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Population Dynamics of Yellowtail Scad, *Atule mate* (Cuvier 1833) in Marudu Bay, Sabah, Malaysia

(Dinamik Populasi Ikan Selar Biasa, *Atule mate* (Cuvier 1833) di Teluk Marudu, Sabah, Malaysia)

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ABSTRACT

The yellowtail scad, Atule mate*, forms important fisheries throughout the Indo-Pacific region. To know about the stock status of* A. mate *in Malaysia, various population parameters were measured, by utilizing length-frequency data, that included asymptotic length (L∞), growth coefficient (K), mortality rates (Z, F and M), exploitation level (E) and recruitment pattern of this species from Marudu Bay, Sabah, Malaysia. Total length and body weight relationship was estimated as* $W = 0.007TL^{3.148}$ ($R^2 = 0.937$)*. The asymptotic length (L∞) and growth coefficient (K) were estimated 27.80 cm and 1.50* yr^{-1}*, respectively. Total mortality (Z), natural mortality (M) and fishing mortality (F) were found to be 4.53, 2.46 and 2.07* yr^{-1}*, respectively. The exploitation level (E) was estimated 0.46. It was showed that the recruitment pattern was continuous with two major peaks per year. Relative yield per recruit predicted a maximum exploitation rate (*E_{max}*) which was 0.55. The current E value (0.46) is lower than the optimum exploitation (E = 0.50) as well predicted* E_{max}*. Therefore, it could be concluded that stock of* A. mate *in the investigated area of Marudu Bay, Sabah is under exploited.*

Keywords: Atule mate*; Marudu Bay; Malaysia; population dynamics; Sabah*

ABSTRAK

Ikan selar biasa, Atule mate*, memainkan peranan penting bagi perikanan di seluruh kawasan Indo-Pasifik. Untuk mengetahui tentang status stok* A. mate *di Malaysia, pelbagai parameter populasi diukur dengan menggunakan data kekerapan panjang termasuk panjang asimtotik (L∞), pekali tumbesaran (K), kadar kematian (Z, F dan M), tahap eksploitasi (E) dan corak pembiakan spesies ini dari Teluk Marudu, Sabah, Malaysia. Hubungan antara jumlah panjang dan berat badan dianggarkan sebagai* $W= 0.007TL^{3.148}$ ($R^2 = 0.937$)*. Panjang asimtotik (L∞) dan pekali tumbesaran (K) dianggarkan secara berturutan sebanyak 27.80 cm dan 1.50* yr^{-1}*. Jumlah kematian (Z), kematian semula jadi (M) dan kematian tangkapan (F) secara berturutan untuk* A. mate *adalah 4.53, 2.46 dan 2.07* yr^{-1}*. Tahap eksploitasi ikan ini (E) adalah 0.46. Terdapat pembiakan berterusan bagi* A. mate*, tetapi dengan dua kejadian besar bagi setiap tahun. Analisis hasil tangkapan bagi setiap pembiakan meramalkan kadar eksploitasi maksimum (*E_{max}*) adalah 0.55. Nilai E terkini (0.46) adalah lebih rendah daripada eksploitasi optimum (E = 0.50) dan juga ramalan* E_{max}*. Oleh yang demikian, ini menunjukkan bahawa stok* A. mate *yang dikaji di Teluk Marudu, Sabah, adalah di bawah tahap eksploitasi.*

Kata kunci: A. mate*; dinamik populasi; Malaysia; Sabah; Teluk Marudu*

INTRODUCTION

Carangid fishes (family Carangidae) form some of the most economically important fisheries throughout the world due to their wide distribution and high value and demand from the seafood industry (Kasim & Hamsa 1994; Lin & Shao 1999; Murty 1991; Pauly 1980). Generally, this family is comprised of 30 genera and 140 species (Silvestre et al. 1989) and some examples of common and important carangid species include round scads, queen fish, trevallies, horse mackerels, jacks and pompanos. These species are found in all the main oceans (Indian, Atlantic and Pacific Oceans) as well as being widely distributed throughout the tropical and sub-tropical Indo-Pacific regions (Froese & Pauly 2013). Carangid fish are mainly pelagic predators that feed on invertebrate, plankton, such as copepods and small fish (Kingston et al. 1999) and depending on the species, the maximum size ranges from 25 to 100 cm (Reuben et al. 1992).

