Fishery, biology and population characteristics of Kawakawa in Perlis the West Coast Of Peninsular Malaysia

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ABSTRACT

Neritic tuna species in Malaysia were longtail tunas, frigate tunas and kawakawa. Neritic tuna contribute 4.5% of Malaysia's marine fish landings in 2015. Purse sienes are the most important fishing gear in neritic tuna fisheries, especially the 40-69.9 GRT and >70 GRT vessel size. It contributed more than 82% of the annual catches of neritic tuna in Malaysia. In Kuala Perlis, neritic tuna species are the second most abundant (13%) landed by purse seines after scad (16%), with longtail tuna dominated the landings followed by kawakawa and frigate tuna. Monthly length weight measurement of the three species of neritic tuna showed a relationship of $W = 0.000062\ L^{2.7759}$ for kawakawa $W = 0.000013\ L^{3.0580}$. Age and growth were estimated using length based methods. The von Bertalanffy growth parameters estimated for kawakawa were $L\infty = 60.43$ cm, annual $K = 0.26$ and $t_{o} = -0.55$ years. Mortality estimated were $M = 0.33$, $Z = 0.80$ and $F = 0.47$ with the exploitation rate $E = 0.59$.

1.0 INTRODUCTION

1.1 Malaysia fisheries profile

In 2013, the fisheries sector contributed RM11,466.53 million to the national economy, an increase of 0.23% compared to 2012. The marine capture fisheries sub-sector which includes coastal and deep sea, is still the largest contributor of 1,482,900 tonnes (84.77%), valued at RM8,335.92 million (77.05%), an increase of 0.72% in terms of quantity and by 4.44% in value compared to 2012.

Fisheries resources in Malaysia waters is divided into two, namely the coastal and deep sea. The coastal waters of the coast up to 30 nautical miles and the deep sea is beyond 30 nautical miles from the coast. In 2013, landings of marine fish landings recorded at 1,482,900 tonnes, an increase of 0.72% compared with 1,472,240 tonnes in 2012.

The contribution of inshore landings has increased by 1.81% from1, 136,182.17 mt in 2012 to 1,156,719.36 mt in 2013. Meanwhile, landings from deep sea has shown a decrease of 2.94% from 336,057.36 mt in 2012 to 326,180.44 mt in 2013. Peninsular Malaysia is still the largest contributor landings in Malaysia. In 2013, it accounted for 1,053,379.34 mt or 71.04% of country's total fish landings. West Coast of Peninsular Malaysia remained the main contributor to the landing with 715,683.93 tonnes (67.94%). Perak and Selangor were the main contributors to the total landings of each of 307,185.94 tonnes (42.92%) and 105,559.82 tonnes (14.75%). On the East Coast, Pahang and East Johor is a major contributor to each of 107,347.92 tonnes (31.79%) and 101,012.53 tonnes (29.91%).

In Peninsular Malaysia, the largest contribution of marine fish landings amounted to 490,951.73 mt (46.61%) were from the trawlers. Landings by purse seiners and anchovy purse also amounted to 267,640.23 mt (25.41%) and the remaining amount to 294,787.38 mt (27.98%) landed by artisanal fishing. However, landings of purse seiners was found decreasing by 9.39% on the West Coast of Peninsular Malaysia from 143,732.07 mt in 2012 to 130,232.00 mt in 2013.

1.2 Fishing areas in Malaysia waters

Malaysia is a maritime nation surrounded by four seas, namely the Malacca Strait, South China Sea, the Andaman Sea and the Sulu Sea. Fishing area in Malaysian waters can be divided into several areas of the West Coast (Malacca Strait) and East Coast (South China Sea) Peninsular Malaysia, Sarawak and Sabah waters including Sulu and Celebes Sea on the east coast of Sabah. Malacca Strait is part of the area included in the Indian Ocean Tuna Commission (IOTC), which includes the states of Perlis, Kedah, Penang, Perak and Selangor. Exclusive Economic Zone (EEZ) in the Malacca Strait is bordered by Indonesia in the west and in the north it is bordered by Thailand (Andaman Sea) (Figure 1).

Figure 1 : Malaysian waters

1.3 Neritic tunas fishing activities

In the early 1980s, small tuna caught as by-catch by drift nets and purse seines. When the tuna purse seine nets were introduced in 1987, neritic tuna fisheries began to increase. Initially, the purse seiners operated by searching for free school tuna before gradually using a spotlight to attract fish and then collect fish (Chee, 1996). A study on tuna tagging was conducted in the South China Sea and the results of this study showed that 50% were recaptured tuna comes from purse seiners (Raja Bidin, 1990).

Neritic tuna catches increase in line with growth in the processing industry (canning) in the country. Other than for domestic use, there is also growing demand from the canning industry in Thailand. The increase in landings of neritic tunas also aided by the use of Fish Collection Device (FAD) and the use of lights when the trawl.

