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Fishing season of large pelagic fish in Idi Rayeuk waters, East Aceh, Indonesia

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ABSTRACT

Large pelagic fish live on the water surface in groups. Skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), mackerel tuna (*Euthynnus affinis*), mackerel (*Scomberomous guttatus*) are species of fishes that mainly catches by fishermen using purse seines. This study aims to determine the length and weight of large pelagic fish in the water of Idi Rayeuk and best the fishing season. This research was conducted in one month. Fish samples were collected from fishermen that used purse seine and landed their catches at the Idi Rayeuk Fishing Port, East Aceh. Additionally, the data was derived from the fishing port time-series during 2015 to 2019. The result showed that the yellowfin tuna (*Thunnus albacares*) has a length between 37 - 58 cm with a weight of 1.0 - 3.2 kg, skipjack tuna (*Katsuwonus pelamis*) 32 - 58 cm in length and weight 0.5 - 3.0 kg, mackerel tuna has 33 - 54 cm of length with a weight of 0.6 - 2.5 kg, and mackerel has 44 - 66 cm of length and weighing 0.7 - 1.7 kg. Its also found that the peak season for catching yellowfin tuna (*Thunnus albacares*) and mackerel tuna is May and June, and the lowest season in December for the yellowfin tuna, and December and January for the mackerel tuna. The peak season for skipjack fishing occurs in May, August, and October, and the low season occurs in November and December. Meanwhile, the peak season for fishing mackerel occurs in May, September, and October, while the low season occurs in January, February, and March.

Introduction

A purse seine is a type of fishing gear that is more effective for catching pelagic fish around the water surface. The purse seine is made from a long net where the length of the bottom net is equal to or longer than the top. The net construction shape varies between areas, such as the shape of a rectangle, trapezoid, and a net bag located at the middle of the net (webbing) and some located at the edge of the net. The characteristic of the purse seine lies at the bottom ring of the net (Chaliluddin *et al.*, 2018; Chaliluddin *et al.*, 2019a).

Large pelagic fish is one of the fisheries commodities with a very high economic value compared to other fish species (Nelwan *et al.*, 2015). The fishing gear often used to catch large pelagic fish is purse seine, longline, pole and line, trolling line (Zainuddin *et al.*, 2017). A purse seine is a fishing gear commonly used by small-scale to large-scale fishers/industry to catch small and large pelagic fish species (Chaliluddin *et al.*, 2019b). Catching these fishes in the right season increases productivity and implements sustainable fisheries by preventing overfishing (Agustina *et al.*, 2016).

In fisheries biology, the fish length-weight relationship is essential for fisheries resource management, for example, in determining the fishing gear selectivity to catch only the suitable size (Aprilla *et al.*, 2021; Chaliluddin *et al.*, 2021). Furthermore, Afdhila *et al.* (2019); Agista *et al.* (2019) stated that the measurement of fish length and weight aims to determine the variation in weight and a certain length of fish individually or in groups as an indication of obesity, health, productivity and physiological conditions including gonad development. Analysis of

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the length-weight relationship can also estimate the condition factor or often called the index of plumpness, which is an essential aspect of growth to compare the condition or relative health condition of a particular fish population or individual.

The study of the fishing season is essential for the fishing business, both in small and large scale/industry. Information on the fishing season can promote the efficient use of fishing gear in the water. This study aims to determine the length and weight of large pelagic fish in the waters of Idi Rayeuk and to determine the right fishing season. The scope of this research is limited to the types of yellowfin tuna (*Thunnus albacares*), skipjack tuna (*Katsuwonus pelamis*), tuna, and mackerel.

Materials and Methods

Location and time of research

This research was conducted in June 2020 at the Idi Rayeuk Fishing Port, Eastern Aceh (Figure 1).

