

Size composition of tuna from purse seiner, longliner, trolling line and fishing lines in southern waters of Java, Indian Ocean, Indonesia

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Abstract. Tuna is one of the dominant catch in the Indonesia's Fisheries Management Area (FMA) 573 (Indian Ocean). Fishing gears which are widely used by fishers in these areas are purse seine, tuna longline, and fishing lines. This study aims to identify the size of tuna captured by fishing fleets using four types of tuna fishing gear (purse seiner, tuna long liner, trolling line, fishing lines) from March to September 2016 in the Indian Ocean. Generally, tuna caught by purse seiner are mostly immature and juvenile. This condition indicates the existence of fishing techniques threatening the sustainability of tuna resources. Among four types of fishing gear, lines fishing are the most appropriate fishing gear to be developed as sustainable fisheries. However, if the regulation related to legal-sized tuna (adult) are enacted, and then fishing lines will require a mini hauler to help pulling large tuna to the boat.

Key Words: tuna capture, fishing gears, mini hauler, fishing techniques, sustainable fisheries.

Introduction. Tuna commodities that are mostly caught by Indonesian fishers in FMA 573 (Indian Ocean) are yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*), albacore tuna (*Thunnus alalunga*) and southern bluefin tuna (*Thunnus maccoyii*). The production of these four types of tuna during the period of 2004 to 2011 reached 1,297,062 tonnes with the composition of *T. albacares* (69%), *T. obesus* (24%), *T. alalunga* (6%) and *T. maccoyii* (1%) (Wudji et al 2015). Indian Ocean Tuna Commission (IOTC) reports that Indonesia produces 27,500 tonnes of *T. obesus*, 9,000 tonnes of *T. alalunga* and 40,000 tonnes of *T. albacares* tuna (IOTC 2016).

Tuna fisheries in the FMA 573 area are currently facing several issues. One of them is the declining of tuna longliner fleet along with the increase of the purse seiner fleet targeting tuna which associated to Fish Aggregating Device (FADs). The number of tuna longliners which are usually operating in the Indian Ocean and unloading at Oceanic Fishing Port of Nizam Zachman (PPS Nizam Zachman) has decreased from 468 units in 2009 to 215 units by 2015, as for purse seiner fleet has increased from 194 units in 2009 to 503 units by 2015 (Anonymous 2016). The consequences of the change in this type of technology toward fishing business performance need to be known, especially with regard to productivity (production per trip) and the size composition of caught tuna.

One consequence from the increasing number of purse seiner fleets which operating around FADs is that there will be more immature or juvenile caught tuna. Menard et al (2000) reports that *T. albacares* and *T. obesus* which are captured off the coastline of South Sherbro, the Atlantic have the average fork length (FL) of 46 cm while Josse et al (2000) states that *T. obesus* and *T. albacares* which are caught in purse seiner in French Polynesia are mostly 50 cm (FL) in size. This problem is a challenge for the management of large pelagic fisheries in Indonesia. Fishing technology should be adjusted with the abundance of fish resources and business performance targets. These performance targets including the quality of the fish that will be produced; such as the

length of the fish. If tuna longliner and purse seiner technology are deemed to be unsuitable then other technologies, such as lines fishing should be considered.

This study aims to obtain information about the size composition of tuna (length and weight) caught by tuna longliner, purse seiner, trolling line and lines fishing in the Indian Ocean. This biological information is essential to determine the type of fishing equipment recommended for Indonesian fishers in the Indian Ocean to implement sustainable tuna fisheries. One of the characteristics of sustainable fisheries is that the catch is dominated by legal-sized fish (Andamari et al 2012).

Material and Method. Data collection (length-weight measurement and amount of production) was performed from March to September 2016 from 25 fishing vessels consisting of 3 units of tuna longliner, 12 units of purse seiner and 10 fishing vessels operating trolling line and lines fishing in the Indian Ocean, south of Java island (Figure 1). This data collection was conducted by a trained observer team, as part of the activities of the observer program of the Ministry of Marine Affairs of Indonesia in 2016. The ships were not chosen randomly, which was previously interviewed to know the location of fishing area.

