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Assessment of sampling programme using Pelogos database to estimate tuna fisheries resources, challenges and management : a case of study West Sumatera, Indonesia

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COMPLETED DISSERTATION

by Wawan ROWANDI

WORLD MARITIME UNIVERSITY
Malmö, Sweden

ASSESSMENT OF SAMPLING PROGRAMME USING PELAGOS DATABASE TO ESTIMATE TUNA FISHERIES RESOURCES, CHALLENGES, AND MANAGEMENT:

A CASE STUDY OF WEST SUMATERA, INDONESIA

by

WAWAN ROWANDI

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2020

DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views and are not necessarily endorsed by the University.

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ABSTRACT

Title of Dissertation : Assessment of Sampling Programme Using Pelagos Database to Estimate Tuna Fisheries Resources, Challenges and Management: A Case Study of West Sumatera, INDONESIA

Degree : **Master of Science**

Tuna fisheries are an important sector of Indonesia's economy. This can be seen from the increase in the amount caught each year. According to a report published by MMAF (2015), in 2005-2012, on average the total amount of tuna Indonesia reached more than one million tons which contributed to 16% of the total tuna caught in the world. Furthermore, Indonesia is also one of the largest countries that catch tuna in the Indian Ocean, with an average catch of 356,862 tons per year in 2009-2012. As the third-largest country producing fish in the world, Indonesia has a significant role in the development of sustainable fisheries. So that it is not only wise to utilize existing resources, but Indonesia must also be able to manage the existing fisheries resources properly.

At present, the MMAF collects data using an integrated system called One Data System that includes information on fish catches from fishing ports. This system connects the central government to the regional governments that have authority over fishing ports or fishing landing sites (Ministerial Decree, 2017). However, One Data System has many issues, including gaps in area coverage and is missing key data parameter requirements for reporting to RFMO. In recent years the Government of Indonesia in collaboration with IOTC and OFCF Japan have developed a new data collection system called PELAGOS. This system aims to collect more complete data from the main tuna fishery areas that are limited in funds and human resources.

This research was conducted in the province of West Sumatera, Indonesia. Data collected with the One Data System and the PELAGOS System were available from four locations where tuna and tuna-like species were landed. These locations were chosen because of the high intensity of landing activities, mostly juvenile bigeye tuna, yellowfin tuna and neritic tuna. Exploratory quantitative approaches were taken to compare the current data collection system with the PELAGOS system. The results showed that PELAGOS has several advantages that can fulfil the reporting data requests to IOTC. The collection of data on different species caught by gear type and in relation to the fishing efforts (days at sea) allowed the calculation of the Catch Per Unit Effort (CPUE) time series and the analyses of length-frequency and catch composition. The results give new insights into the catch rates between the regions and suggest data collection using PELAGOS can continue to be done with several developments and improvements to the PELAGOS application to meet the required data parameters.

KEYWORDS: Fisheries, Tuna, Data collection system, Artisanal fisheries, Catch estimates, Fish stock.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Bappenas	= Badan Perencanaan Pembangunan Nasional (Ministry of National Development Planning Agency)
BPS	= Badan Pusat Statistik (Statistics Indonesia)
CCSBT	= The Commission for the Conservation of Southern Bluefin Tuna
CPUE	= Catch per Unit Effort
DS	= Danish Seine (Payang)
EEZ	= Exclusive Economic Zone
FADs	= Fish Aggregating Devices
FMAs	= Fisheries Management Areas
GDP	= Gross Domestic Product
GT	= Gross Tonnage
IOTC	= The Indian Ocean Tuna Commission
LN	= Lift Net (Bagan)
MMAF	= Ministry of Marine Affairs and Fisheries
NGOs	= Non-Governmental Organizations
Pusdatin	= Pusat Data, Statistik dan Informasi (The Center for Data, Statistics and Information)
PUSHIDROS	= Pusat Hidrologi dan Oseanografi (Oceanography and Hydrology Center)
RFMOs	= Regional Fisheries Management Organizations
TH	= Combination of Troll line and Handline
TL/HL	= Troll line/Handline
TPI	= Tempat Pendaratan Ikan (Fish Auction Place)
WCPFC	= The Western and Central Pacific Fisheries Commission
WPPNRI	= Wilayah Pengelolaan Perikanan Negara Republik Indonesia

1. INTRODUCTION

Tuna fisheries are one of the sectors that have an essential role in Indonesia. It can be seen from the increase in the amount of catch production each year. According to a report published by the Ministry of Maritime Affairs & Fisheries (MMAF) in 2015, between 2005-2012, the average total tuna catch in Indonesia reached more than one million tons, which contributed to 16% of total tuna catches in the world. In 2013 Indonesian tuna exports reached 209,410 tons with a value of USD$ 764.8 million. Indonesia is one of the largest countries that catch tuna in the Indian Ocean, with an average catch of 356862 tons per year in 2009-2012. Besides tuna, other fish species in Indonesian waters are categorized into several groups, namely big pelagic fish, various sharks, billfish, small pelagic fish, reef fish, demersal fish, crustaceans, molluscs (Pusdatin, 2018).

As the third-largest country producing fish in the world (Henriksson et al., 2019), Indonesia has a significant interest and responsibility in the development of sustainable fisheries. Indonesia must be able to manage existing fisheries resources properly. Gillett & Tauati (2018) highlighted that tuna resources have essential economic value and are the primary commodity of the fisheries sub-sector. Therefore, tuna fisheries have a significant contribution to the Indonesian economic sector. In 2019 the fisheries sector contributed 2.65% of the national GDP ((Pusdatin, 2018) in BPS)).

Tuna and tuna-like species are large pelagic fish species that have characteristic migrations from one place to another to find oceanographic, biological, and meteorological conditions that provide suitable habitat (Arrizabalaga et al., 2015). Research conducted by Ahmad et al. (2019) explained tuna are distributed across all waters in Indonesia from the west coast of Sumatera, South Java, Bali waters, Nusa Tenggara, East Indonesia waters, including the Banda Sea, Flores Sea, Maluku Sea, and Makassar Sea. Based on the scale of fishing, Indonesian fisheries are divided into the industrial scale and small-scale fisheries (artisanal fisheries).

As an archipelago country, around 90% of Indonesian fisheries are dominated by small scale fisheries with vessel size below 5 GT (Sunoko & Huang, 2014). Although included in the category of small-scale fisheries, many of them catch tuna as the main target of fishing. 99% of small-scale fisheries employ people who live in areas around the coast and contribute to nearly half the availability of seafood protein from sea produced by small-scale fisheries (Loring et al., 2019).

A large number of small-scale fishing vessels scattered throughout the islands are represents a big challenge for the Indonesian government in conducting sustainable fisheries management. Some challenges that must be encountered include the non-recording of fish catch data caught by fisher and the lack of fisher's knowledge about the importance of reporting fish catch data to officers in the field.

As a member of RFMOs, Indonesia is required to report fisheries data annually. The information is not only limited to the total catch but also data on the number of lists of fishing vessels, the number of fishers, fishing efforts, biological data, types of fishing gear used, and other data that are committed by member states to resolutions agreed upon in the organization. For this reason, proper data management and systems are needed to meet the mandatory data requirements.

The Indonesian government, through MMAF, oversees the responsibility for fisheries resource management in Indonesia. Besides, the national fisheries policy, as well as the strategic plans, recognizes other actors in fisheries management and their roles. The Ministry of fisheries created fisheries policies and laws, and it holds the responsibility of sustainably managing the fisheries activities.

2. BACKGROUND INFORMATION

2.1 Geographical Context

Indonesia is one of the largest archipelagic countries in the world, with more than 17500 islands spread from Sabang to Merauke and is situated between two continents (Asia and Australia) and two oceans (the Indian Ocean and the Pacific Ocean). Indonesia has two-thirds of the sea area, with a coastline of approximately 81000 km. This position provides a wealth of abundant natural resources and a high level of marine biodiversity (Haryanto, 2015).

Geographically, Indonesia (Figure 1) is an archipelagic country with a tropical climate that has a high level of marine biodiversity in the world (Lowe, 2013).

Figure 1. Map of Indonesia and the territorial waters

(Source: http://www.seasite.niu.edu/indonesian/indonesian-map/indo-map-fs.htm).

Based on the distribution of world fisheries management maps published by the Food and Agricultural Organization (FAO), Indonesia has codes 57 and 71 (Figure 2).

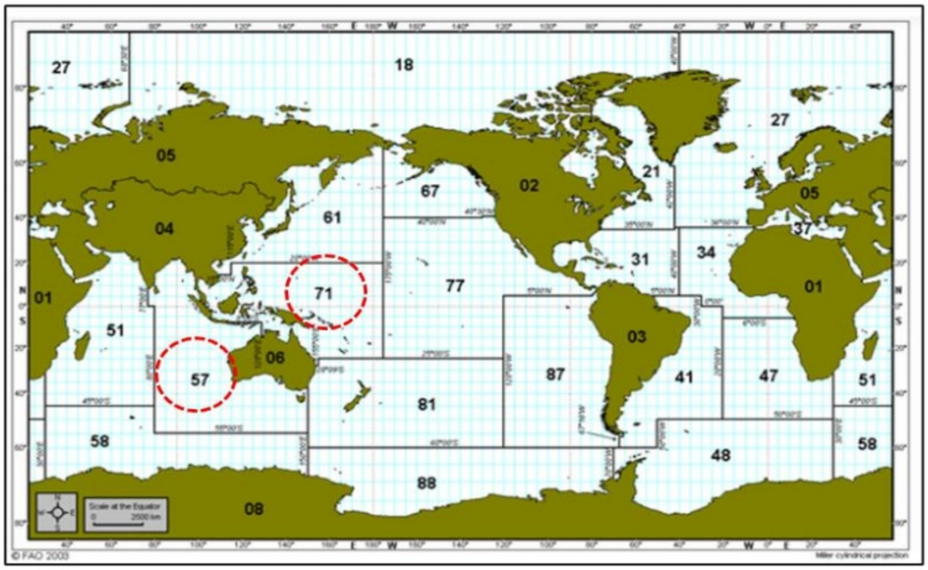


Figure 2. The map of world fisheries management distribution
(Source: adapted from FAO, 2003).

2.2 Coastal Environment Context

Based on data published by PUSHIDROS (2011), Indonesia has sea borders with ten neighbouring countries, namely Malaysia, Singapore, Thailand, China, Philippines, Palau, Papua New Guinea, Timor Leste, Australia, and India (Figure 3).

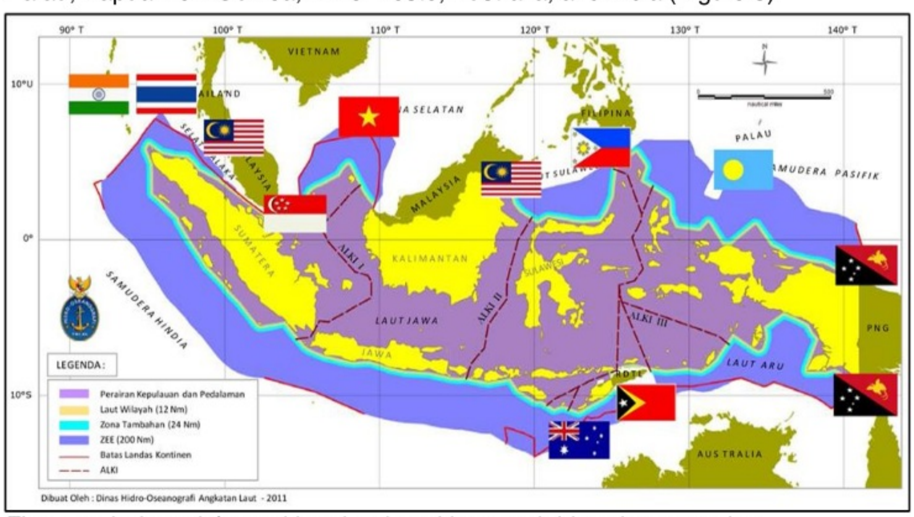


Figure 3. Indonesia's maritime border with ten neighbouring countries
(Source: adapted from Pushidros, 2011).

