**Spawning technique of yellowfin tuna (Thunnus albacares) in floating nets cage**

B Bramantya\(^1\), Gunawan\(^2\) and L A Sari\(^3\)*

\(^1\)Program Study of Aquaculture, Faculty of Fisheries and Marine, Universitas Airlangga, Kampus C Jalan Mulyorejo, Surabaya 60115 East Java, Indonesia

\(^2\)Center for Marine Cultivation Research and Fisheries Extension Gondol, Singaraja Gilimanuk, Buleleng, Bali, 81155, Indonesia

\(^3\)Department of Fish Health Management and Aquaculture, Faculty of Fisheries and Marine, Universitas Airlangga, Kampus C Jalan Mulyorejo, Surabaya 60115 East Java, Indonesia

*Corresponding Author: luthfianaas@fpk.unair.ac.id

**Abstract.** Tuna is a potential commodity because it contributes the largest fishery export. Tuna aquaculture is one of the steps that can be taken to maintain the stability of tuna fishery production. The aquaculture method using floating net cages is the most productive aquaculture technique. The study has performed in the Central Research of Sea Cultivation and Fisheries Extension Gondol, Bali. The purpose is to know how the technique of spawning yellow fin tuna (\textit{T. albacares}) in floating net cages. The control issues and obstacles encountered during the process of raising the broodstock yellow fin tuna. Spawning of yellow fin tuna is done naturally. Broodstock female of yellow fin tuna used from catching process that is choosing broodstock candidate of tuna fish with weight 5 kg and length +25 cm. The weight ratio of yellow fin tuna between male and female is 3:1. Water quality parameters for yellow fin tuna larva among others: temperature 29-30°C; pH 8.2; and DO 6.0 ppm. Based on the calculation, the obtained hatching rate of yellow fin tuna is at 75.34% and the Survival Rate is 0%. Artificial feeds used in the maintenance of larvae are \textit{Nannochloropsis oculate} and \textit{Brachionus rotundiformes}.

1. **Introduction**

Indonesia is an archipelagic country that has a very large sea area and is located between two oceans, the Indian Ocean and the Pacific Ocean. The marine resources owned by Indonesia are very large, both renewable and non-renewable. One of the renewable resources is fishery resources, where tuna fishery is one of the resources that has contributed greatly to the nation's economy for the use of domestic and export markets [1].

Tuna is a potential commodity because it contributes the largest fishery export. In 2011, the realization of tuna exports from Indonesia was 141,774 tons worth 499 million US dollars, up 30.1 percent compared to the previous year, 122,450 tons worth 383 million US dollars. National tuna, skipjack and tuna production in 2011 amounted to 955,520 tons. Tuna production itself is 230,580 tons, thus tuna is a fish that has high commercial value [2].

Tuna aquaculture is one of the steps that can be taken to maintain the stability of tuna fishery production. The most successful countries in tuna cultivation to date are Japan, Australia, and several
countries in Europe while Indonesia as one of the tuna producing countries still only relies on natural catches [3].

Tuna is a marine fish consisting of several species from the family Scombridae, especially the Thunnus genus. This fish is a fast swimmer, it is supported by a torpedo-shaped body and is able to swim up to 77-80 km/hour [4]. The distribution area of tuna in Indonesia includes the western waters and the Sumatra strait, the southern waters of Java, Bali, Nusa Tenggara, the Flores Sea, the Banda Sea, the Sulawesi Sea and the northern waters of Papua, while vertically, the distribution of tuna is influenced by temperature and swimming depth [5].

Yellowfin tuna (T. albacares) is a type of tuna that lives in tropical and sub-tropical areas of the Indian Ocean, Pacific, and Atlantic. This type of tuna is often associated in the same school with the skipjack (Katsuwonus pelamis) and juveniles of the big eye tuna (T. obesus). Juvenile Yellowfin tuna found on the surface of tropical waters. Adult fish are caught in deep water [6].

Indonesia has just started the tuna cultivation business. In 2003, aquaculture experts from Indonesia and Japan collaborated to research the cultivation of yellowfin tuna (T. albacares) at the Center for Marine Cultivation Research and Fisheries Extension Gondol, Bali [7]. During those 3 years, techniques for catching and transporting prospective broodstock have been successfully developed from the fishing location to the rearing tanks on land [8]. Broodstock enlargement techniques, gonad maturation, and spawning [8]. Cultivation of tuna rearing is carried out in large floating net cages which only started in 2013 [9].