1.4 Annual landings of neritic tunas in Malaysia

Neritic tuna species landings in 2013 increased by 3.7% to 66,743.27 mt compared to in 2012 (64,361.90 mt). Neritic tuna species in Malaysia is longtail tunas, frigate tunas and kawakawa. Neritic tuna contribute 4.5% of Malaysia's marine fish landings in 2013. Figure 2 shows the neritic tunas annual landings by states in Malaysia for the years 2013-2015. East Johor had the highest landings for the year 2013-2015, whereas Kedah had the lowest landings since 2015.

Looking at the average monthly landings for the past 10 years on the West Coast of Peninsular Malaysia, October has the highest landing + S.D (1958.03 ± 908.96 mt), while the lowest was landing in January (1077.29 ± 461.68 mt) (Figure 3). Generally, this monthly landings indicate a steady trend with a slight increase in October. As in the West Coast, January and December are the months that have a lowest landing with a value of 736.98 ± 277.61 mt and 406.39 ± 699.0 mt. The highest average monthly landing is in September (2919.28 ± 1301.51 mt).

Fig 4 shows the average monthly landings neritic tuna in East Malaysia for the past 10 years. Overall, the average monthly landings experienced a stable trend by landing the range 809.69 – 1,094.87 mt. The highest landings recorded in September (1,094.87 ± 308.05 mt) and the lowest in December (809.69 ± 288.04 mt).

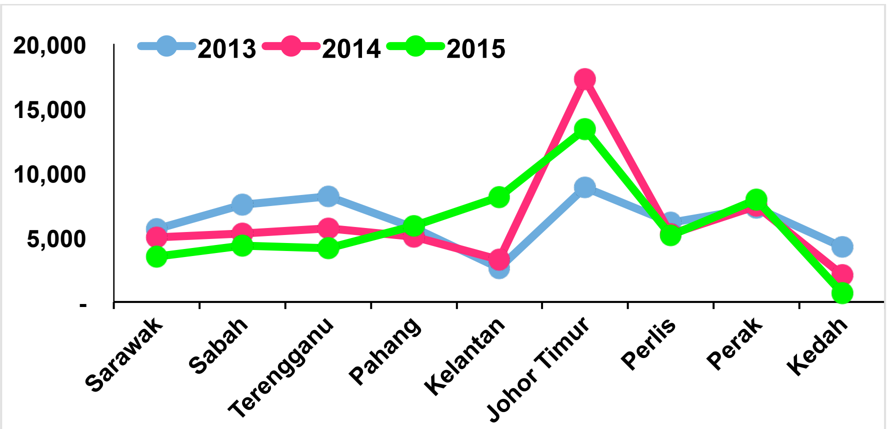


Figure 2: Annual landings of neritic tuna by states in Malaysia, 2013-2015

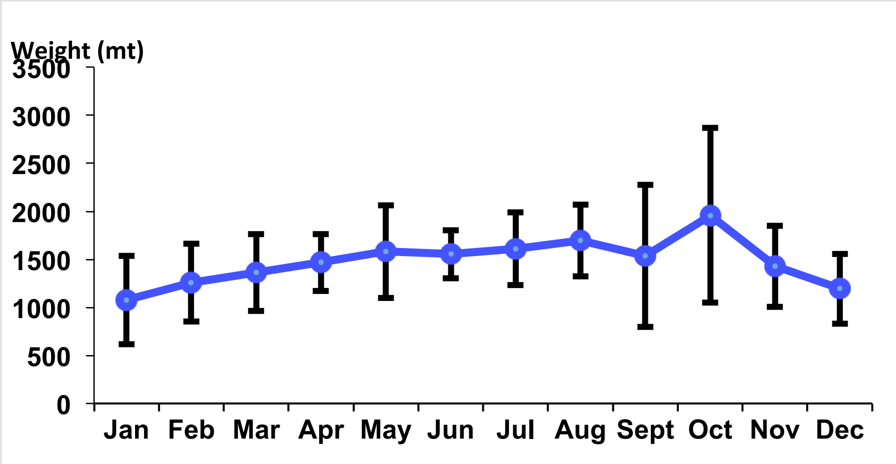


Figure 3: Average monthly landings of neritic tunas in the West Coast of Peninsular Malaysia, 2005-2015

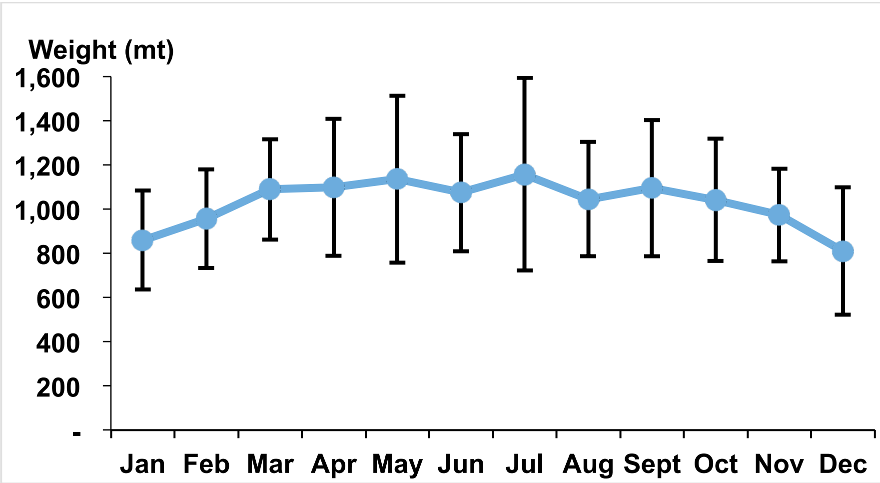


Figure 4: Average monthly landings of neritic tunas in the East Malaysia, 2005-2015

