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Silverside Fish *(Atherinomorus lacunosus)* in Banggai Waters, Indonesia: Almost Extinct?

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Abstract. The most widely of silverside fish *(Atherinomorus lacunosus)* populations living in Banggai waters (Central Celebes). The local name is *sosodek* fish, and we called *Banggai Silverside Fish* (BSF). This species is beneficial to the daily life of the community and has long been established as a "customary fish". Research concerning in Banggai Laut waters (Labobo and Bangkurung), has been carried out in 17th February - 17th March 2016. The research aimed to determine exploitation status of silverside. Data collection techniques consist of sampling and interview. Sampling was conducted on 2,638 individual fish samples, and 391 individues among them for estimating growth pattern. Data analysis using quantitative methods. Silverside fish is always spawning simultaneously just in Boniton beach waters (Bangkurung), only on the night of the full moon, occurs precise at dawn, fainted after spawning, and regained consciousness when the sun rises. The fishermen catch these fish simultaneously with the fishes release their eggs. Growth pattern is "positive allometric", and the growth status of body length is "grows very slowly". While the rates of fishing mortality, natural mortality, exploitation and utilization indicate the level of exploitation has reached the status of "overexploited" until "depleted". Therefore, this fish resource facing very serious problems relating to security in the resource stock. So that needs to be protected and should immediately do the stock's recovery. That should be done are prohibiting fishing activities, initiating the fish protected areas, and designing fish aggregating devise.

Key words: Sosodek, Customary Fish, Fainted

I. INTRODUCTION

The Banggai Islands (Central Sulawesi) is famous since the discovery of the Banggai Cardinal Fish (BCF) as Indonesia native fish resource, which according to the IUCN Red-List has status endangered species in their natural habitat. In addition to BCF, Banggai waters are habitat for species of Banggai silverside fish/BSF *(Atherinomorus lacunosus)* (Fig. 1). In Indonesia, the most widely of silverside fish populations living in waters of Banggai and surrounding (Central Celebes), and a little bit of life in the waters of Ternate (North Mollucas) [1].

Fig. 1. Silverside Fish from Banggai (Indonesia)

Silverside is the most popular type of fish as the main food material and daily food for people in the region Banggai. This fish served as major culinary in variety of custom events, so it has been designated as "indigenous fish". Mentions "head stone fish" or "stubborn fish" because it takes silverside have to use two hands, and can not be eaten with the help of one hand.

BSF dishes was never presented to the Indonesian navy when the Indonesia warships stopped at City of Salakan (Banggai Islands Regency) which is incorporated in "Operation Mandala" to defend West Irian (Papua) of the Dutch army offensive in 1962. The local communities to feed the soldiers and presenting dishes "silverside fish sour sauce" that was also highly favored by the soldiers (Amin 2016, pers. com.)

In the Banggai region, these species live in the waters of Dua Island (Regency of Banggai), Bakalan Island (Regency of Banggai Kepulauan), and in the waters of Banggai Island, also in the waters of Labobo Island and Bangkurung Island (Regency of Banggai Laut). Because of the spread, so silverside become very famous fish in the community of Banggai region. Besides the fish of silverside, in waters of Banggai there are three others species of fish are morphologically similar to silverside.

The waters of Labobo Island and Bangkurung Island in the Regency of Banggai Laut are the primary habitat of silverside since more than a century ago. Silverside also live in the waters between the islands.

The main benefit of silverside fish for the community of Labobo Island and Bangkurung Island is for dayly consumption. Types of cuisine in the form of boiled silverside pregent are eaten with Labobo's cassava fried as fancy food dishes` for the residents of the Labobo island. Silverside also processed into smoked fish, which are sold to the Peleng Island.