Furthermore, Indonesia also has a waters area of 5.8 million KM^2, which is 70% of the total area of Indonesia which has ecosystems of mangrove forests, coral reefs, and seagrass beds ((Dahuri, 1994),(Kusumah, 2018),(Lavery et al., 2013).

In addition to providing goods and services, the coastal environment in Indonesia also experiences various pressures that threaten the sustainability of the ecosystems contained therein ((Nagelkerken, 2009),(Van der Meij & Hoeksema, 2010)). These threats due to climate change impacts and anthropogenic human activities, the result of which are coastal erosion, physical loss of the ecosystem, loss of some habitat, causing less sediment discharge to the coast, overfishing, coral and sand mining, and destructive fishing ((Crain et al., 2009),(Creel, 2003),(Nurdin & Grydehøj, 2014)).

2.3 Fisheries Management Areas

By Ministerial Decree 11 Fisheries Management Areas of the Republic of Indonesia (Figure 4) were formed with the aims of fishing, fish cultivation, conservation, research, and fisheries development, which includes inland waters, archipelagic waters, Indonesia's territorial sea, ancillary zones, and exclusive economic zones.

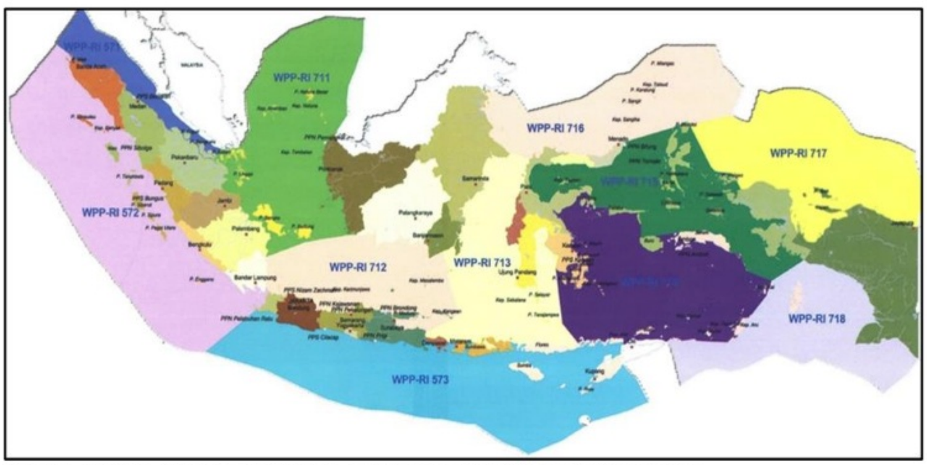


Figure 4. The Eleven Fisheries Management Areas of Indonesia
(Source: adapted from Ministerial Decree, 2015).

The eleven FMAs (called WPPNRI) are:

1. FMA 571 includes the waters of the Malacca Strait and the Andaman Sea;

2. FMA 572 covers the waters of the Indian Ocean west of Sumatera and the Sunda Strait;
3. FMA 573 covers the waters of the Indian Ocean south of Java to the south of Nusa Tenggara, the Sawu Sea, and the west region of Timor Sea;
4. FMA 711 covers the waters of the Karimata Strait, the Natuna Sea, and the South China Sea;
5. FMA 712 covers the waters of the Java Sea;
6. FMA 713 covers the waters of the Makassar Strait, Bone Bay, Flores Sea, and the Bali Sea;
7. FMA 714 covers the waters of the Tolo Bay and the Banda Sea;
8. FMA 715 covers the waters of Tomini Bay, Maluku Sea, Halmahera Sea, Seram Sea and Berau Bay;
9. FMA 716 covers the waters of the Sulawesi Sea and the North of the Island Halmahera;
10. FMA 717 covers the waters of the Cenderawasih Bay and the Pacific Ocean;
11. FMA 718 covers the waters of the Aru Sea, the Arafura Sea, and the eastern part of the Timor Sea.

2.4 Fisheries Management Context

The Ministry of Maritime Affairs is fully responsible for conducting fisheries data collection activities in the field up to publication. Since the revitalization program in the fields of fisheries, agriculture, and forestry was established in 2005, tuna fisheries have become a leading sector and a national program (Jatmiko et al., 2016). Indonesia has a responsibility to provide good, accurate, and reliable data. However, until now, Indonesia still has obstacles in collecting data on fisheries in the field. Therefore, it needs to improve fisheries data collection methods so that the resulting data becomes more accurate and can be accounted for. Data collection and information on capture fisheries activities carried out by enumerators are essential to obtain information related to the amount of fish caught by fishers and landed at landing sites, both government-owned fishing ports and private companies (Moreno, 2014).

To produce good quality data and high levels of accuracy, various methods have been taken by the Indonesian government to improve fisheries data collection in the field.

One example that has been carried out is by the regulation in 2015 by the Director-General of Capture Fisheries (DG-CF) regarding the technical guidelines of strengthening the data statistics of capture fisheries. The purpose of this technical guideline is the development of enhancing information systems and statistical data of capturing fisheries through a series of processes for collecting, processing, analyzing, storing, and presenting data in a more measured, formatted, and focused manner. To achieve these objectives, data collection activities are carried out in stages by data collectors (called enumerators) and processors at the district level and provincial level up to the central government (DGCF, 2015).

At present, the MMAF collects data using an integrated system called One Data System (Ministerial Decree, 2017). One type of the data collected by this system is the data of fish catches at the fishing port. This system connects the central government and regional governments that have authority over areas that have fishing ports or fishing landing sites (Ministerial Decree, 2017). Data on fish catches, collected by enumerators who have been appointed by the regional fisheries agency using the data collection form. However, this data collection has many obstacles, including the number of enumerators not covering the entire fish landing area because the area is too broad so that data collection officers do not reach some places in the field.

The data recorded by enumerators into the data collection form is then tabulated and sent to the data processing officer at the fishing port for verification to ensure that the data collected is under the data collection method. If there is an error in the data collection process, it will make the processing and analysis process difficult. Also, the results that are obtained will become invalid if the data collection is done incorrectly. Some data collection methods have been applied to obtain information about capture fisheries in the field; however, there are still many mistakes made by enumerators in the field. For instance, errors in identifying fish species, so it is necessary to conduct sampling activities to ensure that data collection is carried out according to the correct method so that fisheries stock calculations can be carried out properly (Anas, 2019).

2.5 The study sites

The research was conducted in the province of West Sumatera, Indonesia (Figure 5). Data collection was carried out at four locations where tuna and tuna-like species landings. This location was chosen because of the high intensity of landing activities in those regions, mostly juvenile bigeye tuna, yellowfin tuna, and neritic tuna, which will be discussed in this report.

Notes:

: TPI Pasie Nan Tigo	: TPI Muaro Padang
: TPI Gauang	: TPI Kambang

Figure 5.The map of the study site in West Sumatera, Indonesia.
(Source: Google Maps, 2020).

2.5.1 TPI Gauang

TPI Gauang is one of the tuna landing sites located in the Lubuk Begalung sub-district, West Sumatera Province (Figure 6). TPI Gauang has a strategic location because it is close to the Teluk Bayur commercial port. TPI Gauang is a private landing site area which is the centre of fish landing in the TPI Gauang area. In addition to being a landing site, TPI Gauang is also a marketing place for fresh fish landed by fishers through the auction system. The size of ships that unload fish in TPI Gauang on average is 10-20 GT, with lift net as fishing gear. The types of fish landed vary greatly from tuna, skipjack, cob, and other small pelagic fish such as mackerel and scad.

2.5.2 TPI Pasie Nan Tigo

TPI Pasie Nan Tigo is a landing site which is located in Koto Tangah sub-district, Padang, West Sumatera (Figure 7). This TPI is unique because it does not have a particular building to unload the catches. The fish caught landed in the morning along the coast and directly marketed by fishermen to buyers. Even so, the number of vessels that unload catches is quite a lot and is dominated by vessel size between 10-30 GT with lift net as fishing gear. The types of species landed such as tuna, kawa-kawa, bullet tuna, frigate tuna, long-tail tuna, scad, mackerel, and other small pelagic fish such as anchovies and cob.

2.5.3 TPI Muaro Padang

TPI Muaro Padang (Figure 8) is a fish landing place located in the Batang Arau River, Padang City, West Sumatera. The TPI is small because it only holds a small number of vessels that unload catches from fishing gear such as small handline and danish seine. TPI's location is quite strategic because it is close to the tourist attractions of the Siti Nurbaya bridge. Vessel size landed here between 5-10 GT. The types of fish landed are neritic tuna and other small pelagic fish. Unloading activities at TPI are not too dense like other TPI.

2.5.4 TPI Kambang

Unlike other TPI located in one Regency, TPI Kambang (Figure 9) has a far apart location which is located in the Pesisir Selatan, Lengayang sub-district, West Sumatera. The number of fishing vessels that landed fish in the TPI Kambang between 20-30 GT, with troll-line and handline fishing gear. The types of fish landed include bigeye tuna, yellowfin tuna, neritic tuna, common-dolphin fish and other small pelagic. Besides, not far from the location of TPI, there is a special place to unload reef fish.

2.6 Fishing gears

The types of fishing gear used by fishers at the landing site and included in the artisanal fisheries category according to the IOTC are Bagan (Lift Net/LN), Payang

(Danis Seine/DS), Pancing ulur (Handline/HL), and Tonda-Handline (combination Troll-line and Handline/TH).

2.6.1 Bagan (Lift net)/LN

Bagan (Lift net) is a fishing gear that uses a rectangular net and has a frame made of bamboo (Figure 6). The size of the net varies significantly from 15 to 30 meters and operated by the vessel size 20-30 GT (Figure 7). At the time of operation, usually, a lift net uses tools such as lights and rumpon (FADs) to attract fish because it is operated at night. The targets of the lift net are pelagic fish and tuna. The method of operation is dropping the nets into the water column within a specific time and lift the surface after the fish are trapped into the nets (MMAF, 2010).

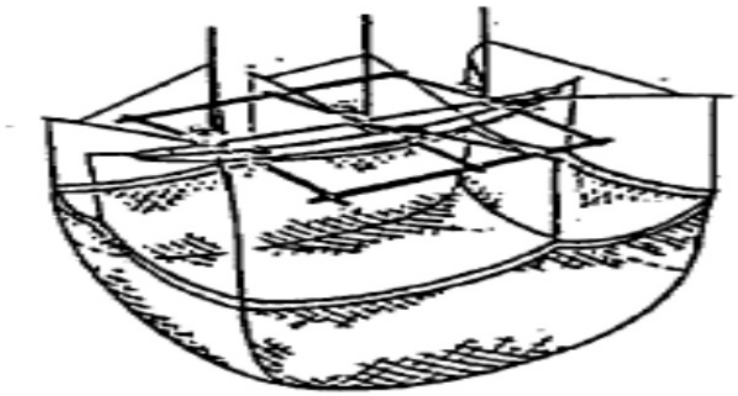


Figure 6. Bagan (Lift net)
(Source: adapted from MMAF, 2010)

Figure 7. Liftnet vessel in TPI Pasie Nan Tigo and TPI Gauang
(Source: Author's own photo).