1.5 Catch by fishing vessels

Purse seines is the most important fishing gear in neritic tuna fisheries and contributed more than 82% of the annual catches of neritic tuna in Malaysia (Ahmad Adnan, et. al. 2015). There are two types of purse seines operating in Malaysia; using FADs and light luring (Sallehudin et. al. 2013). Table 1 showed the total catch and number of licence purse seine in Malaysia for the year 2014-2015. Purse seine in Malaysia is categorized based on GRT, 0-9.9 GRT, 10-24.9 GRT, 25-39.9 GRT, 40-69.9 GRT and 70 GRT and above. In overall, all GRT class have an increased number of licence vessels in 2015 compared to 2014. In 2015, only total catch of purse seine more than 70 GRT have increased (198,223.07 mt), meanwhile other GRT class showed a decreased in landings. There is a small increase in the total catch of neritic tuna for purse seine 40-69.9 GRT and above 70 GRT for the year 2015 compared to 2014.

2.0 METHODOLOGY

2.1 Sampling at landing jetty

Two enumerators were stationed in Kuala Perlis and Tok Bali landing jetty for the purposes of recording data on landings and biological data as required. For each sampled purse seine boats, the information as below must be recorded as in Appendix 1.

i) Vessel registration number
ii) Name of boat skipper
iii) Fishing day
iv) Catch amount

After the basic information is recorded, the enumerators will collect data on the biology. A basket of fish will be taken as sub sample to obtain the catch composition of the boat. The fish in the basket were sorted into species. Each fish were weighted and measured to be recorded in Appendix 2. Specimens were measured to the nearest 10 mm fork length (FL). Enumerators were also recorded the weight and length of 100 selected tuna species for the biological study.

2.2 Procedures in the laboratory

a) A total of 100 fish were sampled and brought back to the laboratory. Each individual fish will be weighed and measured the length and recorded in the forms provided (Appendix 3).

b) Fish body were cut open using a knife to open the abdominal cavity. Fish gonads were examined and determined the stage of maturity with the naked eye recognition and referral of previous study ever conducted. Gonad maturity stage is divided into five stages, namely juvenile, stage I, stage II, stage III, stage IV and V levels.

2.3 Data analysis

Population parameters were estimated from the length frequency data using computer program ELEFAN 1 of FiSAT II software and the Powell-Wetherall plot (Gayanilo et al. 2005). The VBGF model was used to evaluate age and growth. Growth was investigated from length frequency data using the von Bertalanffy growth function :

$$L_t = L\infty \ (1 – \exp \ [-K \ 9t – t_0])$$

Where L_t is the length at age t, $L\infty$ is the theoretical maximum (or asymptotic) length that the species would reach if it lived indefinitely, K is the growth coefficient and t_0 is the theoretical age at zero length (Sparre and Venema, 1998). FiSAT II program only provided estimates of $L\infty$ and K, t_0 was estimated using Pauly's equation (Pauly, 1980) :

$$\text{Log}(-t_0) = -0.3922 - 0.2752 \text{ Log } L\infty - 1.038 \text{ Log } K$$

Length-converted catch curves were developed from the length frequencies to estimate the total mortality (Z) (Gayanilo et al., 2005). Natural mortality (M) was determined using Pauly's equation by taking the mean sweater temperature as 30°C (Pauly, 1983):

$$\text{Log } M = -0.0066 - 0.279 \text{ Log } L\infty + 0.6543 \text{ Log } K + 0.4634T$$

where T is the mean annual habitat temperature. The exploitation ratio (E) was calculated from simple equation of:

$$E = F / Z$$

where F is fishing mortality (F = Z – M).

3.0 RESULT

3.1 Neritic tuna landings

Figure 5 showed the monthly landings of purse seine for the year 2014-2015 in Kuala Perlis. Monthly landings of purse seine in Kuala Perlis is almost constant with a slight decrease in November and December 2014, 6,753.30 mt and 6,458.77 mt consecutively, before sudden increase in January 2015. Nevertheless, this sudden rise only occurred in January 2015 as the purse seine monthly landing continue to be under the level of 8,000 mt a month until December 2015.

