Improving the accuracy of tuna fishery data using the fishing e-logbooks in FMA 573

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Abstract. Collecting daily records from captains on fishing vessels has become easier since the government issued an electronic fishing logbook (e-logbook). With just a few touches on the device's screen, fishermen have been able to record, store, and submit fishing operation data to the government. Fishing logbook data is very important because it can explain fishing coordinates, the number and species of fish per set, the number of effective fishing days, and data on ecologically related species. This research aimed to analyze the accuracy of tuna fishing data reported by fishermen through the e-logbook application for catching fish and then landing their catches in different fishing ports along the State Fisheries Management Area of the Republic of Indonesia 573. This research uses a descriptive method by comparing different sources of tuna data. The results of the analysis showed that the quality of logbook data collected by fishermen tends to be low for all reported tuna species unless it is followed by strict verification, validation, and cleaning activities. The quality and level of accuracy of logbook data were also influenced by the operators' level of compliance and by the reporting rate via e-logbook.
Key Words: data cleaning, data quality, fishing port, settings.

Introduction. Data availability is a fundamental asset in sustainable fisheries' management, therefore data collection should be a top priority, in the context of fisheries catch monitoring by engaged stakeholders, as the primary source of fisheries data (Sondita et al 2022). More specifically, Jaya (2015) stated that restrictions on the use of fish resources will be ineffective if monitoring is not driven by data collection on the number of fish caught. Data collection on fishing activities is important to monitor fishing activities so that fishermen must report catches through fishing logbook (Grilli et al 2021). Fishermen who already have a business permit are required to report all their catches through a fishing e-logbook. This obligation is laid down in Article 4 of the Regulation of the Minister of Marine Affairs and Fisheries No. 33 of 2021 on Fishing Logbook, Monitoring of Fishing Vessels and Fish Transport Vessels, Inspection, Inspection and Marking of Fishing Vessels and Management of Fishing Vessel Manning (MMAF 2021). The obligation to use an electronic fishing logbook applies to all fishing vessels of more than 5 gross tonnages (GT) while fishing vessels of less than 5 GT are not required to use an e-logbook.

The implementation of the e-logbook started at the end of 2018, replacing the manual fishing logbook. It is hoped that the changes to the implementation method of the fishing logbook will provide a solution to various problems that have arisen in the field, such as low data accuracy, the continuous lack of compliance with the logbook reporting requirements, the limited number of staff and the increasing number of logbook entries on land after fishing activities have been completed and the vessel has been unloaded at the fishing port. The fishing logbook is designed to be electronic, in order to make it easy for fishermen to use (Raup et al 2021) and it is hoped that it can improve

reporting, although there are still problems in some places, including application malfunctions during operations, lack of ability to use the technology and internet unavailability (Setyadji et al 2021). Indonesia has successfully supplied as much as 16% of the world's total tuna production (MMAF 2020).

The level of data accuracy is one of the main issues in the government's efforts to improve tuna data. According to Khairani et al (2022), the availability of accurate catch data is needed in planning the development of programs and determining policies that support the development of capture fisheries. Based on research results, tuna fisheries in Indonesia show low accuracy of fisheries data due to funding in the data collection process, poorly trained enumerators, inadequate facilities for checking results, and other causes (Khan et al 2020). In 2021, the Secretariat of the Indian Ocean Tuna Commission (IOTC) published the results of estimates of the number of tuna fish catches in Indian Ocean waters where Indonesian fishermen fish, where the results of the calculations are very different from the tuna fishing data reported by the government. The implementation of the e-logbook by Indonesia, as a tool used to reconstruct the data, is designed to convince the IOTC Secretariat that Indonesian fisheries data are sufficient to estimate the number of Indonesian tuna catches. Another key challenge in optimizing the logbook implementation is related to the reliability of logbook data and the ability of small-scale fishers to manage logbook data (Sari et al 2021). Small scale fishers usually suffer a low fishing technology and skills due to low access to technology. Small-scale fishers do not want to improve their handling because they receive the same and low prices for tuna that they captured (Muawanah et al 2021).

Tuna data collection is a priority because it determines Indonesia's position in the exploitation of this resource at the regional level. Fisheries Management Area (FMA) 573 is a water area dominated by large pelagic fish such as tuna. At the same time, other resources are shrimp and demersal fish, the majority of which are in coastal waters (Suman et al 2016). The waters of the Eastern Indian Ocean, including Fisheries Management Area (WPP) 573, are potential areas for catching national and foreign longline and purse seine tuna (Demi et al 2020). A fishing log book is a tool that records operational data and catch results of the fishery to describe its dynamics and management (Nurhayati et al 2018). Through a fishing logbook, catch data have traceability so that the distribution of fish resources, especially tuna, in the FMA 573 can be mapped. Fishermen's ability to identify catches or the habit of using local names are also barriers to data collection. The e-logbook provides the option to simply select a picture of the fish that matches the catch to minimize identification errors.

