Thesis for the Degree of Business Administration

The Economic Efficiency of the High Seas Long Line Fishery in Sri Lanka:

Special Reference to Dikkowita Harbour of Western Province

by

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(공해에서 조업하는 스리랑카 연승 어업의 경제적 효율성: Western Province 의 Dikkowita 항을 중심으로)

Advisor: Prof. Hee-Dong Pyo

by

Warnasinghe Arachchige Piyathissa

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Abstract

Sri Lankan Fish and fisheries are sold locally and are equally exported. Retailers, commission agents and assemblers constitute part of the local channels, whereas processors, agents and exporters constitute the export channels. Sri Lanka usually exports its fish and fisheries to America, Europe and South East Asian Country. The excessive local demand for fresh fish and fisheries and dried fish in Sri Lanka come from Thailand, India and Maldives. It is evident that there were ample number of researches performed to study the offshore and coastal fishing in Sri Lanka (Dissanayake, and Sigurdsson, 2005; Laknath et al., 2017; Dias et al., 2018; Herath et al., 2019). However, there is no specific research has been conducted to perform in-depth research about the high sea fishing in Sri Lanka. Also, it is observed that various research focuses on the environmental impacts and sustainability of longline fishing (Baker, and Robertson, 2018; Nagle, 2019; Griffiths et al., 2019) but there is no significant economic impact of it. Thus, it is very important to study the factors that make the major economic growth through high sea fishing. Therefore, this project aims to perform an in-depth study on the economic efficiency of the high seas' longline fishery in Sri Lanka. This research project provides a special reference to Dikkowita Harbour of Western Province, Sri Lanka. This thesis presents finding based on survey data collected through a representative sample of 54 registered vessels operating in the Dikkowita Harbour. The cost function result shows the relationship between the independent variables i.e. horse power, length of vessel and fishing days, and the dependent variable; total cost.

Horse power has a negative relationship with total cost, as one percent rise in horse power results in 0.31% decrease in total cost. Also, a percentage rise in length of vessel and fishing days will lead to 3.58% and 0.46% increases in total cost respectively. From the findings it is identified that more than 50 feet length of vessel has the maximum profit, profit margin. However, ROI is high for vessel length less than 40 feet length of vessel, and vessel length less than 40 ft group has the most cost efficiency while the vessel group with the vessel length between 41 and 45 ft group has the least cost efficiency. This shows that the relationship between total cost and cost efficiency is negative, as cost efficiency increases; the total cost decreases due to the fact that total cost is a function of the cost efficiency.

Keywords:

High seas, Fishery, Longline fisheries, Dikkowita Harbour

Acronyms and Abbreviations

GDP – Gross Domestic Production

EU – European Union

GSP – Generalized System of Preferences

CBSL – Central Bank of Sri Lanka

VMS – Vessel Monitoring Systems

AIS – Automatic Identification Systems

Mt – Metric ton

LKR – Sri Lankan Rupees

FAO – Food and Agriculture Organization

MTRB – Motorised Traditional Boats

NTTRB – Ministry of Fisheries and Aquatic Resources Development

OFRP – Out boat engine Fiberglass Reinforced Plastic boats

IDAY – Inboard Single-day boats

IMUL – Inboard Multiday boats

CFHC – Ceylon Fisheries Harbour Cooperation (CFHC)

NARA – National Aquatic Resources Research and development Agency

OBM – Organizational Behaviour Management

USA – United State of America

GVA – Gross Value Added

ROI – Return on Investment

TC – Total Cost

hp – Horse power

L – Vessel Length

d – Fishing days

ft – Feet

S.D – Standard Deviation

n – Number of Vessels

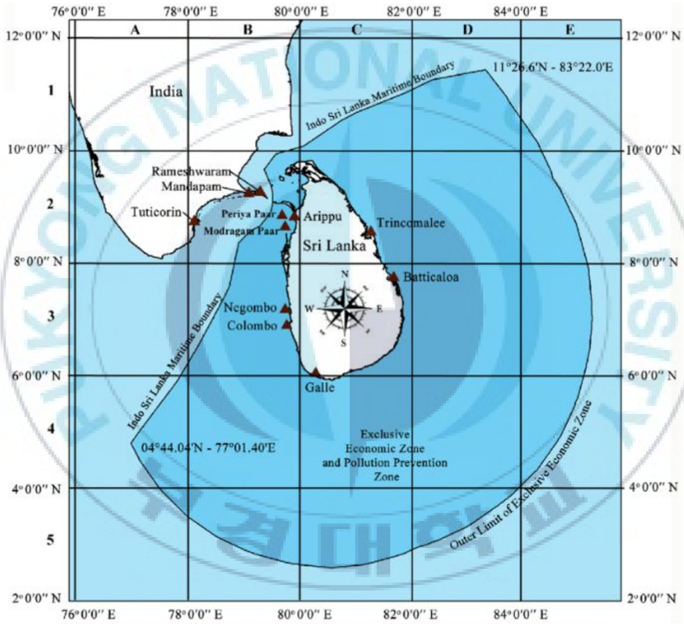
OLS – Ordinary Least Square

Kg – Kilograms

I. INTRODUCTION

1. Objectives of the study

Sri Lanka is an Island state in the Indian ocean, South-east of the Indian Sub-continent between latitudes 6^0-10^0 N longitudes 79^0-82^0 E and total population is 22 million (Rohan, and Yee, 2016). Fisheries sector in Sri Lanka is one of the promising and growing industry (Amarasinghe, and Bavinck, 2017). Sri Lanka has exclusive economic and fishing rights for the 1700 km coastal line and 500,000 square kilometres in the ocean area (Senanayake, 2020).



<Figure 1> Location of Sri Lanka

Source: Maritime Boundaries Geodatabase, Flanders Marine Institute

The fisheries sector plays a key role in the social and economic life of Sri Lanka. This has been described in Central Bank of Sri Lanka (CBSL, 2016) that an essential source of animal protein provides by the fish products and it holds a share of 1% of the Gross Domestic Production (GDP) of Sri Lanka. There are three principal subsectors in Sri Lanka fisheries sector such as coastal, deep-sea and offshore (Perera, 1978).

It is evident that there were ample number of research performed to study the offshore and coastal fishing in Sri Lanka (Dissanayake, and Sigurdsson, 2005; Laknath et al., 2017; Dias et al., 2018; Herath et al., 2019). However, there is no specific research has been conducted to perform in-depth research about the high sea fishing in Sri Lanka (Shobiya et al., 2019). Also, it is observed that various research focuses on the environmental impacts and sustainability of longline fishing (Baker, and Robertson, 2018; Nagle, 2019; Griffiths et al., 2019) but there is no significant economic impact of it. Thus, it is very important to study the factors that make the major economic growth through high sea fishing.

The aim of this project is to perform an in-depth study on the economic efficiency of the high seas longline fishery in Sri Lanka. This research project provides a special reference to Dikkowita Harbour of Western Province, Sri Lanka. The objectives of the study are given below:

- Objective 1: To identify the factors that make the economic growth of high sea longline fishing
- Objective 2: To study the drawbacks of high seas longline fisheries in Sri Lanka
- Objective 3: To assess the level of profit on longline fishery
- Objective 4: To analyse the economic efficiency of longline fishery in Sri Lanka and provide recommendations to make the maximum profit of it

The main research question of this project is provided below:

"What is the economic efficiency of high seas longline fishing in Sri Lanka?".

There are several sub-questions identified to achieve the objectives of this project. Table 1 provides the association between the sub research questions and objectives of this project.

<Table 1> The association between the sub research questions and objectives of this project

Objectives	Sub research Questions
Objective 1: To identify the factors that make the economic growth of high sea longline fishing	What are the factors that make the economic growth of high sea longline fishing?
Objective 2: To study the drawbacks of high seas longline fisheries in Sri Lanka	What are the drawbacks of high seas longline fisheries in Sri Lanka?
Objective 3: To assess the level of profit on longline fishery	What is the level of profit on longline fishery?
Objective 4: To analyse the economic efficiency of longline fishery in Sri Lanka and provide recommendations to make the maximum profit of it.	Is there any revenue growth of longline fishery in Sri Lanka? What are the recommendations that can make to get the maximum profit?

2. Assumptions and Limitations

There are some assumptions were made to perform the research in this project which are:

- The high sea fishery is the key subsector in fisheries industry in Sri Lanka.
- Dikkowita Harbour of Western Province represents all other harbours in Sri Lanka.

The identified limitations of this project are:

- The fishermen who participated in the primary research are a very small population and the responses received from them cannot be generalised for the entire fishermen society in Sri Lanka.
- Every harbour in Sri Lanka is unique and different. This project only considers Dikkowita Harbour. Therefore, the results received cannot be generalised for all the harbours in Sri Lanka.

3. Layout of the Study

The structure of the report is provided below:

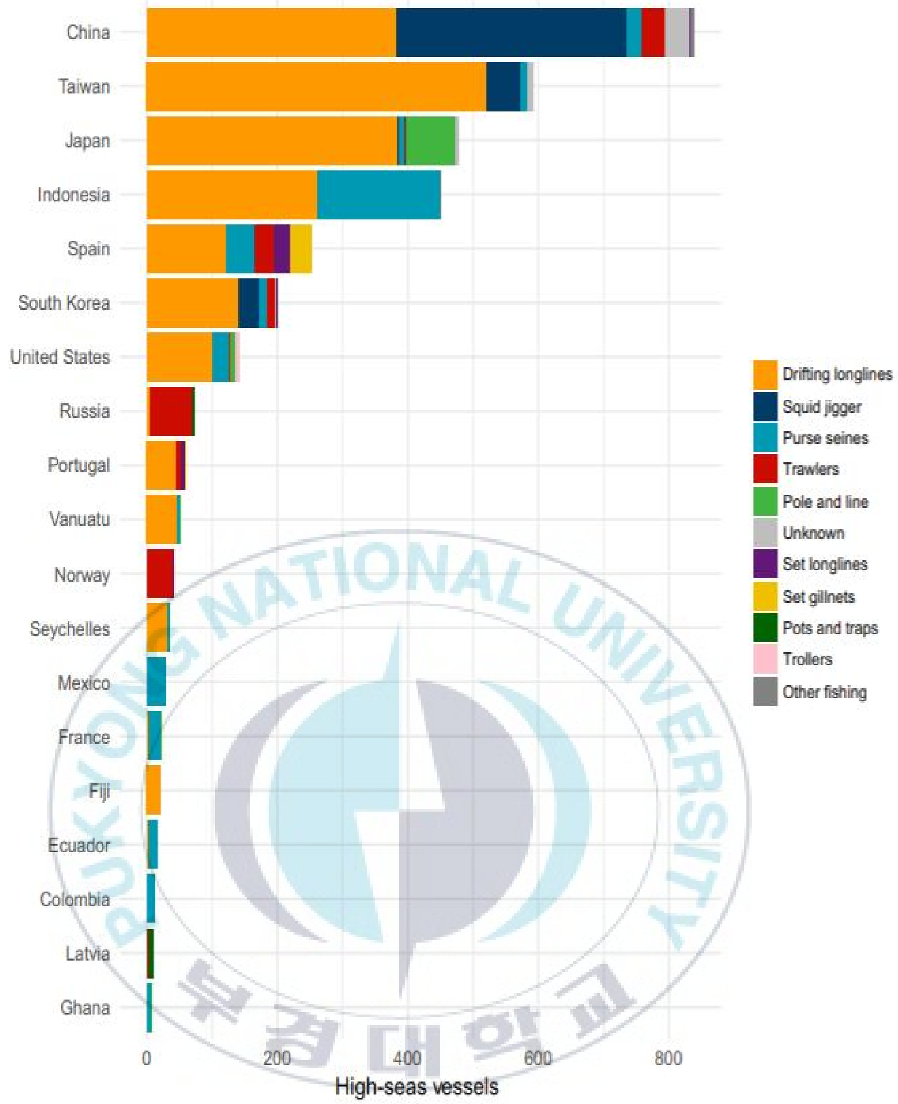
- **Chapter 1.** Describes the brief introduction of the research study, statement of the problem, research objectives, questions, significance, assumptions, limitations and the report structure.
- **Chapter 2.** Provides the review of literature related to the background of high seas longline fisheries in Sri Lanka and other countries.
- **Chapter 3.** Describes all the methods and techniques used to perform the secondary and primary research of this project.
- **Chapter 4.** Provides the complete information regarding the data analysis performed on the results received from the primary research.
- **Chapter 5.** Provides a discussion of the findings from the secondary research and primary research as well as provides the list of recommendations to improve the high seas longline fisheries in Sri Lanka.
- **Chapter 6.** Provides the conclusion and future works of this project.

