Maintenance and spawning on yellowfin tuna broodstock reared in floating net cage

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Abstract. Yellowfin tuna (Thunnus albacares) is one of the fish species that have important economic value which is expected to become one of foreign exchange that can give solution to national economy. Hatchery technology of yellowfin tuna performed at the Research Institute for Mariculture and Fisheries Extension Gondol has been successfully spawned. However, the quality and quantity of eggs produced is still not optimal. The purpose of this study was to determine the performance of spawning on yellowfin tuna broodstock reared in floating net. This research was conducted in cage with a diameter of 48.8 m with a depth of 8 m, filled 90 fishes yellow fin tuna with weights ranging between 50-70 kg per fish. Feed given is: fresh fish, squid and added vitamin C and vitamin E. The study was conducted for 11 months from January to November 2017. The results showed that the yellowfin tuna could spawn monthly. The highest spawning frequency occurred in July at 17 times. The highest total number of eggs harvested was 8,740,350 in October. Hatching rate between 50-92%. Survival activity index (SAI) is 1.8-3.5%. Survival rate of yellow fin tuna during maintenance reached 92.2%.

1. Introduction
The technology of yellowfin tuna hatchery has begun to show results in line with the implementation of activities carried out through several stages starting with the success of its spawning and the technological ability of its seed maintenance to reach more than 60 days. As is the case with the success of marine fish species: milkfish, grouper, snapper and others, that is, it begins with larval maintenance technology with low survival. With the passage of time, gradually the technology can be mastered well until it succeeds in mass production of its seeds. Likewise for yellowfin tuna, we must recognize the biological properties of these fish in nature. Yellowfin tuna or what is often called yellowfin-tuna is one of the important export commodities for Indonesia. One of the main characteristics of yellowfin tuna is the yellow stripe running along the left and right sides of the tuna. The yellow line will appear clear when exposed to light. They live in groups and move so fast that they are difficult to catch.

The potential of yellowfin tuna in Indonesia is very large because this type of tuna is the largest species found in Indonesian marine waters. As is well known, Indonesia is one of the countries with the highest potential for tuna in the world. Recorded total tuna production reached 613,575 tons per year with a sales value of Rp. 6.3 trillion per year. As much as 70% of Indonesian tuna production is exported to Thailand, China, Japan, the United States and the European Union. Nevertheless, tuna is facing a number of challenges, including: decreased productivity, its size continues to decrease, and fishing areas tend to go to the open seas. While the Indonesian fisheries management area , the status of the exploitation level of albacore tuna, yellowfin, big eye and bluefin tuna is very worrying with the...
status of being fully exploited to over exploited. Currently, tuna production still relies on catches from nature so that to preserve it, knowledge about reproduction is very important. Research on the reproductive aspects of yellowfin tuna has been conducted at the Research Institute for Mariculture and Fisheries Extension Gondol Bali. The results of the first yellowfin tuna spawning at BBPPBL Gondol occurred in October-November 2004 for 10 days. The number of eggs produced ranges from 7,000-122,000 eggs / spawning. Egg diameter ranged from 840-990 µm with a hatching rate of 0-51.5%. The size of the yellowfin tuna broodstock spawning between 16-25 kg / fish [1].

Research on the reproduction of yellowfin tuna (Thunnus albacares) is still being carried out in stages. Several studies that have been conducted include: tuna fishing research [2]; domestication of prospective tuna broodstock; the life cycle of indoparasites that infect tuna eggs; aspects of reproduction [3]. Observation of spawning and development of yellowfin tuna embryos (Hutapea et al., 2017); size of tuna caught in deep sea and shallow sea FADs [4] and estimated tuna production in Benoa Bali [5]. Furthermore, conducting research on the spawning of yellowfin tuna broodstock in floating net cage and in a controlled tank, as well as evaluating the productivity of the broodstock and the enlargement of yellowfin tuna. However, the quality and quantity of eggs and larvae obtained are still not optimal. The number of eggs, the hatching rate is still fluctuating, the resulting larvae cannot mass produce seeds for the first generation (G-1) broodstock prospective. Therefore, research on yellowfin tuna broodstock is still being carried out to obtain spawning techniques and larval rearing techniques such as successful hatchery of milkfish, humpback grouper [6] and other marine fish. This study aims to determine the continuity of spawning of yellowfin tuna broodstock reared in floating net cages. The target to be achieved is the production of high quality eggs to support the success of seed production.

2. Methodology
Using 1 floating net cage with a diameter of 48.8 m and a net depth of 8 meters. Floating net cage as a maintenance medium is filled with 90 yellowfin tuna with body weights ranging from 50-70 kg per fish. Yellow fin tuna feed is given in the form of fresh fish, squid and added Vitamin C and Vitamin E. The amount of feed given is between 3-5 percent of biomass. Feed is given once a day in the morning. This research was conducted for 10 months, from January to November 2017. The cleanliness of the nets must always be maintained so that the flow and oxygen in the cage remains optimum. For this reason, cleaning the net is carried out periodically.