Banggai communities, especially for the community in Labobo Island and Bangkurung

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Island, have exploited this species in large quantities because the meat is very delicious. They have exploited silverside for more than a century ago in the waters around on the islands. Since ancient times, people in the region of Banggai utilize silverside fish for family consumption and as bait for fishing of reef fish. These last few years, populations of silverside are diminishing. Currently silverside fish colonies are no longer found in some spots of coastal waters as habitat of silverside fish (Masridin 2016, pers. com.). Even residents of Balakan Island last time heard the voice of the fishermen sell silverside in 1975 or 40 years ago (Amin 2016, pers. com.).

Silverside fish resources to date (December 2016) continues to be extracted, especially when they're releasing the contents of the gonads. This condition is most dangerous and can threaten the sustainability of the species and stocks of silverside fish.

The problems of silverside fish resources in the Banggai waters are: (a) how the condition of biology parameters of silverside fish resources? and (b) how the status of exploitation?

The research aimed to determine exploitation status of silverside in the Labobo and Bangkurung waters, and to determine the cause of the declining population of silverside in the islands waters

II. METHODS

RESEARCH SITE AND PERIOD OF RESEARCH

The research was done by taking in Banggai waters, precisely in the waters around the islands of Labobo and Bangkurung (Fig. 2). While the period of data collection activities at research sites takes place from February 17th until March 17th, 2016. During this period, the authors visited the research site twice to investigate and gain primary data of silverside biology and secondary data of silverside production (2009-2015).
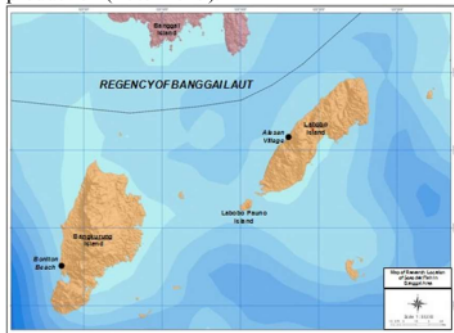

Fig. 2. Map of research location of silverside fish in Banggai area

RESEARCH METHOD

The method of this research is survey method, and also using sampling, dialogue, and documentation methods for data collecting. Primary data was collected with simple random sampling. The data were analyzed with quantitative (regression and comparative).

The silverside fish data (cross section data) were used as the main research materials. Whereas the main research equipments is the pair of scales, the ruler and the camera.

For knowing correlation and determination of all variables, also level of data precision or accuracy, the authors analyzed data using the simple regression method ($Y = \alpha + \beta X + \varepsilon$) between silverside fish yield (dependent variable) with some variables individually (independent variables).

The growth pattern (length-weight relationship/ LWR) is analyzed using simple regression method. The growth parameters (K and L∞) were analyzed by the method of ELEFAN I in Scanning of K-values FISAT II. Analysis of monthly cohort of silverside fish used a model of progression analysis NORMSEP. Total mortality was calculated using the theory that developed by [2] with the assumption that fish samples obtained from a stable population with the addition of a new (recruitment), the mortality rate is constant and using growth models von Bertalannfy. Determining the rate of natural mortality (M) and exploitation rate I used empirical formula of [3]. According to Gulland *in* [4], the fishing mortality rate (F) was determined by the formula: $F = Z-M$ ($F_{opt.} = M$ and $E_{opt.} = 0.5$).

In analyzing a population dynamic, information that is needed is information about the mortality rate in a fishing activity of the exploited ([5], [6]), even this information is one of the base in the management of the fish resources stock [7]. Mortality was measured the rate of natural mortality (M), the fishing mortality rate (F) and the total mortality rate (Z). The rate of natural mortality estimated using an empirical approach [3] which shows the influence of annual temperature, the rate of total mortality estimated by curve catches is linieryzed based on the data length of the fish, and it is assumed that the population has a lifespan of stable [4], and the fishing mortality can be expected to reduce the Z with M ($F = Z-M$). Mortality rate of fish resources can be caused by natural mortality and the fishing moratlity.