The aquaculture method using floating net cages is the most productive aquaculture technique. Some of the advantages possessed by the KJA method, namely high stocking density, adequate quantity and quality of water, no need for soil cultivation, control of predators (predators), harvesting, and yields that do not smell of mud [9]. The study has succeeded in developing techniques for broodstock enlargement, gonad maturation, and spawning using floating net cages.

2. Material and methods

2.1. Spawning of broodstock Yellowfin Tuna (T. albacares)

Prospective broodstock of yellowfin tuna (T. albacares) is obtained by fishing using traditional techniques in offshore waters. The broodstock candidate comes from the North Bali Sea, which is + 20 nautical miles to the North, which is taken for two hours using a motorized boat (two motorized temples) with a capacity of 85 PK fueled by gasoline. The average speed of the ship 14 knots. This is in accordance with the opinion [10] states that horizontally, the distribution area of tuna in Indonesia includes western waters and the Sumatra strait, southern waters of Java, Bali, Nusa Tenggara, Flores Sea, Banda Sea, Sulawesi Sea and northern waters of Papua. The spread of tuna is influenced by temperature and swimming layer.

Selection of prospective yellowfin tuna broodstock after the fishing process is to select prospective brooders of tuna weighing 5 kg and + 25 cm long which can carry eight fish if the fish measuring more than 5 kg carry a little. Fish that are caught are small, so the mortality rate of fish in the storage tank is relatively higher and the growth is slow or it takes time to reach the broodstock [8]. Selection of prospective broodstock of yellowfin tuna if there is a fishing wound on the upper jaw and near the eye due to the careless fishing process, the fish will be released because they tend to experience blindness which will eventually die.

2.2. Feed management

The maintenance of yellowfin tuna broodstock was carried out by giving feed consisting of flying fish and squid at 2.5% of the biomass. The feed is given in a 1:1 ratio [8]. Feeding of yellowfin tuna broodstock is carried out every day at 09.00 AM GMT +7. The amount of feed given to fly fish is 18 kg for morning feeding. The squid was given as much as 19 kg for morning feeding. Feeding of yellowfin tuna broodstock uses flying fish and squid because both of these feed contain high protein values which can trigger the growth and maturity of the gonads. This is in accordance with the
statement of [11], protein is the largest nutrient for the fish body. Therefore feed protein must be used as efficiently as possible for fish growth.

2.3. Broodstock spawning
Yellowfin tuna broodstock spawning occurs naturally. The ratio of the number of males and females for spawning is 3:1. Externally spawning yellowfin tuna broodstock is characterized by a splashing sound on the surface of the water. According to [8] the spawning behavior of yellowfin tuna broods is swimming in pairs, one female is chased by one male for about 15 minutes then swimming to normal again. When the male broodstock is swimming in pairs, it changes color to be darker, so it is clear that the vertical fins are silver along the body and pale (white) at the base of the tail, while for the female broodstock there is no change physically. Yellowfin tuna brood that is ready to spawn measuring 20 kg which is one year old.

The spawning process of the eggs that have been fertilized by the sperm rises to the surface of the water and then is carried by the current to the floating egg collector that is attached to the middle of the floating net keramaba. The egg collector is made of an aluminum frame in the form of blocks equipped with cotton cloth with a mesh size of 400 µm. The harvesting process involves taking a plastic bag at the end of the collector and taking it manually using a scoop with a mesh size of 400 µm. A scoop is used to collect eggs that have escaped from the egg collector by circling the inside of the floating net cage which has been attached with a net with a mesh size of 400 µm.

2.4. Harvesting technique
Harvesting eggs begins with checking the eggs on the egg collectors in the floating marine cage during the day, if there are a lot of eggs then harvesting will be carried out at night. Harvesting of yellowfin tuna eggs is carried out in floating net cages with 18 mains of yellowfin tuna and can be reached in about 5 minutes from the beach. The broodstock spawning check is conducted at 23.00, a sign of the broodstock tuna spawning is the jumping sound of the yellowfin tuna broodstock who spawns. Egg harvesting is done using an eggs collector which is installed in the middle of the floating net cage. Eggs collector will move with the flow of water. Harvesting is carried out in the morning at 09.00 GMT +7. Only eggs that are harvested are accommodated in the eggs collector, this is due to limited tools and the size of the floating net cages. The method of harvesting eggs is by lifting the eggs collector and opening the rope at the bottom of the eggs collector so that the eggs contained in the eggs collector will come out with the water and be accommodated in the bucket. Egg harvesting is done using a small boat (catamaran) because the eggs collector is located in the middle of the marine cage.

