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Selectivity of large pelagic purse seine based on catches in the Maluku Sea–Indonesia

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Abstract

Purse seine is a multi-species fishing gear, which is to catch more than one type of fish. In many cases, overfishing practices are often found and the mesh size of the purse seine is very small, this can affect the catch obtained. What may be affected is the size of the fish and the composition of the type of catch between the number of target species and bycatch. Fishing gear selectivity can be defined as the ability to obtain a specific fishing target according to the type of fish, size or sex (or a 3rd combination) during the fishing process and allows all bycatches to be escaped unscathed. This research was carried out at the Ocean Fisheries Port (PPS) Bitung, starting from January 6 to April 5, 2025, using a purse seine ship operating in Maluku waters. The purpose of this study is to determine the level of purse seine's ability to catch fish according to the desired size and type. This study is expected to provide in-depth insights into the selectivity level of purse seine as a potential solution to overcome excessive capture pressure. This research uses survey, observation, interview, documentation, and literature study methods. It is hoped that the results of this study can provide knowledge about the importance of fishing gear selection. As a result of the research, data on the composition of fish caught consisted of *Katsuwonus pelamis*, *Thunnus albacares*, *Auxis thazard*, *Deceperus macrosoma* and *Selar crumenophthalmus*. *K. pelamis* is the most dominant target species, which is 62.8%. The level of purse seine selectivity based on the catch is moderate. The target species of 62.8% is greater than the bycatch percentage of 37.2%. But when compared to individual catches or the size of fish poles, there are still fish caught that are not mature gonads. The percentage of *K. pelamis* who are eligible to catch is 32%. The level of selectivity based on the size of the fish suitable for catching is relatively low.

Keywords: Purse seine; Composition; Selectivity; *Katsuwonus pelamis*

1. Introduction

Katsuwonus pelamis is a prime fishery commodity widely spread [1] and it is the second largest commodity in Indonesian waters [2][3] which belongs to the large pelagic group, has oceanic characteristics or the nature of always moving from one water to another with oceanographic and biological conditions according to its habitat [4]. The tunas fishing areas are spread across the western to eastern regions of Indonesia. The spread of the Tunas in Indonesia includes the Indonesian Ocean, the west coast of Sumatra, South Java, Bali, Nusa Tenggara, the waters of Eastern Indonesia including the Banda Sea, the Flores Sea, the Maluku Sea, and the Makassar Sea [5][6]. The determination of skipjack fishing locations is determined by different seasons in each water but can be done throughout the year [7].

Purse seine is a multi-species fishing gear, which is to catch more than one type of fish. The capture generally uses small pelagic purse seine [8][9]. In many cases, overfishing practices and very small mesh sizes are often found, this can affect the catch obtained. What may be affected is the size of the fish and the composition of the type of catch between the number of target species and bycatch [10].

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Environmentally friendly fishing gear is fishing gear that does not damage fish habitats (aquatic ecosystems) during the process and after fishing activities are carried out [11]. Fishing gear selectivity can be interpreted as the ability of the fishing gear to obtain a specific fishing target according to the type of fish, size or sex (or a 3rd combination) during the fishing process and allows all unwanted bycatches to be escaped unscathed [12]. An important information that needs to be known in terms of fisheries resource management, is determining fish growth patterns and catch period, so fisherman catching only feasible fish category [13].

Along with the increasing fisheries potential in this region, this study focuses on the selectivity aspect of purse seine as an efficient fishing tool, especially in catching large pelagic fish species. These types of fish resources have great potential in Indonesia, including Tunas, which play an important role in global fisheries [14].

2. Material and methods

This research was carried out at the Ocean Fisheries Port (PPS) Bitung, starting from January 6 to April 5, 2025, using a purse seine ship operating in Maluku waters (FMA-RI 573). The location of the study can be seen in the following image.

