GROWTH, MORTALITY AND EXPLOITATION RATE OF NILE TILAPIA FISH (*Oreochromis niloticus*) AT LAKE BATUR, BALI

Samuel and Ni Komang Suryati [1]

ABSTRACT

A study that was aimed to determine the parameters of the growth, mortality and exploitation rate of nile tilapia (Oreochromis niloticus) were conducted at Lake Batur, Bali from March to November 2011. The study based on a survey with the fish sample was obtained from the fish catch of fishermen using gillnet with mesh size between 1.0 to 4.0 inches. Nile tilapia fish population in Lake Batur was dominated by individual lengths between 18.5 to 22.5 cm with a frequency of 50% and from 23.5 to 27.5 cm by 23%. The dominant pattern of growth was isometric. The results of the parameter analysis of nile tilapia populations using the FISAT program package showed that the asymptotic length/ infinitif length (L_∞) reached 41.45 cm and the growth coefficient (K) = 0.52 per year. Growth performance (Φ') = 3.013, the natural mortality rate (M) of 0.9586 per year, the mortality rate from fishing (F) of 1.1014 per year and the total mortality rate (Z) was at 2.06 per year so the exploitation rate of nile tilapia populations (E) was at 0.535. The nile tilapia in Lake Batur could spawned more than once in a year with peak spawning season occured around March, August and September.

***Keywords:** Growth, mortality, exploitation rate, nile tilapia, Lake Batur.*

INTRODUCTION

Lake Batur is one which is of volcanic lake types, located at the foot of Mount Batur believed as a caldera of ancient volcanic crater (Suryono *et al.*, 2008). Lake Batur is located in Bangli District at an altitude of about 1080 m above sea level and extent of approximately 1605 hectares or 16:05 km2. Each year, started in 2005, the water level of Lake Batur had declined about one meter (Anonymous, 2010). The destruction and deforestation as well as increased human settlement at the around lake area will be one of the causes on the endangerment of biota life, including fish in this lake.

There are fish culture activities with floating net system (KJA) and the main fish kept is the kinds of nile tilapia (*Oreochromis niloticus*) coupled with the condition of Lake Batur which is a closed water system and there is no outlet of Lake Batur leading to the condition more severe. In the other side, Lake Batur have high fertility (Samuel & Suryati, 2011) which is a good aquatic ecosystem for fish. The kinds of fish / shrimp obtained from the catch of fishermen throughout the study in 2011 and identified amounted to 12 species of fish namely are: nile tilapia, java tilapia/mujaer/bali fish, java carp/tawes, snaked head, black lohan, red lohan, black cendol, red cendol, kissing gouramy, catfish, eels, and milkfish and 2 species of shrimps namely are giant freshwater prawn and testes shrimp (Samuel *et al.*, 2011). Based on information obtained from Fisheries Services, District of Bangli, kinds of fish that had been introduced to Lake Batur from the year of 2004-2009 are nile tilapia, java tilapia/mujaer, java carp/tawes and milkfish. But that looks breed and dominant caught by fishermen in the year observation of 2011 was the kinds of nile tilapia.

The study on population dynamics of nile tilapia in Lake Batur, especially about the research on the parameters of growth, mortality, recruitment and exploitation rate since fish stocked in the lake has never been done. This research are needed to know

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how the condition and growth of introduced fish, especially nile tilapia as a dominant species, so that those fish will be able to live naturally and can be managed. The objective of this study is to obtain data and information on the parameters of growth, mortality and exploitation rate of nile tilapia as a useful information for management and development of nile tilapia in Lake Batur in order to remain sustainable and can be utilized in a sustainable manner.

MATERIALS AND METHODS

The study was conducted at Lake Batur located in Bangli regency, Bali Province (Figure 1). The study started from March to November 2011. Fish samples were collected from the catch of fishermen who use fishing gear of gillnets with mesh sizes between 1.0 to 4.0 inches (1, 1 ½, 1 ¾, 2, 2 ½, 2 ¾, 3, 3 ½ and 4 inches). Location of setting gillnets by fishermen existed at some places on Lake Batur namely are : Villages of Songan (Ulun Danu), Toya Bungkah, Pura Jati, Buahan and Village of Trunyan. Total length data of nile tilapia fish is measured to the smallest scale of 0.1 cm and weight fish is weighed to 0.1 gram accuracy for individual nile tilapia. The length and weight measurement data were subjected analyzed to determine the nature growth of fish, whether isometric (b=3) or allometric (b≠3), which is calculated from the relationship between the length and weight of fish using the formula proposed by Effendie (1979), namely : $W = a^* L^b$. where W = weight of fish (gram), L = total length (cm), a and b = constant values.