The collected eggs were first separated from feces and other marine animals using a stratified sieve (first with a mesh size of 1000 µm and secondly with a mesh size of 400 µm). The use of a stratified filter is because according to [12] tuna fish eggs have a size of 800-900 µm, so that the tuna fish eggs will pass through the 1000 µm filter and are stuck in the 400 µm filter.

Then the eggs are placed in a bucket equipped with an aerator and filled with sea water. The egg harvesting activity is carried out repeatedly until you get the eggs that fit your needs. The harvested eggs are put into a transbroodstock fiber tank with a volume of 100 L which has been filled with clean sea water, then the tank is covered with a black cloth and given a light at the bottom of the tank. The purpose of this treatment is to make copepods, small shrimp and feces easier to separate from the eggs.

How to calculate the number of eggs:

\[ \text{Jumlah telur} = \left( \frac{A + B + C}{\\text{ulangan}} \right) \times \frac{\text{volume total}}{\\text{volume sampel}} \]

How to calculate Hatching Rate (HR) or hatchability of eggs:

\[ \text{HR} = \left( \frac{\Sigma \text{Telur yang menetas}}{\Sigma \text{Telur total}} \right) \times 100\% \]
3. Result and discussion

3.1. Egg incubation

Eggs that have been separated with copepods and feces are put into an incubation bath with a volume of 200 liters with 3 aeration points. Before use, the incubation tub is cleaned by rinsing with fresh water, then filling it with sea water. In the incubation basin using a circulation system.

The eggs obtained were counted by the sampling method to determine the number of eggs harvested by taking a sample of 100 ml in a beaker glass and then put it in a petridisk. The sample is calculated using a profile projector and a hand tally counter. The sampling activity was carried out in 3 replications. During the study activities, the number of eggs was obtained with an average of 638 eggs in 3 times of harvesting.

| Date               | Total Eggs | Fertile Eggs | Unfertile Eggs |
|--------------------|------------|--------------|----------------|
| 28 December 2017   | 540        | 507          | 33             |
| January 3, 2018    | 466        | 394          | 72             |
| January 4, 2018    | 908        | 849          | 59             |
| Total              | 1,914      | 1,753        | 164            |
| Average            | 638        | 584          | 55             |

Observation of eggs was carried out under a microscope using the ACT-1 program and measured using a win-roof program to determine the differences and the number of fertilized eggs (fertile) with unfertile eggs. Clear, round water, while unfertilized eggs will settle and become white and damaged. The separation of fertilized and unfertilized eggs is done by turning the water as a medium for concentrating eggs so that the two groups of eggs separate and the damaged eggs collect at the bottom of the tub. Before being stocked in a rearing tub, the eggs are selected as fertile or unfertile and a count is carried out. Based on the calculation results, an average fertile egg is 1.

3.2. Larva handling

The activity of raising yellowfin tuna larvae is carried out in the semi building indoor by using a 6,000 liter volume fiber tub equipped with 6 aeration points. The top of the larval rearing tub is given a roof using transbroodstock white plastic to maintain the temperature stability of the maintenance water, lighting using a 40 watt lamp and using a water change system. The 6,000 L volume fiber bath larval rearing was also carried out in the 10,000 L fiber tub.

The HR calculated for the eggs that have hatched is to determine the number of scattered eggs that hatch in larval rearing. HR calculations on December 28, 2017 with 382 eggs hatched with a total of 507 eggs yielding 75.34%, after calculating the HR, it will be known how many eggs that hatched and did not hatch and how many larvae were in the rearing tub.
counting the number of live larvae, without treatment.

The rearing of yellow fin tuna larvae is carried out in controlled water and feed quality. The rearing of larvae in 6,000 L tubs is carried out until larvae 20 days, and the rearing of yellowfin tuna larvae is carried out in 10,000 L.