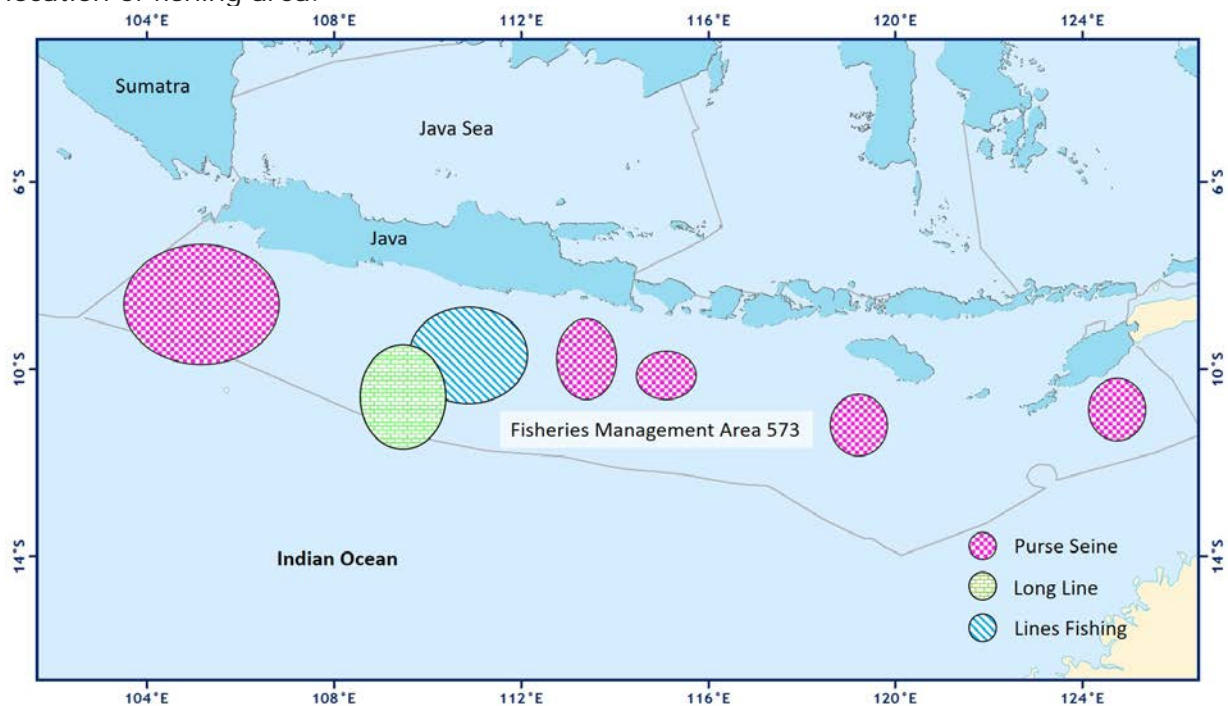


Figure 1. Fishing area for purse seiner, tuna longliner, and fishing lines.

The purse seiners used in this study are made of wood material with the size ranged from 70-171 gross tonnage (GT). The total length of purse seiner is ranged from 200 to 1,200 meters with a height ranging from 40 to 400 meters. The gear is made of nets with mesh of 4-5 cm on the body and cod end with mesh of 2-3 cm. The gear is operated in the morning, around 04.00 AM - 08.00 AM to capture the hordes of fish around the FADs.

Tuna longliner used in this study is based in the port of Benoa, Bali. Two units of tuna longline have a size of 29 GT, equipped with 1,260 and 1,500 units of branch lines, while the other tuna longliner has a size of 56 GT, equipped with 1,000 units of branch lines. Tuna longline is set by being swept away on the waters for 2 hours. The length of one trip of tuna longliner ranges from 30 to 60 days.