II. LITERATURE REVIEW

1. Global pattern of High seas fishing

In the past, there was no proper method to identify the high seas fishing fleet's components to a greater extent. However, now days it can be done easily due to the availability of novel methods for tracking fishing activities such as vessel monitoring systems (VMS) and automatic identification systems (AIS) and individual vessel behaviour, and other characteristics in near real-time (Douvere, 2015). In 2016, at least 3620 specialised fishing vessels, which operate in the high seas were identified, as shown in Figure 2. Furthermore, 154 reefers (a transhipment process which involves refrigerated cargo ships in which fishing vessels transfer their catch at sea) and 35 bunkers (fishing vessels' refuelling tankers) were tracked, and these are critical to high seas fishing fleet's operation. The countries that contributed to 77% of the global high seas fishing fleet include South Korea, Spain, Indonesia, Japan, Taiwan and China. Moreover, they contributed 80% of the entire AIS/VMS-supposed fishing endeavour, which is measured in kilowatt-hours (Table 2). The percentage of the active high seas vessels which utilised longlines amounts to 59%. Additionally, they signified 68% of the entire fishing days. Figure 2 and Table 2 shows the four major fishing gears that operate in high seas. They include trawlers, squid jiggers, purse seiners and longliners.

In 2016, this report discovered that the global high-seas fishing fleet spent a total of 510,000 days at sea, out of which fishing took 77% of the days spent, and each vessel spent approximately 141 days (see Table 2). The kind of fishing conducted varied, depending on the time each fishing vessels spent in high seas and fishing in EEZs (see Figure 3).



<Figure 2> High seas fishing fleet

Source: Sala et al., 2018

The overall cost of high seas fishing can be thoroughly estimated as a result of the classification of global high seas fleet. In 2014, we used speed, transit tracks, trip-level fishing, flag state, gear, engine power, tonnage, vessel-level data on ship length, for estimating the aggregate cost of high seas fishing. The range of the most recent year with a spatial allocation of globally reconstructed catch data is from $6.2 million to $8.0 billion, as shown in Table 2. The cost of labour, especially for Taiwan and China, accounts for the unreliability related to the aggregate costs. However, usually, fisheries data are not readily available.

In 2014, the high seas' aggregate fisheries catch amounted to 4.4 million Mt and generated $7.6 million in total cost, for the landed value of the catch (Table 2). The contributions of countries such as Spain, South Korea, Japan, Taiwan and China towards the aggregate cost for the landed value of the catch include, 8%, 11%, 11%, 13% and 21%, respectively. According to our estimation, the profits of high seas fishing (exclusive of subsidies) ranges from $364 million to over $1.4 billion, worldwide (see Table 2). Furthermore, we projected the sum of $4.2 billion, as government subsidies for high seas fishing, as of 2014. This figure exceeds the net economic benefit of high seas fishing, to a significant extent. The outcome indicates the unlikelihood of the current global-level high-seas fishing if there are no subsidies. Moreover, Russia, Taiwan, generate the majority of the negative returns (see Table 2). Our use of subsidies based on countries for estimating profits shows that the range of subsidy-distorted high-seas profits is from $3.8 billion to 5.6% billion.

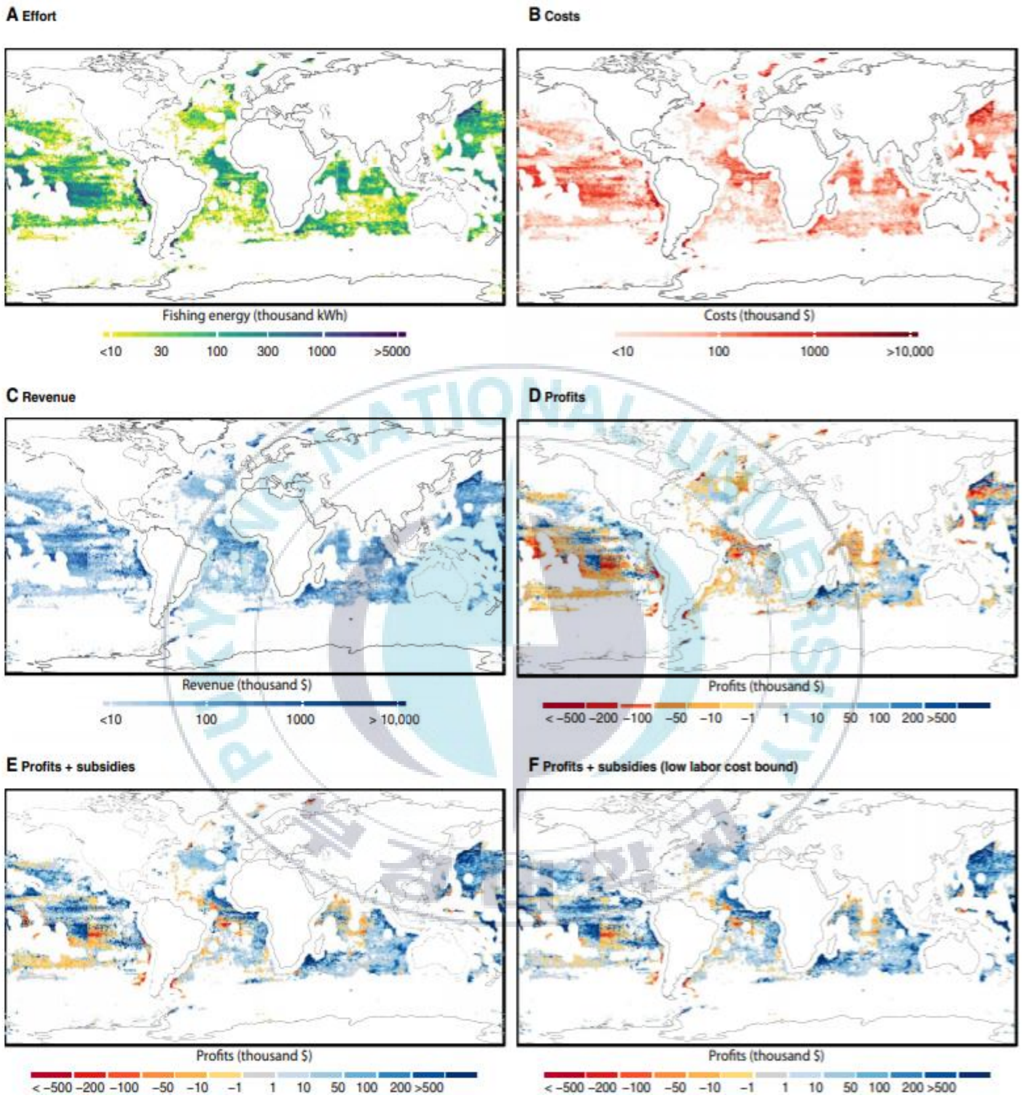
<Table 2> High seas fishing economics

Catch (in thousand metric tons) revenue, costs, subsidies, and profits without subsidies (π) and with subsidies (π^*) for each country. All monetary values reported in million US dollars. These 14 countries accounted for 90% of the high –seas catch.

	Catch	Revenue	Costs		π		subsidies	π^*	
			Lower bound	Upper bound	Lower bound	Upper bound		Lower bound	Upper bound
Global	4391	7656	6228	8020	-364	1428	4185	3821	5613
China	1523	1624	1563	2041	-418	60	418	1	479
Taiwan	545	983	1048	1220	-237	-65	244	6	179
South Korea	403	807	553	605	202	254	409	612	664
Spain	248	637	434	492	145	203	603	749	807
Japan	213	816	639	639	177	177	841	1018	1018
Ecuador	194	271	95	186	85	176	22	107	198
Indonesia	192	384	178	260	123	206	102	226	308
Russia	188	195	153	309	-114	42	12	-102	54
Mexico	107	252	81	184	68	170	32	100	202
United States	93	377	100	162	216	278	256	471	533
Norway	86	107	77	88	19	30	14	33	43
France	58	235	78	86	148	157	195	344	352
Seychelles	55	50	26	50	-1	24	10	9	33
Panama	55	104	32	66	38	72	25	63	98

Source: Sala et al., 2018

The above was calculated spatially in (Table 2). The findings show the impossibility of making a profit from 19% of the current high seas fishing, using the current rate, despite our lowest labour cost projections and subsidies (Figure 3). The unprofitability level increased to 30% from 19% with higher labour costs, and while the organisations received subsidies. Lastly, unprofitability increases to 54% with low wages to labour and the absence of subsidies. This indicates the unprofitability of over half of the current high fishing groundings, as a result of low wages to labour and absence of subsidies.



(A) Fishing effort, (B) economic costs, (C) revenue (landed value of the catch), (D) profits before subsidies, (E) profits after subsidies, and (F) profits after subsidies and low labour costs. Values for costs and profits are scaled averages between lower and upper bound estimates

<Figure 3> High sea fishing in a Global View

Source: Sala et al., 2018

The country-based ranking of subsidies to their high-seas fishing fleets, as shown as follows:

1. Japan (which contributes 20% of the global subsidies)

2. Spain (which contributes 14% of the global subsidies)

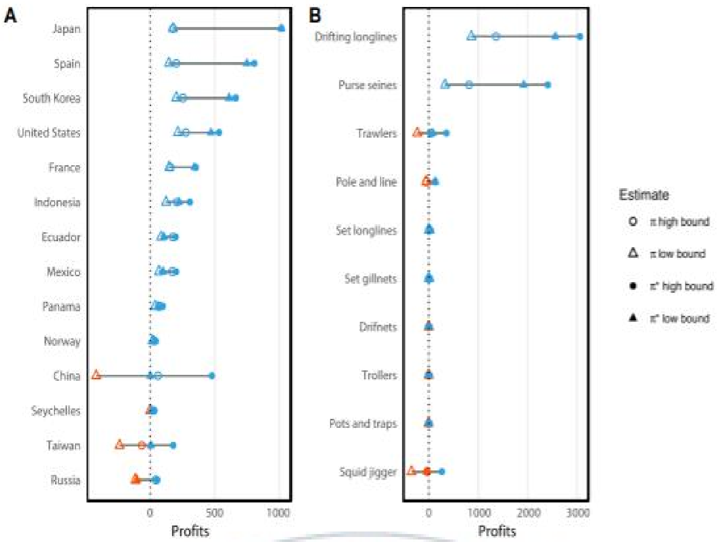
3. China

4. South Korea

5. United State

Remarkable, the subsidies are exceedingly higher than the fishing profits, in these cases. Japan has the most extreme case, as our projection of their high-seas profits is four times less than what they have in reality. Government subsidies are required for the profitability of the present extraction rate of the seventeen countries that contribute 53% of the overall high-seas catch. Forty-seven per cent of the overall high-seas catch amounts to the significant contributions of Taiwan and China alone from among these countries. It can be deduced that subsidies' scale, the impact of subsidies on profitability, and as several of these subsidies reduce fishing's marginal cost could remarkably reduce the high-seas fishing activities when they are not available.

While attempting to find out the fisheries that these high-seas practices take place, we discovered that the most lucrative high-seas fisheries include purse seiners and drifting longliners, which primarily targets large mobile, high-value fishes, including sharks and tuna (Figure 4). The other fisheries scarcely make profit or loss. Our projection includes the inclusion of government subsidies before deep-sea bottom trawling can make a global profit, at the current rates. The greatest loss that could be realised before subsidies amount to $230 million per annum. Also, typically, the lack of subsidies would make squid jiggers run at a loss. The projected maximum loss that it would make per annum is $345 million. Nonetheless, we get a significantly complex outlook after considering the fishing grounds, gear type, and country-based spatial economic patterns.



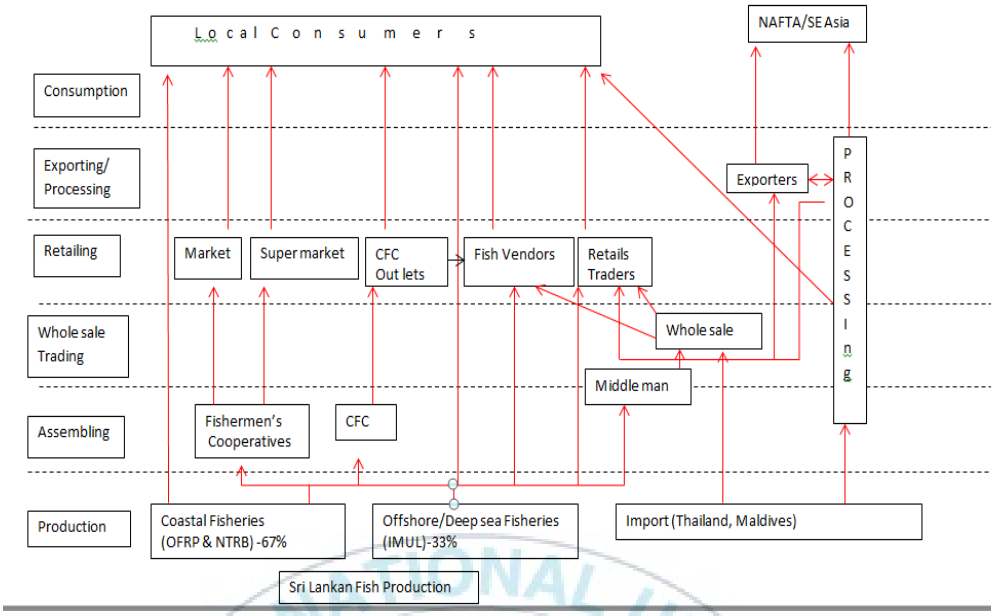
Range of estimates of fishing profits (USS million) before (π) and after (π*) subsidies for (A) major fishing countries and (B) gear types

<Figure 4> High seas fishing economic benefits

Source: Sala et al., 2018

2. The Sri Lankan Fishery Industry

Fish and fisheries are sold locally and are equally exported. Retailers, commission agents and assemblers constitute part of the local channels, whereas processors, agents and exporters constitute the export channels (Marambe et al., 2020). Sri Lanka usually exports its fish and fisheries to America, Europe and South East Asian country. The excessive local demand for fresh fish and fisheries and dried fish in Sri Lanka come from Pakistan, India, Maldives and China (Conway et al., 2006).



