AACL BIOFLUX
Aquaculture, Aquarium, Conservation & Legislation
International Journal of the Bioflux Society

Estimation of production trend of the depik, *Rasbora tawarensis* (Teleostei, Cyprinidae), in Lake Laut Tawar, Indonesia

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Abstract. The objective of the present study was to evaluate the production trend of the depik (*Rasbora tawarensis*) during the last two decades in Lake Laut Tawar. The production trend was examined based on the catch per unit efforts. The direct sampling, fishermen catches collection and fishermen interview were conducted to collect actual fish catches. The results showed that the depik, *R. tawarensis* production (indicated by the catch-per-unit effort (CPUE)) was seasonally dependent where the CPUE was higher in the rainy season compared to dry season. In addition, the CPUE was higher in the new moon according to lunar cycle. The production of depik in particular and fishes of Lake Laut Tawar in general are declining dramatically during the last two decades. The decrease in the water levels, destructive fishing gears, the presence of introduced species and pollution are the main reasons suggested for this phenomenon.
Key words: CPUE, endemic, conservation, dedeuseun, Takengon, Aceh Province.

Introduction. Depik, *Rasbora tawarensis* Weber & de Beaufort, 1916 is an important fish to the region culturally, nutritionally and economically. It is targeted by a large portion of fishermen in Lake Laut Tawar. According to Muchlisin (2010), from a morphologically point of view, *R. tawarensis* is characterised by the presence of two colour ribbons. The first ribbon is silver in colour in life or fresh fish and dark in preserved fish. It is located along the lateral line starting from the operculum to the end of the caudal peduncle. The second ribbon is dark in colour and is located along the dorsal line. The lateral line is complete and it stretches lengthwise below the lateral silver ribbon. The dorsal fin is situated in the middle of body length and the origin of the dorsal fin is above the pelvic base anterior to its posterior margin. The end of the pectoral fins reaches ½ distances of pelvic fins and the top of pectoral fins is not reaching base of anal fin. The mouth position is terminal and non protractile. The caudal fin is deep forked with one small black spot at the end of the caudal peduncle (Plate 1).

Presently, the fisheries activities in Lake Laut Tawar are unregulated and not well managed, resulting in over exploitation and ecological perturbations. The local fishermen claimed that the catches volume of the fish in general and depik in particular have been declined over years. However, no valid data was available on the how many volume of catching decreased in the last two decades.

The depik fish migrates to small tributaries in the northern region of the lake to spawn in specialized spawning area locally called the *dedeseun* and therefore the fish categorized as a potamodromous fish. The *dedeseun* refers to the water spring resources emerging from the rocky mountain around the lake (Muchlisin 2010). According to local fishermen that the number and body size of migrating depik have decreased over the

years during the 1980s, migration rate was at least 15 to 20 times per month in the peak season, with a maximum harvest of 600 kg on every single migration day. However, in 2008 the rate decreased to a maximum of 5 to 10 times in the peak season with a maximum production of 60 kg per migration (personal communication with *dedeseun* trap owners).

Plate 1. A photograph of fresh *R. tawarensis.*

In 1970s, there were more than one hundred *dedeseun* around the lake and most of them were located in the northern and western regions of the lake (personal communication with the head of the local fishermen organization, Lantak). The numbers decreased to 48 *dedeseuns* in 2006 and 13 *dedeseuns* in 2008, and only four *dedeseun* traps have remained active in the dry season of 2009, located in the Gegarang and Kelitu villages.

Declining water level is probably the main reason for the decreased number of *dedeseun* in Lake Laut Tawar. Many *dedeseuns* or tributaries have dried up while others had sluggish water flow. It is believed that water level had declined by 1.5 to 2 m during the last 20 years i.e. an average of 10 cm per year. This decline of water level is probably caused by deforestation during the last two decades coupled with forest fires and land clearance schemes which have resulted in forest and ecological destruction in this region. Besides the water level, other factors could be attributed to the decline in the depik population of Lake Laut Tawar. These include ecological perturbation, pollution, over fishing, climate changes, fishing methods and practices and also very likely predation and competition by introduced species.

