wame-Varoi and the Urika-Ivo arms are considered, with information from analogous habitats in the Kikori-Omati river systems included where appropriate.

This wider setting of the study area including all of the Gulf of Papua and Torres Strait and far Northern Australia is shown in Figure 3.1.

3.2 Physiographic and Oceanographic Setting

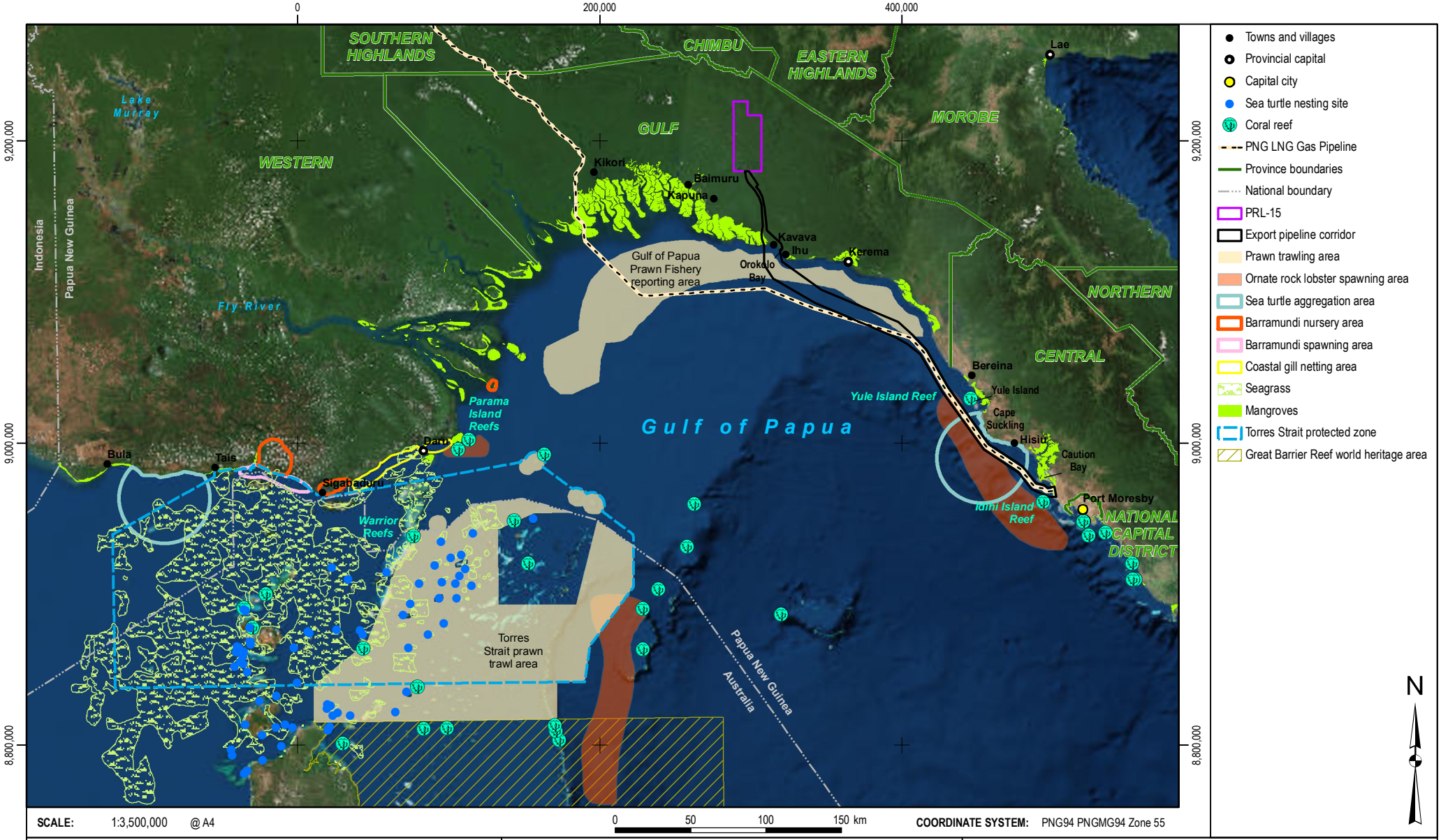
A detailed description of oceanography in the Gulf of Papua is provided in the Physical Oceanography Baseline Report (BMT WBM, 2017a; Part 10 of ESBS Dossier). The area of the gulf that is within the PAOI is set inshore of the continental slope and some 200 km from the reef systems of the Torres Strait. The offshore export pipeline corridor is shorter than that currently installed for the PNG LNG Project and follows that existing route for the eastern portion of the alignment for some 50% of its length from seaward of Iokea in Gulf Province to Caution Bay, Central Province.

3.2.1 Gulf of Papua

The Gulf of Papua can be broadly classed into three coastal ecophysical units:

- Western gulf region (Western Province): Characterized by a broad continental shelf, extensive coastal lagoon and mangrove systems and the complex estuarine delta of the Fly River system and associated high discharge. Reef and seagrass systems are present at the

southern boundary of the gulf, which is the northern extent of the Torres Strait. Nearshore conditions north of Daru are influenced by high sediment delivery and reworking.



TITLE: Environmental Setting of Marine Fisheries Study Area

FIGURE: 3.1

PROJECT: Papua LNG Project

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DATA SOURCES:
Towns and villages, export pipeline corridor, PRL-15, PNG LNG Gas Pipeline supplied by ERIAS Group and TOTAL (2015-2016). 3 nM coastal zone supplied by ERIAS Group (2017). Ornate rock lobster migration route (Moore and MacFarlane, 1984). Coral reef data derived from www.reefbase.org (2017). Barramundi data and coastal gill netting area digitised from Blaber et al. (2009) and Opnai, L.J. & Tekanani, C.D. (1987). Great Barrier Reef world heritage area from UNEP-WCMC (2016). Protected zone from Government of Australia (2014). Sea turtle nesting sites digitised from the following sources: (a). Australian Department of the Environment and Energy: http://www.environment.gov.au/marine/marine-species/marine-turtles (b). Queensland Coastal Plan: State Planning Policy for Coastal Protection Guideline, Annex 6 – Turtle Nesting Areas (c). Limpus et al 1989. (d) Limpus 2009. (e) Gredzens et al. 2014. Sea turtle aggregation areas digitised from WWF Malaysia and seaturtle.org and Government of Papua New Guinea (2015), National Marine Conservation Assessment for Papua New Guinea, Conservation and Environment Protection Authority, 51pp. Province boundaries derived by Mipela GeoSolutions (2016-2017). National boundaries derived from www.naturalearthdata.com (2015) and www.marineregions.org (2017). Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

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T:\Projects\ER1002 Elk Antelope LNG Project EIS-ESHIA\Work Request\R_120 - Fisheries Mapping\ER1002-R_120-81160-Figure 3.1-F.mxd

- Northern gulf region (Gulf Province): Characterized by a broad continental shelf and extensive deltaic mangrove systems associated with the Kikori and Purari river systems and associated high discharge. There are no significant seagrass beds or coral reefs in this region and the nearshore environment is influenced by high sediment delivery and reworking.
- Eastern gulf (Central Province): Characterized by a relatively narrow continental shelf and relatively low influence of riverine discharge in the nearshore environment, although substantial mangrove stands occur in coastal inlets. Fringing and patch reefs and seagrass beds are more common. Along the continental margin, it is influenced by the eastward flowing Hiri Current.

The Purari River is the third largest river in Papua New Guinea and the northern gulf region in general receives high rainfall (3,612 mm mean annual rainfall (Evesson, 1983)). There is no strong seasonal variation in rainfall near the coast. There is high terrigenous sediment delivery into the northern gulf region from the Purari and other rivers. In the nearshore marine environment, seabed sediment transport is controlled principally by wave energy (Hemer et al., 2004) that is typically highest during the southeast trade wind season (April to October). The northwest monsoon wind season (November to March) is typified by calmer sea conditions.

The benthic environment of the inner shelf region of the western and northern gulf regions is dominated by unconsolidated fine-grained sediments, high sedimentation rates and frequent mixing events (Alongi & Robertson, 1995; Wolanski & Alongi. 1995). The high microbial productivity of sediments in this region is hypothesized to support the significant prawn populations that occur in these sectors of the Gulf of Papua.

In the offshore environment, the oceanographic environment of the Gulf of Papua is characterized by the Hiri Current that hugs the continental margin flowing in an easterly direction (Dennis et al., 2001). The Hiri Current separates from the continental margin of southern Papua New Guinea to contribute to the clockwise rotating Coral Sea Gyre situated in the oceanic environment of the northern Coral Sea (Brunskill, 2004; Schiller et al., 2008).

3.2.2 Caution Bay

The nearshore environment at Caution Bay (Central Province) is not influenced by high discharge rivers and receives lower rainfall than the northern gulf region (1,200 mm mean annual rainfall (CNS, 2009)). The dry season is from May to October, with prevailing southeast trade winds. The wet season is from December to March, with prevailing northwest monsoon during which time some 80% of the annual rainfall can occur. April and November are characterized as transitional periods and are associated with generally calmer weather (CNS, 2009).

Mangroves occur but are associated with inlets and low-discharge rivers. Seagrass beds, macroalgae beds, and fringing coral reefs occur in the Caution Bay nearshore region. Further offshore, coral patch reefs occur and a moderately large coral cay reefs occur to the south of Caution Bay, offshore of the settlement of Porebada. Caution Bay is the site of the PNG LNG Facilities, which includes an export terminal and jetty some 1.7 km long. The plant is located on the landward side of littoral mangroves and supralittoral saltpans.

3.3 Anthropogenic Setting

3.3.1 Purari River and Orokolo Bay

PRL-15 is largely unsettled but is used principally by the Pawaian people, who reside in villages along the Purari River. Most of these villages are outside of but near to PRL-15 except for two small villages (Poroi 1 and Mapaio Fish Camp) that are located on the Purari River within the southern part of the licence area. Aside from subsistence livelihood activities of the Pawaian people, the main anthropogenic activities in PRL-15 relate to the recent and ongoing gas exploration activities, including the main operations camp at Herd Base, temporary camps at Antelope-3 Operations Camp (recently recommissioned) and Hou Creek Base (now demobilized), and activities relating to wellpads, access roads, and helipads.

The inland section of the export pipeline corridor is largely unpopulated although the corridor has been modified by large-scale industrial logging. Closer to the coast, the number and size of villages, and hence population density, increases. The seven principal villages in this area are: Evara, Mapaio, Aivai, Akoma, Aiope, Harevavo and Hororo. Anthropogenic activities include clearing of forest for settlements, subsistence agriculture (food gardens, sago planting, coconut plantations), hunting and fishing.

Along the Purari riverways, villages are predominately located on or in the vicinity of the upper reaches of the tidal influence where there is likely to be a greater availability of resources. In addition to subsistence agriculture activities, logging and Project commissioned barges transporting supplies and equipment to the base, regularly travel along the Purari channels.

3.3.2 Caution Bay

Since 2009 there has been significant LNG processing plant and associated marine infrastructure established in Caution Bay. This is expected to have resulted in some changes to socioeconomic conditions for at least some communities in the area. In the immediate vicinity of Caution Bay, there are three villages: Boera, Papa and Porebada, with mixed Motu and Koita ethnicity.

The communities engage in agriculture, hunting and fishing and reefs play an important role in artisanal fisheries. Given the relatively small distance to Port Moresby, and the relatively convenient access to public motor vehicle transport, people in the Caution Bay are likely to interact with Port Moresby markets and services to some degree, including sale of fishery products (Booyong Forest Science, 2017, Part 18 of ESBS Dossier).

4. Approach and Methods

4.1 General Approach

The general approach to this study was to draw on the wide variety of historical and contemporary literature sources and industry databases, supplemented with targeted new information from field surveys to describe the nature of commercial and artisanal fisheries interactions with the environments in the study area. Some quantitative data are available from commercial fisheries databases but artisanal fisheries are typically under-studied. However, for artisanal fisheries, the present study information was available over the following time periods:

- 1970s – Studies related to the Purari River (Wabo) Hydroelectric Scheme.
- 1980s – Expansion and subsequent collapse of the barramundi fishery.
- 1990s – Scientific studies of rock lobster fisheries biology and the Torres Strait region.
- 2000s – Studies related to the PNG LNG and Liquid Niugini Gas projects.
- 2015-2017 – Studies related to the Pasca A Development in the outer Gulf of Papua and the Papua LNG projects.

Therefore, where possible, this study attempts to fulfil the dual aims of describing the existing situation while also describing changes that have occurred in the region over previous decades so that any changes deriving from the Project can be contextualized.

4.2 Information Sources

4.2.1 Commercial Fisheries

Commercial fisheries in Papua New Guinea are regulated by the NFA. The NFA establishes management plans for fisheries sectors that determine catch and gear limits, issues licences, monitors compliance, holds licence-holder logbook records, and conducts a number of independent stock assessments. For this study, Gulf of Papua prawn stock assessment survey data was made available by the NFA. These data were re-analyzed to provide information on the median prawn catch weight and size (all prawns and banana prawns, which are the most valuable species) for each reporting area and the variability between years. This allowed an interpretation of overall prawn productivity in the fishery reporting areas that intersect the proposed export corridor compared with neighboring areas. Data are presented in box-and-whisker plots that illustrate median values and the full range of variability in the data. As the data were highly skewed, catch weights were log transformed for statistical and graphical display. Two-way analysis of variance (ANOVA) of the log-transformed data was performed to explore differences in prawn catches between reporting areas and years.

The NFA also provided data on prawn trawler movements from the electronic vessel monitoring system (VMS). Data were available for seven vessels, over a period from 2010 to 2016. The density of vessel locations within the established reporting areas represents trawl vessel activity and was used as another proxy for the spatial distribution of prawn productivity. These data were

used to interpret to the degree of interaction between trawler activity and the proposed offshore export pipeline corridor.

Information on the tropical rock lobster, barramundi, bêche-de-mer and other relevant fisheries were available via fisheries reports and scientific papers.

4.2.2 Artisanal Fisheries

Information on artisanal fisheries practices was derived from the following sources:

- Historical reports: principally relating to estuarine resource use and barramundi fisheries in the western and northern sectors of the Gulf of Papua.
- PNG LNG Project reports: associated with subsistence resource use in the Kikori-Omati delta region and Caution Bay.
- Liquid Niugini Gas Project reports: associated with subsistence resource use in the Kerema Bay, Caution Bay and Port Moresby harbor areas.
- Papua LNG Project studies, described in the following reports:
  - Household and community surveys associated with the Upstream Land and Natural Resources (and Provisioning Ecosystem Services) Baseline Report (Booyong Forest Science, 2017; Part 18 of ESBS Dossier).
  - Marine Biodiversity Baseline Report (BMT WBM 2017b; Part 12 of ESBS Dossier).
- Published scientific papers and reports.

4.3 Limitations

This study necessarily drew from a variety of information sources that spanned at least four decades. Further, information spanned that which was focused to the study area and that which is more generalized to the whole of the Gulf of Papua or focused in the Western Province sector of the gulf. This study attempts to identify how relevant these diverse information sources are to the study area of the Project. However, this study did not seek to exhaustively quantify the artisanal fisheries resource use for all villages in the study area. Further, the household and community surveys undertaken in the land and natural resources study (Booyong Forest Science, 2017) cited in this report did not seek to resolve taxonomic names for all species reported and therefore confidence in identifications of species in artisanal catches made in the present study are constrained.

