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The Growth Rate of Seabass in Floating Net Cages, Inner Ambon Bay using 1D Ecosystem Model

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Abstract. Inner Ambon Bay is used for fishery research by the government. One of the species that has been cultivated is seabass because it has high economic value. Seabass cultivation in floating net cages has been developed by Ambon Marine Aquaculture Institute (BPBL-Ambon). The characteristics of seawater in Inner Ambon Bay (IAB) based on the observation data in the project "Ocean Current System of Indonesia Waters and Its Effect on Marine Fisheries Production" in May 2017 show that the temperature is in the range 29.8 – 30.9 °C. Meanwhile the salinity is about 26.1 – 31.4 PSU and the chlorophyll concentrations as much as 0.88 – 3.61 mg/m^3. The 1D ecosystem model simulation is performed to know how is the growth rate of seabass is with two-way interaction between nutrient, phytoplankton, zooplankton, and detritus (NPZD) towards zooplanktontivor (fishes which consume zooplankton). The verification of model result (fish mass) with the observation data of fish mass which conduct by BPBL Ambon show the RMSE value is 0.001 kg and the correlation is 0.99. The nutrient concentration since 2016 – 2018 in the range of 3.08 – 3.78 mmolC/m^3. While the phytoplankton, zooplankton, and detritus concentration during 3 years each one is 4.67 – 5.84, 11.53 – 15.77, and 16.88 – 20.67 mmolC/m^3. The fastest growth rate of Seabass with the first scenario is 1.52 grams/day with the duration of 257 days and when the juvenile of seabass spread in January. The fastest growth rate of Seabass with addition feed is 2,23 grams/day during 175 days.

1. Introduction

Ambon Bay is divided by Inner Ambon Bay (IAB) and Outer Ambon Bay (OAB). IAB is the center for cultivation development which managed by Ambon Marine Aquaculture Institute or Balai Perikanan Budidaya Laut (BPBL-Ambon). There are many species of fishes such as Grouper, Pomfret, Seabass, shrimp, and other fishes [1]. Seabass is one of the leading commodities which has high economical because disease resistant, fast growth rate, and easy nursing [2]. Seabass or Barramundi (*Lates calcarifer*) is one of the big demersal that live in the bottom of waters [3]. It can live in the sea which has width salinity range or we can also call euryhaline [4]. Barramundi or Seabass is catadromous [5] which spawn in the sea then grow to maturity in the river [6]. Thus, seabass can be cultivated in fresh water and saline water [7].

Seabass is found in the waters north Java, eastern Sumatra, Kalimantan, South Sulawesi, Tiworu Strait, and Arafura [8]. It can grow up to 3 – 5 kg in weight [9] with a life period of 2 – 3 years [10]. Seabass is also a protandrous hermaphrodite fish [11] that is able to change male sex to female [12].

Types of adult seabass including carnivores [13] or animal eater such as small fish and shrimp [14]. Meanwhile, the juvenile is omnivore [15] which eats basal feed such as zooplankton and phytoplankton or commercial vegetarian feed [16]. The seabass adult with a large body size tends to be silent and wait for prey to eat [17] while the young seabass is actively looking for food [18]. Naturally, seabass until the age of 2 years will live in freshwater [19], while when the seabass is mature or aged 3 – 4 years it will migrate to the estuary and head to the sea for the spawning process [20].

The seabass cultivation in the floating net cage has been researched by the Center for Marine Cultivation Research and Fisheries Extension in Buleleng, Bali [21]. The development of seabass cultivation is carried out because large amounts of fishing cause depletion or extinction [22]. The seabass cultivation in floating net cage should fulfil several criteria such as contain dissolve oxygen with the concentration more than 4 ppm, salinity ranges 10 – 35 PSU, the sea temperature about 26 – 32 °C with pH between 7 – 8.5, nitrite concentration less than 1 ppm and ammoniac less than 0.1 ppm [23]. Meanwhile, the mean of temperature in IAB throughout 2015 was 26 °C in August (southeast season), 27.27 °C in November (transition season II), 30.58 °C in February (northwest season), and 29.95 °C in April (transition season I) [24]. The concentration of dissolved oxygen at Ambon Bay, In February 2009 ranged from 4.424 to 6.091 ppm on the surface layer and 1.671 to 6.128 ppm in the bottom waters, while dissolved oxygen concentration in July 2009 ranged from 4.195 to 6.471 ppm on the surface and a value of 3.347 to 5.801 ppm in the bottom layer of the waters [25]. Salinity in IAB based on the observation in May 2016 ranged 33.3 – 34.2 PSU [26].

Seabass has been cultivated in the floating net cages at Tual City and Ambon City, Maluku [27]. However, the government only spread the juveniles until they grow up and ready to harvest. The government has not developed a cultivation using fishery model that could make prediction and the efficient time to spread the juvenile until harvesting by knowing the growth rate. However, in this research will be focusing to make simulation with 2 interactions between nutrient, phytoplankton, zooplankton, and detritus (NPZD) and the fish which will be concern to Seabass [28].

2. Methodology

2.1 Location of Research and Data

The study area of current research is Inner Ambon Bay that shows in the map below which marked by red points **Figure 1**. There are 8 points to know the distribution of salinity, temperature, and chlorophyll concentration in the surface. As geographic position of the points can be seen in **Table 1**. Meanwhile the location for the model simulation only focusing in point 3. The location is an area of seabass cultivation in floating net cages which conducted by Ambon Marine Aquaculture Institute. The data used to determine the condition of Ambon Bay waters in the form of temperature, salinity, and chlorophyll concentration in May 2017 obtained from a survey that has been carry out in the project "Ocean Current System of Indonesia Waters and its effect of Marine Fisheries Production". The simulation using data nitrate concentration and temperature during 4 years (2015 – 2018) as a model input. Data of temperature and nitrate concentration obtained from Ambon Marine Aquaculture Institute. The verification of fish mass using data of seabass mass in floating net cage with time to spread in February 2018 obtained from Ambon Marine Aquaculture Institute.