In Kuala Perlis, there are three main species of neritic tuna that are landed by purse seine, namely longtail tuna (*Thunnus tonggol*), kawakawa (*Euthynnus affinis*) and frigate tuna (*Auxis thazard*). Longtail tuna dominated the landings in Kuala Perlis with the monthly landings range of 224.13 – 734.92 mt. Highest landings of longtail tuna is in January 2015 with 734.92 mt. Meanwhile kawakawa tuna are experiencing almost a stable landings every month with range of 11.0 – 118.41 mt (Figure 6). Through the Fisheries Statistics recorded by Department of Fisheries Malaysia, landings of frigate tuna is only on March 2014 (14.49 mt) and October 2014 (23.76 mt)

Figure 7 showed the landings of kawakawa in Kuala Perlis for 2009-2015. Landing showed a increased pattern from 2009 to 2013) and decreased from 2013 to present.

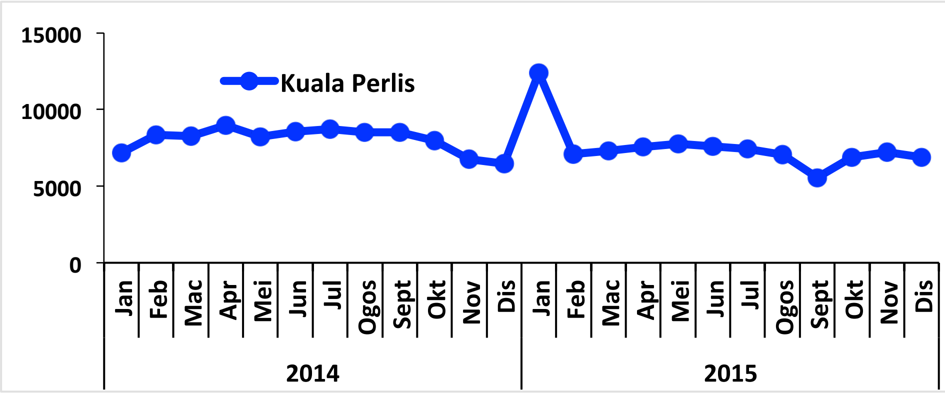


Figure 5: Monthly landings of purse seine Kuala Perlis, 2014-2015. (Resource : Fisheries Statistics)

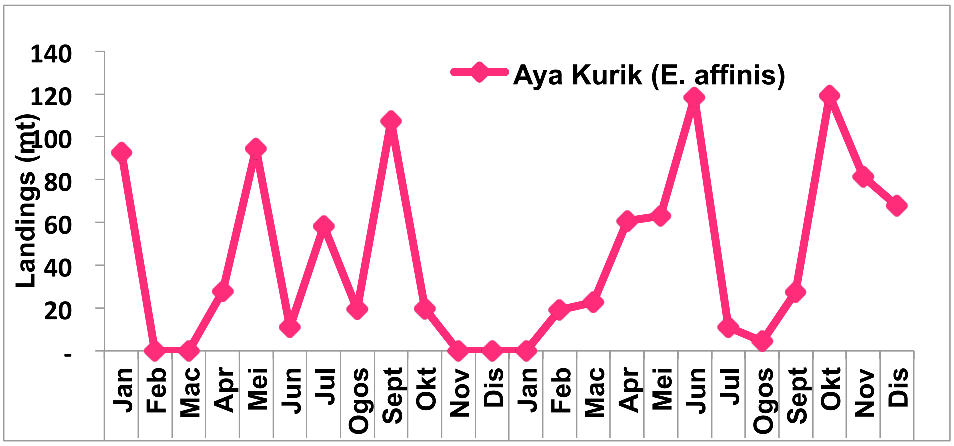


Figure 6: Monthly landings of neritic tuna in Kuala Perlis, 2014-2015. (Resource : Fisheries Statistics)

