Caution Bay fisheries resource use study
754-MELEN224697

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PREPARED FOR

Niugini LNG Operating Company Limited

PREPARED BY

Tetra Tech Coffey
Level 5, 12 Creek Street
Brisbane
Qld 4000 Australia
p: +61 7 3239 9300

ABN 55 139 460 521

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Units and abbreviations

CPUE	catch per unit effort
ESIA	environmental and social impact assessment
h	hour
kg	kilogram
kg/h	kilogram per hour
kg/h/fisher	kilogram per hour per fisher
kg/h/trip	kilogram per hour per trip
LNG	liquified natural gas
mtpa	million tonnes per annum
PGK	Papua New Guinea Kina

Terms

catch per unit effort	Catch (in weight) per fishing effort - i.e., kg/(h x fisher) or kg/h/fisher. This is the primary catch per unit effort method adopted in the 2019 study. A variant of this method was used in the 2012 to 2014 Exxon Mobil surveys, which involved calculating catch (in weight) per hours of fishing per fishing trip (i.e., kg/h/trip). Total catch weights were divided by the total number of hours of each fishing trip without considering the number of fishers fishing at the same time on each trip. Parts of this report have used this method to allow comparison with the 2012 to 2014 data.
fisher	A person involved in the fishing effort. In this report, where total numbers of fishers are reported for all fishing trips, the number does not distinguish repeat fishers from new fishers. That is, the total numbers of 'fishers' reflect the number of fishing participations rather than the number of individuals that partake in fishing. This study did not determine the number of individuals from each village that fish.
fishing effort	The total aggregate time (in hours) spent by all fishers involved in a fishing trip. For example, if three fishers were involved in a fishing trip that lasted one hour from departure to return, the fishing effort would be 3 x 1 = 3 hours. If one fisher was involved in a fishing trip that lasted one hour from departure to return, the fishing effort would be 1 x 1 = 1 hour.
fishing hour	The unit of fishing effort.
fishing trip	Includes the act of fishing but also the travel to and from the fishing site. A fishing trip is defined as an event where a single fisher or group of fishers conducts a fishing event either by vessel or foot.

1. Introduction

Coffey Environments Australia Pty Ltd (now Tetra Tech Coffey Pty Ltd) was commissioned to conduct a study to characterise the fishing practices of local communities in Caution Bay. The data from this fisheries resource use study is being used to support the assessment of a potential expansion of the liquefied natural gas (LNG) Plant near Port Moresby.

This report describes the methods, results, and conclusions of the fisheries resource use study.

1.1. Objectives and key tasks

The objectives of the Caution Bay fisheries resource use study were to:

- Gather data to inform the social baseline to gain an appreciation for peoples' reliance on catch from the fishing grounds in the vicinity of a proposed LNG Plant Jetty expansion; level of effort required to catch the fish, and the associated earnings and uses of the catch; and
- Understand how fishing methods, catch composition, catch per unit effort, and earnings compare to previous monitoring programs completed in 2012, 2013 and 2014.

The following tasks were undertaken as part of the study to achieve the objectives:

- Establish a current baseline on fishing activities (including catch composition, catch per unit effort, equipment used, fishing locations and catch earnings) conducted by residents of the villages near the LNG Plant (i.e., Boera, Porebada, Lea Lea and Papa).
- Undertake a market survey to understand the current market price of commonly sold fish species.
- Use the same survey method as the previous 2012 to 2014 Papua New Guinea Liquefied Natural Gas Project (PNG LNG Project) fisheries monitoring program to enable comparison of data between the surveys where feasible.

1.2. This report

This report presents the following information:

- Section 2 Methods: Description of the survey methods used, including interview details and previous reports and information reviewed.
- Section 3 Results from the 2019 surveys: Summary and interpretation of the study results.
- Section 4 Comparison to previous findings: The findings from the current (2019) study compared those of to the PNG LNG Project fisheries monitoring program (from 2012 to 2014).
- Section 5 Discussion and conclusions: Succinct conclusive statements about the current fishing practices in Caution Bay and how they compare to those reported in the 2012 to 2014 monitoring period.

2. Methods

This section describes the methods used to undertake the Caution Bay fisheries resource use survey and associated data analysis and reporting.

2.1. Review of existing information

Fishing activities and catches were monitored on a quarterly basis between Q4 2010 and Q4 2014 as part of monitoring undertaking for the PNG LNG Project. The monitoring activities involved catch landing surveys and vessel inventories at Porebada, Boera, Papa and Lea Lea.

During 2011, the survey questionnaires were revised to obtain more easily interpretable data from fishers. This change meant that data from 2010 and 2011 could not be directly compared with data from 2012 to 2014.

The following reports were made available to Tetra Tech Coffey and reviewed to inform this study:

- Papua New Guinea LNG Project Fisheries Close out Report – Caution Bay PGLN-EH-SRZZZ-700002 (ExxonMobil 2015)
- Papua New Guinea LNG Project Fisheries Report First and Second Quarter 2013 – Fisheries Report – PGHU-EH-SRZZZ_700017 (ExxonMobil 2013)
- Papua New Guinea LNG Project Caution Bay Fisheries Report 2012 – Yearly Report – PGHU-EH-SRZZZ-700015 (ExxonMobil 2012a)
- Papua New Guinea LNG Project Caution Bay Fisheries Report Q2, 2012 – PGHU-EH-SRZZZ-700012 (ExxonMobil 2012b)
- Papua New Guinea LNG Project Caution Bay Fisheries Report – PGHU-EH-SRZZZ-700004 (ExxonMobil 2011a)
- Papua New Guinea LNG Project Caution Bay Fisheries Quarter 2 & 3, 2011 – PGHU-EH-SRZZZ-700005 (ExxonMobil 2011b)

For the purposes of this report, results from the 2019 surveys are compared with those from the 2012 to 2014 monitoring program as consistent survey methods were used. Comparisons to findings from 2010 and 2011 are made at a high level only, where relevant.

2.2. Study area

The study area was centred around the four closest coastal villages to the LNG Plant in Caution Bay and associated LNG export marine infrastructure (i.e., Porebada, Boera, Papa and Lea Lea) (Figure 2.1). Porebada is the most populous village with 7,193 residents, followed by Lea Lea (4,577 residents), Boera (3,178 residents) and Papa (2,415 residents) (Coffey 2019).

2.3. Field surveys

The catch landing, vessel inventory and market surveys were undertaken between 11 June and 1 July 2019. The survey team comprised two Tetra Tech Coffey staff assisted by trained local assistants from each village. The surveys involved interviewing local fishers and recording the responses using standard survey sheets (see appendices A, B and C). The survey forms are the same as those used in the 2012 to 2014 surveys. Photographs of fish species were taken during the catch landing and market surveys. The methods for community pre-awareness and each survey type are detailed below.

2.3.1. Community pre-awareness

Prior to the surveys commencing, awareness of the field surveys was provided to the study area villages by the ExxonMobil PNG (EMPNG) community affairs team. Feedback from the communities during the awareness session influenced the composition of the survey teams, with communities requesting the local team who had undertaken the previous monitoring in 2012, 2013 and 2014 be re-hired for this work.

This requirement was met at Papa, Lea Lea and Porebada although not at Boera due to the close timing of the awareness and commencement of field surveys at this village. Some fishers at Boera (relatives of the previous survey team) did not agree with this approach and did not participate in the surveys.

2.3.2. Catch landing surveys

The catch landing surveys recorded details of the fishing effort and catches of individuals and groups from each village. The survey form is included in Appendix A. The survey recorded fishing duration (including travel time to/from the fishing site), fishing equipment used, habitat and locations targeted, type of vessel used, catch composition, catch weight, proportion of catch consumed or sold, and expected earnings from the catch to be sold. All types of catch were recorded including finfish and invertebrates (such as crustaceans and molluscs) and are collectively referred to as ‘fish’ throughout this report.

Fishing areas targeted by fishers were obtained by asking household survey respondents to point to a location on a map displayed on a mobile GIS unit.

Catch landing data was obtained through interviews with individuals and group of fishers who volunteered to participate. The survey was conducted for each catch after the fishers returned to land from fishing from the sea and inland waterbodies.

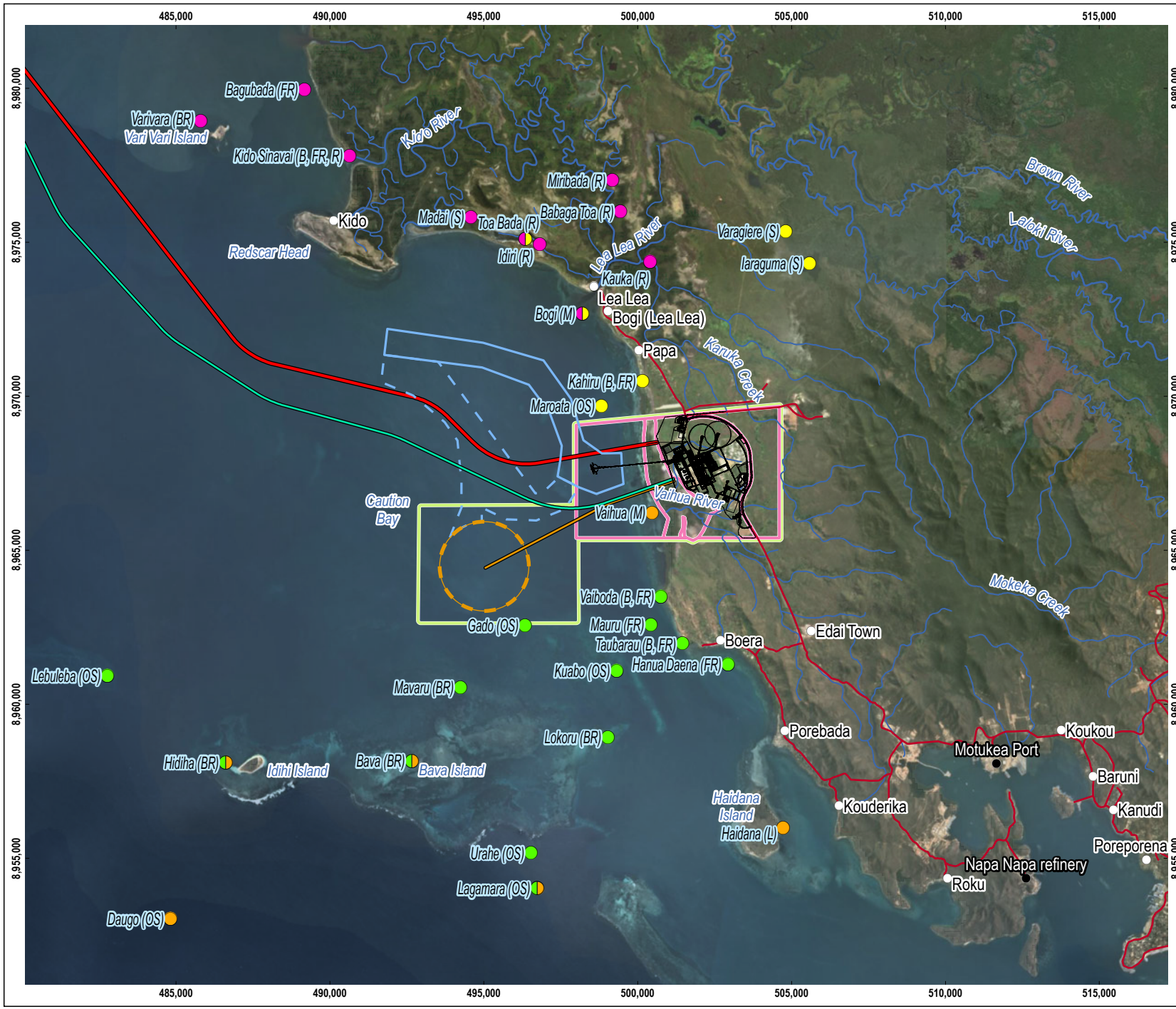
2.3.3. Vessel inventory surveys

The vessel inventory surveys recorded details of where they had been used, whether the vessel was used for fishing, frequency of use, and the fishing equipment used on board the vessel. The survey form is included in Appendix B.

The vessel inventory was completed through interviews with individual and groups of fishers who volunteered to participate in each village. The interviews were conducted by Tetra Tech Coffey staff and local assistants. Vessels returning to land from fishing as well as those moored along the shore at or near the four villages were included in the survey.

2.3.4. Market surveys

Market surveys were undertaken at the main markets where local fishers from the study area sell their catch, specifically markets located at Ranaguri, Koki, and Lawes Road, and small markets near the villages of Papa and Lea Lea. The small markets surveyed included those at Papa Beach, shopping centre market, Lea Lea Bridge and Kampa. Table 2.1 provides a general location description of each of these markets.