Based on these stated problems, a sustainable management of fisheries in general and depik in particularly is crucially needed to maintain fish production in the future and to ensure this endemic species is sustainable. Some biological aspects of the depik have been reported by Muchlisin et al (2010a, 2010b, 2011). However, data on the production trend of the depik during the last two decades was not available. Therefore, this study is important to contribute basic information on production trend of depik in relation to management and conservation of the species. Hence, the objective of the present study was to evaluate the production trend of depik in the Lake Laut Tawar during the last two decades.

Material and Methods

Sampling site. Lake Laut Tawar (04^{o}36'43"N 096^{o}55'25"E) is situated in central Aceh Province, Indonesia about 1200 m above sea level. The lake is an old volcanic caldera of circa 16 km long, 4 km wide with an estimated maximum depth of 80 m and surrounded by mountains reaching above 2000 m (Muchlisin et al 2010b).

Sampling process. The stratified random sampling was utilized in this study. Two sampling periods were conducted in different seasons; the first sampling was in the dry season (23-26 July 2009) and the second sampling was in the wet season (21-24 November 2009). All sampling were done at the same sites for both periods.

The two fishing grounds were selected based on information from local fishermen, and a total of 14 fishing sites (seven sites per fishing ground) were determined randomly

(Plate 2). The coordinates, depths, distances from shore and main water quality parameters of every sampling site were recorded (Table 1).

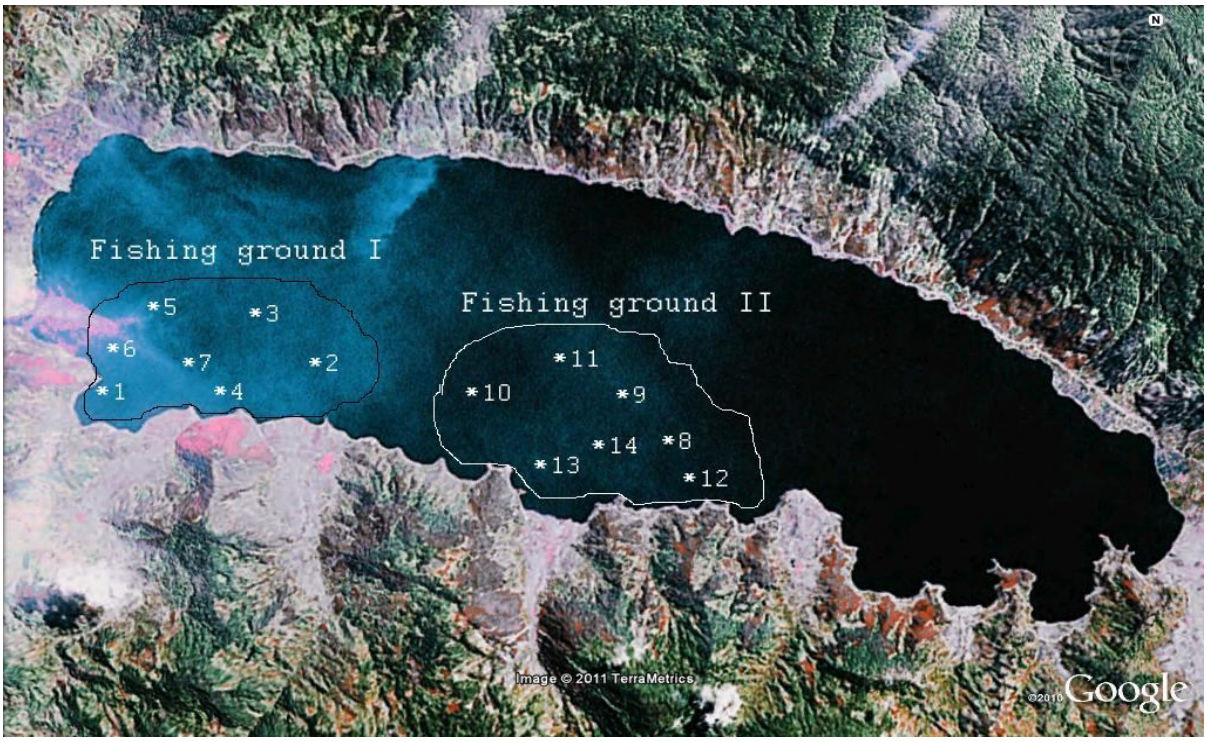

Plate 2. Image of the Lake Laut Tawar showing the sampling sites (photo generated by www.google.com).