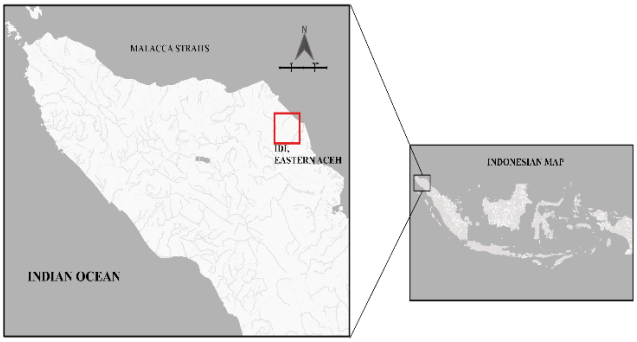

Figure 1. The study area (Idi Rayeuk Fishing Port).

Data analysis

Catch Per Unit Effort (CPUE) was analyzed to calculate the abundance of species and the level of species utilization by dividing total catch with the catch effort (Lestari *et al.*, 2016). The CPUE analysis showed the utilization level of large pelagic fish resources in Idi Rayeuk fishing port, Eastern Aceh.

The fishing season was analyzed based on the Average Percentage Method using five years (60 months) Times Series Analysis (Kekenusa *et al.*, 2016). The formulas used are (Febriani *et al.*, 2014) as follow:

The $CPUE_i$ series was arranged from January 2015 to December 2019.

a) The $CPUE_i$ value per month (2008 - 2015) was calculated using the equation below:

$$CPUE_i = \frac{Catch}{Effort}$$

Notes: *Catch* (C) = Total catch (kg); *Effort* (E) = Total effort (trip); CPUE = Catch Per Unit Effort (kg/trip)

b) Monthly average ratio (Rb)

$$Rbi = \frac{CPUE_i}{RGP_i}$$

Notes: Rbi = the average ratio of the i^{th} month; $CPUE_i$ = CPUE sequence i^{th} (i =1,2,3.....60). Make an i x j matrix for each month starting from June-July, then do the calculations:

c) The average ratio for month i^{th} (RBBi)

$$RRBi = \frac{1}{n} \Sigma RB_{ij}$$

Notes: RRBi = Average Rb_{ij} for the i^{th}-month; Rb_i = the ratio of the monthly mean in the matrix of size i x j (i = 1,2,3... 12), (j= 1,2,3.... n)

d) Total monthly average ratios (JRBB)

$$JRBB = \Sigma \text{ RBBi}$$

Notes: JRBB = the sum of the monthly average ratio; RRBi = Average RBij for i^{th}month (i=1,2,3.... 12)

e) Correction Factors (FK)

The formula to obtain the FK score is:

$$FK = \frac{1200}{JRBB}$$

Notes: FK = Value of correction factors;

f) JRBB = sum of monthly average ratio - Catching Season Index i^{th} month (IMP_i)

$$IMP_i = RRB_i \text{ x } FK$$

Notes: IMP_i = catching season index of the i^{th}-month; RBB_i = average ratio for the i^{th}-month; FK = Value of codirection factors (i = 1, 2, 3, …, 12)

g) The fishing season was determined based on the criteria of season index more than 1 (more than 100%) or above the average, while not in the season if the season index is less than 1 (less than 100%). If IM = 1 (100%), it is equal to the monthly average price; hence it is in a normal or balanced condition.

Results

The measure of large pelagic fish in Idi Rayeuk fishing port

The length-weight relationship of the large pelagic fish was calculated from 128 samples (Table 1). Based on Table 1, the proportion of skipjack tuna (*Katsuwonus pelamis*) caught was longer and heavier than other types of fish. This result is in accordance with the results of research by Zedta *et al.* (2017), which stated that, in general, tuna caught by fishers were longer than 40-60 cm.

Table 1. Length and weight of large pelagic fish in Idi Rayeuk fishing port.