LEGEND

- Village
- Point of interest
- Road
- Watercourse
- PNG LNG pipeline
- Proposed Papua LNG pipelines route
- Existing and proposed plant layout
- PPFL2 boundary
- APPFL boundary
- Current navigational channel
- Proposed navigational channel
- Proposed CALM buoy
- Naphtha and condensate pipelines
- CALM buoy navigational area

Fishing site
- Boera
- Lea Lea
- Papa
- Porebada

Location type

BR	Barrier reef
B	Beach
FR	Fringing reef
L	Lagoon
M	Mangrove
OS	Open sea
R	River
S	Swamp

SOURCE
Fishing sites, infrastructure, roads, watercourses and lease boundary from EMPNGA.
Imagery from Planet Labs.

0 5 km

SCALE **1:175,000**
PAGE SIZE: **A4**
PROJECTION: **WGS 1984 UTM Zone 55S**

EXXONMOBIL PNG ANTELOPE LIMITED

PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 2.1

Caution Bay fisheries resource use study area

TETRA TECH COFFEY

DATE: 04.07.23 PROJECT: 754-MELEN300733 FILE: 224697_20_F02.01_GIS

Table 2.1 Market locations

Market	Closest village / city	Location description
Ranaguri	Port Moresby	On Spring Garden Road, opposite police headquarters.
Koki	Port Moresby	In Port Moresby, off Healy Road; east of Gabatu Motu Motu, a land-tied island.
Lawes Road	Port Moresby	On the roundabout where Champion Parade, Lawes Road and Munidubu Street intersect.
Papa Beach	Papa	At Papa village (not necessarily a permanent market site).
Shopping centre market	Papa	Between Papa village and Lea Lea village, next to a shopping centre just past Papa village.
Kampa	Lea Lea	Outside the trade store located in Lea Lea.
Lea Lea Bridge	Lea Lea	At the roundabout near the bridge in Lea Lea.

The survey identified and recorded fish species sold at each market along with their sale price, using the market survey data form (see Appendix C). Data was obtained through observation of fish sales, and interviews with stallholders when prices were not displayed. Fish species for sale were photographed with permission from the vendors.

The surveys were conducted by Tetra Tech Coffey staff with local assistants. Ranaguri market and Lawes Road market were surveyed on 27 and 28 June 2019, and Koki market on 1 July 2019. The small markets near Papa and Lea Lea were surveyed between the 24 and 28 June 2019.

2.4. Data analysis

This section describes the methods used to analyse the data collected during the surveys. The data analysis included quantitative (i.e., fishing effort, catch per unit effort and estimated earnings) and qualitative (i.e., catch composition) aspects. The analysis of these aspects is discussed below.

2.4.1. Fishing effort

A key metric used in calculations in this report is ‘fishing effort’. Fishing effort is defined as the total aggregate time (in hours) spent by all people involved in a ‘fishing trip’. A ‘fishing trip’ includes the act of fishing but also the travel to and from the fishing site. A fishing trip is defined as an event where a single fisher or group of fishers conducts a fishing event either by vessel or foot. For example, if three fishers were involved in a fishing trip that lasted one hour from departure to return, the fishing effort would be 3 x 1 = 3 hours. If one fisher was involved in a fishing trip that lasted one hour from departure to return, the fishing effort would be 1 x 1 = 1 hour. In summary, the fishing effort is the product of the duration of the fishing trip (presented as hours, h) and the number of people participating in that fishing trip (presented for simplicity as ‘fishers’).

The term ‘fisher’ in this report refers to a person involved in the fishing effort. Where total numbers of fishers are reported for all fishing trips, the number does not distinguish repeat fishers from new fishers. That is, the total numbers of ‘fishers’ reflect the number of fishing participations rather than the number of individuals that partake in fishing. This study did not determine the number of individuals from each village that fish.

2.4.2. Catch per unit effort

Catch per unit effort (CPUE) is an indirect measure of the abundance of a fish species targeted by fishing activities, and was calculated using two methods:

- As catch (in weight) per fishing effort (i.e., kg/h x fisher or kg/h/fisher). For this study, total catch weights were divided by the number of hours fished divided by the total number of fishers contributing to the fishing effort. This approach accounts for the full fishing effort. Note that the total number of hours fished also includes travel time to and from the fishing site as this contributes to 'effort' and allows for comparison to the 2012 to 2014 survey results.
- As catch (in weight) per hours of fishing per fishing trip (i.e., kg/h/trip). Total catch weights were divided by the total number of hours of each fishing trip without considering the number of fishers fishing at the same time on each trip. This calculation allows for direct comparison with the 2012 to 2014 CPUE data (which used this method) but does not account for the total effort i.e., the number of fishers per fishing trip.

2.4.3. Catch composition

The composition of the catch for each village surveyed over the four days was analysed for the following parameters:

- Total weight of fish caught
- Number of fish caught
- Average weight per fish

The diversity in the catch was determined through calculating the number of fish taxonomic families caught. The family each fish belonged to was determined through examining the photos of each fish taken by the survey team. This level of categorisation was used as it was not always possible to identify fish to species level from the photographs which often requires detailed analysis of a specimen. This approach allowed the catch composition data to be compared consistently.

2.4.4. Estimated earnings

The estimated earnings obtained by fishers in each village was determined by identifying the proportion of catch sold and the income expected to be generated from selling this fish. The average sale price on a PGK/kg basis was calculated by dividing the total gross catch income (in PGK) by the total weight of fish sold (kg) for each village.

The expected income per hour of fishing effort can then be determined by dividing the total gross catch incomes (in PGK) per village by the total fishing hours (i.e., fishing effort) per village (which accounts for all fishers' hours). Incomes could not be determined on an individual fisher basis as data collected did not distinguish how much income and catch was attributable to each individual on a given fishing trip.

In some survey responses, respondents did not provide data for sold fish. In these instances, it was assumed that those fish were consumed.

2.5. Survey limitations

The results of the 2019 surveys provide a general understanding of the fishing methods and catches (in terms of key fish types and catch per unit effort) for the study area residents. The quantitative results presented in this report are subject to the following limitations:

- A breakdown by duration of the catch landing survey data for each quarter of each year was not available from the historic (2012 to 2014) reports and similarly for some years (e.g., 2014) only annual data was provided. Consequently, it is not understood how the quarterly monitoring conducted in these years compares to the four-day catch landing survey effort recorded in Q2 2019.

- Variables such as weather, fishing equipment used, and travel time to fishing grounds were not controlled for in the survey design in 2019 or for the 2012 to 2014 surveys. Comparison of seasonal variations between the Q2 2019 results and the historic data was also limited as overall numbers for each year are not broken down by quarter for 2014 data and only some quarterly reports were available for review for other years.
- Catch per unit effort is generally calculated using datasets that span a longer period, usually years (e.g., FAO 2002). The 2019 survey was undertaken over four days in each village and provides an indication of CPUE over this period only.
- Survey participation was voluntary and therefore the survey did not record all catch in each village. Boera had a low participation rate due to community dissatisfaction that the local survey team used in previous surveys was not rehired.
- Surveys were conducted during daylight hours (for security reasons). Most vessels return to the village at dawn and dusk and therefore most fishers had an opportunity to participate in the surveys. Fishers who arrived back in the villages overnight were not able to participate in the catch landing surveys.
- The first day of the survey in each village was a training day for the survey team with actual surveying starting later this day (after training) and was likely to have resulted in lower numbers of interview respondents during the first day as fishers returning at dawn were not surveyed.

3. Results from the 2019 surveys

Table 3.1 details the timing of the catch landing and vessel inventory surveys conducted for each village and any weather observations made when the surveys were conducted.

Table 3.2 Survey dates and weather conditions during surveys

Village	Survey date	Catch landing survey	Vessel inventory	Weather observations
Boera	12 June 2019	✔ (training day)	-	Sunny, strong south-easterly winds
	13 June 2019	✔	✔	Sunny, light south-easterly winds
	14 June 2019	✔	✔	Sunny, strong south-easterly winds
	15 June 2019	✔	✔	Hot and sunny
Lea Lea	26 June 2019	✔ (training day)	-	Dull skies, south-easterly winds and light showers
	27 June 2019	✔	✔	Early morning showers, sunny by 9am, moderate south-easterly winds
	28 June 2019	✔	✔	Sunny day with moderate south-easterly winds
	29 June 2019	✔	✔	Sunny day with moderate south-easterly winds
Papa	24 June 2019	✔ (training day)	-	Cloudy with scattered showers
	25 June 2019	✔	✔	Cloudy with scattered showers
	26 June 2019	✔	✔	Dull skies, south-easterly winds and light showers
	27 June 2019	✔	✔	Early morning showers, sunny by 9 a.m., moderate south-easterly winds
Porebada	17 June 2019	✔ (training day)	-	Hot and sunny
	18 June 2019	✔	-	Hot and sunny
	19 June 2019	✔	-	Hot and sunny. Windy conditions and rough seas since previous night.
	20 June 2019	✔	✔	Hot and Sunny

3.1. Catch landing surveys

The following sections present the results from the catch landing surveys conducted in 2019.

3.1.1. Catch landing participant statistics

Table 3.2 presents a summary of the catch landing survey participant statistics. For each village, the data includes the number of fishers that contributed to the overall fishing effort in the dataset (this number likely includes repeat fishers; in other words, this data was used to calculate total fishing effort not the number of different individuals fishing), the number of interviews conducted with the lead fishers and the number of interview participants, village population, average percentage of population fishing per day, average number of fishers per fishing trip and the total number of fishing trips. The

surveys were undertaken over several days with some participants interviewed more than once resulting in the number of participants being lower than the number of interviews undertaken.

Table 3.3 Summary of data on catch landing survey participants

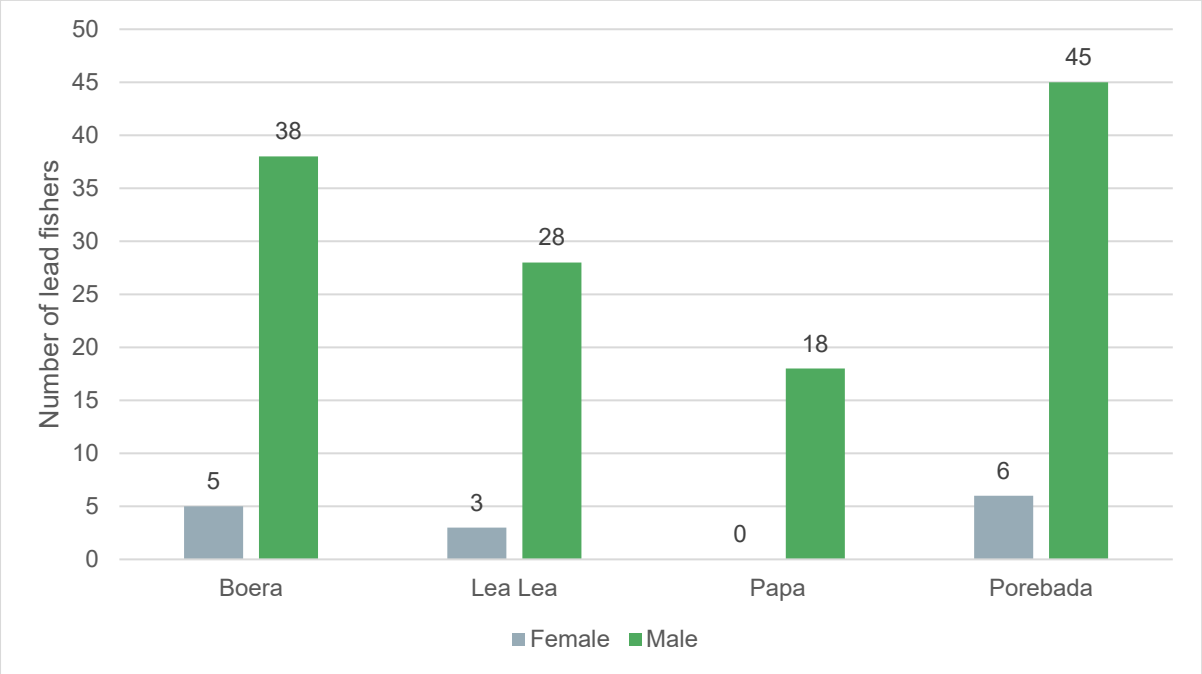
Village	Total number of fishers[a]	Number of interviews	Number of interview participants	Village population[b]	Percentage of population participating in fishing per day (average)[b]	Average number of fishers per fishing trip[c]	Total number of fishing trips
Boera	177	56	43	3,178	1.6%	3.8	115
Lea Lea	170	38	31	4,577	1.1%	4.6	96
Papa	30	22	18	2,415	0.4%	1.4	91
Porebada	208	56	51	7,193	0.8%	3.7	184

(a) Note, this is the total number of participants in all fishing trips over the 3.5 day survey period and the number likely includes repeat fishers. In other words, this data was used to calculate total fishing effort not the number of different individuals fishing.
(b) Source: Coffey 2019.
(c) These numbers are an average of the daily percentage over the 4 day survey period only

Table 3.2 shows that Lea Lea, Boera and Porebada had the highest number of recorded fishers and Papa had a significantly lower number of fishers. This is reflected by the lower number of interviews at Papa and is also due to the smaller fishing groups from that village. Papa fishers were in groups ranging between one and three fishers per fishing trip (i.e., on a single vessel if vessel used for fishing), compared to up to 14 fishers per fishing trip at Boera, up to 10 fishers per fishing trip at Porebada, and up to eight fishers per fishing trip at Lea Lea. Boera had the highest fishing participation rate with an average of 1.6% of the population recorded fishing each day, while Papa had the lowest participation rate with an average of 0.4% of the population recorded fishing each day. The highest total number of fishing trips was recorded at Porebada, while the lowest was recorded at Papa.

