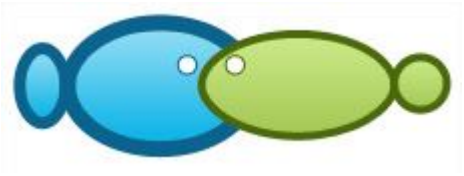

Growth pattern and size structure of skipjack tuna caught in Banda Sea, Indonesia

[1]Muslim Tadjuddah, [1]La Anadi, [1]Ahmad Mustafa, [1]Hasnia Arami, [1]Abdullah, [1]Syamsul Kamri, [2]Nur I. Wianti

[1] Department of Fisheries Capture, Fisheries and Marine Sciences Faculty, Halu Oleo University, Kendari, Southeast Sulawesi Province, Indonesia; [2] Department of Extension of Agriculture, Agriculture Faculty, Halu Oleo University, Jalan H.E.A. Mokodompit No. 1, Kendari, Southeast Sulawesi Province, Indonesia.
Corresponding author: M. Tadjuddah, muslim22jan@gmail.com

Abstract. Fisheries potential in Indonesia's seas regional consists of big pelagic fish potential. One of them is skipjack tuna (*Katsuwonus pelamis*). There are a lot of skipjack tuna fishes in Banda Sea where is located in Regional Fisheries Management (RFM) 714. This region is a skipjack tuna catching area with high utilization status. This research aimed to measure (1) How is the size structure of the skipjack tuna caught every season, and (2) How are the growth parameters of skipjack tuna which landed in Kendari Ocean Fishing Port (KOFP). The analysis used in this research is to measure fork length by using a 0.5 cm accuracy meter of all the skipjacks size which were caught by fishermen. Even they consisted of small, medium and big size. The growth coefficient (K) and length infinity (L∞) were based on Ford Method, while the growth parameters were analyzed by using growth model of Von Bartalanfy. The result can be concluded that the length size structure of skipjack tuna: (1) in west season were dominated by 36.54-37.01 cm size, (2) in west-east season were dominated by 36.89-37.71 cm size, (3) in east season were dominated by 40.96-42.13 cm, (4) in east-west season were dominated by 40.20-51.30 cm size. The growth coefficient (K) of caught with L∞ = 70.1 cm and K = 0260, would reach the value of L∞ at their age of 45.5 months or 3.7 years.
Key Words: West Banda Sea, skipjack tuna, marine resource management, growth model.

Introduction. The Indonesia sea area has the potential of plentiful fish resources. This fisheries potential consists of small and large pelagic fish and demersal fish which are scattered in almost all of Indonesia sea, either in territorial regional sea, archipelago Nusantara sea, and Exclusive Economic Zone (EEZ). One of these areas with potential for large biomass of skipjack tuna (*Katsuwonus pelamis*) is in the Banda Sea located in Regional Fisheries Management (RFM) 714, a skipjack tuna fishing ground with high utilization status. Skipjack tuna fish is an epipelagic fish that inhabits the upper layers of the ocean, spread into the water column above the thermocline, particularly below 100 m of the water column, rarely penetrating the thermocline layer (Sumadiharga 2009). The skipjack tuna is one of the highly migratory species spread in tropical and subtropical seas of the Indian Ocean up to the Pacific Ocean (Brill et al 1999). Presently the problems of the skipjack tuna fishery include (1) high exploitation especially in east season every year, (2) the length size structure of skipjack tuna become smaller each year, and (3) it is more difficult to predict skipjack tuna catchment area due to local climate change on the marine waters. The trend of skipjack tuna production in the research location continues to increase significantly. If no management effort is enforced, it may lead to overfishing in the future. According to Froese (2004), there are three overfishing indicators namely 1) the percentage of the adult fishes that are caught, 2) the percentage of optimum length of fishes that are caught, 3) the percentage of "mega-spawner" that are caught, thus information on the size structure of the tuna fishery is very important.