Two sets of selective gill nets (each net was 20 m in length, 1.5 m in height, and 1.4 cm mesh size) were set up at 0.50 m below the water surface (two nets with the same mesh size in chains). The nets were set up overnight (18.00-07.00 h), and the captured fishes were collected and recorded for number and weight.

Production trend analysis. The production trend of depik was examined based on catch-per-unit effort (CPUE). The daily and seasonal production trends of depik were also examined. Daily catch data were collected from eight fishermen for three months (18 October to 21 December 2009 and 17 January to 20 February 2010). The seasonal production was evaluated based on CPUE data of dry (July 2009) and wet seasons (November 2009) based on a stratified random sampling approach.

The production trend data of the depik for the last several decades were collected by semi-structured interview with fishermen for information on actual catch in the past and present for both wet and dry seasons in general. This was conducted at twenty-five fishing villages located around the lake through interviews with randomly selected fishermen. In total 113 fishermen (50.2% of the total number of fishermen) were interviewed during the study. Of the 113 fishermen, 11 fishermen started for fishing in 1970s, 11 in 1980s, 12 in 1990, 9 in 2000, and 70 in 2009. To approximate randomization, the approach was to interview fishermen met at the shore as well as those in the villages.

Production trend for overall fish species from the lake was also evaluated and compiled from annual reports of government agencies and previous scientific reports and publications. Additional data were collected by using interviews with the local fisheries department officer in Takengon city for information on fisheries legislation, conservation actions, and threats affecting the endemic species and/or their habitat. The head of the fishermen's association "Lantak Laut Tawar" also participated in the survey.

Statistical analysis. Data were subjected to analysis of variance (ANOVA), followed by comparison of means using Duncan's multiple range test to determine significance of each data (Dytham 2003). The statistical analyses were performed using SPSS v14.

Table 1

The GPS coordinates, water depth, distance from the shore and the main water quality parameters of surface water at every sampling site

Sampling point	*Coordinates*	*Depth (m)*	*Distance (m)*	*Temp. (°C)*	*pH*	*Oxygen (ppm)*	*Turbidity (m)*
1	N04°36.4289' E096°52.0731'	10	150	23.6	7.78	6.8	1.9
2	N04°36.5782' E096°52.9060'	50	300	23.28	7.83	6.9	2
3	N04°36.6489' E096°52.7482'	50	800	23.3	7.79	6.9	2.2
4	N04°36.7207' E096°52.5766'	40	600	23.33	7.74	6.8	2.1
5	N04°36.7750' E096°52.3389'	30	500	23.46	7.78	6.8	2.1
6	N04°36.6338' E096°52.0569'	20	150	23.62	7.78	5.8	2.0
7	N04°36.5261' E096°51.9619'	15	150	23.56	7.77	5.7	2.0
8	N04°36.0064' E096°55.6108'	40	50	23.4	7.75	6.4	1.8
9	N04°36.3461' E096°55.1510'	60	800	22.91	7.82	6.8	2.2
10	N04°36.4830' E096°54.6668'	80	900	22.71	7.8	6.8	2.2
11	N04°36.4127' E096°54.8834'	60	600	22.88	7.82	6.8	2.1
12	N04°35.7931' E096°55.5257'	20	50	23.65	7.78	5.6	1.9
13	N04°35.7016' E096°55.2759'	15	75	23.6	7.77	5.6	1.8
14	N04°35.8508' E096°55.0215'	12	30	23.5	7.76	5.4	1.8
	Average			23.30	7.78	6.36	2.01

Results and Discussion

Seasonal production. The CPUEs varied temporally (according to season and week), where the average wet season CPUE was consistently higher compared to the dry season for both fishing grounds. In addition, there was a high variation of CPUE between the first and second fishing ground in the dry season, but not significantly different in the wet season (Fig. 1).