Observation of larval development was carried out every day with the aid of a microscope. Observation of larvae development includes observations of morphological characteristics, measurement of body length, diameter of mouth openings, and stomach contents. The development of yellowfin tuna larvae is based on explanations and secondary data obtained from researchers, as follows:

a. Larva D0, clear transbroodstock. The larvae are still in the planktonic stage, which is hovering in the flow of water. There is melanophore pigmentation all over the body. This pigmentation is thought to function as camouflage against predatory attacks.

b. Larva D1, has a cupula (hairs) at the end of the mouth that functions as a sensor before the eyes function. The circulatory system has begun to develop. Melanophore pigments are still present. Yolksac is running low.

c. D2 larvae, begin to grow pectoral fins and intestines. The mouth starts to open but cannot function properly. Cupula and melanophore pigments are still present in small amounts. Yolksac is finished and there is still oil globule left.

d. D3 larvae, cupula and melanophore pigment begin to disappear. Rotifers are already in the intestines indicating the larvae have started eating.

e. Larva D7, the stomach organs begin to form.

f. D14 larvae, tail and dorsal fin begin to develop so that their swimming ability increases. The fish have started to forage more, giving rise to cannibalism.

g. Larva D15, teeth have begun to form on the upper and lower jaw.

h. Larva D20, tail and dorsal fin have begun to form completely so that the swimming speed of the larvae increases and their space starts to increase.

3.3. Larva feed

Feeding yellowfin tuna larvae is carried out before the critical period of the larvae, namely on the second day (D2) after the eggs hatch, where at D2 the larvae begin to open their mouths with sizes ranging from ± 250-300 μm.

The feed given to tuna larvae is given before the larvae's mouth is open completely. This is done so that when the larvae begin to open their mouths, life feed will be available in the media. Feeding in the form of phytoplankton, Nannochloropsisoculata, was given to D1. This provision is not only to provide life feed for larvae directly but also as life feed for zooplankton (B. rotundiformes) which is added to the larval rearing tub.

Phytoplankton is given once a day, at 08.00 AM GMT +7. The method of administration is by draining into the larval rearing tub through a small tube. The distribution of each trough for maintenance ranges from 50-100 liters can be seen in Annex 12: C3. Plankton are organisms that live floating or floating in water. The ability to move is limited so that the organism is always carried away by the current. Based on its life cycle, plankton is divided into two groups, namely holoplankton which are aquatic organisms where their entire life is planktonic [14].

Directly or indirectly, plankton is a very important factor for fish and biota that live in water, be it fresh, brackish or sea water [15,16,17]. Because plankton, especially phytoplankton, is the primary producer or food-producing organism which is the first in the food chain cycle [14,18,19]. Phytoplankton is a biota that is sensitive to changes in water characteristics. Because of its sensitivity, phytoplankton is often used as an indicator of the ecological conditions of a waters [20,21,22]. The composition and abundance of phytoplankton in a waters are highly dependent on the availability of nutrients [23,24,25]. Nutrients in abundant waters are likely to bloom or explosion of phytoplankton populations in these waters [26,27,28,29].
The administration of zooplankton, namely rotifer (*B. rotundiformes*), was added to the larval rearing tub with a density of 10 ind/ml when the larvae began to open their mouths (D2). The provision of rotifers is intended to meet the nutritional needs of the larvae because during the critical period fish larvae need energy for life development. Rotifer feeding is done by pouring the rotifer from the beaker glass in the area around the aeration. This means that the rotifers can spread quickly in the water. The rotifers added to the larva rearing tub were carried out twice a day, at 08.00 AM and 14.00 PM GMT +7. The density of the rotifers in the larval rearing tub was calculated by taking samples at 4 aeration points. Then the sample is taken to the tuna laboratory to calculate the total density with the help of a profile projector and hand tally counter. The calculation of the total rotifer density is carried out so that the number of rotifers in the waters is not too abundant. The number of rotifers in the waters will have an impact on decreasing water quality because rotifers will reduce the density of phytoplankton and can become competitors in the struggle for dissolved oxygen [30,31].

For D10 larvae, the feed given is in the form of marine fish larvae. Provision of marine fish larvae through the distribution of D1 larvae (milkfish larvae) in the rearing tanks of D10 yellowfin tuna larvae. As the yellow fin tuna larvae age, the larger the sea fish larvae are given. Sea fish larvae are usually given in the form of nener, grouper larvae and anchovies. Juvenile feeding is given regularly ad libitum (as much as possible).