<Figure 5> Fish distribution channel in Sri Lanka

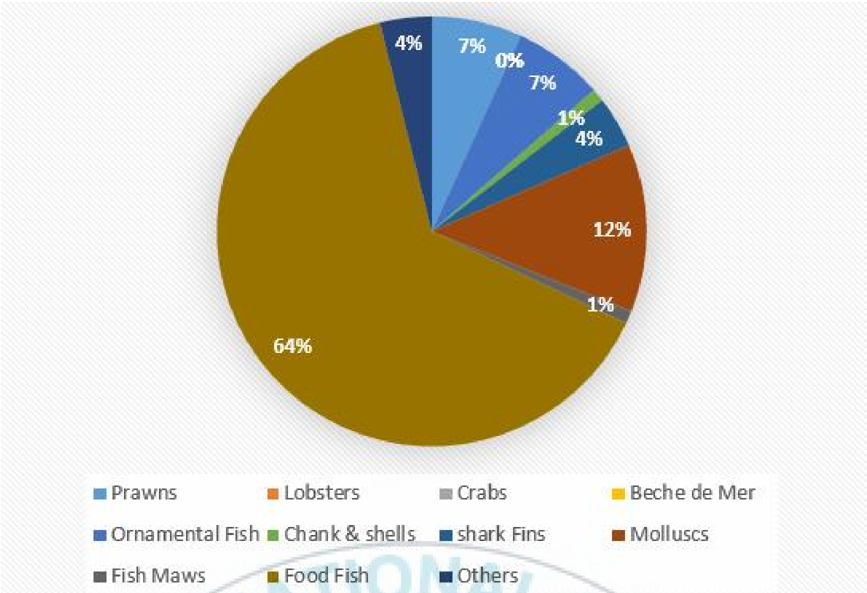
2.1. Fish and Fishery Products' Exports

Over the years, fish and fishery products have been exported from Sri Lanka to Asian, American and European markets. Therefore, the fish and fisheries are classified as crabs, lobsters, frozen fish, aquarium fish, chilled or fresh fish, prawns, as well as other edible fish. Fish and fishery products amounting to 24,827 Mt had been exported in Sri Lanka, as of 2017. The exportation of such products spiked to 41% and realised 39,230LKR Million as export earnings. When contrasted with 2016, it increased by 46%. Table 3 provides details of fish and fishery products' values, as well as export quantities between the year 2012 and 2017. The export quantity's value percentage, as well as each export item's values as of 2017, are shown in Figure 6 and Figure 7.

<Table 3> Fishery and fish export

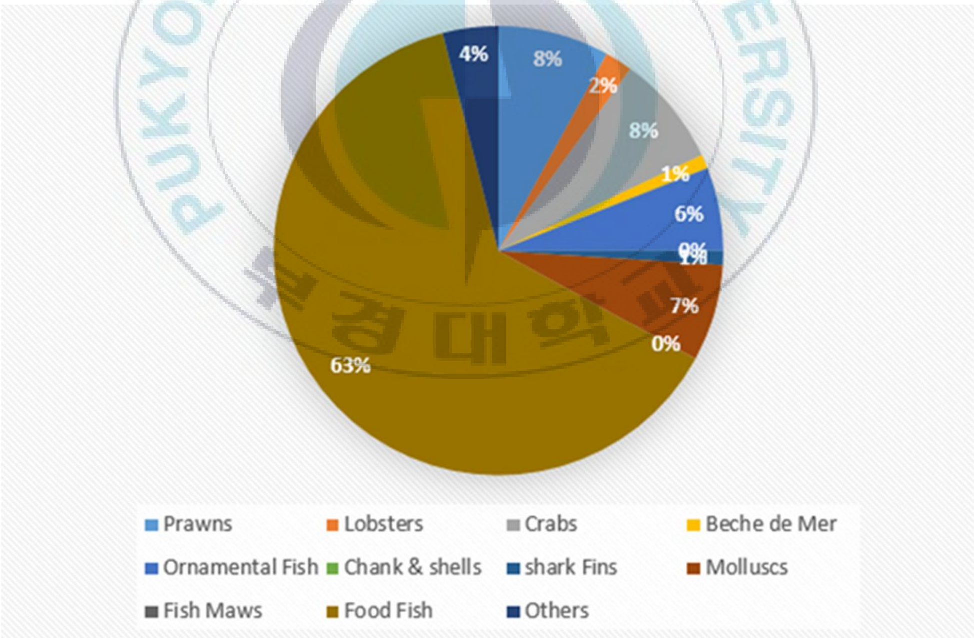
	2012	2013	2014	2015	2016	2017
Quantity (Mt)	18,633	23,911	26,320	17,461	17,593	24,827
Value (Rs. Million)	26,364	31,792	34,796	24,716	26,801	39,230

Source: Ministry of Fisheries and Aquatic Resources Development



<Figure 6> Percentage value of export quantity(Mt) as at 2017

Source: Ministry of Fisheries an Aquatic Resources Development



<Figure 7> Export earning values of fish and fishery products (Rs. Million) as at 2017

Source: Ministry of Fisheries and aquatic Resources Development

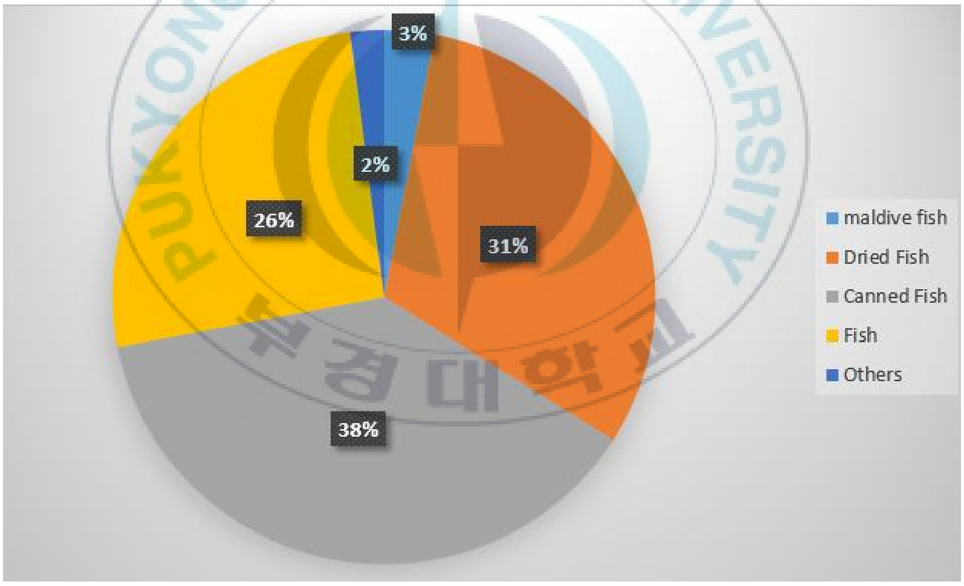
2.2. Fish and Fishery Products' Imports

Sri Lanka is among the leading South Asian countries that imports fish and fishery products. This is specifically as a result of the country's insufficient local production of sprats and dried fish. Hence, importation of a significant amount of sprats and fish, yearly, becomes necessary, in order to meet the excess domestic demand. The critical percentage values, as of 2017, are shown in Fig 8 and Fig 9. As of 2017, 106,020 Mt constitutes the overall import. On the other hand, 33,969 LKR millions constitute the overall value.

<Table 4> Quantity and value of the fishery and fish product imports

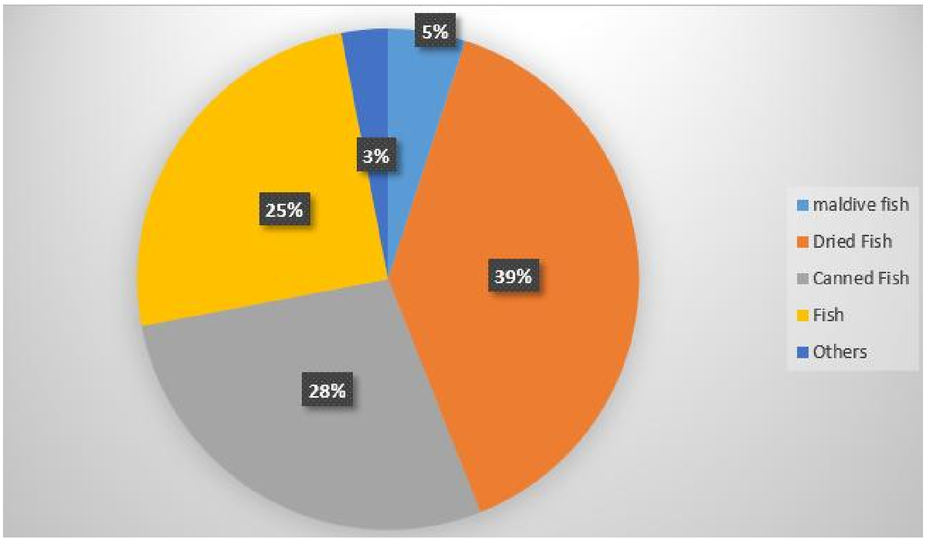
	2012	2013	2014	2015	2016	2017
Quantity (Mt)	71,413	78,400	78,712	120046	115,693	106,020
Value (Rs. Million)	17,400	21,119	18,861	30,729	35,173	33,969

Source: Ministry of Fisheries and Aquatic Resources Development



<Figure 8> Fish and fishery product import quantity(Mt) as at 2017

Source: Ministry of Fisheries and Aquatic Resources Development



<Figure 9> Fish and fishery product import values (LKR) as at 2017

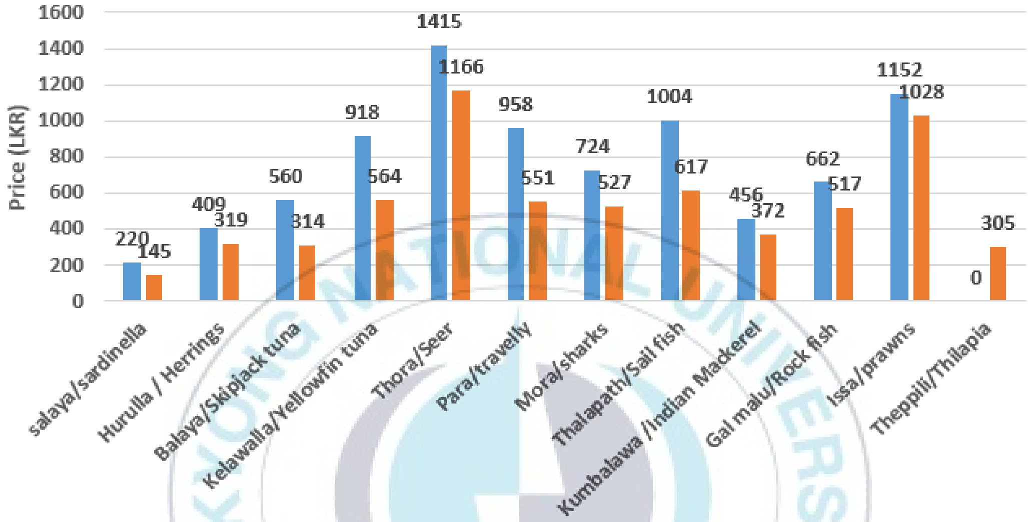
Source: Ministry of Fisheries and Aquatic Resources Development

2.3. Sri Lankan Products' and Consumption of Canned Fish

Canned fish is among the main fish and fishery products which Sri Lanka import every year. As of 2017, it amounted to approximately 28% of the overall export value, and 38% of the quantity imported. By the same year, the country has spent 9,606 LKR million for importing canned fish worthy 40,614 Mt. The Ministry of Fisheries has recently encouraged the private sector to join the fish canning business locally as a countermeasure. This resulted in the establishment, as well as the commencement of the first canning factory in Galle, in 2012. The factory can produce 10,000 units daily. TESS, which stands for tropic engineering supplies and services, invested 170 LKR million in establishing a new factor and began to operate in Paliyagoda. The factory can produce 24,000 cans daily. Currently, the country has six functional canning firms that can produce 4.8 million cans.