It is also to be noted that community surveys undertaken in the land and natural resources study were limited to the upstream sector of the Project at this time and did not extend to Caution Bay. As such, information available for the Caution Bay region is based on reports available from the PNG LNG Project (CNS 2008a, b). These studies are up to eight years old and may not reflect changes to artisanal practices brought about by the subsequent development and operation of the Caution Bay LNG processing plant, and the accompanying socio-economic changes that may have occurred.

Publicly available information on the subsistence lifestyles of villagers is generally available at the scale of the nation, or at best, the province level (i.e., Western, Gulf and Central provinces). Information from particular locations can be generalized to the province level. Resource use practices are environment-specific and so there tends to be more similarities between, say, villages in deltaic mangrove systems across provinces, than between a village in a mangrove system and a village in a coral reef environment within the same province. As such, there is some degree of confidence that artisanal practices reported within an environment in one province in the gulf can be generalized to the same environment elsewhere in the study area. However, this study was not able to locate any information related to artisanal fisheries in the Cape Suckling area. This area is of relevance because here the offshore export pipeline corridor enters the 3 nM coastal zone. Given its proximity to Yule Island that has some unique artisanal practice related to the migratory behavior of ornate rock lobster, and the fact that the physiography of the nearshore environment is different to that of the Purari-Orokolo and the Caution Bay areas (although expected to be more akin to Caution Bay), it is uncertain whether there are practices or events in this area that differ from analogous habitats elsewhere in the study area.

5. Baseline Characterization

5.1 Commercial Fisheries

5.1.1 Gulf of Papua Prawn Fishery

5.1.1.1 Regional Setting and Management

The Gulf of Papua Prawn Fishery (GOPPF) is Papua New Guinea's second largest commercial fishery in terms of commercial value, after the tuna fishery. The annual total catch of prawns is approximately 1,000 tons (tail weight) at an estimated value of PGK10 million (approximately USD 3.3 million[2]) (Liviko et al., 2016). As the name suggests, the fishery is located in the Gulf of Papua in a region extending from Kerema in the east to the mouth of the Fly River in the west over an area of some 9,600 km^2. However, trawling effort is concentrated in approximately 13% of the total fishery area. The inshore limit of the GOPPF is formally stated as 3 nM from shore and the offshore limit approximately at the 40-m depth contour.

Since 1987, Papua New Guinea has also participated in the Torres Strait Prawn Fishery located within Australian Territorial Waters. This consists of four Australian trawlers chartered to PNG fishing companies. An Orangerie Bay (Milne Bay Province) Prawn Fishery has been identified since 1981 but is apparently very limited (two vessels licenced as at 2012) and is not currently operational.

The GOPPF Management Plan allows for a maximum of 15 fishing licences. At the time of writing, there were 10 trawlers licensed in the fishery (Liviko, pers. com., 2016). The number of trawlers actively operating in the fishery ranged from 7 to 12 during the period 2005 to 2011 (Liviko, 2012). Fuel costs, vessel maintenance and export prices of prawns are cited as the main drivers of variable activity in the fishery (Liviko, 2012). The licensing structure of the GOPPF is such that there is limited scope for additional vessels to enter the fishery. Therefore, the NFA and fishing companies intend to explore value-adding potential in the fishery (e.g., Marine Stewardship Council certification of the fishery to enhance exports). The core elements of the management of the GOPPF are summarized in Table 5.1.

The 'coastal waters' zone, extending from the shore to the 3 nM limit, is reserved for customary fishing. The exclusion of prawn trawling in this zone has long been considered important for the protection of juvenile prawn populations (Gwyther, 1980; Wafy, 1991; Liviko, pers. com., 2016). Notwithstanding, Kompas and Kuk (2009) reported that approximately one third of the total catch from the GOPPF came from within the 3 nM zone. Indeed, the re-analysis of vessel position data reported in the present study confirmed significant activity inshore of the 3 nM limit. The seabed in the 2 to 3 nM zone appears to be productive for prawns and is likely important for the commercial sustainability of the fishery. While the encroachment of trawlers into the coastal zone has been the source of some conflict with traditional resource owners, it has also been identified that fishing

[2] Currency conversion in this report has been undertaken at a rate of PGK1 = US$0.32.

companies have the opportunity to enter into resource sharing agreements with landowners to allow fishing in the 2 to 3 nM zone that could result in economic benefits (Liviko, 2012).

Table 5.1 – Summary of Management Aspects of the GOPPF

Management Measure	Details
Effort control	Maximum of 15 licences
Temporal closure	The GOPPF management area is closed from 1 December to 31 March each year, ostensibly to protect brooding females
Spatial closure	Industrial fishing is prohibited within 3 nM of the coast, ostensibly to protect populations of juvenile prawns. While individual fishing companies have apparently sought to enter negotiations with particular landowners to access fishing grounds inside the 3 nM limit in profit-sharing schemes, such arrangements are not supported by NFA
Gear restrictions	Vessels not exceeding 30 m in length and 550 horse power No more than four main nets and one 'try net' towed at the same time Aggregate head rope (with mesh attached) for the main nets not exceeding 60 m and one try net not exceeding 6 m heal line. The maximum total of 60 m swept area can be achieved by twin-rigged (two-net) or quad-rigged (four-net) systems. A small number of stern trawlers using a single net are in operation Meshes for all nets 50 mm (knot-to-knot stretched mesh) or greater
By-catch reduction	Legislation of turtle exclusion device and by-catch reduction device on all vessels Ornate rock lobster captured by prawn trawlers required to be released
Small-scale fishery restrictions	For small-scale beam trawl by dinghy, beam trawls not exceeding 4 m width For small-scale beam trawl by dinghy, beam trawl mesh 50 mm (knot-to-knot stretched mesh) or greater Fish escape panel
Compliance	Vessel licencing and monitoring Catch and effort logging Scientific observer program Biological monitoring targets and thresholds

5.1.1.2 Biological Aspects of the Fishery

Some 20 prawn species have been identified in the GOPPF (Liviko, 2015), 12 of which are most prevalent (Table 5.2). The white banana prawn (*Fenneropenaeus merguiensis*) and Indian banana prawn (*F. indicus*) make up approximately 50 to 60% of the prawn catch and are the most valuable, and thus the target species in the fishery. Black tiger prawns (*Penaeus monodon*) and endeavour prawns (*Metapenaeus demani*, *M. endeavouri*, and *M. ensis*) have secondary economic importance.

Knowledge of the life-cycle of prawns in the Gulf of Papua is central to successful commercial exploitation and sustainable management. Spawning takes place offshore, although the habitat and depth range of spawning are unquantified (Evans & Opnai, 1995). In Australian waters, peak spawning of white banana prawns occurs in September to November (late dry season) and March to May (late wet season) (AFMA, 2016a). The planktonic larvae are passively transported into estuaries where deltaic banks, mangroves and river channels are considered to be important habitats for larval settlement and juvenile moults. Liviko (2012) identified the expansive mangrove-lined estuaries of the Kikori and Purari rivers as known major nursery areas. After several months in these estuarine nursery areas, prawns move into deeper water during the wet

Table 5.2 – Key Prawn Species in GOPPF Listed in Order of Decreasing Commercial Value

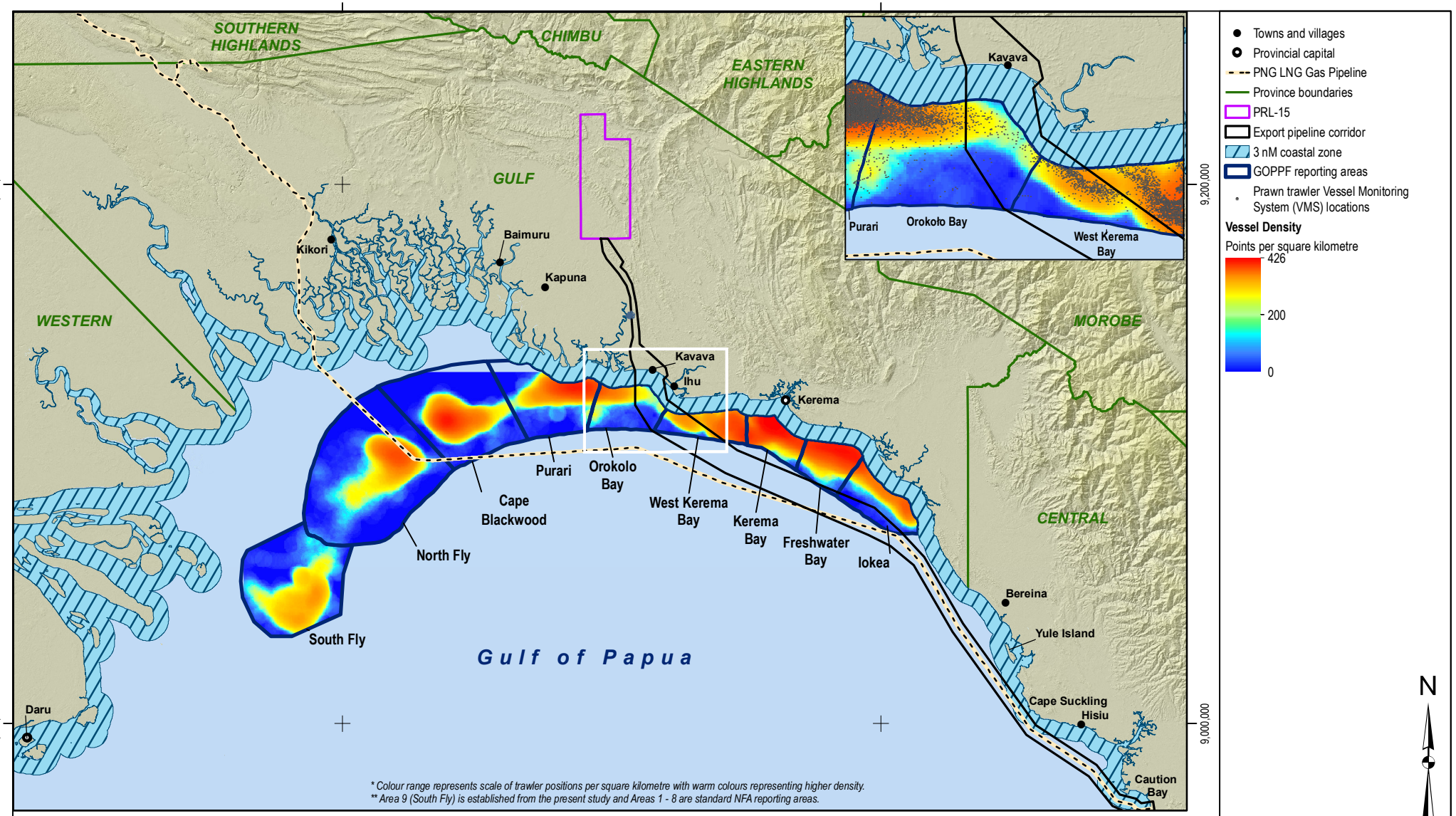
Common Name	Species Name
White banana prawn	*Fenneropenaeus merguiensis*
Indian banana prawn	*Fenneropenaeus indicus*
Black tiger prawn	*Penaeus monodon*
Brown tiger prawn	*Penaeus esculentus*
Japanese tiger prawn	*Penaeus japonicus*
Red endeavour	*Metapenaeus ensis*
Green tiger prawn	*Penaeus semisulcatus*
Blue endeavour prawn	*Metapenaeus endeavouri*
York prawn	*Metapenaeus eboracensis*
Red spot king prawn	*Penaeus longistylus*
Flower prawn	*Parapenaeiopsis sculptilis*
Coral prawn	*Metapenaeopsis wellsi*

season to reproduce. This migration can be influenced by rainfall, salinity, water temperature and other environmental factors, although these influences are somewhat unquantified (Gwyther, 1980; Evans et al., 1997). Highest abundance of the target species in the GOPPF occurs between April and September, coinciding with a period of highest rainfall, with a peak in the April to May period (Liviko, 2012).

5.1.1.3 Fishery Activities

The prawn trawling fleet is stationed in Port Moresby. The majority of vessels are classified as otter trawlers and there are a small number of stern trawlers. Trawlers go to sea for extended periods of four to five weeks and usually fish intensively during all hours of the day (Liviko, 2012). Trawls may last for two to four hours and commercially valuable prawns comprise approximately 25% of the total catch, with the remaining 75% comprising by-catch species. Prawns are graded, packaged and frozen at sea. Good quality prawns, representing about 60% of the prawn catch, are exported from Port Moresby. The remaining catch is sold into the local market via restaurant orders and door sales direct from fishing companies. Japan, Australia, Vanuatu, Korea, China and Taiwan are among the main importers of PNG prawns.

For the present study, vessel position data were available for seven prawn trawlers over variable time periods between 2010 and 2016 and these data reflect the spatial distribution of trawling activity. A total of 88,413 trawler position records were obtained for the GOPPF reporting areas. Average trawling speed is cited as three knots (Liviko, 2012) and this speed was used in the analysis as a cut-off to differentiate active prawn trawling from vessel transiting. The final data set included 26,600 vessel positions that represented the location of all vessels within the prawn fishery reporting area over all times for which data were available between 2010 and 2016. Figure 5.1 shows a map of prawn trawler position point density per reporting area for all seven trawlers for years 2010 to 2016, where speed was 3 knots or less. Warmer colors represent higher density areas. The NFA divides the GOPPF into eight reporting areas and catch data (logbook and observer programs) are reported on the basis of these areas. Trawling activity is focused in sub-areas of the fishery reporting regions. Trawler location data indicates the



TITLE: Density of Prawn Trawler Positions in Gulf of Papua Prawn Fishery Reporting Areas

FIGURE: 5.1

PROJECT: Papua LNG Project

DOCUMENT NUMBER: R_120-81087 **REVISION:** E

DATE: 6/07/2017

DATA SOURCES:

Towns and villages, export pipeline corridor, PRL-15, PNG LNG Gas Pipeline, hillshade supplied by ERIAS Group and TOTAL (2015-2016). DEM (Planet Observer 2015 and TOTAL 2016). Vessel density derived from VMS point data supplied by National Fisheries Authority (2017). 3 nM coastal zone supplied by ERIAS Group (2017). GOPPF areas from Liviko, I (2012). Province boundaries derived by Mipela GeoSolutions (2016-2017).

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T:\Projects\ER1002 Elk Antelope LNG Project EIS-ESHIA\Work Requests\R_120 - Fisheries Mapping\ER1002-R_120-81087-Figure 5.1-E.mxd

existence of a fishing area directly east of the Fly River mouth that is additional to the NFA reporting areas. This region has been digitized to encompass the trawling sites in the area and has been named South Fly in the present study.

Trawling activity is highest in inshore sub-areas of Kerema Bay and Freshwater Bay. Secondary hotspots of activity occur in inshore sub-areas of the Purari reporting area and in the central zone of the Cape Blackwood reporting area. Activity in the Orokolo Bay reporting area is somewhat restricted to the northwestern quarter of the area. The export pipeline corridor traverses an area of relatively low activity in Orokolo Bay and an area of moderate activity in West Kerema Bay. It was reported during discussions with NFA that prawn fishers no longer target the inshore-most sector of the Orokolo Bay reporting area as a result of negative interactions with villagers in the past.