Information on biological aspects of skipjack tuna is indispensable for framework on resource management of the species in the study area. The aspects of biology

examined in this study consist of the largest and smallest skipjack tuna caught during the year and its growth parameter. The research was carried out in order to provide information on the size characteristics of skipjack tuna caught every season in Banda Sea. Based on the description above, the issues to be examined in this study include: (1) the size structure of the skipjack tuna caught every season and landed in Kendari Ocean Fishing Port (KOFP), and (2) their growth parameters. The result of this research can be useful in the management of skipjack tuna in the study area and adds to the knowledge of the skipjack tuna characteristics.

Material and Method. This research was conducted in and around the Banda Sea in Indonesia in RFM 714 area. Fisheries data for this research was compiled from skipjack tuna caught using purse seine, and pole and line, and landed in KOFP in 2013. The data represent aspects of biology of the species obtained through proportionate sampling from observation and enumeration at fish landing sites. Biological data obtained include: fish length or fork length were measured to the nearest 0.5 cm accuracy according to Sparre et al (1989) for all catches whether small, medium or large fish. Catch per unit effort was quantified as number of catches (fish) per unit of fleet catcher per trip, represented as monthly for a year. Ford-Walford method estimated growth parameters such as growth coefficient (K) and length-at-infinity, L∞ (Sparre & Venema 1992). Thereafter, the regression of fish length-at-age *t* (L_t) and fish length-at-age *t+1* (L_{t+1}), estimated growth parameters; where K = -Ln.b and L∞ = a/(1-b). Furthermore, Pauly & Navaluna's (1983) empirical formula estimated the t_0 which is the theoretical life of fish at age zero, as follows:

$$Log\ (-t_0) = -0.3922 - 0.2752\ log\ L_\infty - 1.038\ log\ K$$

The known values of K, L∞ and t_0, determined the Von Bartalanfy growth model of skipjack tuna as follows:

$$L_t = L_\infty\ (1 - e^{-K\ (t-to)})$$

Where: Lt = fish length at age, *t*;
L_∞ = length-at-infinity;
K = growth coefficient;
t = time;
t_0 = age at which the fish length equal zero.

Results

The size structure of skipjack tuna caught in west season (which dominated in rainy season). The length structure of the skipjack tuna landed in KOFP in west season showed that the largest fish size observed was in December (66.82-71.00 cm fork length - FL) with a total catch of 14 fishes and the smallest in January (25.00-25.40 cm FL) with a total catch of 2 fishes. The catches were dominated by the size class 36.54-37.01 cm FL with a total catch of 822 tunas, as shown in Figure 1.

The size structure of skipjack tuna caught in west-east season. The largest skipjack tuna observed in west-east season was 53.21-56.00 cm FL in March with a total catch of 50 fishes and the smallest was in April, with a size of 29-29.43 cm FL (1 individual fish). Fishes of 36.89-37.71 cm FL (776 fishes) dominated the catch (Figure 2).

The size structure of skipjack tuna caught in east season (which dominated the dry season). The catch composition of skipjack tuna caught in east season and landed in KOFP showed that the biggest fish was found in August with a size of 67.24-71 cm FL (6 fishes); the smallest fish was also found in August with a size of 34-35.17 cm FL (4 fishes). In July there was no data regarding the catches of skipjack tuna. The fishes of 40.96-42.13 cm FL (totaling 636 fishes) dominated the catch (Figure 3).

The size structure of skipjack tuna caught in east-west season. The catch composition of skipjack tuna caught in the east-west season showed that the biggest fish size was obtained in November with a size of 68.95-71.00 cm FL with a total number of

13 fishes. The smallest fish was also found in November with a size of 34.00-35.15 cm FL (4 fishes). Fish of 40.20-51.30 cm FL (475 fishes) dominated the catch (Figure 4).