Fishermen play a very important role in the collection of fishing logbook data, as they fill them in on the boat. However, no training has ever been provided to fishermen on how to estimate the number of fish caught and how to report all fish discarded, fish consumed and fish of low economic value, including fish moved in the middle of the sea (transshipment). So far, the implementation of fishing logbooks has been limited to the elimination of obligations, while officers in fishing ports are still focused on the use of electronic logbook devices, so to build consistency it is necessary to apply sanctions and guidance by fishing ports. This situation results in low-quality data from the implementation of the fishing logbook, which indicates that less than 50% of the total reported fishing logbook data is discarded and cannot be used for further processing and analysis. Meanwhile, for the tuna resource, there is no data to show the level of accuracy of data based on fishing logbooks. In this regard, this study aims to analyze the level of accuracy of tuna fishery data reported by fishermen through e-logbooks in several fishing ports along the FMA 573, which are landing sites for tuna catches including albacore (*Thunnus alalunga*), bigeye tuna (*Thunnus obesus*), yellowfin tuna (*Thunnus albacares*), southern bluefin tuna (*Thunnus maccoyii*) and skipjack tuna (*Katsuwonus pelamis*).

Material and Method

Description of the study sites. This research was carried out throughout a 6 months period, from January to June 2023, using the desk study method, based on fishing logbook data combined with field visits to landing ports to observe the implementation of

data collection through fishing logbooks. The selected ports are strategic centers for the landing of tuna caught in FMA 573 and they have implemented the fishing logbook practice. These ports are the Cilacap Ocean Fisheries Port (PPS), the Benoa Port (PU), the Nizam Zachman Jakarta Port (PPS) and the Palabuhanratu Archipelago Fishing Port (PPN), as shown in Figure 1. In this study, PU Benoa is considered as a Class A fishing port or PPS.