Daily production. The weekly production (based on daily catches data of eight fishermen for three months sampling) was evaluated according to the hijri calendar basis, and the results showed that the CPUE were higher in first weeks, although not significantly different from the other weeks (Fig. 2). The fisherman interview data revealed that the CPUE of depik has decreased over the years. The CPUE had declined sharply from 1,165.72 g/m^2 of net in 1970s to only 14.99 g/m^2 in 2009 (Fig. 3).

Overall fish production trend of Lake Laut Tawar. Government official reports and previous studies by Kartamihardja et al (1995) support the fishermen interview data in general. The overall fishes production from Lake Laut Tawar has decreased drastically from 455 tons in 1988 to only 74.5 tons in 2008 (Fig. 4).

The production of depik varied seasonally where the CPUE increased significantly during the wet season. According to local fishermen the daily production of depik also varied and depended on the moon rotation which is related to the hijri calendar. The volume catch was higher in the new and old moon compared to the full moon. In the full moon the night is bright and water visibility high. Most likely fish could detect the net

position and avoid being trapped. This is in agreement with the finding that the higher CPUEs were recorded in the first week (new moon) and fourth week (old moon) according to the Islamic calendar when it is relatively dark. However, the values were not different statistically; this may be due to the lack of replicates.

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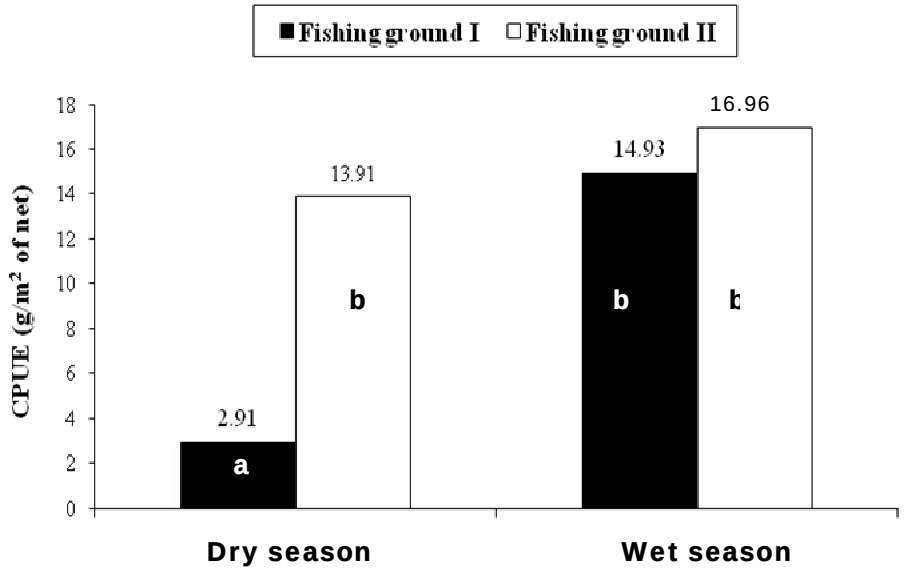

Figure 1. The seasonal production trend of depik according to fishing ground. Bars with the same letter were not significantly different (p>0.05).