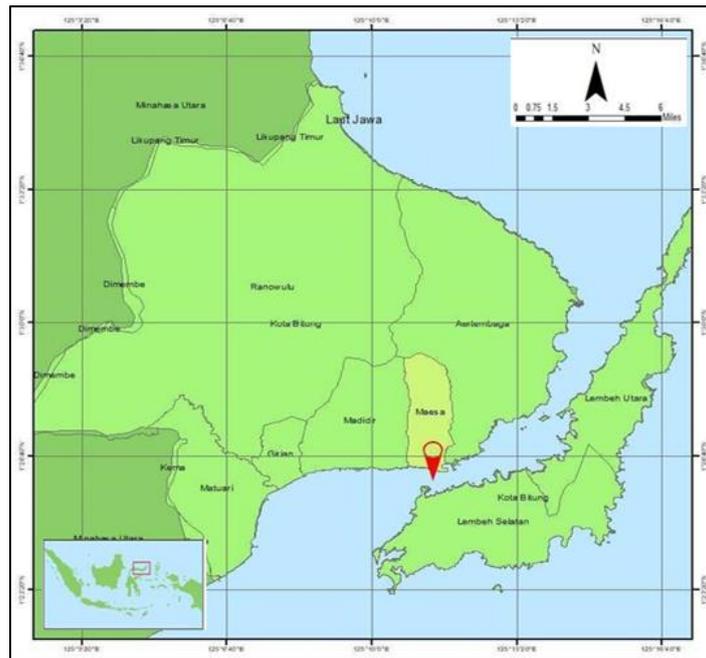


Figure 1 Map of the research location

Tools and materials needed in this study include Meters, Stationery, Cameras, Laptops, Scales, Microsoft Excel, Calipers, Rulers.

2.1. Data collection methods

The methods used in data collection are observation, interviews, documentation, and literature studies. There are two types of data taken in this practical activity, namely primary data and secondary data [15]. Primary data is data obtained directly in the field. Primary data can be in the form of records from observations in the field related to conditions, situations, events or other data. The primary data obtained during the study was in the form of data from interviews, observations, active participation, and documentation in the form of:

- The composition of the fish caught is obtained from the landing of the fish, and the fish caught is sorted according to the type and size, the amount of production per trip.
- Record the position of the fishing area related to the placement of Fish Aggregating Devices (FAD's).
- Measuring the length of the weight of several samples of *K. pelamis* was obtained by measuring the Total length (TL) of the perhauling as one of the selectivity level assessments.
- Interviews with the captain, crew members, Port Heads and related parties.
- Documentation.

The secondary data is by making observations during the fishing operation process starting from the preparation of the operation to the unloading process at the port. Secondary data is obtained from external parties in the form of external data on matters related to practical materials and is already available. The secondary data that is used as a reference is the documents of the ship and crew, and the data of the catch of a trip.

2.2. Data Processing Methods

The data obtained, both primary and secondary data, is then processed by grouping the type and size of the fish caught as material for further data analysis related to the selectivity of fishing gear. The data was processed using Microsoft Excel to determine the composition of the type of catch, namely by comparing the results of target species and bycatch based on the weight of kg [16].

2.3. Data Analysis Methods

The data analysis included the composition of the catch, the type of fish caught and the size of the fish, the placement of the FAD's related to the fishing area, the total length of fish that have been suitable for catching and the level of selectivity of fishing gear through the scoring method [17].

2.3.1. Description Analysis

The analysis used in this study is descriptive analysis, which is analyzing data by describing it or explaining the information collected. The descriptive analysis process in the operation of the purse seine is to make direct observations of all technical activities on the ship. Starting from the preparation, operation, handling of catches, processing and dismantling catches [18]. The analysis used in this study is selectivity analysis based on the composition of the catch, analysis of the relationship between the length of the weight of *K. pelamis* and technical analysis of fishing gear selectivity.

2.3.2. Selectivity Analysis

Fishing gear selectivity can be interpreted as the ability of fishing gear to obtain certain fishing targets according to the type of fish and size during the fishing process and allows all unwanted bycatches to be escaped without injury [19]. Environmentally friendly fishing gear is fishing gear that does not damage fish habitats (aquatic ecosystems) during the process or after fishing activities are carried out.

One of the most common ways to measure the selectivity of fishing gear is to pay attention to the size of the net on the fishing gear, such as a trawl or purse seine. The larger or smaller size of the net can affect which fish can get into the net, and the extent to which non-target fish can escape.

Selectivity formula based on catch [20].

$$S = \frac{NT}{NC} \times 100\%$$

Information:

S : Selectivity of fishing gear

NC : Number of fish that can be caught

Analysis of the number of catches is a focus in the study of purse seine selectivity because this composition provides highly relevant information about the effectiveness of fishing gear in catching target species and the potential impact on bycatch.