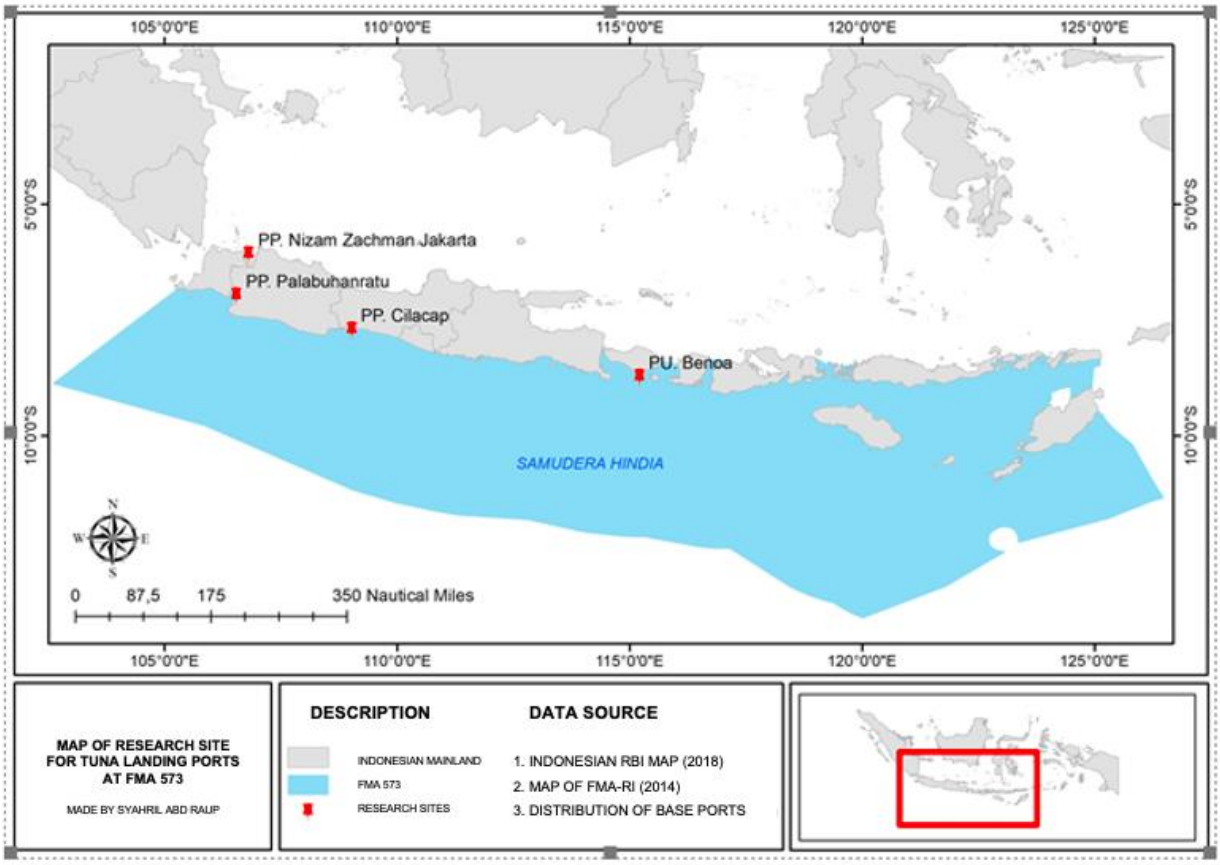

Figure 1. Research site, Indonesia.

Data preparation. The FMA 573 data series for the last five years (2019-2023), limited to purse seine (PS) and longline (LL) gear, were obtained from the Fishing Logbook Information System. Both gear types were chosen because they have the highest productivity compared to other gear types in catching tuna. Observations of the flow of logbook data collection were carried on at each landing port. Information on the flow of logbook data collection is important for describing the relationship between the implementation methodology and the quality and accuracy of the data produced.

Data processing and analysis. The data collected is then analyzed. There are 4 stages of analysis, namely a) suitability analysis of the implementation of logbook data collection, where the logbook data collection activities in each port are compared with the standard methodology for logbook data collection, b) suitability analysis of the reported settings, c) suitability analysis of the fishing operations, and finally d) data cleaning and filtering.

Results

Analysis of the suitability of the implementation of logbook data collection. According to the Minister of Marine Affairs and Fisheries Regulation No. 33 of 2021 on Fishing Logbook, Monitoring of Fishing Vessels and Fish Transporting Vessels, Inspection, Testing and Marking of Fishing Vessels, as well as Management of Fishing Vessel Manning

(MMAF 2021), every fishing vessel that enters the fishing port area to carry out fish unloading activities must first submit the logbook to the designated logbook officer or harbor master officer at the fishing port to obtain a letter of approval to unload fish.

Figure 2 shows that none of the base ports are fully capable of forcing fishing vessels to submit logbooks when entering the port area by the applicable regulations.

At the Palabuhanratu PPN, 71% of vessels entering the port did not submit logbook data to the logbook officer at the fishing port. Meanwhile, other base ports are relatively better at implementing logbook data collection, the more performant being the Benoa PU. Logbook implementation is the main requirement for issuing catch certificates or other similar documents.

In the last 3 years, all the longline vessels entering the Palabuhanratu PPN area have submitted data using e-logbooks. The use of e-logbooks is expected to improve the quality and accuracy of the data produced, but this needs to be further proven, as the quality of data is not equally high in all base ports, given the variability in the level of knowledge of fishermen and logbook officers.