The parameters observed were: Spawning frequency, total number of eggs produced, egg diameter, oil globule diameter, hatching rate, life activity index value of newly hatched larvae (SAI) and survival rate of tuna broodstock during the experiment. In addition, analysis of tuna fish eggs includes: total fat content, protein content, EPA and DHA. As supporting data, water quality observations were: temperature, salinity, and water transparency in floating net cage. Data analysis was done descriptively.

3. Results and discussion
During the maintenance of yellowfin tuna broodstock in floating net cages with productive broodstock size, optimal feed management and an environment that is within tolerance, the yellowfin tuna broodstock can spawn well [7]; [8]; [9]. The results of observing the frequency of yellowfin tuna broodstock spawning during the study are listed in (Figure 1). From Figure 1, it can be seen that the yellowfin tuna reared in floating net cage can spawn every month.
Figure 1. Observations on the spawning and harvesting of yellowfin tuna eggs during the experiment

From the observations on the egg collector that has been setting every day, if tuna eggs are found, it means that there is an indication that spawning occurs at night. Thus, it can be seen that the yellowfin tuna spawning that occurred in January to November were 10, 5, 11, 15, 4, 5, 17, 14, 10, 11 and 7 spawning times, respectively. However, not all spawning, the eggs are harvested every day with the consideration that the sea waves are quite large, there is heavy rain, the quality of the eggs is bad and others. Egg harvesting is carried out at night between 23:00 - 03:00, there are many problem that are sometimes technically difficult to harvest.

From Figure 1, it can be seen that the highest spawning frequency is in July and the lowest is in May. If the total number of eggs found in the egg collector is quite a lot more than 1500 eggs, harvesting will be carried out on the following night, depending on the weather or conditions if possible. Egg harvests are carried out every month, and the most in September is 5 eggs harvested, followed by October 4 harvests. However, the highest total number of eggs obtained was in October: 8,740,350 eggs. Therefore, from the results of spawning every month, the harvested amounts from January to November are as follows: 2, 1, 3, 2, 2, 3, 3, 5, 4 and 2 times the harvest of yellowfin tuna eggs. The total number of eggs that were successfully harvested during each spawning was very fluctuation (Figure 2).

The results of research conducted by [10] stated that yellowfin tuna reared in a controlled concrete tank for the first time spawning measuring with body weights 20 kg. Furthermore [11] said that yellowfin tuna kept in floating net cage with a diameter of 50 m with a net depth of 8 m are setting about 300-400 m from the coast with a water depth of 20-30 meters, feed is given of fresh fish and squid (2 : 1) 3-5 percent of the biomass can be spawned every month. This is consistent with the results of a study by [12] which states that yellowfin tuna (Thunnus albacares) spawn throughout the year.
Although yellowfin tuna can spawn every month, the quality and quantity of eggs produced are not always good. This is evident in the presence of a number of fertilized eggs and unfertile as seen in (Table 1 and Figure 3). This case also occurs in other marine fish, such as napoleon fish (*Cheilinus undulatus*), humpback grouper [13] ; [14], tiger pompano fish [15], and cobia fish [16].

Table 1. Observation results of fertilized and unfertile yellowfin tuna eggs

| Month     | Number of eggs (fertilized) | Number of eggs (unfertile) |
|-----------|----------------------------|-----------------------------|
| January   | 997,850                    | 504,150                     |
| February  | 305,000                    | 107,000                     |
| March     | 501,660                    | 154,340                     |
| April     | 1,459,000                  | 414,000                     |
| May       | 200,000                    | 102,000                     |
| June      | 150,000                    | 67,000                      |
| July      | 1,035,985                  | 532,015                     |
| August    | 520,000                    | 200,225                     |
| September | 6,306,647                  | 866,238                     |
| October   | 6,740,000                  | 2,000,350                   |
| November  | 827,000                    | 700,000                     |

It seems that in September of yellowfin tuna which successfully spawned 10 times and was harvested 5 times eggs, the total number of eggs was 7,172,885 eggs. Of the total number of fertilized eggs 6,306,647, and unfertilized: 866,238 eggs (Table 1). Therefore, the highest percentage of fertilized eggs occurred in September. And the lowest occurred in November, 700,000 eggs unfertilized (Table 1 and Figure 3).
Some of the factors that influence the success of spawning include the maintenance environment, the feed given, the age of the fish and the health condition of the fish. Therefore, if these factors are not optimal, the quality of the eggs produced is not good. Some research results suggest that a better feed composition can accelerate the development of gonads and fecundity, such as humpback grouper [17], it can increase the growth of tiger grouper yuwana [18]. Therefore, the optimal feeding of yellowfin tuna that is kept in floating net cage is tried to be as optimal as possible, namely by adding vitamins.