Of all the carangid fishes that can be found throughout Malaysian marine waters, the yellowtail scad, *Atule mate* (Cuvier 1833), is undoubtedly the most commercially important and can be abundantly found throughout Malaysian coastal waters. Locally known as 'selar', they often inhabit mangroves and bays and their harvests have been increasing from 22,774 metric tons in 2009 to 34,783 metric tons in 2013 (DoF 2013). Currently, these fish are caught from a variety of gear including beach seines, gill nets, hooks and lines and then are normally sold fresh to be fried and grilled at restaurants, but are sometimes dried and salted. Moreover, several issues including the provision of fisheries licenses, fish ground allocation and mesh regulation policies have also been implicated as contributors to causing an imbalance stock position of many economically important fish, including *A. mate* (Andreu-Soler et al. 2006; Awong et al. 2011; Rumpet et al. 1997; Sani et al. 2010; Teh et al. 2011; Vidthayanon 1998).

Several researchers have investigated the distribution and abundance of *A. mate* from several Indo-Pacific regions, including India (Reuben et al. 1992), New Caledonia (Letourneur et al. 1998), Philippines (Olaño et al. 2002) and Thailand (Kongprom et al. 2003). However, the exact and actual fisheries status of this highly commercially important species in Malaysia currently is unknown. Considering that the per capita demand for seafood products in Malaysia is one of the highest in Asia at over 50 kg/year, which is increasing with a growing population (Teh 2012), it is imperative to determine the stock position of commercially important fish species in order for the implementation of sound fisheries policies and sustainability. Of all the tools used for estimating these parameters, FiSAT (FAO-ICLARM Stock Assessment Tools) is one of the most common (Abdussamad et al. 2010; Allam 2003; Balli et al. 2011; Francis & Samuel 2010; Gayanilo et al. 1996; Jaiswar et al. 2003; Mateus & Estupiñán 2002). This is likely because several important population parameters such as asymptotic length ($L\infty$) and growth coefficients (K), mortality (natural and fishing) as well as their level of exploitation (E) can be estimated from only length-frequency data. Due to the commercial importance of *A. mate* to many communities in Malaysia, the aim of this study was to investigate the population dynamics of *A. mate* in order to assess their stock position in the estuarine waters of Marudu Bay, Sabah, Malaysia.

METHODS

STUDY SITE AND SAMPLING DESIGN

This study was conducted in the mangrove estuarine waters of Marudu Bay, Sabah, Malaysia (Figure 1). The samples of *A. mate* were collected every month in day time between October 2012 and September 2013. Five sampling stations were selected and each station was approximately 1 km apart from each others in the Marudu Bay. It is assumed that samples of *A. mate* collected from the five stations could be representative of Marudu Bay. The specific locations of the stations were St. 1 (N 06º 36.169' E 116º 46.400'), St. 2 (N 06º 36.651' E 116º 48.895'), St. 3 (N 06º 36.700' E 116º 47.775'), St. 4 (N 06º 36.751' E 116º 47.816') and St. 5 (N 06º 37.502' E 116º 47.775'). The distance of St. 1 from the coast line was approximately 2 km. Fish samples were collected by using a gill net, which was 140 - 150 m in length and 1.0 - 1.5 m in width. The net was divided into five sections, each with a different mesh size in order to obtain variable size of fish. The section of net was attached together side by side. The mean mesh sizes were 1.25 (± 0.01) inches in the first section, 1.50 (± 0.01) inches in the