2.6.2 Payang (Danish seine)/DS

Payang (Danish seine) is a fishing gear made from nets which has a cod-end at the end of the net (Figure 8). Payang (Danish seine) has wings on both sides and is connected by a rope and operated by the vessel size between 5-10 GT (Figure 9). The method of operation is encircling the fish schooling and directing the fish into a bag and then pulling it onto the boat. The length of the nets used depends on the size of the ship operating it.

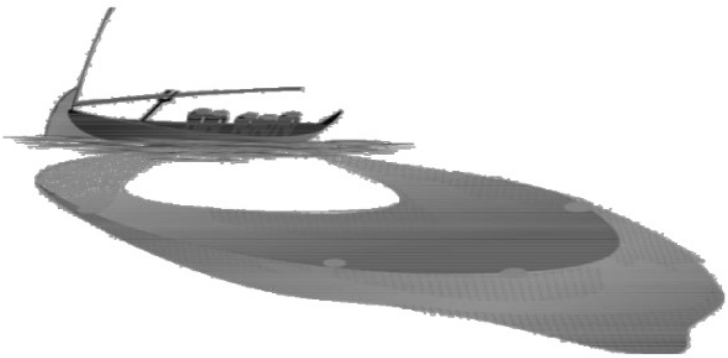


Figure 8. Payang (Danish seine)
(Source: adapted from MMAF, 2010).

Figure 9. Payang (Danish seine) vessel in TPI Muaro Padang
(Source: Author's own photo)

2.6.3 Troll line and Handline/(TL/HL)

Troll line (Tonda) and Handline are fishing gear consisting of a fishing line made of monofilament with a hook at the end of the rope which is given live bait or artificial bait (Figure 10). The difference lies in the method of operation. Troll line is operated by pulling a fishing rod that has been given bait when the ship moves so the position of the fishing line is horizontal. At the same time, Handline is operated by extending a fishing line that has been given bait with a vertical position when the ship is stopped. Both of those fishing gear operated by the vessel size 20-30 GT (for TH) (Figure 11) and 5-10 GT (for HL) (Figure 12).

(a) (b)

Figure 10. (a) Troll line, (b) Handline
(Source: adapted from MMAF, 2010)

Figure 11. Trolling-Handline vessel in TPI Kambang
(Source: Author's own photo)

Figure 12. The handline vessel in TPI Muaro Padang
(Source: Author's own photo)

2.7 Fish species

In this study, the types of fish that will be discussed are the types of tuna and neritic tuna managed by IOTC. The types of fish are Bigeye tuna/BET (*Thunnus obesus*), Yellowfin tuna/YFT (*Thunnus albacares*), Skipjack tuna/SKJ (*Katsuwonus pelamis*), Longtail tuna/LOT (*Thunnus tonggol*), Bullet tuna/BLT (*Auxis rochei*), Frigate tuna/FRI (*Auxis thazard*), and Kawakawa/KAW (*Euthynnus affinis*) are shown in Table 1.

Table 1. The types of species managed by the Indian Ocean Tuna Commission

No	Name of Species	Scientific Name	FAO Code	Figure
1.	Bigeye tuna	*Thunnus obesus*	BET	
2.	Yellowfin tuna	*Thunnus albacares*	YFT	

3.	Skipjack tuna	*Katsuwonus pelamis*	SKJ	
4.	Longtail tuna	*Thunnus tonggol*	LOT	
5.	Bullet tuna	*Auxis rochei*	BLT	
6.	Frigate tuna	*Auxis thazard*	FRI	
7.	Kawakawa	*Euthynnus affinis*	KAW	

Source: adapted from the IOTC species identification card, 2013.

2.8 Problem statement

Until recently, tuna fisheries data was collected by the Indonesian government authorities but have not met the criteria needed to meet the requirements of the IOTC, including those with respect to biological data parameters such as size-frequency and adequate spatial and temporal resolution of the required catch data. This precludes the application of stock assessments and hampers fisheries management. In recent years the implementation of a new data collection and processing system (the

PELAGOS application) is designed to meet data criteria required for IOTC compliance. As the PELAGOS data collection system has only recently been implemented, research is needed to assess its utility for providing better advice for fisheries management.

2.9 Objectives of the research

The overall objective of this research was to assess the new sampling method using the PELAGOS application and explore its potential to better understand the status of tuna fisheries in different landing sites. To this end, the research reported here had the following objectives:

1. Evaluate the differences between the previous data collection system with new PELAGOS system;
2. Describe the PELAGOS system and the data types collected;
3. Undertake exploratory data analysis of the PELAGOS database and develop indicators of fish stock status, such as catch per unit effort, catch composition and size-frequency distribution.
4. Compare and discuss the completeness of the data, and sources of uncertainties (by spatial and temporal, by species and by gear) across several landing sites, and the implications of the new data for informing fisheries management.

3. MATERIAL AND METHODS

This research used data for seven tuna species recorded by the enumerator at the landing site and inputted by an officer in the central government. Data was available from four landing sites, namely TPI Gauang, TPI Pasie Nan Tigo, TPI Muaro Padang, and TPI Kambang. The data recorded is; (1) vessel information, in general, covering the time and place of data collection, vessel size, type of fishing gear, species and volume of catches, the day at sea; (2) details of sampled vessels; (3) species landed and the amount of weight of fish in a basket; (4) individual weights and lengths of fish. The data series was collected from 2015-2019 (PELAGOS) (five years). The data collected is expected to provide information about the condition of fish distribution both spatially and temporally, informing the status of fish production, so that can be the basis for calculating fisheries stock assessment and making decisions for fisheries management.

The method used in this research used statistical approaches (Creswell and Creswell, 2017) & comparative analysis (Ragin, 2014) to analyze and compare the results of data processing that has been collected by previous data collection systems with data collected by the PELAGOS system. The purpose of this comparison is finding out the data parameters and describing it in the form of tables and graphs.
The variables that are compared in this research are:

1. The data collection system before the development of the PELAGOS application and the data collection system currently running based on the completeness of parameter data generated from each system;
2. Total catch and catch composition based on fishing gear by species at each landing site;
3. Catch per unit effort based on the length of days at sea in each region based on the type of fish and the type of fishing gear;
4. Length frequency based on the length distribution of fish caught.

The data on the processing results at each fish landing site will be explained in general terms; however, the comparison will focus on fish landing sites that have the same type of fishing gear, namely TPI Gauang and TPI Pasie Nan Tigo.

4. RESULTS

4.1 Comparison of Data Collection Systems

Some of the existing data collection systems, the following comparison of data collection systems (Table 2), are discussed in this study.

Table 2. Comparison of data collection established by MMAF

No	Data Parameters	Data Collection System		
		Before 2017 (Excel Formatted)	Start from 2017 up to now (One Data)	Pelagos Data (Tuna sampling program)
1	Total catch	v	v	v
2	Catch by gear	v	v	v
3	Catch by species	v	v	v

4	Total vessel	v	v	v
5	Size Frequency	-	-	v
6	CPUE data	-	-	v
7	Seasonal data	-	-	v
8	Data by vessel ID	Available in each district	Available in each district	v
9	Catch composition	-	-	v
10	Weekly data	-	-	v
11	Annual data	v	v	v
12	Type of Sampling	Village	District	Daily in the landing site & have a fixed schedule (4 days a week) if no sampling day, the enumerator will record only the total catch
13	Target scale (Industrial/Artisanal)	Both from province level	Both from province level	Artisanal directly from the enumerator

4.2 Pros and Cons of PELAGOS System

The following are the advantages and disadvantages of data collection using PELAGOS (Table 3).

Table 3. The pros and cons of PELAGOS database system

No	Parameters	Pros	Cons
1	Estimate total catch (volume, number)		
	- Target species	V	Only focus to IOTC species
	- Bycatch		Does not show the detail of species
	- By landing sites	V	
	- By the time (weekly/ quarterly/annually)	V	
2	Size frequency by (species, gear, landing site, month)	V	
3	Information about discard species	-	N/A

4	Trends in catches across years (seasonality)	V	
5	Spatial and temporal data	V	Limited (due to budget restrictions) and does not show specific coordinates
6	Other biological information	For now only size-frequency	Does not include observation for gonads, otoliths and muscle tissues
7	CPUE	V	
8	Information about the number of active vessels, fishing effort by region, and use of FADs	V	Not including the specific location (coordinate)
9	Data analysis	Tables and graphics	Without maps

4.3 Types of Data Generated by PELAGOS Systems

4.3.1 Total catch data landed

The data analyzed is tuna fishery data that is collected and recorded by enumerators routinely every day at each landing site and input into the PELAGOS application. The following are the distribution of tuna fisheries data collected over five years (2015-2019) at TPI Gauang, TPI Pasie Nan Tigo, TPI Muaro Padang and TPI Kambang based on the type of species (Figure 13).

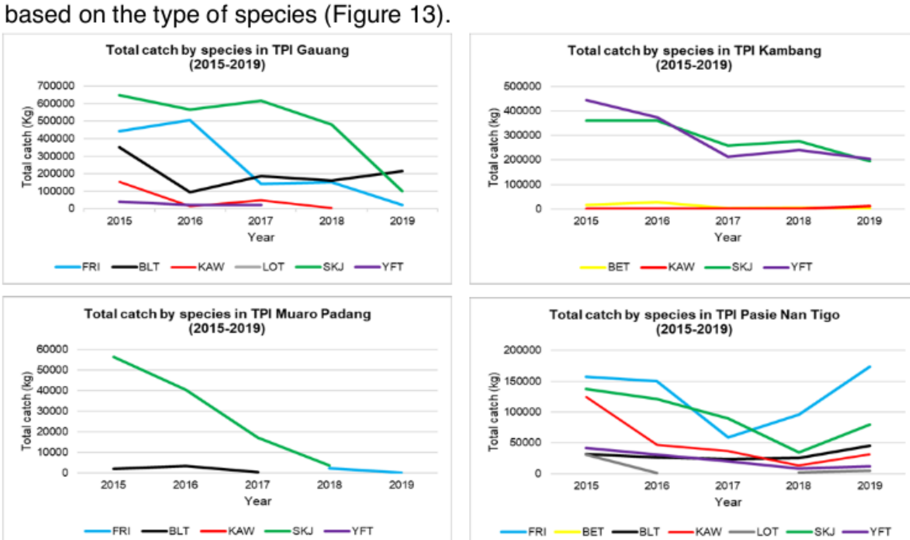


Figure 13. Total catch landed in all landing sites from 2015-2019

From the results of data processing above, it can be seen that each TPI has a different number of catches each year. In general, the four fish landing sites experienced a decrease in the number of fish catches. The total catch was highest in TPI Gauang. SKJ was the species that landed in with the greatest volume. Meanwhile, the lowest number was at TPI Muaro Padang. YFT was the type of fish with the enormous volume landed in TPI Muaro Padang. In the position of the second-largest number of catches was TPI Kambang. Uniquely, in 2015 YFT was the most dominant type of fish landed, but in the following year, SKJ replaced that position. Unlike the others, TPI Pasie Nan Tigo is dominated by neritic tuna species with FRI being the most landed species. Instead, it was a little different at the TPI Pasie Nan Tigo there was an increase in the last year.