The constant value of b obtained from the above equations were then tested for accuracy against the values b = 3 by using the "t-test". Estimation of growth parameters from Von Bertalanffy model namely asymptotic total length ($L\infty$) and growth coefficient (K) were calculated using the program Elefan I (1987) in the program package computer FISAT (Gayanillo *et al.*, 1995). Estimating the value of to (age at time of zero length) was calculated by using the Pauly equation (1984), namely:
$\text{Log } (-t_0) = -0{,}3922 - 0{,}2752 \text{ Log } (L\infty) - 1{,}038 \text{ Log } (K)$. Growth performance index (Φ ', phi-prime) was calculated using the equation of Pauly and Munro (1984) as follows:
$\Phi' = \text{Log}_{10}K + 2\ \text{Log}_{10}L\infty$. The natural mortality rate (M) was estimated by using an empirical model of Pauly (1980), namely:
$\text{Log } (M) = -0{,}0066 - 0{,}279^*\text{Log } (L\infty) + 0{,}6543^*\text{Log } (K) + 0{,}4634^*\text{Log } (T)$,
Where: $L\infty$ = asymptotic total length, K = coefficient of growth and T = average water temperature of Lake Batur (22.42 ° C). The coefficient of total mortality (Z) was obtained from the catch curve based on length converted catch curve (Pauly, 1983) that the calculation is done using a computerized program package FISAT (Gayanilo *et al.*, 1995). Fishing mortality coefficient (F) was calculated from equation F = Z-M. The exploitation rate (E) was calculated using the equation E= F/Z (Pauly, 1980).

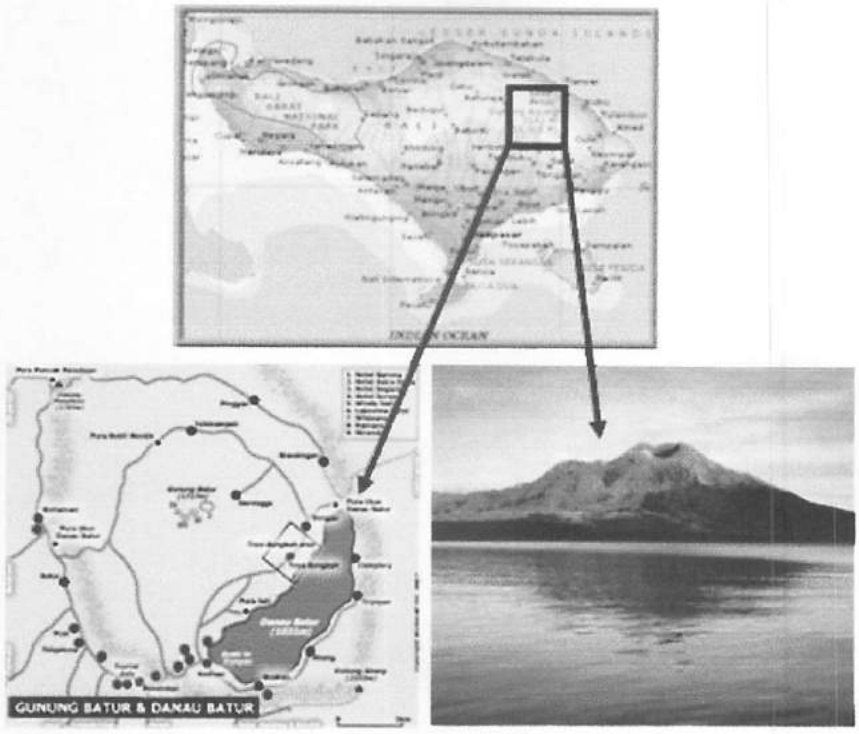


Figure 1. Nile tilapia Research Location of Lake Batur, Bali.

RESULTS AND DISCUSSION

From the research, nile tilapia, *Oreochromis niloticus* (Cichlidae family) are widely caught on Lake Batur, Bali as shown in Figure 2, is gray colored or black on the back and whitish on the abdomen and there are several lines of dark transverse bars (striped) 7-8 pieces. Sharp spines on the dorsal fin accounted for 15-16 pieces and soft spines numbered between 11-13 pieces. Anal fin were 3 spines and 8-11 fingers.