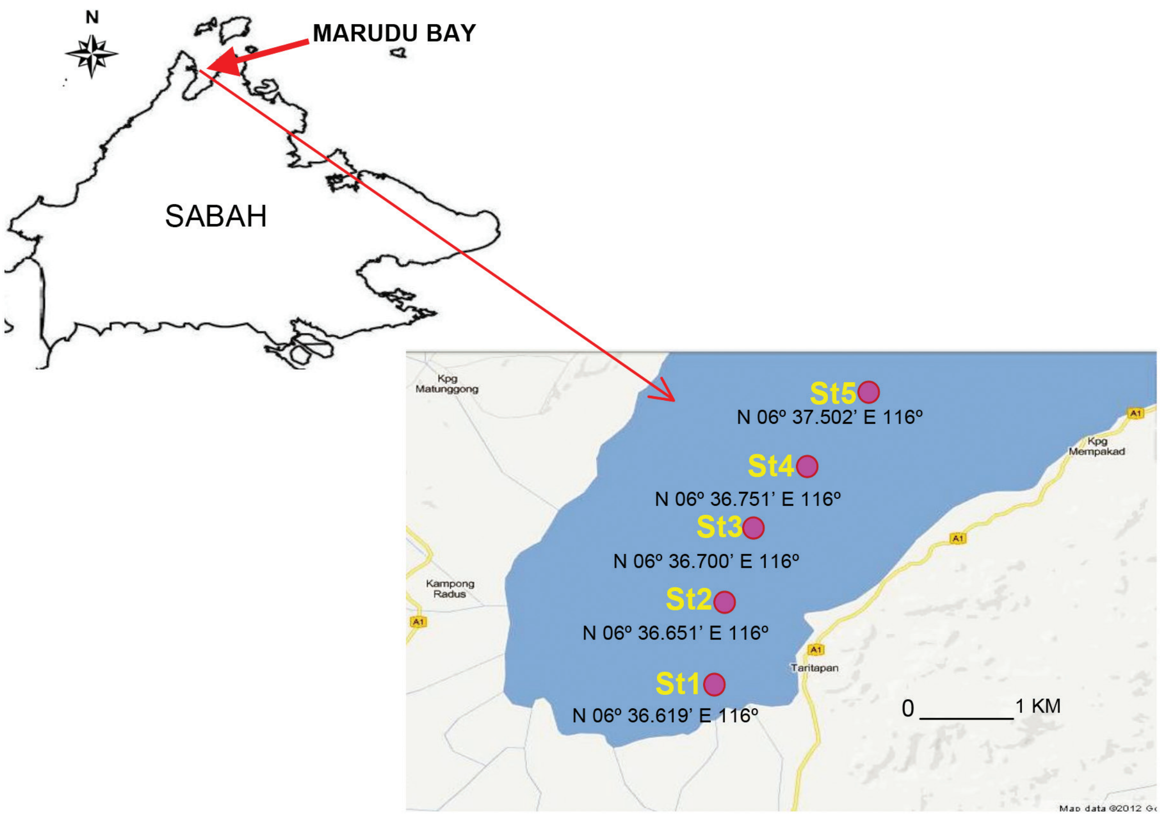

FIGURE 1. Geographical location of the sampling stations in the Marudu Bay, Sabah, Malaysia

second section, 1.75 (± 0.03) inches in the third section, 2.00 (± 0.04) inches in the fourth section and 2.50 (± 0.1) inches in the fifth section. For each station, the deployment of gill net was ranged from 30 - 60 min. After collecting the fish samples, they were immediately preserved in ice.

SPECIES IDENTIFICATION

A total of 788 individuals of *A. mate* were collected and species identification was done by using the references and manuals of Ambak et al. (2010), Mohsin and Ambak (1996) and Rumpet et al. (1997). The lengths and weights were measured using a digital caliper (0.1 mm) and electronic balance (0.001 g), respectively.

DATA ANALYSIS

The equation $W = a L^b$ was used to calculate the length-weight relationship according to Ricker (1975) and Quinn II and Deriso (1999), where W is the weight (g); L is the total length (cm); a is the intercept (condition factor); and b is the slope (growth coefficient, or fish relative growth rate). To estimate the a and b parameters, a least squares linear regression was used on log-log transformed data: $Log_{10} W = Log_{10} a + b Log_{10} L$ and to quantify the strength of this relationship, a coefficient of determination (R^2) was used (Scherrer 1984). Additionally, 95% confidence limits of a and b as well as the statistical significance of r^2 were calculated.

Various growth parameters that included the von Bertalanffy growth function (VBGF), asymptotic length ($L\infty$) and growth co-efficient (K) parameters were estimated using ELEFAN-I routing (Pauly & David 1981), which was incorporated into the FiSAT software. To estimate the reliability of the K value, a K scan routine was conducted. The growth performance index (φ') was calculated based on the $L\infty$ and K estimates according to Pauly and Munro (1984) from the following equation:

$$\varphi' = 2 \log_{10} L\mu + \log_{10} K$$

The total mortality (Z) was estimated from length converted catch curve (Pauly 1984) while the natural mortality rate (M) was estimated using the empirical relationship (Pauly 1980), which is as follows:

$$Log_{10}M = -0.0066 - 0.279Log_{10}L_{\infty} + 0.6543.Log_{10}K + 0.4634\ Log_{10}T$$

where M is the natural mortality; L is the asymptotic length; K is the growth coefficient of the VBGF; and T is the mean annual water temperature °C. The obtained Z and M values, which were the total mortality and natural mortality, respectively, were subtracted from each other to estimate the fishing mortality (F).

Meanwhile, the exploitation level (E) was calculated from the following equation according to Gulland (1971):

$$E = F/Z = F/ (F+M).$$

The capture probability of each length class was calculated by using the ascending left arm of the length-converted catch curve according to the method of Pauly (1987). A curve to estimate the length at first capture L_C was produced by plotting the cumulative capture probability against the mid-length. The L_C was used as corresponding to the cumulative 50% probability.