5.1.1.4 Fishery Productivity

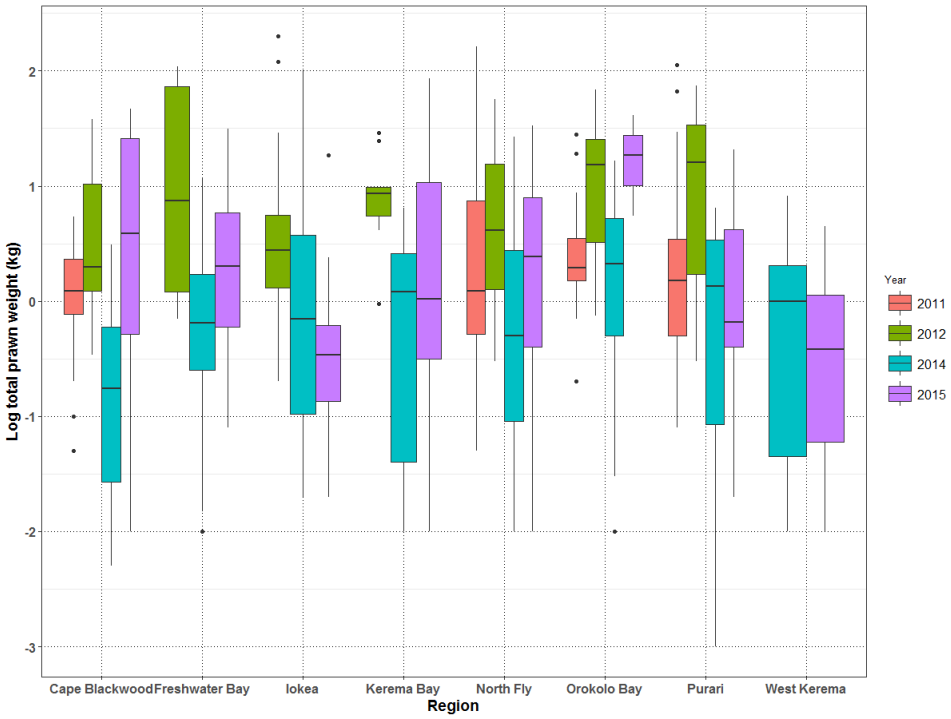
Collaborative biological surveys are undertaken most years by NFA and the prawn fishing industry to inform prawn stock assessments. Replicate trawls are undertaken within each reporting area to determine the prawn biomass range in each reporting area, used as a proxy for commercial prawn catches. Effort and methods of the stock assessment vary between surveys (Liviko, 2015) and conclusions of this analysis should be viewed with some caution. Prawn catch data for the period 2011 to 2015 showed that the total biomass of prawns was variable among years (Figure 5.2). Analysis of variance (ANOVA) confirmed significant interactions between year and region for the total prawn catch. For the 2015 survey, there were significant differences in mean prawn weight among region (ANOVA, df=7, $p<0.01$) and Tukey's pair-wise comparisons showed that mean total prawn catch in the Orokolo Bay reporting region was significantly higher than that in West Kerema and Iokea. Total prawn catch weight for Orokolo Bay was not significantly different from other regions.

For white banana prawns (*Fenneropenaeus merguiensis*) only, the most commercially valuable species, catches were similarly variable among years (Figure 5.3) and no significant differences between reporting areas could be detected. For the most recent survey in 2015, the highest mean banana prawn catch was recorded in the Kerema Bay reporting region but differences between regions were not statistically significant.

White banana prawn carapace length, a proxy for prawn tail length and thus economic value, had significant statistical interactions between regions and years (ANOVA, df=22, $p<0.01$) (Figure 5.4). For the most recent data only (2015), there was a significant difference in mean white banana prawn size between regions (ANOVA, df=7, $p<0.01$). Mean banana prawn length in the Orokolo Bay region was significantly lower than that in Kerema Bay, West Kerema Bay and Iokea but was higher than that in Cape Blackwood and North Fly.

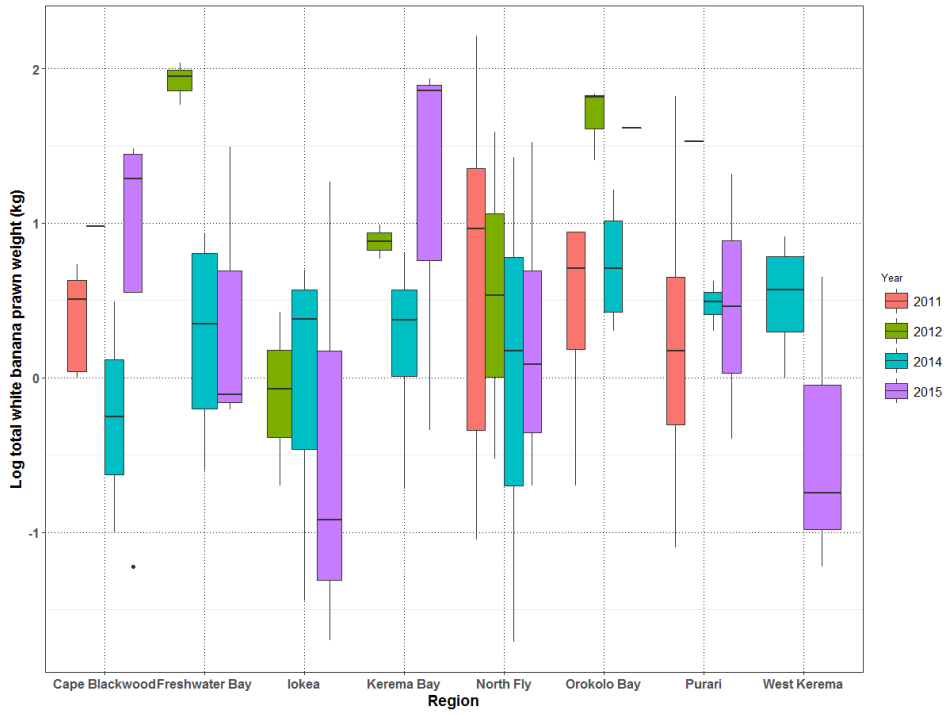
Together, these results indicate that the areas of the GOPPF intersected by the offshore export pipeline corridor (Orokolo Bay and West Kerema) are not particularly high activity or high productivity areas.

Figure 5.2 – Total Prawn Catch in Fishery Reporting Areas



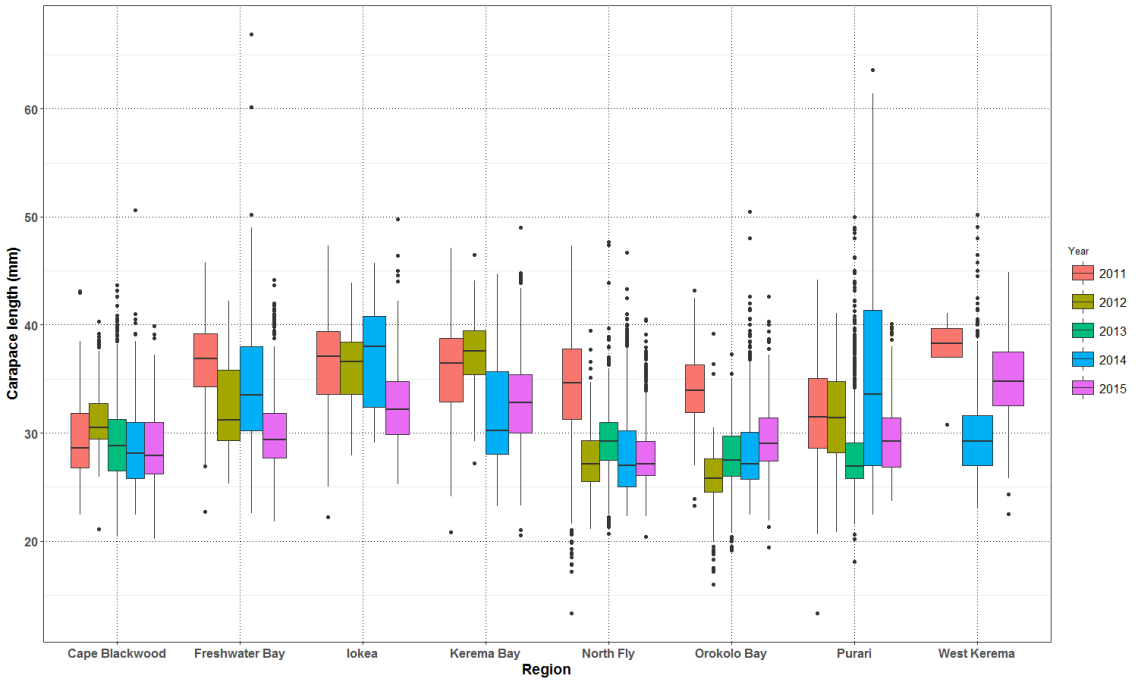
Source: National Fisheries Authority prawn stock assessments (see Section 5.1.1.4). Note: Box-and-whisker plots show 25% to 75% quartile range of data (solid coloured box), median (horizontal line inside box), the range of data in the 1.5 × interquartile range (whisker lines), and outliers beyond the 1.5 × interquartile range (points).

Figure 5.3 – White Banana Prawn Catch in Fishery Reporting Areas



Source: National Fisheries Authority prawn stock assessments. Note: As per Figure 5.2.

Figure 5.4 – White Banana Prawn Carapace Length



Source: National Fisheries Authority prawn stock assessments. Note: As per Figure 5.2.

5.1.2 Torres Strait Tropical Rock Lobster Fishery

5.1.2.1 Regional Setting and Management

Access to the Torres Strait Tropical Rock Lobster Fishery (TSTRLF) is shared by Australia and Papua New Guinea under the Torres Strait Treaty (1985). The treaty creates a Protected Zone to 'protect the traditional way of life and livelihood of the traditional inhabitants and specifies the shares of the commercial fisheries for each party and their responsibilities for the sustainable development of fisheries within the Protected Zone' (Ye & Dennis, 2017). Under the treaty, PNG cross-endorsed vessels are entitled to take 25% of the total allowable catch (TAC) within the Australian area of jurisdiction and Australia is entitled to take 75% of the TAC (AFMA, 2016b). In the Australian area of the jurisdiction, management of the Protected Zone is subject to the *Torres Strait Fisheries Act 1984* and is managed by the PZJA, an authority that represents a number of government agencies included the Torres Strait Regional Authority. Under this management system, licences are allocated to Australian and PNG nationals, on the basis of agreed shares. The target species of the fishery is the ornate rock lobster, *Panulirus ornatus*. Papua New Guinea's activity in the TSTRLF involves several hundred divers that access reefs in the Torres Strait usually from motorized dinghies using hookah equipment. Lobsters are caught using hand spears, hand-operated nooses or simply by hand capture. The majority of fishing targets the Warrior Reef system (comprising Silver, Wapa and Kokopi reefs), located some 300 km southwest of the Purari River mouth (well outside the PAOI) (see Figure 3.1). The township of Daru (Western Province) is the main port servicing the fishery. The PNG fishery principally involves export of frozen lobster tails to USA. The number of PNG cross-endorsed freezer

vessels licenced in the fishery has decreased in recent years, as has the reported catch of lobsters. In the 2014 to 2015 season, the PNG catch was reported to be 192 t (representing about 66% of its TAC) (Williams & Mazur, 2016) and it was reported that there were no PNG-owned freezer boats operating. By way of comparison, the Australian catch in the 2014 to 2015 season was 303 t representing about 50% of its TAC.

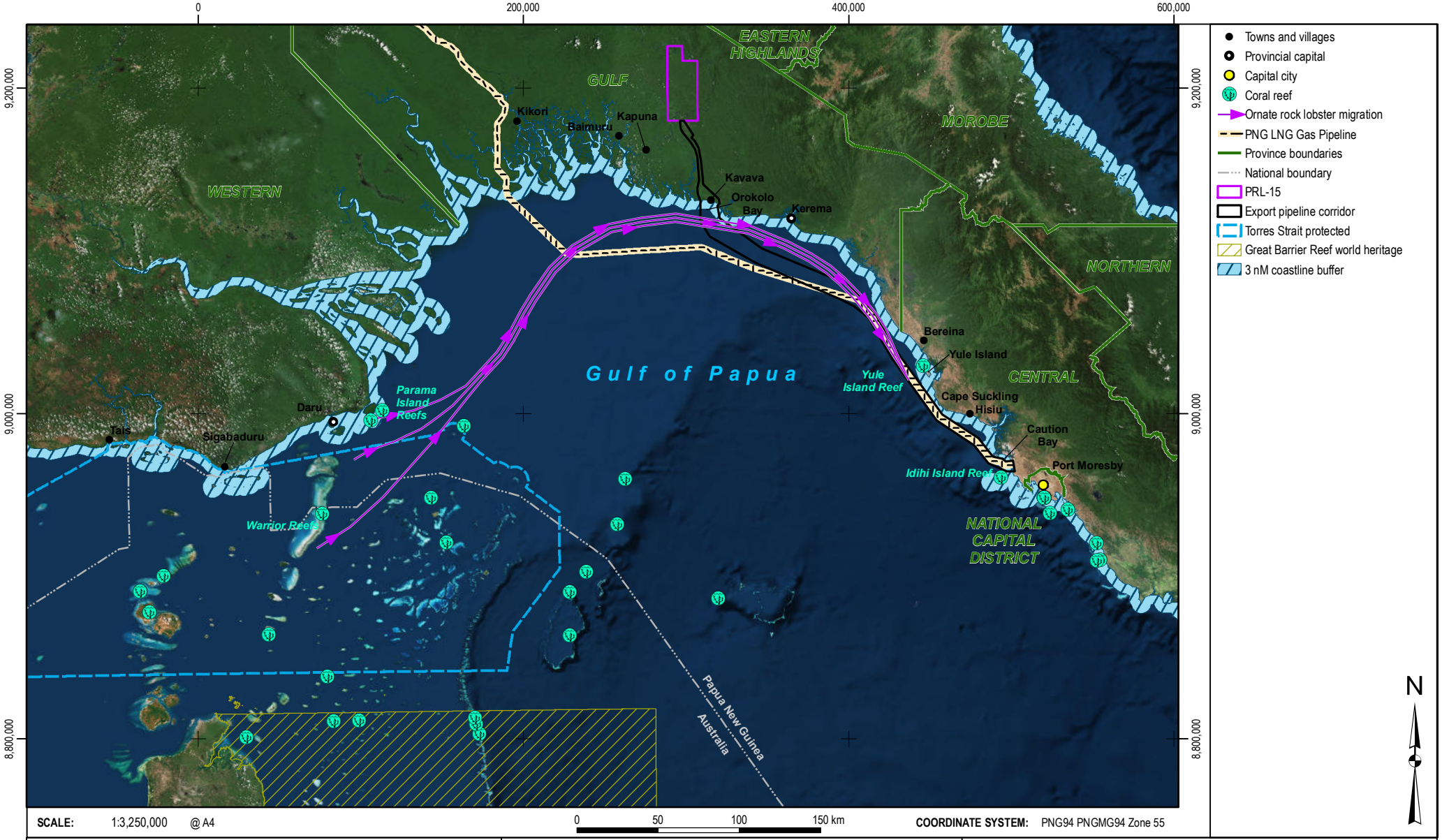
Jogo (2015) reported that of the seven licenses for freezer vessels allowed to operate in the fishery, there was one currently active, operated by Maru Marines Limited. The freezer boat in turn supports five to six outboard motor-driven dinghies operated by divers who are licensed to have hookah gear, and operate year round with no significant seasonal cycle. Maru Marines processed about 32 tons per annum (tpa) of live and frozen lobster at its fish factory. The total annual export value of the PNG portion of the fishery is estimated at approximately PGK4 million (approximately US$1.3 million). Since 2012, NFA and at least one fishing company based in Daru (Maru Marines Ltd) have been moving to phase-in the export of live lobsters that are significantly higher value than frozen tails.