Table 1 Geographical position of the points

Point	Longitude (°S)	Latitude (°E)
1	3.63848	128.2385
2	3.64845	128.2275
3	3.63529	128.2312
4	3.63761	128.2164
5	3.64548	128.1975
6	3.64846	128.2141
7	3.65836	128.2035
8	3.66281	128.1951

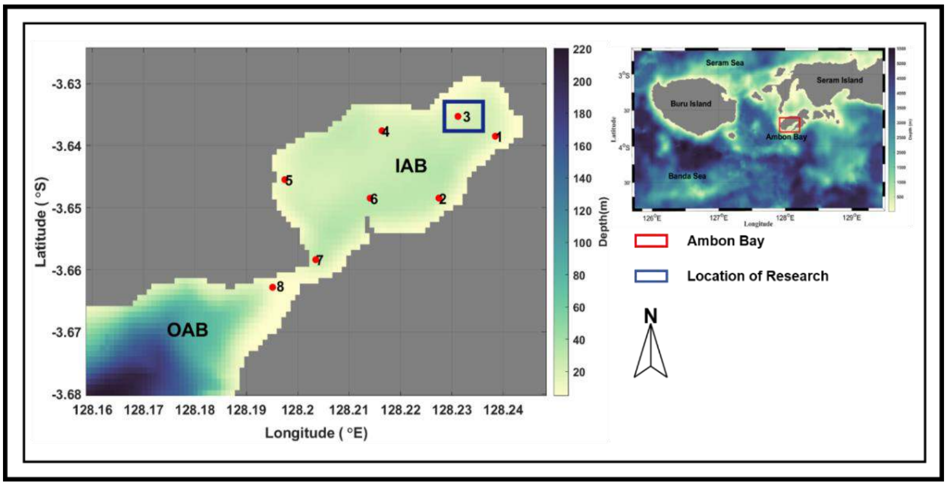

Figure 1 Location of research (blue rectangle) is located of Seabass cultivation in floating net cages [29]

The initial value of nitrate concentration is 0.546 mmolC/m^3 that the average of observation data during 4 years (2015 – 2018). Meanwhile for the phytoplankton is 0.072 mmolC/m^3 and zooplankton is 0.237 mmolC/m^3. The phytoplankton concentration came from National Aeronautics and Space Administration [30]. While the zooplankton concentration is the average of copepods concentration which dominated in Maluku and Ambon Sea [31]. The zooplankton concentration used for the initial value is the average of copepods concentration in the Maluku waters and Banda Sea from the National Oceanic and Atmospheric Administration [32]. The initial value of detritus is zero, because we assume there is no death organism which change into detritus. In this research simulate 2 scenarios using only natural feed and natural feed with addition feed.

2.2 Governing Equation in the Model

In this research, simulate 1 dimensional ecosystem model therefore only a point. There is no boundary condition and no effect of current. The result only compute NPZD concentration depend on time. The simulation of NPZD can be calculated using the equations (1) to (7). The equation (1) shows about the nutrient uptake $(M(N))$. Nutrient uptake is nutrient which need and absorbed by phytoplankton as their nutrition. The value of nutrient uptake $(M(N))$ in equation (1) is influenced by the intensity of sunlight (r), the bulk nutrient variable (N^2), and the integration of the square of half saturation (α) with the bulk nutrient. The main nutrient of phytoplankton are nitrate, phosphate, and silica. However, in this research only use nitrate concentration because this concentration had absorbed by phytoplankton in large amount [33]. The equation (2) used to calculate sunlight intensity (r). It is affected by the maximum sunlight absorbed for nutrient uptake (r_{max}), temperature (T), (T_0) is the minimum temperature limit for the phytoplankton growth which depends on latitude position (θ), a half of day length from noon until in the next day $\left(\Delta d(t)\right)$ in IAB, and the exponential of half saturation (α) with temperature (T). Equation (3) shows that changes in nutrient concentration are affected by the concentration of nutrients needed by phytoplankton $(M(N))$, the concentration of phytoplankton metabolic waste $(l_{PN}P)$, the rate of mineralization of detritus into nutrients $(l_{DN}D)$, the concentration of zooplankton metabolic waste $(l_{ZN}Z)$, nutrients derived from the fish respiration process (l_{FN}), and nutrients derived from the carbon conversion process using the Redfield ratio $\left(Q_N^{import}\right)$. The Redfield ratio states the ratio of carbon (C), nitrogen (N), and phosphorus (P) atoms found in phytoplankton and water. Equation (4) states the change in the concentration of phytoplankton with time. The concentration of phytoplankton will increase if the concentration of nutrients needed by phytoplankton was higher. The decrease in phytoplankton concentration was influenced by the concentration of phytoplankton metabolic residues, the feeding rate of zooplankton to phytoplankton $(g(P)Z)$, and the rate of phytoplankton death $(l_{PD}P)$. The change of zooplankton concentration with time based on equation (5) will increase if the feeding rate of zooplankton to phytoplankton was higher and the decrease in zooplankton concentration is influenced by the concentration of metabolic waste of zooplankton, zooplankton mortality rate, and zooplankton mass flux, namely the number of concentration of zooplankton eaten by zooplanktontivores. Increased detritus concentration with the time in equation 6 is affected by the death rate phytoplankton and zooplankton, and also the rate of change of fish into detritus L_{FD}. The detritus concentration will decrease if the rate of detritus mineralization and the rate of detritus are high deposited into sediment $(L_{DD_{sed}})$. Equation (6) showed the change of detritus deposited over time is affected by the rate at which detritus is deposited and bulk detritus. The equation (7) stated the change of detritus into sediment $\left(\frac{dD_{sed}}{dt}\right)$ influenced by detritus rate deposited into sediment $\left(L_{DD_{sed}}\right)$ and the amount of detritus in the water (D).

$$M(N) = \frac{rN^2}{\alpha^2 + N^2} \tag{1}$$

$$r = r_{max}\theta(T - T_0)\Delta d(t)\exp(\alpha T) \tag{2}$$

$$\frac{d}{dt}N = -M(N)P + l_{PN}P - l_{DN}D + l_{ZN}Z + Q_N^{import} + L_{FN} \tag{3}$$

$$\frac{d}{dt}P = M(N)P - l_{PN}P - g(P)Z - l_{PD}P \tag{4}$$

$$\frac{d}{dt}Z = g(P)Z - (l_{ZD} + l_{ZN})Z - G_F \tag{5}$$

$$\frac{d}{dt}D = l_{ZD}Z + l_{PD}P - \left(l_{DN} + l_{DD_{sed}}\right)D + L_{FD} \tag{6}$$

where;

$$\frac{dD_{sed}}{dt} = l_{DD_{sed}}D \tag{7}$$

The availability of zooplankton will affect the growth of zooplanktontivor. In this research, zooplantontivor are teleost and crustacea. The high growth rate of zooplanktontivor will affect the productivity of seabass which is a zooplanktontivor predator. The zooplankton mass flux (G_F) is influenced by several variables in equation (8). The parameter (f_{con}) is unit conversion factor of gkm^{-3} to mmolCm^{-3}, $\left(g_i^x(Z)\right)$ is consumption rate maximum food of an individual in the class. The symbol of x includes crustacea (cr), teleost (tel), and seabass (sb). (B_i^x) is the rate of biomass for each class. The symbol of (L_{FN}) in equation (9) expressed the integration of the NPZD model with the fish growth rate model. The value of (L_{FN}) is the integration of nutrient inputs derived from respiration rate of teleost, crustacea, and seabass which are influenced by the total of biomass for each class. While the (L_{FD}) in equation (10) described the rate of fish change into detritus which is influenced by the rate of excretion $\left(L_{x_iD}\right)$ and mortality $\left(\mu_{x_i}\right)$.