According to [32], feed given when the larvae reach a length of 4.5 mm, larvae feed changes from rotifer to artemia nauplii. Whereas in the maintenance of yellowfin tuna larvae in Gondol 2016, larvae feed was not added with artemia nauplii, this was done because D2-D4 larvae could consume rotifers (*Branchionus rotundiformes*).

**Table 2. Type of feed for yellow fin tuna larvae**

| Type of Feed          | Larva Age |    |    |    |    |    |
|-----------------------|-----------|----|----|----|----|----|
|                       | D0 | D1 | D2 | D10| D15| D20|
| *N. oculata*          | x  | x  | x  | x  | x  | x  |
| Rotifer               |    |    |    |    |    |    |
| *B. rotundiformes*    |    |    |    | x  | x  | x  |
| Marine fish larvae    |    |    |    | x  | x  | x  |

*X mean larva age (day)*

**Figure 1. Rotifera**

3.4. Water quality management

Management of water quality in larval rearing tanks begins with filtering using sand filters and filter bags. Oxygenation and aeration are given to larval rearing tanks to maintain dissolved oxygen levels. Measurement of water quality, namely temperature, is carried out 2 times a day, namely in the morning.
and evening. Water quality for larval rearing requires maintenance to be in optimal conditions, so water quality management must be maintained according to the Table 3. The larvae hatched until they were D-5 and added fish oil to the surface of the rearing water twice a day. This is so that the fats or mucus released when the larvae hatch can be pushed away from aeration and then after collecting them, they are taken with a beaker glass. Water change was started when the larva was 7 days old (D-7) by 5% and continued to increase as the larvae grew older. Cleaning the bottom of the tub (buffing) begins when the larvae are 12 days old. Penyifonan is done once a day, namely after the larvae are 15 days old (D15). This penyifonan function is to clean the larvae tub of dirt that has settled at the bottom of the rearing tub and from dead larvae.

**Table 3.** Water quality management in rearing yellowfin tuna (*T. albacares*) larvae

| Treatment                  | Days after hatching |
|----------------------------|---------------------|
| Fish oil                   | x                   |
| Change of Water            | 5%---10%---15%---20%---30%---50% |
| Tub bottom cleaning        | x x x x x           |

*X* mean the day of water quality treatment

Water quality management carried out in the study is by checking water quality parameters twice a day. The water quality parameters that were checked included temperature, salinity, and dissolved oxygen. Examination of water quality parameters is carried out using several tools, namely a DO meter to measure dissolved oxygen content in water, a thermometer to measure water temperature, and a refractometer to measure the salinity of sea water. Measurement of water quality parameters such as salinity, pH and DO is done once a month. Meanwhile, temperature measurements are carried out 2 times a day. The results of water quality measurements in the main tub are shown in Table 4.

**Table 4.** The results of measuring the water quality of the rearing yellowfin tuna larvae

| Parameter                   | Amount     |
|-----------------------------|------------|
| Water volume                | 6 -10 m³   |
| Temperature                 | 29-30ºC    |
| Water color                 | Clear      |
| Salinity                    | 34-35 ppt  |
| DO (Dissolved Oxygen)       | 6.0 ppm    |
| pH                          | 8.2        |

There is a difference in the range of values at the measured temperature during the maintenance of yellowfin tuna larvae in street vendors with the statement of [33] that the optimal water quality, such as temperatures ranging from 23.5-25.5ºC, pH ranges from 7.8-8.2. This difference may be due to different cultivation locations and different season conditions.

### 3.5. Cultivation Barriers

The problem that arises both in the hatchery and rearing of yellowfin tuna is that capital includes a fairly large maintenance cost, especially the cost for feed given to yellowfin tuna broodstock which is quite a lot and is fresh feed. In addition, maintenance of marine cage often becomes an obstacle in the process of raising and growing yellowfin tuna. Extreme natural factors such as large waves which result in turbid waters can cause fish to become stressed and can lead to death. The relatively high mortality rate of larvae is caused by the condition of the aquatic environment, the quality of life feed and disease so that it reduces the survival rate (SR) of larvae is still an obstacle in this yellowfin tuna research.
4. Conclusion
The yellowfin tuna spawning with ratio of the number of males and females to spawn, 3:1. The spawning process on 18 December 2017 - 18 January 2018 was carried out as many as 3:1. The spawning process of yellowfin tuna produces 1,914 eggs. Calculation of the Hatching Rate (HR) 382 eggs with a total of 507 eggs yielding 75.34% and a Survival Rate (SR) of 0%.