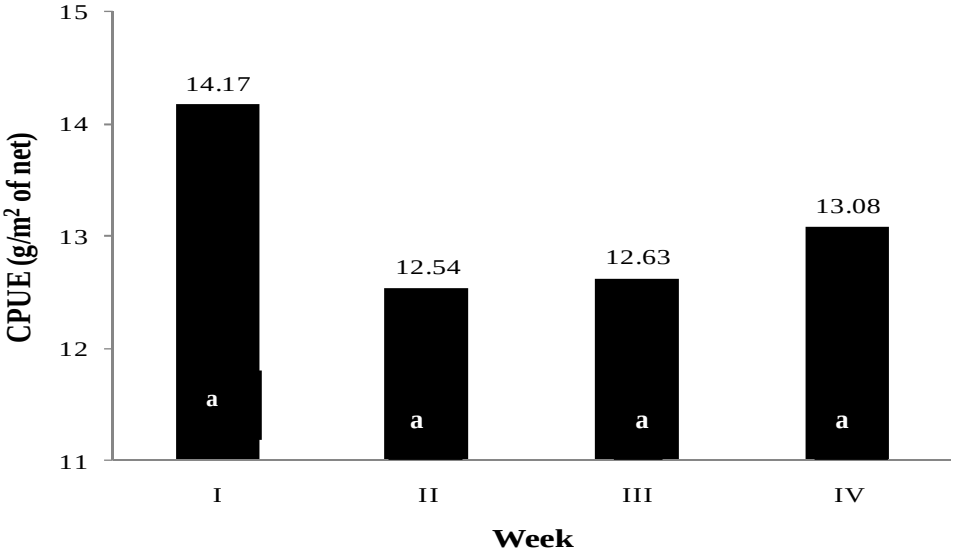

Figure 2. The average daily production (in CPUE) of depik according to hijri week calendar. The daily data obtained from three months fishing activities by 8 fishermen. Bars with the same letter were not significantly different (p>0.05).

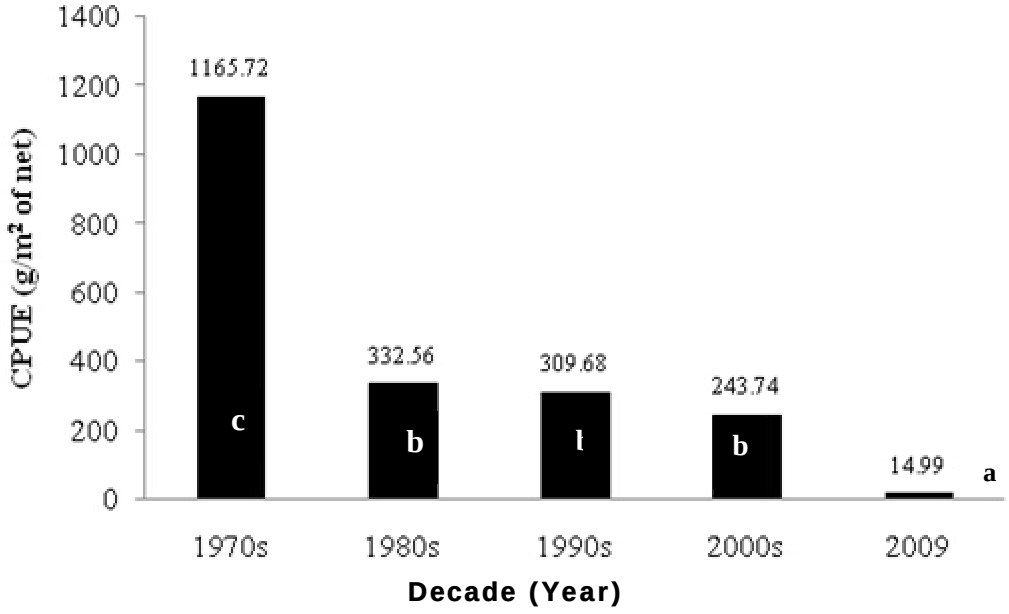

Figure 3. A graph of CPUE trend during the three last decades. The graph was generated from fishermen interview data. Bars with the same letters were not significantly different ($p>0.05$).