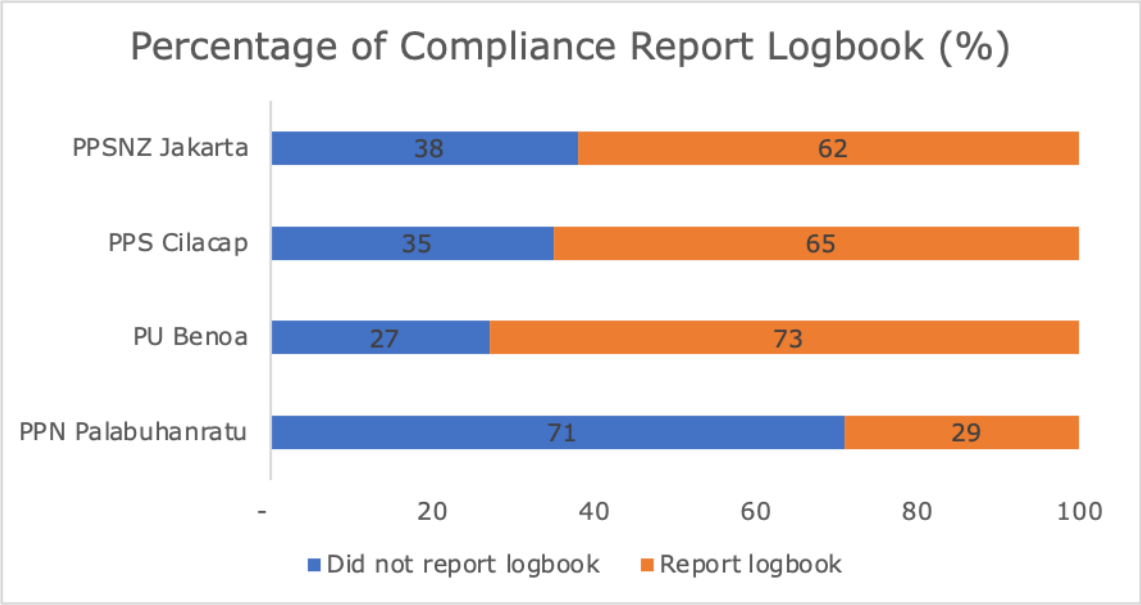

Figure 2. Percentage of compliance with logbook reporting in 2023.

This situation of the use of e-logbooks in the PPSs is very different: in the last 3 (three) years, the level of use of e-logbooks by operators was still relatively low, at an average of approximately 50-60% (Figure 3).

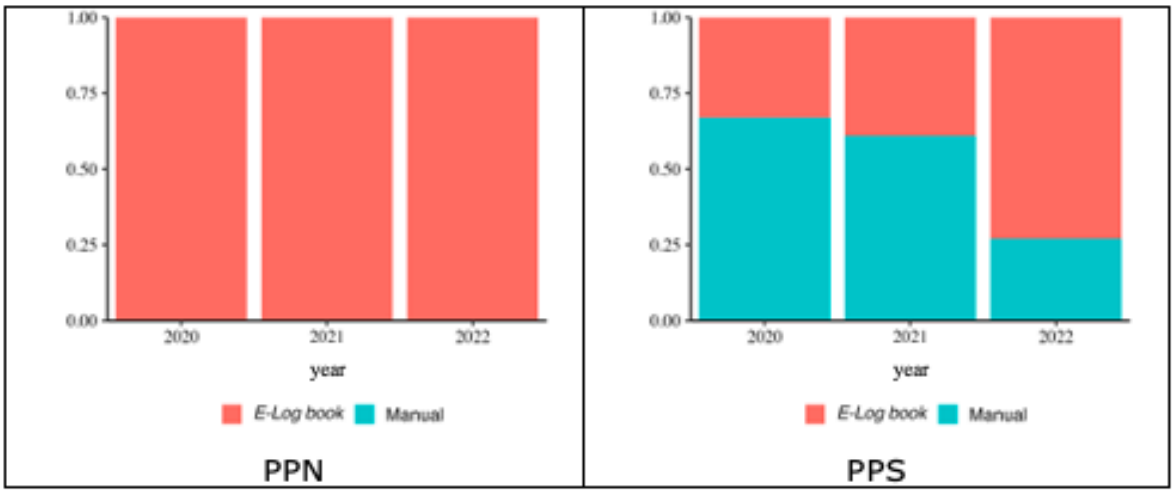

Figure 3. Percentage of e-logbook use in PPNs and PPSs during the period 2020–2022.

PPSs should use more e-logbooks, compared to the number of officers and the facilities and infrastructure supporting the collection of logbook data. In 2020, the level of e-logbooks used in PPSs reached only 33% of the total logbooks submitted, which is the lowest level compared to the first year of e-logbook implementation, when e-logbooks reached up to 46% of the number of logbooks submitted by the fishing vessels.

Suitability analysis of reported settings. One of the indicators used by the validators to ensure that the logbook data reported by fishermen can be processed is the number of reported fishing trips compared to the number of days at sea. The number of settings that are less than 50% of the number of days at sea is considered to be incorrect data and cannot be processed for further analysis. This determination is based on the assumption that fishing vessels can make at least one setting per day so that if half of the days at sea are setting, it is considered that the reported data are good, while at the same time not making it difficult for fishermen to carry out operational fishing activities. However, the percentage of settings considered valid should be evaluated each year, taking into account the quality of the data produced and the willingness of the fishermen themselves.

Based on Figure 4, the number of fishing settings reported by fishermen who land their catches in Palabuhanratu PPN has tended to decrease in the last 3 years.