2.3.3. Catch Diversity Index Formula

The data analysis method used to base on weighting is based on the criteria of environmentally friendly fishing gear in accordance with the Code of Conduct Responsible Fisheries (CCRF). Food and Agriculture Organization (FAO) sets a set of criteria for environmentally friendly fishing technologies [21]. The selectivity score of fishing gear is as follows:

- The tool caught more than three species of vastly different sizes score 1.
- The tool caught three species of vastly different sizes score 2.

- The tool captures less than three species of approximately the same size with a score of 3.

Formula for Gonad Maturity Level (GML) of *K. pelamis*:

$$GML = \frac{N_{MG}}{N_T} \times 100\%$$

Information:

GML : Gonad Maturity Level
 N_{MG} : Number of fish that have reached gonadal maturity
 N_T : Number of target species

Measuring the length of the fish can provide an indication of the extent to which the fishing gear is targeting adult fish that have reached reproductive size. If most of the fish caught are young, then the fishing gear may not be selective. How to measure the length of fish using Total length by the purposive sampling method with per-hauling catches. According to research [22], *K. pelamis* caught in North Maluku waters began to mature gonads at a length of 43 cm.

- Analysis of catch data. Statistical analysis of catch data can provide an idea of the composition of the species caught, the size distribution of fish, and the extent to which fishing gear can select target fish.
- Analysis using scoring method

A score of 1 indicates a low level of selectivity, a score of 2 indicates a moderate level of selectivity and a score of 3 indicates that the level of selectivity is high. The way to get a score is by adding up all the scores from each selectivity assessment factor and then looking for the average.

There are several aspects of selectivity that are the author's subcriteria, namely purse seine selectivity can be calculated using several parameters, such as using the Catch Diversity Index, the number of target species and bycatch results, and using the GML.

2.3.4. Analysis of the composition of the catch

The composition of fish catches is calculated to determine the number of fish species in a certain unit of volume. According to [23] the composition of fish catches can be calculated using the following formula:

$$P = \frac{N_1}{N} \times 100\%$$

Information:

P : The percentage of one type of fish caught.
 N_1 : Number of catches (Kg).
 N : Total catch.

In this study, the author used *K. pelamis* as a variable target species to measure the total length to determine the level of selectivity of fishing gear.

3. Results and discussion

3.1. Fishing Ground

A fishing area is a water area where a fishing gear can be operated perfectly to exploit available fish resources. Factors that affect the determination of fishing areas include weather conditions, currents, waves, wind, and the existence of fish groups. In addition, the fishing location must also ensure a sufficient distance from other vessels and have a water bottom with a depth greater than the depth of the net based on the provisions that have been given, namely FMA-RI 715 covering the waters of Maluku.

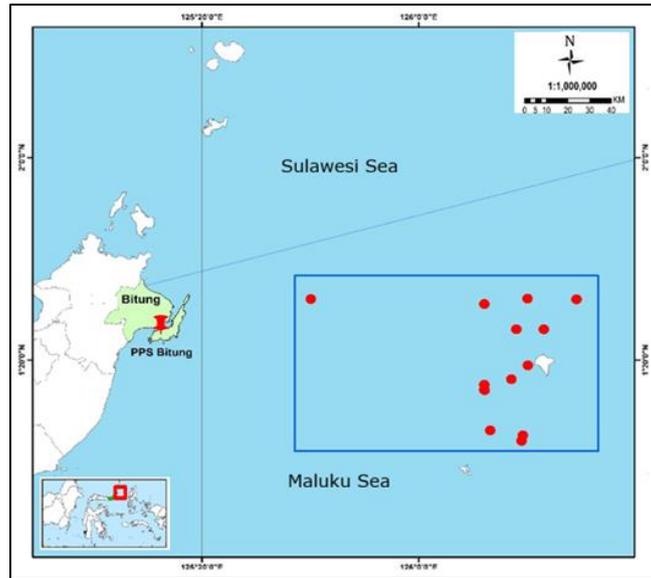


Figure 2 Map of the Fishing ground

3.2. Composition of the catch

In the implementation of the research, the data collected there were several types of fish caught such as *K. pelamis*, *D. macrosoma*, *T. albacares*, *A. thazard* and *S. crumenophthalmus*. The dominant catch caught in each setting is fish whose lives are schooling like *K. pelamis*.