By using a backward projection on the length axis from the set of length frequency data in FiSAT, the stock recruitment pattern was measured by a backward projection on the length axis. This routine reconstructed recruitment pulses from the time series of length-frequency data, which determined the frequency (per year) and relative strength of each pulse. The inputted values were $L\infty$, K and t_0 (t_0 = 0). NORMSEP in FiSAT produced a normal distribution of the recruitment pattern according to Pauly and Caddy (1985).

The estimated length structured virtual population analysis and cohort analysis was analyzed using the FiSAT routine. The $L\infty$, K, M, F, a (constant) and b (exponent) values were inputs in a VPA analysis and the t_0 value was assumed to be zero. This method was first published by Fry (1949) and subsequently modified by Jones (1984) and Pauly (1984).

A model to estimate the relative yield-per-recruit (Y/R) and relative biomass-per-recruit (B/R) was based on Beverton and Holt (1966) and subsequently modified by Pauly and Soriano (1986) and then incorporated into the FiSAT software. In addition, this analysis also produced values for the maximum allowable limit of exploitation (E_{max}) and maximum relative yield-per-recruit. Both the exploitation rate and unexploited relative biomass-per-recruit (B/R) ($E_{0.5}$) were estimated based on an increase of 10% of its value at E = 0.

The exploitation rate was estimated at the point where there was a 10% increase in relative yield-per-recruit from its value of E = 0 ($E_{0.1}$) and the exploitation rate corresponding to 50% of the unexploited relative biomass-per-recruit (B/R) ($E_{0.5}$).

RESULTS

The length frequency distribution and basic population characteristics of *A. mate* are shown in Table 1. The length-weight relationship parameters, growth constant (a) and relative growth rate or exponent (b) of *A. mate* was estimated to be 0.007 and 3.148, respectively. The length-weight relationship of *A. mate* from Marudu Bay, Sabah, Malaysia could be described as follows:

$W= 0.007TL^{3.148}$ or Log

$W= 3.148\ Log\ TL - 2.18$ ($R^2 = 0.937$)

Scattered plots of the total length and body weight of *A. mate* are shown in Figure 2 and log values of these parameters were plotted against each other to obtain a linear relationship (Figure 3).

TABLE 1. Monthly length frequency data of *Atule mate* collected between October 2012 and September 2013 from the mangrove estuarine waters of Marudu Bay, Sabah, Malaysia

Mid-Lengths (ML)	Oct/12	Nov	Dec	Jan/13	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
8.0	1	2	2	1			7					
10.0	30	8	6	21	1				20	17	8	8
12.0	18	14	17	88	22				26	18	5	2
14.0	4	7	26	7	16	1	11	3	17	3	24	26
16.0	3	2	5	7	18	6	42	8	11	1	11	12
18.0		2		6	3	5	43	17	6	1	9	10
20.0		1				9	21	16				2
22.0			1			7	15					1
24.0						2	3	8				
26.0						1		2				
Sum	41	37	50	130	60	31	143	55	80	40	60	61
Total	788											

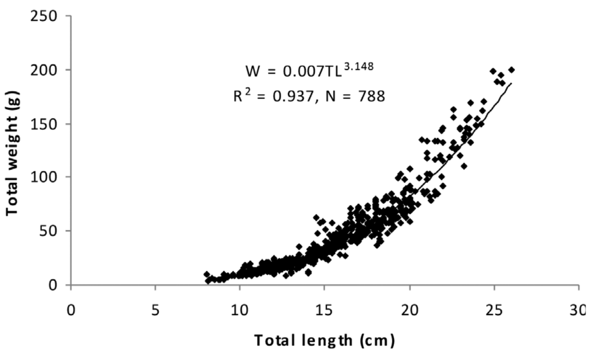

FIGURE 2. Length weight relationship (Arithmetic scale) of *A. mate* in Marudu Bay, Sabah, Malaysia

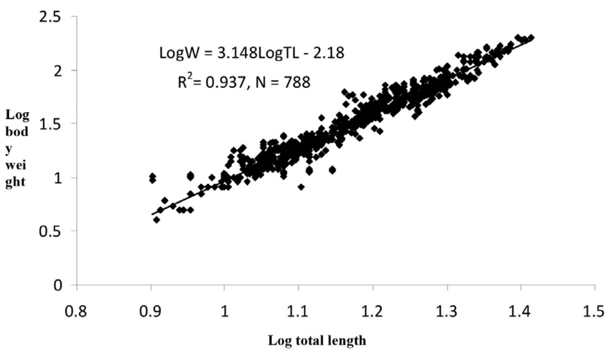

FIGURE 3. Length weight relationship (Logarithmic scale) of *A. mate* in Marudu Bay, Sabah, Malaysia

