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Profit Estimation Model in Aquaculture Based on Market Preference: Application to Red *Tilapia* Culture in Reservoir of Wadaslintang, Indonesia

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ABSTRACT

The purpose of this study was to develop the model of profit estimation in Aquaculture. This research used a model of von Bertalanffy length growth combined with the length-weight relationship, and developed an equation of time harvest to produce the target of fish weight as the market preferences. That also developed an equation to estimate the fish biomass, and the profit in aquaculture. The Profit is a total of revenue minus total of cost. Both the harvested biomass of fish and price of fish affect the revenue of aquaculture. The components of costs were a cost of seed procurement, cost of feed procurement, cost of transportation of products and the daily cost. The daily cost of aquaculture in floating cages were a cost of labour, cost of vitamins, cost of energy, cost of assets depreciation, cost of supporting equipment and cost of maintenance assets that converted to IDR (Indonesian Rupiah) (day) $^{-1}$. The research proved if lthe model in this study could be used to estimate the profit of aquaculture. In case of red *Tilapia* culture (floating cage) in Reservoir of Wadaslintang, aquaculture at 120 days produced a fish average weight of 200 g (profit IDR. 13,507,167), then at 143 days produced 250 g (profit IDR. 17,975,723), at 164 days produced 300 g (profit IDR. 21,853,697), at 185 days produced 350 g (profit IDR. 25,387,418), at 204 days produced 400 g (profit IDR. 28,181,081), at 223 days produced 450 g (profit IDR. 30,507,200), and at 242 days produced 500 g (profit IDR. 32,297,418).

Keywords: profit, von Bertalanffy, floating cage, Red *Tilapia*, Reservoir of Wadaslintang

INTRODUCTION

The goal of business activities is getting the profit, including aquaculture. Aquaculturists or fish farmers need an information about how much the profit of aquaculture in several business scenarios. Information of profit in several scenarios could be used to set the strategies of aquaculture and to minimize the risk of business.

Each type of business has some different characteristics. The modelling of aquaculture business could not ignore the biology factors of fish cultured. The biology characteristic of fish cultured influence both a revenue and costs, then also influence the profit of aquaculture business. So, the modelling of profit estimation in Aquaculture could use a bioeconomic approach.

Bioeconomic is a multiple approach study which combine science of biology, mathematic and economic. The application of bioeconomic in aquaculture need a growth model of fish, both an individuals and biomass of fish. The growth of fish is influenced by several factors, that is an average growth of fish, initial fish populations and mortality rates. The biomass of fish influence both a revenue and costs of aquaculture. Total revenue is multiplication price and biomass of fish. Biomass growth also affects the total cost, especially the cost of feed procurement and cost of transportation harvesting.

There was several studies of aquculture bioeconomics. Bjorndal (1988) developed a general rule in the optimization of the harvest time. The Model of Bjorndal used Beverton-Holt growth model to optimize the profit of aquaculture, but Bjorndal ignored fixed capital in the decision harvest. Arnason (1992) addressed the interdependence of optimal feeding path and harvesting time. Arnason continued the study of Bjorndal (1988), but the Model of Arnason assumed the profit optimization was be influenced only by feeding and harvest time factors. Heap (1993) also continued the study of Bjorndal (1988) and Arnason (1992). But Heap focused on optimalization of the feeding process to generate optimal profits. Strand and Mistiaen (1999) also continued the study of Bjorndal (1988) and Arnason (1992) by incorporating a piecewise-continuous price factors in the model. The model of Strand and Mistiaen assumed that the fish cultured was a single fish with no natural mortality. Antonelli, Bischi, and Lamantia (2005) were develop the bioeconomic model of the interaction between aquaculture and open sea fisheries. Yu and Leung (2006) were develop the bioeconomic model of optimal partial harvesting schedule for aquaculture operations.

Springborn *et al*. (1992) conducted a modelling to optimum harvest time in aquaculture used a fish growth model of von Bertalanffy that assumed a length exponent is 3. Springborn, et al (1992) also assumed if the price of fish was a constant, and the costs consisted of start-up costs (fingerling cost, pond lime and preparation cost), the daily cost during treatment (manure cost, cost of manuring labour, and fixed cost) and harvesting cost (cost of harvest labour, transportation cost and interest on operating cost).