4.3.2 Catch composition

Based on data catch composition processing and analysis using the PELAGOS, the following results were obtained (Figure 14):

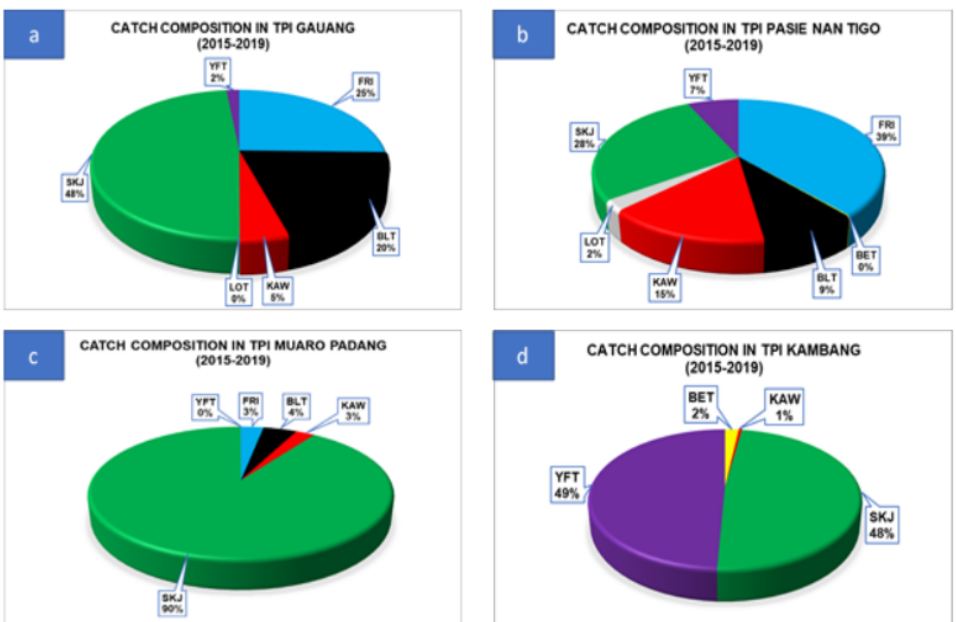


Figure 14. Catch composition based on the type of species in all landing sites

a. TPI Gauang

In general, the types of fish landed at TPI Gauang during the 2015-2019 period are SKJ 48%, FRI 25% and BLT 20%. Although they dominate the catch landed at TPI Gauang, these three species do not have a consistent landing pattern every year.

b. TPI Pasie Nan Tigo

Unlike TPI Gauang, the types of fish landed at TPI Pasie Nan Tigo during 2015-2019 was 39% FRI, 28% SKJ and 15% KAW. However, the composition of the types of catch at TPI Pasie Nan Tigo is quite diverse. Based on the analysis of the data obtained, all kinds of fish that were the objects of this study were found in this area, although in quite a small percentage.

c. TPI Muaro Padang

The results showed the composition of tuna species caught in the waters of the West Indian Ocean and landed at TPI Muaro Padang from 2015-2019, dominated by SKJ and BLT.

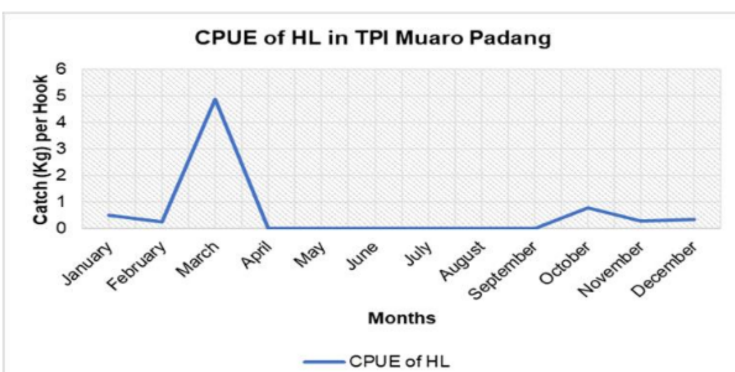
d. TPI Kambang

Unlike other TPIs, TPI Kambang has an equitably large fish catch composition, namely YFT 49% and SKJ 48%. Meanwhile, different types such as BET 2% and KAW 1% only.

4.3.3 Catch per Unit Effort Data

This research, the CPUE data at each landing site was divided into two, namely based on the type of fishing gear and the total catch for each species only describing a comparison between TPI Gauang and TPI Pasie Nan Tigo.

a. CPUE based on fishing gear



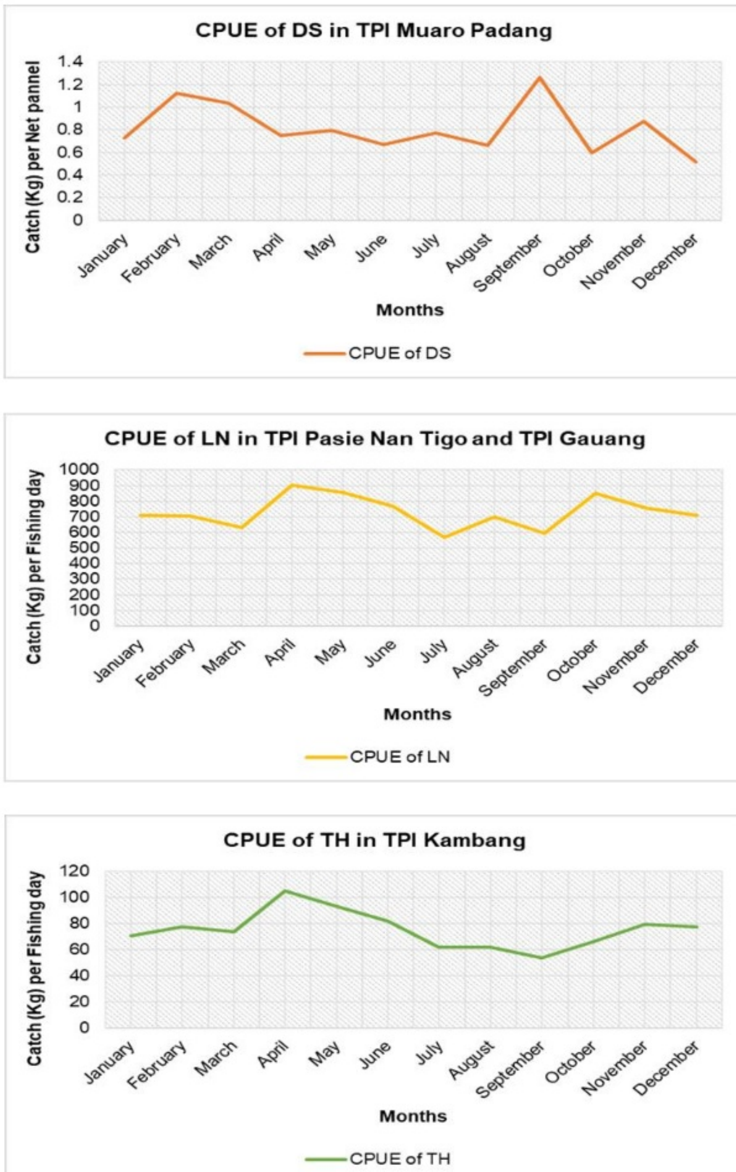


Figure 15. CPUE data by types of fishing gear

Based on the results above, data processing using PELAGOS obtained catch data per unit effort from each fishing gear as follows:

(1) CPUE Handline (HL) has a relatively high level of productivity with the peak of catching in March, while the lowest effort occurs from April to September. This is because based on information obtained from the results of an enumerator's discussion with local fisher, the weather in April-September is bad enough so that it does not allow fishers to catch the fish resulting in decreased catches.

(2) CPUE Danish Seine (DS) calculated based on net panels operated by fishers. It can be seen from January to February that the number of fish catches has increased. However, it regularly decreased from February to August and expanded in September before declining again. The highest fishing activity occurred in September, and the lowest occurred in October.

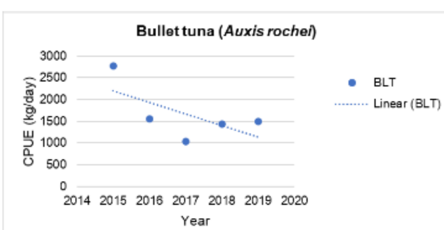
(3) CPUE Lift Net it can be seen to fluctuate but gently sloping. The increase and decrease in the catch were not very sharp. The highest fishing activity occurred in April, and the lowest occurred in July and increased back in the following month.

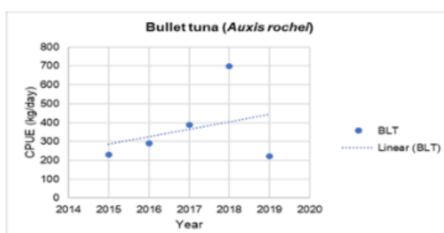
(4) CPUE Trolling-Handline

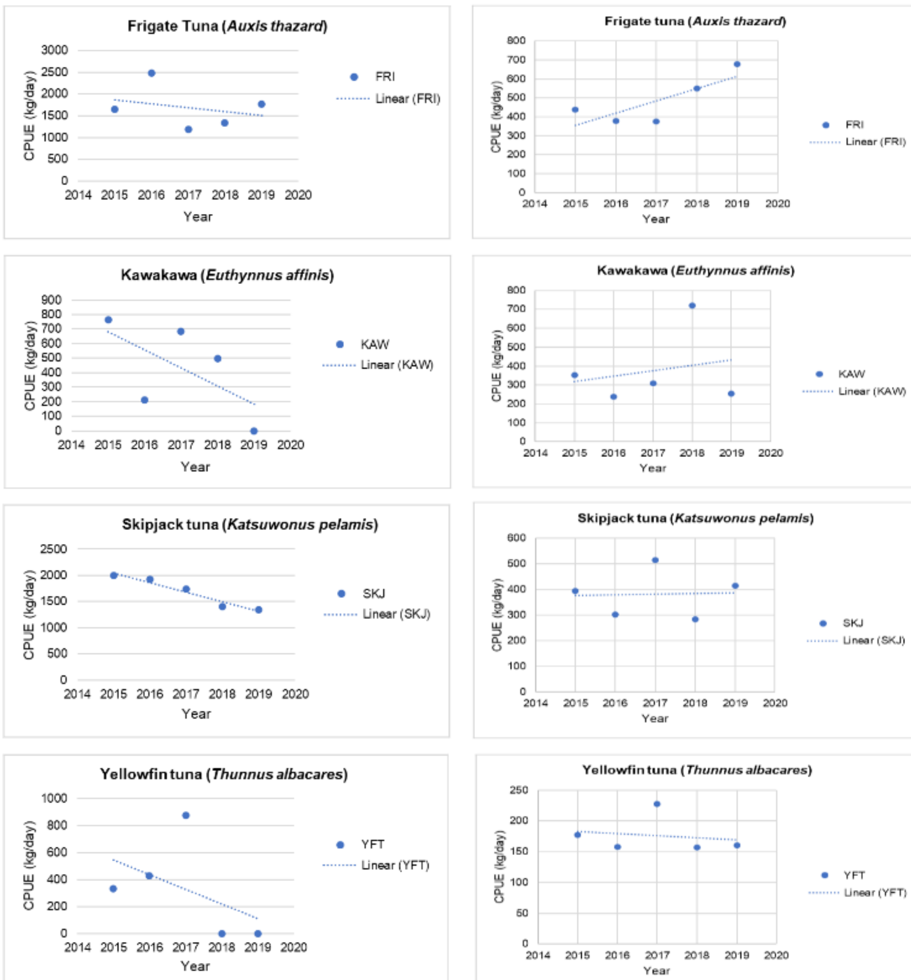
Just like the Lift Net fishing gear, the combination of Trolling and Handline fishing gear also experience quite gentle fluctuating movements. During the period 2015 to 2019, the highest number of arrests occurred in April, and the lowest occurred in September.

b. CPUE based on types of species

In the PELAGOS application, the CPUE data displayed is based on fishing gear only, so this research tries to explore and compare CPUE data based on species with the same fishing gear (Lift Net / LN) at TPI Gauang and TPI Pasie Nan Tigo (Figure 16). From the comparison results obtained the following data:







(a) (b)

Figure 16. CPUE by types of species in TPI Gauang (a) and TPI Pasie Nan Tigo (b)

From the analysis of the CPUE data obtained, this research conducting a comparison of two different landing sites which is used the same fishing gear (Lift Net/LN), namely TPI Gauang and TPI Pasie Nan Tigo. These results of the comparison showed that there was a decrease in the catch at TPI Gauang for almost all species, but on the contrary, there was an increase in TPI Pasie Nan Tigo. Meanwhile, the other CPUE performances of TPI Kambang and TPI Muaro Padang can be seen in the Appendix a.