$$G_F = f_{con}\left[\sum_{i=1}^{5} g_i^{cr}(Z)B_i^{cr} + \sum_{i=1}^{6} g_i^{tel}(Z)B_i^{tel} + \sum_{i=1}^{2} g_i^{sb}(Z)B_i^{sb}\right] \tag{8}$$

$$L_{FN} = f_{con}\left[\sum_{i=1}^{5} L_{CR_iN}B_i^{cr} + \sum_{i=1}^{6} L_{TEL_iN}B_i^{tel} + \sum_{i=1}^{7} L_{SB_iNB_i^{sb}}\right] \tag{9}$$

$$L_{FD} = f_{con}\left[\sum_{i=1}^{5}\left(L_{CR_iD} + \mu_{CR_i}\right)B_i^{cr} + \sum_{i=1}^{6}\left(L_{TEL_iD} + \mu_{TEL_i}\right)B_i^{tel} + \sum_{i=1}^{7}\left(L_{SB_iD} + \mu_{SB_i}\right)B_i^{sb}\right] \quad (10)$$

The effective growth rate model of seabass is expressed using equation (11) which is influenced by the total feed consumed by seabass $\left(g_i^{tel,cr}\right)$ and rate of depletion of nutrients and detritus. Equation (12) depends on the maximum growth rate of teleost and crustacea which is influenced by the availability of zooplankton $\left(g(Z)\right)$, Eppley factor is the effect of temperature on phytoplankton and zooplankton, and interannual grazing variation $\left(Q(t)\right)$. The loss rate concentration of nutrients and detritus formulated in equation (13) and (14). The value of 0.0625 is a constant based on the formula by Fennel and Neumann [28]. Equation (15) show that the availability of zooplankton is influenced by the exponential value of zooplankton with the Ilev factor ($I_Z = 1\ \mathrm{m}^3/\mathrm{mmolC}$). Eppley factor $\left(A(t)\right)$ in equation (16) is affected by the reference temperature $\left(T_{ref} = 18\ ^\circ\mathrm{C}\right)$; $a = 0.063/^\circ\mathrm{C}$; $b = 0.106/^\circ\mathrm{C}$; $c = 0.002/^\circ\mathrm{C}$; and Θ is step function. Equation (17) calculate grazing variation interannual which influenced by the season in Indonesia especially in Ambon Bay which express by parameter d.

$$g^{eff} = g_i^{tel,cr} - L_N - L_D \quad (11)$$

where;

$$g_i^{tel,cr} = g_{tel_icr_i}^{max}\, g(Z)A(T)Q(t) \quad (12)$$

$$L_N = 0.0625\left[g_i^{tel,cr} + 0.5A(T)Q(t)g_{tel_icr_i}^{max}\right] \quad (13)$$

$$L_D = 0.0625 g_i^{tel,cr} \quad (14)$$

$$g(Z) = [1 - \exp(-l_Z Z)] \quad (15)$$

$$A(T) = \Theta\left(T_{ref} - T\right)\exp(\alpha\, T) + \Theta\left(T - T_{ref}\right)\exp(bT - cT^2) \quad (16)$$

$$Q(t) = [\Theta(t - d_0) - \Theta(t - d_{365})](t - d_0)\frac{0.9}{d_{220}} \quad (17)$$

The simulation of the ecosystem model used in the research is also influenced by mass class for the seabass as the main predators in cages, teleost as seabass feed at a mass of more than 100 grams, crustaceans as feed for barramundi at a mass of more than 50 grams, and seabass at a mass less than 50 grams will consume zooplankton as their main feed. The growth rate of seabass is influenced by the mass class listed in **Table 2**. The mass of seabass harvested in floating net cage cultivation in IAB is 300 – 400 grams, while the mass of seabass harvested in cultivation by the general public is 500 grams.

Table 2 Mass of Seabass, Teleost, and Crustacean [28]

Class	Mass (gram)		
	Teleost	Crustacean	Seabass
1	2 ≤ mass < 5	2 ≤ mass < 5	2 ≤ mass < 10
2	5 ≤ mass < 10	5 ≤ mass < 10	10 ≤ mass < 35
3	10 ≤ mass < 30	10 ≤ mass < 15	35 ≤ mass < 100
4	30 ≤ mass < 60	15 ≤ mass < 20	100 ≤ mass < 200
5	60 ≤ mass < 150	20 ≤ mass < 35	200 ≤ mass ≤ 400
6	150 ≤ mass < 240	-	401 ≤ mass < 800
7	-	-	800mass < 1500

2.3 The Verification of Model Result

The verification for model simulation using observation data. The model simulation result in the form of fish mass using the mass of seabass in the floating net cage obtained from Ambon Marine Aquaculture Institute. The model verification uses several statistical parameters, namely Root Mean

Square Error (RMSE) and Correlation Coefficient (CC). As mathematically can be expressed by equation 18 and 19.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(y_i - x_i)^2}{n}} \quad (18)$$

$$CC = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2(y_i - \bar{y})^2}} \quad (19)$$

where;

x_i	= model result data	$\bar{y}$	= average of observation result
$\bar{x}$	= average of model result	n	= amount of data
y_i	= observation data	i	= data sequence

3. Result and Discussion

3.1 Physics Condition

The **Figure 2 (a)** shows the distribution of surface salinity in IAB ranges 26.1 - 31.4 PSU. The lowest salinity in point 1. Based on monitoring data in IAB, sea surface salinity in the southeast monsoon ranged from 32.12 - 33.98 PSU. The salinity which is located in the west of IAB was lower than the in the upstream of IAB. This condition influenced the transport process of nutrients and plankton from the bottom to the surface. The process affected algae bloom in IAB waters. Meanwhile, based on monitoring data in 2016, the salinity in April was about 30.67 - 33 PSU, in July ranged 26.31 - 33.47 PSU, and in October was in the range 31.09 – 34.03 PSU. The value of salinity was lower than in OAB because it was found 13 rivers that empties in IAB.