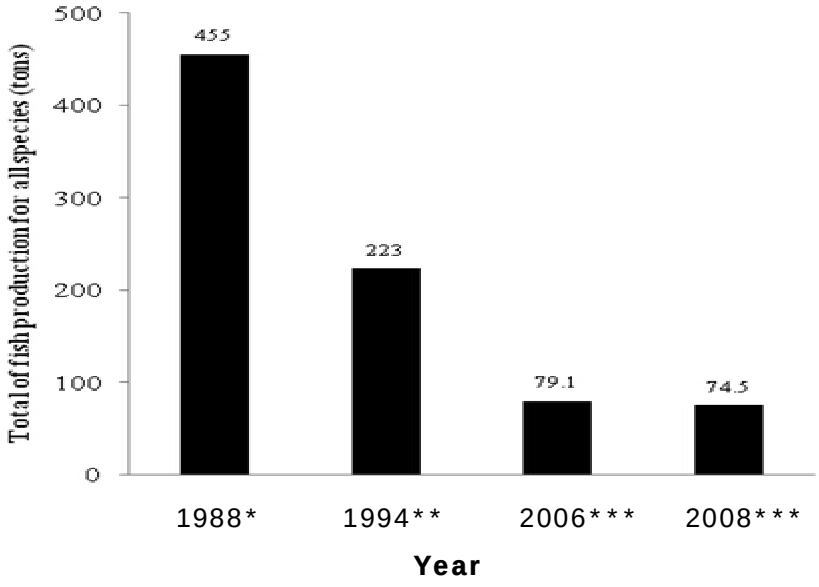

Figure 4. Overall fishes production trend from Lake Laut Tawar: *Aceh Provincial Fisheries Department (1989), **Kartamihardja et al (1995), ***Aceh Tengah Planning & Development Board (2009).

In general, the fish production of Lake Laut Tawar has decreased up to 83.5% during the last two decades. A parallel trend also occurred in the depik production where the CPUE declined drastically (up to 98%) during the last three decades.

The authors suspect that the depletion of the depik population began in the middle of the 1980s when intensive deforestation occurred and selective gillnet were introduced. Decreasing fish production not only occurred in Lake Laut Tawar but also occurred in other Indonesian lakes, for example Lake Tempe South Sulawesi. Cholik & Anggraeni (1994) reported that fish production in Lake Tempe decreased up to 66.7% during 1950 to 1994. In addition, increasing numbers of fishermen during the 1990s and use of small

selective gillnets probably resulted in over fishing and thus low catch per unit efforts. The interview data also revealed that most of the fishermen started to fish during 1990s.

A possible explanation for the increasing number of fishermen in the 1990s may have been security reasons. Aceh Province was in chaotic security condition during the three decades and the 1990s was the peak of the conflict. According to fishermen many farmers had to abandon their traditional livelihood to become fishermen for security reasons and to avoid threats by conflicting parties.

Another factor for the decline in fish production could be the receding water level. It is believed to have decreased to 150 cm during the last two decades (Plate 3). Many tributaries which had acted as spawning sites of the depik have dried up while the rest of the existing tributaries have decreased water velocity and volume. According to the fishermen, from the 1970s to 1980s the depik was the main fish target, but now this has changed to other species, for example tilapias and carps. Introduced species known to modify lake habitats are abundant throughout the lake, especially tilapia (*Oreochromis niloticus* (Linnaeus, 1758)), platyfish (*Xiphophorus sp.*) and common carp (*Cyprinus carpio* Linnaeus, 1758). The African catfish (*Clarias gariepinus* (Burchell, 1822)), an invasive predatory fish was also commonly found in the lake. Hence, besides the water pollution and decreasing water levels, presence of introduced species such as tilapias, African catfish (*C. gariepinus*) and platyfish (*Xiphophorus sp.*) pose additional problems to the fish survival and growth in the lake.