Silverside fish population and exploitation rate were estimated by the equation that developed by [21] using production data (alleged) along the period 2009-2015. The data obtained from interviews with fishermen on the island Labobo special fishing of silverside fish. According to Pauly *in* [4], the exploitation rate is determined by comparing the fishing mortality of the total mortality follows the equation: $E = F/Z$

III. RESULT AND DISCUSSION

DEFINITION/MEANING OF SILVERSIDE

Local name of silverside fish in Banggai is *sosodek*. The word of sosodek that comes from Banggai language, consists of two words namely *"soso"* and *"dek"*. *"Soso"* means compressing or pressed, and *"dek"* is sealed across the gap (usually is used on the wooden boat). Thus, silverside is

translated loosely to "strengthening the group to avoid interference" (Masridin 2016, pers. com.).

UTILIZATION/EXPLOITATION

The silverside fishing ground in the coastal area around Labobo Island is 2-25 meters from the coastline. Fishing activities that are only done by six people of Labobo Island who work as a traditional fisherman. While the people of Bangukurung Island do not work as fisherman fish fishermen, but a few of them catch sosodek just before spawning.

Fishing equipment used consists of a mesh with a diameter of 6 meters (1 unit) and an outboard motor boat (1 unit) for each fisherman. In addition to fishing nets, sometimes fishermen use vertical line, beach seine, and gill nets to catch sosodek.

Fishermen operate an average of 8 fishing days per month or 96 days per year. Sosodek fishing time is done from morning until afternoon for 12 months / year. The most important sosodek fishing period lasts only 6 months / year, ie July-December period when spawning season.

REPRODUCTION SIMULTANEOUSLY

Banggai silverside fish are spread over the waters of the Banggai area, but their reproductive activities are concentrated only in the waters of Boniton beach. This fish is an "endemic fish" in Banggai area, especially in the waters around the Labobo Island and Bangkurung Island (Banggai Laut Regency). Silverside live in beach shallow waters with swimming range 0-20 meters from the beach, in waters up to a depth of 2-3 meters. Silverside adolescents and adults are only found in the waters around the Island of Labobo throughout the year. While, the spawning area just found in the waters of Boniton beach, Kanari Village (Bangkurung Island).

Fish of silverside has many unique, especially in the reproductive period is when will and ongoing spawning. Silverside only spawn during the six months per year i.e during the period July to December when the fish measuring 100-120 mm individual. The incidence was as follows:

- The whole silverside (male & female) may be pregnant in bulk and simultaneously in the Labobo Island waters
- All of silverside pregnant swim together toward the waters of Labobo Pauno Island (Small Labobo Island) on the night of 14 AH (moslim year). Thus, fish silverside not found at all in the waters of Labobo.
- The whole silverside united to form resembles a large fish, then went swimming at night 15 AH lunar month toward spawning waters in the area Bangkurung (Boniton beach, Kanari village), and arrived in the waters before dawn.
- All silverside fishies spawn after dawn that begins with males releasing sperm (up white waters) and females release their eggs.
- When spawning, silverside body in an upright/standing with the head on the top of the water, shaking his body.

- Silverside whole experience "broken belly" and fainting (torpor) after the spawning process is completed.
- All the silverside suspended animation, awakened when the sun is shining bright (about 7 AM).
- Furthermore, the entire silverside is in a state of "broken belly" swim with leaving the Bangkurung waters to Labobo waters

Genesis mass reproduction of silverside fish is ongoing and repeated continuously every year at the time and the same waters. This event has been going on since more than a hundred years ago. According to another version, silverside perform mass reproduction of each month throughout the period of one year.

GROWTH PARAMETERS (K & L∞)

Scientific informations related to the biological aspects including the growth parameters of fish is one of the factors on which to base the management of fish stocks in the waters ([7], [8], [9], [10], [11]) state that fish growth forecasts are being exploited is very important to prevent overfishing. Each fish species can have different biological properties. Fish with larger body size and long theoretical age usually have low reproductive potential, whereas fish body size smaller dan the short theoretical of lifespan typically have a high reproductive potential [12]. Fast or slow of growth of a species, represented by the value of K and r [13]. Fish that have a growth coefficient (K) is great in general have a shorter lifespan [14]. Reference [15] explains, LWR depicted in two forms namely isometric and allometric, with the equation: $W = aL^b$.