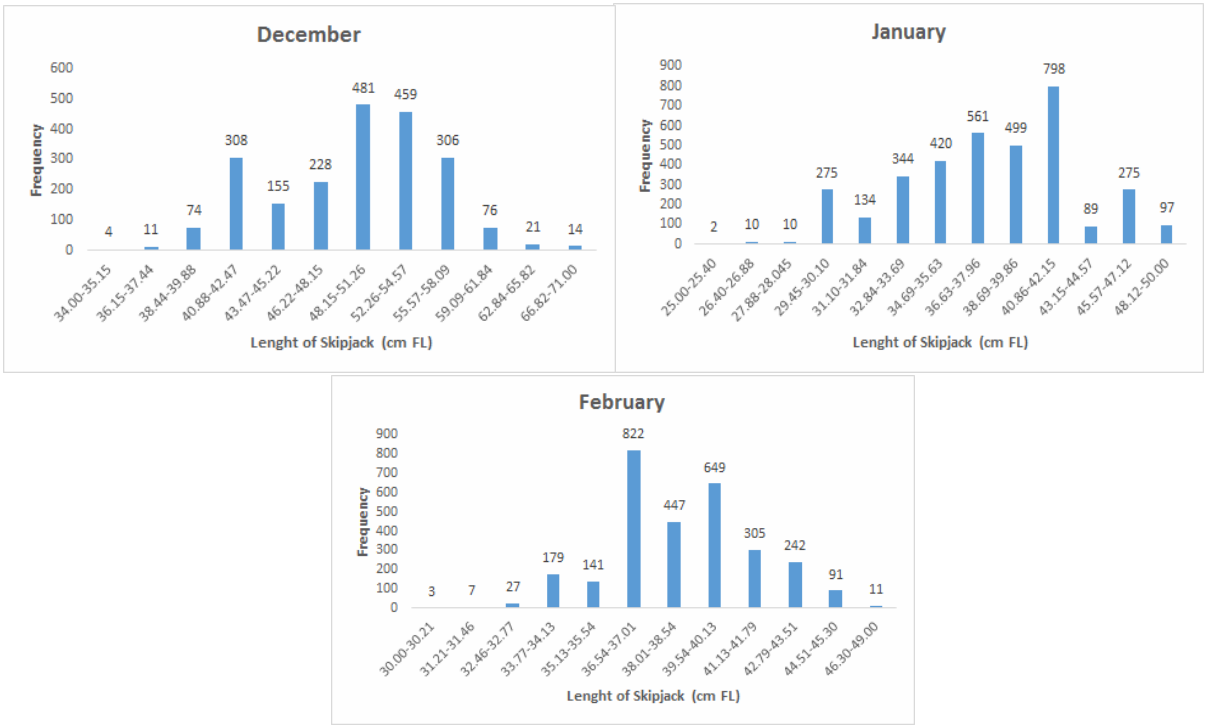

Figure 1. Size structure of skipjack tuna caught around the Banda Sea, Indonesia, in the west season (December to February).