5.1.2.2 Biological Aspects of the Fishery

The ornate rock lobster undertakes an extensive breeding migration from northern Torres Strait into the Gulf of Papua and in an easterly direction through the gulf (Figure 5.5). Female and male lobsters in the 2+ age that leave the Torres Strait from early September to late November and walk up to 400 km to the main breeding site at Yule Island and other reefs throughout Central

Province (Moore & MacFarlane, 1984), arriving between late November and early April. Panama Island near the Fly River delta is also a breeding site. Moore and MacFarlane (1984) reported that the migration did not follow a specific depth contour or substratum type. The lobsters are thought to move against the prevailing bottom current, and orientate with respect to this current. The arrival of lobsters at Yule Island and other reefs in the Gulf of Papua is the basis of a seasonal subsistence/artisanal fishery (see Section 5.2.3.4). Further, the lobster migration interacts spatially with the prawn trawl fishery. All lobsters inadvertently caught in prawn trawls must be released. Migrating lobsters have the potential to intersect with the existing PNG LNG Gas Pipeline and the proposed Papua LNG export pipeline corridor at several locations (see Figure 5.5).

There is mass natural post-spawning mortality of lobster in the vicinity of Yule Island and there is no return migration from the Gulf of Papua back into Torres Strait fishery by migrating adults (Dennis et al., 1992). From the spawning grounds, phyllosoma stage larvae spend nine to eleven months in the zooplankton. The general model of larval transport involves movement of phyllosoma, principally via the Coral Sea gyre, from the Gulf of Papua to the northwestern Coral Sea and from there via the Queensland Current to the northern Great Barrier Reef and Torres Strait (Pitcher et al., 2005; Dao et al., 2015). Larval transformation takes place during this period and pueruli stage larvae settle onto reef and grow. Lobsters from the Torres Strait, Papua New Guinea and the Australian east coast (Pitcher, 1991) and indeed the entire southeast Asian region (Dao et al., 2015) are considered to be of the same genetic stock.



SCALE: 1:3,250,000 @ A4

COORDINATE SYSTEM: PNG94 PNGMG94 Zone 55

TITLE: Migration Route of the Ornate Rock Lobster

FIGURE: 5.5

PROJECT: Papua LNG Project

DOCUMENT NUMBER: R_120-81088 **REVISION:** E

DATE: 6/07/2017

DATA SOURCES:

Towns and villages, export pipeline corridor, PRL-15, PNG LNG Gas Pipeline supplied by ERIAS Group and TOTAL (2015-2016). 3 nM coastline buffer supplied by ERIAS Group (2017). Ornate rock lobster migration route (Moore and MacFarlane, 1984). Coral reef data derived from www.reefbase.org (2017). Province boundaries derived by Mipela GeoSolutions (2016-2017). National boundaries derived from www.naturalearthdata.com (2015) and www.marineregions.org (2017). Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

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5.1.3 Bêche-de-mer Fishery

5.1.3.1 Regional Setting and Management

Bêche-de-mer is a general term that is applied to any species of sea cucumber (Holothuroidea) of commercial or export value. Papua New Guinean fishers access bêche-de mer via:

- The Torres Strait Bêche-de-mer and *Trochus* fisheries located in the same Torres Strait Protected Zone that supports the tropical rock lobster fishery and managed by the same Authority.
- The coastal zone of Papua New Guinea, managed by the NFA via the National Bêche-de-mer Fishery Management Plan (NFA, 2016).

In the Torres Strait, the main species of commercial interest are:

- Black teatfish (*Holothuria whitmaei*).
- Pricky redfish (*Thelenota ananas*).
- Sandfish (*Holothuria scabra*).
- White teatfish (*Holothuria fuscogilva*).

The modern sea cucumber fishery in Torres Strait began in about 1990 when PNG nationals started fishing sandfish (*Holothuria scabra*) on the northern Warrior Reefs (Skewes et al., 2006) (see Figure 3.1 for location of Warrior Reefs). The fishery was closed from 1993 to 1995 due to concerns about overfishing and subsequent management appears to have been successful in sustaining the fishery and viable populations in the Torres Strait 'Protected Zone', although there are still concerns about overfishing of *H. sabra* (Woodhams & Mazur, 2016). The level of Papua New Guinea's participation in the Torres Strait bêche-de-mer fishery today is unclear, but Daru is generally the port of most interest and, similar to the tropical rock lobster fishery, the Warrior Reef system is the focus area of fishing (Lokani et al., 1996; Long et al., 1996).

Outside the Torres Strait region, the bêche-de-mer fishery is the most valuable coastal fishery in Papua New Guinea (ADB, 2014). Although considered an artisanal and subsistence fishery, the total annual export is estimated to average approximately 400 t for a value of some PGK21 million (approximately US$6.7 million), peaking at 556 t (PGK52 million; approximately US$16.6 million)[3] per annum in 2007. Therefore, while fishery has a lower catch weight than the prawn fishery, the commercial value overall is greater, highlighting the potential value of so-called coastal fisheries in Papua New Guinea. The species of sea cucumber occurring in the coastal waters, and thus potentially subject to fisheries are listed in Table 5.3.

[3] Comparable value today allowing for inflation is approximately PGK73 million (approximately US$23 million).

Table 5.3 – Sea Cucumbers from PNG Waters

Species Name	Common Name	Species Name	Common Name
Actinopyga echinites	Deepwater redfish	*Holothuria lessoni*	Golden sandfish
Actinopyga lecanora	Stonefish	*Holothuria leucospilota*	White threadfish
Actinopyga mauritiana	Surf redfish	*Holothuria nobilis*	Black teatfish
Actinopyga miliaris	Hairy blackfish	*Holothuria scabra*	Sandfish
Bohadschia argus	Tigerfish	*Pearsonothuria graeffei*	Flower fish
Bohadschia similis	Chalkfish	*Stichopus chloronotus*	Greenfish
Bohadschia vitiensis	Brown sandfish	*Stichopus hermanni*	Curryfish
Holothuria atra	Lollyfish	*Stichopus horrens*	Dragonfish
Holothuria coluber	Snakefish	*Stichopus naso*	Pink curryfish
Holothuria edulis	Pinkfish	*Stichopus ocellatus*	Ocellated curryfish
Holothuria flavomaculata	Red snakehead	*Stichopus vastus*	Brown curryfish
Holothuria fuscinaraea	Labuyo	*Thelenota ananas*	Prickly redfish
Holothuria fuscogilva	White teatfish	*Thelenota anax*	Amberfish
Holothuria fuscopunctata	Elephant trunkfish	*Thelenota rubralineata*	Candy cane
Holothuria hilla	Tiger tail		

Source: NFA (2016).

Milne Bay Province is the main focus of the PNG bêche-de-mer fishery and is indeed the most important coastal fishery in that province (Skewes et al., 2002). While the Milne Bay fishery is classed as an 'artisanal' fishery, operating at the 'community level' (Skewes et al., 2002), it is potentially larger than other commercial fisheries in Papua New Guinea. Catches in Milne Bay Province in 2001 peaked at over 209 t (dry weight) with a value estimated at over PGK8 million (approximately US$2.6 million)[4]. In fishery-independent surveys, lollyfish (*H. atra*) (49% by weight), greenfish (*S. chloronotus*) (17%) and amberfish *(T. anax*) (8%) were the most abundant species (Skewes et al., 2002). Premium value bêche-de-mer species (*H. nobilis*, *H. fuscogilva*, *H. scabra* and *T. ananas*) comprised only 9% by weight of all commercial holothurians.

In 2009, a moratorium was placed on the PNG bêche-de-mer fishery mainly due to concerns about over-fishing, particularly for the high-value *H. scabra* (sandfish) and *H. nobilis* (black teatfish). Associated with the fishery concerns are potential negative impacts to mangroves and other coastal forests associated with wood harvesting for bêche-de-mer smoking. However, during this moratorium, illegal harvesting of bêche-de-mer occurred in Western Province for sale to outside buyers, especially from Merauke in Indonesia (Jogo, 2015). Also during this time, there was reported to be illegal harvesting in Milne Bay Province[5]. During the period of the moratorium, stock assessments were completed of the main targeted reef areas of Parama Island and the northern Warrior Reef systems (e.g., Wapa, Auwo, Maza, Otamabu and Kokopi reefs).

The moratorium was lifted on 1 January 2017 and the National Bêche-de-mer Fishery Management Plan (NFA, 2016) calls for provincial TACs to be set. At the time of writing, the TACs were not published, but historical data suggest that Central Province contributes relatively

[4] Comparable value today allowing for inflation is approximately PGK13 million (approximately US$4.1 million).
[5] http://www.thenational.com.pg/boats-caught-fishing-illegally/

little to the overall fishery. A previous TAC set for the Gulf of Papua was the lowest among all areas (1 t) (Kinch et al., 2008). By comparison, the TAC for Western Province was 17 t and Milne Bay was 140 t. A compulsory closed season applies to all provinces and will occur each year, from 1 October to 31 March. This information indicates that the Central Province and the Gulf of Papua contribute relatively small catches to the bêche-de-mer fishery and interactions between this fishery and the PAOI are not significant at the national scale.

5.1.4 Barramundi and Jewfish Fishery

5.1.4.1 Historical Fishery Activities

The PNG commercial barramundi fishery was established in the late 1960s and grew rapidly through the early 1970s. By the mid-1980s, the barramundi fishery was the fourth largest commercial fishery in Papua New Guinea after tuna, prawns and lobster, in terms of total production (Opnai & Tenakanai, 1986). At this time, the total catch of the commercial fishery had reached around 200 to 300 t/year, caught mainly in the Daru area (Fisher, 2010). However, the annual catch of the Daru-based fishery declined significantly in the early 1990s, to as low as 4 t/year, which led to the closure of much of the commercial fishery.

Until at least 1990, there were two bases for the barramundi fishery: Daru and Baimuru. The Daru-based fishery exploited the area of the Fly River-Lake Murray and along the coast from the mouth of the Fly River to the mouth of the Binaturi River west of Daru. Village-based fishers in the vicinity of Daru would land their product directly to the Western District Seafoods factory or offload to freezer vessels. The Baimuru-based fishery exploited the northern Gulf of Papua including the Turama, Kikori, Era and Purari rivers. On-shore freezer facilities were located at Ihu, Baimuru and Kikori. At Kikori the government-sponsored freezer was producing 12 t of barramundi by 1977. The Kikori operation ceased shortly after due to the difficulties of maintaining quality control of the frozen product. In 1979, an old hotel in Baimuru was converted into a processing plant (Stevens, 1980) where whole or filleted barramundi were processed, along with threadfin salmon (family Polynemidae) and jewfish (family Scaenidae). In 1979/80, this Baimuru coastal fisheries station purchased over PGK36,000 of fish from individual villagers (Haines & Stevens, 1983). In 1983, the PNG Government and the International Funding for Agriculture Development developed two coastal fisheries centres at Samarai and Baimaru. The main objective was to promote the artisanal fisheries in these two areas and provide facilities for processing and delivery of product to markets. The Baimuru Fishing Company Ltd was established at Baimuru during 1982 to 1983 and in 1984 a substation was opened at Kikori to produce iced fish for processing at Baimuru.

The Daru coastal barramundi fishery was based principally on the seasonal breeding migration (September to January). Catches made by local fishers was either taken to processing plants at Daru or to freezer vessels anchored close to fishing grounds. The freezer vessels also engaged in their own gill netting (Fisher, 2010). The mouth of the Fly River was a focus area for the fishery during the spawning migration. Outside of the spawning migration period, fishing activities were focused upstream in the Fly River in Middle Fly region including Lake Murray and occasionally to other associated waterways. Although inland catches were generally lower than in the coastal areas, high catches were sometimes taken when water levels dropped. On-shore freezer facilities operated by village cooperatives were established at Bosel in the Middle Fly and at Samari village

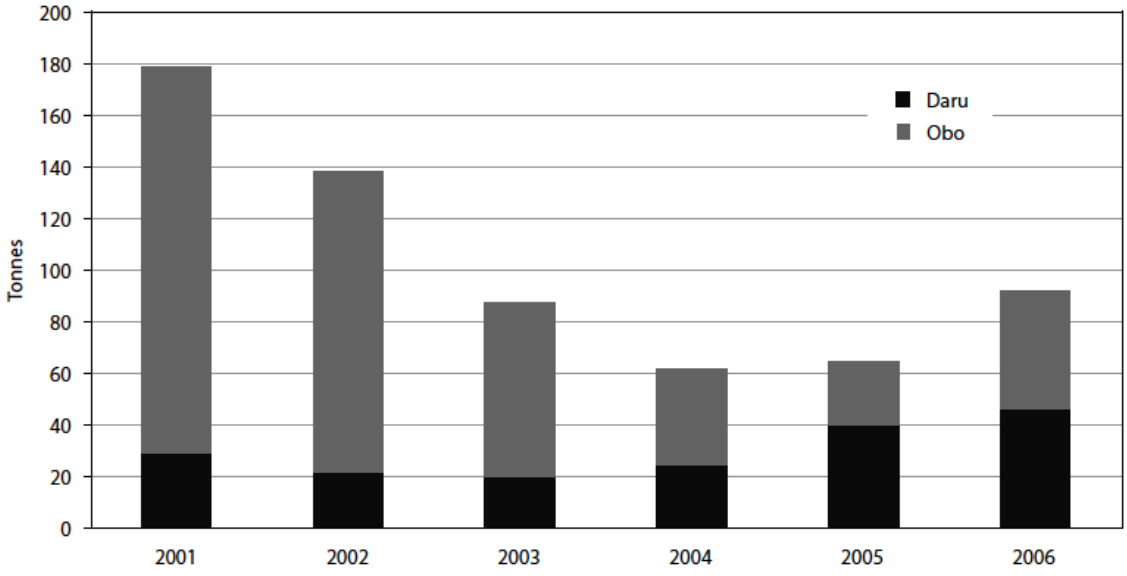
on Kiwai Island in the mouth of the Fly River. At these facilities, fishes were filleted and packed and sold to either the freezer vessels or to the plant at Daru (Fisher, 2010).

The demise of the barramundi fishery in the Gulf of Papua, and the apparent challenges related it its recovery, are generally attributed to overfishing and, particularly for the Fly River populations, the somewhat unquantified changes brought about by mine waste and tailing reaching the Fly River and tributaries from the Ok Tedi copper mine (Swales et al., 2000; Blaber et al., 2009).

5.1.4.2 The Fishery Today

The PNG barramundi (*Lates calcarifer*) fishery is based mainly in Western Province and operates under a management plan developed under an Australian Centre for International Agricultural Research funded project that passed into law in 2003. The NFA reports that barramundi exports in 2000 were 23.5 t (approximately PGK402,000); in 2001 were 21.5 t (approximately PGK353,000); in 2002 were 31.5 t (approximately PGK600,000) and in 2003 exports were 10.6 t (approximately PGK230,000). These figures are substantially higher than the 1.6 t reported for the wild capture barramundi fishery in Western Province, the principal base of the wild capture barramundi fishery in Papua New Guinea (Jogo, 2015). The NFA figures may include aquaculture-derived product. The values cited by Jogo (2015) are also substantially lower than those reported by Fisher (2010) for sales of barramundi from fishers to the Daru processing facility (presumed to be whole fish weight) for the preceding decade, even accounting for a 0.48:1 ratio[6] of filleted barramundi to whole fish (Figure 5.6). This suggests that there have been recent declines in the activity, at least in the wild capture barramundi fishery.