The gender of each lead fisher interviewed was recorded as part of the survey (Figure 3.1). The number of male lead fishers was much higher than the number of female lead fishers in each village. This result is consistent with previous studies (e.g., Coffey Natural Systems 2008), which found that offshore fishing is primarily a male activity, while women were more commonly involved in mud crab and shellfish collection in the mangroves. No lead female fishers were recorded in Papa.

Figure 3.2 Gender of lead fishers participating in the survey



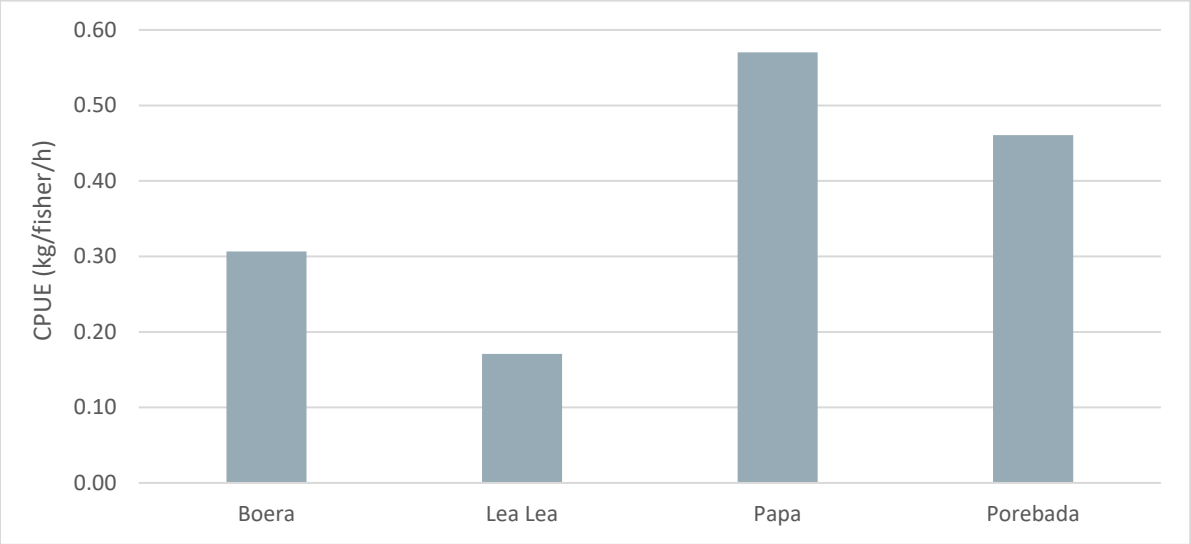
3.1.2. Catch per unit effort

Table 3.3 and Figure 3.2 present the total CPUE (kg/h/fisher) recorded at each village over the four-day survey period. The CPUE is calculated by dividing the weight of fish caught by the total fishing hours (including time spent fishing and travel time to and from the fishing site) for all fishers participating in the fishing effort (i.e., it accounts for the full fishing effort over that period, not the number of individual fishers).

Table 3.4 Catch for unit effort (kg/h/fisher) by village over the survey period

Village	Total weight fish caught (kg)	Total fishing hours for all fishers (i.e., total fishing effort) (h)	CPUE (kg/h/fisher)
Boera	520.9	1699.6	0.31
Lea Lea	320.7	1,876.3	0.17
Papa	70.9	124.3	0.57
Porebada	756.1	1,640.8	0.46

Figure 3.3 Catch per unit effort calculated for each village over the survey period



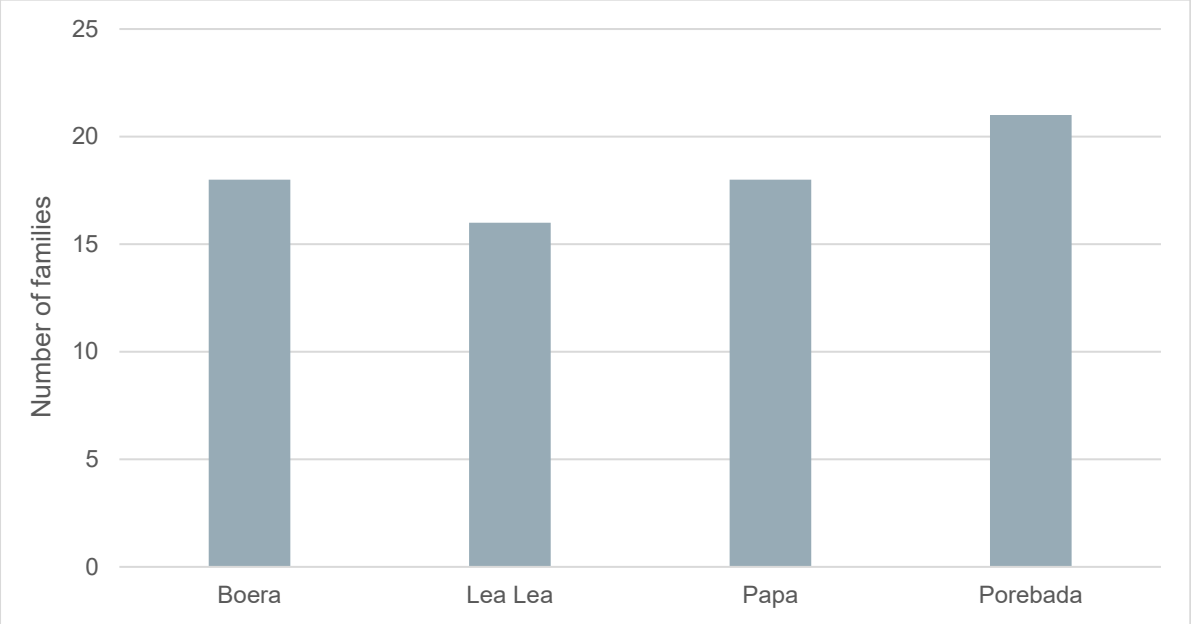
3.1.3. Catch weight and composition

Catch composition recorded for each village during the survey is shown in Table 3.4. The number of fish taxonomic families caught across all four villages ranged from 15 to 21 (Figure 3.3), indicating that, overall, the diversity of catch is similar between villages.

Table 3.5 Catch composition for each of the four survey villages

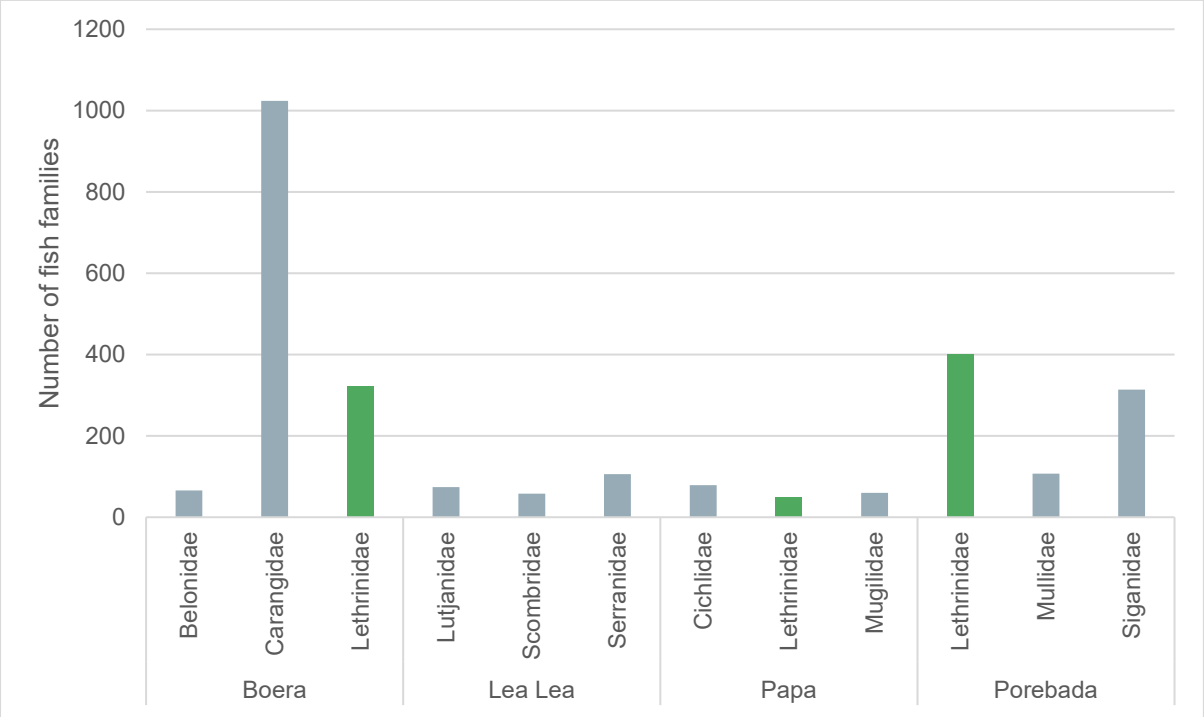
Parameter	Village			
	Boera	Lea Lea	Papa	Porebada
Number of fish families caught	18	16	18	21
Total weight of fish (kg) caught	520.9	320.7	70.9	756.1
Number of fish caught	1,775	607	339	1,164
Average weight per fish (kg)	0.29	0.53	0.21	0.65

Figure 3.4 Number of fish families caught by village



The three most common families of fish caught in each village are shown in Figure 3.3, as well as the number of individual fish that were caught from each family.

Figure 3.5 Common fish families of the fish species caught in each village



The results show that fishers in Porebada caught the greatest total weight of fish, as well as the greatest variety of fish (in terms of fish families). Boera caught the second most varied range of fish families and recorded the highest number of total fish, dominated by species form the family Carangidae. This family includes jack mackerel and scads (Plate 3.1). Lethrinidae (green bars in Figure 3.4) was the most common fish family caught at Boera and Porebada and the third most common at Papa, and includes species such as bream, emperor bream and emperor (Plate 3.2).

Photo credit: Coffey

Plate 3.1
Scads (Family: Carangidae) at fish market

Photo credit: Coffey

Plate 3.2
Emperors (Family: Lethrinidae) at fish market

3.1.4. Catch earnings

Figure 3.5 presents the total weight of fish landed by the fishers surveyed and the proportion of that catch consumed and sold for each village. The results show that most of the catch from Lea Lea and Porebada fishers was sold (83% and 76%, respectively), whereas approximately two-thirds and more than half of the catch from Boera and Papa fishers was consumed (64% and 55%, respectively).

Figure 3.6 Total weight of fish caught, and expected to be consumed and sold over the survey period