Table 2. Observation results of egg diameter size and oil bubble diameter from the spawning of yellow fin tuna broodstock

| Month   | Egg diameter (μm) | Diameter of oil globule (μm) |
|---------|------------------|-----------------------------|
|         | Avg.  | Max. | Min. | Std.dev. | Avg.  | Max. | Min. | Std.dev. |
| January | 879.5 | 915.7 | 847.9 | 19.7 | 208.6 | 228.9 | 197.6 | 8.5 |
| February| 936.8 | 998.5 | 858.0 | 34.9 | 206.1 | 230.3 | 166.7 | 13.6 |
| March   | 901.5 | 936.9 | 859.1 | 17.6 | 195.7 | 208.3 | 182.0 | 7.5 |
| April   | 876.9 | 920.6 | 847.9 | 21.3 | 188.1 | 208.7 | 150.8 | 12.9 |
| May     | 889.5 | 936.0 | 786.0 | 31.1 | 188.2 | 198.1 | 177.5 | 6.1 |
| June    | 888.2 | 936.2 | 780.9 | 30.7 | 187.5 | 197.8 | 177.7 | 6.8 |
| July    | 892.7 | 931.0 | 842.5 | 19.9 | 200.9 | 218.7 | 187.9 | 7.4 |
| August  | 889.5 | 962.2 | 843.1 | 30.3 | 189.5 | 202.9 | 172.9 | 9.4 |
| September| 880.9 | 920.4 | 826.9 | 22.4 | 189.3 | 213.8 | 182.1 | 9.1 |
| October | 857.0 | 894.8 | 821.9 | 20.8 | 201.0 | 229.8 | 182.5 | 13.4 |
| November| 875.2 | 925.3 | 840.1 | 21.7 | 207.2 | 237.4 | 186.3 | 11.2 |

Some vitamins are also quite well used in feeding marine fish broodstock, such as vitamin C and vitamin E. Vitamin C is a vitamin that is thought to play a role in the reproductive cycle and can affect egg quality. While, vitamin E affects the function of the cell membrane forming egg tissue. One indicator of egg quality is the size of the egg diameter.

Egg quality is a reflection of the chemical composition of the yolk which is influenced by the nutritional state of the feed and the conditions of the broodstock. Egg size can be genetic as indicated by small variations in egg size or as a result of food and environmental influences. Anyway egg size
very important for the survival and growth of the post larvae. The results of observations of the diameter of yellowfin tuna eggs during the study ranged from 857.0 - 936.8 μm, maximum: 998.5 μm and minimum: 780.9 μm. While the diameter of the oil globule is between 187.5 - 208.6 μm, maximum 237.4 μm and minimum: 150.8 μm (Table 2).

The results of this study are in line with the results of research conducted by [19] that the diameter of yellowfin tuna eggs carried out in Japan is > 900 μm and the diameter of the oil bubbles > 200 μm. While, the hatchability of eggs ranged from 50 - 92%, and the life activity index for newly hatched larvae was between 1.8-3.5% (Table 3). From the results of research on marine fish spawning, that eggs that have low hatching rate or below 40% will effect of larvae grow. Such as slow larval growth, and there is often mass death before the larvae are 45 days old. This incident also often occurs in other marine fish such as: humpback grouper [17], napoleon fish and cobia fish [16].

### Table 3. Observations of the range of hatching rate and life activity index of the newly hatched larvae during the experiment

| Month    | Hatching rate (%) | Life activity index of the newly hatched larvae (%) |
|----------|-------------------|-----------------------------------------------------|
| January  | 75 - 80           | 2.1 – 3.0                                           |
| February | 80 - 90           | 1.9 – 2.3                                           |
| March    | 65 - 75           | 2.2 – 3.1                                           |
| April    | 70 - 92           | 2.1 – 3.2                                           |
| May      | 50 - 65           | 1.9 – 2.1                                           |
| June     | 70 - 80           | 2.1 – 3.2                                           |
| July     | 60 - 75           | 1.8 – 2.4                                           |
| August   | 75 - 80           | 2.0 – 3.0                                           |
| September | 85 - 90          | 2.4 – 3.5                                           |
| October  | 80 - 92           | 2.3 – 3.4                                           |
| November | 85 - 90           | 2.2 – 3.3                                           |

### Table 4. Analysis of eggs from the results of the spawning of yellowfin tuna broodstock reared in floating net cages

| No | Parameter Test | Unit | Analysis results Tuna Eggs * | Specifications / Methods |
|----|----------------|------|-------------------------------|--------------------------|
| 1  | Total fat      | %    | 19,22                         | Gravimetric              |
| 2  | Protein        | % BW | 53,86                         | Kjeldahl                 |
| 3  | EPA            | % Relatif | 8,81                   | Cromatography Gas        |
| 4  | DHA            | % Relatif | 18,59                 | Cromatography Gas        |