Species	Length fish (cm)	Weight fish (Kg)	Total (individual)
Yellowfin tuna	35 – 43	0.7 – 1.5	12
(*Thunnus albacares*)	44 – 52	1.6 – 2.4	20
Skipjack tuna	32 – 42	0.5 – 1.5	9
(*Katsuwonus pelamis*)	43 – 54	1.6 – 2.7	23
Mackerel tuna	35 – 43	0.6 – 1.4	19
(*Euthynnus affinis*)	44 – 53	1.5 – 2.4	14

Indian Spanish Mackerel (*Scomberomous guttatus*)	47 – 54	0.7 – 1.4	11
	55 – 63	1.5 – 2.3	21

Annual catch per unit effort report for large pelagic fish in Idi Rayeuk fishing port

Large pelagic fish landed and recorded in Idi Rayeuk fishing port during 2015 - 2019 are shown in Table 2. The species of large pelagic fish recorded were yellowfin tuna (*Thunnus albacares*), skipjack tuna (*Katsuwonus pelamis*), Mackerel tuna (*Euthynnus affinis*), and Indian Spanish Mackerel (*Scomberomous guttatus*). The largest catch is skipjack tuna (*Katsuwonus pelamis*), followed by Mackerel tuna (*Euthynnus affinis*).

Table 2. The annual catch per unit effort of big pelagic fish in Idi Rayeuk fishing port.

No	Spesies	Year	Production (Kg)	Effort (Trip)	CPUE (Kg/Trip)
1.	Yellowfin tuna (*Thunnus albacares*)	2015	242,431.00	2,368.00	102.38
		2016	211,733.00	2,899.00	73.04
		2017	403,404.00	3,185.00	126.66
		2018	221,292.00	3,739.00	59.18
		2019	235,028.00	3,235.00	72.65
2.	Skipjack tuna (*Katsuwonus pelamis*)	2015	7,521,349.00	2,368.00	3,176.25
		2016	2,419,114.00	2,899.00	834.46
		2017	2,669,081.00	3,185.00	838.02
		2018	9,691,706.00	3,739.00	2,592.06
		2019	6,907,629.00	3,235.00	2,135.28
3.	Mackerel tuna (*Euthynnus affinis*)	2015	3,767,035.00	2,368.00	1,590.81
		2016	2,093,602.00	2,899.00	722.18
		2017	1,867,142.00	3,185.00	586.23
		2018	6,451,584.00	3,739.00	1,725.48
		2019	2,332,552.00	3,235.00	721.04
4.	Indian Spanish Mackerel (*Scomberomous guttatus*)	2015	2,572.00	2,368.00	1.09
		2016	4,040.00	2,899.00	1.39
		2017	2,148.00	3,185.00	0.67
		2018	3,530.00	3,739.00	0.94
		2019	2,395.00	3,235.00	0.74

Source: East Aceh Fisheries Service 2015 - 2019

Based on Table 2, the highest catch per unit effort of yellowfin tuna (*Thunnus albacares*) occurred in 2017, skipjack tuna (*Katsuwonus pelamis*) occurred in 2019, tuna occurred in 2018, and Indian Spanish Mackerel (*Scomberomous guttatus*) occurred in 2016.

Fishing season for large pelagic in the Idi Rayeuk waters

The fishing season with an average index value of 100% showed the normal fishing season, the peak season occurs if the index value of the fishing season is above 100%, and the lean season is when the index value is below 100%. Meanwhile, the fishing season index above the average value is called to be a good time to catch fish (Simanjuntak *et al.*, 2018).

The results of time series data analysis for the Idi Rayeuk fishing port on large pelagic fish explained as follows. Yellowfin tuna (Thunnus albacares) fishing season occurs in May-August with the peak fishing season in May, while the lean season occurs in December - January (Figure 2).

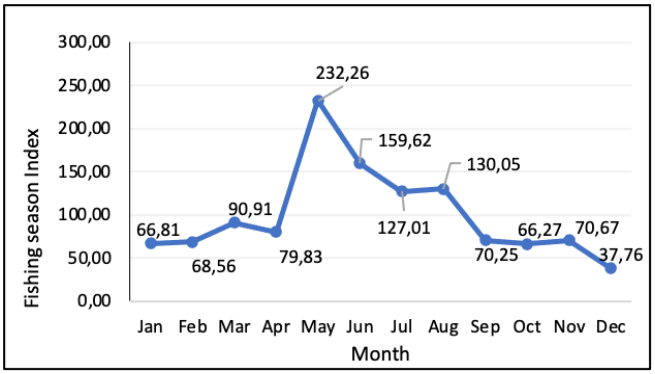

Figure 2. Yellowfin tuna (*Thunnus albacares*) fishing season in Idi Rayeuk waters.