The growth parameters (K & L∞) were analyzed by the method ELEFAN I in *Scanning of K-values* FISAT II against 2,638 individues of silverside. Obtained K value of 0.930/year and L∞ value of 111.83 mm. Value t_0 (theoretical age at the time of the silverside fish length is equal to zero) by the empirical equation [3] obtained a value of -0.5 years (Fig. 3).

Fig. 4 shows that the estimated maximum length (L_{max}) of silverside fish was observed 106.50 mm. While the maximum length of the fish is predicted to 107.44 mm, and at a 95% confidence interval of 104.82 to 110.05 mm.

The growth curve of silverside fish length used Von Bartalanffy model, equation $L_t = 111.83 \{1\text{-exp}^{-1,1(t+0,5)}\}$. When the fish aged 1 year and 5 months, the fish theoretical length reached 100.48 mm, while the fish asymptotic length (L∞) reaching 111.83 mm allegedly occurred at the age of 6 years and 1 month (Fig. 5).
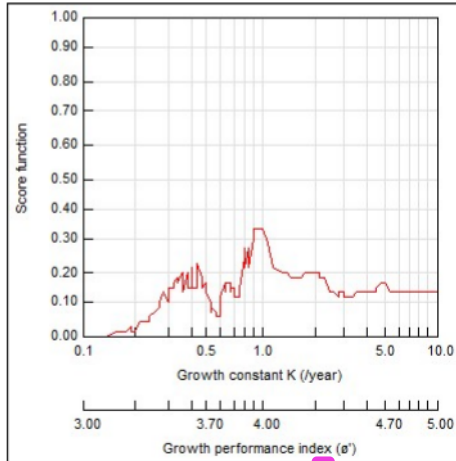
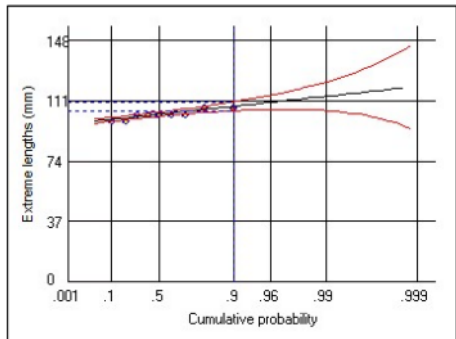Fig. 3. The curve of K and L∞ value with method ELEFAN I Scanning of K–values FISAT II

Fig. 4. Curve of maximum length estimation of silverside fish

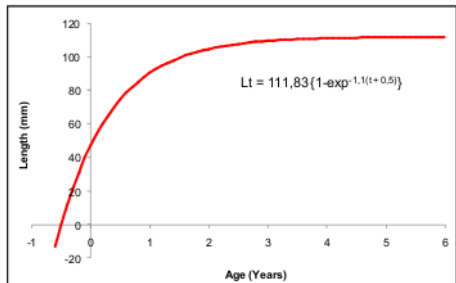$$Lt = 111,83 \{1-exp^{-1.1(t+0.5)}\}$$

Fig. 5. The length growth curve of silverside fish with plot age (years) and the theoretical length (mm)

The growth rate of the fish began to experience a slowdown during the age of the fish have reached 3 years and 9 months onwards. This is in accordance with the opinion of [16] and [17] which states that the larger the body size of the fish (old age), the smaller or slower growth rate.