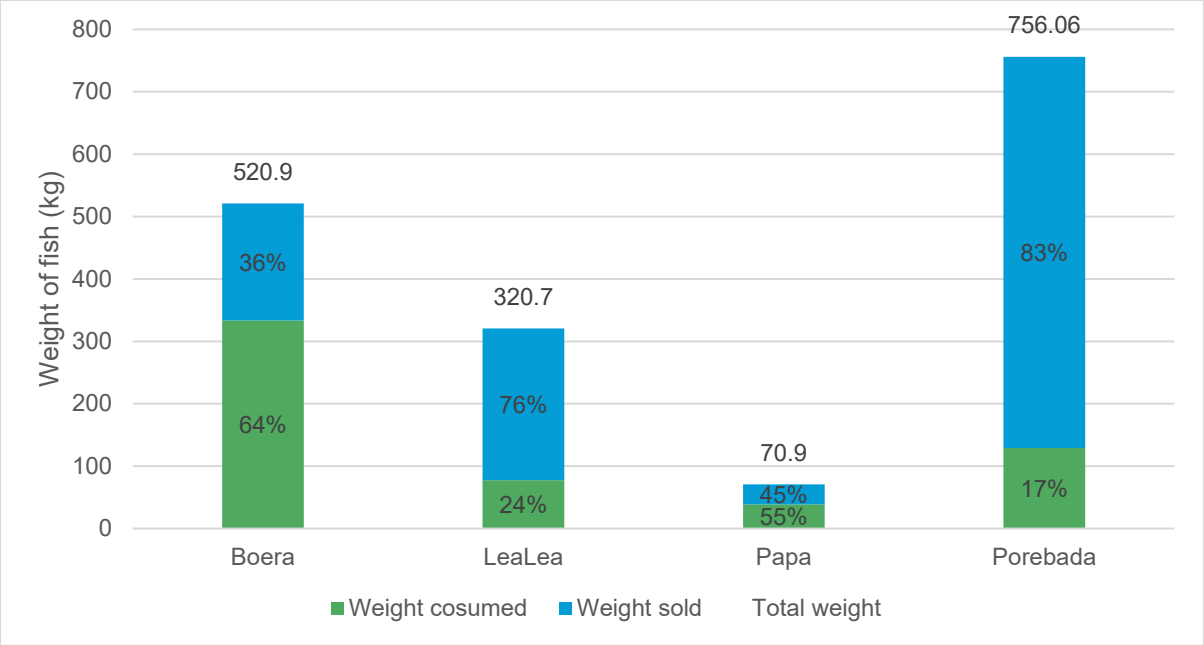
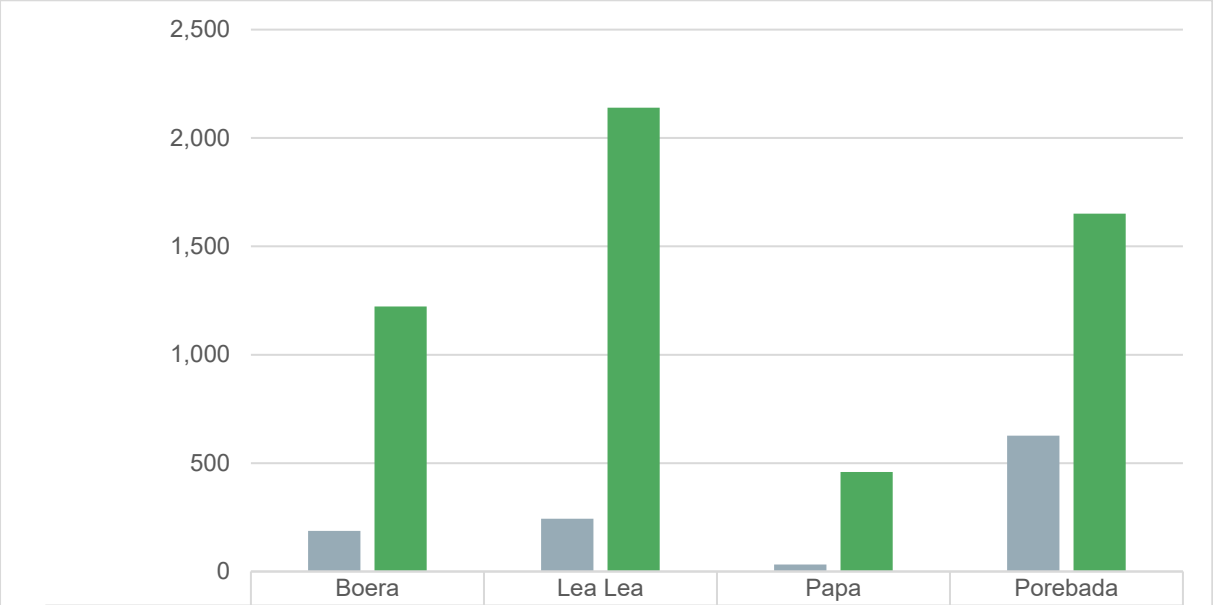


Figure 3.6 presents the total expected income from the sale of fish along with the weight of the fish sold.

Figure 3.7 Total expected income generated by sale of fish catch over the survey period



	Boera	Lea Lea	Papa	Porebada
Weight sold (kg)	187.3	243.2	32.1	626.9
Income (PGK)	1223	2140	459	1651

The highest total income per village expected from the sale of fish during the survey period was recorded at Lea Lea (2,140 PGK), followed by Porebada (1,651 PGK), Boera (1,223 PGK) and Papa (459 PGK). Lea Lea fishers had less fish to sell (by weight) than Porebada fishers, which indicates

that Lea Lea fishers expect to sell higher-value species and/or sell their catch at markets that fetch higher prices (Table 3.5).

Table 3.5 presents the average expected sale price per kilogram for the catch that was expected to be sold in each village and the gross expected income on a PGK per fishing hour basis. As described in Section 2.4.4, income can only be derived on a 'fishing hour' basis, not per fisher.

Table 3.6 Average expected sale price and gross income per fishing hour

Village	Average expected sale price per kilogram (PGK/kg)	Gross expected income per fishing hour (PGK/h/fisher)
Boera	6.53	1.14
Lea Lea	8.80	1.30
Papa	14.30	3.94
Porebada	2.63	0.88

The results indicate that fishing is most lucrative (higher expected income per hour) for Papa fishers, whose catch is sold at a higher price per unit weight and the CPUE is the highest of all the villages. The data does not consider the cost of fuel for fishing trip or other additional fishing-related costs (i.e., it represented a gross income calculation and is not an indication of profit).

3.1.5. Fishing equipment

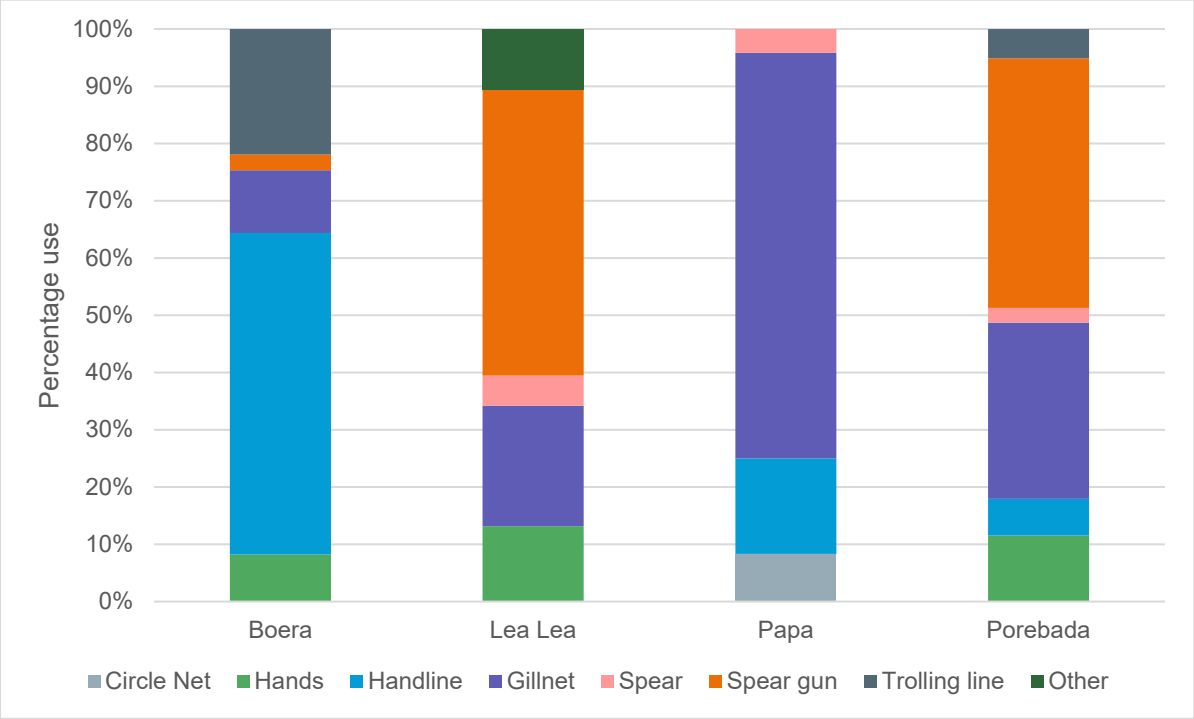
Table 3.6 presents the different types of fishing equipment used in each village and the total number of interview respondents who used each type over the survey period.

Table 3.7 Fishing equipment use at each village

Village	Circle net	Hands	Handline	Gillnet	Spear	Spear gun	Trolling line	Other
Boera	0	6	41	8	0	2	16	0
Porebada	0	9	5	24	2	34	4	0
Papa	2	0	4	17	1	0	0	0
Lea Lea	0	5	0	8	2	19	0	4

Fishing equipment use by respondents interviewed in each village is also shown in Figure 3.7 as a percentage to allow a direct comparison between villages (i.e., accounts for the different number of interviews between villages).

Figure 3.8 Equipment use percentages by respondents interviewed in each village



The primary equipment types used for fishing differed between the villages. Handline use was most common for Boera fishers, spear gun use was most common for Porebada and Lea Lea fishers, and gillnet use was most common for Papa fishers. Hands were used to catch sea urchins in fringing and barrier reefs and crabs and molluscs along the beaches and mangroves. In all cases where the lead fisher was female, the fishing method was by hand collection.

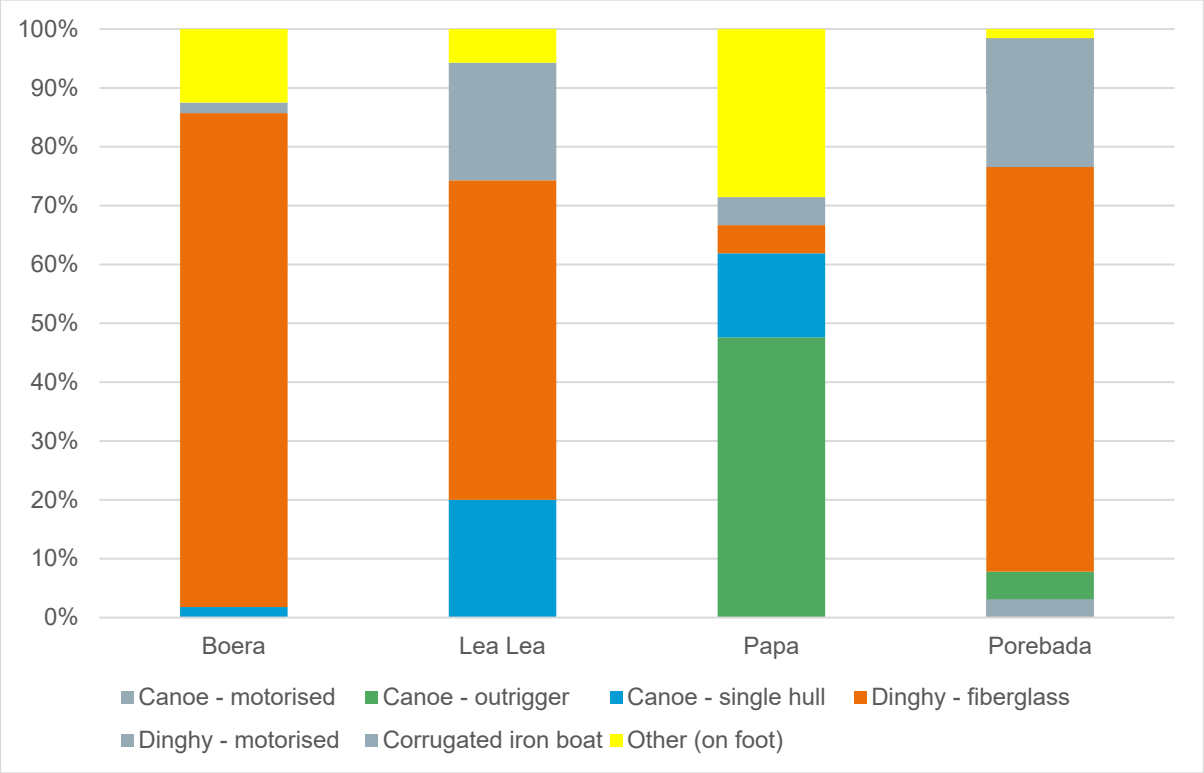
3.1.6. Vessel types

Table 3.7 presents the total number of each vessel type at each village recorded during the vessel inventory survey. Figure 3.8 presents the use of each vessel type by the respondents to the survey as a percentage for each village.

Table 3.8 Vessel type use at each village

Village	Canoe - motorised	Canoe - outrigger	Canoe - single hull	Dingy - fiberglass	Dingy - motorised	Other (corrugated iron boat)	Other (on foot)
Boera	0	0	1	47	1	0	7
Lea Lea	2	3	0	44	8	6	1
Papa	0	10	3	1	1	0	6
Porebada	0	0	7	19	7	0	2

Figure 3.9 Vessel type usage for survey respondents by village



Fiberglass dinghy was the most common vessel type used by fishers interviewed in Boera, Porebada and Lea Lea, as well as overall. For Papa fishers, the most common vessel type used was an outrigger canoe.