The purpose of this study was to develop the model of profit estimation in Aquaculture. Indonesia have some major aquaculture commodities, including Shrimp, Milkfish, Cat Fish, Seaweed, Grouper, *Gouramy*, Common Carp and Red *Tilapia*. In this study, the model of profit estimation was applied to the red *Tilapia* culture in floating cages in the Reservoir of Wadaslintang, Indonesia.

MATERIAL AND METHOD

This research used applied research approach. Applied research is application research to solve the spesific problems, and could be divide of evaluation research, research and development, and action research (Kuncoro, 2003). The aquaculturist need a profit model to estimate their profit in several scenarios based on market preference, especially a size of fish harvested.

Data

This research used both the primary and secondary data. The secondary data collected from several references, including the government publications, journals and data owned by aquaculturist. The primary data were collected by observation and indepth interview with the key informants, including an aquaculturist, and fish traders. The respondent of aquaculturist is the Cooperative of Serba Usaha Bersama Maju Sejahtera management. This research used a several data, including aquaculture cost, price of fish, fish growth, length of fish, weight of fish, FCR (Food Convertion Ratio), initial weight of fish, density of fish, and Mortality Rate (MR).

Financial Analysis

Projection of cashflow (both cash inflow and cash outflow) would be implemented to analysis a business feasibility of aquaculture. Financial analysis used net present value (NPV), internal rate of return (IRR) and payback periods. In this research, inflation rate would be assumed 5%/years dan discount rate would be assumed 12%.

Model of Fish Growth

The growth of fish has certain characteristics, which each species has different characteristics. In this study, fish growth used the von Bertalanffy length growth model, by the following equation:

$$L_t = L_{inf}\left[1 - e^{-K(t-t_o)}\right] \quad (1)$$

Where

L_t	=	the length of the fish at time t (cm)
L_{inf}	=	the maximum length of fish or the infinity length of fish (cm)
E	=	exponential number
K	=	the growth coefficient of fish
T	=	the age of fish (day)
t_o	=	the initial age of fish have length

Estimation to L_{inf} used Walford growth transformation equation (equation 2). Estimation to K and t_o used an equation (3).

$$L_{t+1} = L_{inf}\left(1 - e^{-K}\right) + L_t . e^{-K} \quad (2)$$

$$Ln\left(L_{inf} - L_t\right) = Ln.L_{inf} + K.t_o - K.t \quad (3)$$

If L_{inf}, K, t_o and t were known, then the length of the fish could be estimated used an equation (1). While the growth in weight of the fish can be estimated by used an equation of length-weight relationship.

$$W_t = aL_t^b \quad (4)$$

$$W_{inf} = aL_{inf}^b \quad (5)$$

$$W_t = W_{inf}\left[1 - e^{-K(t_a + t_{ao} - t_o)}\right]^b \quad (6)$$

Where

W_t	=	the weight of fish at time t (g)
a and b	=	Constants
W_{inf}	=	the maximum weight (infinity weight) of fish (g)

Several equation above would be used to develop equation to estimated the time of aquaculture (t_a) to produce a certain fish weight as the target and also to estimated the fish biomass at t_a (B_{ta}).

Model of Profit Estimation

The profit of business is depend on a revenue and cost. The profit of aquaculture at time t_a (Π_{ta}) is the total of revenue (TR_{ta}) minus total of cost (TC_{ta}).

$$\Pi_{ta} = TR_{ta} - TC_{ta} \quad (7)$$

In this research, equation (6) would be used to develop equation (7). After estimated the time of aquaculture (t_a) to produce a certain fish weight as the target, the equation (7) could be used to estimate the profit of aquaculture which t_a influenced both TR_{ta} and TC_{ta}.

RESULT AND DISCUSSION

Model of Fish Weight Growth and Fish Biomass Growth

Developing equation to estimated a fish weight used equation (6). If t_{ao} is the age of fingerling at the first time cultured (day), so equation of t and W_{ta} are:

$$t = t_{ao} + t_a \quad (8)$$

$$W_{ta} = W_{inf}\left[1 - e^{-K(t_a + t_{ao} - t_o)}\right]^b \quad (9)$$

In this study, the biomass of fish (B_{ta}) during a certain aquaculture time (t_a) was the average weight of fish (W_{ta}) multiplied by the number of cultured populations which were still alive at the time t_a. The number of fish populations t_a (N_{ta}) depend on the initial population size (N_o), the fish mortality rate (MR) and aquaculture period (t_a). Mortality rate (MR) is reversed from the fish survival rate (SR_{ta}). In this study, the unit of the fish mortality rate was in % per day.