RECRUITMENT

Recruitment (addition of new individuals) of silverside fish in research sites occur throughout the year (Fig. 6). The addition peak of new individual fish occurred in twice in a year. The first addition peak of new individual occurred in April (12.54%)

and May (16.02%). While the second addition peak of new individual occurred in July (11.56%) and August (10.36%).
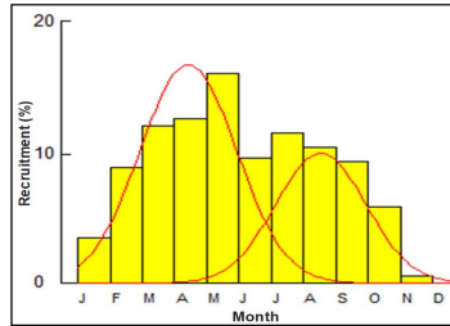

Fig. 6. The annual additional pattern of new individual of silverside fish

Based on recruitment patterns, presumably silverside fish spawning performs throughout the year with two peak spawning season in a year. It is based on the pattern of recruitment peaks that occur are defined in these months the fish population relatively abundant and exploited. This situation is relevant to the statement of [15] that is meant to recruitment is the addition of new individual into the fishery stock that caught by fishing gear. The addition of new individual of fish resources in the waters of each class size is very closely related to conditions of environmental factors [7].

GROWTH PATTERN

Unique attributes like a fish body shape will help us determine the ability of the species can survive in waters, as well as instructions regarding environmental factors that can be adopted by fish [12]. [7] states that the relationship between the length and weight of the fish can be used assess the condition of the fish, a fish that has a high weight per unit length of the fish is considered healthy and in good shape. [7] explains, the index of length-weight relationship (LWR) fish can be used to assess the relative condition of individual fish habitat or to compare the condition of fish populations in different habitats.

Growth sampling is done by catching silverside using cover net in coastal waters on Alasan Village, District of Labobo. Sampling is done five times, with the results of as many as 2,638 individues and total weight of 15.90 kg (average body weight = 6.03 grams/individu). Silverside lightest weights are 5.0 grams individual (9 indivdues) and the heaviest is 14 grams individual (1 individu). While most short silverside (total length) is size 60 mm individual (2 individues) and the longest is 105 mm individual (1 individu), so the average length of 85.5 mm individual.

The results of the analysis of LWR against 391 individues of silverside generate value b (slope) of 4.25 (Table 1). Referring to [15], the value of b is means the following: (a) the growth pattern is an allometric positif i.e. weight growth faster than the

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growth of long, and (b) silverside body shape is fat or chubby.

TABLE 1.
THE GROWTH PATTERN OF FISH SILVERSIDE

Sampling Time on 2016 (Month)	Total Sample (individues)	Value of Growth Pattern (b)	Growth Pattern
February	200	3.00	Isometric
March	191	4.82	Allometric Positive
February & March	391	4.25	Allometric Positive

Source: Sampling Result (2016)

Conditions of growth pattern and body shape of silverside thought to be caused by the depletion of silverside natural feed stocks (plankton). Plankton population decline is due to the damage or destruction of coral reef ecosystems in the waters around the Island Labobo. The rise of the activity of the bombing of coral reef resources, the most dominant conducted by the fishermen entrants and very little is done by the local fishermen.

MORTALITY RATE

The value of total mortality rate (Z) silverside amounted to 6.24/year, and the rate of natural mortality (M) at a mean annual waters temperature of $30^{\circ}C$ is 1.22/year (Fig. 7).
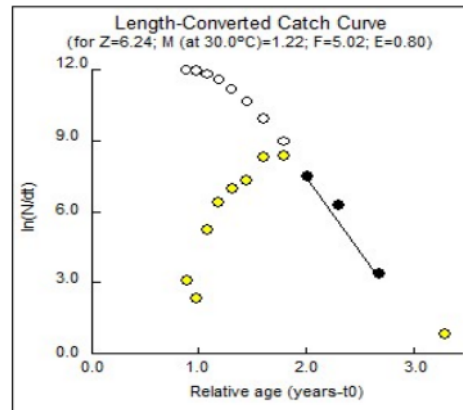

Fig. 7. Curve of the silverside catches are linearized based on length composition data

The theory stated by [3] that the natural mortality expressed great when its value has reached 1.5/year. Based on this, the natural mortality of silverside in the Labobo waters relatively small (M = small). Meanwhile, the fishing mortality rate of silverside fish is 5.02/year. It is clear that the level of exploitation of silverside fish has intensified. [3] explains that the fishing optimum rate will occur if it is equal to the value of the natural mortality rate ($F_{opt.}$ = M).