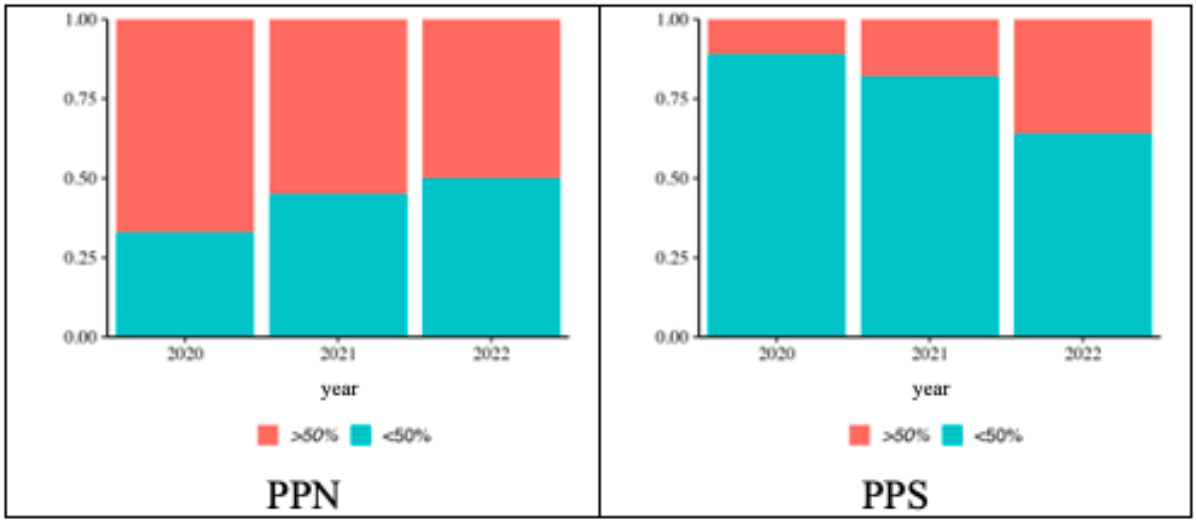

Figure 4. Percentage of number of logbook settings in PPNs and PPSs during the period 2020–2022.

In 2019, the number of settings reported by more than 50% of the fishing vessels reached more than 80% of the fishing days, and this number continued to decrease in 2020 and 2021. As much as 45% of the fishing vessels reported settings below 50%, compared to the days spent at sea in 2021, which is an indicator that the quality of the data produced is increasingly deteriorating and is a sign for the Port Authority to make immediate efforts to improve the logbook data collection system.

Many factors can lead to poor quality logbook data, such as the suitability of fishing locations for the type of fish caught, the number of hooks per set, and the number and type of catches made with the fishing gear. However, the decreasing number of reported settings is a factor that greatly influences the quality of the data. Although, based on previous data, all longline vessels in the Palabuhanratu PPN are already using electronic logbooks, this does not appear to be a guarantee that the quality of the data will improve. Other factors determining the quality of logbook data are the fishermen's ability to use e-logbooks and their willingness to fill in the catch data correctly. Meanwhile, in PPSs, the average number of reported settings above 50% of the number of days at sea is very low, compared to the PPNs. Over 3 years, the number of vessels reporting settings above 50% of the number of days at sea was less than 20%, and in 2020, this figure reached only 11%. This condition reinforces the assumption that many

fishermen submit logbook data only to fulfil their obligations, especially when the base ports do not carry out initial verification of logbook data, so they cannot detect the fraudulent fishing vessels (that do not report settings above 50% of the days at sea; this aggregated information is accessible only by the validator, at the headquarters). The availability of human resources and supporting infrastructure for data collection at the PPSs needs to be optimized accordingly.

Fishing operations suitability analysis. One of the analyses used to determine the quality of the resulting logbook data is the fishing suitability analysis. This analysis is carried out by comparing the data generated by logbook data with other data collection activities, such as: comparing catch data reported through logbooks with landing data in fishing ports, recorded by enumerators; comparing the reported setting locations with the Vessel Monitoring System (VMS) data; comparing the size of the vessel with the number of fish transported; comparing the fishing area and base port with the vessel permit; comparing the type of fish reported with the fishing gear used. Based on the 6 fishing operational variables selected, where logbook data reported by fishermen were tested against other data considered to have a higher level of accuracy, it was found that the variable that most often did not correspond to the actual situation during the period 2020-2022 was the reporting of the amount of catch, in other words, the number of fish reported is lower than the number of fish landed (Table 1).