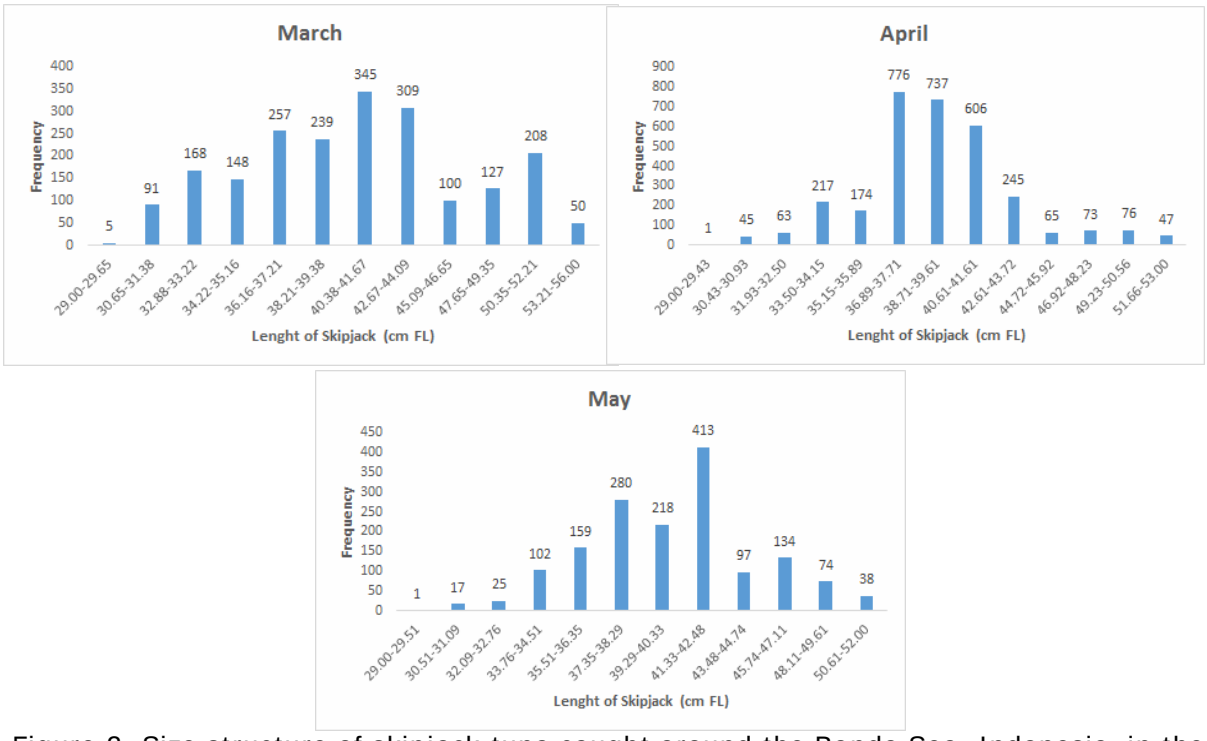

Figure 2. Size structure of skipjack tuna caught around the Banda Sea, Indonesia, in the west-east season (March to May)

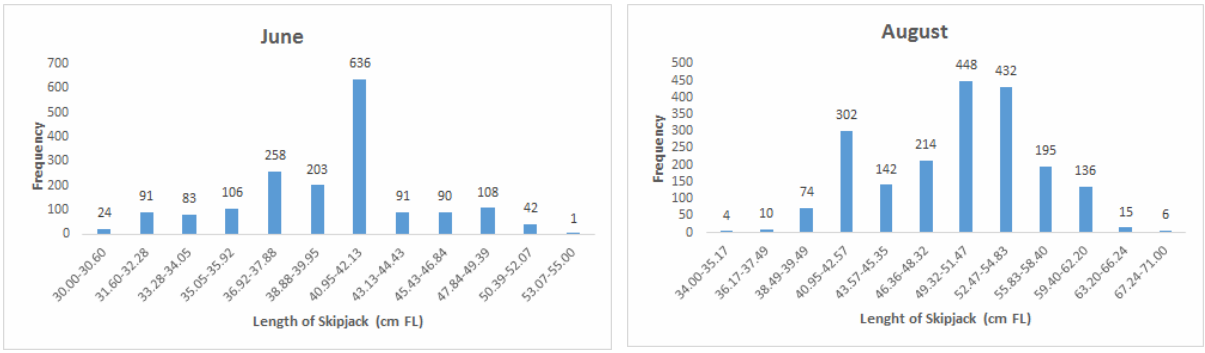

Figure 3. Size structure of skipjack tuna caught around the Banda Sea, Indonesia, in the east season (June and August).