Table 1 Types of Fish Caught



Katsuwonus pelamis



Thunnus albacares



Decapterus macrosoma



Auxis thazard



Selar crumenophthalmus

3.2.1. Composition of the catch in January

In January there were three trips, the dominant fish caught on the second trip were *K. pelamis*, *D. ruselli*, *T. albacares*, and *A. thazard*. The percentage of fish caught can be seen below on the table below.

Table 2 Composition of January Catch

No	Fish Type	Catch (kg)	Percentage (%)
1	<i>Katsuwonus pelamis</i>	61,486	69.2
2	<i>Thunnus albacares</i>	17,379	19.6
3	<i>Auxis thazard</i>	6,197	7.0
4	<i>Deceperus macrosoma</i>	3,729	4.2
	Total	88,791	100

3.2.2. Composition of the February catch

In February there were two trips, the dominant fish catch in the first and second trips, namely *K. pelamis*, *T. albacares*, *A. thazard*, *D. macrosoma* and *S. crumenophthalmus*. The percentage of catch can be seen below.

Table 3 February Catch Composition

No	Fish Type	Catch (kg)	Percentage (%)
1	<i>Katsuwonus pelamis</i>	22,567	55.0
2	<i>Thunnus albacares</i>	11,300	24.0
3	<i>Auxis thazard</i>	3,606	8.0
4	<i>Deceperus macrosoma</i>	5,474	12.0
	Total	46,482	100,0

3.2.3. Composition of March catches

In March there was one trip, the dominant catch caught on the sixth trip was *K. pelamis*, *D. ruselli*, *T. albacares*, and *A. thazard*. The percentage of fish catch can be seen below.

Table 4 Composition of March Catch

No	Fish Type	Catch (kg)	Percentage (%)
1	<i>Katsuwonus pelamis</i>	13,966	54.4
2	<i>Thunnus albacares</i>	2,950	11.5
3	<i>Auxis thazard</i>	838	3,3

4	<i>Deceperus macrosoma</i>	7,896	30.8
	Total	25,650	100.0

3.2.4. Composition of the catch for 3 months

During the 3-month period from January to March 6 trips were made and achieved a total catch of 160,923 kg. In January there were 3 trips with a total catch of 88,791 kg, in February there were two trips with a total catch of 46,482 kg. And in March there was 1 trip with a total yield of 25,650 kg.

Table 5 Composition of the catch over three months

No	Fish Type	Catch (kg)	Percentage (%)
1	<i>Katsuwonus pelamis</i>	101,019	62.8
2	<i>Thunnus albacares</i>	31,629	19.7
3	<i>Auxis thazard</i>	10,641	6.6
4	<i>Deceperus macrosoma</i>	17,099	10.6
5	<i>Selar crumenophthalmus</i>	535	0.3
	Total	160,923	100

From the table above, it can be seen that the most dominant type of fish caught in the total catch is *K. pelamis* as much as 63% or 101,019 kg; followed by *T. albacares* by 20% or 31,629 kg; *D. macrosoma* as much as 11% or 17,099 kg; *A. thazard* by 7% or 17,099 kg; and *S. crumenophthalmus* as much as 0% or 535 kg with the lowest percentage.

Based on the data on the catch during the three months, it is known that *K. pelamis* is a target species, the highest number of target species was obtained on the second trip in March which reached 22,000 kg, which describes a percentage of 67% of the total target species and a total bycatch of 10,689 kg with a percentage of 33%.

3.2.5. The Contribution of Purse Seine Selectivity to the Sustainability of Fish Resources

Selective fishing gear helps maintain the balance of fish populations by targeting adult fish that have reached reproductive size. This supports population regeneration and ensures that the reproductive cycle can continue. Selectivity helps reduce the risk of overfishing or overfishing. By selectively catching fish, fishermen can focus their efforts on species that have populations that can be well maintained.

Some of the contributions of purse seine selectivity to the sustainability of fish resources include:

- Protection of Young Fish
- Bycatch reduction
- Regulatory Compliance
 - The suitability of the fishing ground permit for the location of the FAD's.
 - Suitability of the size of the net to the ship's permit.
 - Suitability of the type of purse seine with the ship's documents.

In addition to the positive contribution of purse seine selectivity to the sustainability of fish resources, there are also several challenges faced in the process of implementing selectivity, including:

The main challenge in implementing fishing gear selectivity is technological imperfections. Although there have been advances in the development of more selective fishing gear, these technologies have not always been optimally effective and often still have some by-catch rates or non-target catches.