4.3.4 Length-Frequency Data

This research also compares length-frequency in both TPI based on the type of fish by fishing gear (Figure 17). The class interval for measuring the length of fish is 2 cm. Based on the data analysis of the size of the sampled fish landed at each landing site, the following results were obtained:

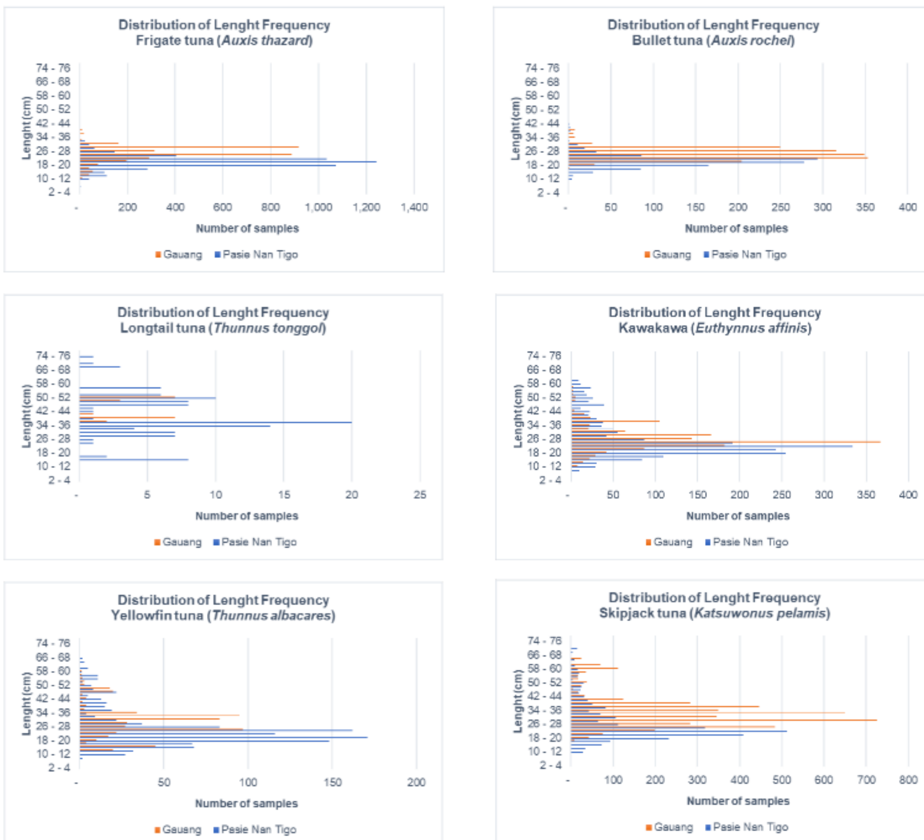


Figure 17. Comparison Length-frequency in TPI Gauang and TPI Pasie Nan Tigo

In addition to using class intervals, this research also analyzed fish sizes based on minimum length, maximum length and an average length of fish from the number of fish samples of seven species (BLT, BET, FRI, KAW, LOT, SKJ and YFT) which is briefly presented in Table 4.

Table 4. The length frequency of fish sampled

Species Code	LandingSiteCode	Length (cm)			
		Average of Length	No. of samples	Max of Length	Min of Length
BLT	GA	23.9	1552	39	20
	PT	20.89	952	32	13
	MP	29.27	176	31	23
	KA	■	■	■	■
BET	GA	■	■	■	■
	PT	■	■	■	■
	MP	■	■	■	■
	KA	34.11	260	54.5	23
FRI	GA	26.53	2432	39	16
	PT	20.69	3940	33	3.5
	MP	30.08	125	38	19
	KA	■	■	■	■
KAW	GA	31.23	915	58	10
	PT	28.69	1349	63	8
	MP	24.23	170	40	16
	KA	27.5	355	45	19.5
LOT	GA	41.5	20	52	36
	PT	34.5	110	75	14.5
	MP	■	■	■	■
	KA	■	■	■	■
SKJ	GA	32.24	3875	65	17
	PT	27.35	2080	76	9
	MP	31.2	2662	58	20
	KA	32.64	8550	55.7	19
YFT	GA	30.15	340	58	23
	PT	25.94	1000	61	9
	MP	35.4	5	36	35
	KA	32.15	8376	57	18.5

■ : no sampling of these species in that TPI

(Source: PELAGOS Database, 2020).

From the table above, it can be seen that the length of the fish landed at each landing site has a different size. From the sampling conducted during the 2015-2019 period, it was found:

a. Bullet tuna/BLT (*Auxis rochei*) had the longest size of 39 cm sampled at TPI Gauang from 1552 samples and the shortest of 13 cm at TPI Pasie Nan Tigo from 952 samples.

b. Bigeye tuna/BET (*Thunnus obesus*) had the longest size of 54.5 cm and the shortest 23 cm at TPI Kambang from a total sample of 265 individuals. Meanwhile, other TPIs did not land the BET species and/or were not sampled.
c. Frigate tuna/FRI (*Auxis thazard*) had the longest size of 39 cm which was sampled at TPI Gauang from 2432 samples and the shortest of 3.5 cm at TPI Pasie Nan Tigo from a total sample of 3940 individuals.
d. Kawakawa/KAW (*Euthynnus affinis*) had the longest size of 58 cm sampled at TPI Gauang from 915 samples and the shortest 8 cm at TPI Pasie Nan Tigo from a total sample of 1349 individuals.
e. Longtail tuna/LOT (*Thunnus tonggol*) had the longest size of 75 cm and the shortest 14.5 cm in TPI Pasie Nan Tigo from a total sample of 110 samples.
f. Skipjack tuna/SKJ (*Katsuwonus pelamis*) had the longest size of 76 cm and the shortest of 9 cm sampled at TPI Pasie Nan Tigo from 2080 samples.
g. Yellowfin tuna/YFT (*Thunnus albacares*) had the longest size of 61 cm and the shortest of 9 cm sampled at TPI Pasie Nan Tigo out of 1000 samples.

5. DISCUSSION

The objectives of this research are to evaluate the results of data analysis produced by the PELAGOS system and to show the differences in the results obtained with the previous data collection system. From the results of the research obtained, it showed that there are several differences from the PELAGOS system with the previous data collection system. The differences include several data parameters required in reporting to the IOTC.

This research demonstrated several possible data parameters that could be used in general estimation parameters used in fisheries management such as Catch per Unit Effort (CPUE), catch composition, length-frequency, seasonal data and length-weight relationship. These data parameters are instrumental in fisheries stock assessment, where it could not be done in the previous system. Using these data and estimation methods, the study found that it is possible to detect differences between landing sites and highlights some of the strengths and limitations of this data for fisheries management.

5.1 Transformation of Data Collection system

Data collection in the field is an essential aspect of fisheries science and underpins much of fisheries management policies (Ramirez-Monsalve et al., 2016). In 2015 the Indonesian Government Ministry of Maritime Affairs and Fisheries updated its fisheries data collection system intending to collect data that is more detailed, reliable, and with a higher level of accuracy. Indonesia is a member of regional fisheries management organizations (RFMO's) including the Indian Ocean Tuna Commission (IOTC), The Western and Central Pacific Fisheries Commission (WCPFC), and The Commission for the Conservation of Southern Bluefin Tuna (CCSBT). As a form of accountability for its membership to RFMOs, Indonesia is required to report data on tuna catch by Indonesian-flagged vessels (Ministerial Regulations, 2014). To meet the data needs, the MMAF carry out fisheries data collection activities and report to the IOTC and other regional bodies.

The fisheries data collection developed by the MMAF, however, has not been able to meet the data needs of the IOTC such as CPUE, biological data such as size-frequency, a correlation between length-weight and other data. To overcome this problem in 2014, the Indonesian government, in collaboration with IOTC and OFCF, Japan conducted a trial of a new data collection system in several centres of tuna landing in the West Sumatera region. The data collection application system that was built to accommodate this was named the PELAGOS database system. Different from the system that has been carried out, data collection using the PELAGOS database system combines several parameter data such as length-weight relationships in one database required for reporting to the IOTC, thus making it easier for users and time efficiency in the data processing.

5.2 Types of Data Provided by PELAGOS Systems

The Pelagos data system offered a number of advantages over the previous system. For example, because the Pelagos system reported data on (estimated total catch, biological data, fishing trends, spatial and temporal data, CPUE, catch composition and data analysis). It was possible to study fish phenologies at sites, and the length distribution in the data of artisanal fisheries. It was possible to compute new parameters such as age, gonad maturity level can be used in fisheries stock assessment in the future. The brief description of the data parameters generated by the PELAGOS system are as follows:

1. Estimated total catch

   Information on catches is the result of the calculation of the number of total yields that have been calculated based on the fish weight per basket that has been previously measured. To calculate the total number of catches of one vessel is taken by multiplying the total weight of fish in one basket into the entire basket of fish.

2. Biological data

   Biological data is one of the critical data parameters to determine the distribution of fish from the size, types of species, age, level of maturity of fish gonads (McBride et al., 2013). Currently, PELAGOS display data on length-frequency, weight and correlation between the length-weight.

3. Data on fishing trends

   Results from PELAGOS catch can be visualized weekly, monthly and annually. Also, it can show data in time series across years based on landing sites and fishing gears. In calculating fish stocks, fishing trend data is beneficial to find out how many fish populations have been caught from water that is a fishing ground (Anticamara et al., 2011).

4. Spatial and temporal data

   PELAGOS also produces spatial data based on the fishing ground, landing area, and temporal data based on the time/period of capture (weekly/monthly/annually). Spatial and temporal data are used to determine the condition of an area associated with time variables (Nippgen et al., 2015).

5. Catch Per Unit Effort

   In fisheries and conservation biology, the catch per unit effort (CPUE) is an indirect measure of the abundance of a target species (Yadav et al., 2016). The movement of the catch per unit efforts (CPUE's) is inferred to signify changes to the target species true abundance (Grüss et al., 2019). A decreasing CPUE indicates overexploitation, while an unchanging CPUE indicates sustainable harvesting (Janc et al., 2018).

6. Data analysis

   Analysis of data generated by PELAGOS is in the form of tables and graphs that are automatically processed by the system. This aims to minimize human error in data processing and analysis. It makes it easier for data users to understand and translate the data generated (Senders & Moray, 2020).

From the results above, it can be confirmed that the PELAGOS system can cover data shortages that cannot be generated from data collected using the previous system required in IOTC reporting.

5.3 Exploratory Data Provided by PELAGOS Systems

There were a number of apparent differences between the previous data collection system and the PELAGOS system. For instance, total catch, variety of the catch, CPUE, size-frequency. Moreover, this research could identify temporal and spatial variation in abundance, CPUE, and species lengths, as supported by figures 14, 15-16 and 17. The differences that could detect between locations, gear types, years, species might be explained by sampling factors such as total vessels and types of species that were sampled. The exploration data generated by the PELAGOS system are as follows:

a. Data on the total landing of fish catches

From the data on total fish landings, it is clear there were differences in the volume of fish catches landed at each landing site. Although, in general there was a decline, there was an increase at one of the landing sites. This research could confirm that there were seasonal/annual fluctuations that differed by location, such as described in figure 13. These differences might be due to factors such as fishing ground, types of fishing gear, operational cost, fish value, and active fishing vessel. The first is associated with changes in the location of the fishing grounds. According to Salmarika and Wisudo (2019), the decline in tuna production that has occurred is due to fishing areas becoming further away so that it requires operational costs. Besides, the value of fish can influence catch rates. Fishers assume that in terms of value, tuna is much higher in price than other species. But, sometimes, the market demand for tuna is low, resulting in low selling prices. This condition causes an abundance of tuna and tuna-like species in nature because fishers prefer to catch other fish species as a target, which has good value in the market (Asche, 2015).