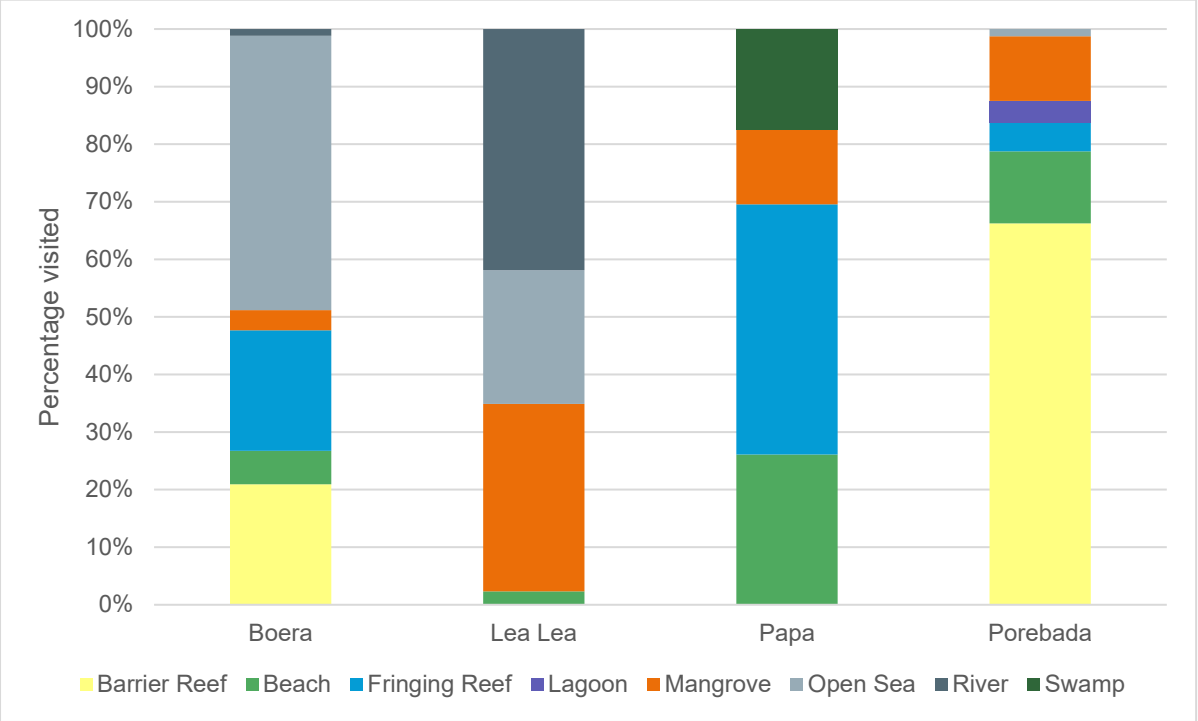
3.1.7. Fishing locations

The habitat types at each fishing location targeted by the four villages were identified during the surveys, with results presented in Table 3.8. Locations identified by fishers are shown in Figure 2.1. Figure 3.9 presents the habitat type for each fishing location as a percentage for each village.

Table 3.9 Habitat types at each location fished (as identified by fishers) during the survey period

Village	Barrier reef	Beach	Fringing reef	Lagoon	Mangrove	Open sea	River	Swamp
Boera	18	5	18	0	3	41	1	0
Lea Lea	0	1	0	0	14	10	18	0
Papa	0	6	10	0	3	0	0	4
Porebada	53	10	4	3	9	1	0	0

Figure 3.10 Habitat types at fishing locations visited by respondents from each village



Over the survey period, fishers from each village conducted most of their fishing at habitats that were in proximity to their respective villages. For example, Boera fishers mainly fished in the open sea, Lea Lea fishers mainly fished in rivers, Papa fishers at fringing reefs, and Porebada fishers predominantly fished at barrier reefs.

3.2. Vessel inventory

Table 3.9 provides a breakdown of the use of vessels in each village over the survey period, i.e., for fishing, fishing and other activities, or for non-fishing activities only.

Table 3.10 Vessel uses in each village

	Number of vessels		
Village	**Fishing only**	**Fishing and other***	**Other* uses only**
Boera	6	0	0
Lea Lea	1	44	0
Papa	5	5	0
Porebada	2	8	3

* 'Other' includes transport and collection of marine resources other than fish

The results show that in Boera, the vessels surveyed were used exclusively for fishing purposes. In Lea Lea, Papa and Porebada vessels were used for both fishing exclusively, as well as fishing and other activities. Porebada was the only village surveyed which recorded vessels which were not used for fishing.

3.3. Market surveys

The number of different fish and other marine species recorded at each market surveyed is shown in Figure 3.10. The markets in Port Moresby generally had the largest range of seafood for sale, with the Koki fish market having the greatest range of species available to consumers. Lea Lea Bridge had the second highest number of marine species available for purchase. The market at Papa Beach had only one species for sale.

Figure 3.11 Number of fish species identified at each market place

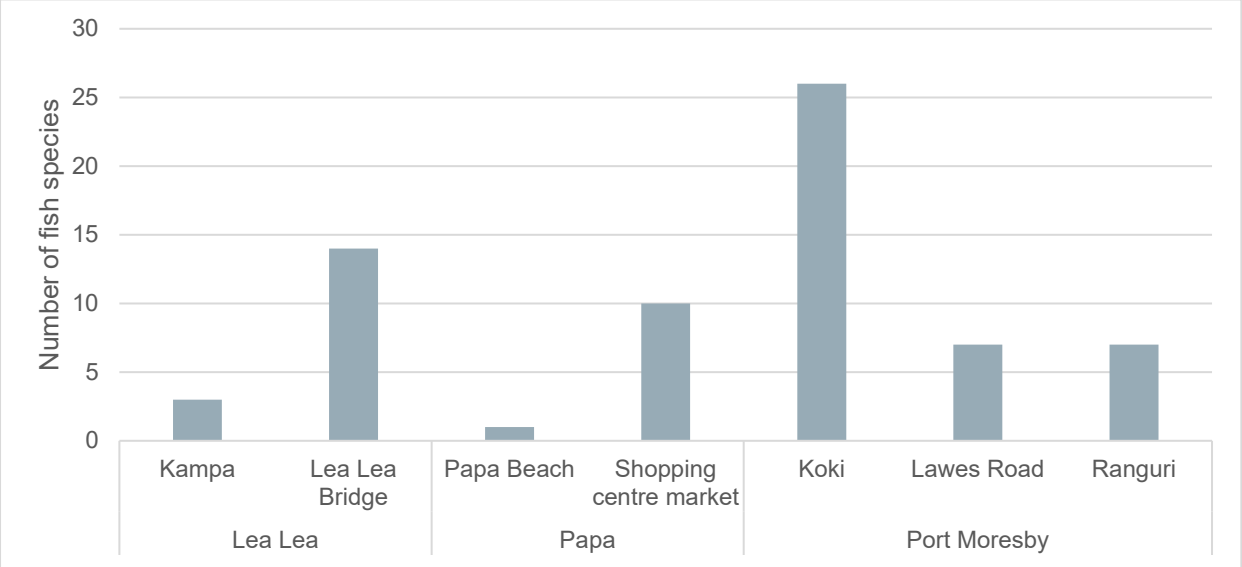


Figure 3.11 to Figure 3.13 show the number of fish species sold in markets around Lea Lea, Papa and Port Moresby respectively, as well as the average cost of each species (per fish). Green bars on the graphs in Figure 3.11, Figure 3.12 and Figure 3.13 represent the fish species sold at markets that were also caught by fishers from at least one of the four villages during the catch landing surveys.

Figure 3.12 Number of fish and average cost per species for sale at Lea Lea markets

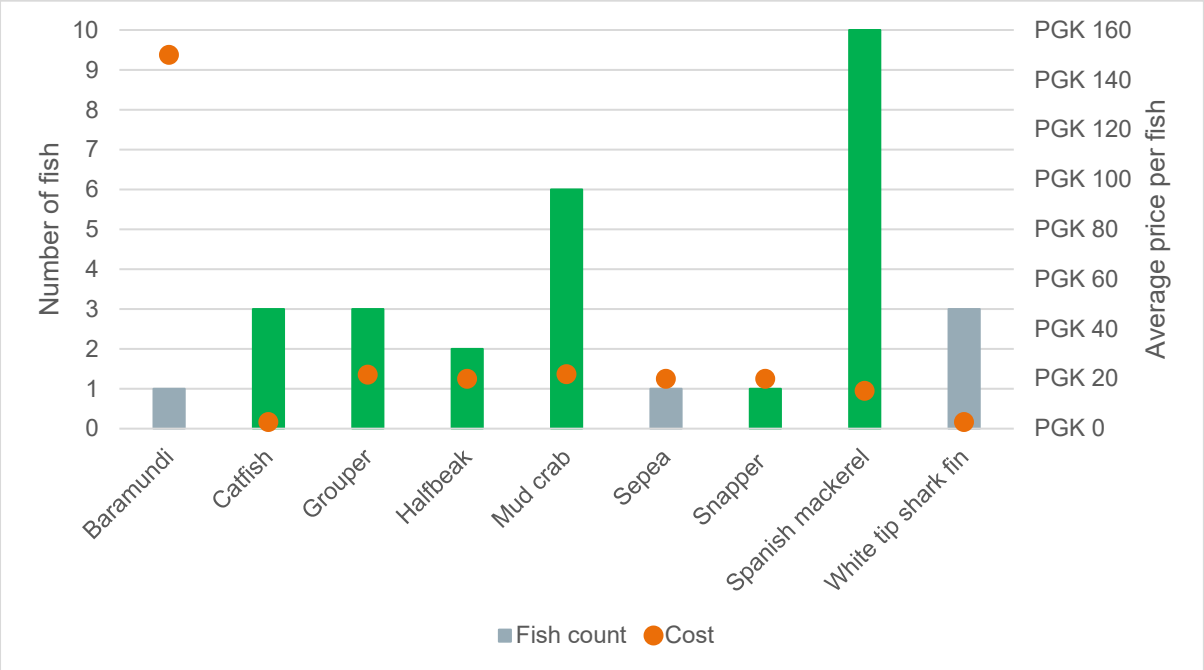


Figure 3.13 Number of fish and average cost per species at Papa

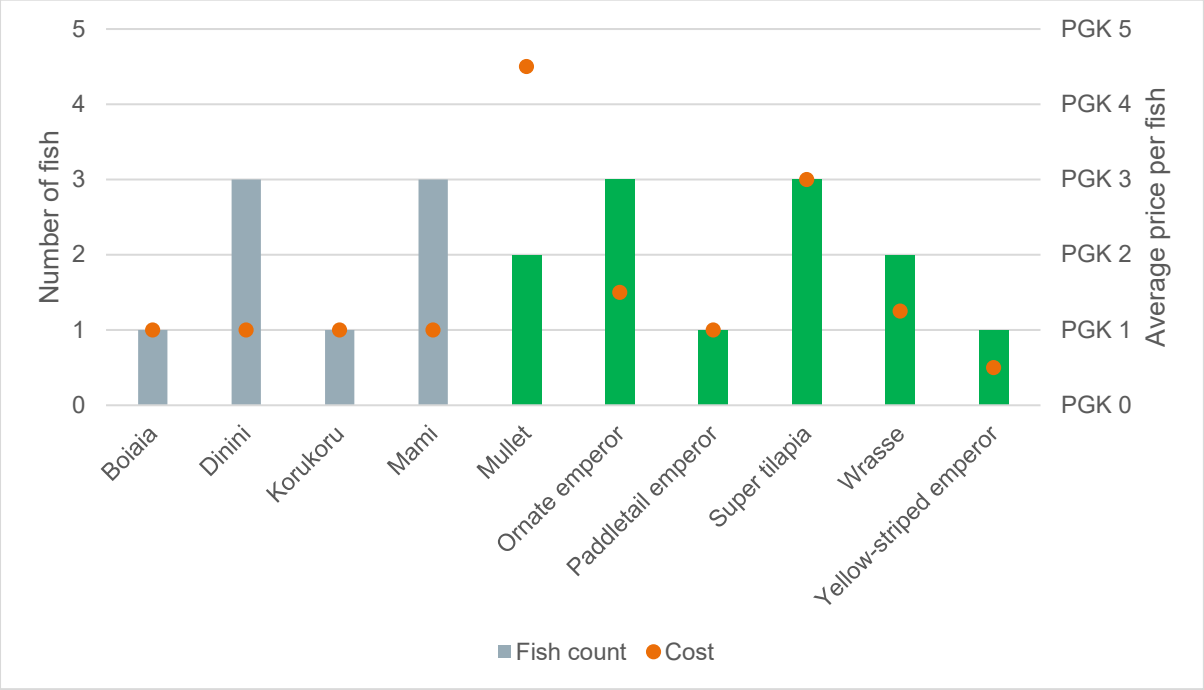
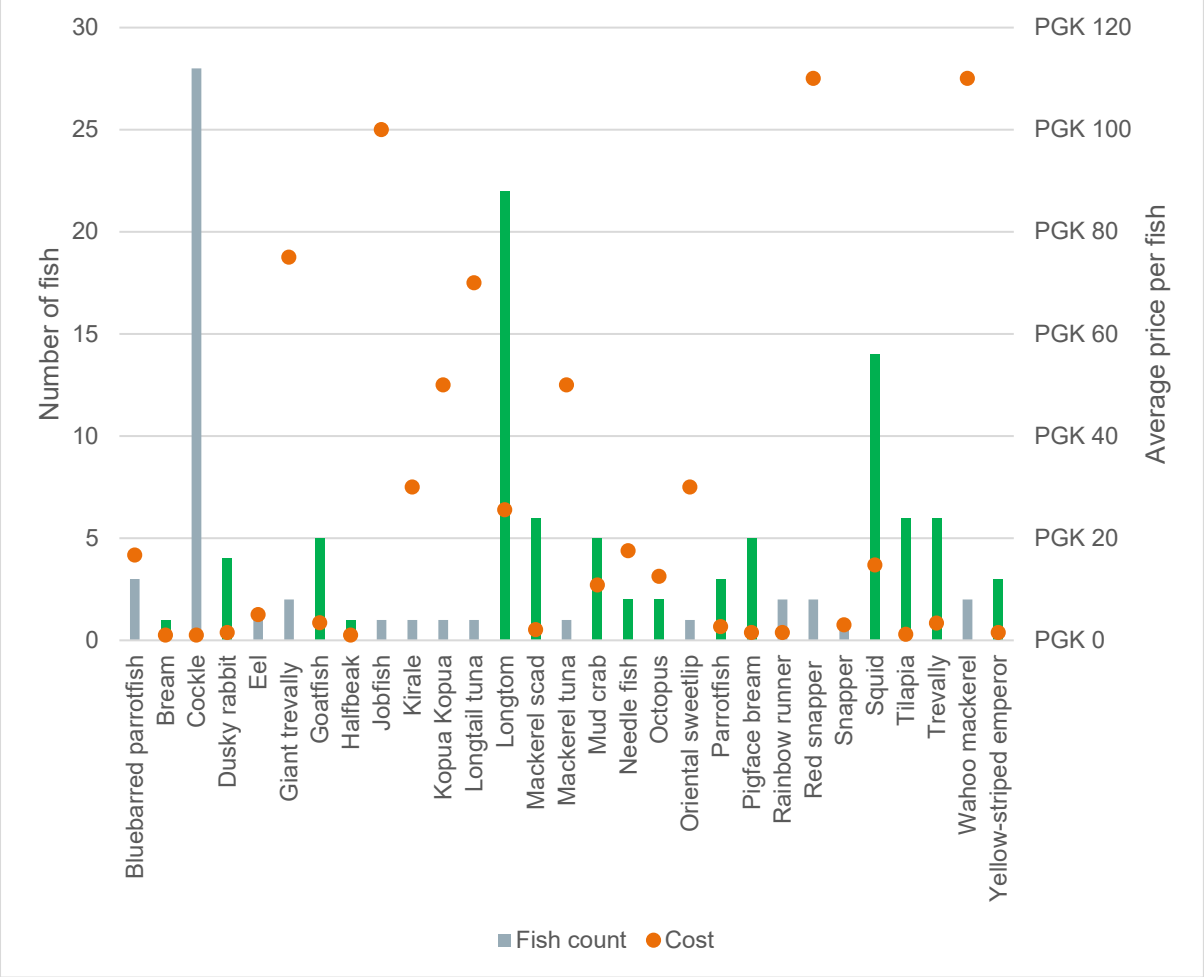