Survival activity index (SAI) is the ability of newly hatched larvae to live by relying on energy reserves, namely egg yolks and oil granules. From the results of the SAI test (Table 3), it can be seen that the highest index value reaches 3.5%. Testing the resistance of these larvae without being given food and aeration as a source of oxygen. Index of larval life activity is closely related to the quality of the eggs produced. This can illustrate that the higher the SAI value is an indicator of increasing egg
quality, so that it is thought to be able to increase the survival power of the larvae produced. Thus, from the observation that the quality and quantity of eggs produced is quite good, it is expected that the tuna seed production techniques will be successful gradually until prospective tuna broodstock are obtained.

In the formation of egg cells and the development of egg embryos in marine fish, it is necessary to have optimal composition and nutrition through the feed given if the fish are kept in a controlled tank or in floating net cage. In biosynthesis, steroid hormones occur in several stages of the hydroxlation reaction which indirectly accelerates the process of ovarian formation. The results of the analysis of yellowfin tuna eggs carried out at the Integrated Research and Testing Laboratory of Gajah Mada University, Yogyakarta (Table 4) indicate that the quality of eggs from the results of spawning is quite good. Therefore, it is hoped that the mass production of tuna seeds will be resolved and there will be no more problems.

**Table 5.** Total mortality of yellowfin tuna broodstock reared in floating net cage during the experiment

| Date / Month / Year | Standard Length (cm) | Body Weight (kg) | Gonad Weight (g) | Sex (M/F) | Remark   |
|--------------------|----------------------|------------------|------------------|-----------|----------|
| 24-02-2017         | 152                  | -                | -                | -         | Decomposed |
| 27-02-2017         | 114                  | -                | -                | -         | Decomposed |
| 10-04-2017         | 134                  | 40.32            | 566.41           | M         | -        |
| 19-05-2017         | 143                  | -                | -                | -         | Decomposed |
| 19-05-2017         | 128                  | -                | -                | -         | Decomposed |
| 02-09-2017         | 103                  | -                | -                | -         | Decomposed |
| 05-09-2017         | 145                  | 62.70            | 743.79           | M         | -        |

**Table 6.** Water quality parameters in the yellowfin tuna rearing media in floating net cage

| Water quality / Month | Temperature (ºC) | Salinity (ppt)  | Brightness (meter) |
|-----------------------|------------------|-----------------|--------------------|
| January               | 28.0-29.5        | 32.0-34.0       | 5.5-7.5            |
| February              | 28.5-30.0        | 32.0-34.0       | 6.0-8.0            |
| March                 | 28.0-30.0        | 32.0-34.0       | 6.0-7.5            |
| April                 | 28.0-30.0        | 33.0-34.0       | 5.5-8.0            |
| May                   | 28.0-30.0        | 32.5-34.0       | 5.5-7.5            |
| June                  | 28.5-30.0        | 32.0-34.0       | 6.0-8.0            |
| July                  | 28.5-30.5        | 33.0-34.0       | 6.5-8.0            |
| August                | 28.0-30.5        | 32.5-34.0       | 6.5-8.0            |
| September             | 28.5-30.5        | 32.5-34.0       | 5.5-7.5            |
| October               | 28.0-29.5        | 32.0-34.0       | 5.5-7.5            |
| November              | 28.5-30.0        | 32.0-34.0       | 6.0-8.0            |

During the research, from January to November, there was a death of the yellowfin tuna broodstock. Of the 90 yellowfin tuna broodstock kept in the floating net cage, it turns out that 7 of them died. In February 2 fish, April 1 fish, May 2 fish and September 2 fish. This death is suspected because on the date of the month the rainfall is quite high, then there are big waves so that the quality
of the waters in the floating net cage is not good. The dead tuna broodstock has a standard length between 103-152 cm. Two male sexes (Table 5). Thus, the survival of yellowfin tuna broodstock reared in floating net cages during the study was still quite high, namely 92.2%.

The results of the observation of water quality parameters which include: temperature, salinity, water transparency are in the optimal range to support the maturity process of gonads and the spawning of yellowfin tuna reared in floating net cage (Table 6).

4. Conclusion
Yellowfin tuna (*Thunnus albacares*) kept in the floating net cage during the study can spawn every month. The highest spawning frequency occurs in July, which is 17 times. The highest number of eggs harvested was 8,740,350 in October. Hatching rate of eggs is between 50-92%. The index of life activity for newly hatched larvae (SAI) was 1.8-3.5%. The survival rate of broodstock yellowfin tuna during maintenance in floating net cage reached 92.2%.

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