Lines fishing vessel used in this study (10 units) are based in Sendangbiru, Malang. Each fishing vessel operates a troll line, kite line and "tombo" fishing line (dropline). Troll line is operated by towing the lines on a moving ship so that the fishing line will be near the surface of the water. The kite line fishing is operated using a kite instead of a fishing rod to catch the tuna that is close to the water level. The tombo fishing line is operated by drowning the line vertically to catch the tuna in a more distant

water column, away from the water surface; this fishing rod is made of iron with diameter of 4 mm, with a length of 6 cm and a width of 2.5 cm. All of these fishing gears are operated around FADs every day (morning and afternoon) in one trip. The length of one trip is ranged from 10 to 15 days with effective time for fishing of 5-13 days.

Data related to fish size from purse seiner were collected from catch samples, as for longline and lines fishing, data were collected from all catches. Generally, fishes that are caught in tuna longline and lines fishing are weighing of 5-85 kg per individual. The data is very difficult to obtain from weighing on ships, especially when the ocean is wavy. The size for these large fishes is obtained from estimation based on length-weight relationship curves ($W = aL^b$) equation (Effendie 2002).

Informations related to length at first maturity (L_m) of *T. albacares* tuna, *T. obesus* and *T. alalunga* from other research i.e. Zhu et al (2008), Itano (2000), Nootmorn (2004) and Chen et al (2010), were used to determine the reproductive status of tuna captured by fishing fleet in this research (Table 1). A tuna is considered to be an adult if the length of its FL $\geq L_m$ adopted in this research (Table 1).

Table 1

The value of length at first maturity (L_m) of three species of tuna caught in the Indian Ocean

Species	L_m (cm, FL)	Sexes	Source	The value used in the study
<i>T. albacares</i>	102		Zudaire et al (2013)	110
	114	Male	Zhu et al (2008)	
	98.13		Itano (2000)	
<i>T. obesus</i>	88.08	Female	Nootmorn (2004)	90
	86.65	Male	Nootmorn (2004)	
<i>T. alalunga</i>	78	Male	Chen et al (2010)	80
	83	Female	Chen et al (2010)	

Results and Discussion

Length-weight relationship of tuna. Data of weight only measured from the catch of purse seine, the weighing measurement of tuna on tuna longline and lines fishing were highly difficult to perform due to the large size of the catch, narrow workspace on fishing vessel and wave conditions. Therefore, length-weight relationship approach of tuna catch from purse seine was used to obtain the average weight of tuna from longline and lines fishing (Table 2).

Table 2

Coefficients a and b for length-weight relationship of 3 species of tuna from the southern waters of Java island (Indian Ocean) to calculate the estimated weight of tuna caught by longlines and lines fishing during the research

Species	a	b	n	R^2	Source
<i>T. albacares</i>	0.00001	3.0164	444	0.955	The catch of a purse seine
<i>T. obsesus</i>	0.00002	2.96062	504	0.939	The catch of a purse seine
<i>T. alalunga</i>	0.000003	3.42	386	0.859	Triharyuni et al (2012)

The chart showing the relationship between the length and weight for the *T. albacares*, *T. obesus* and the *T. alalunga* are presented in Figure 2, each chart is provided with the length at first maturity indicator (vertical line). Tuna with FL > L_m (vertical line) is categorized as adult fish, otherwise if FL < L_m then the fish is categorized as juvenile or immature fish.