Figure 3.14 Number of fish and average cost per species at Port Moresby



Barramundi was the most expensive fish being sold in Lea Lea, with a price of PGK 150 per fish, although only one barramundi was for sale. Generally, fish that were more common were being sold at a cheaper price. Spanish mackerel (Plate 3.3) was the fish most frequently for sale in Lea Lea at an

average cost of about PGK 15 per fish. The cheapest seafoods for sale in Lea Lea were catfish and white tip shark fin (Plate 3.4) for an average of PGK 2.67 per fish.

The fish species identified at Papa markets were all being sold within a narrow price range (mostly 1 to 5 PGK). The cheapest fish at the Papa markets was the yellow-striped emperor (Plate 3.5) and the most expensive fish was mullet (Plate 3.6). The price for the sole yellow-striped emperor was PGK 0.5 and the average price for the two mullets was PGK 4.50.

At markets in Port Moresby, red snapper and wahoo mackerel each occurred twice in total, with average prices per fish of PGK 110. The jobfish (Plate 3.7) was observed only once, for a price of PGK 100. The shellfish cockle (Plate 3.8) were the most common marine species being sold and amongst the cheapest species for sale overall, being sold in bundles of four for PGK 1. The next most available fish were longtom (Plate 3.9) and squid (Plate 3.10), selling for an average price of PGK 25.5 and PGK 14.7 per fish, respectively.

The survey sought to compare the prices of fish for sale at markets in the villages with the sale prices of fish in Port Moresby. Only one species occurred at both a village and Port Moresby market. The yellow-striped emperor was found at markets in Papa, selling for an average of PGK 0.50 per fish, and in Port Moresby, selling for an average of PGK 1.50 per fish. This price difference could indicate that fresh fish are worth more in Port Moresby than in Papa and/or may be due to varying sizes of fish for sale.

Super tilapia (Plate 3.11) was identified for sale at markets in Papa and tilapia was identified in Port Moresby. Super tilapia is a genetically improved strain of tilapia that has been developed as a fast-growing species to help feed growing populations around the world, including in Papua New Guinea. The average cost of super tilapia in Papa was PGK 3 and the average price of tilapia in Port Moresby was PGK 1.67.

Photo credit: Coffey

Plate 3.3
Juvenile Spanish makerel (Family: Scombridae) at fish market

Photo credit: Coffey

Plate 3.4
White tip (Family: Carangidae) fins at fish market

Photo credit: Coffey

Plate 3.5
Yellow-striped emperor Lethrinus ornatus (Family: Lethrinidae) at fish market

Photo credit: Coffey

Plate 3.6
Mullet sp. (Family: Mullidae) at fish market

Photo credit: Coffey

Plate 3.7
Jobfish sp. (Family: Lutjanidae) at fish market

Photo credit: Coffey

Plate 3.8
Cockle at fish market

Photo credit: Coffey

Plate 3.9
Longtom (Family: Belonidae) at fish market

Photo credit: Coffey

Plate 3.10
Squid at fish market

Photo credit: Coffey

Plate 3.11
Tilapia (Family: Cichlidae) at fish market

4. Comparison to 2012 to 2014 survey results

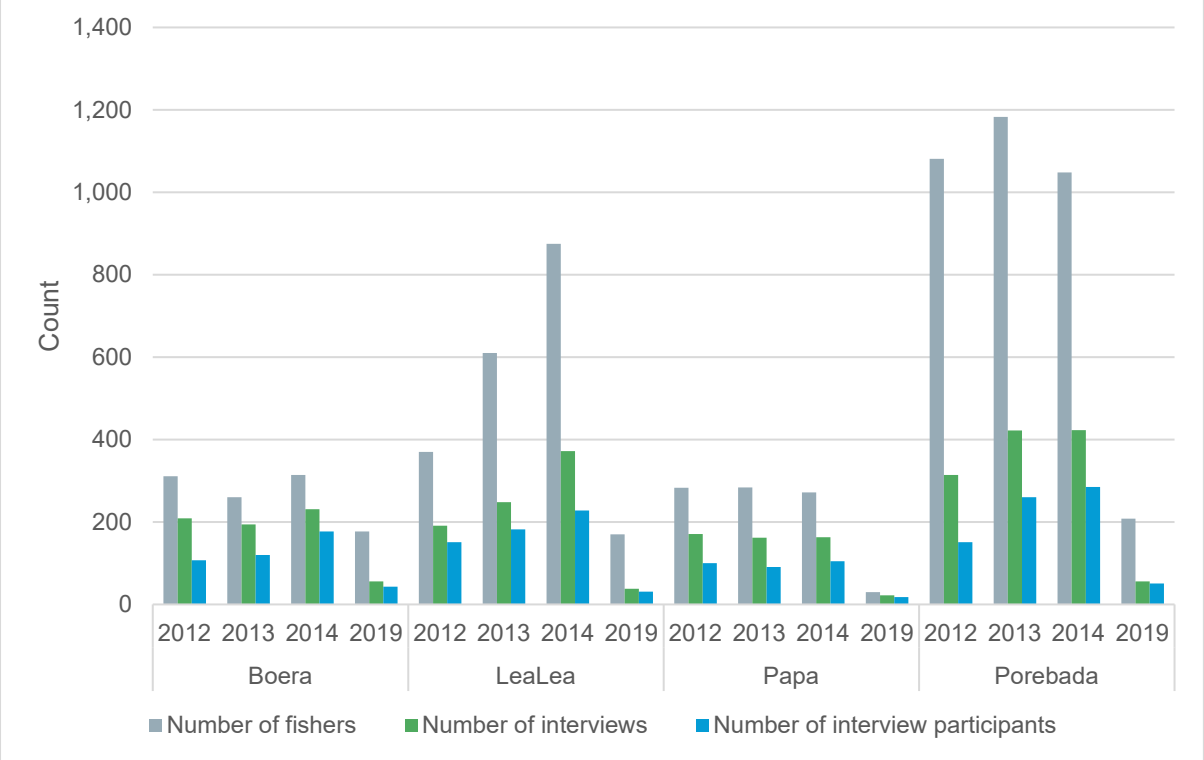
This chapter compares catch landing and market data collected in 2019 to data from 2012 to 2014. Vessel inventory and market survey data was not collected in previous survey years.

4.1. Catch landing participant statistics

Figure 4.1 provides an overview of the catch landing participant statistics from 2012, 2013, 2014 and 2019. Between 2012 and 2014, 3,100 catch landing surveys were conducted, representing 6,891 fisher participations in the fishing effort (i.e., the number of fishing trips multiplied by the number of fishers involved in each trip; this is not the number of different individuals who fish). For simplicity, this metric is referred to as 'fishers' in this section. The 2019 data was consistent with previous years' data, with Porebada having the highest number of fishers.

As expected, the data from 2019 generally had lower numbers of fishers than in previous surveys, reflective of the reduced survey effort in 2019 (i.e., one survey in Q2 2019 compared to four quarterly surveys in each of the previous years (2012 to 2014). The survey durations also varied between surveys.

Figure 4.15 Number of fishers, interviews and participants in surveys undertaken in 2012 to 2014 and 2019

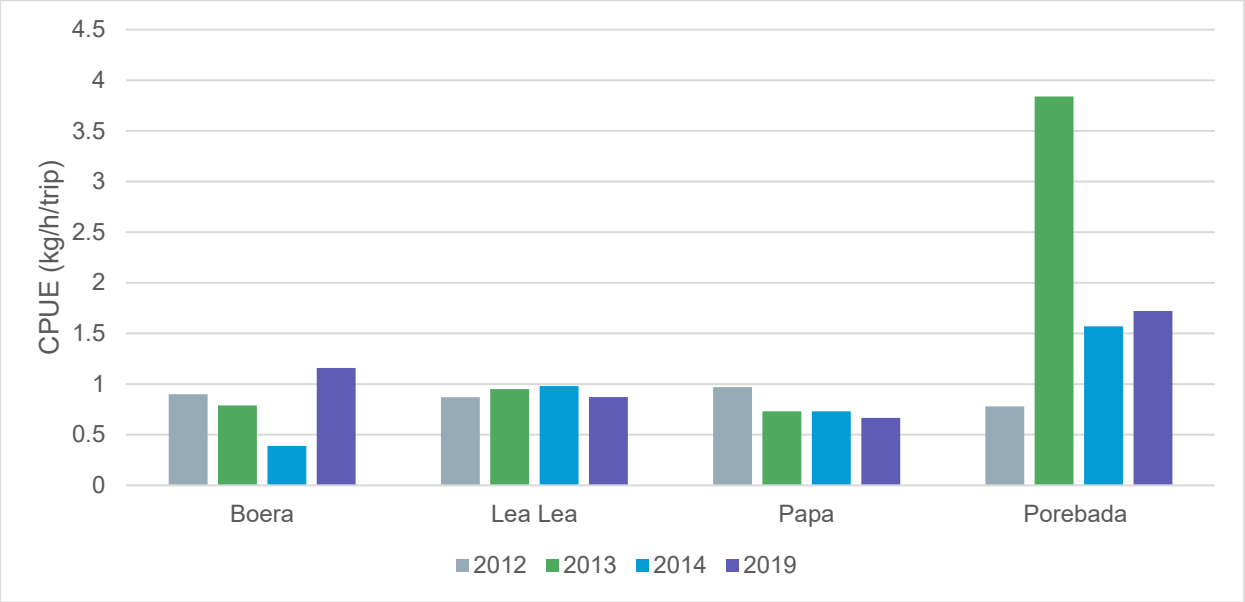


4.2. Catch per unit effort

The CPUE in previous reports was calculated by dividing 'catch' as defined by the total weight of all fish in kilograms caught in each village by the 'effort' as defined by the total time spent fishing per trip (kg/h/trip). This method differs from the typical approach of calculating CPUE (section 2.3.2) as it does not consider the number of fishers participating in each fishing trip (and therefore underestimates total effort and overestimates CPUE). For example, under this method, a fishing trip comprising two fishers fishing for one hour is the same effort as a fishing trip comprising one fisher fishing for one hour.

To allow for comparison with previous data, the 2019 CPUE was calculated using the kg/h/trip method with results shown in Figure 4.2.