Skipjack tuna (*Katsuwonus pelamis*) catch for five years (2015-2019) showed a fluctuating trend (Figure 3). Based on this figure, the skipjack tuna (*Katsuwonus pelamis*) fishing season occurs three times within a year, namely May, August, and October, with the peak season occurring in August, the lean season occurs in November.

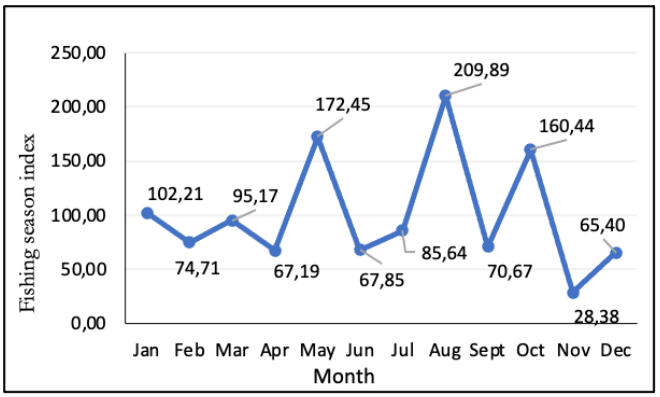

Figure 3. Skipjack tuna (*Katsuwonus pelamis*) fishing season in Idi Rayeuk waters.

Mackerel tuna (*Euthynnus affinis*) catches for five years (2015-2019) trend varied (Figure 4). Based on this figure, the tuna fishing season occurs three times a year, namely February, May, and June. The peak fishing season occurs in May, and the lean fishing season occurs in December.

The catch of Indian Spanish Mackerel (*Scomberomous guttatus*) for five years (2015-2019) has fluctuated (Figure 5). Based on this figure, the fishing season of Indian Spanish Mackerel occurs three times a year, namely in May, September, and October, with the peak season of fishing occurring in September and the lean season occurring in January, February and March.

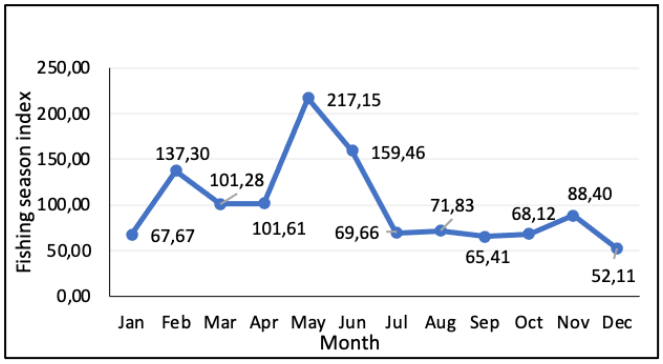

Figure 4. Mackerel tuna (*Euthynnus affinis*) fishing season in Idi Rayeuk waters.

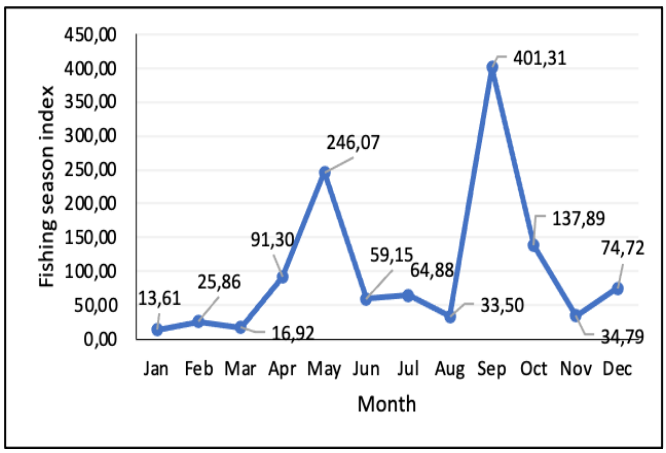

Figure 5. Indian Spanish Mackerel (*Scomberomous guttatus*) fishing season in Idi Rayeuk waters.