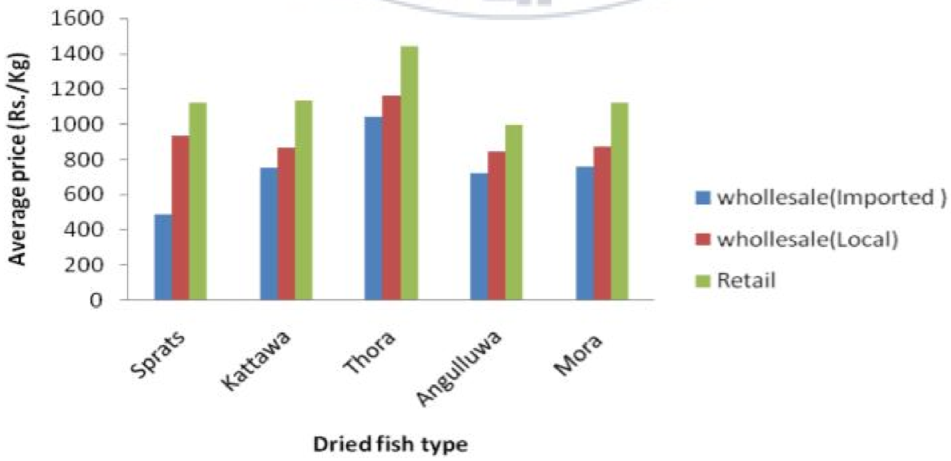
2.4. Fish Price

The major regulators of fish price include market demand and supply. Moreover, the earnings and perspectives of customers play a significant role in market price. Usually, from among the freshwater fisheries, the tilapia species are deemed as high-value species, while among the marine fish, the yellow-fin tuna, travelly, Sailfish and seer are categorised as high-value species. Low-value species fish included Hurulla and Salaya. As of 2017, LKR. 249 constitute the difference between the wholesale and retail price margin, and at the same time, the reported highest retail and wholesale price for seer. The common fish found in the coastal communities include Kelawalla, Balaya and Tuna Species, and they have a high market value. In 2017, the wholesale price difference from the retail price by LKR 246, and 354 respectively. The disparities in the chosen fish species' whole and retail price, as of 2017, are shown in Figure 10.



<Figure 10> Wholesale and retail prices of different fish types as at 2017

Source: Ministry of Fisheries and Aquatic Resources Development



<Figure 11> Wholesale and retail prices of imported and local dried fish types as at 2017

Source: Ministry of Fisheries and Aquatic Resources Development

2.5. Fish and Fishery Products' Consumption

According to Food and Agriculture Organisation (2015), the most significant source of animal protein for the inhabitants of several third-world countries such as Sri Lanka includes the unique blend of relatively cheap and highly proteinase fish. FAO (2011) argued that canned, dried and fresh fish amount to approximately 56.1% of the animal protein which Sri Lankans consume. Moreover, it is common among consumers. The sequence of the consumptions of canned, dried and fresh fish per capita, is 11.8, 3.6 and 1.4, per annum. There has been a 30% increase in Sri Lankans' fresh fish consumption, per capita, over the last ten years. The consumption of canned fish doubled in the same period, even though dried fish consumption reduced by 9% (see Table 5).

<Table 5> Per capital consumption of fresh, dried and canned fish (kg/year)

	2006/2007	2009/2010	2012/2013	2016
Fresh Fish	9.1	10.8	10.9	11.8
Dried Fish	3.9	3.8	3.6	3.6
Canned Fish	0.7	0.7	0.6	1.4

Source: Ministry of Fisheries and Aquatic Resources Development

2.6. Affiliated Industries

Downstream, upstream and fisheries affiliated industries are pivotal. Moreover, they affect the fishery industry's sustainable development in Sri Lanka, directly. They produce inputs that relate to infrastructure and production to achieve the fishery industry's sustainable development. Inputs relating to infrastructure include landing centres, anchorages, and harbours. On the other hand, the main inputs relating to production include ice, fishing gear, and fishing boats/crafts.

2.7. Socioeconomics

The input of the fishery sector in the country's Gross Domestic Production (GDP) as of 2017, is 1.3%. However, it creates employment as currently, it provides direct or indirect income to more than two million people. According to MFARD (2018), the number of people that are directly employed as active fishers as of 2017, is 281,465. In that same year, the inland fishing households were 54,170, while the marine fishing households were 183,650.

<Table 6>Social indicators related to fisheries industry in 2015 - 2017

			2015	2016	2017
1.	Fisheries Inspector Divisions (Marine)	Numbers	148	148	149
2.	Marine Fishing Households.	Numbers	190,960	188,685	183,650
3.	Marine Fishers (Men & women)	Numbers	221,560	218,830	220,870
4.	Marine Fishing House hold Population	Numbers	830,560	827,480	802,340
5.	Fisher Organizations (FO) - Marine	Numbers	927	802	808
6.	Fisher Organizations (FO) - Inland	Numbers	337	287	319
7.	No. of Memberships in FO - Marine	Numbers	86,410	85,208	86,347
8.	No. of Memberships in FO - Inland	Numbers	19,306	12,155	12,401

Source: Ministry of Fisheries and Aquatic Resources Development

2.8. Fisherman's Welfare

It was in 2010 that the community of organisation was established. It aimed to assist the fishers' community. Currently, more than one thousand fishers' community organisations were set up. MFARD (2017) further stated that by the ending of 2017, the community had 98,748 members. By 2010, the Diyawara Diriya loan scheme was established and is currently supported by the Bank of Ceylon to offer a lower interest rate. It has made significant contributions to the growth of the fisher's socioeconomic ranking. In the two schemes, the Ministry of fisheries charges the bank 4% interest.

Concerning the fishers' welfare, the Ministry of fishes introduced two streams of insurance scheme (one of them is 750 LKR per annum, while the other is 1500 LKR per annum). The Bank of Ceylon provided more than 900 beneficiaries (in both the inland and marine fisheries industries) with loans amounting to 1 LKR billion, in this scheme. The qualified fishers could use the loan to buy fishing equipment, engines and boats. The interest rates and collative securities of this loan scheme are low. Moreover, the bank intends to use the second phase of the 'Diyawara Diriya' to provide loans amounting to 2 LKR billion. In 2013, the fisheries information centre which the National Aquatic Resources Research and Development Agency (NARA) introduced for information dissemination, provided a

Hotline number. By 2018, it resolved more than 1000 queries. This service is prevalent with the group of fishermen.

In 2017, Wawak Samaga Gamak/Kalapuwak Samaga Gamak" launched a scheme with aims to develop the fishers' socioeconomic and fisheries status. NARA completed five lagoons' environmental profiling successfully in this scheme. In 2016, it launched a skipper-training scheme, for multiday boat skippers, which aims to improve the fishers' skills. It has the support of the Ocean University of Sri Lanka, and more than 150 skippers have been trained. Currently, NARA collaborates with an external instructor to conduct a mechanical training program for OBM operators. As of May 2019, more than forty fishers had been trained.

2.9. World Fisheries

<Table 7> Fish production globally in million Mt

Category	2011	2012	2013	2014	2015	2016
Production						
Category						
Inland	10.7	11.2	11.2	11.3	11.4	11.6
Marine	81.5	78.4	79.4	79.9	81.2	79.3
Total capture	92.2	89.5	90.6	91.2	92.7	90.9
Aquaculture						
Inland	38.6	42.0	44.8	46.9	48.6	51.4
Marine	23.2	24.4	25.4	26.8	27.5	28.7
Total aquaculture	61.8	66.4	70.2	73.7	76.1	80.0
Total world fisheries and aquaculture	154.0	156.0	160.7	164.9	168.7	170.9

Source: FAO, 2018

Over the years, fish has been increasingly produced globally, and by the end of 2016, it has produced 170.9 million tonnes. In that same year, the contribution of capture fish production amounted to 53% of the overall global fish production. In 2016, the leading countries producing inland water capture fisheries included Bangladesh, Myanmar, India and China, while Peru, Russia, USA, and China, are the leading countries producing marine capture fish.

2.10. Fish Production

As the increase in inland fish production resulted in the decrease in marine fish production in 2017, the overall fish production of the year before and the current year did not change. There was a 2% reduction of the country's fish production from 456,990 Mt to 449,440 Mt, in 2016. At the same time, there was an 11% increase of the aquaculture and inland fish production, from 73,930 Mt in the year before, to 81,870 Mt. The major cause of the growth seen in aquaculture and inland fish production, alludes to the rise in fingerlings' stocking, into inland water bodies. Moreover, in 2017, coastal fish production had a 5% increase, amounting to 259,720 Mt, while there was a 4% increase in offshore fish production, amounting to 189,720 Mt. The sectoral fish production of from 2012 to 2017, can be seen in Table 8.

<Table 8> Annual fish production by sub sectors (Mt)

Sector	2012	2013	2014	2015	2016	2017
Marine Sector	417,220	445,930	459,300	452,890	456,990	449,440
Coastal	257,540	267,980	278,850	269,020	274,160	259,720
Offshore / Deep Sea	159,680	177,950	180,450	183,870	182,830	189,720
Inland and Aquaculture Sector	68,950	66,910	75,750	67,300	73,930	81,870
Total	486,170	512,840	535,050	520,190,	530,920	531,310

Source: Ministry of Fisheries and Aquatic Resources Development

The current leading contributor to the subsector remains the coastal fishery. Its contribution to the country's overall fish production amounts to approximately 49% of the overall fish production. As of 2017, the fisheries industry contributed 1.3% to the GDP at a constant price. When contrasted with the previous year, the fisheries industry contributed a stable percentage to the GDP.

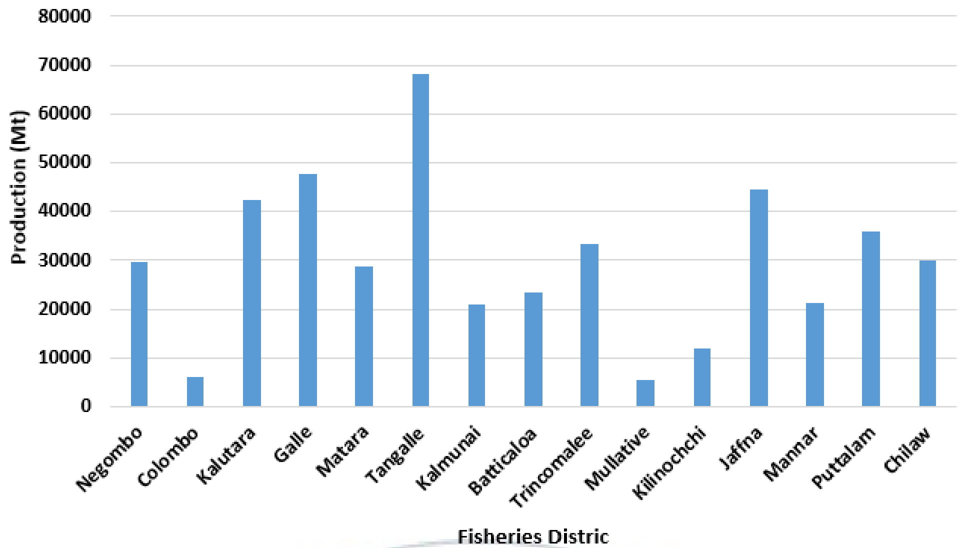
2.11. The Production of Marine Fish

In 2017, the contribution of the Coastal, Deep-sea and Marine fisheries to the country's overall fish production amounted to approximate 449,440 Mt or 85%, even with their experience of 2% decline marginally, as against its figure of 456,990 Mt, which was produced in the previous year. The catch composition primarily consists of tuna species such as Kelawalla (yellow-fin tuna) and Balaya (Skipjack tuna). As of 2017, their contribution to the country's overall marine fish production amounted to 9% and 13% respectively. When contrasted with the year before, Balaya's catch/production experienced a 21% increase. The leading commercial groups' marine fish catch is shown in Table 9. As of 2017, the contribution of the leading fisheries districts (Galle and Tangalle) to the overall marine fish production, was 26%. Moreover, the contribution of Trincomalee (7%), Putlam (8%), Kalutara (9%) and Jaffna (10%), respectively, to the country's overall marine fish production, has been significant. The fisheries districts' fish production in 2017 is shown in Figure12.

<Table 9> Marine fish catch by major commercial group (Mt)

Commercial Group		2013	2014	2015	2016	2017
Thora	Seer	25,650	30,000	8,940	7,440	7,790
Paraw	Carangids	25,160	29,270	34,050	32,620	23,690
Balaya	Skipjack tuna	73,350	61,750	54,040	47,730	57,960
Kelawalla	Yellowfin tuna	45,760	45,200	46,430	39,600	38,960
Other Blood Fish	Other tuna like species	50,200	59,190	46,930	38,750	44,520
Thalapath	(Other bill fish)	***	***	26,040	32,530	33,180
Others		225,810	233,890	236,460	258,320	243,340
Total		445,930	459,300	236,460	456,990	449,440

Source: Ministry of Fisheries and Aquatic Resources Development



<Figure 12> District marine fish production(Mt) – 2017

Source: Ministry of Fisheries and Aquatic Resources Development

2.12. The Production of Inland and Aquaculture Fish

MFARD (2018) argued that in 2017, aquaculture and inland produce fish worth 81,870 Mt, which amounts to 15% of the country's overall fish production. The country's leading fish producing districts are Hambantota (11%), Ampara (13%), and Anuradhapura (19%). The year 2017 breakdown of the inland fish catch (Mt), based on the major species is shown in Table 10.