Table 1

Suitability of fishing operations

Variable	*% Non–compliance*		
	2020	*2021*	*2022*
Fishing gear setting and VMS	28%	34%	31%
Fishing production	30%	35%	32%
Match between vessel size and number of catches	19%	7%	13%
Fishing area	12%	13%	13%
Fishing port	1%	1%	1%
Suitability of fishing gear for type of fish	10%	11%	10%

In 2020, the non-compliance of fishermen in reporting the quantity of catch data according to the number of fish landed reached 30% and it increased in 2021 and 2022.

In Figure 5 it can be seen that based on fish landing data, the number of skipjack catches landed in PPNs in 2021 was 643 tonnes, while based on the logbook data, the amount of skipjack production was only 77 tonnes or 8 times lower than the landing data by enumerators.

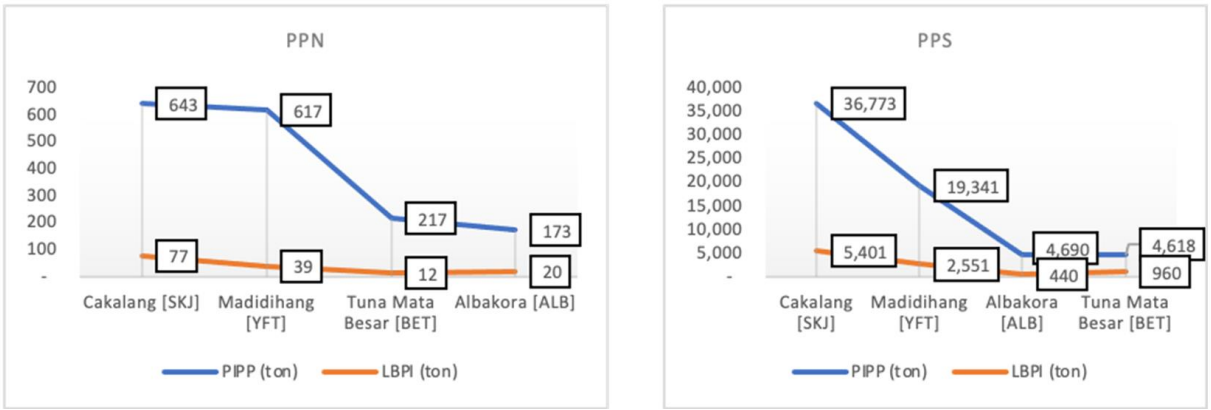

Figure 5. Comparison of tuna catches by enumerators and logbooks in PPNs and PPSs, 2021.

A similar situation was observed with other tuna species, the yellowfin tuna reported through landing data was 617 tonnes, which was very different, namely 16 times higher than the yellowfin tuna data reported through the logbook data, namely only 39 tonnes. The same situation occurred with the number of tuna landings at PPS in 2021, where the number of skipjack landings recorded through landing data was 36,773 tonnes, or 7 times higher than the number of skipjack landings recorded through the logbook data of only 5,401 tonnes. The same is true for the yellowfin tuna production data, with 19,341 tonnes recorded by the enumerator at the port, or 8 times more than the logbook data figure of 2,551 tonnes. Figure 5 shows that the accuracy of the tuna production data reported through the logbook data is very low and therefore needs to be validated before being used in data analysis.

The suitability of fishing gear setting locations and the VMS suitability are the next variables with the highest level of non-compliance. This condition indicates that the setting data reported in the logbook do not correspond to the actual fishing location. There are still many fishermen who hide the location of the setting, as it is usually related to the location of the fish aggregating devices (FAD) installation. They keep the location of the FAD secret to avoid being disciplined by supervisors in the field for not having a permit, and also to avoid revealing the location of the FAD to other fishermen. In addition, skippers often do not report setting locations for more than 50% of the days at sea (Table 2), even though the compliance of fishermen with the logbook is partly determined by the number of setting reports.

Table 2

The difference in the number of logbook settings not reported in PPNs and PPSs, 2020–2022

Year	*Fishing Port*	*Setting limit 50%*	*Reported setting*	*Unreported setting*	*% Unreported setting*
2020	PPN	1,811	1,791	20	1%
	PPS	26,257	6,584	19,673	75%
2021	PPN	915	717	198	22%
	PPS	31,026	9,517	21,509	69%
2022	PPN	28	27	1	4%
	PPS	20,695	7,877	12,818	62%

In 2020, up to 75% of fishermen based in PPSs did not report the location of Longline (LL) and Purse Seine (PS) settings. This figure improved in 2021 and 2022 to 69% and 62% respectively, as shown in Table 2 above. The low compliance of fishermen and economic operators in reporting the location of setting sites is also influenced by a low awareness of the importance of submitting data so reporting setting data is seen as interfering with their fishing activities. Beyond the non-compliance of fishermen and economic operators, as shown in Table 1 above, 99% of LL and PS vessels land their catches in the PPNs and PPSs of the FMA 573 by the base port indicated in the license documents. The two types of tuna vessels also have a high level of compliance with the suitability of fishing areas for catching fish, with 87% of LL and PS vessels catching fish by their license. Other data that show a high percentage of compliance is the match between fishing gear and the type of fish caught. This is sufficient to show that logbook data can be used to measure the productivity of fishing gear and also the composition of fish caught by each type of gear.