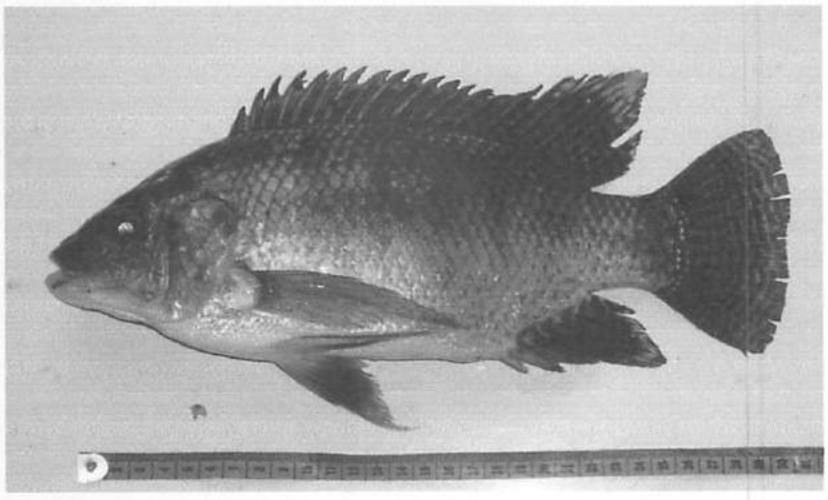
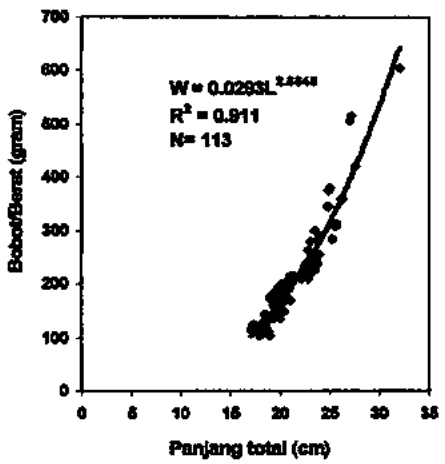


Figure 2. Nile tilapia (*Oreochromis niloticus*) from Lake Batur, Bali.

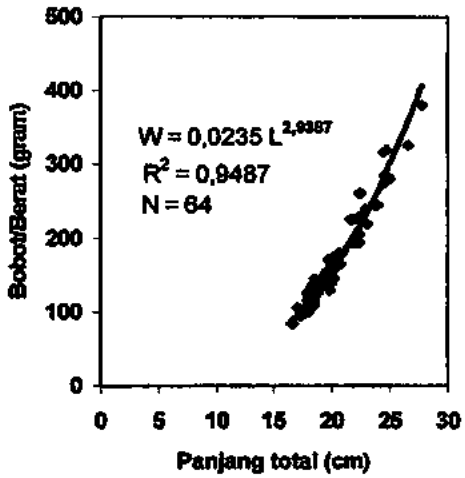
The results of the length-weight relationship analysis from four sampling times, showed that the growth pattern of nile tilapia in Lake Batur on February, May, September and November are isometric and allometric positive (Table 1 and Figure 3).

Table 1. Growth pattern of nile tilapia fish (*Oreochromis niloticus*) at Lake Batur (2011)

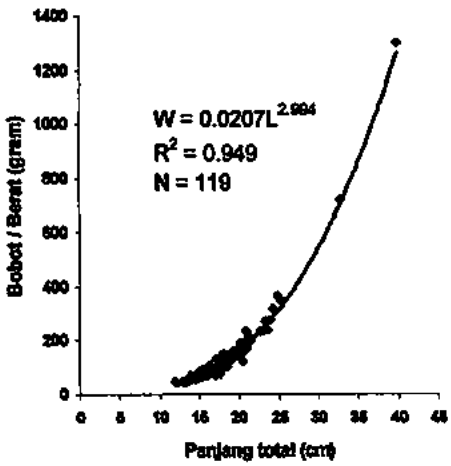
No	Months of Sampling	N	Length-weight relationship parameters			Value t-calc.	Value t-tab	Growth pattern
			a	b	R^2			
1	February-2011	113	0.0293	2.89	0.91	1.347	1.960	Isometrik
2	May-2011	64	0.0235	2.94	0.95	0.707	2.000	Isometrik
3	September-2011	119	0.0207	2.99	0.95	0.094	1.980	Isometrik
4	November-2011	147	0.0161	3.07	0.99	2.814	1.960	Alometrik (+)