<Table 10> Inland fish catch by major species (Mt)

Species	2012	2013	2014	2015	2016	2017
Tilapia	39,590	39,070	46,610	40,504	43,836	50,065
Carps / Mirigal	3,570	3,450	3,920	2,847	3,363	4,250
Catla / Rohu	12,460	8,980	11,020	9,117	7,772	8,435
Hiri Kanaya	670	590	580	358	230	330
Lula	1,770	2,040	2,230	1,582	1,849	2,765
Cultured Shrimps	3,310	4,430	5,040	6,836	6,028	4,630
Fresh water prawns	290	540	460	374	705	890
Culture Milk fish & sea bass	130	90	70	78	174	290
Other wild fish	7,160	7,720	5,820	5,604	9,973	10,215
Total	**68,950**	**66,910**	**75,750**	**67,300**	**73,930**	**81,870**

Source: Ministry of Fisheries and Aquatic Resources Development

Inland and aquaculture predominantly produced the Tilapia species. As of 2017, its contribution amounted to approximately 62%. Furthermore, the primary focus of cultivated shrimps is on export markets. Its contribution to the overall production amounts to approximately 9%. The contribution of fingerlings' stocking and release into inland water bodies has been significant and has increased inland fisheries and production.

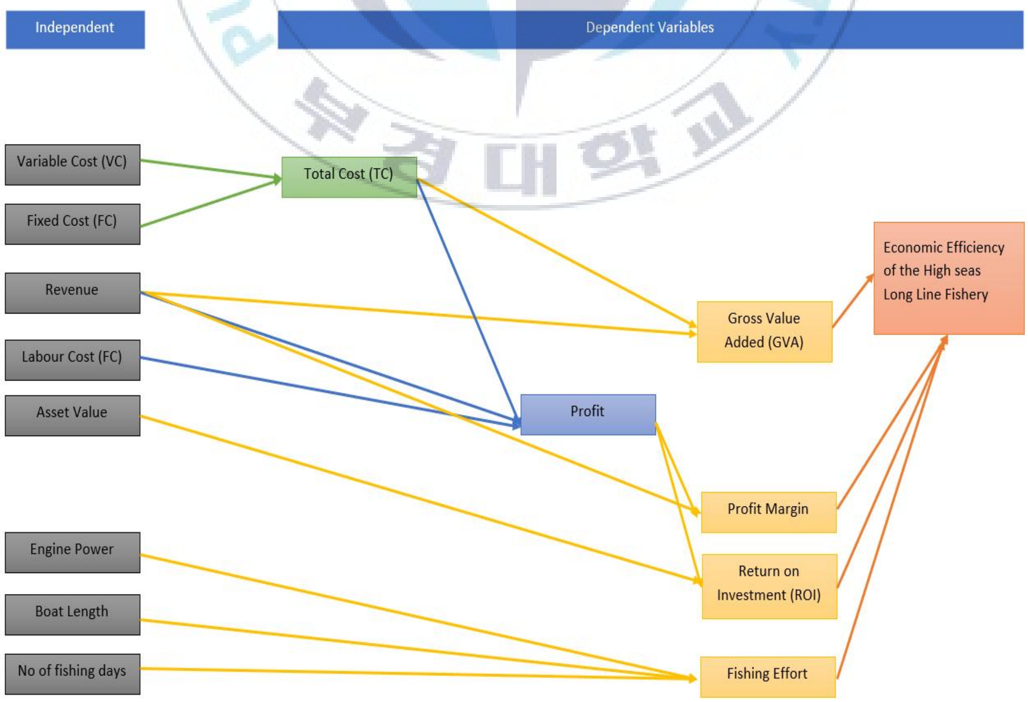
III. METHODOLOGY

1. Introduction

This chapter provides a complete information regarding the method adopted to perform the research as well as the conceptual diagram designed to assist the research. Moreover, the formulas that will be used to perform the analysis is also provided.

2. Conceptual Diagram

Many researchers are convinced that conceptual framework is a tool structured to give the best natural progress on a particular ideology to be studied with in-depth analysis (Camp, 2001). It combines the concept to be studied, empirical evidences on the concept and similar theories of relevance which can be used to advance and synthesis the researcher's contribution to knowledge, which he wants to reveal to the world (Peshkin, 1993). The conceptual diagram consists of independent and dependent variables. The defined conceptual diagram for this research is provided in figure 13.



< Figure 13> Conceptual framework for the research

3. Research Design

This research mainly focuses on the secondary and primary research. The secondary research will use systematic review to study the existing literatures (see section 3.4) and the primary research will use the mixed methodology to gather qualitative and quantitative data (see section 3.5).

4. Secondary Research

When it comes to doing a systematic review of a particular study, some of what is being targeted are; classification or recognition, decisively analysing and incorporating the results to be significant, good quality personal work which attempts to solving the research questions posed (Lin et al., 2001).

- Step 1: Focuses on identifying the research questions that can be used for the research (see section 1.3).
- Step 2: Identifying the related research works. The keywords identified to perform the research are 'high seas long line fishery' AND 'high seas long line fisheries in Sri Lanka' AND 'Economic efficiency of the high seas long line fishery in Sri Lanka'. The databases that will be used to search for the journals are google scholar, ARCHIMER, Web of Science, and BIOONE.
- Step 3: Measuring the quality of the study.
- Step 4: Summarize the identified evidence.
- Step 5: Interpret the Outcomes from the research.

5. Primary Research

The mixed methodology research is one of the studies that focuses on gathering of qualitative and quantitative data (Yoshikawa et al., 2008). The main reason for selecting mixed methodology research is their benefits which are listed below:

- It incorporates the benefits of the quantitative and qualitative research methods shown in Table 11.
- It does not limit the collection of data.
- It improves the accuracy of the gathered data.

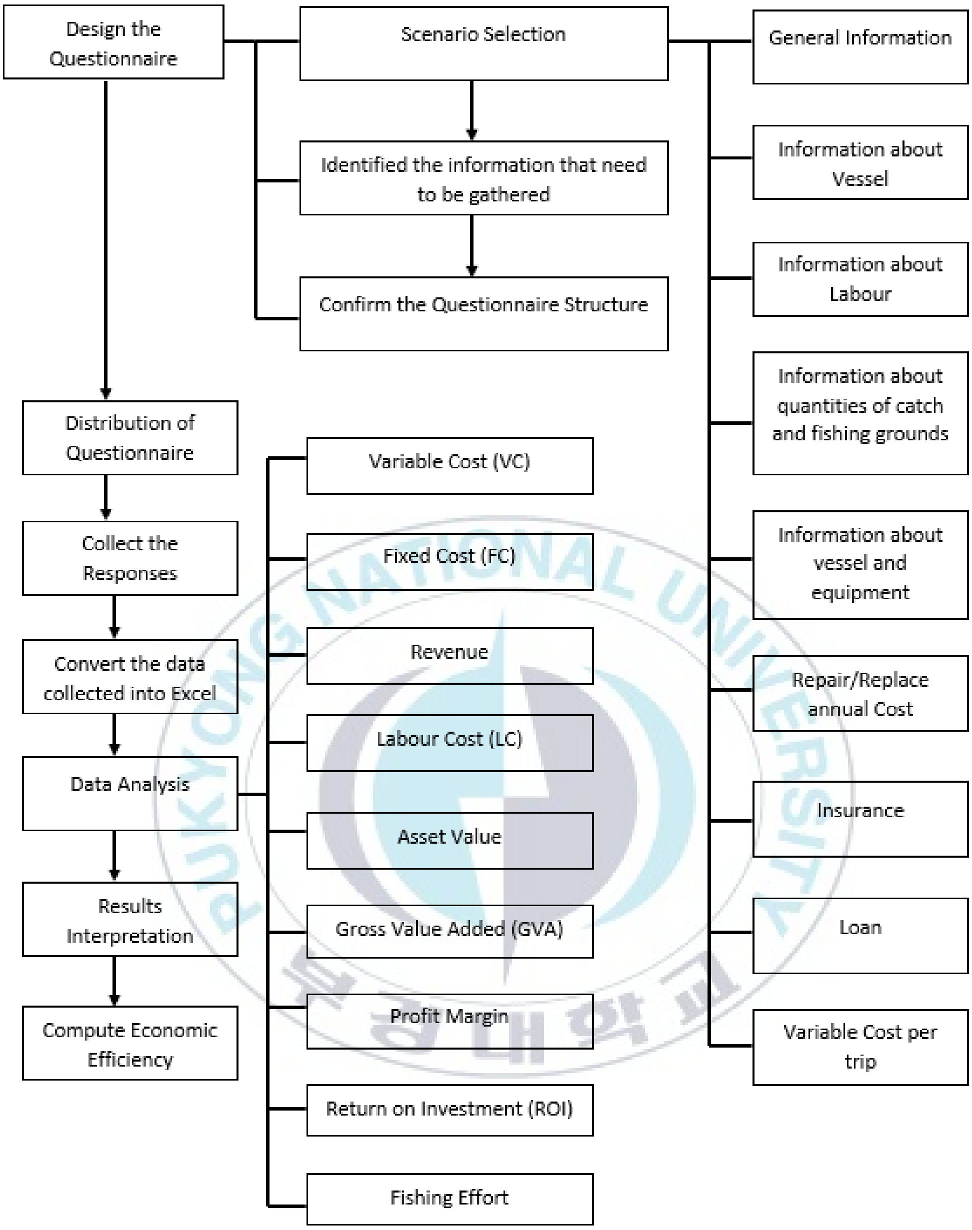
The quantitative research method mainly focuses on gathering data that are quantifiable (Sukamolson, 2007). The quantitative data is generally gathered through questionnaires, surveys and so on. On the other hand, the qualitative research method mainly focuses on gathering descriptive data (Marshall 1996). The qualitative data are gathered through observation, focus group, interview and so on. The benefits and drawbacks of the quantitative and qualitative research methods are provided in Table 11.

<Table 11> The benefits and drawbacks of the quantitative and qualitative research methods (Yvonne Feilzer, 2010)

	Quantitative Research	Qualitative Research
Benefits	• Easy to gather • Less time consumption • Cost effective. • Easy to perform analysis	• Provides detail and in-depth study. • Can capture the individual experience and expressions.
Drawbacks	• The description of the responses is limited because of the quantifiable feature of the data.	• Time consuming • Costly • Not easy to gather • Analysing the qualitative data can be difficult.

5.1 Data Collection Methods

This research use interview approach for the qualitative data collection and survey for the quantitative data collection. Interview is a conversation between two or more people where the questions will be asked and the answers for the questions will be discussed. On the other hand, survey is a technique of research for gathering data from already identified group of people from which information and education on the difference subject matter of interest can be extracted.



<Figure 14> The framework of survey

The figure 14, above provides a theoretical framework of the project. The primary research conducted in this project mainly focuses on the questionnaire. The questionnaire designed for this project intends to gather information such as general information about the participant, information about the vessel, information about labour, information about quantities of catch and fishing grounds, information about vessel and equipment, repair/replace annual cost, insurance, loan, and variable cost per trip. The design questionnaire for this project is provided in appendix 1. The scenarios decided to gather information are from the people associated in Dikkowita Harbour of Western Province, Sri Lanka.

In total 54 participants' responses were gathered, and the data were inserted into Excel for effective analysis. The analysis of this project includes a variable cost (VC), fixed cost (FC), revenue, labour cost (LC), asset value, gross value added (GVA), profit margin, return on investment (ROI) and fishing effort. From the analysis performed the economic efficiency was computed in this project.

5.2 Research Participants

The identified research participants for the primary research are people who are working in the Dikkowita Harbour of western province Sri Lanka. The simple random sampling method was used to select the participants for the primary research.

5.3 Data Analysis

The quantitative data was analysed using the statistical analysis and the qualitative data was analysed using the thematic analysis. The thematic analysis focuses on identifying the common theme from the data gathered.

6. Formulas

The brief explanation of the variables identified in the conceptual diagram in figure 13 and the formulas used are provided below:

Variable Cost: A company expenditure which is subject to changes in relative measure to the production productivity. Goes up and down subject to the quantity of company's production; as production rises, variable cost also rises in proportion, if production reduces, it falls as well. Price of raw material and binding of product are examples.

Fixed Cost: A constant expense which does not subject to change whether there is a rise or fall in the volume of goods or services manufactured or the one traded for money. Company factors this kind of expenses into their budget whether there is production or not. In totality, company have total cost which is the addition of both variable cost and fixed cost. However, steps must be taken to water down fixed costs.

Total Cost: A combination of total fixed cost and total variable cost. The formula is provided below:

$$Total\ cost = Fixed\ Cost + Variable\ Cost$$

Revenue: The overall revenue is the total volume of goods and services earmarked to be traded for money. Computed through, multiplication of overall volume of goods and services that have been traded for money by the worth of the products.

Gross Value added (GVA): A financial output metric assessing the impact of a business ancillary, firm or community to financial system, manufacturer, subdivision or area. It makes available, dollar worth of the volume of merchandise and services manufactured in a nation, with the exception of the expenditures on the materials consumed for the sake of the production which has direct impact. GVA would therefore, regulate GDP through the effects subvention and taxes have on the goods.

Labour Cost: The price paid for labour is the total pay given to worker, including other add-ons attached to boost morale to work and what is paid to the government by the company's owner. The labour price is sub-divided into direct and operating cost. Direct cost includes workers' salary who engage in production of product, this does not exclude those on the assemblage station. Operating cost is related to labour support; this includes workers who service machine for optimum functioning.