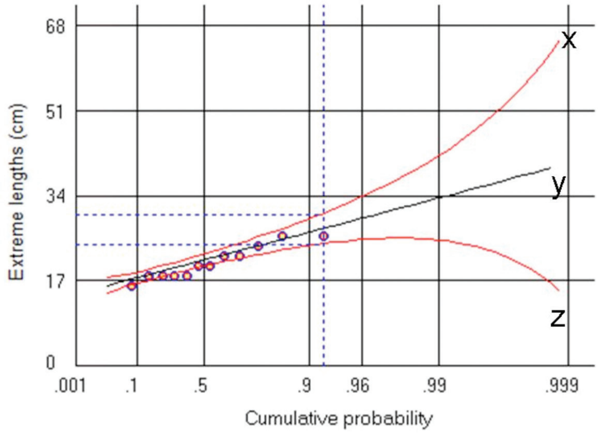

FIGURE 4. Maximum length for *A. mate* from Marudu Bay, Sabah, Malaysia, based on the extreme value theory (Formacion et al. 1991). The maximum length value and the 95% confidence intervals were obtained from the intersection of overall maximum length from the y and x, z lines, respectively

The FiSAT output, together with Figure 4, clearly showed that the observed and predicted extreme lengths (L_{max}) were found to be 26.00 and 27.24 cm, respectively. The 95% confidence interval range for extreme length was calculated as 24.16 - 29.84 cm (Table 2). The best VGBF growth constant (K) value was estimated as 1.50 yr^{-1} (Figure 5). The response surface (Rn) was 0.20, which selected the best growth parameter combination from $L\infty$ = 27.80 cm and K = 1.50 yr^{-1} (Table 2). After superimposing the optimized growth curve on the restructured length-frequency histograms (Figure 6) the growth performance index (φ') of *A. mate* was estimated to be 2.08 (Table 2).

The total mortality coefficient (Z) and natural mortality (M) were calculated as 4.53 yr^{-1} (Figure 7) and 2.46 yr^{-1}, respectively. Based on Z, the fishing mortality (F) was 2.07 yr^{-1} (Table 2) and the exploitation rate (E) was calculated as 0.46 (Table 2). The length of which 25% ($L_{25\%}$) and 75% ($L_{75\%}$) of the fish were retained in the gear was estimated to be 8.70 and 11.80 cm, respectively (Figure 8). The length at first capture ($L_{50\%}$), which represents the length at which

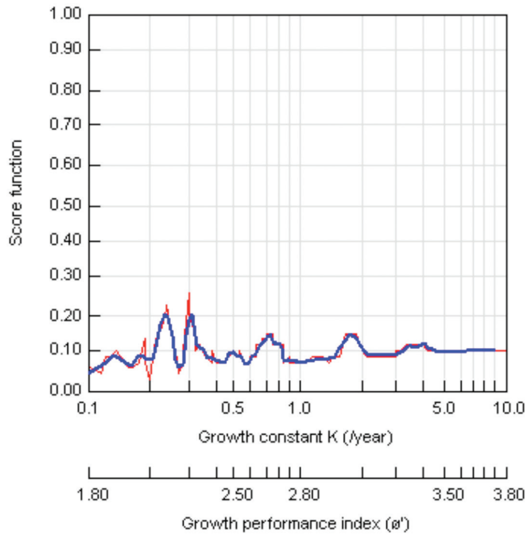

FIGURE 5. K-scan routine for best value of von Bertalanffy growth function (VBGF), asymptotic length (L_μ) and growth coefficient (K) of *A. mate* using ELEFAN-1 from the Marudu Bay, Sabah, Malaysia

TABLE 2. Estimated population parameters of *A. mate* from Marudu Bay, Sabah, Malaysia

Population parameters	A. mate
Predicted extreme length (L_{max}) in cm	27.24
95% Confidence interval (cm)	24.16 - 29.84
Asymptotic length (L_μ) in cm	27.80
Growth co-efficient (K yr^{-1})	1.50
Response surface (Rn)	0.20
Growth performance index (φ')	2.08
Natural mortality (M yr^{-1})	2.46
Fishing mortality (F yr^{-1})	2.07
Total mortality (Z yr^{-1})	4.53
Exploitation level (E)	0.46
Allowable limit of exploitation (E_{max})	0.55
Sample number (N)	788

50% of the fish population becomes vulnerable to the fishing gear used, was calculated to be 10.20 cm (Figure 8). The recruitment patterns of *A. mate* were continuous with two major peaks per year (Figure 9). The recruitment varied from 0.01% to 20.20% in the investigated area.