The transfer of fish landing sites is thought to be one of the factors causing the decrease in the amount of fish caught in a TPI. This transfer was caused by several things, for example, the damage to the TPI facilities, which resulted in the ship being unable to dock at the port. Candra (2020) explained that the decline in the amount of fish production at TPI Kambang is caused by many vessels at TPI Kambang that land their catch at TPI Pasie Nan Tigo due to there was silting at the mouth of the river at the entrance to the TPI Kambang. Also, another factor that triggers the movement is that the price of fish at other TPIs is higher than in TPI, where fish unloading is usually carried out ((Lubis, 2019),(Tan, 2014)).

Finally, the low catch may be due to the large number of vessels that are not fishing due to permit problems. Nova (2016) highlighted that most of the vessels owned by fishers have their fishing permits almost entered the deadline and have even expired. This results in the fishing vessel unable to fish if it does not have a license. This resulted in a decrease in the catch landed at the TPI.

b. Variation of types of fish catches

The catch composition (Figure 14) is a proportional representation of species that are caught during fishing activities that are landed on each fishing trip. This variety of catch is caused by certain fishes living in association with other types of fish which live together in the same habitat ((Humphries et al., 2019),(Wootton, 2012)).

From the data analysis carried out on the composition of the catch landed at the four TPIs, Skipjack tuna (*Katsuwonus pelamis*) is the type of species that is landed the most in general. According to Firdaus (2019), the western waters of Sumatera are one of the areas that have considerable fishery potential, especially for tuna and skipjack. Aziz et al. (1998) added that only about 14.6% of the total potential of Skipjack tuna in the western waters of Sumatera.

Even though using the same fishing gear, namely Lift Net, TPI Gauang, and TPI Pasie Nan Tigo have differences in terms of variations in the catch landed. If analyzed based on the diagram shown, TPI Pasie Nan Tigo has more fish species than TPI Gauang. However, based on the quantity of fish landed, TPI Gauang has a higher number of tuna and tuna-like species than TPI Pasie Nan Tigo. This is because the fishermen using lift nets at TPI Gauang are targeting tuna and tuna-like as the main targets.

Furthermore, Zedta and Novianto (2018) explained, skipjack tuna is a type of fish that is mostly found in the Indian Ocean, which borders Indonesian waters. They added that skipjack is caught in many kinds of fishing gear such as lift net, hand-line, troll-line. This type of fishing gear is a type of fishing gear that is commonly found in the West Sumatera region.

In fisheries science, the composition of the fish catch is one of the supporting elements for calculating fisheries stocks in the ocean (Peninno et al., 2016). Knowing the species composition in an area will help in making policies, including determining the type of fishing gear that is compatible with the types of fish that live in the area ((Giovos et al., 2018),(Pennino et al., 2016)).

c. Effort Data

Garner and Petterson (2015) explained that fishing effort is the total capacity of various types of fishing units that are joined as a fishing fleet to obtain catches. CPUE (catch per unit effort) is the fish catch divided by the fishing effort, and it can be used as an index of relative abundance for the species of interest ((Carruthers et al., 2010);(Firdaus et al., 2019)).

As different fishing gears have different catch rates (Figures 15), it is crucial to control for gear type when computing CPUE. Each fishing gear (HL, DS, LN, and TH) has a different ability to catch tuna and neritic tuna. Based on the fishing gear, calculation of the CPUE (*Catch per Unit Effort*) value of the four fishing gears that catch tuna and neritic tuna, lift net has the highest CPUE value. It was thus necessary to standardize the capture effort by gear first before looking for the value of CPUE ((Bentley et al., 2012); (Gibson-Reinemer et al., 2017)).

Based on species in the comparison between TPI Gauang and TPI Pasie Nan Tigo, has a significant comparison where TPI Gauang has decreased CPUE while TPI Pasie Nan Tigo has experienced an increase (Figure 16). According to Ikhsan et al. (2015), the decline that occurred at TPI Gauang is thought to be due to several factors, among others (a) the reduced fleet of ships operating at TPI Gauang due to operational cost, (b) natural factors such as weather/climate, and (c) the spread of tuna in the Indian Ocean that has not been detected properly. Firdaus (2019) highlighted that many vessels do not go fishing because of the high operational costs that have to be incurred by fishers to go to sea. Besides, a study conducted by Damayanti et al. (2017) explained that the decline in the fish catch is thought to be due to the high intensity of fishing for tuna, which causes a decrease in tuna stocks. Meanwhile, the increase at TPI Pasie Nan Tigo, the enumerators explained, many vessels from other areas were unloading fish at TPI Pasie Nan Tigo, which increased the number of catches landed in the area. The arrival of fishing vessels from other regions contributes to an increase in the total yield landed in an area (Belhabib et al., 2014).

According to Bladon (2016), the CPUE trend consists of three categories, namely:

1. The increasing trend of CPUE is an illustration that the level of exploitation of fish resources can be said to be still at the developing stage;
2. The flat/stable CPUE trend is an illustration of that the level of exploitation of fish resources has approached saturation of efforts; and
3. The downward trend in CPUE is an indication that the level of exploitation of fish resources, if left unchecked, will lead to a state called ‘overfishing’ or even ‘overfished’.

Based on the results of the analysis, it shows that the decline in the catch that occurred at TPI Gauang proves that there has been a decrease in CPUE (downward trend). So that to prevent the growth of overfishing, the government needs to evaluate fishing activities at TPI Gauang. One way to do this is to limit the number of fishing vessels (Anderson et al., 2019). The decrease in CPUE is one indication of a decline in the stock of fish resources in nature ((Nelwan et al.,(2010), Rousseau et al., (2019)). This decrease is due to the likely increase in the number of fishing fleets every year.

The increase in the number of fishing fleets has an impact on increasing the intensity/effort of fishing at sea which can lead to overexploitation of fish resources at sea (Pomeroy, 2012). If there is a continuous decline in fish stocks, it can trigger growth overfishing and threatening the sustainability of fish resources in the sea (Liang and Pauly, 2017).

According to Carlson et al. (2012), the growth of an overfishing event will occur if the decrease in fish biomass caused by fishing activities is much more significant than the addition of biomass generated from the growth process in nature. In addition, other research mentioned, the growth of overfishing is also marked by the smaller size of the fish caught as a result of continuous exploitation (Sánchez-Hernández et al., 2016).

In the current data collection, calculating CPUE is difficult due to the limited data variables available from the data collected. In contrast to the PELAGOS system, data collection is carried out in an integrated manner based on fishing vessel data associated with sampling on the same vessel, and the CPUE calculation is carried out automatically, making it easier for data processors to get CPUE data quickly.

d. Size-Frequency Data

The analyses of length-frequency data (Figure 17) showed that the FRI, LOT, and YFT species landed at TPI Pasie Nan Tigo have a range length-frequency more than the fish landed at TPI Gauang. On the other hand, the BLT, KAW, and SKJ species landed at TPI Gauang had more range and length frequencies than fish landed at TPI Pasie Nan Tigo with the same type of species. The two TPIs both use lift net as fishing gear. Novita et al., (2019) explained that the reason a lot of small fish are caught is due to the mesh-size of the lift net, which the fisherman operates is 2.5 inches so that the tiny size causes all sizes to get trapped in the net.

The composition of the catch in this study showed that small-sized target fish are more dominant than larger fish. According to Wagiyo et al. (2018) that the similarity of habitats where fish and the characteristics of pelagic fish swimming in groups (*schooling*) cause fish of various sizes to interact with each other in the same area.

Also, in several different areas such as Sibolga, which catches fish in the Indian Ocean, the fish caught has decreased in terms of size (Fadhilah et al., 2019). Furthermore, she added the decrease in the size of the fish caught is due to the tiny mesh size.

Based on the length-frequency table and graph presented, when compared with the ***Lm* size** (length at first maturity) issued by FishBase (Table 5), in general, average fish caught at the four landing sites are small fish below ***Lm*-size**. The catch of these little fish is suspected because, in fishing operations, fishers use FADs, which are used by fishers at the fishing ground to attract fish to gather. The installation of this FAD resulted in all fish of various sizes, from small to large ones gathering around the FADs to be caught. This assumption is strengthened by the results of research conducted by Sudirman & Mallawa, (2012) explained that fishing using attractors in the form of FADs is, in principle making it a gathering place for plankton and zooplankton. So, it attracts and invites fish from various sizes to come together to find food. Besides, the distance of the installation between FADs increases the likelihood of juvenile-sized fish being caught (Widodo et al., 2014). Another study highlighted the FADs could attract various types of fish and multiple sizes, both juvenile and adult-sized fish in different abundances (Wiadnya et al., 2018).

The use of FADs is an alternative to attract fish in fishing activities. Even so, its use must be regulated, such as what fishing gears may use FADs and must be selective. This is intended so that the fish caught in FADs are fish of suitable size, not undersize fish. So that fish resources remain sustainable. According to Babcock et al. (2013), a decrease in the small size of fish caught in water is an indicator of overfishing. Apart from the two TPI Gauang and TPI Pasie Nan Tigo, the fish landed at TPI Kambang and TPI Muaro Padang are also dominated by small fish (can be seen in Appendix b).

Table 5. Standard of length at first maturity

No	Species	Scientific name	L maturity (cm)	Range	Max Lenght	Common length	Max Published weight (kg)	Age (years)
1	Bigeye tuna	*Thunnus obesus*	100	100 - 125	250	180	210	11
2	Yellowfin tuna	*Thunnus albacares*	103.3	78-158	239	150	200	9
3	Kawakawa	*Euthynnus affinis*	39.8	40-65	100	60	14	N/A
4	Frigate tuna	*Auxis thazard*	29.5	29-?	65	60	1.7	5
5	Bullet tuna	*Auxis rochei*	20.7-23.6	35-?	50	N/A	N/A	N/A
6	Longtail tuna	*Thunnus tonggol*	N/A	N/A	145	70	35.9	19
7	Skipjack tuna	*Katsuwonus pelamis*	40	40-45	110	80	34.5	12

Source: adapted from FishBase.org (2020).

The results of the data exploration showed, the use of PELAGOS data to calculate indicators commonly used in fisheries management can generally be used. However, the sample size is small, which creates some uncertainties. One of the uncertainties arising from the small sample size (limited to only for species managed by IOTC) and the limited number of vessels sampled is the high bias in estimating total catch and on CPUE calculations. Besides, data limitations for this calculation include information on the number of settings in one operation. To perform the ideal CPUE calculation, information on the number of settings (for lift net) or the number of hooks (for troll-line/handline) is needed (Smith et al., 2018).

5.4 Potential for developing stock assessment tools

Stock assessment is an application of statistics and mathematics to a group of data to determine the status of fish stocks quantitatively to estimate fish stocks and alternative fisheries policies in the future (Hilborn & Walters, 2013). Furthermore, stock assessment uses some statistical calculations to predict changes in the fish population in four stages, including:

(1) Estimation of stock characteristics (growth, natural mortality and due to capture and reproductive potential);
(2) Estimation of fish abundance in the sea;
(3) The relationship between effort and arrest mortality and;
(4) Estimation short-term and long-term production in the form of capture scenarios based on abundance and current stock characteristics.