$MR = SR_{ta}/t_a$ (10)
$N_{ta} = N_o(1\text{-}MR.t_a)$ (11)
$B_{ta} = W_{ta}.N_o.(1 - MR.t_a)$ (12)
Maximum fish biomass (B_{max}) could be estimated by the first derivative of the fish biomass equation (12) to t_a equal to zero or $dB_{ta}/d_{ta} = 0$. Based on equation (9), the equation to estimate the aquaculture time to generate the target of size harvest (W_{ta}) was:

$$t_a = -\frac{\ln\left(1-\left(\frac{W_{ta}}{\mathrm{W_{inf}}}\right)^{1/b}\right) + (\mathrm{K}.t_{ao}) - (\mathrm{K.t_o})}{\mathrm{K}} \quad (13)$$

Model of Profit Estimation

Total of revenue is influenced by the biomass of harvested fish (B_{ta}) and the price of harvested fish (P_{fi}). Total of costs consist of the cost of procurement of seeds (C_s), the cost of procurement of feed (C_{fe}), the cost of transportation of products (C_{tr}) and cost of daily (C_{dy}). The daily cost of aquaculture in floating cages in this model are cost of labor (C_l), cost of vitamins (C_v), cost of energy (C_e), cost of assets depreciation (C_{dp}), cost of supporting equipment procurement (C_{st}) and cost of maintenance assets (c_{am}) were converted to units of IDR/day.

$TR_{ta} = B_{ta}.P_{fi}$ (14)
$TC_{ta} = C_s + C_{fe} + C_{tr} + C_{dy}.t_a$ (15)

The cost of procurement of seeds is influenced by the price of seeds (P_s), and biomass of seeds in the initial period which influenced by the initial fish population (N_o) and the average weight of the seeds at the initial of the aquaculture periods (W_o). The procurement cost of feed is influenced by prices of fish feed (P_{fe}) and the amount of feed given. The amount of feed is estimated by biomass gain (B_{ta}-$N_o.W_o$) and food conversion ratio (FCR). The cost of transportation of products is influenced by a tariff of transportion (P_{tr}) and fish biomass.

$C_s = P_s.N_o.W_o$ (16)
$C_{fe} = (B_{ta}\text{-}N_o.W_o)\ FCR.P_{fe}$ (17)
$C_{tr} = B_{ta}.P_{tr}$ (18)

In intensive aquaculture, the procurement cost of artificial fish feed has a large proportion in the composition of costs. Furthermore, by using equation (7), (14), and (15), the equation of profit is:

$$\Pi_{ta} = W_{\inf}\left(1-e^{-K(t_a+t_{ao}-t_o)}\right)^b N_o(1-MR.t_a)P_{fi} - P_s.N_o.W_o -$$
$$\left(W_{\inf}\left(1-e^{-K(t_a+t_{ao}-t_o)}\right)^b N_o(1-MR.t_a) - N_o.W_o\right)FCR.P_{fe} - W_{\inf}\left(1-e^{-K(t_a+t_{ao}-t_o)}\right)^b N_o(1-MR.t_a)P_{tr} - C_{dy}.t_a$$

Subject to: (i) $dB_{ta}/dt_a \geq 0$
(ii) $t_a \geq 0$ (19)

Profit equation above could be used in various types of aquaculture. However, if the method of culture does not using floating cages, it is necessary to adjust the cost, especially the component of daily cost (C_{dy}). If W_{inf}, K, t_o, t_{ao}, t_a, b, N_o, MR, P_{fi}, P_s, W_o, FCR, P_{fe}, P_{tr} and C_{dy} are known, so the profit of aquaculture could be estimated. If aquaculturist have W_{ta} as the target of fish size harvested, so by use equation (9) could be estimated the value of t_a. Then by use equation (19) could be estimated the profit of aquaculture at W_{ta} as the target of fish size harvested.