VPA showed that the minimum and maximum fishing mortalities of *A. mate* were recorded for the mid-lengths as 0.1 and 2.5 yr^{-1}, respectively (Figure 10). The fishing mortality (F) was comparatively high over the mid-lengths between 18 and 20 cm. The F value reached a maximum of 2.54 yr^{-1} at 18 cm with an average value of 0.90 yr^{-1}. The relative Y/R and B/R of *A. mate* were computed using knife-edge procedure assumptions. The maximum allowable exploitation (E_{max}) to give a maximum relative yield-per-recruit was 0.55 (Figure 11). The exploitation level at which an increase in relative yield per recruit was 10% of the marginal increase ($E_{0.1}$) was 0.48. Meanwhile, the exploitation level ($E_{0.5}$) that corresponded to 50% of the relative biomass per recruit of the unexploited stock was 0.32.

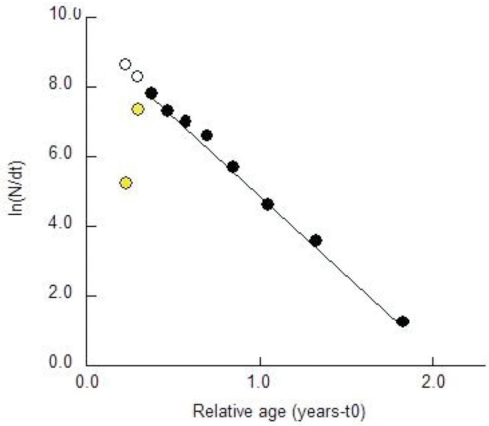

FIGURE 7. Length-converted catch curved of *A. mate* from Marudu Bay, Sabah, Malaysia. The darkened full dots represent the points used in calculating through least square linear regression and the open dots represent the point either not fully recruited or close to L_∞

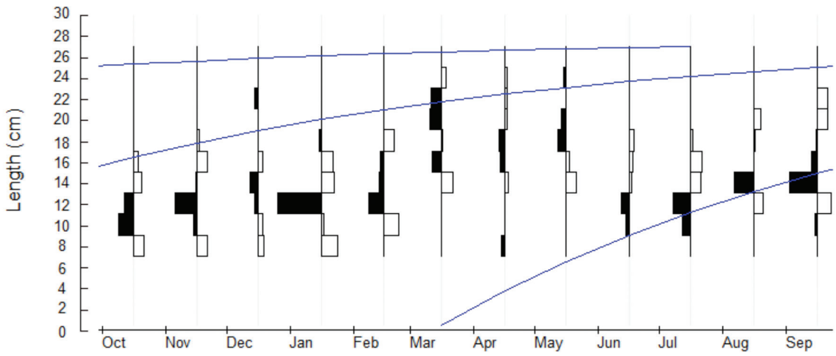

FIGURE 6. von Bertalanffy growth curves of *A. mate* from Marudu Bay, Sabah, Malaysia, superimposed on the restructured length-frequency histograms. The black and white bars are positive and negative deviations from the 'weighted' moving average of three length classes and they represent pseudo-cohorts

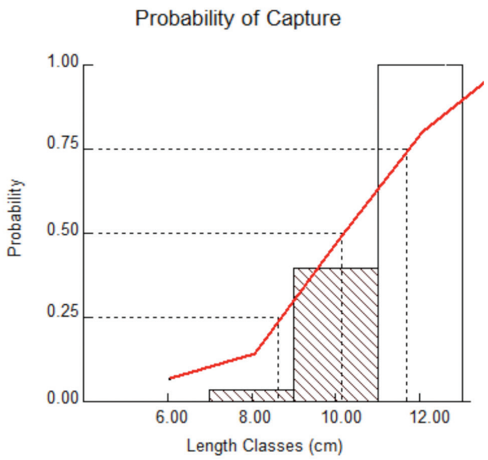

FIGURE 8. Capture probability of each length class of *A. mate* from Marudu Bay, Sabah, Malaysia ($L_{25\%}$ = 8.70 cm, $L_{50\%}$ or Lc = 10.20 cm and $L_{75\%}$ = 11.80 cm)