Profit Margin: One of the mostly widely used productivity measure used in determining the extent firms or corporations generate income. That part of what has been traded for money, which has now turned to profit. In other words, it showcases the dollar value the business has amassed for each good traded. For example, assuming a business gives out information that it generated 35% profit margin during the previous three months, this means that after deductions, the business now worth 0.35dollar income for each money amassed on sales.

The formula for the profit margin is provided below:

$$Profit\ Margin = \frac{profit * 100}{Gross\ Revenue}$$

Return on Investment (ROI): A productivity assessment employed to appraise effectiveness of venture or putting side by side the effectiveness of arrays of various ventures. It tends to assess the returns volume on a venture directly, relating it to cost incurred on the venture. Computing ROI, the gain amassed on the venture divided by the venture's expenditure. The output is given in a percentage or ratio.

The formula for the return on investment is provided below:

$$Return\ on\ Investment = \frac{profit * 100}{Total\ assets}$$

Cobb-Douglas Production Function: Charles Cobb and Paul Douglas in 1928 reported their assumption which centred on production output is the outcome of volume of labour and tangible capital put into a venture. This investigation gave a computation which is still relevant in this present time; this is due to its precision.

Production function of Cobb-Douglas reveals the link between tangible capital and labour, also known as inputs, and volume of yield produced. An avenue for computing the contribution of the variations in the inputs made available for production, the relevant effectiveness, and outcomes of production lifecycle.

Total cost (TC) is function of horsepower (hp), length of vessel (L) and number of fishing days (d) using Cobb-Douglas function: $TC = Ahp^{\alpha}L^{\beta}d^{\Upsilon}$

$\ln TC = a_0 + \alpha \ln hp + \beta \ln L + \Upsilon \ln d$ (setting $\ln A = a_0$) where TC is the total cost, hp is horse power of vessel, L is the length of vessel and d is fishing days of vessel.

The returns to the variable inputs also can be measured by output elasticities (FAO, 2003b). In this case, the parameters are the horse power-output elasticity (α), the length of vessel - output elasticity (β), and the fishing days-output (ϒ). The signs of all estimated parameters are positive and it is explained below. When the engine capacity is higher, vessels can quickly travel between the fishing ports and fishing grounds. There are high speed vessels that are in increased demand, driven by both and market and safety reasons (Parente, 2004). Moreover, it is important factor that increase in engine power of a fishing vessel for the enlargement of the usual size of vessel length. Parente pointed out that higher length vessels can be carried out larger volume thereby cumulating the corresponding value of the fishing effort and increasing the more chances of catching fish. Fishing days are calculated as actual fishing time of each vessel by way of the time spent on searching for fish, looking for fishing grounds, preparing or maintaining the fishing gear, and harvesting. However, it is calculated average number of days per trip as fishing time in this study. The fishing effort is measured by differences in relative fishing power, because fleet often varies according to size of length, horse power, and fishing days. If vessels have low fishing effort, its relative fishing efficiency will be low and vice versa. The difference in relative standardised effort for all vessels may indicate that vessels are heterogeneous, which is determined by cost and efficiency perspective. In this case, we represent vessels along relative standardised effort axis, from the most cost efficient one to the left and the least cost effective ones to the right. Relative standardised effort of an average vessel was chosen from a range of relative standardised efforts for all vessels to compare with that of the remaining vessels and then we may imply that what vessels and what vessel group have the most cost efficiency. In addition, vessels vary with engine capacity, hull length and number of fishing days so that defining relative standardised efforts for each vessel will define the average revenue of relative standardised effort for all vessels is the same.

7. Summary

The secondary and primary research approaches are discussed in this chapter. It is also discussed the economic efficiency of the high seas long line fishery in Sri Lanka with the special references to Dikkowita Harbour of Western Province.

IV. DATA ANALYSIS

1. Introduction

This chapter provides the complete information regarding the descriptive analysis performed as well as the empirical model analysis performed on the data gathered.

2. Descriptive Statistics

<Table 12> Descriptive statistics of the data

Criteria	Mean	Standard Deviation	Minimum	Maximum
Length (ft)	46.09	4.52	38.00	54.00
Engine Power(hp)	292.13	105.17	90.00	400.00
Average fishing days per trip (days)	37.06	6.59	17.00	51.00
Gross Revenue per trip	3.524	1.374	1.389	7.093
Variable Cost per trip	1.313	0.411	0.772	2.205
Maintain and Repair cost per trip	0.133	0.069	0.017	0.325
Insurance per trip	0.012	0.004	0.005	0.025
Labour cost per trip	1.105	0.545	0.241	2.568
Depreciation per trip	0.135	0.067	0.056	0.449
Loan interest per trip	0.064	0.132	0.00	3.545
Calculated value per total Asset	8.218	4.389	0.981	16.772

Unit of measure – million LKR

Source: research's finding and computations

It is obvious from the analysis in table above that, hull length for the sample given ranged from 38ft to 54ft, with an average length of about 46.09ft. Engine capacity varied from 90 to 400 hp, with the mean of 292.13 hp. The fishing days' range from 17 days to 51 days, with 37.06 days as the average number of fishing days. Additionally, the table also reflect some key economic indicators of the analysis, in term of cost, revenue, loan, interest and depreciation. On the revenue side, the gross revenue ranges between 1.389 million LKR and 7.093 million LKR, while the average gross revenue is 3.524 million LKR. The total variable cost per trip is within the range of 0.772 million LKR and 2.205 million LKR, and the average total variable cost per trip is 1.313 million LKR. The maintain and repair cost between 0.017 million LKR and 0.325 million LKR, while the average repair is 0.133 million LKR. Not only that the insurance cost is within the range 0.005 million LKR and 0.025 million LKR, while the average total insurance cost is 0.012 million LKR and total labour cost varies between 0.241 million LKR and 2.568 million LKR, average labour cost value is 1.105 million LKR. The computed depreciation ranges between 0.056 million LKR and 0.449 million LKR and the mean average of the computed depreciation is 0.135 million LKR. The total loan cost varies between 0.0 million LKR and 3.545 million LKR, the average of this total loan cost is 0.064 million LKR. Finally, total assets range between 0.981 million LKR and 16.772 million LKR, the mean average of the total asset is 8.218 million LKR.

<Table 13> Descriptive statistics of the data for Vessel length

High seas long liners (Vessel length (ft))								
	L ≤ 40		41 ≤ L ≤ 45		46 ≤ L ≤ 50		51≤ L	
	n =10		n =10		n = 26		n = 8	
Criteria	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Length (ft)	39.40	0.70	43.30	1.25	47.46	1.39	53.50	0.76
Engine Power(hp)	137.00	56.97	240.00	95.80	342.12	51.46	388.75	9.91
Average fishing days per trip (days)	29.40	5.50	36.60	6.22	38.42	5.39	42.75	2.92
Gross Revenue per trip	2.364	0.771	2.433	0.625	3.708	0.904	5.739	0.877
Variable Cost per trip	0.946	0.105	1.046	0.194	1.352	0.332	1.975	0.154
Maintain and Repair cost per trip	0.098	0.045	0.128	0.059	0.143	0.070	0.151	0.094
Insurance per trip	0.009	0.003	0.11	0.003	0.013	0.004	0.016	0.004
Labour cost per trip	0.708	0.388	0.693	0.306	1.178	0.398	1.881	0.447
Depreciation per trip	0.077	0.230	0.128	0.030	0.153	0.083	0.156	0.035
Loan interest per trip	0.008	0.028	0.029	0.073	0.074	0.161	0.144	0.136
Calculated value per total Asset	3.250	1.110	4.863	1.390	9.516	3.127	14.402	2.353
Average catch per trip (kg)	3,142.50	1,038.03	3,206.90	799.26	4,842.31	1,164.77	7,442.38	1,085.37

Unit measurement: million LKR

Source: research's finding and computations

In addition, the sample vessel groups are categorized based on boat length (ft). These four vessel groups are quite heterogeneous in terms of technical and operational characteristics such as hull length, horse power and number of fishing days. With the engine capacity of less than or equal 40 (ft), the average engine power of this vessel group was 137 hp; and the average fishing days of 29.4 days per trip. The number of fishing days, in average, the other performance indicators for the vessel group with the vessel length greater than 50 (ft) were higher than those of the vessel group with the vessel length of less than other groups.

The last group (>50 ft) had a mean vessel length of 53.5 ft and the number of fishing days of this group is higher than that of fishing fleet with the vessel length ranging from other groups. Table 13 also describes the average economic variables for each of the four vessel groups. Gross revenues of these four vessel groups, ranging from the smallest to the largest vessel length, were 2.364 million, 2.433 million, 3.708 million and 5.739 million LKR respectively. For the costs, except the maintenance and repair costs, vessels with the vessel length of larger than 50 ft had the largest costs. Finally, the calculated value of total assets (including the vessel and equipment) were 3.250 million LKR for vessel group with the vessel Length of less than or equal 40 ft, 4.863 million LKR for group with the vessel group ranging from 41 ft to 45 ft, 9.516 million LKR for vessel group 46 ft to 50 ft and 14.402 million LKR for the last group.

3. Empirical Model Analysis

<Table 14> Empirical model analysis for vessel length

	Vessel Length (ft)			
Criteria	$L \leq 40$	$41 \leq L \leq 45$	$46 \leq L \leq 50$	$51 \leq L$
Gross Revenue	2.364	2.433	3.708	5.739
Gross Value added	1.408	1.376	2.342	3.747
Gross Cash flow	0.699	0.682	1.164	1.865
Profit	0.613	0.525	0.937	1.565
Profit Margin	25.96%	21.59%	25.29%	27.27%
Return on Investment (ROI)	18.88%	10.81%	9.85%	10.87%

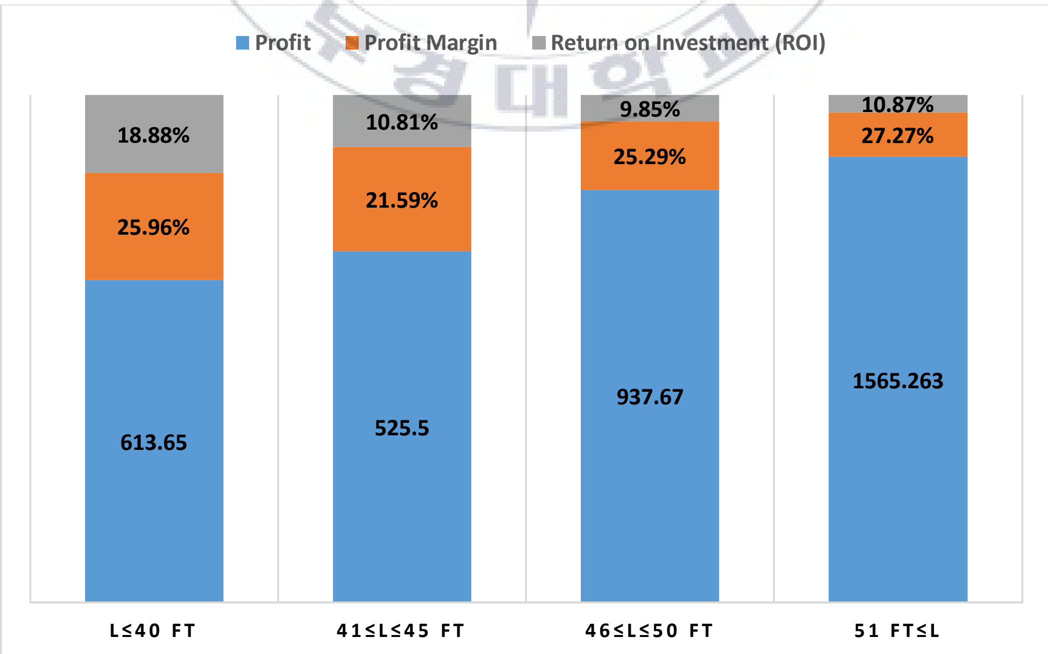
Unit of measurement: Million LKR

Source: research's finding and computations

There is a comparison of some important economic performance indicators between four longline groups which are categorized according to vessel length. It is indicated that the vessel group with vessel length of less than or equal 40 ft has an average gross cash flow of 0.699 million LKR, translating into a profit of 0.613 million LKR, profit margin of 25.96%, and return on investment of 18.88%.

The results are also predicted that, an average vessel in a group with vessel length ranging from 41 ft to 45 ft has an average gross cash flow of 0.682 million LKR and profit of 0.525 million LKR, corresponding to a profit margin of 21.59% and return on investment of 10.81%. Moreover, an average gross cash flow and profit of the $46 \leq L \leq 50$ ft vessel group were 1.164 million LKR and 0.937 million LKR respectively, as well as profit margin was 25.29% and return on investment was 9.85%. Overall, we can summarize that vessel group with the vessel length of larger than 50 ft gets the highest gross cash flow and profit but its profit margin and return on investment are lower than the smallest vessel group. These positive results shack some lights over the fishery under open access. First, the offshore tuna-longline fishery is integrally risky because of weather and distance. This can imply that the more risk fishermen have, the more income they may get. Second, due to high capital investment and operational expenses incurred, there are few fishermen who can afford shifting to offshore tuna longline operations (Table 14).