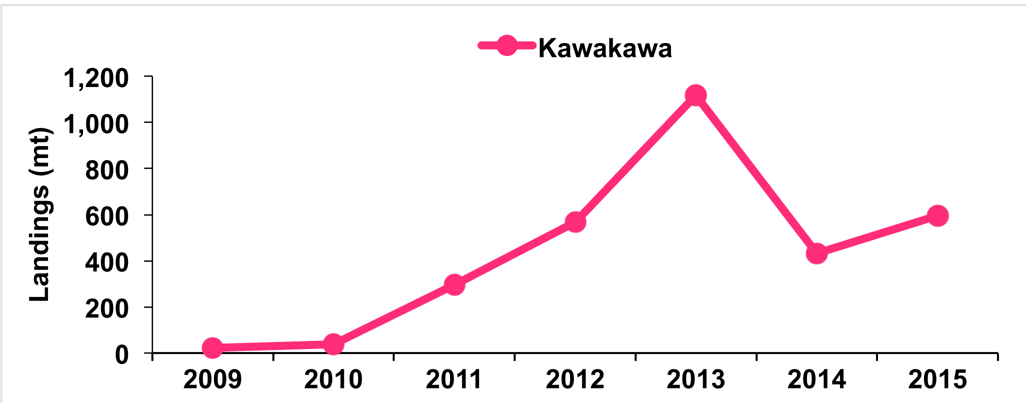


Figure 7 : Landings of neritic tuna in Kuala Perlis, 2009-2015

3.2 Catch per unit effort (CPUE) in Kuala Perlis

Figure 8 shows a comparison of purse seine CPUE and CPUE neritic tuna species in Kuala Perlis. Overall, the CPUE of purse seiners fluctuate with the range between 0:54 to 1:58 mt / vessel / fishing days and a substantial increase in January (2.67 mt / vessel / day fishing) and December 2015 (3.83 mt/vessel/day fishing). CPUE for neritic tuna species also showed a similar pattern, with the range between 0:03 to 0:08 mt / vessel / fishing days with January and December 2015 had the highest CPUE 0:16 and 0:23 mt / vessel / fishing days.

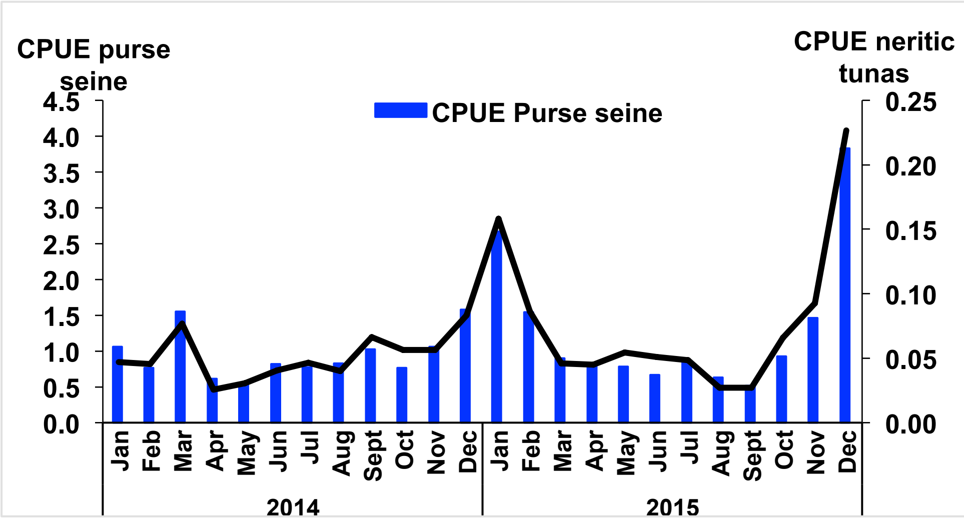


Figure 8 : Comparison of purse seine CPUE and neritic tunas CPUE in Kuala Perlis

3.3 Population dynamics

3.3.1 Length frequency

The length frequency distribution of kawakawa in Kuala Perlis is 160-580 mm with major modes were at 330 mm. Length at first maturity for kawakawa is 430 mm (Figure 9). Thus this means that most kawakawa landed in Kuala Perlis was caught before reaching first maturity. Whereas in Tok Bali, almost 27% are kawakawa landed exceeded or reached a length of first maturity.

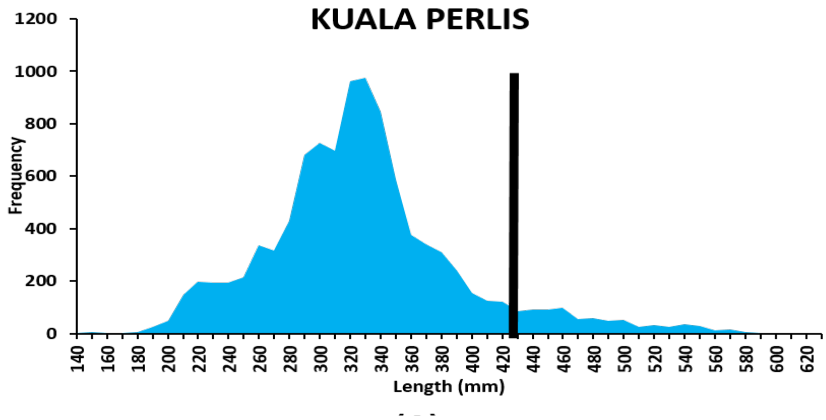


Figure 9: Length at first maturity (Lm = 430 mm) and length frequency distribution of kawakawa (*Euthynnus affinis*) caught in Kuala Perlis

3.3.2 Length-weight relationship

The length-weight relationship of kawakawa in Kuala Perlis was estimated as W = 0.000062 L $^{2.7759}$, where 'W' is the weight of the fish in g and 'L' is fork length in mm. (Figure 10).