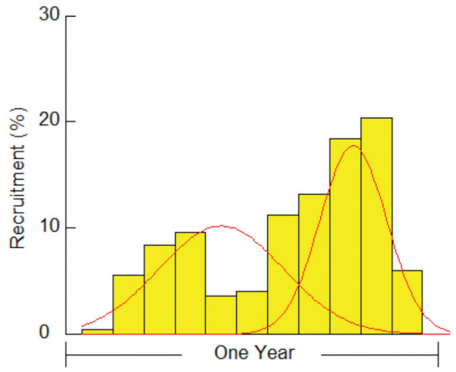

FIGURE 9. Recruitment pattern of *A. mate* in Marudu Bay, Sabah, Malaysia

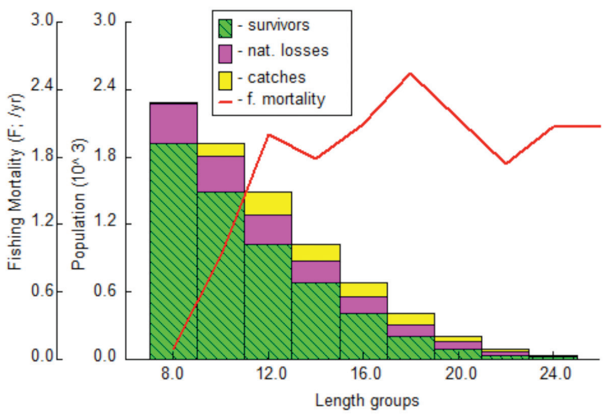

FIGURE 10. Virtual population analysis of *A. mate* in Marudu Bay, Sabah, Malaysia

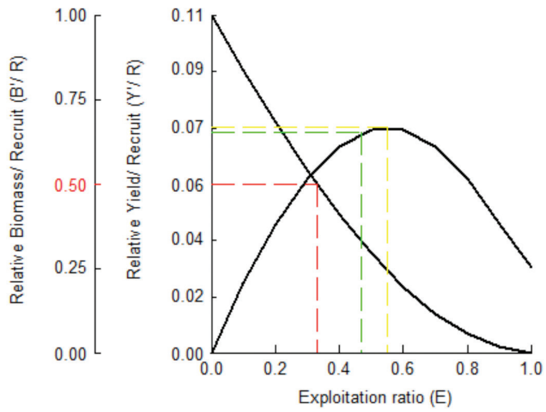

FIGURE 11. Relative Y/R and B/R of *A. mate* in Marudu Bay, Sabah, Malaysia, using a knife-edge procedure

DISCUSSION

The use of weight-length relationships in fisheries studies has been shown to be particularly useful for estimating the biomass of populations based on length data which is generally easier to measure as well as examining changes with life history (Cushing 1988). In general, the growth coefficient (b) of fish generally falls between 2.5 and 3.4 and when the value is 3, the length-weight relationship is characterized as having isometric growth in which the body size and weight grow in equal proportions (Carlander 1977). In the present study, the estimated b of *A. mate* was 3.148, indicating positive allometric growth in which the fish body length grows faster in relation to their body size (Ricker 1975). Positive allometric growth generally indicates good overall health for most of the fish (Froese 2006) and the obtained value can be used to provide information regarding the suitability of the environment for a particular species. Similarly, a study of *A. mate* in India by Reuben et al. (1992) yielded the b value = 3.225, indicating the same situation of positive allometric growth with present study. It can be assumed from these studies that *A. mate* live in favorable environments, likely due to high food abundance and/or low competition among other aquatic animals.

The estimated asymptotic length (L∞) was 27.80 cm and VGBF growth coefficient (K) was 1.50 yr^{-1} in the present study. These values are similarly used to indicate the overall health of aquatic animals, which may be compared with the same species at different geographical locations (Table 3). For example, the highest L∞ value of 34.00 cm was reported from India (Reuben et al. 1992), while the lowest value of 27.80 cm was recorded in the present study. In contrast, the highest K value of 1.50 yr^{-1} was observed in this study while the lowest K value of 0.85 yr^{-1} was found in Indian waters (Reuben et al. 1992). Meanwhile, the values for L∞ and K in Thailand (Kongprom et al. 2003) and Philippines (Olaño et al. 2002) fell in the middle from the present study and those of Reuben et al. (1992) (Table 3). This means that the values of L∞ and K from studies in a tropical region (Malaysia, Thailand and Philippines) are only slightly different to each other. This is may be due to the similarities in the characteristics of habitat and climate. The index of

TABLE 3. Growth parameters (L_μ, and K) and exploitation level (E) of *A. mate* from different geographical locations