Cleaning and filtering data. Data cleaning and filtering will also be carried out to improve processing and analysis. This aims to minimize data inconsistencies and errors in data entry, including setting the format of departure and arrival dates, setting the number of days at sea to be at least 50% of the length of days at sea, and ensuring that geo-reference points do not intersect land or exceed the boundaries of the area of interest (Raup et al 2022). The data cleaning and filtering process produces quality data, while data that does not match the criteria is not used in the analysis process.

Based on Table 3, there is a difference in the number of tuna catches reported in 2022 at the PPNs in the logbook, before and after cleaning. All tuna production data at the PPNs were corrected when data cleaning was performed, or in other words, the difference in production data before and after cleaning is 100%. Meanwhile, in PPSs, there are differences between the number of tuna catches reported and the number of catches after data cleaning: the largest difference was found in the records of the skipjack tuna, with 80%, followed by the yellowfin tuna, with 71%, bigeye tuna, with 81% and albacore tuna, with 51%. In total, the difference in tuna production records before and after cleaning was 76%.

Table 3

The difference in logbook tuna catches in PPNs and PPSs before and after data cleaning, 2022

Fishing port type	*Catch composition*	*Before cleaning (ton)*	*After cleaning (ton)*	*Difference*	*% Difference*
PPN	Yellowfin tuna	5	-	(5)	-100%
	Albacore	3	-	(3)	-100%
	Skipjack	3	-	(3)	-100%
	Bigeye tuna	1	-	(1)	-100%
	Grand total	12	-	(12)	-100%
PPS	Skipjack	4,514	910	(3,604)	-80%
	Yellowfin tuna	1,362	394	(969)	-71%
	Bigeye tuna	813	154	(659)	-81%
	Albacore	508	251	(258)	-51%
	Grand total	7,198	1,708	(5,490)	-76%

The magnitude of this difference indicates that up to 5,490 tonnes of tuna production in PPSs and 12 tonnes in the PPNs cannot be processed and analyzed further. The large differences in the amount of tuna catch data that cannot be analyzed prove that the production data obtained from the logbook cannot be used as a reference for calculating the volumes of tuna landed in PPNs or PPSs.

The results of this analysis can also be used as a first indication that caution should be taken when using logbook data to determine the composition of tuna catches by gear. In addition to the correction of tuna catch production data, which are considered to be inconsistent and erroneous at the time of data collection, data clearance can also correct setting points (Table 4).

Table 4

The difference in the number of fishing logbook settings coordinates in PPNs and PPSs, before and after cleaning 2020-2022

	PPNs			*PPSs*		
Year	*Before cleaning*	*After cleaning*	*% Difference*	*Before cleaning*	*After cleaning*	*% Difference*
2020	629	315	-49.92%	4,912	1,015	-79.34%
2021	415	156	-62.41%	7,660	3,900	-49.09%
2022	15	0	-100.00%	6,510	3,570	-45.16%

Table 4 shows that in 2020, as many as 314 setting coordinates were corrected in PPNs, or 49.92% of the 629 total setting coordinates (before cleaning), while 3,898 were corrected in PPSs, or 79.34% of the 4,912 total setting coordinates (before cleaning). Even in 2022, as many as 15 setting coordinates were corrected in PPNs, or 100% of the 15 total setting coordinates (before cleaning), so that when plotted on the map it looks as if there are no PS and LL setting coordinates in the PPNs in 2022 (Figure 6).

Meanwhile, in 2022, in the PPSs, the corrected setting points will be 2,940 points or corrected by 45.16%, so when plotted on a map, the setting points can still be used to describe the distribution of fishing areas for vessels using PS and LL gear based on PPS, as shown in Figure 6. The results of plotting the setting points on a map can be used to determine the location of each vessel's settings, including the compliance check according to the permitted fishing routes.