Figure 5.6 – Total Catch of Barramundi Sold to the Daru Processing Facility, 2001 to 2006



Source: Fisher (2010).
Note: Weights are presumed to be whole fish weight. Obo refers to the Obo Fishing Company, based at the junction of the Fly and Strickland rivers, a cooperative fish processing facility established in 1999 owned by local fishers established with

[6] Conversion factor cited by the Queensland Department of Aquaculture and Fisheries for barramundi aquaculture.

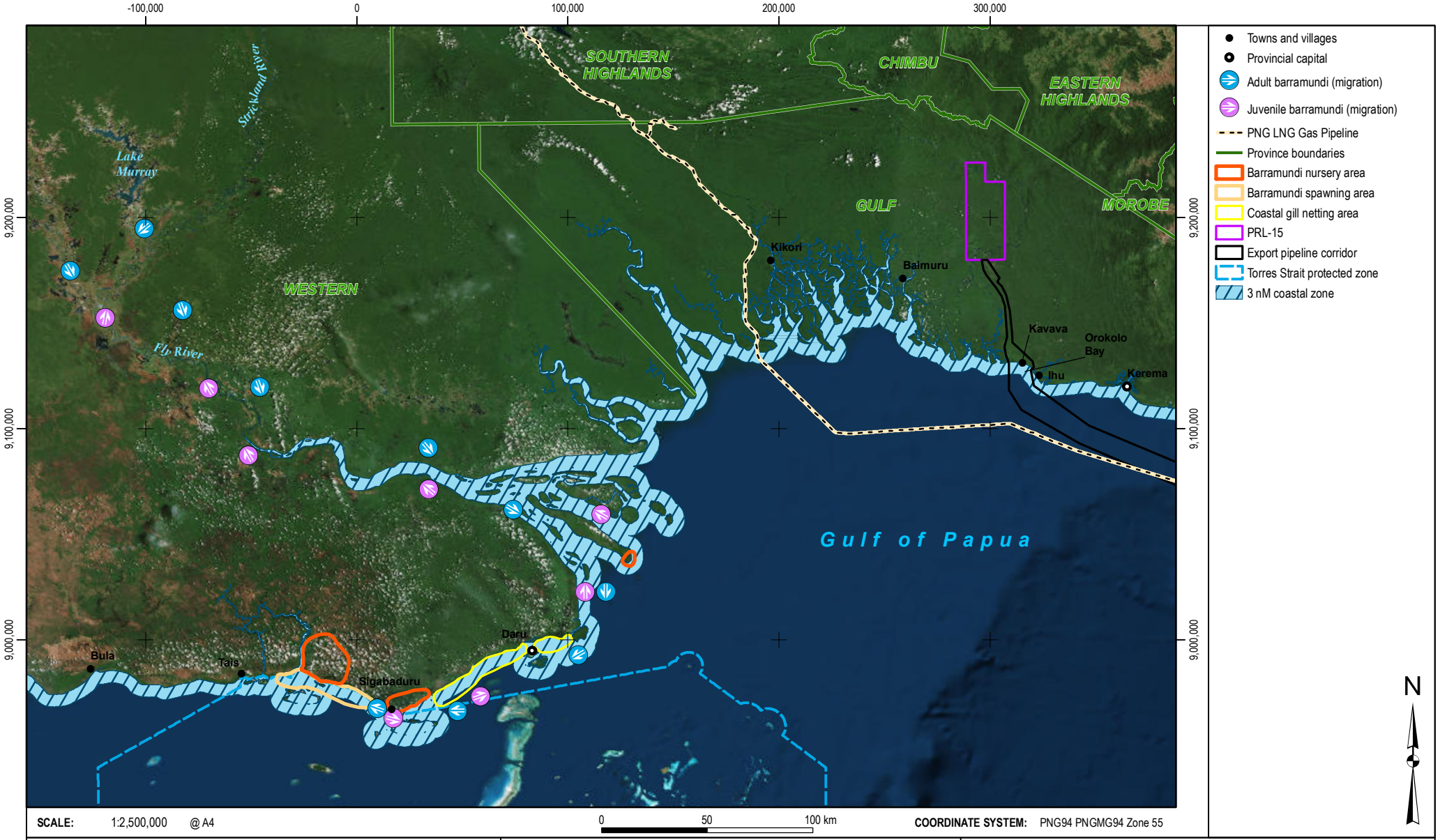
significant contributions from Ok Tedi Mining Limited. The status of the fishing company today is not confirmed but is apparently not in operation.

Today, the wild caught barramundi fishery in Western Province consists of two fishing companies based in Daru (Jogo, 2015). The wild caught barramundi fishery is apparently supplemented with jewfish (family Sciaenidae) (Busilacchi et al., 2014) and the fishery is often referred to as the barramundi–jewfish fishery. Fishes are harvested using gill nets, with a maximum allowable mesh size of 6 inches, reducing to 5 inches during the peak spawning period of 1 September to 31 October between Sui Village and Buzi Village. A minimum size of barramundi allowable for sale or export is set at 36 cm total length. The main spawning and breeding grounds between Sigabaduru Village and the Papua New Guinea/Irian Jaya border are closed to commercial fishing during peak spawning periods, 1 October to 30 November each season. The TAC for the fishery is set at 260 t (whole weight), exported as frozen fillets. In addition, the swim bladders of barramundi and jewfish are sold into the Indonesian and wider Asian market (Busilacchi et al., 2014) where they are used for making Isinglass, a pure form of animal jelly used in beverage processing and some foods. In addition to this commercial fishery, barramundi remains an important element of the subsistence fishery.

Barramundi aquaculture has long been identified as a potential supplier of fingerlings to small-scale fish farms in the Fly River and cage aquaculture facilities in the middle and south Fly River (Fisher, 2010). The Papua New Guinea Sustainable Development Program co-invested in the Western Province Sustainable Aquaculture Program to develop cage culture of barramundi, supported by a barramundi hatchery in Daru. Initially, this enterprise supplied fingerlings to local fish farmers in the south and middle Fly River districts. The intention was to further provide fingerlings to commercial scale cage culture facilities and to release fingerlings to replenish wild populations. The hatchery produced 200,000 fingerlings for this purpose in one spawn period (Jogo, 2015). The status of this enterprise today is unclear but it is apparent that the WPSAP in Daru is not currently operating. The only other barramundi aquaculture enterprise in Papua New Guinea at this time is Bismark Barramundi, which harvests brood stock from the Kikori and Galley Reach (Central Province) river systems in southern Papua New Guinea and transports them to a hatchery facility in Madang Province. Larvae are cultured and fingerlings transferred to marine cages until market-sized fish are harvested and frozen fillets exported.

5.1.4.3 Biological Aspects of the Fishery

In Papua New Guinea, barramundi (*Lates calcarifer*) occurs naturally only in the southern part of the country. The species is most abundant in rivers with substantial lake and swamp systems, and with extensive estuarine reaches. Thus the rivers of the Gulf of Papua are considered key habitat for the species. Barramundi is a protandrous hermaphrodite that starts life primarily as males, with the proportion of females in the population increasing with length. Males mature at about 4 years old and typically become females at about 7 years of age (i.e., 0 to 4 years juvenile fish, 4 to 7 years males fish, and 7+ years mostly females). The species has a catadromous life-cycle and undertakes migrations from adult freshwater foraging habitat to coastal spawning grounds. In the Gulf of Papua, a spawning migration involving the Fly River is well documented and the relevant characteristics of the barramundi life cycle are summarized in Figure 5.7.



TITLE: Barramundi Life Cycle and Coastal Gill Netting Area

FIGURE: 5.7

PROJECT: Papua LNG Project

DOCUMENT NUMBER: R_120-81086 **REVISION:** D

DATE: 6/07/2017

DATA SOURCES:

Towns and villages, export pipeline corridor, PRL-15, PNG LNG Gas Pipeline supplied by ERIAS Group and TOTAL (2015-2016). 3 nM coastal zone supplied by ERIAS Group (2017). Barramundi data and coastal gill netting area digitised from Blaber et al. (2009) and Opnai, L.J. & Tekananai, C.D. (1987). Protected area by Government of Australia (2014). Province boundaries derived by Mipela GeoSolutions (2016-2017). Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

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Adults migrate from the middle Fly River main channel and floodplain off-river water bodies, including Lake Murray, to an area near Sigabaduru to the west of Daru during the late dry season (September to January). Most fish that take part in this spawning migration are 3 to 4 years old. Moore (1982) indicated that a high spawning migration corresponds to a substantial lowering of inland water level. Gonad maturation takes place in estuarine waters (salinities of 28 to 36%).

Opnai and Tenakani (1986) listed spawning areas between Sigabaduru and Jarai and at Kiwai Island. The fecundity of barramundi is among the highest of any bony fish, with estimates of from 0.6 to 2.3 × 10^6 eggs per kilogram of body weight (Blaber et al., 2009) and up to 32.2 × 10^6 eggs per kilogram estimated by (Moore, 1982). Eggs hatch in coastal waters near coastal swamps during the months of November to February, and during spring tides the larvae (5 mm length) migrate into the coastal swamps that provide nursery habitat with high food resources and reduced predation. Growth rate is rapid and, by March to July, the juveniles now some 200 to 300 mm in length migrate back to coastal waters where they congregate on the coast until they are 6 to 12 months old (Blaber et al., 2009). At this stage, the juvenile populations are vulnerable to the coastal gill net fishery that targets the eastwards migration along the coast of Western Province as they make their way to the Fly River mouth.

Migration into inland waters of the middle Fly River, lower Strickland River, and Lake Murray begins when they are more than one year old and is where they grow to become adults. Not all individuals take part in this inland migration. Milton and Chenery (2005) found that about 50% of individuals sampled from the Kikori River had taken part in a migration and those that had migrated had only migrated once despite being sexually mature for at least four years. Post-spawning migration of adults back to freshwater reaches also occurs and some fish may repeat the spawning cycle, but not necessarily on an annual basis.

The model for barramundi spawning in the Gulf of Papua is that fishes from all rivers in the gulf migrate to the same spawning grounds in Western Province. This differs from the stock structure in northern Australia where stock differentiation can occur at scales of 100 to 150 km (Shaklee & Salini, 1985; Salini & Shaklee, 1986). Moore and Reynolds (1982) first suggested that individuals from the Fly River system and rivers in the northern Gulf region return to their respective areas after spawning. The distance between the Purari River and the Western Province spawning area (some 200 to 300 km) is well within the known migration distances of barramundi (over 600 km reported by Moore and Reynolds (1982)). Blaber et al., (2009) reported that fish tagged in the Kikori and Purari rivers were recaptured on the coast around Daru and genetic studies have confirmed that the Fly River and coastal populations in Western Province represent one genetic stock (Fisher, 2010). Further, the barramundi fisheries management plan states that with the exception of a Mullins Bay (Milne Bay Province) population, the populations of barramundi in all areas of Papua New Guinea genetically comprise one stock, with considerable genetic mixing of fishes from the Gulf of Papua deltaic systems with those of Morehead and Bensbach Rivers to the west and Merauke River further west in Irian Jaya.

The single-stock model of stock structure barramundi in the Gulf of Papua dictates that the species interacts with the PAOI via its habitation of the coastal, estuarine and freshwater reaches of the Purari River and via its migrations to and from the spawning grounds in Western Province.

5.1.5 Finfish Trawl Fishery

The NFA conducted trial mid-water trawl fishing in the Gulf of Papua in 2015. Few details are available about the scope of the fishing trial but the key information available at the time of writing, representing just one report from the NFA Observer Program, can be summarized as follows:

- One vessel fished for a 52-day period in the Gulf of Papua.
- A total of 153 t of finfish was landed.
- The main target species is jewfish (also known as croakers, family Sciaenidae). Several other marketable species were also recorded including 'red snapper' (family Lutjanidae), red emperors (possibly *Lutjanus sebae* or mixed species of the family Lethrinidae). Prawns were also caught in relatively small numbers during the trial.
- The trial deployed trawl nets of a variety of dimensions to test efficacy, towed at a speed of 8 to 10 knots, for one hour.
- Trial fishing was more than 10 nM from land in areas southwest of Umuda Island, south of Akoma and Orokolo Bay, and around the Kumul Marine Terminal prefecture. The vessel also scouted new areas, presumably on the basis of local knowledge and echo-sounding and these new areas were deemed to be the most productive.
- Trawling near current lines and seamounts was reported to result in good catches.
- Catches of croaker were reported to be especially productive during the first quarter and full moon phases. Croaker catch was reported to be highest in an area southwest of Umuda Island and in the Kumul Marine Terminal area.
- The Gulf of Papua mid-water trawl fishing trial was deemed to be productive and successful.

The presence of croakers, snapper and prawns in the catches indicated that the trial fishing was a demersal trawl exercise and that there is a potential fishery being assessed. The scant locational data available suggests that the most productive grounds are further offshore than the offshore export pipeline corridor, although this is not confirmed.

5.1.6 Shark Fishery

Commercial drift-netting for sharks in Papua New Guinea waters began as a result of favorable fishing trials conducted 30 km offshore in the western Gulf of Papua during late 1976 and early 1977 (Richards, 1994). Five vessels, using drift-nets averaging 9 km in length operated during 1981, but this was reduced to two vessels in 1982. One to two vessels were active in the fishery from 1982 until the end of 1992, licensed to fish with shorter gill nets of 1.6 km in length.

Reliable data for this fishery are only available for 1981 and 1982 during which time the fishery yielded a total of 810-t and 405-t of sharks, respectively. Average catches rates were 1.01 t/day in 1981 and 0.80 t/day in 1982. The catch was dominated by the scalloped hammerhead shark (*Sphyrna lewini*), which accounted for 40% of the total catch by weight.

An incidental catch of pelagic species of bony fish, principally barred Spanish mackerel (*Scomberomorus commerson*) was reported to account for approximately 8% of the catch, by weight. No information was recorded regarding other components of the incidental catch, though anecdotal information from PNG crew members on the drift-net vessels suggests that cetaceans and turtles were frequently entangled in the nets.

Papua New Guinea fisheries authorities reportedly received complaints from prawn trawlers operating in the area regarding the navigation hazards caused by drift-nets and vessels (Richards, 1994). Notwithstanding that licences precluded fishing west of 144° 30' W in the Gulf of Papua (a line approximately offshore of the Kikori River mouth), there were many sightings and several apprehensions of the vessels in the Torres Strait Protection Zone by PNG enforcement officers. By 1993, the fishery was inactive and this coincided with global moves to control international sanctions on drift-net fishing (Kumoru, 2003).

The fishery is not active today, but sharks are a major component of GOPFF by-catch and the region supports significant shark populations that are an important resource in subsistence and artisanal fisheries (see Section 5.2 below).

5.2 Artisanal Fisheries

5.2.1 Overview

Fishing and harvesting of marine and estuarine resources are integral to subsistence lifestyles and cultural identity in most coastal areas of Papua New Guinea, with the possible exception of Port Moresby and other major capital cities. The total volume and economic value of coastal artisanal fishery production in Papua New Guinea is estimated to exceed that of the commercial fisheries (Gillett, 2009). Artisanal fisheries occur principally within the 'coastal zone' between the shore and 3 nM offshore and, in terms of fisheries management, this zone is 'reserved' for artisanal use. In a 1990 census, some 23% of all rural households in the country reported to engage in fishing of some kind (marine and freshwater) with 60% of catch going to home consumption only and 40% going to both consumption and sale (Gillett, 2009). Indeed, within the PAOI, village surveys also indicated that fishing is an important activity for most villages with catches being used for household consumption and sales (although reports of the ratios of these uses differs) (Booyong Forest Science, 2017).