Figure 4.16 Catch per unit effort (kilograms per hour per trip) fished for each village



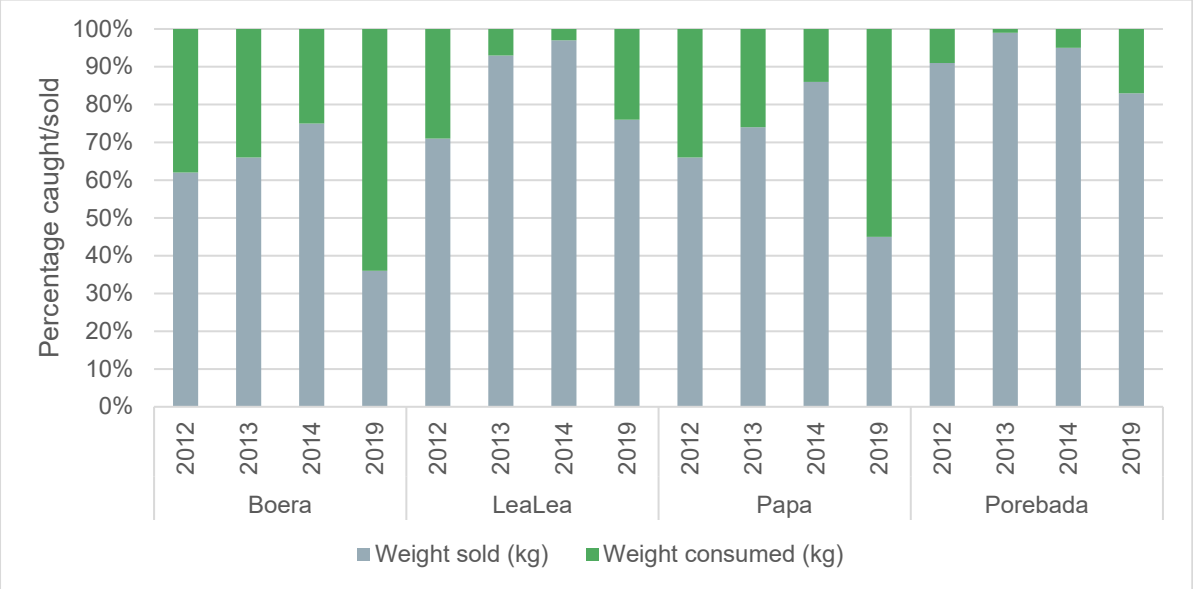
Using this method, the catch per unit effort has been fairly consistent for Boera, Lea Lea and Papa across the survey years. The catch per unit effort for Porebada has been more variable.

The lowest CPUE was recorded in 2014 in Boera (0.39 kg/h/trip). The highest CPUE occurred in 2013 at Porebada (3.84 kg/h/trip) and could be the result of much larger individual fish being caught (as recorded in the surveys). Several sharks were caught that year (with a total weight of 115 kg), as well as large species of longtom, which comprised 92% of the total catch weight in the third quarter of the year (ExxonMobil 2015).

4.3. Catch weight and composition

The percentage of total catch that was sold or kept for personal consumption (by weight) is presented in Figure 4.3. Total catch statistics per year over all surveys are not presented as the survey effort (i.e., duration of each survey) varied across years.

Figure 4.17 Percentage of total catch sold and kept for personal consumption (by weight) at each survey village

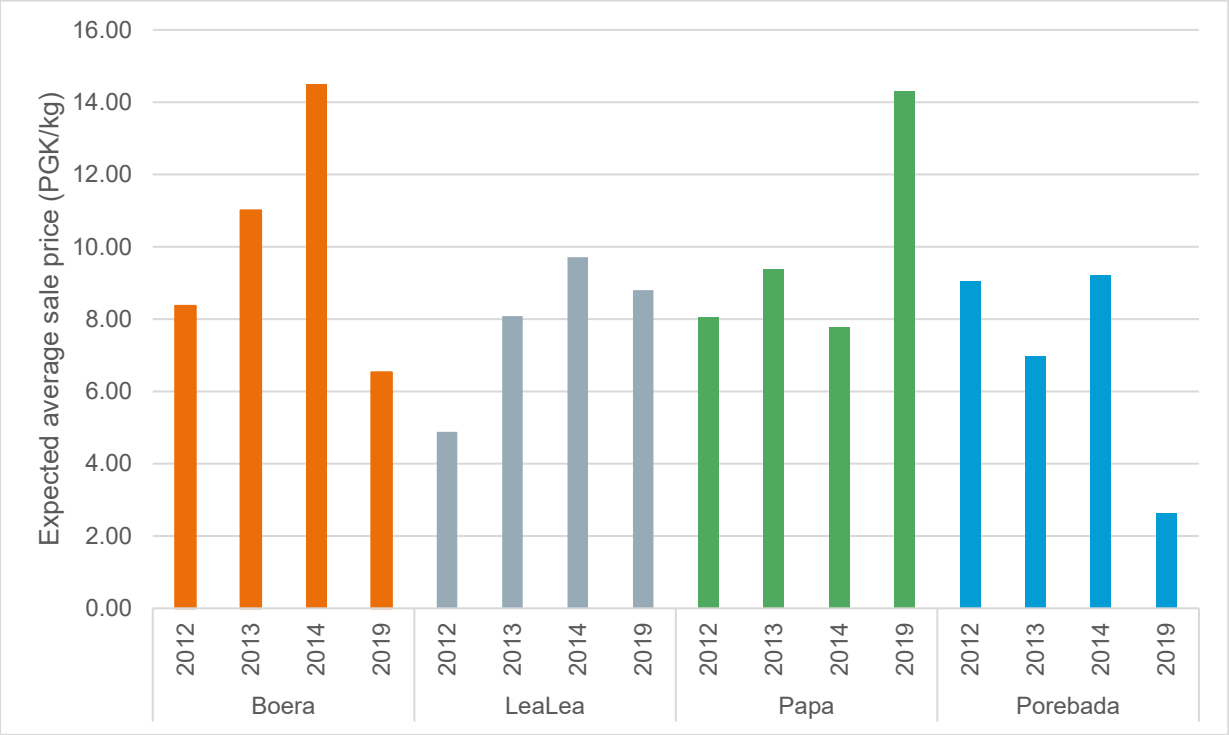


Fishers from Boera and Papa kept more catch for personal consumption in 2019 (greater than 50% of the total catch was retained) than in the other survey years where personal consumption accounted for 14% to 38% of the total catch in the two villages. Fishers from Porebada and Lea Lea sold 83% and 76% of their total catch during the 2019 survey period, respectively, which consistent with data collected from previous years.

4.4. Catch earnings

To account for the varying survey effort across each year, catch earning comparisons were made on an 'expected sale price per kilogram of fish basis' rather than comparing total income from fish sales. Figure 4.4 shows the average sale price per kilogram of fish (PGK/kg) that each village expected to attract during each survey year.

Figure 4.18 Expected average sale price per kilogram of catch sold by village



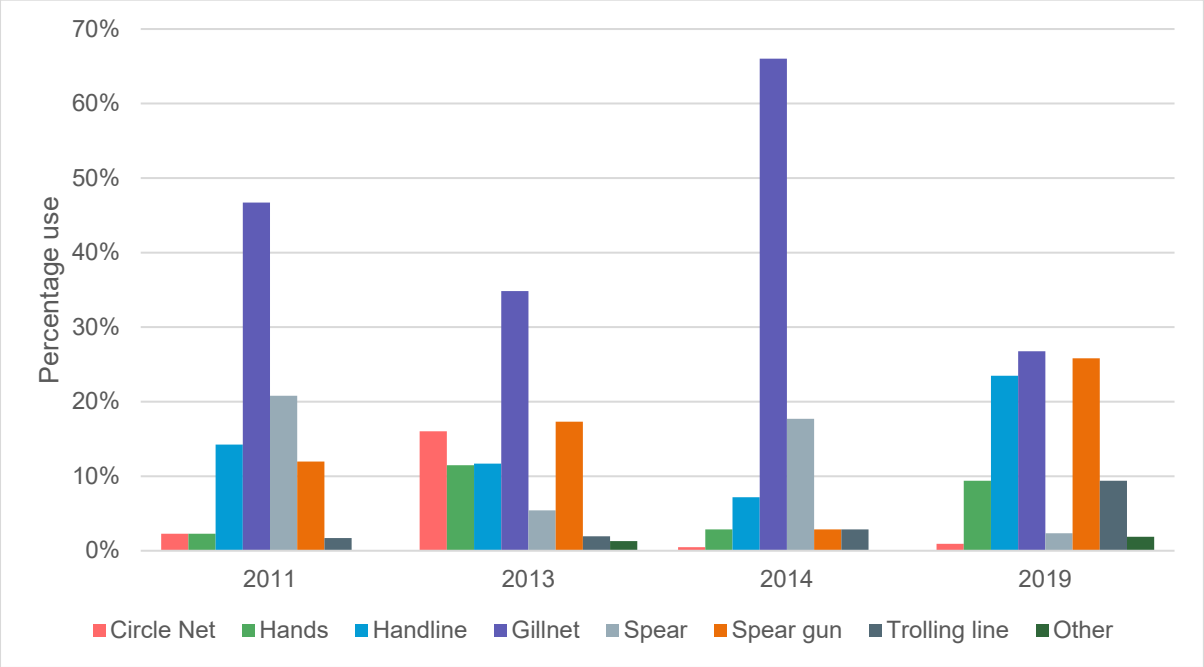
During the 2019 survey period, Papa fishers expected to receive the highest sale price per kilogram which was also more than what they expected to receive in all the previous years (2012 to 2014); PGK 14.30 in 2019 compared to between PGK 7.78 and PGK 9.38 from 2012 to 2014.

The average expected sale price for the fish sold by Porebada fishers during the survey period was less in 2019 than in other years at PGK 2.63/kg. Boera fishers also saw a lower sale price for the fish caught during the 2019 survey period when compared to previous surveys, while the expected value of fish caught by Lea Lea fishers remained similar to the 2013 and 2014 data.

4.5. Fishing equipment

The use (as a percentage) of each type of fishing equipment for all survey years is presented in Figure 4.5. A breakdown of 2012 data was not available, so results from a 2011 report (ExxonMobil 2011a) are presented in the figure.

Figure 4.19 Fishing equipment use by year across all villages

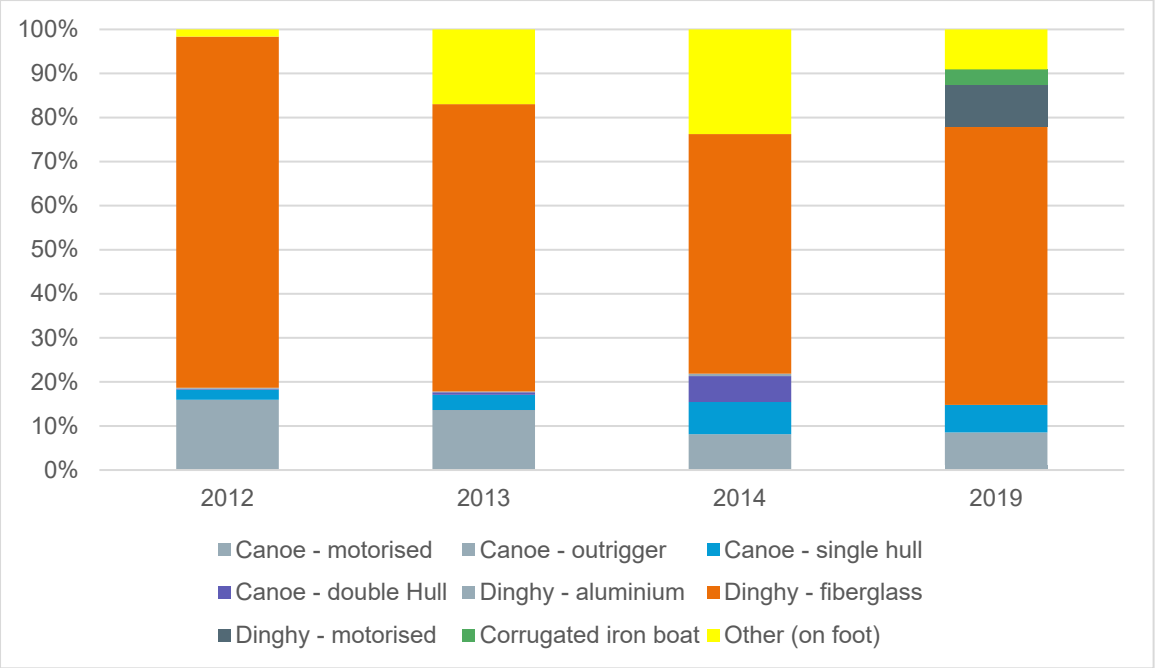


The gillnet was the most common type of equipment used for fishing activities over the years surveyed. In 2019, the different equipment used was more evenly spread, with the gillnet still being the most popular although by a smaller margin. Handlines and spear guns were also frequently used equipment. A breakdown of data by village was not available from the 2011, 2013 and 2014 survey reports.