Various methods are used in calculating fish population stock. Widodo (2002) explained, In Indonesia, the estimation of fish stocks is carried out by several approaches, as described below:

1. Census or transect methods are used to study fish stocks that have slow-moving characteristics, such as ornamental fish and reef fish.
2. The swept area method is used to estimate the demersal base fish stocks by sweeping the fishing area using trawling fishing gear.
3. The acoustic method is a method that can be used to estimate both pelagic and demersal fish using echo sounders.
4. The surplus production method is used to estimate fish using time series data on fish catches and fishing efforts at fish landing sites.

Based on the explanation above, several methods that can be used to assess fish stocks in nature based on the data generated by the PELAGOS system are:

a. The surplus production method

Pedersen & Berg (2017) explained that the surplus production model is one of the models commonly used in fish stock assessments. This is because this group of models can be applied with the availability of time series data on catch and catch effort, which is generally available at each fish landing site from PELAGOS. Furthermore, Haddon (2010) and Zhang (2013) explained the surplus production model is closely related to a stock as a whole, the total effort and total catch obtained from the stock without considering in detail several variables such as growth and mortality parameters or size effects mesh against the age of the fish caught.

The surplus production method is a relatively simple holistic model in calculating fish stocks when compared to the analytical model (Steinshamn, 2011). This is since there are fewer data variables required only by using data series as a basis for calculation. As an illustration, the surplus production method does not need to determine the age class of the species to be calculated by its abundance because it only uses existing series production data, so the calculation of age determination is not necessary ((Skonhoft et al., 2012),(Kizhakudan, 2017)). This powerfully supports the condition of data availability in Indonesia, so that the calculation of fish stocks in Indonesia using the surplus production method can be one of the ways that can be used to assess fishery stocks.

Nevertheless, Zhang (2013) revealed that the model applied in fisheries may be different for different types of fish. It means, fish with the same species but living in different areas are not necessarily able to use the same method. Similar to fish of different species but living in the same regions, the suitable model may be different.

b. Length-based Fish Stock Assessment

According to Mildenberger et al. (2017), besides using the surplus production method, the study of fisheries stocks with limited data can use fish length-frequency data as the basis for calculation. Length-frequency is one of the biological parameters that is the output result of the PELAGOS application. Length-based stock assessment is one of some fishery stock assessment methods that can be used if the availability of information on fisheries data in an area is quite limited (Chrysafi & Kuparinen, 2016). Currently, the method of estimating fish stocks using length-frequency as the basis for calculation has been developed.

Chong et al. (2020) mentioned several existing methodologies including length-based integrated mixed-effects (LIME), length-based Thompson and Bell (TB), length-based risk analysis (LBRA), and length-based spawning potential ratio (LBSPR). The usefulness of length-frequency data is not only used as a basis for stock assessment, but it is also widely used in calculating parameters such as mortality, recruitment, fishery population estimation and catch selectivity (Rudd & Thorson, 2018). With the calculation of fish stocks based on length measurements, it can be used as a reference as a legal basis for fishing based on size for sustainable fisheries in the future (Takar and Gurjar, 2020).

5.4 Limitations of this study

Based on the results of comparisons made to the PELAGOS system and the previous data collection system, the PELAGOS system has several advantages that can be used to cover the incomplete data generated by the previous data collection system. However, this study still has limitations. Some of the limitations of this study include:

1. A limited number of species that are the object of research (tuna and neritic tuna);
2. The small number of samples taken and no information for bycatch and discarded catch. Both of them are significant in stock calculations ((Oliver et al., 2015),(Zeller et al., 2018));
3. The data used is still limited (only five years) so that it is not sufficient to be used as a basis for a fishery stock assessment;
4. The number of landing sites covered is still small and does not meet the requirements to represent the entire Indonesian territorial waters that are included in the IOTC competency area;
5. There are still weaknesses in the PELAGOS system, and there are still many evaluations and an increasing capacity for the database system. As the data parameters shown are incomplete, it does not have a map as a capture fisheries performance.

From the results of the research and discussion described in this study, it provides new insights into the level of catch between regions that can be analyzed spatially and temporally. Also, the results indicate that there are some differences in the composition of the landed fish catch, making it possible to study the species abundance levels in each area. Based on the total number of catches analyzed based on the time series, it shows the level of utilization carried out by fishers who can provide an overview of the status of fishing activities. So that the results of this study suggest that data collection using the PELAGOS system can continue to be carried out with some development and refinement of the PELAGOS application to meet the required data parameters and if needed the range of the data collection area can be expanded.

5.5 Challenges in capture fisheries management

Data collection in the field of fisheries must be done correctly and adequately. This is because fisheries data collection is an essential component that becomes the primary input variable in determining fisheries policymaking. At present, the capture fisheries data can be said to not be optimal and efficient because they are still incomplete (capture fisheries data collection is done in different echelons) (Yunanda, 2019). The main cause is the transfer of authority in the field of capture fisheries data collection which was initially carried out by Echelon II at the Directorate General of Capture Fisheries to the Secretariat General of MMAF. The transfer of authority resulted in changes to the data collection system that had been built before being replaced by a new data collection system and which was considered a comprehensive and proactive database system. However, the new system that has been created has not been able to meet the demands of diverse data, both from other agencies, and requests from international organizations.

Unlike data collection carried out at fishing ports which are recorded based on the results of auction listing at TPI in general, data collection using the PELAGOS system is carried out directly by visiting the fishing vessel that has unloaded fish at the same time. The sampling of 30% was carried out on the vessels that landed their fish on the same day to obtain detailed data and information from the vessels, including the composition of the catch. It is different from the previous data collection, which only got information on fish species and the total aggregate catch from the landing vessels. As additional information, the enumerators' sampling activities were carried out four times a week, according to a random number schedule (Appendix c) to obtain more accurate information. Besides, measurement of fish weight was carried out using scales and fish length using a measuring board to get fish biology information (Appendix d). Taking biological data such as length and weight of fish during sampling has difficulties because only one enumerator carried it out.

Another factor that becomes a problem in the implementation of data collection and processing is the limited human resources that manage to capture fisheries data consisting of enumerators, data processors and supervisors who are directly related to the activities of collecting and processing fisheries data (Purcell et al., 2014). A large number of vessels that land fish per day requires a lot of time and personnel to collect data as a whole. Enumerators are the spearhead in field data collection activities (Wanchana et al., 2015). Whether or not the data is collected is the responsibility of the enumerator. For this reason, the ability and understanding of enumerators in understanding what needs to be done is a key factor in the success of field fisheries data collection (Doddema et al., 2018). At present, the number of enumerators conducting data in the field is 4756 people spread throughout Indonesia

(Pusdatin, 2020). Data processor is the person in charge of inputting data and analyzing data collected by the enumerator (Bradley et al., 2019). The number of data processors available today is around 1094 people. The supervisor is the person in charge of supervising the implementation of data collection. Besides, the supervisor's job is to validate the data entered by the data processor. Supervisors consist of central validators totalling 43 people with ten people focused on capture fisheries (Pusdatin, 2020).

The lack of infrastructures such as the TPI building requires fishers to unload the fish on the beach such as in TPI Pasie Nan Tigo or a makeshift demolition site without a roof like in TPI Muaro Padang. This causes poor quality of landed fish which results in low selling value. Besides, limited facilities such as computers are used to input and process data that has been collected by enumerators using data collection forms. This needs to be done because the more data collected the computer with sufficient capacity is required. Thus, the data processing can run well, and the results are as expected.

Conversely, if adequate facilities do not support it, the resulting output data is less than optimal, for example, the inaccurate results of the calculated data analysis. The impact resulting from inaccurate capture fisheries data is the creation of a fisheries development policy formulation that is not on target, resulting in mismanagement (Sampson, 2011). Besides, the inaccuracy of data and information on capture fisheries it also has an impact on investment in capture fisheries that is not appropriate, for instance, mistakes in determining the location of fishing ports, determining the amount of fishing vessel allocation and so on (Bappenas, 2014).

In addition, from the research results that have been stated earlier, because of the additional details in the data, it is possible to detect differences between species, location, time, abundance, length distribution (Figure 13, 14,15,16 and 17). Examples that deserve attention include changes in fishing trends illustrating patterns of fishing seasons on a weekly/monthly/annually basis. Such patterns previously could not be explained by previous data collection systems. This is because the data displayed is aggregate capture data. The difference between four locations between species can indicate that each place has a different abundance both from the type of species and from the number of fish populations that are in it. This data will make it possible to study the phenology of the study area, its correlation with environmental parameters such as temperature, currents, salinity and phytoplankton abundance. A number of reasons may explain why there may be differences between the parameter estimates for different locations/species/times. However, this research is still limited to only one province. And a more detailed analysis of biological parameters such as gonad maturity level, length maturity cannot be displayed using the PELAGOS application because there are still many obstacles and limitations that must be faced. However, it is possible that this analysis can be carried out in the future.

6. SUMMARY AND CONCLUSION

Indonesia as a member state of the Regional Fisheries Management Organizations, one of them is IOTC which is required to report fisheries data annually. To fulfil this request, the government is trying to build a data collection system and continue to make improvements so that data is complete and has a high level of accuracy in accordance with the request. Several systems have been built including formatted excel applications and One Data System. However, the system is still unable to meet complex data requests so that the government collaborates with IOTC to get assistance related to tuna fisheries data collection.

With the development of a new data collection system to accommodate data requests, it means that the government has a different system to complement the current data shortages. This research evaluates the data systems using a comparative analysis method to see whether the system can complete and meet the data criteria that are compliance by the Indonesian government to the IOTC.

After analyzing the data generated by PELAGOS and comparing them with the current data collection system, PELAGOS database system has several advantages that can complement the reporting data requests to IOTC. One of its benefits is biological parameters such as CPUE trend, fish length, catch composition, and fishing trends in series required in calculating fishery stocks which are integrated into one application. In addition to comparing existing fisheries data collection systems, this research also discusses the challenges encountered by the government. However, it is only limited to the technical aspects of data collection and institutional aspects that are directly involved in fisheries data collection activities. The results of this analysis have provided an overview to produce several recommendations for decision-makers about calculating fisheries stocks in the future (Appendix e).