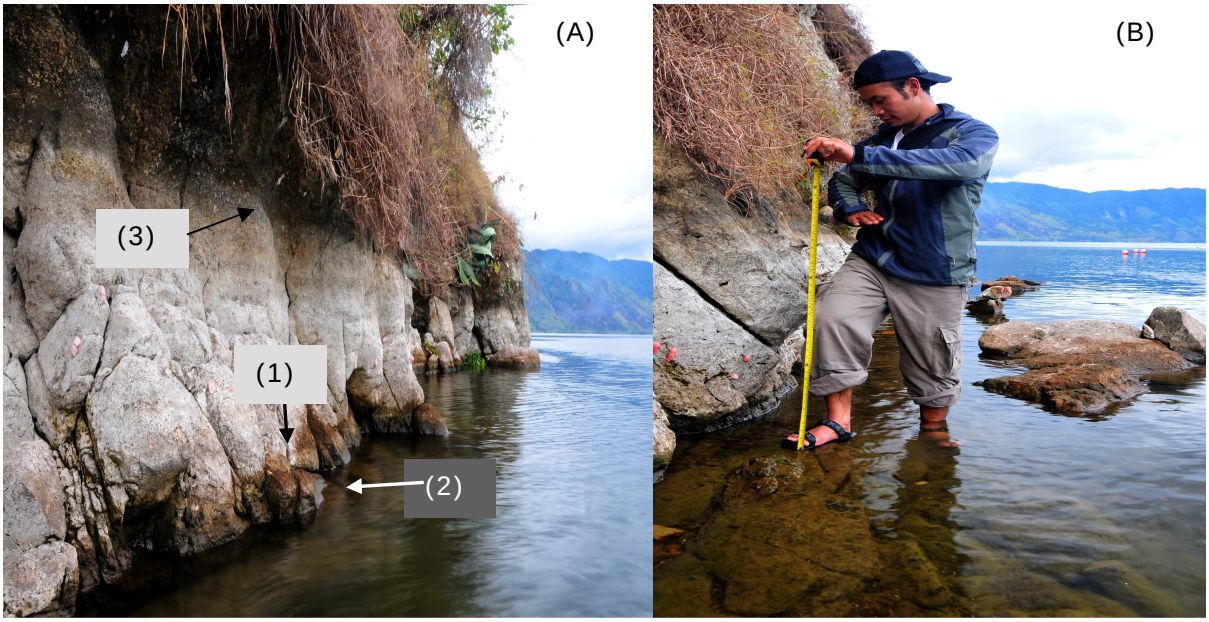

Plate 3. The evidence of decreasing of water level is marked in the rocky cliff. (A) at the Ujong Baro site, (B) at the Tanyor Nunguk site. (1) the high tide level in the dry rainy season, (2) the low tide level in the dry season, (3) the initial water level in the 1970s.

Before the 1980s, most of the fishermen used traditional fishing gears to catch depik, for example *penyangkulan* (stationary lift nets) and *dedeseun* (barrier tributary traps). These gears captured the bigger migratory fish near to shore and operated only in the rainy season. On the other hand, gillnet (at that time only hand-made gillnet) was not commonly used, because they were costly, time consuming to produce and needed special skill to develop this gillnet. With the introduction of factory-made gillnet in the early 1990s, the traditional gears were substituted by this more efficient gillnets. Indeed, gillnets are operated both in the rainy and wet seasons, everywhere in the lake, and can catch more fish including small fishes (below than 40-50 cm).

Conclusions. The depik, *R. tawarensis* is widespread in the lake but most abundant in shallow water and near shore however, the size is small on average for this areas. In

contrast, the bigger fish was found in deep water offshore, but with lower abundance. The distribution of depik was more spatially than seasonally dependent. However, the production was seasonally and spatially dependent. The production of depik in particular and fishes of Lake Laut Tawar in general are declining dramatically during the last two decades. The decrease in the water levels, destructive fishing gears and the presence of introduced species are the main reasons suggested for this phenomenon.

Acknowledgements. We express appreciate to Professor Siti-Azizah from Universiti Sains Malaysia for her suggestion during manuscript preparation. The technical assistance by Mr. Syafei and all members of Ichthyological Research Group of Syiah Kuala University are also acknowledged. This study was supported by The Mohammad bin Zayed Species Conservation Fund (Grant No. 0905687), for which I express sincere thank.

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Received: 28 June 2011. Accepted: 05 September 2011. Published online: 24 September 2011.
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How to cite this article:
Muchlisin Z. A., Fadli N., Rudi E., Mendo T., Siti-Azizah M. N., 2011 Estimation of production trend of the depik, *Rasbora tawarensis* (Teleostei, Cyprinidae), in Lake Laut Tawar, Indonesia. AACL Bioflux **4**(5):590-597.