5. References
[1] Mahrus 2012 *Distribution of Length and Weight of Southern Bluefin Tuna (Thunnus macoyii Castelnau, 1872) Captured from the Waters of the Indian Ocean and landed in Bali’s Benoa Harbor* (Depok: Faculty of Mathematics and Natural Science Universitas Indonesia).
[2] Ministry of Marine Affairs and Fisheries (KKP) 2014 *Tuna Exports Increase* (Jakarta: KKP).
[3] Hutapea J H, Setiadi A, Gunawan, and Pernama I G N 2014 *Proceedings of the Aquaculture Technology Innovation Forum*.
[4] Kantun W 2012 *Stock Condition, Kinship Relationship and Genetic Diversity of Thunnus albacares Yellowfin Tuna in WPPRI 713* (Makassar Strait, Flores Sea and Bone Bay) (Makassar: Hasanuddin University).
[5] Miazwir 2012 *Analysis of Biological Aspects of Reproduction of Yellowfin Tuna (Thunnus albacares) Caught in the Indian Ocean* (Depok: Faculty of Mathematics and Natural Science Universitas Indonesia).
[6] Nikijuluw V P H 2008 *Status of Indian Ocean Tuna Resources Implications for Indonesia* (Jakarta: Research at the Capture Fisheries Research Center).
[7] Kordi K M G H 20110 *Cultivation of catfish in tarpaulin ponds (Yogyakarta: Andi).*
[8] Hutapea J H, Pernama G N, and Andamari R 2007 *J.Ris. Akuakultur* 2(1), 9-14 [in Indonesian].
[9] Kordi K M G H 2011 *Seagrass Ecosystem (Seagrass): Function, Potential, and Management* (Jakarta: Rineka Cipta).
[10] Hutapea J H, Pernama I G N, Nakazawa A, and Kitagawa T 2005 *Broodstock Management of Yellowfin Tuna (Thunnus albacares) in Controlled Concrete Tubs* (Gondol Bali: Center for Marine Cultivation Fisheries Research).
[11] Sanjayasari D and Kasprijo 2010 *JPK*. 15(2), 89-97 [in Indonesian].
[12] Gunawan, Hutapea J H, Setiadi A, and Mahardika K 2015 *J. Ris. Akuakultur;* 13(4), 309-316 [in Indonesian].
[13] Hutapea J H, Gunawan, Setiadi A, Andamari R, Zafran, and Marzuqi M 2009 *Strengthening Research on Yellowfin Tuna (Thunnus albacares)* Hatchery Technical Report 13 p.
[14] Nybakken J W 1992 *Marine Biology a Ecologist Closer* (Jakarta: PT Gramedia).
[15] Sari L A, Wulansari P D, Nindarwi D D, Arsad S, and Affandi M 2019 *Ecol. Environ. Conserv.* 25 S26-S31.
[16] Sari L A, Purseyto K T, Arsad S, Masithah E D, Setiawan E, and Affandi M 2019 *Pollut. Res.* 38, S27-S32.
[17] Sari L A, Satyantini W H, Manan A, Purseyto K T, and Dewi N N 2018 *IOP Conference Series: Earth and Environmental Science* 137(1).
[18] Syaifudin M, Sulmartiwi L, and Andriyono S 2017 *JAFH* 6(1), 41-47 [in Indonesian].
[19] Putri A D A and Tjahjaningsih W 2018 *JAFH* 7(3), 111-117 [in Indonesian].
[20] Wijaya T S and Hariyati R 2009 *Buletin Anatomi dan Fisiologi* 19(1), 55-61 [in Indonesian].
[21] Pratama N A, Rahardja B S, and Sari L A 2020 *IOP Conference Series: Earth and Environmental Science* 441(1).
[22] Holy N H and Sari L A 2020 *IOP Conference Series: Earth and Environmental Science* 441(1)
[23] Radiarta 2013 *Jurnal Bumi Lestari* 13(2), 234-243 [in Indonesian].
[24] Damayanti K Y, Mubarak A S, and Sari L A 2020 *IOP Conference Series: Earth and
6. Acknowledgement

The authors gratefully acknowledge the publication support from the Annual Work Plan Budget (RKAT) of the Faculty of Fisheries and Marine as well as the instrument laboratory support.