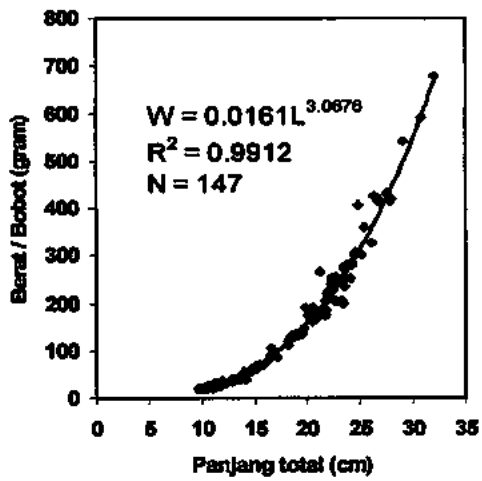
survey-1 (February-2011)



survey-2 (May-2011)



survey-3 (September-2011)



survey-4 (November-2011)

Figure 3. Length-weight relationship curve of nile tilapia fish at Lake Batur (2011).

Isometric growth patern of nile tilapia fish from the study showed that the length accretion is proportional to the weight accretion, while the positive allometric mean weight accretion is faster than the length. The fish having isometric and positive allometric growth patterns means the condition of the fish is of good quality. Furthermore, from 6907 nile tilapia fish that was measured their total length from March to November 2011 (Appendix 1), it turned out that the nile tilapia population was dominated by individuals who were size between 18.0 to 23.0 cm with a frequency of 50% and between 23.0 to 28.0 cm by 23% (Figure 4).

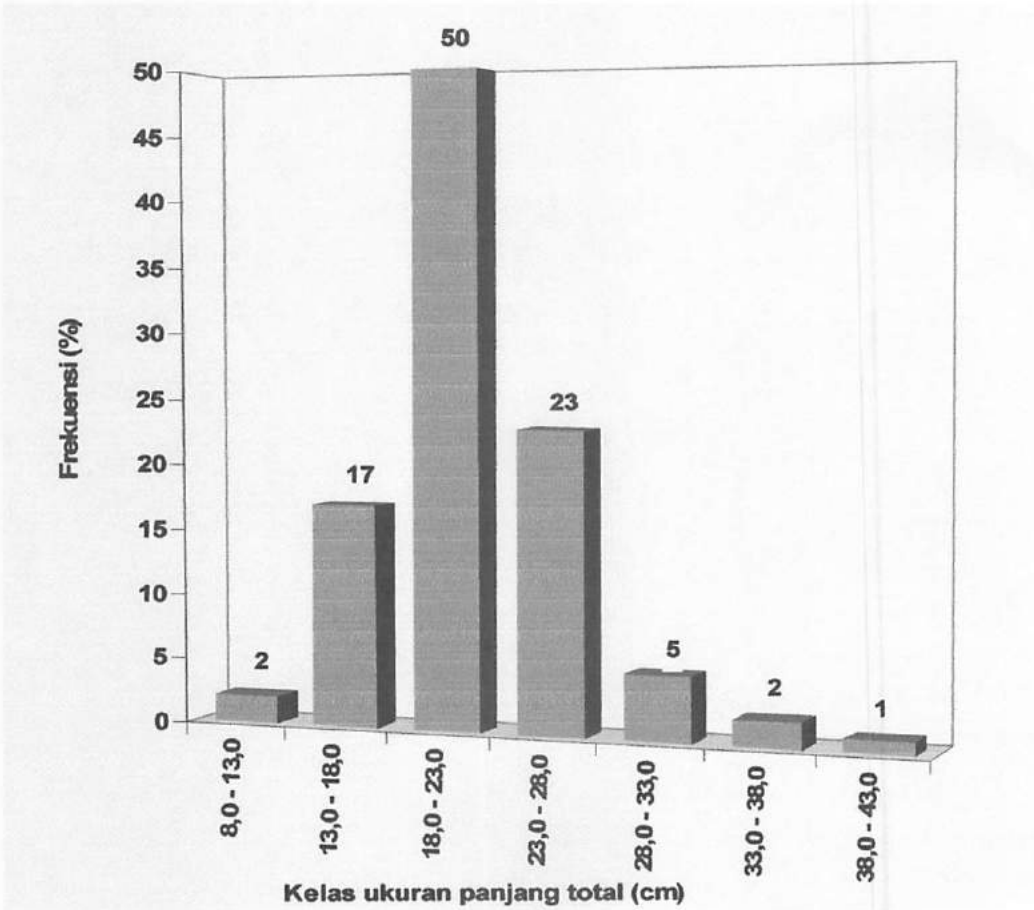


Figure 4. Size distribution of total length on the nile tilapia at Lake Batur, Bali.