While, the sea surface temperature in IAB based on **Figure 2 (b)** had the highest value in the range of 29.8 °C – 30.9 °C. In 2014 monitoring data showed the distribution of sea surface temperature in February, was in the range of 28.63 °C – 29.94 °C. While in July, the temperature was about 26.31 °C – 26.91 °C. Based on monitoring in 2016, the sea surface temperature in March, April, July, and October, respectively in the range of 29.87 °C – 31.06 °C, 29.36 °C – 31.22 °C, 25.82 °C – 27.15 °C, and 28.71 °C – 30.55 °C. The distribution of sea surface temperature was highest in northwest monsoon, after that would decrease in transition 1 monsoon until in southeast monsoon (the lowest temperature). Then the temperature would increase in transition 2 monsoon. The oceanographic parameters in IAB include salinity and temperature accomplish the criteria for seabass cultivation using floating net cage. The comparison of salinity and temperature from observation data with the reference shows on **Table 3**. The distribution of chlorophyll concentration in the surface based on **Figure 2 (c)** ranged between 0.88 – 3.61 mg/m^3. The lowest chlorophyll concentration was in point 2 while, the highest chlorophyll concentration was in point 3.

The conditions in IAB include physics, chemical, and biology parameters that are affected by the condition in OAB which is directly adjacent to the Banda Sea. Furthermore, the geographic condition in IAB is as the estuaries of some rivers that can influence temperature and salinity. The observation data in Ambon Bay was taken in 2017 with 8 points which can represent the spatial distribution in IAB. The data include temperature, salinity, and chlorophyll concentration.

Figure 3 explain the vertical profile of temperature, salinity, and chlorophyll concentration at point 3 which is the location of cultivation. The maximum depth is 46 m. In **Figure 3 (a)** shows the vertical profile of salinity in the surface until 5 m ranged 31 – 33.4 PSU. Meanwhile, the depth after 5 m was stable in the range 33.5 – 33.7 PSU. The profile of temperature in **Figure 3 (b)** ranged 28.5 – 29 °C, then the value decreases with increasing depth. The pattern of chlorophyll concentration is the same as the temperature profile. **Figure 3 (c)** shows that on the surface, the concentration is about 0.9 – 1.6 mg/m^3. The chlorophyll concentration also decreases until 0.6 mg/m^3 in the maximum depth. The chlorophyll concentration is influenced by sun intensity.

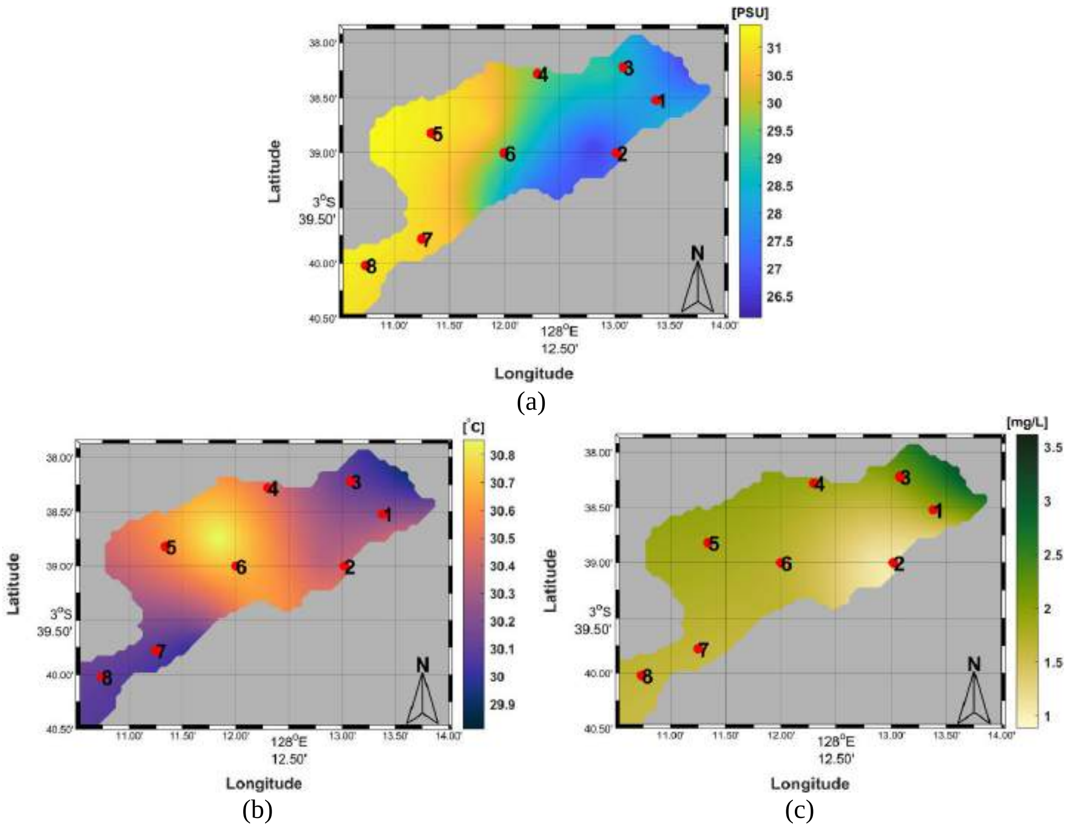

Figure 2 Distribution of (a) Sea Surface Salinity, (b) Sea Surface Temperature, (c) Surface Chlorophyll Concentration at IAB in May 2017

Table 3 The Comparison of Water Condition in IAB with the Optimum Water Condition for Seabass Cultivation []

Parameters	**Condition in IAB**	**Optimum Condition for Cultivation**
Temperature	25.8 – 31.22 °C	26– 32 °C
Salinity	26 – 34.03 PSU	10 – 35 PSU