Financial Analysis of Red Tilapia Culture in Reservoir of Wadaslintang

Aquaculturist or fish farmers at Reservoir of Wadaslintang-Indonesia inconsolidated in Cooperative of *Serba Usaha Bersama Maju Sejahtera*. Aquaculturist of Red *Tilapia* (*Oreochromis niloticus*) at Reservoir of Wadaslintang use floating cage. There are several size of floating cage in Reservoir of Wadaslintang, but this research assumed:

- 1 unit of floating cage have 12 cage. Cage size was 5x5x5 m^3. The investment cost of floating cage was IDR. 88,000,000 $(unit)^{-1}$. Floating cage could be used 10 years.
- The investment cost of boat was IDR. 5,000,000. The boat could be used 5 years.
- The investment cost of machine to boat was IDR. 5,000,000. The boat machine could be used 5 years.
- The size of fingerling was 25 g. Initial of fingerling was 4,000 fish $(unit)^{-1}$ of floating cage. The price of fingerling was IDR. 20,000 $(kg)^{-1}$.
- The cost of maintenance assets was IDR. 1,200,000 $(years)^{-1}$.
- The aquaculture periods was 4 months per cycle.
- The cost of vitamins was IDR. 1,000,000 $(cycle)^{-1}$ of aquaculture.
- The cost of energy was IDR. 300,000 $(months)^{-1}$.
- The cost of supporting equipments was IDR. 300,000 $(years)^{-1}$.
- The labour cost was IDR. 10,725,000 $(years)^{-1}$.
- The price of artificial feed was IDR. 9.000 $(kg)^{-1}$.
- Food conversion ratio (FCR) was 1,3.
- The cost of transportation of products was IDR 1,000 $(kg)^{-1}$.
- The average of fish harvested was 250 g.
- The survival rate (SR) of fish cultured was 80% for 4 months, or the mortality rate (MR) was 0,1,667% $(days)^{-1}$.
- The price of fish harvested was IDR. 17,000 $(kg)^{-1}$.

Financial analysis could be done by use above data. The forecasting of cashflow in bussiness of red *Tilapia* culture in Reservoir of Wadaslintang would be done in 10 years.

In the beginning (the first year), the business of red Tilapia culture still loss, but take a profit in the next years. The financial analysis in NPV, IRR and payback periods proved if the business of red *Tilapia* culture use floating cage in Reservoir of Wadaslintang-Indonesia were feasible (NPV IDR. 456,478,569 for 10 years, IRR 348%, and payback periods 1.29 years).

Table 1. The Cashflow Projection

Periods (Years)	1	2	3	4	5	6	7	8	9	10
The Cost of Investment										
Floating Cage	88,000									
Boat	5,000					6,381				
Machine	5,000					6,381				
The Cost of Operational										
Seeds	72,000	75,600	79,380	83,349	87,516	91,892	96,487	101,311	106,377	111,696
Maintenance of Assets	1,200	1,260	1,323	1,389	1,459	1,531	1,608	1,688	1,773	1,862
Vitamins	3,000	3,150	3,307	3,473	3,646	3,829	4,020	4,221	4,432	4,654
Energy	3,600	3,780	3,969	4,167	4,376	4,595	4,824	5,066	5,319	5,585
Supporting Equipment	300	315	331	347	365	383	402	422	443	465
Labour	10,725	11,583	12,510	13,510	14,591	15,758	17,019	18,381	19,851	21,439
Feed	294,840	309,582	325,061	341,314	358,380	376,299	395,114	414,869	435,613	457,394
Transportation	28,800	30,240	31,752	33,340	35,007	36,757	38,595	40,524	42,551	44,678
Revenue	489,600	514,080	539,784	566,773	595,112	624,867	656,111	688,916	723,362	759,530
Profit / (Loss)	(22,865)	78,570	82,151	85,883	89,772	81,060	98,041	102,433	107,003	111,758
Discount Factors	1.00	0.89	0.80	0.71	0.64	0.57	0.51	0.45	0.40	0.36
PV of Profit/(Loss)	(22,865)	70,151	65,490	61,130	57,052	45,996	49,671	46,335	43,217	40,301

Note: Unit in IDR. 1,000 (except a *discount factors*), and PV is present value.