In the Purari River delta, villagers historically participated in small-scale commercial fisheries on a scale that is considered artisanal, and these activities supplemented subsistence fishing practices. Therefore, in the discussion below on artisanal fishing, there is some inevitable overlap between subsistence and artisanal-scale sale and trade of produce.

5.2.2 Historical Fishery Activities

Haines (1978) estimated the subsistence fishery in the Purari and Kikori delta to be 600 t/year from village catches. The author noted that a large part of the catch included small fishes such as gobies, perchlets, gudgeons and small catfish and that the fishing gear available to villagers in the early to mid-1970s was not adequate to catch large barramundi. That situation changed when monofilament gill nets were introduced to the Kikori and Purari systems by PNG Government fisheries extension staff and these nets soon became the most effective fishing method. By the

late 1970s, most village gill nets were 5 to 7 inch mesh designed specifically for barramundi, although smaller mesh nets were also used. However, Haines and Stevens (1983) considered this netting equipment to be under-utilized because people had no need for the quantity of fish caught, and were unskilled in net repair. Paddle-canoes were reported to be prevalent and lack of fuel was a limitation for the use of outboard engines. This situation has not changed since the late 1970s and Booyong Forest Science (2017) reported that the same limitation of fuel availability still exists today.

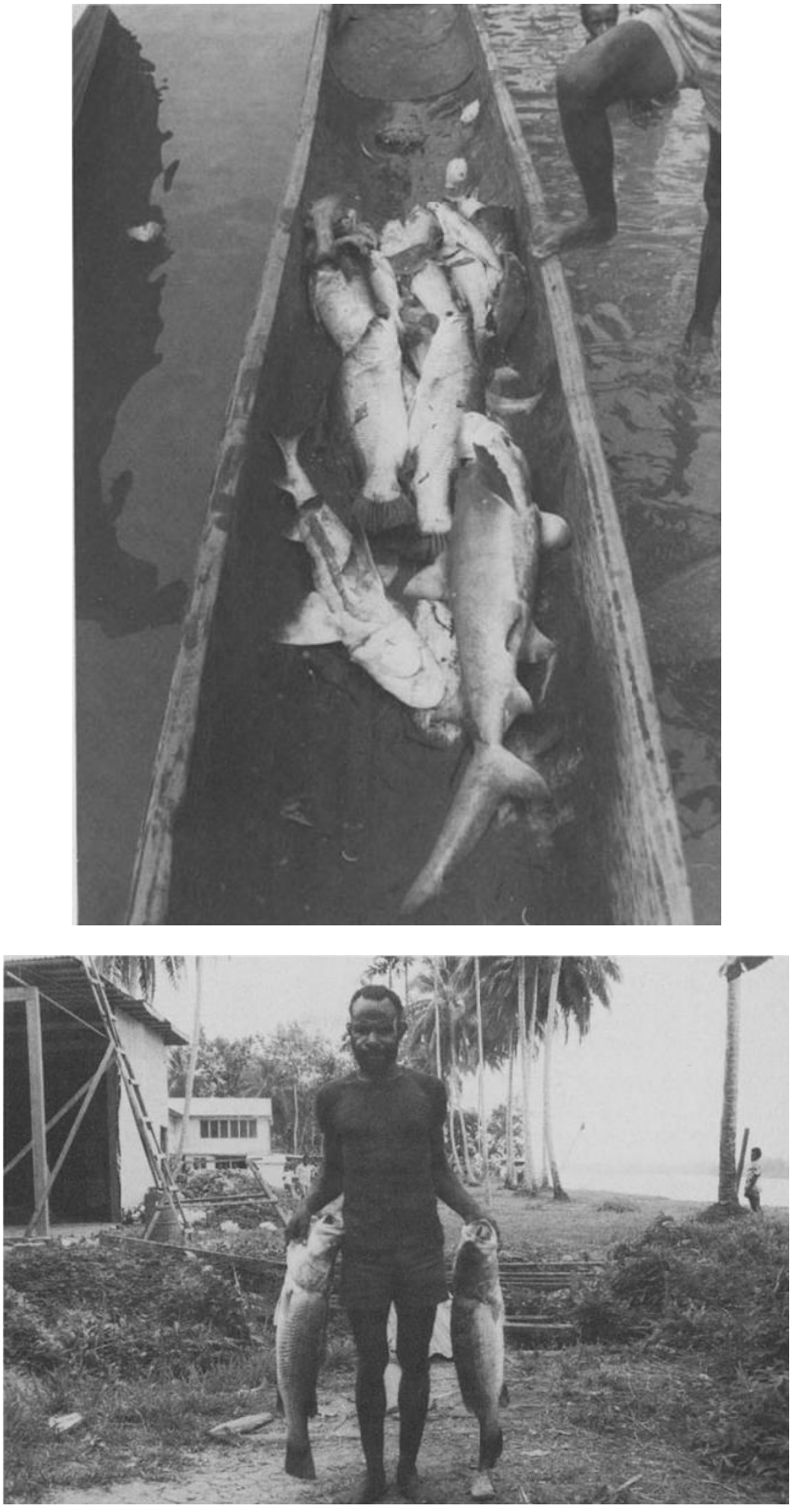
Fishing in the Purari River delta was reported to be secondary to the production of sago and other terrestrial resources in the subsistence diet, except on Urama Island in the Kikori delta where villagers have no sago stands and instead trade crabs and smoked fish for sago (Haines & Stevens, 1983). Historically, archerfish (presumably the spotted archerfish, *Toxotes chatareus*) were reported as being particularly important in subsistence catches in the Purari River delta region (Haines & Stevens, 1983). This species was sampled during surveys for the Papua LNG Project (BMT WBM, 2017b) but no specific mention was made of its importance during village surveys in 2016 (Booyong Forest Science, 2017). The traditional methods used for catching fish are by hook-and-line, hand-trap (a basket-like device, open at one end, which is used to actively catch fish after stalking), spear or bow and arrow (Haines, 1978). Pernetta and Hill (1981) provide a detailed description of the types of fish traps employed in the Gulf of Papua region, some of which are still likely to be in use today. The authors also describe a small v-shaped framed net used by women to herd and collect small fishes and prawns in shallow water, a practice still in use today. Crabs are normally caught by hand or in hand-traps and finely woven triangular dip nets and used by women for prawns and small fish.

In Haines' (1978) study, data presented for the village of Worowam (downstream of Baimuru, near Era Bay at the mouth of the Era River) typifies the situation in an estuary-mangrove dominated location. Data presented for Barea (also known as Varia), another coastal village within the PAOI in the Purari River delta, typifies a coastal marine environment. In both areas, the suite of traditional fishing gear described above was in use and gill nets were a recent introduction with this method resulting in the highest catches. The triangular dip nets used by women were reported to catch prawns (*Macrobrachium* in most freshwater areas and *Penaeids* in saline reaches) and small fish, with prawns comprising up to 20% of total catch. The village of Worowam regularly engaged in selling or trading of fish, mostly to access sago that does not grow in that area. Trading or selling was direct to villagers or at the Baimuru market. Fish were cooked and smoked for sale while crabs (almost exclusively mud crab, *Scylla serrata*) were sold live.

At Worowam, the key species of subsistence importance were, in decreasing order of catch weight, catfish (approximately 20 species in the genera *Arius*, *Nedystoma* and *Hemipimelodus*), threadfin salmon (*Polydactylus sheridani,* now *P. macrochir)*, *Eleutheronema tetradactylum*), 'other species' (mixed small bodied species), barramundi and sharks, rays and sawfishes. A similar mix of species, but a different order of importance was reported at the coastal village of Barea, where the key species in decreasing order of total catch weight were sharks, rays and sawfishes, barramundi, threadfin salmon, catfish and beach salmon (*Leptobramma muelleri*). Photographs from this era are suggestive of the importance of barramundi to subsistence and

artisanal fisheries in the Purari River delta and coastal environment (Plate 5.1). Barramundi were particularly important to subsistence fisheries in Western Province (Haines, 1978) where *Derris*

Plate 5.1 – Gill Net Catch from the Purari River Delta (Top) and Fisherman Delivering Barramundi to the Baimuru Fish Plant (Bottom)



Source: Haines and Stevens (1983).

root poisoning of the nursery swamps and small-mesh gill nets in coastal waters were methods used to catch juvenile barramundi.

Haines (1978) reported that the number of fishing trips per person in the Purari region was considered to be low (0.4 to 2.7 trips per person over a 25 day period). This corresponds with findings of Lambert (1977) for the village of Ihu (on the eastern shore of Orokolo Bay) where 75% of individuals had not consumed any protein in the preceding 24 hour period, despite widespread ownership of canoes and nets. However, it is noted in village surveys for the Papua LNG Project that significant seasonal fluctuation in fishing activity was reported (Booyong Forest Science 2017). Species movements were noted as being important for subsistence resource use by Haines (1978). During September to October, large numbers of *Acetes* spp. prawns were reportedly transported downstream and were scooped up 'by the bucketful'. In the Vailala River and at the village of Ihu, during March to April, Goldie River mullet (*Cestraeus goldiei*) (termed 'salmon' by locals) in 'running ripe' spawning condition were able to be dip-netted in large numbers in estuarine habitats.

Haines (1983) reported that the village of Worowam was the only village regularly engaged in the trade of fish and crabs for much of their terrestrial food resources. The crabs, principally mud crabs (*Scylla serrata*), were caught predominately by women and transported live. The fish was usually smoked so that it lasted for several days. The products were either traded directly with other villages or sold in Baimuru market. Pernetta and Hill (1981) noted that, along with crabs, molluscs and echinoderms were predominantly harvested by women whereas fishing for finfish and hunting for resources such as turtles, dugong (historically hunted mainly in Western Province but apparently not a feature of the northern Gulf subsistence fishing practices) and crocodile were activities undertaken by men. Mollusc shells were recognized as an important feature in the manufacture of artefacts and customary adornments (Pernetta & Hill, 1981). Shark teeth and sawfish rostra were reportedly used to create club weapons. Turtle shell was used in the manufacture of fish hooks, and turtle shell and crocodile teeth were used in adornments.

As described in Section 5.2.2 above, village-based commercial fishery ventures in the Purari River delta have been limited in number and short-lived. One possible exception was a venture by the Kikori Local Government Council (LGC) that installed a 3.5-t freezer in Kikori in 1975. This was to be provided with fish from fourteen village-based freezers. By 1983, Haines and Stevens (1983) reported that all of the village freezers had failed, but the main freezer continued to receive fish with production reaching about one tone of barramundi fillets per month. The facility is not active today.

The Baimuru LGC started purchasing mud crabs for live shipment to the New Guinea highlands late in 1977 (Haines & Stevens, 1983). The council continued to purchase crabs until September 1978 when recurrent financial losses forced them to cease. The Department of Primary Industry then took over the business and expanded into frozen fish production in February 1979. The Baimuru LGC, together with the Gulf Investment Corporation, resumed control when the operation returned to profit in March 1979. Mangrove clams, at first sold live in the shell but later sold as frozen, shelled product, were also provided to the Baimuru facility by villagers.

Haines and Stevens (1983) reported that the main constraint of fish production in the Purari River delta was not low production but the lack of transportation of the product to Baimuru. To overcome this problem, a trial fishing program was established during which a freezer barge was chartered. The vessel stayed in selected villages for four to five days, lent nets to villages and purchased fish from them. The villagers were gradually introduced to commercial fishing, without unduly disrupting their traditional activities. A high quality product was produced as the fish were frozen immediately. However, the Baimuru facility was not able to be sustained and is not active today. It is unclear whether Haines and Stevens' (1983) conclusion that the lack of fish was not a limiting factor is still true today.

Efforts to develop a more sustainable fisheries base in the Purari River delta region have focused on Baimuru on the Pie River estuary. This location was considered the only place in the northern gulf region where a major fishing facility can be developed because the Pie River estuary has a relatively large tidal range and no bar across its mouth. Baimuru also has a 1,000 m airstrip and is only one hour flying time from the capitals of the highland provinces where the major market for fish products was envisaged. Baimuru is also located a maximum 12 hours steaming time from the major prawn trawling grounds, which is about half the distance from Port Moresby, where the trawlers are normally based. No such sustained development has occurred at Baimuru, however, there have been some efforts since the 1980s to establish fisheries enterprises at Kerema.

Research into fisheries potential in the region peaked during the mid-1970s to 1982. During this period the PNG Department of Primary Industry investigated the feasibility of formalizing the sale of by-catch from the GOPPF (Haines & Stevens, 1983). During a trial, a single trawler landed 3,165 t of by-catch at the Baimuru facility, obtained from three days of prawn trawling. The catch was sorted to identify the marketable portion (dominated by unidentified fishes) and this was distributed throughout the country. Additionally, a Taiwanese gill netting vessel landed over 5 t of shark carcases at the Baimuru plant. These were filleted on a commission basis and the fillets sent to the vessel's agents in Port Moresby. The formalization of usage of the prawn trawl fishery by-catch apparently did not eventuate, but as described below, the trade or sale of by-catch directly from trawlers to local villagers appears to be active today.

There has been at least one reported outbreak of an ulcer disease among the fish populations of the Purari River delta from November 1975 to mid-1976 (Haines, 1983). An initial fish kill affected mainly archerfish (*Toxotes* sp.), spotted scat (*Scatophagus argus*) and gudgeons (family Eleotridae). The disease was observed in all estuarine and some freshwater areas between Merauke (Irian Jaya) and Port Moresby during early 1976. All species of bony fishes were affected. In the early stages of the outbreak about 50% of the fish caught by gill net in the Purari River delta and near Kikori exhibited ulcerous lesions. Two months later the percentage infection of the gill net catch had dropped to around 10, and fish were caught with what appeared to be healed lesions. Haines (1983) reported that local residents had never noticed the disease before.

Crocodile farming is included in the current discussion as it involves the saltwater crocodile (*Crocodilus porosus*) and the New Guinea crocodile (*C. novaeguineae*), both of which have affinities to estuarine and coastal habitats. Pernetta and Burgin (1983) reported that crocodile farming in the Purari area is limited. Of the crocodiles in village-based farms inspected by Pernetta and Burgin (1983), approximately 70% were *C. porosus* and 30% were *C.*

novaeguineae. This was purported to reflect the greater skin value of *C. porosus* rather than the relative abundance of the two species in the area. The paucity of crocodiles in the area was identified as the main limitation of the activity. In the Purari River delta region, the number of crocodiles held in village-based farms in the delta area averaged 17, compared with the national average of over 30 individuals per farm. An enterprise called Evara Trading, based in Baimuru, reported to purchase between 20 and 30 skins per month, with the majority coming from Wabo and Poroi on the Purari River (Pernetta & Burgin, 1983). Of the skins purchased, 80% are from *C. porosus* and only 20% from *C. novaeguineae*. The only other licensed skin buyer in the area was reportedly located at the village of Old Iari (a settlement outside the PAOI in the Purari River delta region).

Reports of crocodile hunting activities in the Purari River delta region (Apiope, Kinipo, Mirimarua, Maipenaru and Korovaki) indicated that crocodiles were caught by spearing and by hand (assisted by a forked stick in some situations) from the main channel and tributaries (Pernetta & Burgin, 1983). The number of crocodiles caught was less than 20 per wet or dry season, with the exception of Korovaki where some 400 crocodiles were caught in a dry season. At these locations in the delta, the number of crocodiles in farms ranged from 0 to 80 from 1977 to 1979. The green sea turtle (*Chelonia mydas*) and hawksbill turtle (*Eretmochelys imbricata*) were reported by Pernetta and Hill (1981) as the most important species for subsistence resource use, being hunted as adults and eggs harvested. However, in the gulf deltaic region, these species appear to be less important than the pig-nosed turtle (*Carrettochelys insculpta*). Freshwater turtle species featuring subsistence resource use were reported to be New Guinea snake-necked turtle (*Chelodina novaeguineae*), northern snake-necked turtle (*C. siebenrocki*) and New Guinea snapping turtle (*Elseya novaeguineae*) (Pernetta & Hill, 1981).