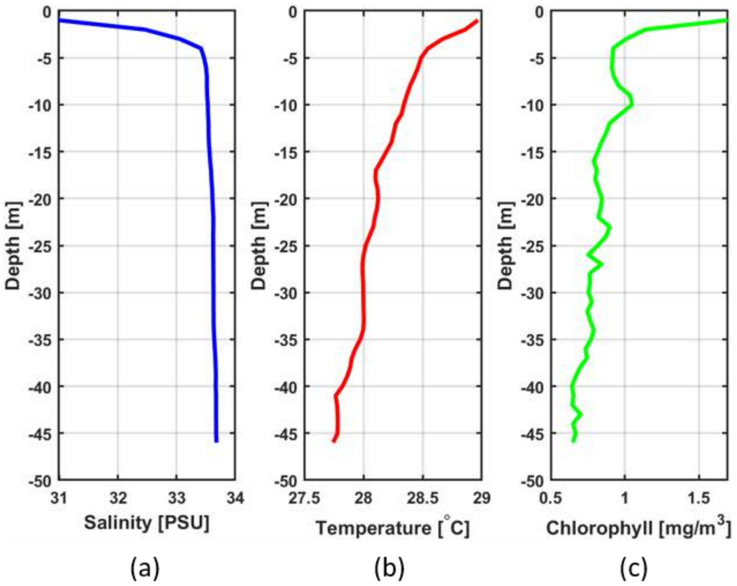

Figure 3 The Vertical profile of (a) salinity, (b) temperature, and (c) chlorophyll concentration in point 3

3.1. Simulation Result for NPZD concentration

In **Figure 4** shows temperature and nitrate concentration which are used as input model. The data are used as input during 4 years. It would start in January 2015 until December 2018 which is per day. The daily temperature in the figure shows that throughout 2015 - 2018 in the range 25.2 - 31.5 °C. The lowest temperature occurred in August 2015, meanwhile the highest temperature in November 2016. In **Figure 4** shows nitrate concentration in the floating net cages in IAB during 2015 - 2016 in the ranges 0.5 - 1.4 mmolC/m^3. The highest nitrate concentration occurred in October 2017. Meanwhile the concentration in the early and the middle of 2015, the early and the end of 2016, 2017, also throughout 2018. Nutrient concentrations fluctuate every year depending on the season. In **Figure 4** shows nutrient concentrations have an opposite pattern with temperature. In 2016 - 2018, the concentration of nutrients is minimum in the early and the year, however, it reaches a maximum in the middle of the year or during the southeast season.

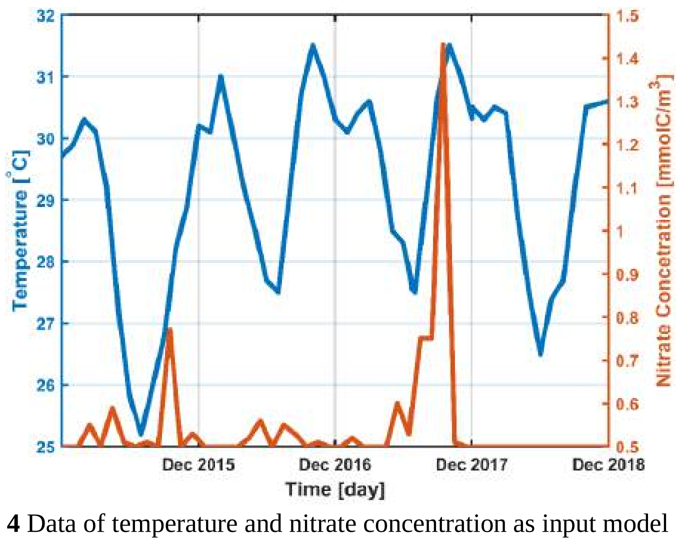

Figure 4 Data of temperature and nitrate concentration as input model

Meanwhile, the output model of nutrient concentration wass affected by the rate of detritus into nutrients ($L_{DN}D$). The nutrient concentration would increase when the water had an optimum temperature of around 27 - 28 °C. The highest nutrient concentration was in October 2017 about 1.4 mmolC/m^3. Meanwhile, **Figure 5** show the nutrient concentration as output model was in the range of 3.48 mmolC/m^3. The difference between input and output was 2.08 mmolC/m^3. It shows the output of nutrient concentration has been integrated with other parameters which affect the enhancement of nutrient concentration.

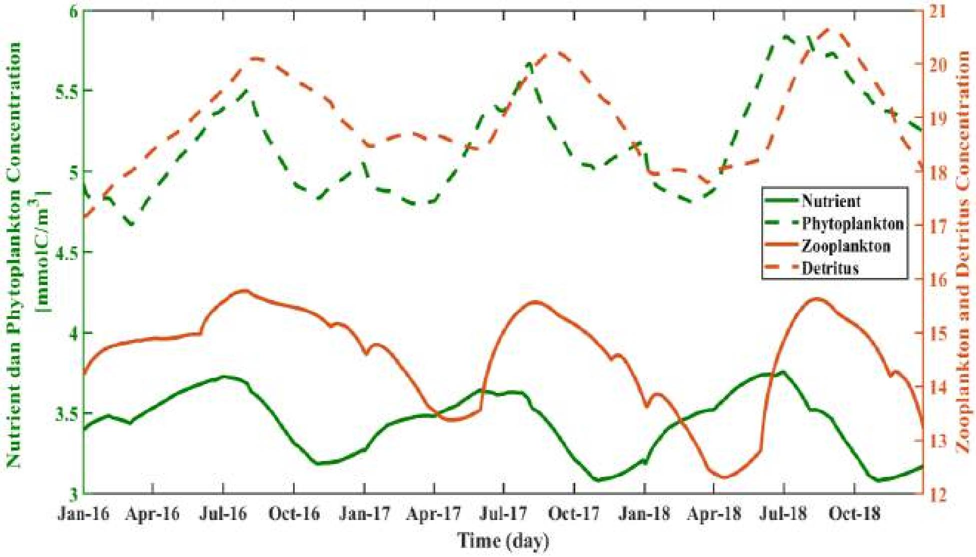

Figure 5 Nutrient, Phytoplankton, Zooplankton, and Detritus Concentration based on Model Simulation

Figure 5 shows the NPZD concentration during 3 years (2016 - 2018) in the floating net cages after the juveniles were stocked. The phytoplankton concentration had the same pattern as the nutrient concentration. When the nutrients increased, which occurred in the middle of the year, it would be followed by the enhancement of phytoplankton concentration. The zooplankton concentration also followed the pattern of phytoplankton concentration. However, there was a time lag between phytoplankton and zooplankton patterns. When the concentration of phytoplankton rises, the zooplankton concentration would increase in the next few days. The detritus concentration had a similar pattern with the zooplankton concentration with a gap of several days. A lag of several days was the life duration of zooplankton until they perished and were changed into detritus.