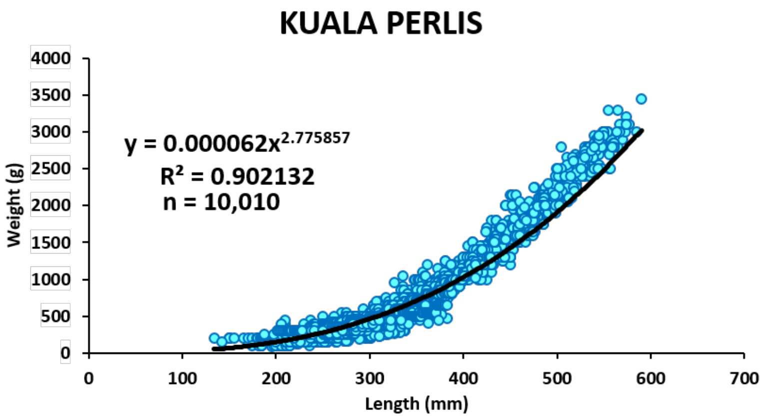


Figure 21 : Length-weight relationship of kawakawa (*Euthynnus affinis)* in Kuala Perlis

3.3.3 Growth Parameters

The estimated von Bertalanffy growth parameter of kawakawa for the Kuala Perlis are **L** $_{oo}$ = 604.28 mm, and K = 0.26 (Table 1). The majority of captured fish was within the size of 200 – 475 mm (Figure 11). The estimate growth performance index (**Ø**) for kawakawa were 4.98, which gave indication that the parameters estimeted conformed the von Bertalanffy condition. The **L** $_{oo}$ and K found using this prosess were within the ranges estimated in FiSAT II

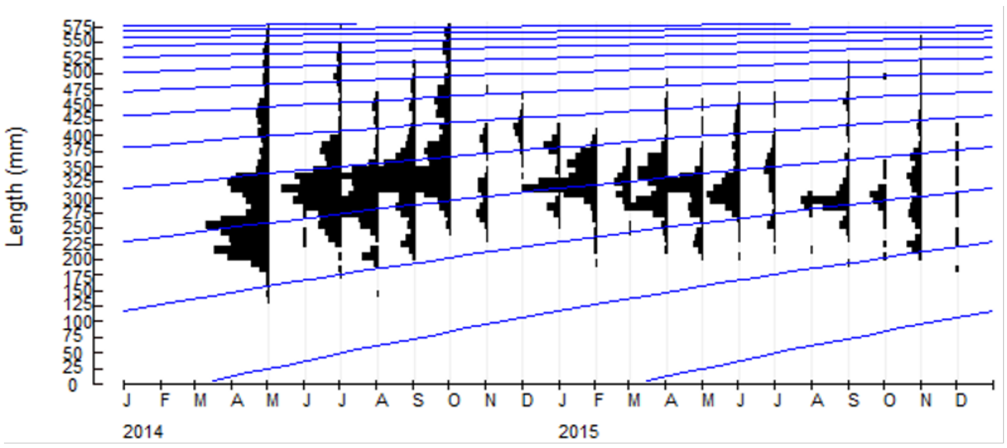
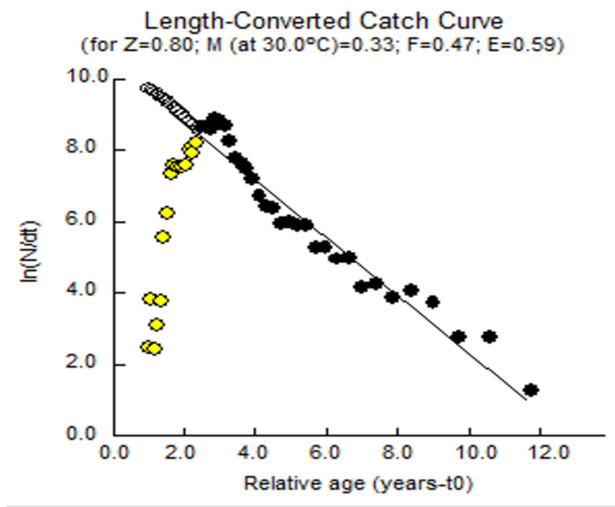


Figure 11: The Von-Bertalanffy graph plot of kawakawa (*Euthynnus affinis*) in Kuala Perlis

3.3.4 Mortality and exploitation rate

Table 1 showed the growth parameters of kawakawa in Kuala Perlis. The natural mortality rate (M), fishing mortality rate (F) and total mortality (Z) of kawakawa in Kuala Perlis were 0.33, 0.47 and 0.80, respectively (Figure 12). The exploitation rate of kawakawa in Kuala Perlis (E = 0.59) is higher than the predicted value (E_{max}) 0.47 and 0.56 (Table 2 & Figure 13), respectively, which showed that kawakawa was heavily exploited in Kuala Perlis .