5.2.3 Artisanal Fisheries Today

5.2.3.1 Overview

Much of the subsistence and artisanal fisheries activity occurring in the Gulf of Papua today remains largely undocumented, unquantified or is highly generalized. Teh et al. (2014) attempted to reconstruct a view of the non-commercial marine fisheries in Papua New Guinea, with a focus on the contributions of the fishery sector variously described as the ‘small-scale’, ‘artisanal’ and ‘coastal fisheries’. More information on subsistence fishing in the area comes from village surveys undertaken for the Papua LNG Project (reported in Booyong Forest Science (2017)) and other development projects in the region.

Subsistence and artisanal fishing is generally confined to the ‘coastal zone’, described as the area from the shore to a distance of 3 nM offshore (Dalzell, 1991). While sea cucumbers have been over-exploited (see above and Kinch et al., 2008), and *Trochus* is considered to be at or near their maximum sustainable yield, coastal finfish and other invertebrates are still considered to be generally under-exploited (Friedman et al., 2008).

In general terms, knowledge of artisanal fishing practices in Papua New Guinea involve reef habitats where invertebrates are collected by hand and free diving on reef flats and intertidal areas (Kinch, 2002; Friedman et al., 2008) and in deeper water where fish are caught using handlines, gill nets, hand spears, or traps (Friedman et al., 2008). For example, typical coastal

subsistence catches reported for Milne Bay Province comprise about 130 species of fish (NFA, 2007), estimated to comprise about 30% reef fishes, 10% pelagic species, and the remaining 60% comprises a mix of crustaceans, molluscs, invertebrates, and seaweeds. However, in practice, fishing effort is highly targeted towards maximum yields from the habitats that are available to people within their customary areas and towards seasonal abundance and movements of species. As such, villagers located near mangrove-lined estuaries with no coastal reef systems will obviously focus their efforts on maximizing yields from the estuarine system.

Paddle canoes are a key to people accessing fisheries resources. The introduction of fiberglass banana boats powered by outboard engines has generally been associated with the expansion of the range through which people can fish, and therefore the species available. However, access to fuel and maintenance of equipment are still generally regarded as limiting factors.

This review could find no mention of artisanal fisheries targeting of dugong in the western and northern Gulf of Papua. Dugong are unlikely to feed in the vicinity of the Purari River delta and other major river mouths as a result of the high turbidity and absence of significant seagrass beds, although transiting individuals may be encountered (BMT WBM, 2017b). Surveys conducted for the PNG LNG Project EIS did not find evidence of dugong feeding trails in seagrass meadows in Caution Bay (CNS, 2009). In addition, community consultation conducted as part of these surveys indicated that dugongs do not occur in Caution Bay. Larger scale indigenous hunting of dugong appears to be restricted to the Torres Strait (Marsh et al., 1997).

Two species of dolphin (*Orcaella heinsohni* and *Sousa sahulensis*) are expected to occur in the Gulf of Papua, including river mouths (BMT WBM, 2017b). Booyong Forest Science (2017) reported from villager interviews that *O. heinsohni* was occasionally hunted in the Purari River delta estuary and that ‘bottlenose’ dolphin (species unconfirmed) was occasionally utilized in the open ocean environment of the gulf. However, no records of artisanal fisheries interactions with dolphins were noted in other reports and data reviewed in the present study.

The artisanal targeting of dolphins and dugong is therefore considered to be relatively minor compared to other marine resources.

5.2.3.2 Purari River Delta

Qualitative observations have been made of subsistence fisheries resource use in the Omati-Kikori delta (CNS, 2008a), which is expected to have some similarities with those in the Purari River delta. The primary fishing methods were reported to be gill nets, hand lines, cast nets and spears. The species caught included barramundi, threadfin salmon, catfish, black bass, bream, nursery fish, pony fish, prawn (including the giant river prawn), mudcrab and crocodile. There was no quantification of catches, activities or species-level identifications in the Omati-Kikori studies. Fiberglass dinghies with outboard motors and dugout canoes powered by paddles and/or outboard motors were in use. These vessels are also used for transportation. It was reported that fishing is considered an essential subsistence activity and the selling of surplus catch to markets and logging camps is opportunistic and not regular. Commercial-scale activity (i.e., selling fish to processing facilities) has apparently declined as villagers have sought other sources of income. It was also reported that fishing in the main channel of large turbid channels was limited and the net

and lines are preferentially set in backwater eddies along the banks of these waterbodies, at the confluence of tributaries and in smaller tributaries.

The status of subsistence and artisanal fishing in the Purari River delta and coastal zone reported by Booyong Forest Science (2017) appears to be subtly different to that reported by CNS (2008a) for the Kikori-Omati delta. In the Papua LNG PAOI, fishing was reported to be important for subsistence but community-level surveys concluded that the primary motivation for fishing was commercial benefit, with direct consumption being a secondary motivation. However, at the house-hold level, surveys showed that there was a low volume of sales and a high volume of household consumption, indicating that most of the catch was consumed rather than sold (Booyong Forest Science, 2017). The survey results suggest a degree of opportunistic artisanal sale or trade during times of excess fisheries or terrestrial resources, and when the opportunity exists for cash income arises. Similar to the results reported for the Kikori-Omati delta, the majority of fishing activity in the Purari lowlands occurs in tributaries rather than the main channel. Most fishing grounds are within customary lands in the Purari River delta although the main channels of the Purari River are openly accessible by local villagers.

Studies for the Project confirmed that many of the traditional fishing techniques historically reported in the area are still in use in the Purari River delta, namely the use of *Derris* root poisoning, woven fish traps and v- and y-shaped scoop nets (Booyong Forest Science, 2017). The relatively modern monofilament gill nets and steel fishing hooks that have been reportedly in use in the region since the 1990s are still in use across the PAOI. Importantly, it was noted in 2016 studies that the large 5 to 7 inch mesh gill nets that historically were used to target barramundi exist in some villages but smaller sizes are now preferred among inland villagers due to the declining stock of large-bodied species (Booyong Forest Science, 2017). The limitations associated with cost and repair of monofilament gill nets that were reported in historical studies are still cited today.

5.2.3.3 Orokolo Bay and Coastal Surrounds

In Orokolo Bay, fishing is centred on the marine environment and coastal marine resources are reported to be accessible by all local villages (Booyong Forest Science, 2017). The small outrigger canoes and y-nets (Plate 5.2 and Plate 5.3) are traditional methods that are still in use today among the coastal Orokolo villages, with canoes used primarily to set gill nets and, secondarily, to fish in deeper water with hook and line. The traditional practice of fishing with bow-and-arrow in shallow water that was reported in the area previously (Williams, 1940, cited in Booyong Forest Science (2017)) is said to be ineffective and rarely practiced.

Subsistence and artisanal fishing in the coastal marine environment is strongly seasonal. Southeast trade winds (May to October) create sea conditions that are dangerous for outrigger canoes and restrict fishing in the open coastal environment and the river mouths in the Purari River delta region. Respondents in 2016 surveys identified that threadfin salmon (family Polynemidae) were seasonally abundant, being targeted in the April to July period. Interestingly, there was no specific mention of barramundi seasonality in the surveys conducted by Booyong Forest Science (2017). This is despite household surveys revealing that barramundi was among the top three fisheries species consumed (along with prawns and sharks) in villages of the Purari River delta (ERIAS Group, 2016). It is interesting to note that many residents of the freshwater

sections of the Purari River mentioned a near complete decline of several species in these habitats, including barramundi and black bass (*Lutjanus goldiei).*

Plate 5.2 – Y-net Fishing in Shallow Waters of Orokolo Bay



Plate 5.3 – Fisherman in the Purari River delta with Dug-out Canoes, Gill Nets and Artisanal Fish Catch



There is a perception that boat and barge activity and chemical contamination has led to a reduction in fish resources over the past decade, although it is also noted that village surveys in this area indicated that over 23% of respondents remarked that they had consumed barramundi within the previous two weeks (Booyong Forest Science, 2017).

Qualitative observations of subsistence catches in the Purari River delta in 2016 were in general agreement with historical studies, with respect to faunal composition. Elasmobranchs (sharks, sawfishes and rays), barramundi, threadfin salmon (family Polynemidae) and mullet (family Mugilidae) were recorded in catches in marine and river mouth habitats (Plate 5.4). In estuarine reaches, there was a dominance of black bass (*Lutjanus goldiei)*, emperors (family Lethrinidae) and several species of catfish in the estuarine and lower freshwater zones. Prawns are common throughout the system and in some villages of the PAOI and are more often consumed than finfish or sharks.

An unpublished study undertaken in the Kerema region in 2009 generally agrees with the findings of Booyong Forest Science (2017). The 2009 study reported that subsistence and artisanal fishers in the Kerema region were observed using small mesh gill nets to target queenfish and trevally (family Carangidae) in open waters from motorized and non-motorized vessels. In the 2009 study, fishers mentioned that those with motorized vessels visit and board prawn trawlers to help with work on these vessels and in return receive by-catch and prawns below market size. Additionally these vessels were also observed to fish with handlines behind the trawlers for large queenfish, trevally and whaler sharks which are attracted to trawlers as a result of discarded fish. The trade of prawn trawler by-catch to local villages was also reported in village surveys for the Project, but the unpublished 2009 report is the first to mention the boarding of prawn trawlers by fishermen to work in return for by-catch.

Another unpublished study undertaken in 2012 reported that fishers from coastal communities in Kerema Bay fish in-shore areas using handlines and a range of nets ranging from 0.5 to 7 inch mesh size. Sawfishes and stingrays were identified as being important in subsistence catches. Sea turtles were reported to be captured on some occasions. Estuarine and mangrove habitats around Kerema were acknowledged to be productive areas and there was limited reef and seagrass habitat.

5.2.3.4 Offshore Export Pipeline Corridor

Subsistence and artisanal fishing activity occurs within the offshore export pipeline corridor where the corridor traverses the 3 nM coastal zone. This occurs at three areas (Figure 5.8):

- Landfall section of the pipeline corridor at Orokolo Bay.
- Offshore of Cape Suckling, south of Yule Island.
- Landfall section of the pipeline corridor at Caution Bay (discussed in Section 5.2.3.5).

Plate 5.4 – Compilation of Species from Artisanal Catches in the Orokolo Bay Region



Blue threadfin (*Eleutheronema tetradactylum*)



Juvenile sharks (family Carcharinidae)



Lesser queenfish (*Scomberoides lysan*)



Narrow sawfish (*Anoxypristis cuspidata*)



Dorab wolf herring (*Chirocentrus dorab*)



Winghead shark (*Eusphyra blochii*)



Mackerel (*Scomberomorus* sp.)



Trevally (possibly *Caranx herberi*)

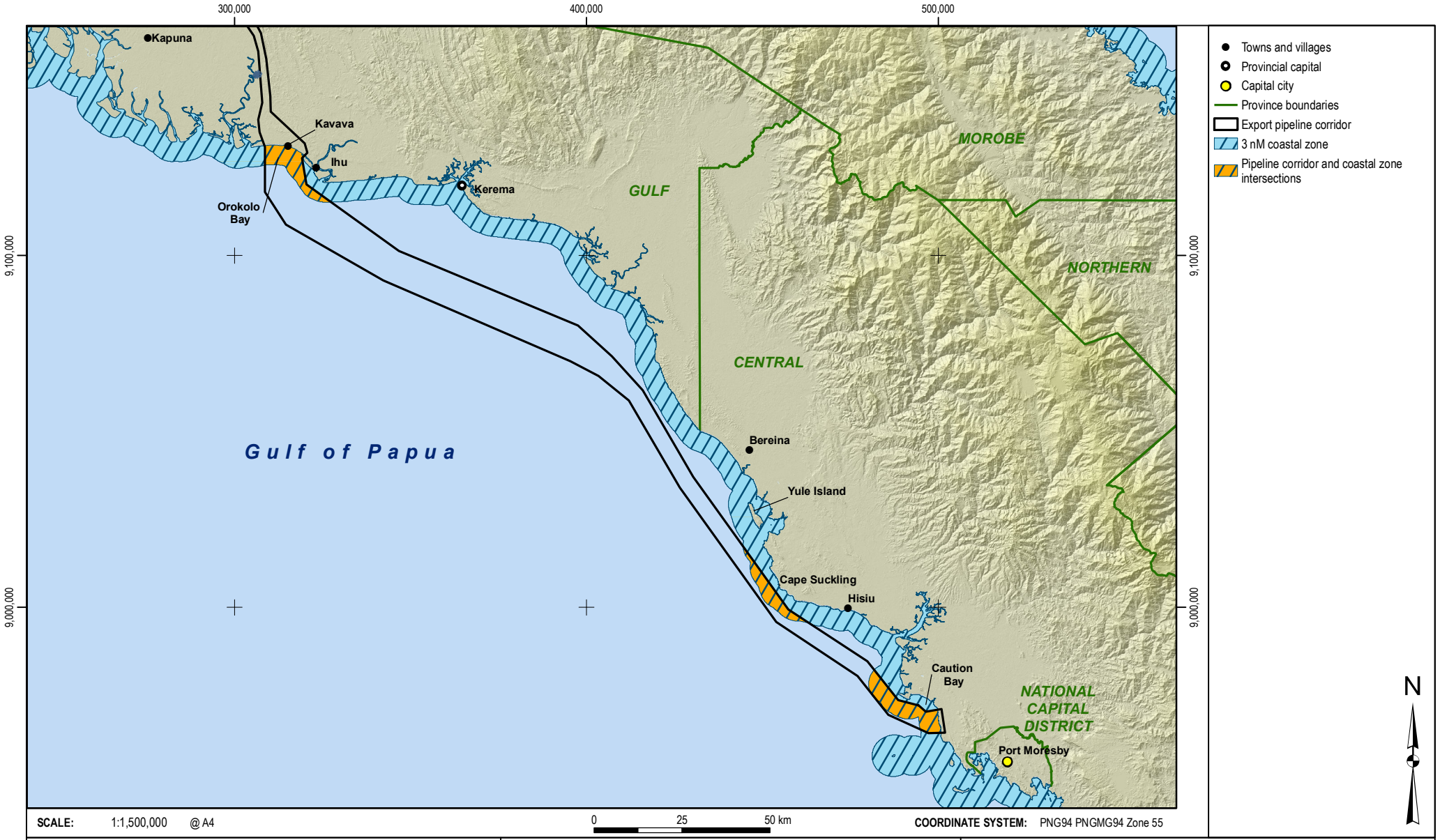


Scaly jewfish (*Nibea squamosa*)



Longfin beach salmon (*Leptobrama pectoralis*)

Note: Species identifications from photographs only and considered accurate with a moderate degree of certainty.



TITLE: Locations of the Intersections Between Export Pipeline Corridor and the 3 nM Coastal Zone

FIGURE: 5.8

PROJECT: Papua LNG Project

DOCUMENT NUMBER: R_120-81085 **REVISION:** D

DATE: 6/07/2017

DATA SOURCES:

Towns and villages, capitals, export pipeline corridor, hillshade supplied by ERIAS Group and TOTAL (2015-2016). DEM (Planet Observer 2015 and TOTAL 2016). 3 nM coastal zone supplied by ERIAS Group (2017). Province boundaries derived by Mipela GeoSolutions (2016-2017).