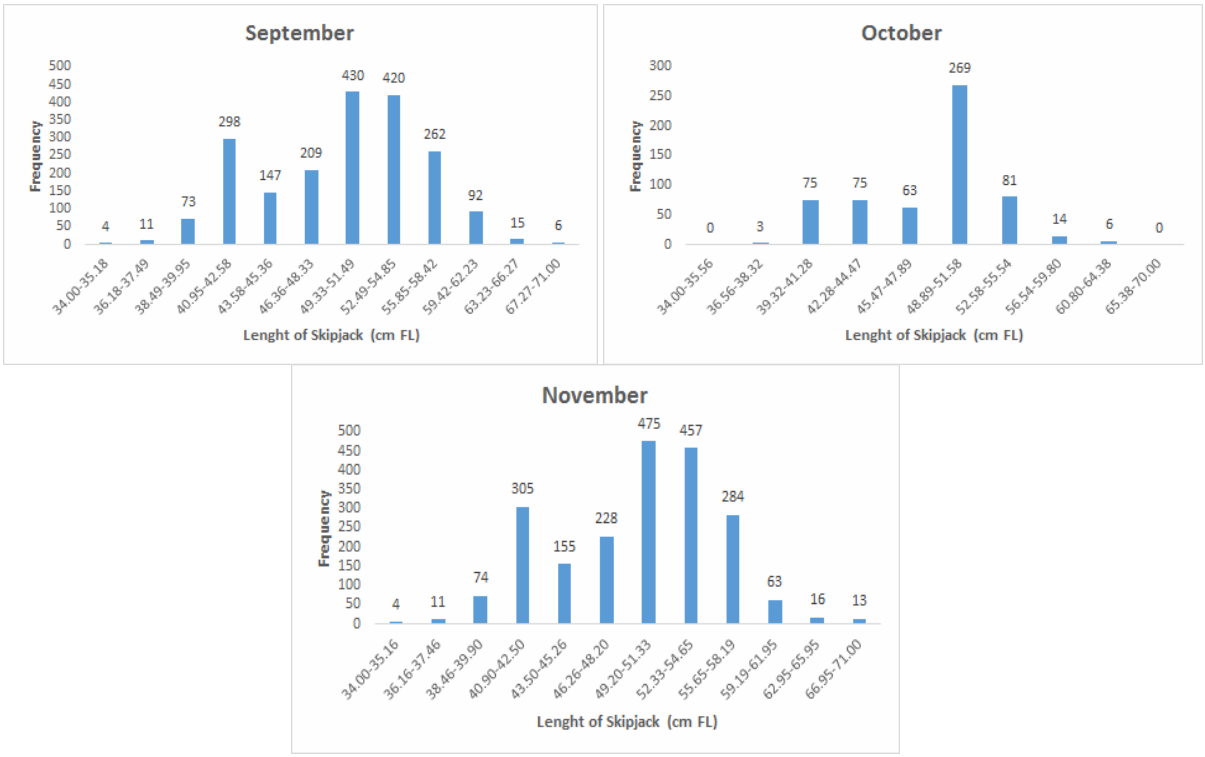

Figure 4. Size structure of skipjack tuna caught around the Banda Sea, Indonesia, in the west-east season (September to November)

Growth parameters. The results on the analysis of growth parameters using Walford Plot estimated lenght-at-infinity (L∞) of 70.1 cm, growth coefficient (K) of 0.260 while t0 was 0.4915 for skipjack tuna caught in the Banda Sea Indonesia (Table 1). Consequently the Von Bartalanfy growth model of the skipjack tuna (Figure 5) could be expressed as follows:

$$Lt = 70.1[1\text{-}e^{-0.260 + 0.4915}]$$

Table 1

Growth parameters of skipjack tuna caught in the Banda Sea, Indonesia

Species	*Growth parameter*		
	L ∞	*K (month)*	t_o
Skipjack tuna (present study)	70.1	0.260	0.4915
Skipjack tuna (Jamal 2011)	75.9	0.19	0.36
Skipjack tuna (Wailenury 2014)	97.6	0.41	0.29