The results of the analysis on the frequency distribution of monthly catch using FISAT program package (Figure 5) showed that the growth model of nile tilapia in Lake Batur followed von Bertalanffy equation as follows : Lt = 41.45 (1 - exp (- .52 * (t - (-0.2867))) or Lt = 41.45 * (1 - e-0, 52 (t +0.2867)). From the growth model provides information that nile tilapia in Lake Batur is able to grow up to 41.45 cm with the growth rate coeficient (K) of 0.52 per year. Growth coefficient (K) is a curvature which gives an idea of how fast a species can grow up to asymtotic length ($L\infty$) (Sparre & Venema , 1999 ; Pauly, 1983).

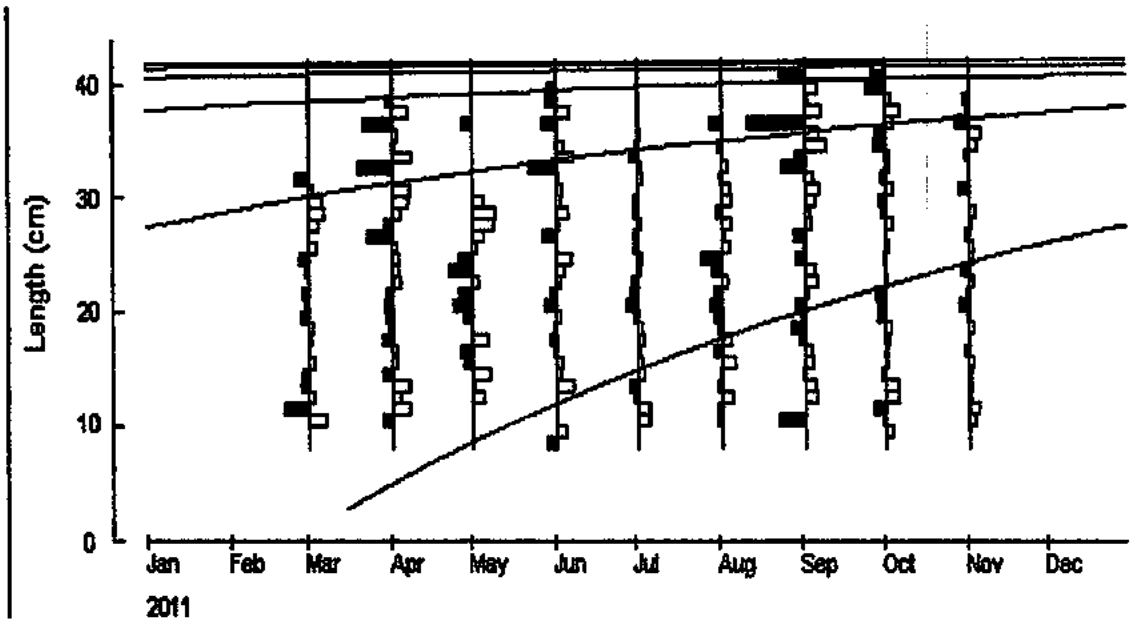


Figure 5. The growth curve of nile tilapia (*Oreochromis niloticus*) at Lake Batur, Bali

Nile tilapia (*Oreochromis niloticus*) fish at Lake Batur is the result of introduction fish spread by local agencies (Inland Fisheries Service, District of Bangli, Bali). The results of observation showed that the stocked nile tilapia can tolerate water quality conditions of the lake so that they can adapt and proliferate. It can be Seen from the fish catch of fishermen who use gear of gillnets, the results are dominated by a population of nile tilapia (*Oreochromis niloticus*). Growth rate of nile tilapia in Lake Batur is almost equal to the growth rate of java tilapia fish in Lake Ranau based on the research of Utomo *et al.* (1990), just only, the java tilapia fish in Lake Ranau can reach a maximum length of 48.3 cm. Growth index value (Φ', phi-prime) of nile tilapia at Lake Batur is at 3.013 (Table 2). This growth index value is higher than the existing nile tilapia in Lake Tempe (2.346) and lower than nile tilapia fish in the Malahayu Reservoir (3.410). This is suggested that the growth performance of nile tilapia in Lake Batur is better than nile tilapia in Lake Tempe and lower than nile tilapia in Malahayu Reservoir.