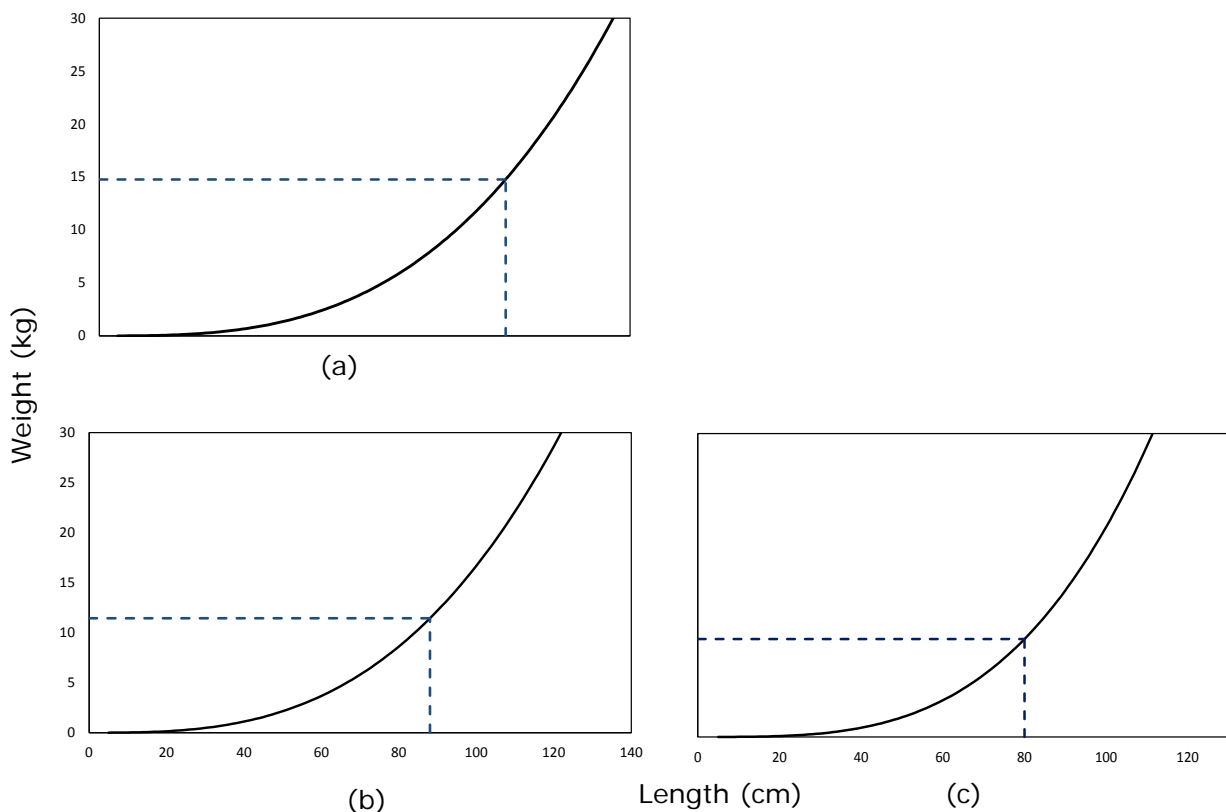


Figure 2. Length-weight relationship patterns of 3 species of tuna caught in the Indian Ocean.

Based on the length-weight relationship in Table 1, the total estimated of tuna production from purse seiner, tuna long liner and lines fishing vessel (operating lines and trolling line) for 6 months are 996 tonnes, 29 tonnes and 8.89 tonnes respectively. The average production per trip of purse seiner, tuna longliners and lines fishing vessel are 83 tonnes, 9.7 tonnes and 0.9 tonnes respectively (Table 3).

Table 3

Short description of the fishing fleet activities (12 purse seiner, 3 tuna longliner and 10 fishing lines vessel that became the object of research from March-September 2016)

No	Subject	Types of fishing unit		
		Purse seine	Tuna longline	Fishing lines
1	Fishing base	Nizam Zachman Oceanic Fishing Port, Jakarta	Benoa Port, Bali	Sendang biru Fishing Port, Malang
2	Fishing ground – Indian ocean	Off the southern coast of Java, Bali, NTB, NTT	Off the southern coast of Central Java / Yogyakarta	Off the south coast of East Java - western part
3	Number of trips	12	3	10
4	Work days (days)	433	102	147
5	Number of setting	407	77	97
6	Total production (kg)	995,534	29,149	8,892
7	Average per trip (kg)	82,961	9,716	889