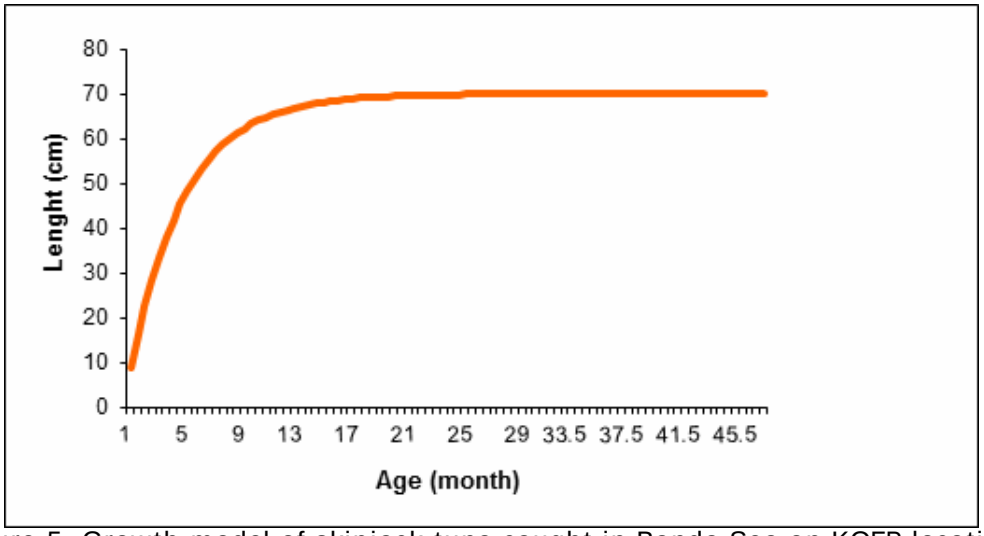

Figure 5. Growth model of skipjack tuna caught in Banda Sea on KOFP location.

The growth chart (Figure 5) shows that the growth of skipjack tuna will be closer to L∞ at the age of 17 months or 1.4 years and will reach L∞ at the age of 45.5 months or 3.7 years.

Discussion

Size structure of skipjack tuna. The size distribution and range of sizes (from largest to smallest) of skipjack tuna encountered in this study have been reported for east-west transitional, east, west-east transitional and west seasons. Differences in the size structure of the skipjack tuna samples indicate that the dominant larger-sized fishes came to the surface marine waters in east-west transitional season and east season. This could be attributed to higher concentration of plankton on the marine surface water than layers below in Banda Sea in east-west transitional season and east season. Therefore the surface layer became more fertile. Thus the fishes migrated to the marine surface, approached the beach and were easy to catch by fishermen. On the other hand, Jamal et al (2011) and Kekenusa (2006) reason that fishing activity for skipjack tuna in west season was not good because of pollution and decreased salinity of marine waters from rainwater in that season.

Susaniati et al (2014) report that skipjack tuna in the marine waters around the Flores Sea, have fork length ranging from 18 to 73 cm, the dominant length group being 23-28 cm in the west to east transitional season (March-April). In the east monsoon (May to August), the fork length ranges from 13 to 73 cm, the dominant length being 23-28 cm. In the east to west transitional seasons (September-October), the fork length ranges from 13 to 63 cm, the dominant length being 23-28 cm. Then in the west season (November-February), the fork length range from 13 to 38 cm, the dominant length being 18-23 cm. Meanwhile, Syamsuddin et al (2008), found the size composition of skipjack tunas caught using pole and line in Kupang marine waters to be from 29 cm to 58.9 cm fork length; with fish of 47 to 49.9 cm (17.90%) having the highest occurrence. It was followed by fishes of 44 to 46.9 cm (16.64%), and 38 to 40.9 cm (16.36%). By comparison, the dominant size of skipjack tuna caught in this research location was better than 70.1 cm fork length reported in other studies. This result indicated that the fork length size was still within the size range.