The average economic performance indicators of a long line in Dikkowita was illustrated in Figure 15. From this, we can see that, Large group ($51 \leq L$) has the highest efficiency in profit and profit margin and small group ($L \leq 40$) has the highest return on investment.



<Figure 15 > Average economic performance indicator of four vessel groups

Source: research's finding and computations

<Table 15 > Skipper share of gross revenue

Size class (ft)	Skipper share of gross revenue(%)
L≤40	6.80
41≤L≤45	6.19
46≤L≤50	6.33
51≤L	6.09

Source: research's finding and computations

The value obtained via the existence of fishing activities and the value placed by the society on fishing products i.e. the catch value is economic advantages derived from fishing. This work has assumed that the economic advantages and monetary revenue are the same through the assumption that value placed on catch by the society is the same with monetary revenue, the market by which the fishers vend their catch are assumed also to be of efficiency and competitiveness in nature.

Table 15 is the skipper share estimation of gross revenue utilized to estimate the skipper labour imputed value. Expectantly, smaller boats skipper's share happened to be more valuably higher in term of gross revenue percentage than that of the larger boats. When smaller boat was utilized, the labour was seen to be a factor more essential for production. Gross revenue was lower relatively in the smaller sized boats, therefore, a reduced percentage might not have given skippers as an attachment to those boats, most especially, because an increased absolute income which might be smaller in percentage share, would have been taken from the larger boats.

<Table 16> Comparative skipper income estimate per class size

	L≤40	41≤L≤45	46≤L≤50	51≤L
Skipper share (LKR)	160,735	150,588	234,775	349,469
Average number of days per trip	29.40	36.60	38.40	42.75
Skipper share per day (LKR)	5467.12	4114.43	6113.93	8174.71
Skipper share per hour (LKR) (assumption 12 hours per day)	455.59	342.87	509.49	681.22

Source: research's finding and computations

If we are to assume boat skipper performed for twelve hours out of twenty-four hours on the average, the largest boat skipper gave close to 681.22 LKR per hour in income term. On the condition that the figure appears reasonable for the role executed at a higher level by the larger boat skipper.

4. Result of Total cost function

By performing regression analysis of the Stata, Total cost by means of some technical and operational characteristics of the vessels such as vessel length (L), horse power (hp) and fishing day (d) as independent variables, we show the result of ordinary least square (OLS) estimation in Figure 16.

```
. (4 vars, 52 obs pasted into editor)
regress lntc lnhp lnl lnd

      Source |       SS       df       MS              Number of obs =      52
-------------+------------------------------           F(  3,    48) =   51.95
       Model |  4.94547881     3  1.64849294           Prob > F      =  0.0000
    Residual |  1.52316554    48  .031732615           R-squared     =  0.7645
-------------+------------------------------           Adj R-squared =  0.7498
       Total |  6.46864435    51  .126836164           Root MSE      =  .17814

------------------------------------------------------------------------------
        lntc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnhp |   -.310882   .0926098    -3.36   0.002    -.4970864   -.1246775
         lnl |   3.577316   .4658682     7.68   0.000     2.640625    4.514007
         lnd |   .4568248   .1618762     2.82   0.007     .1313508    .7822987
       _cons |    1.14596   1.282079     0.89   0.376    -1.431833    3.723753
------------------------------------------------------------------------------

.
```

<Figure 16> Regression analysis result

Source: research's finding and computations

When considering the result of the standardised residuals two outlier can be identified at the 5% significance level. Those are number 38 and 50 in basic data. After removing this two data, outlier effect can be removed. After that, regression analysis has been done by using Stata 10 data analysis soft wear. Also, multicollinearity and heteroskedasticity had been considered. According to that result there is no multicollinearity effect or heteroskedasticity effect. According to the regression analysis, the "R "square value (goodness of fit) is 0.76. So we can be assumed, 76% variability of the dependent variable can be explained by the independent variable, and adjusted "R "square value, which is adjusted for the sample size and number of explanatory variables, represent 75%. Also, P value for F-statistic is identified as less than 0.01 which measures the significance or relevance of the set of parameters as a whole, and the higher F-value the better significance of the model. All parameter estimate is said to be significant at the level of 1%, except the coefficient associated with technological efficiency, A.

<Table 17> Parameter estimate and test statistics of total cost function

	Estimated Coefficient	T- value	P - value
A	1.14596	0.89	0.376
α	-0.310882	-3.36	0.002
β	3.577316	7.68	0.000
Υ	0.4568248	2.82	0.007

Source: research's finding and computations

According to Table 17, the estimated coefficients of horse power, length of vessel and fishing days are estimated to be -0.310882, 3.577316 and 0.4568248 respectively. It means that if increasing horse power partially by 1% total cost decrease 0.31% (the relationship between total cost and alpha is vice versa) and length of vessel and fishing days partially by 1%, the total cost will go up by 3.58%; and 0.46% respectively, with other variables holding constant. In addition, a change in vessel length influences the total cost more than that in fishing days.

Considering the Figure 17 and Figure 18, there is no heteroscedasticity and multicollinearity. There is no time series data to analyse autocorrelation test because survey data were related to one year fishing operation.

```
tat hettest

sch-Pagan / Cook-Weisberg test for heteroskedasticity
     Ho: Constant variance
     Variables: fitted values of lntc

     chi2(1)      =     1.15
     Prob > chi2  =   0.2843
```

<Figure 17> Regression analysis for heteroscedasticity

Source: research's finding and computations

```
estat vif
```

Variable	VIF	1/VIF
lnl	3.52	0.284127
lnhp	3.11	0.321710
lnd	1.62	0.616546
Mean VIF	2.75	

<Figure 18> Regression analysis for multicollinearity

Source: research's finding and computations

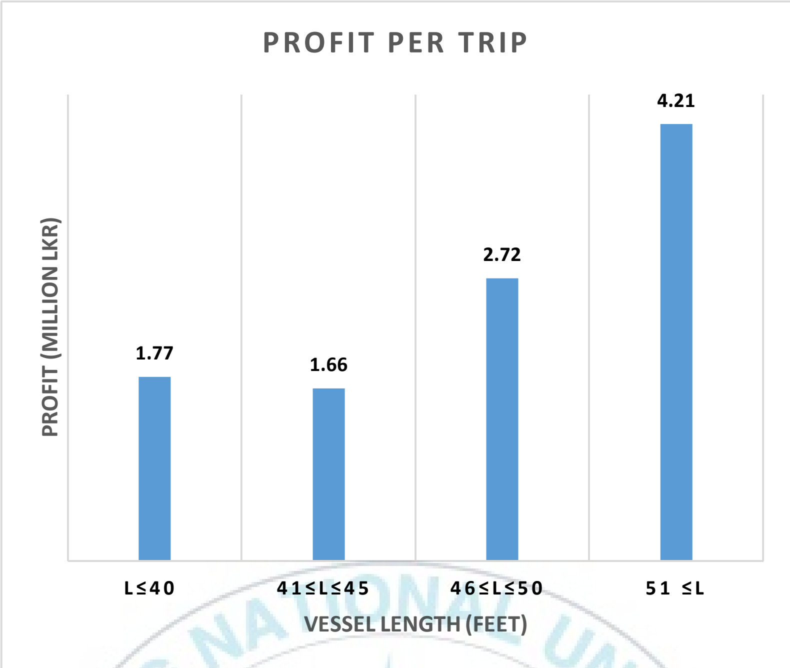
V. DISCUSSION AND RECOMMENDATION

This chapter provides complete information regarding the discussion and recommendation of this project.

1. Discussion

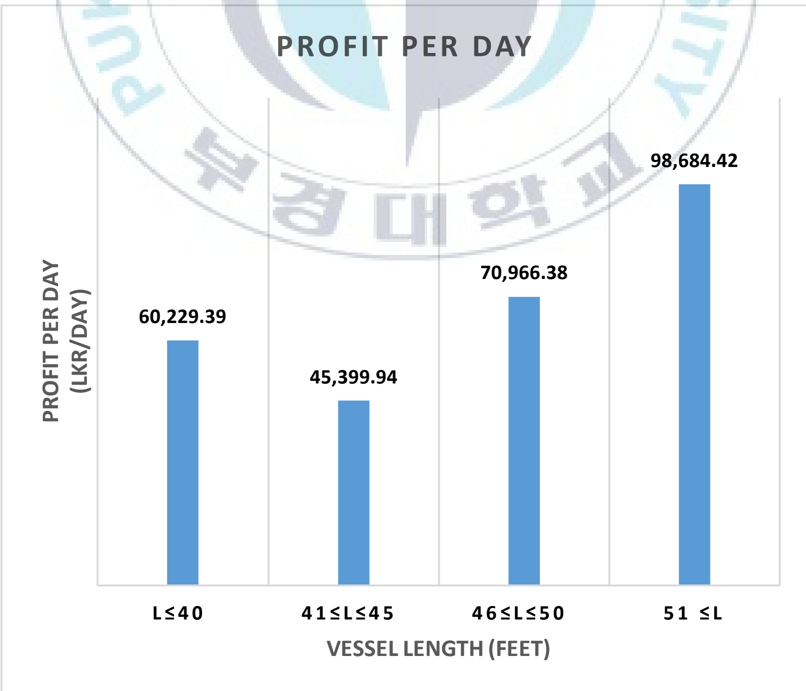
Surprisingly, these empirical results have shown that the lowest ROI is for bigger vessels while the highest ROI is for the smallest vessel group. This can be explained as follows: it can be seen from table 14 that the repair and maintains cost of this vessel group is lowest while this kind of cost for the smallest vessels is highest. This can indicate that almost all of the vessels with a larger vessel are relatively new. However, these big investments in the large vessel are insufficient because some of them, especially fishermen with few years of high seas fishing experience have just entered this fishery, are not equipped with enough information on high sea resources and advanced fishing technologies. This can cause them to have lower fishing efficiency. In addition, because of seasonal effects, some largest-size longliners may not fish in certain months if their trip revenue does not cover variable costs or some other large vessels still catch tuna or other fish in the sub season but most of them incurred an economic loss while the small vessels may change to fishing squid or still operate longline owing to lower trip variable costs. Further, due to the limitation of vessel owners' finance, some fishers were capable to invest into the small vessels.

The average profit per trip indicators of a long line in Dikkowita was illustrated in Figure 19. From this, we can see that, Large group ($51 \leq L$) has the highest profit and length ($41 \leq L \leq 45$) has the lowest profit per trip.



<Figure 19> Profit of four vessel groups

Source: research’s finding and computations



<Figure 20> Profit comparison

Source: research’s finding and computations

It is depicted the profit accrued to the organization while using different types of vessel length for operation. The vessel length that is less than or equal 40ft, brings in a profit of 1.84 million LKR during the period under review, next to it is the vessel length between the range of 41 and 45ft, this category brings in 2.33 million LKR in profit, also, the vessel length between 46 and 50, accrues 2.97 million LKR to the organization during the period of review. The vessel length that is greater than 50ft, brings in a profit of 4.41 million LKR during the period. This clearly shows that vessel length greater than 50 ft have the highest capacity to bring in more profit to the organization (Figure 20).

<Table 18> Cost efficiency for four vessel groups

Vessel Length (ft)	Average Total Cost per trip (LKR)	Average Total Catch per trip (kg)	Average Cost Efficiency (LKR/kg)
$L \leq 40$	527,445.07	3,142.50	167.84
$41 \leq L \leq 45$	684,686.62	3,206.90	213.50
$46 \leq L \leq 50$	872,486.48	4,842.31	180.18
$51 \leq L$	1,331,575.90	7,442.38	178.92

Source: research's finding and computations

Based on the average cost per relative catch for 54 vessels of this sample calculated above, we can divide them into four vessel groups which are categorized according to a vessel length and then calculating the average cost per relative standardised catch for an average long liner of each vessel group. This will help us to know what vessel group gets the most cost efficiency.

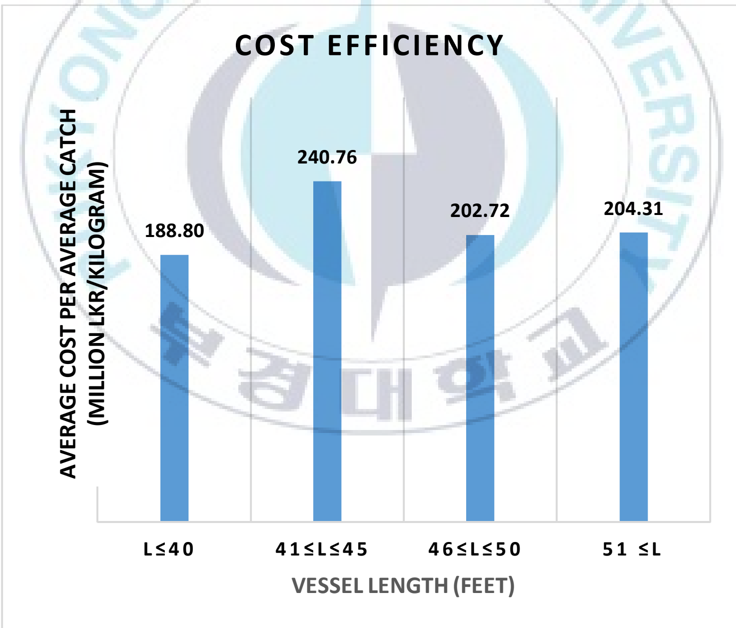
The cost of $L \leq 40$ is efficient at 167.84 LKR per kilogram, while the capacity of catch of this kind of vessel is expressed as the average total catch per trip to the tune of 3,142.5 kilograms, this is what determines the average total cost realised per trip which stands at 527,445.07 LKR. In a nutshell, the average total cost is a function of the average total catch per trip and average cost efficiency.