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In the Orokolo Bay region, there are some 14 coastal villages whose coastal marine fishing activities and practices (described in Section 5.2.3.3) have the potential to occur within the offshore export pipeline corridor. Unlike Caution Bay that has seagrass and coral reef habitats that are specific targets for subsistence fishing, the fishing activities at Orokolo Bay are reported to be somewhat generalized throughout the coastal zone (Booyong Forest Science, 2017). Offshore of Orokolo Bay, the predominant habitat is sublittoral sediment beds with small, isolated rocky reefs (BMT WBM, 2017b). Although unconfirmed during site surveys, such isolated seabed features may be targeted by subsistence fishers off Orokolo Bay at particular times. However, the predominant practice at Orokolo Bay appears to be one of fishers ranging throughout the sediment habitat of the coastal zone in motorized or paddle canoes, with a likely focus in and around river mouths. This fishing principally occurs during the calm period of November to April, using mainly gill nets and hook-and-line techniques to target elasmobranchs, threadfin salmon, beach salmon, croakers and barramundi. In addition, hand-netting for small fishes and prawns is common in shallow, wadable areas.

Subsistence fisheries activities in the Orokolo Bay area have a secondary interaction with the offshore export pipeline corridor via interactions between villagers and prawn trawlers operating in the Gulf of Papua Prawn Fishery. Villagers are reported to purchase/trade by-catch from the prawn trawlers and there was at least one observation of this occurrence during field surveys (Booyong Forest Science, 2017). It is unknown whether the practice previously reported in the Kerema region of villagers boarding prawn trawlers to work in return for by-catch occurs among villages in the Orokolo Bay area. Furthermore, the extent to which previous 'negative interactions' between Orokolo Bay villagers and prawn trawlers (which has been reported to influence the proximity to which trawlers are willing to approach Orokolo Bay) has a bearing on this trade in by-catch today is unknown.

Perhaps the most comprehensively documented coastal artisanal fishery relevant to the offshore export pipeline corridor is that associated with ornate rock lobster around Yule Island and along the northwestern shoreline of the mainland to the southeast of Yule Island. Spawning lobster appear on reefs around Yule Island from November to April (MacFarlane and Moore, 1986) and die after spawning. The spawning population forms the basis of an artisanal dive fishery at Yule Island that has highest catches from mid-January to mid-February that occurs in two pulses – the first comprising equal numbers of males and females and the second comprising females almost exclusively (Dennis et al., 1992). Lobsters are in poor condition at this time, attributed to their long migration from Torres Strait (some 400 km) (see Figure 5.5). Dennis et al. (1992) reported that lobsters are processed at a processing facility on Yule Island. The status of that facility today is unknown. Divers target the lobster aggregation and catches can be significant with 9,200 kg of whole lobster reported for 345 fishers over an annual harvest period (Dennis et al., 1992).

5.2.3.5 Caution Bay

Fringing reefs and seagrass beds occur in Caution Bay (BMT WBM, 2017b). These habitats, along with mangrove-lined estuaries, were identified as target areas for subsistence resource use (CNS, 2008b). A variety of coastal reef species, benthic species and pelagic species that typify the fauna of these areas, were reported in subsistence catches. Netting/trapping, multiple-hook long-lines, single-hook bottom-lines and hand-spear, speargun and trolling were reported as

fishing methods. Diving with spearguns is a regular activity, occurring mostly at night. Dynamite fishing and *Derris* root poisoning is reportedly rarely used in the area (CNS, 2008b).

Surplus catch that is not used in local households is sold or traded for other produce, principally at markets in Port Moresby. Similar to reports in the northern gulf region, finfish fishing is mainly undertaken by men while crab and shellfish collection in mangroves is mainly by women. Snails collected from the mangroves are used for fishing bait (CNS, 2008b). Offshore fishing is reportedly hampered by strong winds from June to September during the southeast trade wind season. Esso Highlands Limited (2012) reported that subsistence fishing in Caution Bay targets the following habitats:

- Mangroves, where black bass, mud crab and shellfish are targeted.
- Beaches and onshore fringing reefs, where mainly invertebrates are harvested.
- Inner reefs, which are shoals 10 to 15 m deep that occur between the fringing and the barrier reefs, where a variety of fishes and invertebrates are harvested.
- Barrier reefs located off Daugo, Bava and Hidihi islands, where a variety of fishes and invertebrates are harvested.
- Pelagic environment, where pelagic fish (e.g., families Carangida, Belonidae and Scomberomoridae) are targeted.
- Deep reefs to the west of Idihi, locally called LebuLebu, where deep bottom fishing targets finfish.

These findings generally agree with a study in Caution Bay undertaken in 2009 that reported all reef and inter-reefal habitats were fished, with a predominance of hook-and-line fishing from non-motorized canoe. Small-bodied fish species such as goatfish (Family Mullidae), threadfin bream (Family Nemipteridae) and small emperors (Family Lethrinidae) were observed in catches. The spearfishing activities noted in CNS (2008b) by free-diving targeting a range of small demersal reef fish species were also observed in the 2009 study. Fishing was also reported to occur from motorized vessels using spotlights at night targeting longtom (Family Belonidae).

The occurrence of net fishing in Caution Bay is also reported in the 2009 study. Gill netting involved large (approximately 800-m) and small (less than 30-m) nets, with the larger nets apparently used to target large-bodied species such as spangled emperor (*Lethrinus nebulosus*) and sharks and rays. The small nets targeted a variety of small reef fish. Game fishers, including charter fishing operations, based at Port Moresby were reported to frequent the area offshore of Caution Bay targeting pelagic species, particularly various billfishes (Family Xiphiidae).

6. Conclusions

The Gulf of Papua is a biologically rich area that supports commercial prawn trawling (PNG's second largest commercial fishery), smaller scale but still regionally significant barramundi and jewfish fisheries, lobster fisheries and a range of artisanal/subsistence fisheries. Commercial barramundi fisheries activity at this time is located exclusively in the western sector of the gulf. Historically, fishers located in the Purari/Kikori systems were engaged in small-scale commercial barramundi fishing activities. However, over-fishing and other factors have created a situation whereby barramundi appear to presently have a reduced commercial importance in artisanal catches in the Purari region.

Artisanal fisheries are almost exclusively within the 3 nM coastal zone and the offshore export pipeline corridor intersects this zone in three locations: at the upstream coastal extent of the export pipeline corridor (Gulf Province), adjacent to Cape Suckling (Central Province) and at the downstream coastal extent of the export pipeline corridor (Central Province). The artisanal fishing practices and species of importance are expected to differ at these three locations and are likely to be tuned to the conditions, seasonality, species movement patterns and habitats in the area. However, the following key principles are expected to apply:

- In the region of the offshore export pipeline corridor at Orokolo Bay and the Purari River delta, the estuarine areas, river mouths, mangroves and the nearshore sediment environments appear to be key habitats for artisanal fisheries. Prawns, elasmobranchs, barramundi, threadfin salmon and mud crabs appear to be the species of key importance to regular artisanal catches. Therefore, ecosystem processes involved in the maintenance of life history patterns of these species are key sensitivities. These include maintenance of habitat connectivity along migration pathways, maintenance of water and benthic habitat quality in the nearshore environment and maintenance of accessibility of people to fishing areas. In this region, artisanal fisheries interact with commercial prawn fisheries in that these two sectors target the same species at times and by-catch from the commercial fishery appears to be a resource for coastal communities.

- At Cape Suckling south of Yule Island, artisanal practices have not been surveyed. However, based on its physiographic setting, which is akin to Caution Bay rather than the northern gulf of Papua region, it is expected that reefs and the pelagic environment will be the key habitats for artisanal fishers. Given the vicinity of villages at Cape Suckling to Yule Island, artisanal fishers in this area may engage in harvesting of seasonally abundant ornate rock lobster. The Cape Suckling area does not appear to have large estuarine reaches or mangroves and these habitats appear to be restricted to areas southeast of the cape. The key sensitivities in this region are expected to be the same as those at Caution Bay, with the potential additional focus on ornate rock lobster.

- In the Caution Bay area, there has been significant industrial development since the last detailed artisanal resource use survey and the situation with respect to current practices is unconfirmed. However, there are fewer large rivers and mangrove systems, more numerous fringing and patch reefs, and previous studies reported that a diverse range of reef and

pelagic species feature in artisanal catches. Reefs and reef-associated fish species appear to be of particular focus and thus the ecosystem processes that support reefs and the associated habitat complexes and the life cycles of reef species are expected to be key sensitivities.

Sea conditions (driven primarily by wind seasons), access to fuel to run outboard engines, access to and maintenance of gill nets and other fishing gear, and access to infrastructure to get products to markets (e.g., freezers, reliable transport) are often cited as the key limitations on artisanal fisheries. As such, it is expected that subsistence reliance on marine and estuarine fisheries is secondary to gardening and terrestrial resource use. However, marine and estuarine fisheries are clearly important to the health and cultural identity of all coastal peoples.

This study did not identify any recorded artisanal targeting of dugong in the western and northern Gulf of Papua or the Caution Bay area. Occasional hunting of dolphins is reported in the Purari River delta estuary (apparently *Orcaella heinsohni)* and in the offshore environment of the gulf (‘bottlenose’ dolphin - species unconfirmed) (Booyong Forest Science, 2017). However, artisanal fisheries targeting of dolphins and dugong is not reported in other literature. It is therefore concluded that interactions with these marine mammals is opportunistic and of lower importance than targeting of other marine species.

The NFA did not report any instances of negative feedback or complaints from the commercial prawn fishery with respect to the PNG LNG Gas Pipeline and there have not been any reports of concerns about net entanglement or standoff areas (Liviko, pers. com., 2016). The Papua LNG export pipeline corridor traverses the prawn fishery region across two fishery reporting areas: Orokolo Bay and West Kerema Bay. Re-analysis of trawler VMS position data, that was used as a proxy for prawn productivity, and catch data from stock assessment surveys in the present study indicated that: (a) trawling intensity in these two regions, as a whole, is lower than in neighboring areas, namely Kerema Bay, Freshwater Bay and Cape Blackwood, and (b) the offshore export pipeline corridor traverses low-activity areas of the Orokolo Bay and West Kerema Bay reporting areas. Marine transport routes to the Purari River delta will also traverse areas of the GOPPF potentially including high productivity areas of Cape Blackwood, Purari and Orokolo Bay reporting areas.

Studies have attempted to identify environmental factors influencing prawn catch in the fishery. However, the only consistent pattern in analyses is that prawn catch is strongly correlated to fishing effort, which is highest during the period April to September. It is also recognized that the movement of prawns from offshore spawning grounds to nursery grounds in the mangrove systems of the Purari and Kikori deltas, and later into the nearshore coastal environment (inshore of 3 nM), is key to the life cycle of prawns and the productivity of the fishery. Therefore, maintenance of the ecosystem processes that support that life-cycle is important for the maintenance of the commercial fishery.

By-catch from the prawn fishery is large, making up at least 75% of the total biomass of trawls. Some villagers, presumably those with motorized dinghies or canoes, reportedly access by-catch from trawlers by trading village products or as a form of payment for working on-board. Further, while the prawn fishery management plan states a 3 nM inshore limit to the fishery, a measure implemented to protect juvenile prawns, trawling apparently occurs inshore of this limit, potentially

under cooperative agreements with landowners. The nature and scale of such cooperation is unquantified at this time but is mentioned because: (a) it may represent a supplemental artisanal/commercial resource to villagers, and (b) may cause associated existing impacts to marine habitats and communities under baseline conditions.

The objectives of this study have been successfully met and a characterization of the commercial and artisanal fisheries of the marine and estuarine zones of the study area has been made using the best available existing data and information. The key species, equipment and limitations to fisheries resource use are also characterized. This review also profiles the relevant historical scenarios that will provide important context to the assessment of potential future changes. A potential limitation to the present study is that there is limited information available for Cape Suckling (an area where the export pipeline intersects the 3 nM coastal zone). Therefore, there may be local-scale fisheries practices and resources in the region of Cape Suckling that are not reflected in, or able to be extrapolated from, the present study.

7. Abbreviations and Glossary

7.1 Abbreviations

ANOVA: analysis of variance

CEPA: Conservation and Environmental Protection Authority

EIS/ESHIA: environmental impact statement/environmental, social and health impact assessment

GOPPF: Gulf of Papua Prawn Fishery

IFC: International Finance Corporation

km: kilometer

LGC: Local Government Council

LNG: Liquefied Natural Gas

m: meter

NFA: National Fisheries Authority

nM: nautical mile (1 nM = 1,852 m)

PAOI: Project area of Influence

PGK: Papua New Guinea Kina (currency)

PNG LNG: PNG LNG Project (ExxonMobil)

PS: performance standard (from IFC performance standards)

PZJA: Protected Zone Joint Authority

t: metric ton (weight)

tpa: tons per annum

TAC: total allowable catch

TEP PNG: Total E&P PNG Limited

TSTRLF: Torres Strait Tropical Rock Lobster Fishery

US$: United States dollar

VMS: vessel monitoring system

7.2 Glossary

Term	Definition
Brooding	A behavior involving the incubation of eggs. In prawns, eggs are secured to the underside of the tail, covered by the swimming legs (pleopods)
Catadromous	The behavior of migrating downstream from lakes and rivers to the sea to spawn
Coastal zone	Starts from the lowest low-tide point and extends up to three nautical miles towards the sea
Elasmobranch	Cartilaginous fishes of the class Chondrichthys that includes sharks, rays and sawfishes
Gill net	A net with monofilament nylon (fishing line) meshes (gaps) stretched between a float line at the top and a weighted line at the bottom, designed to entrap a fish around the head and gills
Offshore	Situated at sea beyond the 3 nautical mile coastal water limit
Onshore	Terrestrial or on land
Palaemondid prawn	Prawns of the family Palaemonidae, typified by enlarged pereiopods (thoracic legs) in males. In the context of the present study, this group can generally be considered as the freshwater and estuarine shrimps that are not targeted by the commercial fishery
Penaeid prawn	Prawns of the family Penaenidae. In the context of the present study, this group can generally be considered as the marine prawns that are targeted by the commercial fishery
Purari River basin/catchment	A catchment 33,670 km^2 in size that occupies a considerable portion of the central and southern part of mainland Papua New Guinea. It lies between the Kikori and Vailala rivers and extends from the highest mountain of Papua New Guinea, Mount Wilhelm to the Gulf of Papua
Purari River delta	A large area of low, flat depositional land within the Purari River catchment where the Purari River main channel branches into several smaller distributary rivers channels before flowing into the Gulf of Papua
Phyllosoma	A larval stage of crustaceans during which time the lobster larvae take on a leaf-like form and are planktonic. The phyllosoma go through a number of growth stages in this form, prior to transforming into pueruli (see below)
Pueruli	Plural of pueruli, describing a particular larval stage (the puerulus stage) of crustaceans. For lobsters this represents a settlement stage and the larvae takes on the form of a juvenile lobster
Protandrous hermaphrodite	An organism that is born as male and changes to female at a certain time in its life cycle and upon attaining a certain size
Vessel monitoring system	Automated beacon used by commercial fishing vessels that logs vessel position, heading and speed at regular intervals and is used by regulatory authorities to monitor compliance.
Y-net	A hand-operated net of a variety of sizes with a rigid frame and inner mesh, designed to scoop small fishes and prawns

8. References

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