Growth parameter. The growth curve (Figure 5) shows the relationship of growth patterns and maximum age of the fish populations in some marine waters. The result of this research showed that the growth coefficient (K) of skipjack tuna caught in the Banda Sea have a length-at-infinity (L∞) of 70.1 cm and growth coefficient (K) of 0.260; attaining L∞ at the age of 45.5 months, or 3.7 years. This information indicates that tuna do not grow fast in length when it reaches the maximum age. The L∞ and K values of

skipjack tuna obtained in this study are lower than the values obtained from other researches in different marine sites.

Jamal et al (2011) showed that skipjack tuna caught in the marine waters of the Bone Gulf have L∞ of 75.97 cm at age 84 months, meanwhile those caught around West Sumatra have L∞ of 87.8 cm at age 120 months. On the other hand, Waileruny et al (2014) stated that the skipjack tuna caught in the Banda Sea, around Ambon City and Center Maluku revealed L∞ of 97.6 cm and growth coefficient rate (K) of 0.41 per year at the age 84 months. Based on these results, it could be deduced that skipjack exhibit spatial and temporal variations in growth rate. In explaining this phenomena, Merta (1992) stated that the differences in growth parameters (L∞ and K) of the same fish species from different locations could be attributed to respective environmental factors such as the availability of food, water temperature, dissolved oxygen, fish size and gonado maturity, in different marine waters.

Conclusions. Based on the length size structure, skipjack tuna landed in KOFP were dominated by fish of 36.54-37.01 cm fork length in west season, 36.89-37.71 cm fork length in west-east season, 40.96-42.13 cm fork length in east season, and 40.20-51.30 cm fork length in east-west season. The growth coefficient (K) and length-at-infinity (L∞) of skipjack tuna caught were 0.260 and 70.1 cm, respectively; with tendency to reach L∞ at the age of 45.5 months or 3.7 years.

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Authors:
Muslim Tadjuddah, Department of Fisheries Capture, Fisheries and Marine Sciences Faculty, Halu Oleo University, Jalan H.E.A. Mokodompit No. 1, Kendari, Southeast Sulawesi Province, Indonesia, e-mail: muslim22jan@gmail.com
La Anadi, Department of Fisheries Capture, Fisheries and Marine Sciences Faculty, Halu Oleo University, Jalan H.E.A. Mokodompit No. 1, Kendari, Southeast Sulawesi Province, Indonesia, e-mail: andreas.kdri@gmail.com
Ahmad Mustafa, Department of Fisheries Capture, Fisheries and Marine Sciences Faculty, Halu Oleo University, Jalan H.E.A. Mokodompit No. 1, Kendari, Southeast Sulawesi Province, Indonesia, e-mail: astafa_611@yahoo.com
Hasnia Arami, Department of Fisheries Capture, Fisheries and Marine Sciences Faculty, Halu Oleo University, Jalan H.E.A. Mokodompit No. 1, Kendari, Southeast Sulawesi Province, Indonesia, e-mail: arami79-firazufpsd@yahoo.co.id
Abdullah, Department of Fisheries Capture, Fisheries and Marine Sciences Faculty, Halu Oleo University, Jalan H.E.A. Mokodompit No. 1, Kendari, Southeast Sulawesi Province, Indonesia, e-mail: Nasal_ab@yahoo.com
Syamsul Kamri, Department of Fisheries Capture, Fisheries and Marine Sciences Faculty, Halu Oleo University, Jalan H.E.A. Mokodompit No. 1, Kendari, Southeast Sulawesi Province, Indonesia, e-mail: syamsulkamri@gmail.com
Nur Isiyana Wianti, Department of Extension of Agriculture, Agriculture Faculty, Halu Oleo University, Jalan H.E.A. Mokodompit No. 1, Kendari, Southeast Sulawesi Province, Indonesia, e-mail: yanthimuslim@gmail.com

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