The more selective application of fishing gear often requires significant investment in technological development and change. Fishermen and the fishing industry may face high initial costs to replace or modify their equipment.

The implementation of more selective fishing gear can have a social and economic impact on the fishing community. For example, changes in certain types of fishing gear or fishing practices may require adjustments and impact fishermen's livelihoods and incomes.

Ensuring compliance with regulations that require the use of more selective fishing gear can be difficult. Without effective enforcement, fishermen may be less motivated to change their practices.

Some fishers may face market pressure to meet high consumer demand, which may not always prioritize the selectivity aspect. This can make it difficult for fishermen to opt for more selective fishing practices without sacrificing profits.

3.3. Analysis of Fishing Gear Selectivity

3.3.1. Analysis Based on Target Species and Bycatch

The nature of fishing gear that catches fish of a certain size and species is called selectivity. The composition of the catch produced varies according to the type of fishing gear used. The composition of the catch is related to the selectivity of fishing gear to catch certain species with a specified size as well [24]. The total target species for six trips from March to May, which had a catch of *K. pelamis* reached 101,019 kg with a total catch from March to May of six trips, reaching 160,923 kg with five types of fish.

According to [25] fishing gear with a high level of selectivity is fishing gear that catches less than 3 species, from the field data obtained shows that there are caught fish that number more than three species, and the percentage of target species that reaches 62.8% can be said to be a selectivity value of 2. A selectivity value of 2 means that the level of selectivity of the purse seine is moderate.

Table 6 Composition of Target species

No	Fish Type	Catch (kg)	Percentage (%)
1	<i>K. pelamis</i>	101,019	62.8
	Total	101,019	62.8

The total presentation of the target species fish, namely *K. pelamis*, was 63% or 101,019 kg of the total fish caught.

Table 7 Bycatch Composition

No	Fish Type	Catch (kg)	Percentage (%)
1	<i>T. albacares</i>	31,629	19.7
2	<i>A. thazard</i>	10,641	6.6
3	<i>D. macrosoma</i>	17,099	10.6
4	<i>S. crumenophthalmus</i>	535	0.3
	Total	59,904	37.2

The total presentation of fish from bycatch is, *T. albacares* of 19.7% or 31,629 kg; *A. thazard* by 6.6% or 10,641; *D. macrosoma* amounted to 19,099 kg and *S. crumenophthalmus* from the total fish bycatch amounted to 59,904 kg.

Based on the comparison of the percentage of target species and bycatch, fishing gear has a moderate selectivity value. The percentage of target species of 62.8% is much greater than the percentage of bycatch fish of 37.2%. The comparison can be seen in the following diagram.

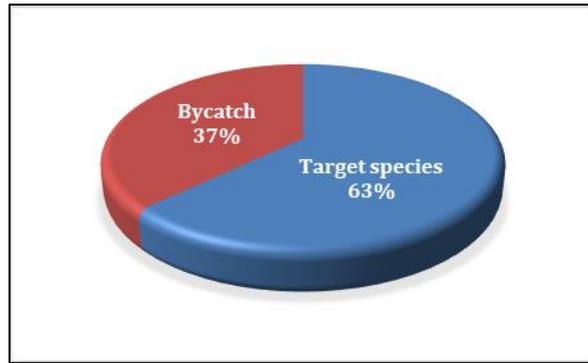


Figure 3 Target Species and Bycatch Percentage Chart.

Analysis of catch composition also helps in assessing the impact of bycatch or non-target fishing. If the catch is dominated by bycatch, then this indicates a lack of selectivity in purse seine operations. From the diagram above, the number of target species of fish dominates the overall catch, which is 62.8%. This shows that the level of purse seine selectivity is at a moderate level.

3.3.2. Analysis Based on Total Length Size of Target Species

The fish measured 165 samples. The sample taken represents the entire population randomly selected in each setting using the Total Length (TL) method. *K. pelamis* generally are 30-60 cm. The measured *K. pelamis* have the smallest class length of 30 cm and the largest 57 cm. According to research [26], *K. pelamis* caught in the waters of North Maluku began to mature gonads at a length of 43 cm. Fishing operations carried out during the study were carried out as many as six trips. Here is a table of the overall length of the weight of the *K. pelamis*.