Discussion

The measure of large pelagic fish in Idi Rayeuk fishing port

The relationship between fish weight and length is one of the complementary information important to fisheries resource management. Yellowfin tuna (Thunnus albacares), landed at Idi Rayeuk fishing port, has a length between 37 - 58 cm with a weight of 1.0 - 3.2 kg with an average length of 45 cm. These results are in accordance with Darondo *et al.* (2020), which stated that the distribution of the fork length distribution of caught yellowfin tuna ranges from 35 - 61 cm with an average length of 46 cm.

Skipjack tuna caught was 32 - 58 cm in length and weight 0.5 - 3.0 kg. The average length of the skipjack tuna is about 45 cm. The results were similar to studies by Anggraini *et al.* (2015) and Diningrum *et al.* (2019), Kantun *et al.* (2018), that stated the distribution size of skipjack tuna caught by purse seine in the eastern part of Flores Sea has fork length ranging from 19.5 to 59.5 cm, the average individual length is 41.9 cm, and the dominant length ranges from 19.5 to 24.5 cm and 45.5-49.5 cm.

Mackerel tuna (*Euthynnus affinis*) landed in Idi Rayeuk fishing port during the study have a length of 33 - 54 cm with a weight of 0.6 - 2.5 kg. These results are in accordance with the research results of Agustina *et al.* (2018), Ekawaty *et al.* (2018), Hidayat *et al.* (2018), which state that tuna length ranged from 24 - 71 cm with an average of 51.66 cm and weight 0.21 - 7.05 kg with an average of 2.72 kg. The catch of Indian Spanish Mackerel (*Scomberomous guttatus*) landed at Idi Rayeuk fishing port has a size between 44 - 66 cm and a 0.7 - 1.7 kg weight. These results are almost the same as the study results by Kalsum *et al.* (2019), which stated that the mature Indian Spanish Mackerel (Scomberomous guttatus) with gonads and those that are caught are ≥ 42.34 cm in size.

Fishing season for large pelagic fish in the Idi Rayeuk waters

Indonesia has four periods of fishing seasons based on wind circulation, which are the western season (December-February), the first transitional season (March-May), the eastern season (June-August), and the second transitional season (September-November). In general, the fishing season in Indonesia occurs throughout the year; however, during the western season, fishing activity decreases significantly due to the water conditions that do not allow fishing. This condition is in accordance with Susanto (2015), which states that the fishing season in Indonesia occurs throughout the year and the fertility level in the waters of the Sunda Strait reaches its peak in June to September, which is indicated by the abundance of chlorophyll-a which is higher than the other month. The highest concentration of chlorophyll-a is in Lampung waters and the Malacca Strait. The waters of Idi Rayeuk are located next to the Malacca Strait, hence the similar character in terms of currents, waves, temperature, salinity, to water transparency.

For five years (2015 - 2019), the fishing season for yellowfin tuna in and landed at Idi Rayeuk waters fluctuated. This result may be because the yellowfin tuna stock did not increase significantly from year to year, while the effort increased. As a result, the catch per unit effort received by fishers decreased. A very striking catch per unit effort occurred in 2019, where the effort was extensive, while the catch obtained was not too significant compared to 2017. The highest catch was in May and can be categorized as the best fishing month compared to the catch in the other months, while the lowest fishing season occurs in December (Nurhayati *et al.*, 2018).

Tuna and skipjack are fast-swimming fish, migrate over long distances and live in groups searching for food. The distribution of skipjack tuna covers a fairly wide distribution area, including those that spread and

migrate across oceans throughout tropical and subtropical waters, namely to the Indian Ocean, Pacific Ocean, and the Strait of Malacca. Tuna and skipjack live in surface layer waters and prefer a temperature of 16-30°C and a salinity of 32 - 36 ppm. In western Indonesia, tuna and skipjack tuna occupy the Indian Ocean and Malacca Straits, along the North and East coast of Aceh, the west coast of Sumatra, South Java, Bali, and Nusa Tenggara. In eastern Indonesia, they mostly can be found in the Banda Flores Sea, Halmahera, Maluku, Sulawesi, Pacific waters in the north of Papua, and the Makassar Strait (Ahmad, 2015).