The nutrient concentration in 2016 that shows in **Figure 5** ranged 3.18 - 3.78 mmolC/m^3, in 2017 reaches 3.08 - 3.64 mmolC/m^3, and in 2018 about 3.09 - 3.76 mmolC/m^3. In 2016 phytoplankton concentration reached 4.67 - 5.5 mmolC/m^3 and in 2017 between 4.8 – 5.7 mmolC/m^3. Meanwhile in 2018 it was in the range of 4.8 - 5.84 mmolC/m^3. The zooplankton concentration in 2016 was 13.36 - 15.77 mmolC/m^3, it reached 12.29 - 15.56 mmolC/m^3 in 2017 and it was around 11.53 - 15.63 mmolC/m^3. While the concentration of detritus in 2016 until 2018 each one reached 18.4 - 20.1 mmolC/m^3, 17.78 - 20.23 mmolC/m^3, and 16.88 - 20.67 mmolC/m^3.

3.2. Fishery Simulation Result

The **Figure 6** shows the comparison between the fish mass from floating net cage in IAB and fish mass as a model result. The graph in **Figure 6** shows the line had same pattern. Then the calculation for the value of root mean square error and correlation coefficient. The result show that the RMSE is 0.006 kg or 6 grams, while for the correlation coefficient show the result is 0.99. For these parameters, we can see the model has good result.

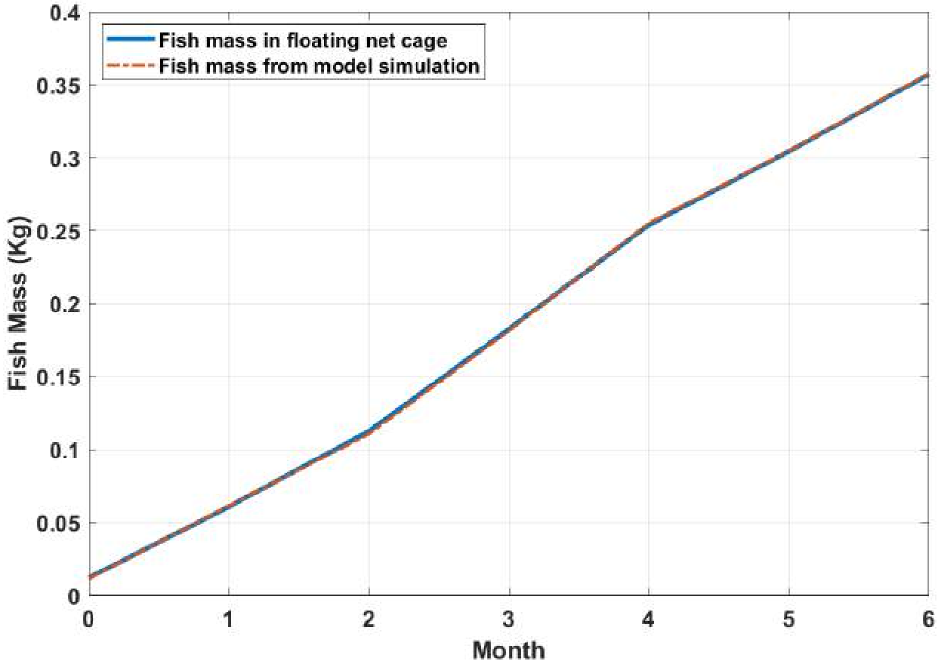

Figure 6 The comparison of fish mass in cage with model simulation result

3.2.1. *Using Natural Feed.* The growth of seabass with scenarios using only natural feed was carried out to determine the level of water quality that affects the growth of seabass. The growth of seabass with the spread time for fishes which have mass 10 grams (mass class 2) carried out at the end of February until the harvest period with a mass of 300 - 400 grams (mass class 5). The mass class of seabass can be seen in **Table 4**. Seabass in mass 2 would grow to a mass of fewer than 35 grams. The growth duration of seabass in class 2 took 72 days. The growth of seabass in mass class 3, with a mass of 35 to 100 grams took 113 days. Meanwhile, the growth of mass classes 4 and 5 respectively took 75 and 59 days. The growth duration of seabass with time to spread in February was 319 days with a growth rate of 1.22 grams/day as shown in **Figure 8**.

The growth of seabass with time to spread in cages from January to December can be seen in **Figure 8**. The growth of seabass with natural food is fastest when the time to spread is carried out in January with the growth duration of 257 days and the growth rate of 1.52 grams/day. The figure shows the growth of seabass with time to spread in January with the growth duration of mass class 2 which is shown in Figure took 70 days, during 43 days in mass class 3, 36 days on mass class 4, and 104 days on mass class 5. The longest growth of seabass occurred when the spread time is carried out in September. The growth duration of seabass is 345 days with a growth rate of 1.13 grams/day. The growth duration of seabass in mass class 2 took 75 days, 65 days for fish which was in mass 3, the fish in class mass 4 and 5 respectively need 78 and 127 days.

The availability of feed in the form of zooplankton, crustacean, and teleost in **Figure 7** has an average of 304 grams for zooplankton, 887.6 grams for crustacean, and 528.5 grams for teleost. The availability of natural food affects the growth of seabass with the fastest in January and the longest in September. In January the mass of zooplankton increased until March then decreased until October. The first 3 months after spread time, the seabass consume zooplankton. After that in the next month, seabass consumed crustacean as its main feed. Crustacean would increase in June, thus it would accelerate the growth of seabass with a mass of more than 100 grams. The growth of seabass at the spread time in September was the longest due to the availability of feed in the form of zooplankton which continued to decline until the beginning of the following year, thus greatly affecting the slow growth of seabass in the nursery phase. Seabass at a mass of more than 50 grams began to use crustacean as their main feed. However, the crustacean mass began to increase in July and were maximum in October. Teleost has eaten by seabass at a mass of more than 100 grams is not optimal to accelerate the growth of seabass because the average availability is only 528.5 grams. The availability of natural feed has not been able to supply the feed used for the growth of seabass. The availability of natural feed has not been able to supply the needs of the feed used for the growth of seabass. The feed requirement of seabass used for optimal growth can be shown in **Table 4**.