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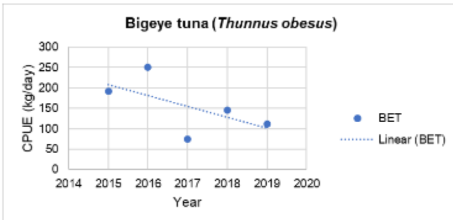
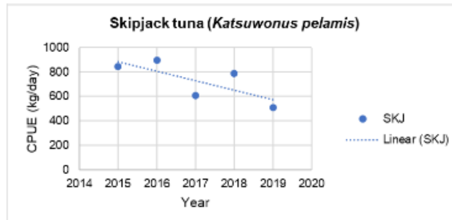
8. APPENDIXES

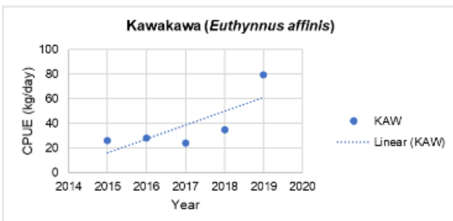
<u>Appendix a.</u>

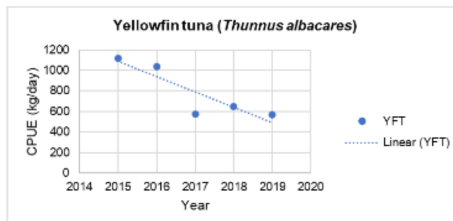
Trend CPUE

TPI Kambang

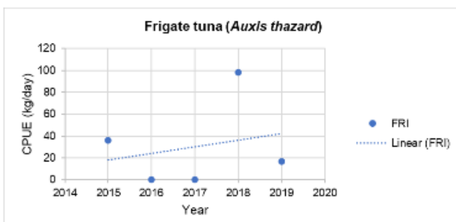


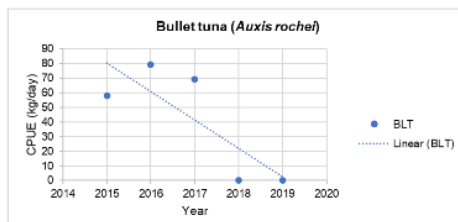


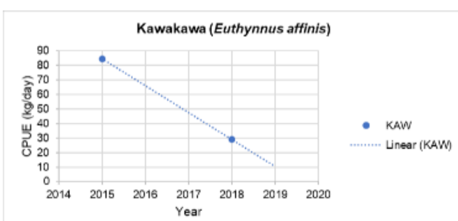


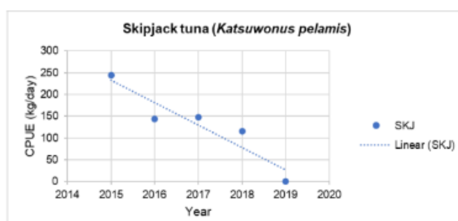


TPI Muaro Padang





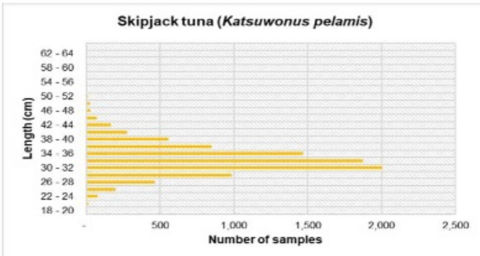


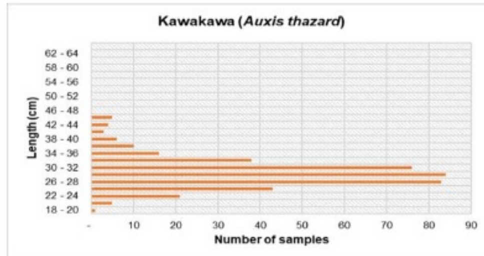


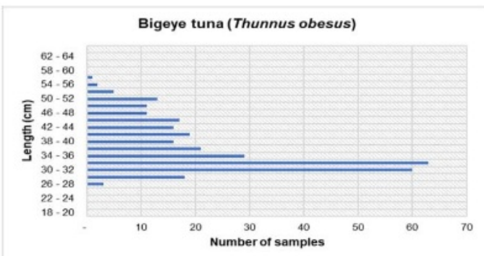
Appendix b.

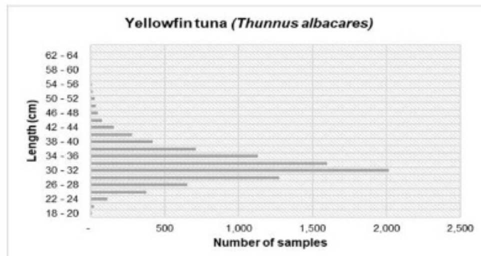
Length-Frequency

TPI Kambang









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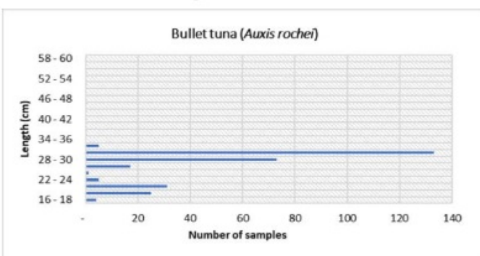
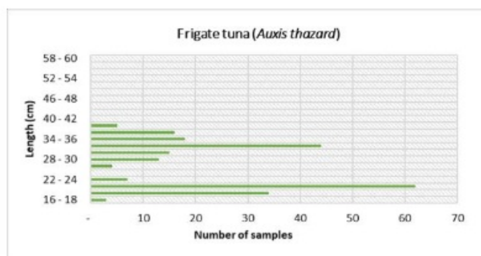
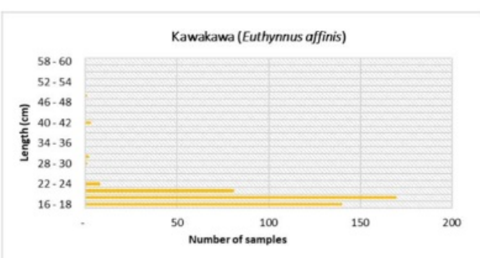
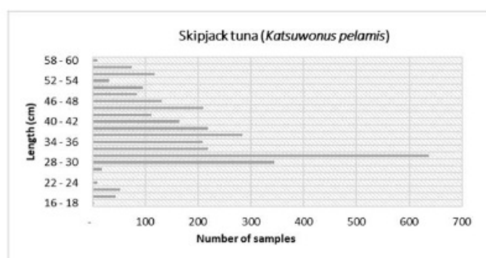
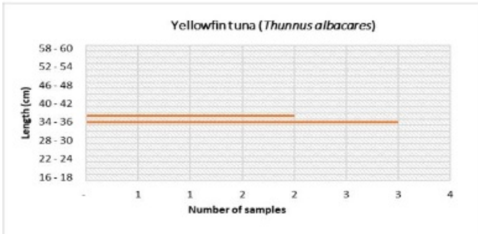








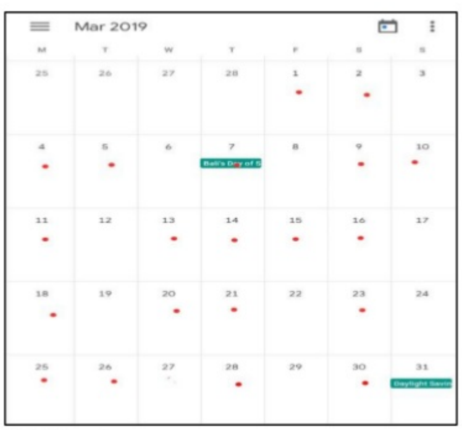


Appendix c.

Sampling schedule

TPI Pasie Nan Tigo

TPI Gauang

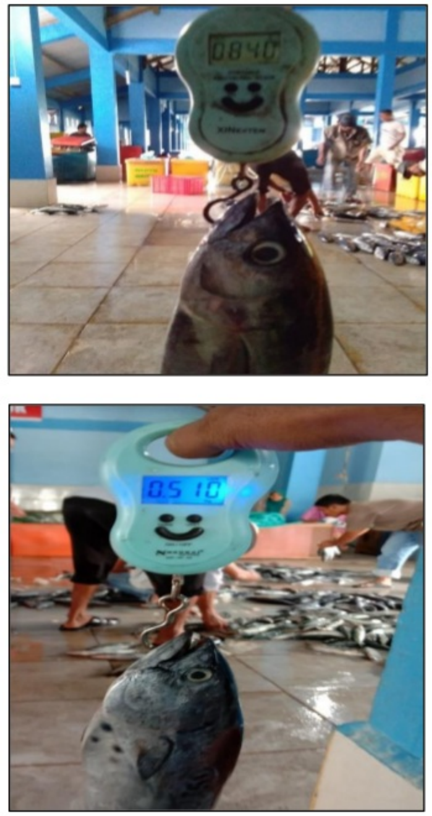


TPI Kambang

TPI Muaro Padang

Appendix d

Fish measurements



Length-frequency

Weight measurement

Appendix e

RECOMMENDATIONS

From the research results obtained, data collection using the PELAGOS system has several advantages that can complement the data requirements requested by the IOTC. Also, it has implications for fisheries management in the future. So that MMAF can consider the PELAGOS system as a system that can continue to be used and developed. Thus, this study provides several recommendations that can be considered:

A. Increase the capacity of PELAGOS Applications

Like other applications in general, PELAGOS also has advantages and disadvantages in the process of producing the expected data output, so it is necessary to update and increase the capacity through evaluation of the results of the analysis of the data generated. The PELAGOS developments that need to be added include:

a. The addition of a database on fish species caught is not only for the species managed by IOTC.
b. It is necessary to separate the catch, which is the main target and bycatch from fishing gear operated by fishers.
c. It added discarded catch data information. This is very important because this information can provide an overview of what types of fish live in the fishing area.
d. The addition of biological information is not only length-frequency and weight, but it is necessary to have information about the standard size of how many fish are fit to be caught.
e. It is necessary to add a specific coordinate for the fishing area. These coordinates function to detect and determine the position of the spawning area or not. So, fishers can catch fish that are worthy of being caught or not.
f. Addition of a location map in the output data which aims to determine the abundance of fish resources in the area, the density of fishing fleets for sustainable fisheries management in the future.

A. Institutional Aspects

1. Training enumerators regularly annually

Training is one of the essential activities that institutions need to carry out for fisheries stakeholders who collect data in the field. This aims to improve the ability of officers in the field. This capability must be possessed by officers in the field, be they officials from the government or private agencies (fishing companies). For this reason, it is crucial to provide training and information to officers with complete knowledge starting from various aspects such as biology, ecology, the identification process, making & reporting data and regulations so as not to deviate from applicable regulations. One of the basic abilities that data collectors must-have in the field is the identification of fish species. Concerning the need for the assessment of fish resource stocks, the ability to identify species is the basic knowledge of a stock assessment that determines the next stage. If this primary stage is not well mastered, it will produce inaccurate information and will affect the next step. If this happens, the resulting data and information will be biased, such as the results that under-estimate or overestimate. Inaccurate information will affect the optimal level of exploitation and management steps in the future.

2. **Increasing the number of personnel both enumerators, data processors and supervisors**

Thus, the need for large amounts of human resources to carry out data collection, processing and supervision. Based on the data submitted by Pusdatin, the number of stakeholders who handle fisheries is very minimal when compared to the number of areas that have fishery activities. The additional personnel is intended to cover areas that have fishery activities in each province so that all data can be recorded. Besides, data processors and supervisors need to be added so that each individual works optimally and is not overloaded because they handle too many areas that have fishing activities.

3. **Increase budget allocation for the data collection on capture fisheries**

Data collection in the field is an activity that not only requires manpower and human resources but also requires substantial funds. This is because data collection activities need funds for printing forms, paying enumerators' salaries, buying equipment for sampling such as scales, measuring instruments, transportation costs if the location is in trouble and purchasing facilities such as computers to input and process data. For this reason, the planned budget must be reasonable so that data collection runs optimally and efficiently as expected.

4. Provision of infrastructure and facilities

To obtain good quality data, of course, it must be supported by adequate infrastructure such as a fish landing building. This is necessary so that fishers can unload their catch in a suitable place. In addition, the enumerator can take fish sampling for easy measurement without worrying that the record form will be damaged in the event of rain. Besides, in carrying out data processing, of course, it must be supported by an adequate facility such as computers as a tool for storing data that has been collected.

5. Introducing rewards and punishment system

There is a system of rewards for those who capture fisheries that report correctly and adequately such as additional capture quotas for example and punishment to those who do not report their data properly for example in the form of revocation of fishing permits. Sometimes vessel owners or captains are reluctant to provide catch data. They are worried that if they report their catch, they will be subject to taxes or other levies. The enumerator is only in charge of collecting data in the field. This concern of the owner or captain of the fishing vessel made it difficult for the enumerators to collect data. So, by introducing a rewards and punishment system can be an alternative to increase the awareness of fishers and fishing companies in reporting data correctly (so that there is no manipulation of data).