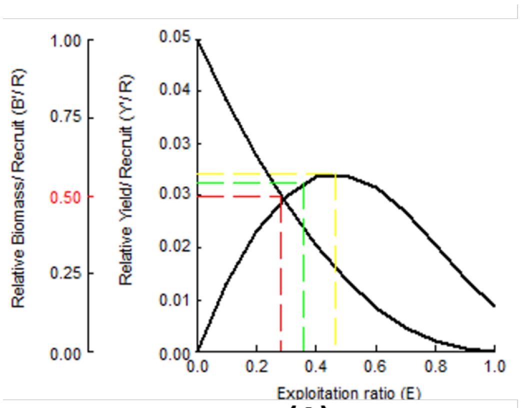


(A)

Figure 12 : Mortalities and exploitation rate of kawakawa (*Euthynnus affinis*) in Kuala Perlis estimated using length converted catch curve

Table 1 :Growth parameters of kawakawa, in Kuala Perlis

Spesies	Common name	Location	L oo (mm)	K	Ø	Z	M	F	E
Euthynnus affinis	Kawakawa	Kuala Perlis	604.28	0.26	4.98	0.80	0.33	0.47	0.59



(A)

Figure 13 : Relative yield and spawning biomass per recruit (Y/R, V/R) of kawakawa (*Euthynnus affinis*) in Kuala Perlis

Table 2 : Relative yield and spawning biomass per recruit (Y/R, V/R) of kawakawa, frigate tuna and longtail tuna in Kuala Perlis and Tok Bali

Location	Species	E-10	E-50	E-max	Lc/L∞	M/K
Kuala Perlis	Kawakawa	0.36	0.28	0.47	0.22	1.74

3.5 Morphological studies of ovary

Based on the morphological observations of the gonads, collected from the specimens of kawakawa were classified into different stages Orange (1961) (Table 3).

A total of 542 specimens of kawakawa were collected for five months period (March – August 2015). Length range of the kawakawa collected were 259 – 485 mm with the range weight of 240 – 1800 g. 254 specimens collected were juveniles, where the sexes of the gonads observed cannot be determined. Male specimens collected were 157 and 131 female specimens (Figure 14). 85% of the specimens were classified into immature gonads (juvenile and stage 1), and 15% were mature gonads (stage 2 and 3) (Figure 15).

Table 3: Stages of gonad development

Stages	Male	Female
Stage 1 : Immature	Testes very slender and elongated; each cell possesses a large nucleus with eccentric nucleolus.	Ovaries are slender and ribbon like; sex could not be easily determined by gross examination.
Stage 2 : Maturing	Enlarged testes; size of lobules increases with relative decrease in interlobular mass	Ovaries enlarged, light pinkish and do not fill more than 1/3rd the length of body cavity; ova are visible only when closely examined.
Stage 3 : Mature	Milt is extruded out of the fish with slight pressure; the lobular wall becomes thinner and volume increases	Ovaries have reddish tinge imparted due to profuse blood supply.
Stage 4 : Ripe	Lobules become very thin; some empty lobules observed.	Mature ova large, spherical and easily separable.