The presence of large pelagic fish in the waters is greatly influenced by the level of gonad maturity of the fish. The gonad maturity level is closely related to the spawning season and the presence of these fish in the waters. The spawning season of skipjack tuna and yellowfin tuna in the waters of Tomini Bay occurs in May. According to Widodo (1986), the spawning season occurs approximately one month after the highest percentage of fish that are mature gonads. Therefore, the skipjack and yellowfin tuna spawning season are estimated to occur in the middle of the year and towards the end.

Research regarding the spawning and fishing season of yellowfin tuna has been carried out in various waters. Itano (1995) and (Barocas *et al.*, 2021) found that the spawning and fishing season for yellowfin tuna in Hawaiian waters occurs from April to September, in Philippine waters occur from March to December (Rola *et al.*, 2018), and in the Pacific waters occur in July, August, and September (Kikawa, 1962; Macusi *et al.*, 2021). Furthermore, in the eastern Pacific waters, the spawning and fishing season occur in January-March (Joseph, 1963; Calderwood *et al.*, 2021), waters near the Hawaiian Islands, the spawning and fishing season occurs from June to December (Richard and Simmons, 1971; Duarte *et al.*, 2018; Miyamoto *et al.*, 2019), and the spawning and fishing season for yellowfin tuna in the Andaman sea takes place from November to April (John, 1995; Gabriela *et al.*, 2021; Owusu *et al.*, 2020; Yıldız *et al.*, 2020). The peak season for fish spawning and fishing in the Indian Ocean occurs in April and August (Hutapea *et al.*, 2006; Widodo and Suwarso, 2005).

The fishing season for Mackerel tuna in Idi Rayeuk waters occurs in May and June. December - January is not suitable for fishing and is included in the western season characterized by extreme weather and high sea waves that can reach 1-3 m preventing fishers from catching fish. The western season (especially in January) is also known as the famine season. The fishing season for Mackerel tuna occurs in the first transitional season to the end of the second transitional season marked by the emergence of anchovies. This phenomenon shows the existence of a food chain mechanism in the area, swarming small pelagic fish inviting the arrival of large pelagic fish. The abundance of anchovy almost coincides with the tuna fishing season, but the Mackerel tuna fishing season is relatively shorter (Syahrir, 2011).

The fishing season for Indian Spanish Mackerel occurs during the first transitional season and the eastern season. This result is in line with Masturah *et al.* (2014), which states that the distribution of Indian Spanish Mackerel fish in 2011 in the eastern season is more towards Kalimantan Island, while in the eastern season in 2012-2013 it is more towards the Island of Sumatra. Pelagic fish include predatory fish, where these fish eat smaller fish such as anchovies, the appearance of anchovy indicated as the fishing season for Indian Spanish Mackerel (Syahrir 2011). The lowest Indian Spanish Mackerel fishing season occurs in January - March (west season). This result is consistent with Lee (2010), who stated that the alleged low season for fishing Indian Spanish Mackerel in the Malacca Strait occurred in January - March (west season). In the west monsoon, the weather starts to be dominated by large waves and high wind speeds.

Conclusion

The length of the large pelagic fish landed at the Idi Rayeuk fishing port varies in length; Yellowfin tuna were ranging from 37 to 58 cm with a weight of 1.0 - 3.2 kg, skipjack tuna ranging from 32 to 58 cm, and a weight of 0.5 - 3.0 kg, mackerel tuna ranging from 33 - 54 cm weighing 0.6 - 2.5 kg and Indian Spanish Mackerel ranging from 44 to 66 cm and weighing 0.7 - 1.7 kg.

The peak fishing season for large pelagic fish landed at Idi Rayeuk fishing port was based on 2015-2019 data, yellowfin tuna in May, skipjack tuna in August, mackerel tuna in May, and Indian Spanish Mackerel in May.

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