Table 2. Parameter values of nile tilapia in Lake Batur and in other water bodies

Waters Body	L∞ (cm)	K (yr^{-1})	Φ'	Z (yr^{-1})	M (yr^{-1})	F (yr^{-1})	E	Sumber/Source
Danau Batur	41.45	0.52	3.013	2.06	0.959	1.101	0.535	Samuel, 2012
Danau Tempe	31.76	0.22	2.346	1.02	0.51	0.51	0.50	Samuel *et al.*, 2010
Waduk Malahayu	38.90	1.70	3.410	4.80	2.43	2.37	0.49	Purnomo, 2011

Population parameter of nile tilapia in Lake Batur obtained from the results of analysis and the results of all calculations are listed in Table 3. Based on analysis using FISAT II program by entering the parameter values of L_∞, K and the mean temperature of the water is obtained natural mortality of nile tilapia in Lake Batur (M) of 0.95859 or M = 0.959. Furthermore, the analysis of the model using length converted catch curve, The value of total mortality (Z) was 2.06. The value of fishing mortality (F) was obtained from F = Z - M was equal to 1.1014. The value of exploitation rate of E = F / Z was equal to 0.535. The value of exploitation rate (E) of 0.535 indicated that the level of exploitation rate of nile tilapia in Lake Batur has passed an optimum value (E = 0.5). This means that there needs to be an effort to reduce the amount of fishing gear in Lake Batur especially fishing gears of nile tilapia gillnets. However, because nile tilapia which was breed in Lake Batur was result of the introduction activities carried out by the local Fisheries Service, so that, fears of the above can be minimized.

Table 3. Analysis results of growth parameter, mortality and exploitation rate of nile tilapia (*Oreochromis niloticus*) from Lake Batur, Bali

No	Parameters	Symbol	Values
1	Asymtotic length	L_∞	41.45
2	Growth coeficient	K	0.52
3	Age at size 0 cm	to	-0.2867
4	Natural mortality	M	0.9586
5	Fishing mortality	F	1.1014
6	Total mortality	Z	2.0600
7	Exploitation rate	E	0.5347

The results of the analysis with the FISAT program to determine the recruitment pattern of nile tilapia in Lake Batur can be seen in Figure 6. From the figure showed that nile tilapia in Lake Batur had two peaks of recruitment in a year. This was indicated that nile tilapia in the lake waters might spawned more than once a year. Suspected that spawning season of nile tilapia in Lake Batur was closely related to the coming dry season was around the month of March and the coming of the rainy season was around on August and September. It could also be connected with the movement of the lake water level in the months when the lake water level moves up and when the water levels go down. Nile tilapia spawned in Lake Batur was expected in March, August and September, not much different from the existing nile tilapia in Lake Tempe was around March and September (Samuel & Makmur, 2010).

During the study, the total length size of nile tilapia a lot caught ranged from 18.0 to 23.0 cm with a frequency of 50% and from 23.0 to 28.0 cm with a frequency of 23%. This was suggested that nile tilapia caught by fishermen in Lake Batur was dominated by small to medium size which also indicates the occurrence of over exploited or overfishing.