The composition of the length and weight of the captured tuna. The catch of purse seiner is dominated by immature and juvenile fish, both *T. albacares* and *T. obesus* (Figure 3A, Figure 3B and Table 4). The number of adult fish of both tuna (*T. albacares* and *T. obesus*) from this fishing boat is less than 10%. While in contrast, the catch of tuna longliner is dominated by adult *T. albacares* and *T. obesus* (>85%) (Figure 3C, Figure 3D and Table 4). The composition of juvenile and adult *T. alalunga* caught in tuna longline are 49.54%:50.46% (Table 4), respectively. In lines fishing, on one hand, the portion of adult *T. albacares* tuna caught in this gear is 40,8% while on the other hand, the portion of adult *T. alalunga* caught in this gear is 100% (Figure 3F, Figure 3G and Table 4). On the other hand, no adult *T. albacares* is caught on trolling line (Table 4).

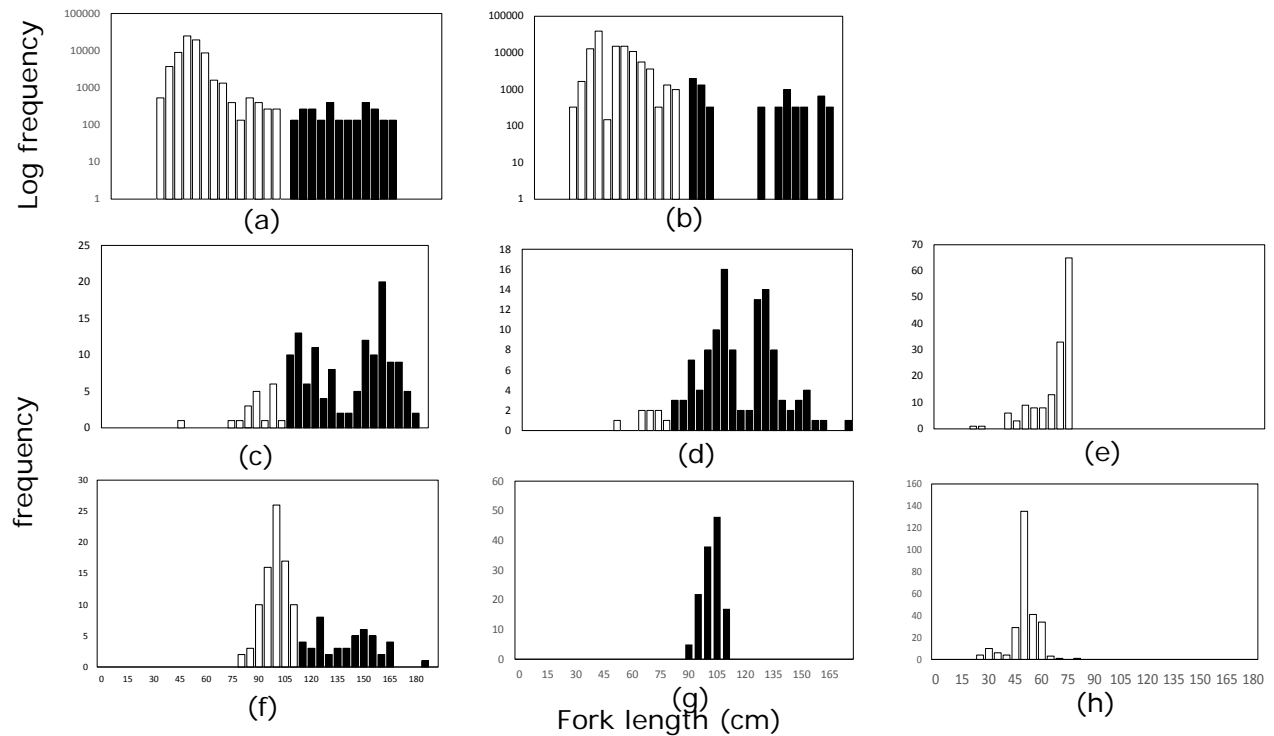


Figure 3. Length composition of *T. albacares*, *T. obesus* and *T. alalunga* caught by 12 purse seiner, 3 tuna longliners, 10 fishing vessels which simultaneously operating lines fishing and trolling line in the period of March - September 2016 at WPP573-Indian Ocean. Description: white bar: juvenile and immature fish; black bar: adult fish.