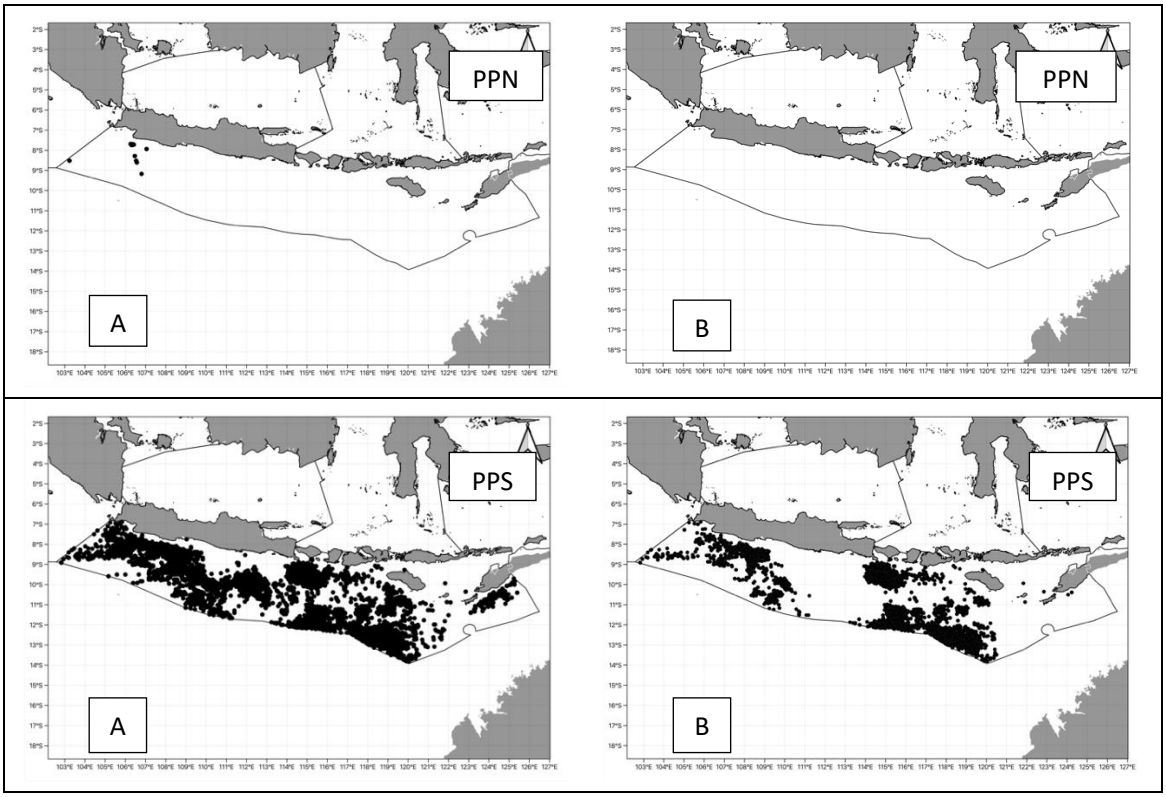

Figure 6. Distribution of fishing logbook setting coordinates in PPNs and PPSs before (A) and after (B) cleaning data Logbook 2022.

Conclusions. The implementation of an e-logbook is a solution offered by the government to increase the accuracy of tuna data, especially in FMA 573. This data can be used to formulate national tuna fishery policies and for reporting by the Indonesian government to the IOTC. However, the government needs to closely monitor the data collection through e-logbooks. It was found that in PPNs 71% of the fishermen did not report logbooks when the vessel entered the fishing port. The 29% who reported had all used e-logbooks. The situation is slightly different in PPS, where 66% reported a logbook when entering a fishing port, but the use of e-logbooks is still low, although tending to improve year on year. Non-compliance among fishermen is still very high, particularly in catches and gear reporting location. This situation has a major impact on the quality and accuracy of the data produced. The higher the level of non-compliance by fishermen in implementing e-logbooks according to the established standards, the lower the quality and accuracy of the data produced. The difference between the tuna production data reported through the logbook and the actual tuna catch data (landing data) indicate that logbooks cannot be used for policy analysis activities. Meanwhile, fishing locations generated from logbook data can still be used with a high degree of accuracy as long as the verification stage is carried out when fishermen submit logbook data before fish unloading activities and when the logbook data is submitted and stored in the database. The next stages are validation and data cleaning. It is very important to institutionalize each of these stages in the e-logbook data collection process, i.e. to establish standards for verification, validation, and data cleaning, and at the same time to identify the parties that will carry out these activities, and not just to focus on increasing the compliance of fishermen in reporting logbook data.

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Conflict of interest. The authors declare no conflict of interest.

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