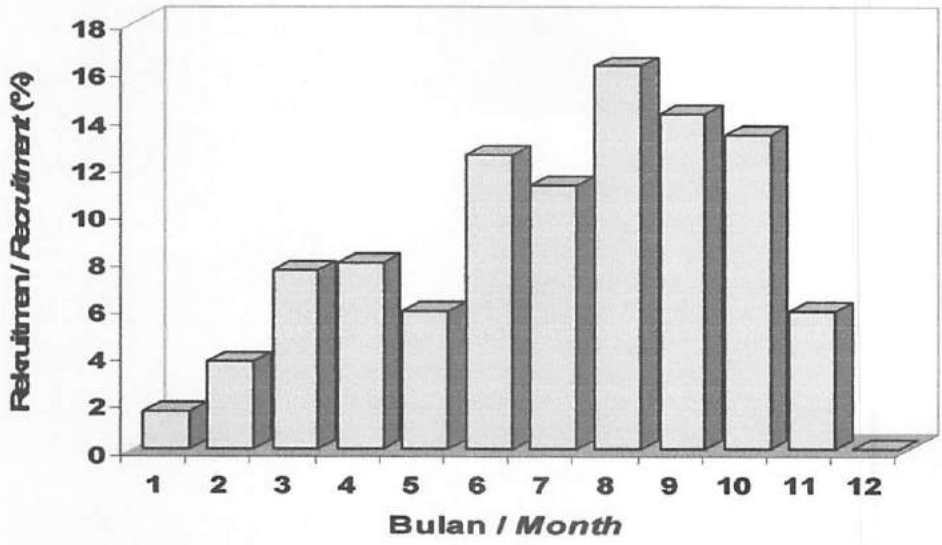


Figure 6. Recruitment pattern of nile tilapia at Lake Batur, Bali in 2011

CONCLUSION

1. The growth of nile tilapia in Lake Batur generally isometric (b=3), the length accretion was proportional to the weight accretion.
2. Fish of nile tilapia in Lake Batur can grow up to asymtotic length ($L\infty$) = 41.45 cm with the growth rate (K)= 0.52 / year, the exploitation rate (E)= 0,535 has already passed an optimum value (E = 0.5).
3. Nile tilapia in Lake Batur could spawned more than once a year and it was expected to spawn on March, August and September.

SUGGESTION

1. Because the exploitation rate of tilapia in Lake Batur is above the optimum value, it was necessary to reduce the intensity of the fishing of this fish, it was to reduce the amount of gillnet gears.
2. In an effort towards conservation and sustainable use of nile tilapia fish resources in Lake Batur, it needed to be preserved fish stocking activities had been run quite well in this lake.

ACKNOWLEDGEMENT

This paper is a contribution of the research activity "Characteristics of the aquatic environment, fish biology and fisheries development potential of Lake Batur, Bali", in 2011, in Research Institute for Inland Fisheries Palembang.

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Appendix 1. Length frequency data of nile tilapia fish catch from Lake Batur, Bali in 2011

No	ML	March	April	May	June	July	Augt	Sep	Oct	Nov	Total
1	8,5	0	0	0	3	0	0	0	0	0	3
2	9,5	0	0	0	1	0	0	0	1	0	2
3	10,5	1	2	0	3	1	1	6	2	3	19
4	11,5	16	1	0	0	2	2	5	4	5	35
5	12,5	10	5	1	7	5	2	6	3	12	51
6	13,5	20	5	3	5	8	5	10	5	18	79
7	14,5	21	24	4	20	8	10	25	15	27	154
8	15,5	16	27	11	29	12	6	30	20	33	184
9	16,5	26	38	19	56	18	28	51	28	54	318
10	17,5	33	68	16	73	24	22	97	42	58	433
11	18,5	38	65	35	81	38	60	138	53	67	575
12	19,5	70	72	59	73	62	82	111	104	92	725
13	20,5	68	66	86	103	88	103	111	112	115	852
14	21,5	77	53	88	74	85	102	58	125	98	760
15	22,5	60	25	55	44	78	71	30	84	72	519
16	23,5	59	21	90	26	54	96	21	72	84	523
17	24,5	56	18	57	12	45	104	32	56	45	425
18	25,5	22	19	30	17	48	36	22	35	38	267
19	26,5	20	36	14	18	42	33	25	32	35	255
20	27,5	6	22	5	11	34	12	10	18	24	142
21	28,5	2	11	2	6	34	14	8	22	18	117
22	29,5	1	4	1	6	28	4	3	18	20	85
23	30,5	1	2	0	5	20	3	2	10	23	66
24	31,5	2	3	0	5	14	2	2	12	17	57
25	32,5	0	6	0	9	12	1	4	8	14	54
26	33,5	0	1	0	2	12	0	3	8	12	38
27	34,5	0	3	0	4	8	1	1	10	6	33
28	35,5	0	2	0	4	5	0	2	8	4	25
29	36,5	0	5	1	7	3	2	12	4	8	42
30	37,5	0	1	0	3	0	0	2	2	5	13
31	38,5	0	3	0	7	0	0	5	3	6	24
32	39,5	0	0	0	6	0	0	2	5	0	13
33	40,5	0	0	0	4	0	0	8	5	0	17
34	41,5	0	0	0	0	0	0	1	1	0	2
Total		625	608	577	724	788	802	843	927	1013	6907