For the vessel length of $41 \leq L \leq 45$, the interaction between average total catch per trip of 3,206.9 kilograms and the average cost efficiency of 213.5 LKR per kilogram, produces the average total cost per trip of this vessel length which is to the tune of 684,686.62 LKR.

For the one with 46 ≤ L ≤ 50 vessel length, the average cost per trip realised is 872,486.46 LKR, which is a product of the interaction between average catch per trip of this vessel at 4,842.31 kilograms and the average cost efficiency of 180.18 LKR per kilogram.

The vessel length of 51 ≤ L, has an average total cost per trip to the tune of 1,331,575.9 LKR, from the collaboration between the average total catch per trip which is 7,442.38 kilograms and the average cost efficiency of 178.92 LKR per kilogram.

The above analysis helps to see that vessel length of 41 ≤ L ≤ 45 ft group has the least cost efficiency while the vessel length L ≤ 40 group has the most cost efficiency. This shows that the relationship between total cost and cost efficiency is negative, as cost efficiency increases; the total cost decreases due to the fact that total cost is a function on the cost efficiency.



<Figure 21> The cost efficiency among four vessel groups

Source: research’s finding and computations

2. Recommendation

Based on the findings, the following recommendations are made:

- The horse power shows a negative relationship with total cost, meaning that the higher the horse power the lower the total cost, this is commendable in such a way that the more the horse power used by the vessel, the lower the total cost incurred, it is therefore recommended that, government can gear up effort towards technology advancement which will help in manufacturing more of cost effective horse power.
- The length of the vessel reveals a positive relationship with total cost, this implies that the longer or larger the vessel, the higher the total cost, it is also safe to say that the smaller the length of the vessel, the lesser the total cost, it means that smaller vessels are cost effective more than the longer ones. However, when it comes to the harvest and profit, it is lesser in smaller vessel groups than larger vessel groups. Thus, government should motivate fishermen to use larger vessel groups for fisheries industry to get the maximum economic benefit.
- The relationship between fishing days and total cost is direct, the more the fishing days spent on the high sea for catch and other related activities, the more the total cost incurred. It is not possible to say they should spend few days fishing because a lot of factors determine the number of days spent which might be beyond the control of the fishermen, but it can be recommended that, government can create a program, it could be subsidy program, soft loan or grants among others, that will soften the effect of the total cost incurred while fishing days spent on the high sea prolongs, this would plug the hole bored by the total cost incurred on their profitability.
- The government should provide insurance facilities and loan payment methods to encourage the high sea fishery.
- The government should introduce new technologies to improve the productivities of the high sea longline fishery.
- The government should encourage the new generation for fisheries industry.
- The government or private sector should start vocational training centres for fishermen and build up its professional fishermen's jobs.

The following are the recommendations that the fishermen should consider improving their turnovers.

- Get sufficient help from the government.
- Learn to use new technologies.
- Learn to use vessel size more than 50 ft to ensure efficiency.

VI. CONCLUSION AND FUTURE WORKS

1. Conclusion

The research of this project evaluated and analyses the economic efficiency and cost efficiency of high seas longline fishery in Dikkowita Harbour, Sri Lanka based on cost and benefit statistics obtained in 2019. The study analysed and assessed economic performance of high sea longline fishery. The projected economic performance of fisheries in 2019 is relatively high. Four factors may explain this: volatile fisheries, cost-effective vessels, high operating costs and high capital investment.

This study has also examined that the vessel group with the bigger vessel length has the lowest cost efficiency while the least vessel length gets the highest cost efficiency and return on investment (ROI). The key reasons for this are that the capital investment in the biggest vessel is large but the skill of some fishers to capture on high sea grounds is limited, lack of novel fishing technology and the impact of the seasonal factor also lead to the cost inefficiency of the largest length vessels. As well as, some fishermen do not like to move from traditional method, attitude and life cycle. On the other hand, the main reason for decrementing ROI is high loan interest cost. Because of large vessels have brought utilizing loan. In this project evaluated that every fisherman had a low educational background and they were only traditional family members, its effect to develop the fisheries industry. Next fact, every fishing vessel had caught same fishing ground. It's meant they didn't try to find the new fishing ground and improve their harvest in the high seas and many fishermen didn't have to buy large vessel due to lack of financial ability.

The study of cost-efficient vessels reveals that vessels' costs efficiency vary in relative standardized fishing (due to the same average revenue of relative standardized effort). The vessels have a heterogeneous cost efficiency. 95% owners have gained profit while 5% owners have suffered economically (loss). This statistic provides an interesting observation why many investors want to invest capital into high seas longline fishery in Sri Lanka.

It is recommended in this research that the government policies should incorporate to encourage the use of modern fishing facilities, provide effective methods to perform high seas fishing, weather indicators, and effective rescue methods. Moreover, the insurance policies for the fishermen should be revised to motivate them to continue their day-to-day duties. Even though, this project finds some interested observations, it is important to perform the study in other harbours in Sri Lanka to provide a general observation.

2. Future Works

The following are the suggested future works for this project:

- Future work 1: To perform primary research on other categories of fishery like offshore.

- Future work 2: The data gathered from a single harbour cannot be generalised for the entire Sri Lanka. Therefore, it is expected in the future to perform primary research on all the harbours in Sri Lanka.

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Appendices

1. Survey Questionnaire

Dear Respondent,

I am Warnasinghe Arachchige Piyathissa, Master student at **Department of Marine Fisheries and Business Economics, Pukyong National University in South Korea**, undertaking thesis on the topic of "The Economic Efficiency of the High seas Long Line Fishery in Sri Lanka: Special Reference to Dikkowita Harbour of Western Province"

Your answers are intended to guide the researcher to estimate the Economic Efficiency of the High seas Long Line Fishery in Sri Lanka. Therefore, I urge you to be sincere as possible in answering the questions.

The answers are strictly for academic use. Therefore, the confidentiality of your answers are highly guaranteed.

Highly appreciate your kind consideration and cooperation.

Thanks for your understanding and cooperation.

QUESTIONNAIRE ON MARINE FISHERIES IN DICKOVITA, WESTERN PROVINCE, SRI LANKA

I. General information:

Name of interviewee..

Age...................... Vessel owner is captain or not? Yes ☐ No ☐ ....

Address.. Phone no - ....

II. Information about vessel

1. Registered vessel number .... 2. Length(ft) ....
3. Year of building vessel .... (if owner does not know, please stick here)
4. Engine power (hp) ....

III. Information About labor

Skipper	Crew (including skipper)
1. Skipper information a. Skipper education level .... b. Age .... years c. Experience .... years d. Vocational training period .... days e. Does skipper come from traditional household? Yes/No	2. Average crew size (persons) .... 3. Income of one trip per person(LKR).....................

IV. Information about the quantities of catch and fishing grounds

1. Number of trips (2019)	
2. Average quantities of catch per trip	
a. Yellowfin tuna (kg)	
b. Big eye tuna (kg)	
c. Other fish (kg)	
3. Average numbers of days per trip (days)	
4. Fishing ground	

V. Information about vessel and equipment.

Items	Basic information	Purchased year	Value (LKR)	Estimated Present Value (LKR)	Built year	Estimated lifespan
Hull						
Engine						
Long liners						
Hooks						
Electronic equipment						
Others						
Total						

VI. Repair/Replace annual cost

	Cost (LKR)
1. Hull	
2. Engine	
3. Fishing equipment	
4. Others	
5. Total	

VII. Insurance

	Cost (LKR)
Insurance	

VIII. Loan

Source of loans	Monetary Value	Time of borrowing	Debt at end of year (LKR)	Interest payment In year
1. Program				
2. Bank				
3. Private				
Total				

IX. Variable cost per trip

	Quantity	Value (LKR)
1. Fuel		
2. Lubricant		
3. Ice		
4. Bait		
5. Provision		
6. Others		
Total		

X. Average revenue (LKR) and crew share (%)

1. Total revenue for all (LKR)	
2. Average revenue per trip (LKR)	
3. Percentage earning to labors after deducting variable costs per trip (%)	
4. Average price per year (LKR/kg)	
a. Yellowfin tuna	
b. Big eye tuna	
c. Others	

XI. Comments from interviewer

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2. Regression analysis result

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.838422483
R Square	0.70295226
Adjusted R Square	0.685129396
Standard Error	0.200028631
Observations	54

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	4.734279664	1.578093221	39.4410374	3.20229E-13
Residual	50	2.00057266	0.040011453		
Total	53	6.734852324			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.550818105	1.425005712	1.088289045	0.28168556	-1.311390102	4.413026313	-1.311390102	4.413026313
lnhp	-0.26794371	0.10016708	-2.67496776	0.01007382	-0.469135211	-0.066752208	-0.469135211	-0.066752208
lnl	3.477535232	0.515917577	6.740486047	1.5287E-08	2.441284281	4.513786183	2.441284281	4.513786183
lnd	0.378482126	0.180345853	2.09864613	0.04092003	0.01624682	0.740717431	0.01624682	0.740717431

RESIDUAL OUTPUT

Observation	*Predicted lnTC*	*Residuals*	*Standard Residuals*		*out*
1	14.88345516	0.156830333	0.807217993		FALSE
2	14.94254947	0.050438473	0.259610766		FALSE
3	14.37070936	0.316063184	1.626801939		FALSE
4	14.30235971	-0.173645545	-0.893767207		FALSE
5	14.45195499	0.123870618	0.637571762		FALSE
6	14.26206753	0.269586258	1.387581562		FALSE
7	14.15760772	-0.127348748	-0.655473969		FALSE
8	14.15793899	0.226600059	1.166328235		FALSE
9	14.2926985	-0.197947654	-1.018852064		FALSE
10	14.41995153	0.049794818	0.256297824		FALSE
11	14.25720341	-0.015480188	-0.07967774		FALSE
12	14.31832205	0.183972987	0.946923358		FALSE
13	15.24082244	0.172571193	0.888237433		FALSE
14	15.05151014	0.191196775	0.984104761		FALSE
15	15.26481289	-0.081819742	-0.421132615		FALSE
16	15.2067703	0.110058292	0.566478639		FALSE
17	15.23191657	0.085079138	0.437908981		FALSE
18	14.88675003	0.051854028	0.266896742		FALSE
19	14.99251253	0.081150735	0.417689184		FALSE
20	15.20778049	-0.057048021	-0.293630628		FALSE
21	15.10067325	-0.002402143	-0.01236402		FALSE
22	15.22322864	0.159135419	0.819082454		FALSE
23	15.22719408	-0.213462946	-1.098710483		FALSE
24	14.58843257	0.151158303	0.778023613		FALSE

25	14.83876448	0.153636444	0.790778798	FALSE
26	14.88930372	-0.031129728	-0.160227144	FALSE
27	14.87972138	0.23275584	1.198012521	FALSE
28	14.83606563	-0.153499603	-0.790074469	FALSE
29	14.85367262	-0.249295699	-1.283144467	FALSE
30	14.42061875	0.032727769	0.168452389	FALSE
31	14.76854046	0.134009007	0.689754845	FALSE
32	14.58514102	-0.024631822	-0.126781916	FALSE
33	14.65413255	0.001573922	0.008101097	FALSE
34	14.74301514	-0.100119747	-0.515324173	FALSE
35	14.54167093	0.00449933	0.023158404	FALSE
36	14.7059758	0.334282141	1.720576335	FALSE
37	14.81780373	-0.190852711	-0.982333839	FALSE
38	14.82281416	-0.454400774	-2.338836337	TRUE
39	14.55927831	-0.057584048	-0.2963896	FALSE
40	14.59402874	-0.336069289	-1.729774926	FALSE
41	14.77175753	0.352688368	1.815314627	FALSE
42	14.83606563	0.008314064	0.042793137	FALSE
43	14.62923764	-0.309775031	-1.59443632	FALSE
44	14.58500993	0.100301253	0.516258399	FALSE
45	14.61334471	-0.087412049	-0.449916653	FALSE
46	14.26429041	-0.24386137	-1.255173552	FALSE
47	14.65413255	-0.306220107	-1.576138848	FALSE
48	14.66510382	0.056421102	0.290403826	FALSE
49	14.64283374	0.178890518	0.920763495	FALSE
50	14.8449715	-0.490171778	-2.522952496	TRUE
51	14.70255004	0.06986682	0.359609988	FALSE
52	14.77772235	-0.245674243	-1.264504552	FALSE
53	14.66530514	-0.016100441	-0.08287023	FALSE
54	14.65413255	0.126626235	0.651755139	FALSE

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