Table 4
The number (individual) and percentage (%) of adult fish caught by purse seiner, tuna longliner, trolling line and lines fishing in the Indian Ocean in the period of March - September 2016

Type of fishing unit	<i>T. albacares</i>			<i>T. obesus</i>			<i>T. alalunga</i>		
	FL <110 cm	FL ≥110 cm	Adult fish (%)	FL <90 cm	FL ≥90 cm	Adult fish (%)	FL <80 cm	FL ≥80 cm	Adult fish (%)
Purse seine	24.186	2.004	7.6	36.416	15.17	4.0	-	-	-
Tuna longline	19	128	87.1	9	122	93.1	217	221	50.46
Fishing lines	77	53	40.8	-	-	-	0	145	100.0
Trolling line	268	0	0	-	-	-	-	-	-

The low number of adult tuna in purse seine and trolling line is caused by the fishing ground which located in the water layer near the surface (Menard et al 2000; Josse et al

2000). Naturally, juvenile fish are aggregating in the upper layer while the adult fish are in the lower layer. While on tuna longliner, the lines are placed at depths of more than 100 meters, resulting to the high number of adult tuna caught on this fishing gear (Nugraha & Triharyuni 2009; Barata et al 2011; Bahtiar et al 2014). The size composition of tuna is determined by the suitability of the zone of action position (in this case is the depth of the fishing line) and the swimming layer position of the targeted fish.

The fishers who operate lines fishing have flexibility to determine the size of the hook used and fishing ground. They can change methods and set the fishing depth a lot easier and faster compared to those who use purse seine and tuna longline. This is one of the advantages of lines fishing compared to other fishing gears (Nugraha et al 2010).

The weight of allowable/legal-sized tuna is different among the three species of tuna. Adult *T. albacares* is categorized allowable to catch (legal-sized) if minimum weigh is >15 kg. The allowable catch/legal-sized for *T. obesus* weighing of 10.6 kg for males and 11.5 kg for females. As for *T. alalunga*, the allowable size to catch is 9 kg for male and 11 kg for female specimens. From Figure 4A and 4B, it can be concluded that the catch of purse seiner is dominated by juvenile and immature tuna. While in contrast, the catch of tuna using lines fishing is dominated by adult fish (Figure 4C and 4G).