4.6. Vessel types

The percentage use of each type of fishing vessel by survey year is presented in Figure 4.6.

Figure 4.20 Vessel use by type for all villages by year

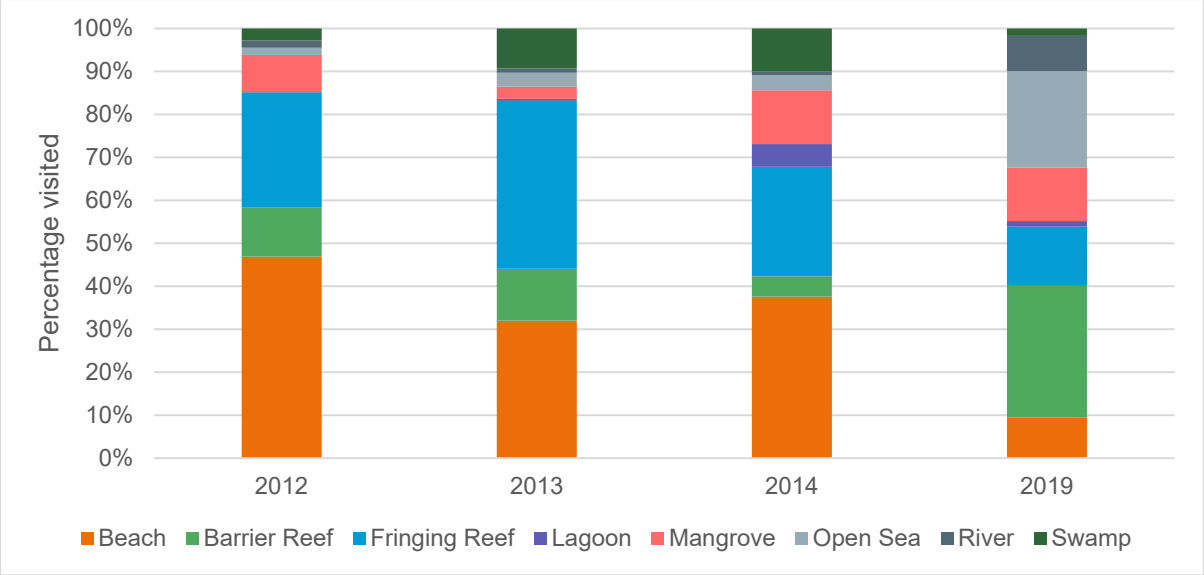


Fibreglass dinghy was the most common type of vessel used for fishing in each year. Walking to fishing grounds (from the beach) and using an outrigger canoe were the other most common types. A breakdown of data by village was not available from the 2012 to 2014 survey reports.

4.7. Fishing locations

The habitat types at fishing locations most frequented by year for all villages are shown in Figure 4.7.

Figure 4.21 Fishing sites visited by habitat type for all villages



The results show that the most common fishing locations during the 2019 survey period were at barrier reefs and in the open sea. In previous years, beach and fringing reef were the most frequented habitat types where fishing was conducted for each of the surveys.

The data suggest a change in habitat type targeted by fishers between 2014 and 2019. The potential reasons for this change cannot be determined by the data available and may be influenced by a multiple factors such as weather (e.g., during poor weather conditions, visits to the open sea are less likely) or seasonal movement of target fish species or price of specific species.

5. Discussion and conclusions

This study has provided data regarding the fishing activities of residents in the four coastal villages closest to the LNG Plant.

The 2019 survey found that the highest average percentage of the population that fished per day was at Boera (1.6%), followed by Lea Lea (1.1%), Porebada (0.8%) and Papa (0.4%). The average number of fishers per fishing trip was highest at Lea Lea (4.6), followed by Boera (3.8), Porebada (3.7), then Papa (1.4). The lower number of fishers per trip at Papa is reflective of their predominant fishing locations with most fishing being undertaken onshore (i.e., beach, mangrove and swamp) and close to shore (i.e., fringing reef) where fishing is typically done by single fishers (e.g., foraging for mud crabs). In contrast, fishing at Boera, Lea Lea and Porebada was more focussed on offshore locations (i.e., barrier reefs and open sea), and this type of fishing typically involves several fishers in a vessel.

During the 2019 survey period, the highest CPUE (0.61 kg/h/fisher) was recorded at Papa, and the lowest CPUE (0.17 kg/h/fisher) at Lea Lea[1].

Relative to total weight caught, Boera fishers were recorded as consuming the highest proportion of their catch (64%) in 2019, despite catching the second highest total weight. This finding is consistent with 2012, 2013 and 2014 data, where fishers from Boera was also noted as consuming the highest proportion of their catch. Porebada fishers have consistently sold the highest proportion of their catches, indicating that fishers from this village fish more to earn an income, whereas Boera fishers do so primarily to feed themselves (and their families).

The most visited fishing grounds (by habitat type) reported during the 2019 survey differed to those reported during the 2012 to 2014 surveys (albeit fishers are still selecting fishing locations that are closest to their respective villages). Barrier reefs and open ocean habitats were more popular fishing locations during the 2019 survey period than beach and fringing reef areas.

During the 2019 survey period, the expected sale price received per kilogram of fish by Papa fishers was greater than it had been during previous surveys, with fishers expecting to receive an average of PGK 14.30/kg. For Porebada fishers, the sale price for the fish caught during the 2019 survey period was less (at PGK 2.61/kg) than what was expected to be received in 2014 (PGK 9.22/kg), while Boera and Lea Lea fishers sold their catch for similar prices to what they had reported during previous surveyed years.

The 2019 survey found that fishers from different villages used different primary types of fishing equipment. The most common fishing equipment used across all villages were gillnet, spear gun and handline. Gillnets were used less frequently in 2019 than in 2011 to 2014, while spear gun and handline fishing methods were used more frequently in 2019 compared to 2011 to 2014.

[1] Additional CPUE calculations using the formula from previous monitoring events (2012 to 2014) showed that fishers from Porebada had the highest CPUE (1.72 kg/h/trip) and fishers from Papa had the lowest CPUE (0.72 kg/h/fishing trip).

6. References

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ExxonMobil, 2012b. Papua New Guinea LNG Project Caution Bay Fisheries Report Q2, 2012 – PGHU-EH-SRZZZ-700012P

ExxonMobil, 2011a. Papua New Guinea LNG Project Caution Bay Fisheries Report – PGHU-EH-SRZZZ-700004

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Food and Agriculture Organization of the United States (FAO), 2002. Sample-based Fishery Surveys – A Technical Handbook. United Nations, Rome, Italy.

Appendix A – Catch landing survey forms

Survey Form No:

IMS No:

Catch Landing Survey

Part 1: Surve/ Interviewer Profile.

1.1 Survey Quarter		1.2 Date *(dd/mm/yy)*	
1.3 Interviewer First Name		1.4 Interviewer Last Name	
1.5 Interview Start *(24hrs)*		1.6 Interview Stop *(24 hrs)*	
1.7 Interview Location			

1.8 Survey Site	☐ Omati River	1.9 Survey Village	☐ A'idio	☐ Bisi	☐ Dopima	☐ Goare	☐ Mubagowo
	☐ Caution Bay		☐ LeaLea	☐ Boera	☐ Papa	☐ Porebada	

Part 2: Interviewee Profile

2.1 Lead Fishermen Name		2.2 Lead Fishermen Last Name	

2.3 Village		2.4 Gender	2.5 Age Range	
☐ LeaLea	☐ A'idio	☐ Male	☐ LT 8	☐ 25-45 (Employable)
☐ Papa	☐ Bisi	☐ Female	☐ 8-16 (School age)	☐ 46-64
☐ Boera	☐ Dopima		☐ 17-25	☐ 65+
☐ Porebada	☐ Goare			
☐ Other	☐ Mubagowo			

Part 3: Fishing Trip Details

3.1 Start Date *(dd/mm/yy)*		3.3 Time Departed *(24hrs)*		3.5 # of Fishers
3.2 Finish Date *(dd/mm/yy)*		3.4 Time Returned *(24hrs)*		

Part 4: Gear Used

4.1 Gear Used *(Mark the Most Used)*	4.2 % of catch weight by gear	4.3 Comments
☐ Circle Net		
☐ Hands		
☐ Handline		
☐ Gillnet		
☐ Spear		
☐ Spear Gun		
☐ Trolling Line		
☐ Other		

Part 5. Fishing Habitat & Fishing Ground

5.1 Location		5.2 Name of the fishing ground	5.3 # Days per Week	5.4 Tide:
(Caution bay)	*(Omati River)*			
☐ Beach	☐ Dirt Creek		☐ 1 x	☐ High
☐ Barrier Reef	☐ Flood Plain		☐ 2 x	☐ Low
☐ Fringing Reef	☐ Kemei		☐ 3 x	☐ Low-High
☐ Lagoon	☐ Shorelines		☐ 4 x	☐ High-Low
☐ Mangrove	☐ River Oxbows		☐ 5 x	5.5 Weather / Current
☐ Open Sea			☐ 6 x	☐ Good
☐ River			☐ 7 x	☐ Ok
☐ Swamp				☐ Poor

Part 6: Vessel Used on the Trip			
6.1 Owner Name		**6.2 Total Fuel Used** *(Ltrs.)*	
6.3 Type of Vessel		**6.4 Total Fuel Cost** *(PGK)*	
☐ Canoe – Outrigger	☐ Dinghy – Aluminum	**6.5 Fisher's Contribution to Fuel Cost** *(PGK)*	
☐ Canoe – Single hull	☐ Dinghy – Motorized	**6.6 Length** *(m)*	
☐ Canoe – Double hull	☐ Cargo Boat	**6.7 # Sails**	
☐ Canoe – Motorized	☐ Logging Barge	**6.8 # Paddles**	
☐ Dinghy – Fiberglass	☐ Tug Boat	**6.9 Outboard Motor Size** (*Horse Power*)	
☐ Raft	☐ Other		

Part 7: Species Catch Composition									
7.1 Local Name (Motu/Koitabu)	7.2 Common Name (English)	7.3 Species Name	7.4 Type of Fish *(Deep Water, Mangrove, Mixed Reef, Pelagic, Freshwater or Crustaceans or Mollucs or Shells)*	7.5 Total # of Fish Caught	7.6 Total Weight *(Kg)*	7.7 Weight Consumed *(Kg)*	7.8 Weight Sold *(Kg)*	7.9 Value of Weight Sale *(PGK)*	7.10 Photo I.D

*** Use the picture guide to identify species and weight*
*** Take a photograph of the fish weight.*

Field verification _____ *Date* _____ *IMS Verification* _____ *Date* _____

Modified13/03/14

Appendix B – Vessel inventory survey form

Survey Form No:	IMS No:

Vessel Inventory Survey Form				
Part 1: Survey / Interviewer Profile.				
1.1 Survey Quarter :		**1.2 Date** (*dd/mm/yy*):		
1.3 Interviewer First Name:		**1.4 Interviewer Last Name:**		
1.5 Interview Start (*24hrs*)		**1.6 Interview Stop** (*24 hrs*):		
1.7 Interview Location:				
1.8 Survey Site	Caution Bay	**1.9 Survey Village**	☐ LeaLea	☐ Boera
			☐ Papa	☐ Porebada
Part 2: Interviewee Profile				
2.1 Vessel Owner First Name:		**2.2 Vessel Owner Last Name:**		
2.3 Phone #		**2.4 Alternate Phone #**		
2.5 Vessel Location				

Part 3: Village & Vessel Use				
3.1 Name/Destination:				
3.2 Village:	**3.3 Where Used**	**3.4 # Use / Week**	**3.5 Type of Use**	**3.6 Used For**
☐ LeaLea	☐ Mangrove	☐ **1 x**	☐ Rent	☐ Transport
☐ Papa	☐ Beach	☐ **2 x**	☐ Loan	☐ Fishing
☐ Boera	☐ River	☐ **3 x**	☐ Fishing Group/ Other	☐ Collecting
☐ Porebada	☐ Lagoon	☐ **4 x**		☐ Water
	☐ Fringing Reef	☐ **5 x**		☐ Other
	☐ Barrier Reef	☐ **6 x**		
	☐ Open Sea	☐ **7 x**		

Part 4: Gear Used on Vessel			
4.1 Gear Used: (*Mark all that apply*)	**4.2 % of Use** (*0, >10, 10-25, 25-50, 50+*)	**4.3 Mono/Nylon, Mesh Size, 2.5,3, 3.5, 4" Length of net (M) Depth in (meshes)**	**4.4 .Quantity:**
☐ Circle Net			
☐ Spear Gun			
☐ Spear			
☐ Handline			
☐ Trolling Line			
☐ Spotlight			
☐ Diving Torch			
☐ Battery			
☐ Flippers			
☐ Other			

Appendix C – Market survey data form

Date	Market	Time	Surveyor name
Species (include photograph if unsure of species)	**Price 1** (include units)	**Price 2** (include units)	**Price 3** (include units)

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