Fish Growth Estimation

Application of equation (4) could to estimate the length-weight relationship of red tilapia. To estimate the value of a and b could use an equation:

$$LnW_t = Lna + bL_t \quad (20)$$

Equation (20) was applied to the case of red *Tilapia* culture in floating cages in the Reservoir of Wadaslintang, Indonesia. Based on the analysis, the length-weight relationship of red *Tilapia* culture in floating cages in the Reservoir of Wadaslintang were:

$$W = 0.016\, L_t^{\,3,005} \quad (21)$$

Infinity length (L_{inf}) of red tilapia estimated at 50.04 cm and infinity weight (W_{inf}) estimated at 2.095 kg. From several studies in various locations, red *Tilapia* has a diverse both the infinity length and infinity weight. The research of Grammer, *et al* (2012) proved if tilapia (*Oreochromis niloticus*, Linnaeus, 1758) in Coastal of Mississippi (USA) could reach a length of 40 cm and a weight of 1,293 g. The study of El-Bokhty (2010) in Manzalah Lake (Egypt) showed that the red *Tilapia* (*Oreochromis niloticus*) has an infinity length of 22.67 cm. The research of Ahmed *et al*. (2003) showed that *Oreochromis niloticus* in Kaptai Dam (Bangladesh) has an infinity length of 55.59 cm with equation total of length (TL) - weight (W) follows the equation $W = 0.0366\ TL^{2,844}$. The research of Dache (1990) proved that the infinity length of the fish *Oreochromis niloticus* in Lake Victoria (Kenya) were 61.3 cm. The research of Asila and Okemwa (1999) showed that *Oreochromis niloticus* (L) in Lake of Victoria (Kenya) has an infinity length about 122 cm.

In this study, the K value estimated at 0.00294133586234927 and value t_0 is 2.21945945860328. By using equations (1) and (6), the equation length and weight of red tilapia cultured in floating cages in the Reservoir of Wadaslintang as the following equation:

$$L_t = 50,04\left[1 - e^{-0.00294(t-2.219)}\right] \quad (22)$$

$$W_t = 2.095,47\left[1 - e^{-0.00294(t-2.219)}\right]^{3,005} \quad (23)$$

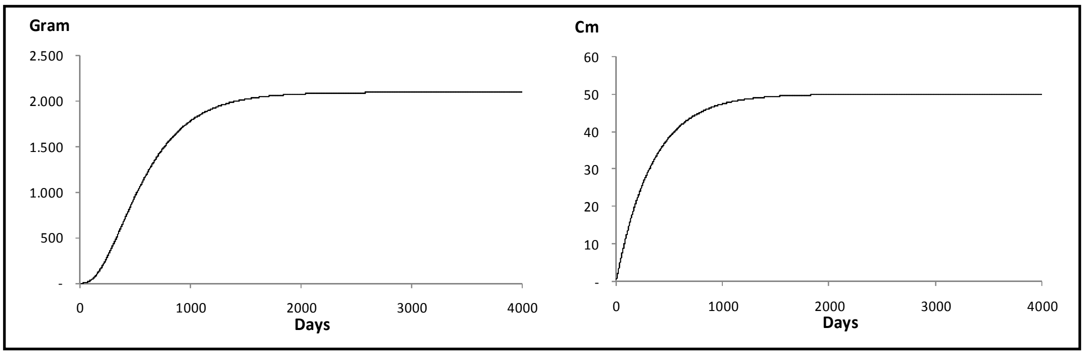

Figure 1. Simulation of Length (cm) and Weight (g) Red *Tilapia* Growth

Equation (13) could be estimated the time of aquaculture to produce a certain size of fish harvest as the target. If the target of fish size were 0.2 g, the time of aquaculture were 120 days. If the target of fish size were 0.25 g, the time of aquaculture were 143 days. If the target of fish size were 0.3 g, the time of aquaculture were 164 days.

Profit Estimation

Profit estimation of red tilapia culture in floating cages in the Reservoir of Wadaslintang used several assumptions:

Table 2. Assumptions to Profit Estimation

	Value
Cost of Daily (C_{dy})	IDR. 81,164 (day)$^{-1}$
Cost of Labour (C_l)	IDR. 29,384 (day)$^{-1}$
Cost of Vitamins (C_v)	IDR. 8,219 (day)$^{-1}$
Cost of Energy (C_e)	IDR. 9,863 (day)$^{-1}$
Cost of Depreciation Asset (C_{dp})	IDR. 29,590 (day)$^{-1}$
Floating Cages	IDR. 24,110 (day)$^{-1}$
Boat	IDR. 2,740 (day)$^{-1}$
Machine	IDR. 2,740 (day)$^{-1}$
Cost of Supporting Equipment (C_{st})	IDR. 822 (day)$^{-1}$
Cost of Asset Maintenance (C_{am})	IDR. 3,288 (day)$^{-1}$
Cost of Seed Procurement (C_s)	IDR. 23,702.833
Price of Seed (P_s)	IDR. 20,000 (kg)$^{-1}$
Initial Seed Weight (W_o)	0.0246 kg
Initial of Seeds Populations (N_o)	48,000
Price of Fish Feed (P_{fe})	IDR. 9,000 (kg)$^{-1}$
FCR (Food Convertion Ratio)	1.3
Price of Transportation Harvest (P_{tr})	IDR 1,000 (kg)$^{-1}$
Prices of Fish Harvest (P_{fi})	IDR. 17,000 (kg)$^{-1}$
Mortality Rate (MR)	0.1667% (day)$^{-1}$
Fish Growth Coefficient (K)	0.00294133586234927
Estimation of t_0	2.21945945860328
Estimation of Initial Age of Seeds (t_{ao})	90 day
Assumption of b value	3

Note: U.S. $ 1 equal to IDR. 11,783 on February 17, 2014

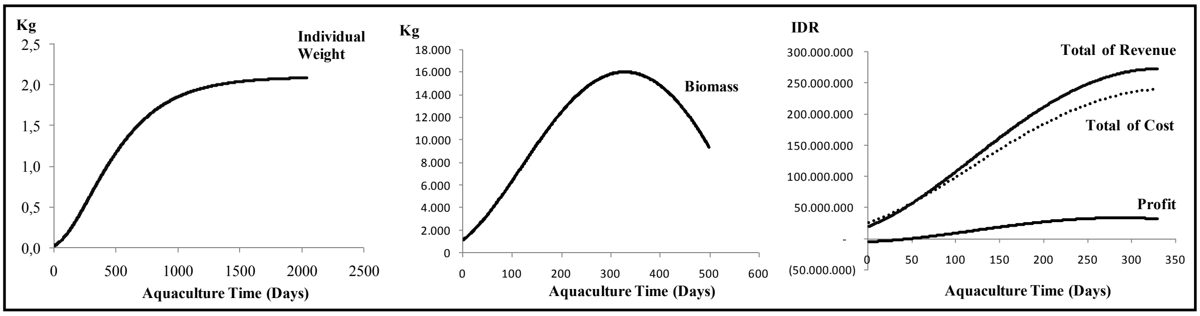

Figure 2. Simulation of Weight Individual Fish, Fish Biomass, Revenue, Cost and Profit

In the beginning, fish biomass has asignificant growth, but at any given time they decreasing caused by the mortality rate. The growth pattern of fish biomass affects to pattern of both cost and revenue. The largest proportion of costs in floating cages of red *Tilapia* culture was the cost of feed. On the red *Tilapia* culture in floating cages, artificial feeding was intensified because fish density was relatively high and the availability of natural feed was insufficient to meet the nutritional needs of fish cultured. For comparison, the study of Rahayu (2011) proved that the cost proportion of feed procurement in the red *Tilapia* culture in running water pond in Klaten-Indonesia could reach 65.55% of the total of cost.

In principle, the business need to take into account the market demand, which the market has a certain preference. Based on the survey results, aquaculturist at Subdustrict of Wadaslintang harvested the red *Tilapia* in range betwen 200-500 g. The fish harvested sold in fresh fish condition to local market in Regency of Wonosobo and Regency of Kebumen.

Table 3. Profit Estimation

Size of Fish Harvested (g)	Aquaculture Time (days)	Revenue (IDR)	Cost (IDR)	Profit (IDR)
200	120	130,795,505	117,288,338	13,507,167
250	143	155,842,184	137,866,461	17,975,723
300	164	177,912,243	156,058,545	21,853,697
350	185	198,621,299	173,233,881	25,387,418
400	204	215,762,779	187,581,698	28,181,081
450	223	231,055,830	200,548,630	30,507,200
500	242	244,230,200	211,932,782	32,297,418

The aspects of market preference do not be ignored, because the aquaculturist could not force consumers to buy the fish on based not their preference. But, market preference are dynamic and there are the possibility of inter-regional markets have a different preference.