The rate of fishing mortality of silverside in the study location showed greater when compared with the value of the natural mortality rate, so that the rate of fishing has passed an optimum value. Meanwhile, according to [5], the exploitation status of silverside fish has reached overexploited, this is due to the fishing mortality value is greater than the value of natural mortality (F > M).

Uncontrolled fishing factors has changed the relative abundance of individual or species in waters communities that directly have a negative impact on fertility waters, ecosystem biomass, age of first fish mature gonads, or the dynamics of the food chain ([18], [19]). So, [20] expressed the need for fishing activity that precautionary factor that selective fishing to size fish, and usually it is done for reasons of biology and economics.

ESTIMATED OF POTENTIAL SUSTAINABLE FISH

Estimation of the potential stock of silverside fish resource in the waters of Labobo Island is predicted using models of [21]. The model has been widely adopted by institutions of management of fisheries resources in the world with the aim of sustainability of fish resources. To estimate the stock a fish resources in the waters, the assumptions used consisted of: (a) the stock of fish resource spread evenly in these waters, (b) all the data of fish catches obtained from the area of these waters, (c) all results catches landed in the area, and (d) the level of fishing technology has not changed significantly during the period of data collection ([4], [22], [23]). [4] explain, the regression analysis was used to obtain a phenomenon/description of the effect of fishing effort (f) of the catch per unit effort (CpUE).

No figures of silverside fish production volume that published officially by the Department of Marine Affairs and Fisheries (DMAF) and the Central Statistics Agency (CSA) of Banggai Laut Regency. For that conducted interviews with a number of fishermen who catch silverside only. From the interview it is known that catches silverside estimated to reach 19.20-24.40 tonnes/unit/year during the period 2009-2015 (Table 2).

TABLE 2.
THE SILVERSIDE FISHERY IN LABOBO PERIOD 2009-2015

Year	F (units/year)	Y (tons/year)	U (tons/unit/year)
2009	5	122.00	24.40
2010	5	118.00	23.60
2011	5	114.00	22.80
2012	5	112.00	22.40
2013	6	128.00	21.33
2014	6	124.00	20.67
2015	6	115.20	19.20

The results of the analysis using a model of [21] shows the alleged magnitude of the result as follows: stock of silverside fish resources = 123,18 tons/year, maximum sustainable yields (Y_{MSY}) = 61,59 tons/year, number of catches allowed (NCA) = 49,27 tons/year, maximum of sustainable fishing effort (f_{MSY}) = 7,00 unit/year, and Maximum of sustainable CpUE (U_{MSY}) = 18,9 tons/unit/year.

Analysis results of the variables of fishing effort (f) and catch per unit effort (CpUE) of silverside using regression analysis model of surplus

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production [21] obtained values as follows: r = 86.75% (0.8675), R $Square$ (R^2) = 75.25% (0.7525), and $Adjusted$ R^2= 70.30% (0.7030).

Based on the analysis, the value of the regression statistics are as follows

- Variable of fishing effort (f) has a correlation/relationship is very strong (75%<r<100%) with variable of catch per unit effort (CpUE) because the value of the correlation coefficient (r) of 86.75%.
- Values of determination/effect (R^2 = 75.25%) means that as much as 75.25% of data fishing effort be able to explain influence variation CpUE.
- Adjusted R^2 = 70.30% means as much as 70.30% of the sample were able to find answers required from the population, which means the sample has a "high degree of precision". The remaining 29.70% of the samples are not included in this research.

The resulting equation between CpUE (U) and fishing effort (f) silverside is Y /f = 37.80 f - 2.90 f² . While the regression equations obtained between the results CpUE silverside with fishing effort is Y/f = U = 37.80 - 2.90 f. The equation is meaningful, more the number of fishing effort (fishing gear nets) of silverside sought by the fishermen then CpUE will likely decrease.