Location	L_μ (cm)	K yr^{-1}	E	Source
Marudu Bay (Malaysia)	27.80 TL	1.50	0.46	Present study
Gulf of Thailand (Thailand)	31.00 TL	1.40	-	Kongprom et al. (2003)
Lagonoy Gulf (Phillipine)	31.22 TL	0.97	0.65	Olaño et al. (2002)
Kerala (India)	34.00 TL	0.85	0.65	Reuben et al. (1992)

phi prime by Munro and Pauly (1983) has been shown to be suitable for comparing and estimating the overall growth performance of different fish stock species. The calculated value for the growth performance index (φ') of *A. mate* during the present investigation was 2.08. The phi prime value, ϕ' is expected to be relatively constant for a species or within a genus. The phi prime value in previous studies by Lavapie-Gonzalez et al. (1997), Oakley and Bakhsh (1989) and Reuben et al. (1992) were estimated at higher values of 2.55, 2.99 and 2.93, respectively. This indicates that the comparison between the present study and previous studies shows that these values are more or less the same.

For mortalities of *A. mate*, the natural mortality was 2.46 yr^{-1} and since this was higher than the fishing mortalities of 2.07 yr^{-1} (Table 2), this indicates an imbalanced stock position. The overall total mortality (Z) of *A. mate* was 4.53 yr^{-1} in Marudu Bay and is similar to 5.03 yr^{-1} from Lagonoy Gulf, Philippines (Olaño et al. 2002). Meanwhile, since the exploitation level (E) of *A. mate* was estimated to be 0.46, this indicates this species is under-exploited in Marudu Bay, Sabah. This is based on the assumption that any stock is optimally exploited when the fishing mortality (F) is equal to the natural mortality (M), or E = (F/Z) = 0.5 (Gulland 1971). The exploitation level value in the present study was lower than those from Kerala coast, India (Reuben et al. 1992) and in Lagonoy Gulf, Philippines (Olaño et al. 2002), which were both 0.65 (Table 3). The higher values of E (E > 0.50) indicate an 'over-fishing' condition of *A. mate* in India and Philippines since the yield is considered over-exploited if the E value is greater than 0.5 (Gulland 1971).

This study showed that the recruitment pattern of *A. mate* is likely continuous but with two major peaks per year, in January and August, that can potentially produce two major cohorts in Marudu Bay. Similarly, Reuben et al. (1992) also reported two main recruitment events per year for *A. mate* off the coastal waters of Kerala, India. This similarity could possibly be due to biological characteristics and/or the seasonality of the monsoons influencing some environmental factors such as salinity, which is well known to trigger spawning as shown in other species (de Vlaming 1972; Omori 1978).

The maximum allowable limit of exploitation rate (E_{max}) value in the population study of fisheries can be described as the value of exploitation level (E) giving the maximum relative yield-per-recruit (Beverton & Holt 1966; Pauly & Soriano 1986). If the E value is higher than the E_{max} value, then the stock of the fish is in danger of becoming depleted. In this study, the E_{max} value that gives a maximum relative yield-per-recruit (Y/R) of 0.55, was higher than the exploitation rate (E) of 0.46 for *A. mate* and is comparable to the optimal exploitation level of 0.50. This further indicates that the fishery of *A. mate* is below the optimal exploitation level. Moreover, this exploitation rate is also below the more conservative yield concept ($E_{0.1}$ = 0.48), where the marginal increase in relative yield-per-recruit is 10% of its value at E = 0. This showed that the fishery of *A. mate* is likely under-exploited in terms of relative yield-per-recruit. Thus, the fishing pressure on the stock is low and slightly higher yields of *A. mate* (E = 0.47 – 0.50) could potentially be made without necessarily leading to over-exploitation (E ≥ 0.50) (Figure 11).

The current situation in Marudu Bay where the fisheries of *A. mate* is under-exploited may be attributed to this area having numerous tributaries that are still largely fringed with mangrove forests, which is well known to provide important habitats for *A. mate*, as well as their prey such as small fish, cephalopods and invertebrate zooplankton (Jakobsen et al. 2007; Yusoff et al. 2012). Additionally, these tributaries have been shown to have little to no pollution, likely related to relatively low industrial and agricultural activities in the area (Aris et al. 2014). These points to future research directions such as determining the extent of dependence *A. mate* have on the surrounding mangrove areas for habitats and food.

The present work is the first to offer baseline information regarding the fisheries status of the commercially important *A. mate* in Malaysia, which will be useful for the management of their sustainable fisheries. Although *A. mate* in Marudu Bay, Sabah is currently underexploited while the population parameters suggest this species lives in a favorable environment. However, considering this species forms an important fisheries industry in Malaysia, periodic monitoring in this area may be needed to prevent a population decline.

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