CONCLUSION

Profit estimation model in this study could be applied to estimate the profit of aquaculture in a certain of fish size target. In case of red *Tilapia* culture use floating cage in Reservoir of Wadaslintang, aquaculture at 120 days produced a fish average weight of 200 g, and get profit IDR. 13,507,167. Aquaculture at 143 days produced a fish average weight of 250 g, and get profit IDR. 17,975,723. Aquaculture at 164 days produced a fish average weight of 300 g, and get profit IDR. 21,853,697. Aquaculture at 185 days produced a fish average weight of 350 g, and get profit IDR. 25,387,418. Aquaculture at 204 days produced a fish average weight of 400 g, and get profit IDR. 28,181,081. Aquaculture at 223 days produced a fish average weight of 450 g, and get profit IDR. 30,507,200. Aquaculture at 242 days produced a fish average weight of 500 g, and get profit IDR. 32,297,418.

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REFERENCES

Ahmed, K.K.U., S.M.N. Amin, G.C. Haldar, and S. Dewan. 2003. Population Dynamics and Stock Assessment of *Oreochromis niloticus* (Linnaeus) in the Kaptai Reservoir, Bangladesh. *Indian J. Fish*, 50 (1) : 47-52.

Antonelli, G., G. I. Bischi, and F. Lamantia. 2005. Mathematical Bioeconomic Modelling of The Interaction Between Aquaculture and Open Sea Fisheries. Editor: Kenneth J Thomson and Lorenzo Venzi. 95th EAAE Seminar, Civitavecchia (Rome), 9-11 December 2005.

Arnason, R. 1992. Optimal Feeding Schedules and Harvesting Time in Aquaculture. Marine Resource Economics, 7: 15-35 pp.

Asila, A.A. and E. Okemwa. 1999. Growth Parameters for *Lates niloticus* (L), *Bagrus docmak* (Forsskal), *Oreochromis niloticus* (L), *Clarias gariepinus* (Burchell) and Synodontis Species Derived from Tag Return. KMFRI; Kenya, 204-207 pp.

Bjorndal, T. 1988. Optimal Harvesting of Farmed Fish. *Marine Resource Economic*, 5: 139-159.

Dache, S.A.O. 1990. Observations on the Fisheries, Growth and Mortality Rate of *Oreochromis niloticus* (Tilapia) in the Nyanza Gulf of Lake Victoria. Kenya Marine and Fisheries Research Institute, 59-65 pp.

El-Bokhty, E.E.B. 2010. Fisheries Management of *Oreochromis niloticus* and *Oreochromis aureus* Caught by Trammel Nets and Basket Traps in Lake Manzalah, Egypt. *World Journal of Fish and Marine Sciences* 2 (1): 51-58.

Grammer, G.L., W.T. Slack, M.S. Peterson and M.A. Dugo. 2012. Nile Tilapia *Oreochromis niloticus* (Linnaeus, 1758) Establishment In Temperate Mississippi, USA: Multi-Year Survival Confirmed by Otolith Ages. *Aquatic Invasions* 7: 367-376.

Heap, T. 1993. The Optimal Feeding of Farmed Fish. *Marine Resource Economics*, 8: 89-99

Kuncoro, M. 2003. Metode Riset untuk Bisnis dan Ekonomi. Erlangga; Jakarta.

Rahayu, W. 2011. Analisis Pendapatan Usaha Pembesaran Ikan Nila Merah (*Oreochromis* sp) pada Kolam Air Deras Di Kecamatan Polanharjo Kabupaten Klaten. *Jurnal Ilmu-Ilmu Pertanian* 7(1): 1-13.

Springborn, R.R., A.L. Jensen, W.Y.B. Chang, and C. Engle. 1992. Optimum Harvest Time in Aquaculture: an Application of Economic Principles to a Nile tilapia, *Oreochromis niloticus* (L.), growth model. *Aquaculture and Fisheries Management*, 23: 639-647.

Strand, I., and J.A. Mistiaen. 1999. Optimal Feeding and Harvest Time for Fish with Weight-Dependent Prices. *Marine Resource Economics*, 13: 231-246.

Yu, R. and P. Leung. 2006. Optimal Partial Harvesting Schedule for Aquaculture Operations. *Marine Resource Economics*, 21: 301-315.