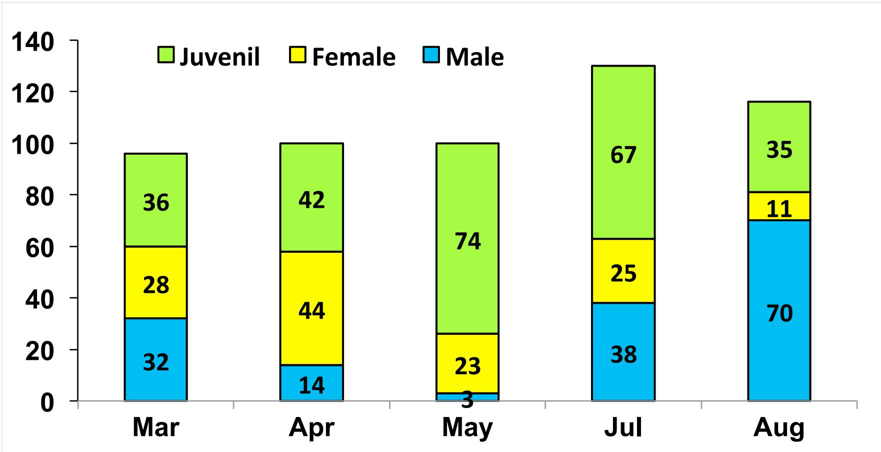


Figure 14: Number of male, female and juvenile gonad from Mac – August 2015

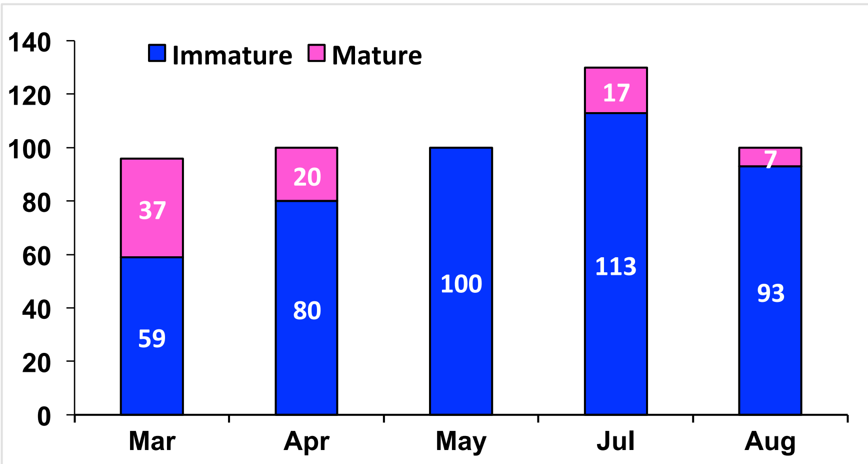


Figure 15: Number of mature and immature gonad collected from Mac – Aug 2015

4.0 Discussion

Fishing for neritic tunas such as kawakawa, frigate tuna and longtail tuna is mainly confined to the coasts of Peninsular Malaysia, with only small fisheries off Sabah and Sarawak. These species have traditionally been caught in Malaysia at subsistence levels by fisherman using a variety of fishing gears (Chee, 1995). Purse seines contributed more than 82% of the annual catches of neritic tuna in Malaysia, thus making it the major fishing gears in neritic tuna fisheries. There are two types of purse seines operating in Malaysia; using FADs and light luring (Sallehudin et. al.

2013). Application of FAD has facilitate and increase efficiency for tuna fishing (Noraisyah and Raja Bidin, 2009).

Earlier studies on growth of kawakawa from different regions have indicated that growth as in most tuna species is fast with the fish having a longevity of 2 to 8 years (Pratibha Rohit et. al. 2012). The length weight relationship of kawakawa caught from different regions has been estimated by several earlier studies and the values of 'a' and 'b' obtained are as in Table 4. For the present study, kawakawa in Kuala Perlis exhibit isometric growth with the 'b' value close to 3. Growth parameters in the von Bertalanffy equation as estimated by earlier studies and present study are given in Table 5. Kawakawa is a fast growing fish attaining a maximum length of around 600 mm (Kuala Perlis). However the L_∞ estimated from other regions are much higher which ranged from 810 – 890 mm, than the estimated value obtained in the present study. The 'K' value obtained from this study also revealed a smaller value than earlier studies in other regions.

Table 4: Estimated value of 'a' and 'b' of kawakawa in the length-weight relationship

Region	**'a' value**	**'b' value**	**Reference**
Philippines waters	0.0334	2.838	Ronquillo, 1963
South China Sea	0.0885	2.5649	Williamson, 1970
Indian waters	0.0191	2.95	James et. al. 2003
Veraval, India	-1.9313	3.056	Ghosh et. al. 2010
Indian waters	0.0254	2.889	Pratibha et. al. 2012
Kuala Perlis, Malaysia	0.000062	2.776	Present study
Tok Bali, Malaysia	0.0000068	3.163	Present study

Table 5 : Estimates of growth parameters of kawakawa from earlier and present studies in the regions

Region	**L_∞**	**K**	**t_o**	**Reference**
Maharashtra, India	817	0.79	-0.0227	Khan, 2004
Persian Sea of Oman	877	0.51	-0.23	Taghvai, 2010
Veraval, India	725	0.56	0.0327	Ghosh et.al. 2010
Indian waters	819	0.56	-0.0317	Pratibha et.al. 2012
Kuala Perlis	604	0.26	-0.55	Present study
Tok Bali	530	0.19	-0.39	Present study

Differences in growth patterns may be the result of differences in genetic structure and or differences in temperature, density of food and diseases (pauly 1994, Wootton 1998). Said Kota et all, (2012) reported, the difference in growth rate can be attributed to several reasons including prevailing eco-biological conditions of the habitat during timt to time.

Mortality and exploitation rates of kawakawa from different regions are presented in Table 6. Exploitation rate (E = 0.59) obtained for kawakawa in Kuala Perlis exceeded the E_{max} value (E_{max} = 0.47) which show that the stock are heavily exploited. Taghvai (2010) estimated the exploitation rate of kawakawa in the Persian Sea of Oman as 0.65 and Pratibha et.al. (2012) estimated the exploitation rate of 0.36 in the Indian waters.

Table 6 : Estimates of mortality, exploitation rates of kawakawa from earlier studies and present in the regions

Region	**Z**	**F**	**M**	**E**	**Reference**
Maharastra, India	2.24	-	2.24	-	Khan, 2004
Persian sea of Oman	2.37	1.71	0.65	0.65	Taghvai, 2010
Veraval, India	1.69	0.75	0.94	0.36	Ghosh et.al. 2010
Indian waters	1.68	0.75	0.93	0.36	Pratibha et.al. 2012
Kuala Perlis	0.80	0.33	0.47	0.59	Present study

In Kuala Perlis, kawakawa of size range 180 – 580 mm FL represented the catches throughout the year. Common size in commercial catches ranged from 250 – 400 mm FL. Mean length of kawakawa caught in Kuala Perlis is 320 mm FL. Peak period of occurrence of commercial size is January to June. In sampling areas, the kawakawa caught were below the size of first maturity (L_m = 430 mm), thus indicating that the fish did not have the chance to spawn for the first time in their life.

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