Realisticity of the equations/models can be tested based on the value of effort. The model is said to be realistic if the undertakings (f) is smaller than -a/b (f<-a/b). The level of effort the highest occurred in 2015, namely 6 units/year, while the value of -a/b of the year amounted to 13 units of equipment/year. Then the level of effort in 2015 is still not exceeds the value -a/b (6<13). Thus, the equation obtained from the analysis with surplus production models [21] be realistic to use the results to estimate maximum sustainable yields (Y_{MSY}), maximum sustainable fishing effort (f_{MSY}) and the value of maximum sustainable CpUE (U_{MSY}) of silverside in the study site.

ESTIMATION OF STANDING STOCK

To estimate the potential stock of reserves and catchment silverside, then the analysis used is a model developed by [24]. Results of linear regression analysis based on the model of [23], the value a = -778.2605, the value of b_1 = 64.9866, b_2 = -1.4243, and b_3 = 0.3211, with a value of R^2 = 96.77% (CpUE variations can be explained by variations in fishing effort of 96.77%). Subsequently obtained value of r (the natural growth rate of the stock biomass constant) = 64.9866, the value of q (cathability coefficient) = 0.3211, and the value of k (carrying capacity/maximum carrying capacity of the natural aquatic environment) = 142.089. By using the parameter r, q and k then the stock position at this time (standing stock) acquired potential stockpiles of sustainable (Be) on the current conditions of silverside fish in the waters of Labobo and Bangkurung of 71.044 tons/year.

EXPLOITATION RATE

The rate of exploitation (E) fish Silverside obtained values of 0.80/year. It explains that 80% of fish deaths in the study site due to the presence of fishing pressure/exploitation. [5] and [3], states that the optimum exploitation rate would have reached if it is equal to 0.5/year ($E_{opt.}$ = 0.5/year). While the rate of exploitation of fish Silverside amounted to 0.80/year, so that the value has exceeded the threshold value E_{opt}. It shows that the exploitation of silverside fish resources status of the study sites has reached overexploited (E>0.5).

THE LEVEL AND STATUS OF EXPLOITATION

Referring to yield of silverside on 2015 amounted to 115.20 tons, the level of exploitation silverside amounted to 187.05%. If it is associated with the opinion of [25], the utilization rate silverside already is in the category of "depleted", which means "reserve of silverside fish resources drastically reduced every year so that the sustainability of resources is very threatened, the fishing effort must be stopped ".

Drastic decline in fish populations in Banggai silverside fishing waters due to death allegedly caused by three things as follows:

(a) carried out by the local fishermen who catch silverside in conditions gonads mature. Silverside mass catch are carried out by fishermen when silverside swim from waters of the Labobo Island to the waters of Labobo Pauno Island, and toward the waters of Boniton beach in the Canary Island Village (Bangkurung) through Labobo Pauno Island, for spawning. Such conditions occur repeatedly every mid-month in the year of AH. The result is not going on spawning and the absence of a new generation of silverside.

(b) carried out by fishermen from outside of the Banggai region, which catch fish by using light (light fishing). Silverside fish is not the target fish but were caught by fishermen because it possesses a positive phototaxis, and

(c) cutting/felling of the protective trees on the coastal plains that jutting into the waters of the coast, where the waters beneath the trees as habitat for fish silverside

IV. CONCLUSIONS

Utilization of silverside fish resources in the Banggai waters been done in an uncontrolled. While the silverside fish population status in the Labobo and Bangkurung waters currently is depleted or endangered. In order to improve the condition of silverside fish resources, to all stakeholders in Labobo and Bangkurung advisable to do: (1) prohibiting silverside fishing activities during 2016 and initiating the parent fish protected areas in the waters of Bangkurung Island, and (2) designing and setting fish aggregating devise (FAD) in beach waters near the sites of protective trees have been felled by Labobo residents.

V. Acknowledgmenet

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