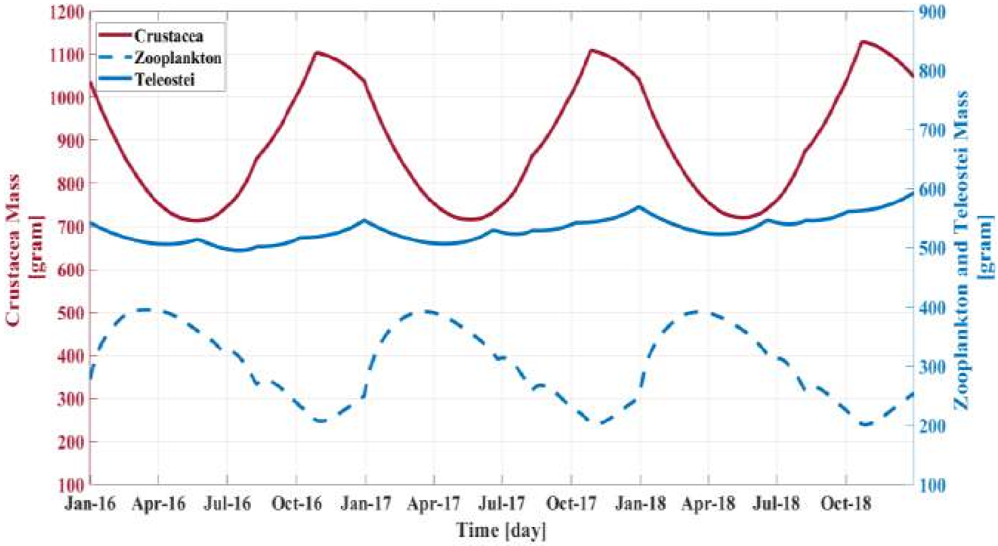

Figure 7 The Availability of natural feed for seabass in the floating net cage, IAB

Table 4 The Availability of Feed for Seabass with mass 10 – 400 grams [34]

Mass Class	Mass (gram)	The Needs of Feed (%) from Fish Mass	The Needs of Feed (gram) from Fish Mass
2	10 ≤ mass < 35	5 – 10 %	0.5 - 1 ≤ mass< 1.75 – 3.5
3	35 ≤ mass < 100	5 – 10 %	1.75 – 3.5 ≤ mass < 5 – 10
4	100 ≤ mass< 200	3 – 5 %	3 – 5 ≤ mass < 6 – 10
5	200 ≤ mass ≤ 400	3 – 5 %	6 – 10 ≤ mass < 12 – 20

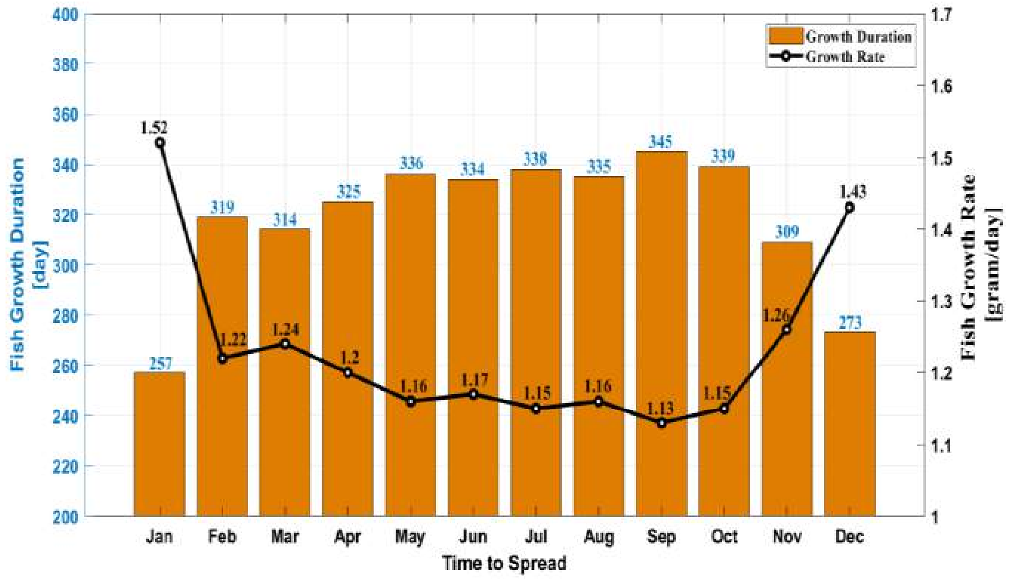

Figure 8 The growth duration and growth rate of seabass using natural feed simulation

3.2.2. Using Natural and Addition Feed

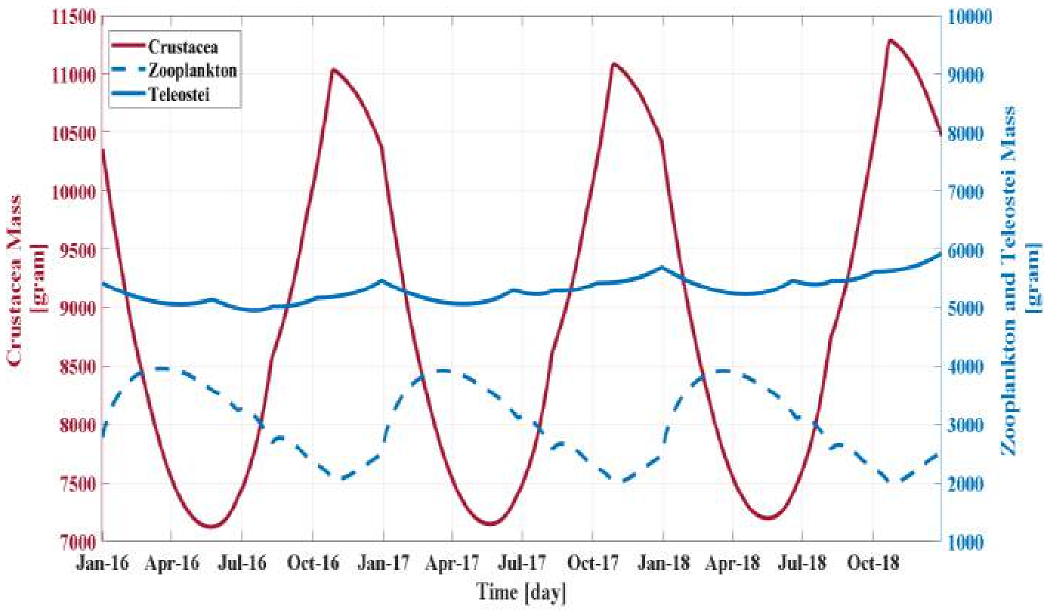

Figure 9 The availability of feed for seabass (natural feed with addition feed) in the floating net cages, IAB