Table 8 Length and Weight *K. pelamis*

N	Total Length (cm)	Weight (gr)	W = a.L ^b			
	Min-Max	Min-Max	a	b	r	Growth Pattern
165	30-57	300-3,320	-6.12	3,53	0.98	Positive allometrics

The relationship between the length of the weight of *K. pelamis* was obtained from the result that this fish has a long relationship of weight which is allometric positive, the value of b is 3.53 > 3 so it can be interpreted that *K. pelamis* caught has a growth pattern of weight faster than the growth of the length of the pole. Based on the above equation, the determination coefficient obtained is 0.95 showing that the length variable has a very strong influence of 98% on the weight variable with a tightness value of 0.98, while 2% is explained by other factors. For more details, see Figure 4.

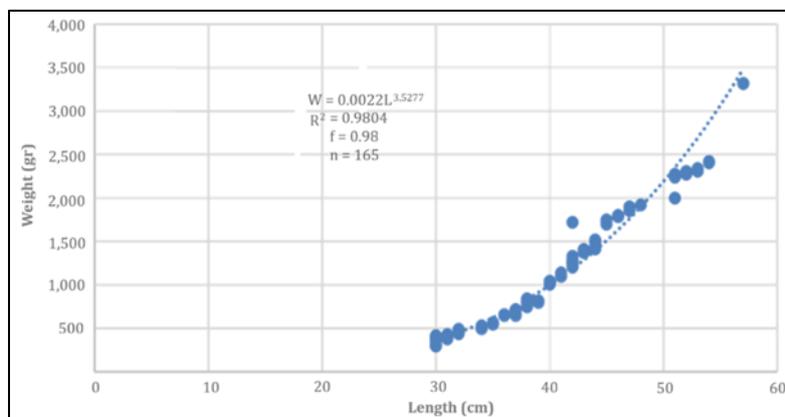


Figure 4 Length relationship of weight of *K. pelamis*

How to measure the length of *K. pelamis* can be seen in the following picture.

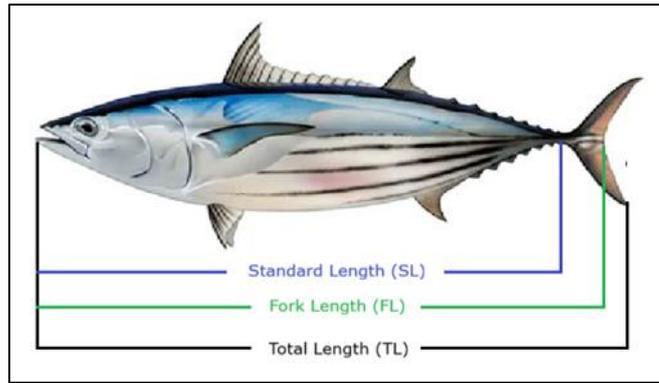


Figure 5 How to measure *K. pelamis*

The length of the *K. pelamis* class that is included in the catchable category is 43.0-60.9 cm with a total of 53 individuals, while the length of the *K. pelamis* class that is included in the non-catchable category is 30.0-42.9 cm with a total of 112 individuals. Thus, the total number of *K. pelamis* measured as many as 165 fish. Those that have been eligible to catch are 53 while those that are not eligible to catch are 112 fish.

Table 9 Interval Classes Size *K. pelamis*

Class (cm)	Number (fish)	Percentage (%)	Description
30.00-31.99	30	18.2	Not Fit to Catch
32.00-34.99	11	6.7	Not Fit to Catch
35.00-36.99	6	3.6	Not Fit to Catch
37.00-38.99	23	13.9	Not Fit to Catch
39.00-40.99	15	9.1	Not Fit to Catch
41.00-42.99	27	16.4	Not Fit to Catch
43.00-44.99	18	10.9	Worth Catch
45.00-46.99	10	6.1	Worth Catch
47.00-48.99	4	2.4	Worth Catch
51.00-52.99	15	9.1	Worth Catch
53.00-54.99	5	3.0	Worth Catch
57.00-57.99	1	0.6	Worth Catch
TOTAL	165	100.0	