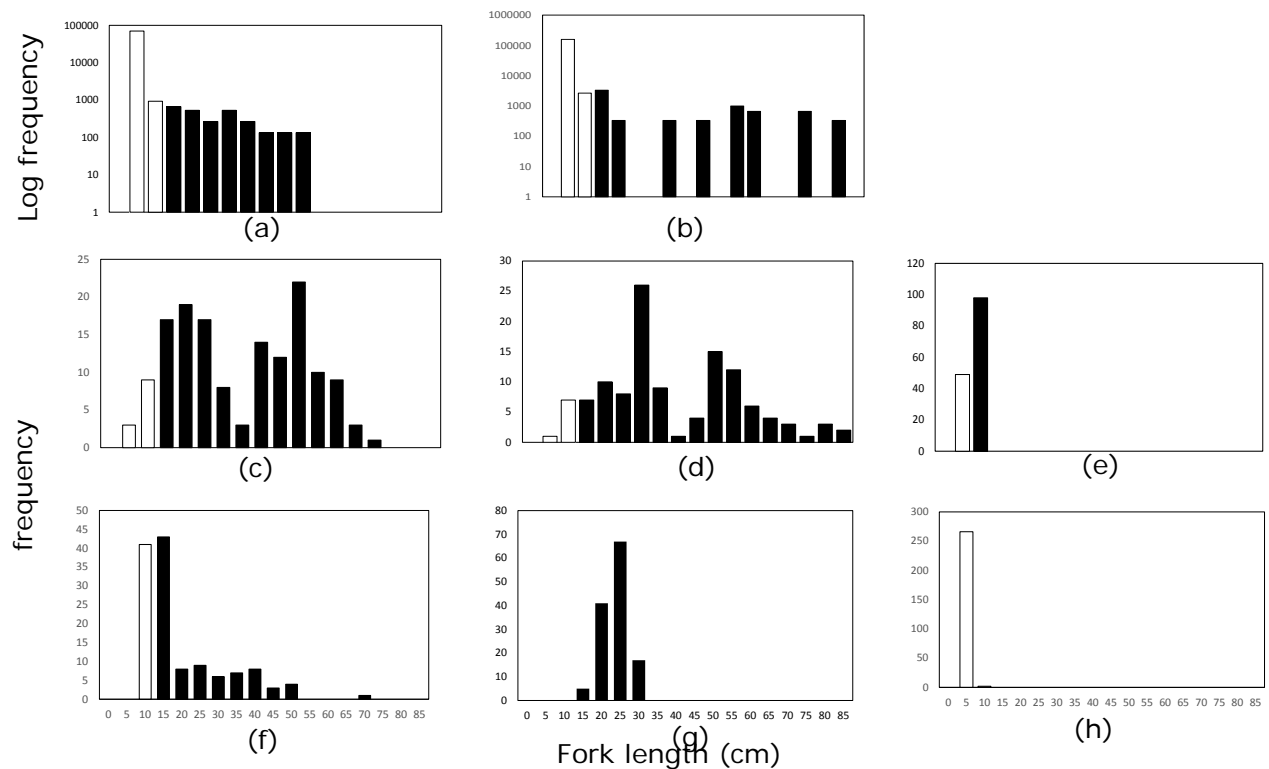


Figure 4. Weight composition of *T. albacares*, *T. obesus* and *T. alalunga* caught by 12 purse seiner, 3 tuna longliners, 10 fishing vessel which simultaneously operating lines fishing and trolling line in March-September 2016 at WPP573-Indian Ocean. Description: white bar: juvenile fish; black bar: adult fish.

Issues concerning the size of catch seem to be of great importance if regulations related to legal-sized fish were to be applied on tuna fisheries, following the regulations on crab fisheries and lobsters (Ihsan et al 2015). The fishers should try to minimize the chances of catching juvenile and immature fish. This effort can be done by adjusting the depth of the fishing line and by using a certain size of hook. These efforts are meant to realize the selective fishing. Technically, these two things are fairly easy to do, but economic and customary considerations may be an obstacle.

The size of each tuna is an important matter for lines fishers, not only in terms of business profits but also in terms of technical aspects of safety in fishing process. Should the regulation of legal-sized tuna being enacted, lines fishing vessel are expected to

increase. In order to maintain the safety on fishing operation, fishing vessel needs to be equipped with certain fishing tools to handle tuna with the weight of ≥ 20 kg. One tool that may be used is a line hauler called a mini hauler. Mini hauler, as fishing tool, needs to be designed according to the behavior and weight of the fish and the design of fishing vessel on which it will be installed. The bigger the fish the more power it produce when struggling or swimming at burst speed (Bainbridge 1958). The placement of this tool should be adjusted to the stability and the load distribution of the vessel, including the fishers (Susanto et al 2010).

Conclusions. Tuna caught by purse seiner was dominated by juvenile and immature, meanwhile in longline and lines are dominated by adult tuna/legal-sized tuna. Tuna longline and lines fishing might become alternatives to replace purse seiner and trolling line fishing in order to implement the minimum-size regulation referring to length at first maturity. Line fishing has advantages compare other fishing gears, because its flexibility using different methods depend on target and condition.

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