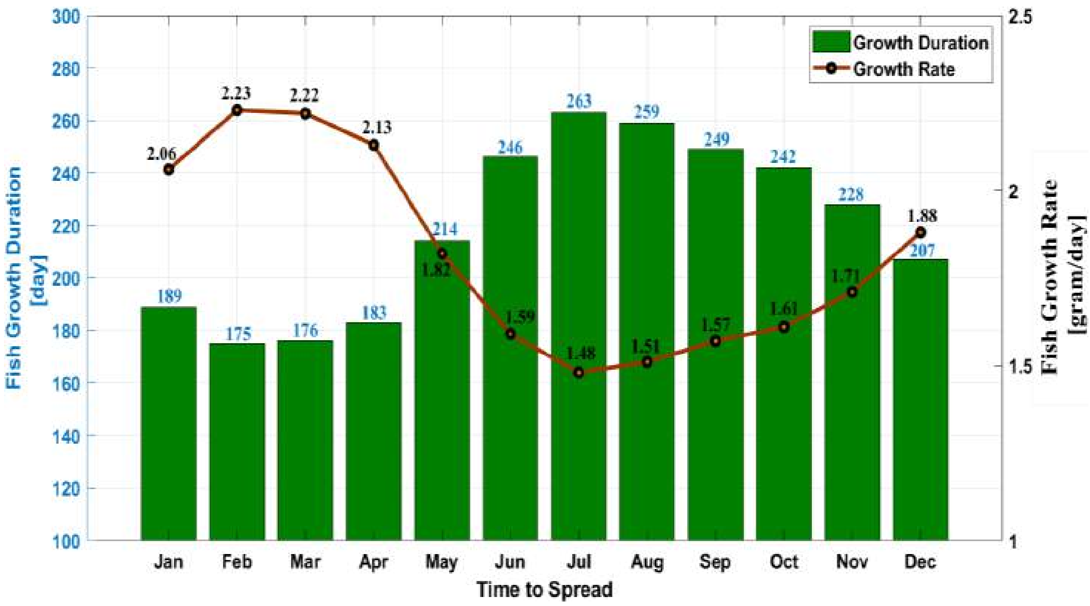

Figure 10 The growth duration and growth rate of seabass using natural feed and addition feed simulation

A total of 1000 seabasses were spreading in a floating net cage in IAB with a size of 4 x 4 x 3 m or a volume of 48 m^3. The 2.223 kg of feed adds up to cages when the juvenile is stocked in February. The feed used is in the form of special pellets for fish which size was 2 - 2.2 mm for seabass in the lowest mass (10 - 12 grams) and 13.6 - 15 mm for seabass with the mass of 300 - 400 grams. However, in this simulation, the pellet assumed as zooplankton, crustacea, and Teleostei (same with natural feed). The scenario model with adding some feed into a floating net cage was carried out to determine the difference in the growth of seabass. The amount of feed added was by the needs of 1000 fishes in a cage based on the percentage of feed needs based on the fish weight in **Table 4**. Seabass with a mass of 10 - less than 50 grams consumed zooplankton, while the seabass with a mass of 50 to 100 grams will consume crustacea and a small amount of zooplankton. Seabass with a mass of more than 100 - 400 grams consume crustacea and Teleost.

The addition of feed affects the growth of seabass. **Figure 10** shows the growth duration and growth rate of seabass when the stocking time is from January to December. The growth of seabass with the fastest duration and growth rate occurred in February. The growth duration of seabass with the time to spread in February until ready to harvest for 175 days with a growth rate of 2.23 grams/day. The growth duration for mass class 2 was 70 days, 38 days for mass class 3, 37 days for mass class 4, and 30 days for mass class 5. The longest growth of seabass occurs when stocking time is done in July with a fish growth rate of 1.48 grams/day for 263 days. The growth duration of seabass for mass class 2 was 67 days, 51 days for mass class 3, 55 days for mass class 4, and 90 days for mass class 5.

The addition of feed greatly affects the growth of seabass from the beginning of stocking juveniles in a cage until they are ready to be harvested. It can be seen in **Figure 9** regarding the availability of feed. The average growth of seabass with adding feed has a growth duration of 7.3 months with a growth rate of 1.82 grams/day. The growth of seabass with only natural feed has an average growth duration of 10.6 months and a growth rate of 1.2 grams/day. The most significant difference in growth was influenced by feed that occurred at the time of stocking in February with a difference in growth duration of 144 days or 4.8 months and a difference in the growth rate of 1.01 grams/day. The period of stocking for juveniles in December had the smallest difference in growth duration, which was 66 days or 2.2 months with a difference in the growth rate of 0.45 grams/day. The difference of growth duration and growth rate between scenario using only natural feed and scenario using addition feed with the time of spread from January until December can be seen on **Table 5**.

Table 5 Comparison of seabass growth using only natural feed and natural feed with addition of feed

Month	**Growth Duration (day)**			**Growth Rate (day)**		
	Natural Feed	**Natural Feed + Adding Feed**	**Difference**	**Natural Feed**	**Natural Feed + Adding Feed**	**Difference**
January	257	189	68	1.52	2.06	0.54
February	319	175	144	1.22	2.23	1.01
March	314	176	138	1.24	2.22	0.98
April	325	183	142	1.2	2.13	0.93
May	336	214	122	1.16	1.82	0.66
June	334	246	88	1.17	1.59	0.42
July	338	263	75	1.15	1.48	0.33
August	335	259	76	1.16	1.51	0.35
September	345	249	96	1.13	1.57	0.44
October	339	242	97	1.15	1.61	0.46
November	309	228	81	1.26	1.71	0.45
December	273	207	66	1.43	1.88	0.45

4. Conclusion

The characteristic include salinity, temperature, and chlorophyll concentration in Inner Ambon Bay is appropriate for seabass cultivation. The model simulation has good result using statistic verification. The value of RMSE is 0.006 kg with CC is 0.99. The scenario model using natural feed shows the growth of seabass is fastest if the time of spread is done in January with a growth duration of 257 days and a growth rate of 1.52 grams/day. Meanwhile for simulation with addition feed, the fastest if the time of spread is done in February with growth duration of 175 days and a growth rate of 2.23 grams/day.

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