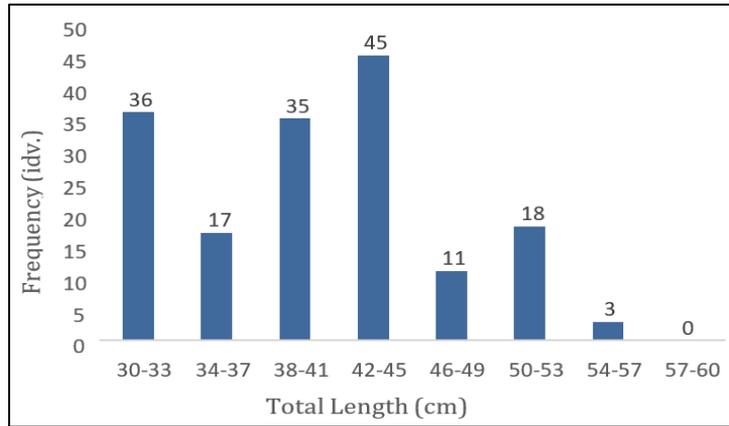


Figure 6 Distribution Graph of the Size Class of *K. Pelamis*

Furthermore, to determine the level of selectivity of purse seine, a data tabulation process can be carried out based on the interval of the *K. pelamis* size class. From the target data of the *K. pelamis* species as many as 165 fish, it is known that the fish that are suitable for catching are 53 fish or 32%, while the fish that are not suitable for fishing amount to 112 fish or 68%.

From the table, it is known that the dominant size of *K. pelamis* is the 30-31 cm and 37-38 cm classes, with a total of 30 and 27 or 18.2% and 16.4%, respectively. The least size of *K. pelamis* is class 54-57 with a total of 6 heads or 3.6%. Based on the number of fish caught that are suitable to catch, the level of Purse seine selectivity is relatively low.

Table 10 Presentation of *K. pelamis*

Criteria	Number (fish)	Percentage (%)
Worth Catching	53	32
Not Fit to catch	112	68
Total	165	100

The assessment of the selectivity level of purse seine fishing gear using three factors, namely the composition of the catch, the size of the length of the fish suitable for catch, and the bycatch result.

Fish caught in the category of fish suitable for catch are 32% and are not suitable for fishing at 68%. This is in accordance with the opinion [27] which states that the determination of the suitability of fish to be caught is closely related to the determination of the selectivity of the fishing operation, from the three factors used to assess the selectivity level of purse seine getting a score of 5 Based on this score, the purse seine is classified as a fishing gear that has a low level of selectivity.

Table 11 Selectivity Factors

Selectivity level factor Score	Indicators	Selectivity criteria	Score
Target species composition	62,8%	Medium	2
Size of fish suitable for catch	32%	Low	1
Number of fish caught	5 types	Low	1
Mesh size	1 inch	Low	1
Total score			5
Average			1

Based on table 19, it can be concluded that purse seine is a fishing gear that has a low level of selectivity because the average number of selectivity scores obtained from the assessment factor of the selectivity level of fishing gear is that Purse seine has a high selectivity value if catching approximately 3 species of fish and the result of the size of the target fish is still in the category of fish suitable for catch. In environmentally friendly fishing, bycatch results also affect the selectivity of fishing gear.

4. Conclusion

- The most dominant fish caught was *K. pelamis*, followed by *T. albacares*, *D. macrosoma*, *A. thazard*, and *S. crumenophthalmus*.
- The total number of fish caught during 6 trips amounted to 160,923 kg, of which *K. pelamis* was 62.8% or 101,019 kg, *T. albacares* was 19.7% or 31,629 kg, *D. macrosoma* was 10.6% or 17,099 kg, *A. thazard* was 10.641% or 6.6 kg and *S. crumenophthalmus* was 0.3% or 535 kg.
- Based on the analysis of target species and bycatch, it can be concluded that the purse seine has a moderate degree of selectivity. The percentage of target species of 62.8% is greater than the bycatch percentage of 37.2%. This shows that the purse seine is more selective in capturing *K. pelamis* as a target species. However, the fishing gear can still catch other fish that are not the target of the catch, namely *T. albacares*, *A. thazard*, *D. macrosoma* and *S. crumenophthalmus*.
- Based on the results of this study, it can be concluded that the level of selectivity of purse seine is relatively low with a score of 5 out of 4 assessment indicators. In the composition of the weight of the target species, moderate selectivity was obtained with a score of 2, the size of the fish suitable for catching was obtained with low selectivity with a score of 1, the bycatch result was obtained with low selectivity with a score of 1 and the net size included low selectivity.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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