
**Length Frequency Distribution and Population Parameters of Kawakawa
(*Euthynnus affinis*-Cantor, 1849) Caught by Purse Seine in the Indian Ocean (a
Case Study in Northwest Sumatera IFMA 572)**

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ABSTRACT

*Kawakawa is an Indo-West Pacific species, found in warm waters including oceanic islands and archipelagos. The aims of this research were to provide length frequency distribution and population parameters of kawakawa caught by purse seine in the Indian Ocean. The data is the time series data from the research before. Data collection was conducted during a period of July 2012 to December 2013. The result showed that from 4,225 fish were collected with ranged from 23.5 – 61.5 cm, the Von Bertalanffy growth function estimates were $L_{\infty} = 64.58$ cm, $K = 1$ year⁻¹ and $t_0 = -0.12872$ years. The annual instantaneous rate of total mortality (Z) was 6.47 year⁻¹, the natural mortality (M) was 1.44 year⁻¹ and the fishing mortality (F) was 5.03 year⁻¹. The exploitation rate ($E = 0.78$) is almost same with the predicted value ($E_{max} = 0.799$) indicating that *Euthynnus affinis* was fully exploited in the Indian Ocean.*

Key words : *length frequency, population parameters, kawakawa, purse seine*

INTRODUCTION

Kawakawa is an Indo-West Pacific species. It is found in warm waters including oceanic islands and archipelagos. A few stray specimens have been collected in the eastern tropical Pacific. Like other scombrids, *Euthynnus affinis* tend to form multispecies schools by size especially with small *Thunnus albacares*, *Katsuwonus pelamis*, *Auxis* sp. and *Megalaspis cordyla* comprising from 100 to over 5,000 individuals. But during certain periods of the year, there is a tendency for the fish to remain scattered (Collette & Nauen 1983). Kawakawa is piscivorous, most important prey items of the immature smaller *Euthynnus affinis* were the larval anchovy and lanternfish while the matured fish *Decapterus* spp and *Scomber australicus* (Chiou, et al., 2004). Kawakawa are medium-sized schooling pelagic fish distributed throughout the Indo-West Pacific between latitudes 35°N and 38°S, longitudes 32°E and 137°W, in water temperatures of 18 – 29°C (Collette & Nauen 1983).

This pelagic and oceanodromous species occurs in open waters, but it always remains close to the shoreline. It is found to 50 m depth. The young may enter bays and harbours. It forms multi-species schools by size with other scombrid species, comprising from 100 to over 5,000 individuals. It is a highly opportunistic predator feeding indiscriminately on small fishes, especially on clupeoids and atherinids (e.g., 78% by weight, 71% frequency in eastern Australia (Griffiths *et al.*, 2009). It also feeds on squids, crustaceans and zooplankton (Collette, 2001).

In Indonesia, the production of kawakawa from Indian Ocean is the largest among the other types of neritic tuna from 2001 to 2010. With neritic tuna production reached 1,325,232 tons of that time, the production of kawakawa is the highest with 27% followed by frigate and bullet tunas (25%), longtail tuna (24%), Narrow-barred Spanish mackerel (18%) and Indo-Pacific king mackerel (6%) (FAO, 2012).

The aims of this research were to provide length frequency distribution and population parameters of kawakawa caught by purse seine in the Indian Ocean.

MATERIALS AND METHODS

The data analyzed were collected by enumerator on fish landing site in Sibolga, Western part of North Sumatera. The data is the time series data from the research before. Data collection was conducted during a period of July 2012 to December 2013.

Length measurements were pooled into groups of 2 cm length intervals and monthly data were then analyzed using FISAT II software (Version 1.2.2) (FAO, 2013). The growth parameters K and L_{∞} of the von Bertalanffy growth function were estimated by ELEFAN 1 as defined by Sparre & Venema (1998). Instantaneous total mortality (Z) was estimated from a length-converted catch curve which makes use of growth parameters and length frequency data. Natural mortality (M) will be calculated from Pauly's M equation which makes use of environmental temperature (i.e., annual mean habitat temperature for the study area was 28°C) and the VBGF growth parameters K and L_{∞} . The instantaneous fishing mortality (F) was taken as the difference between total and natural mortality: $F = Z - M$. The level of exploitation ratio (E)-fraction of death caused by fishing which maximizes yield recruit⁻¹ was estimated using the relative yield recruit⁻¹ (Y/R) and biomass recruit⁻¹ model of Beverton (1966). The Beverton & Holt (1996) yield recruit⁻¹ model modified by Pauly & Soriano (1986) was used to determine the size at which yield recruit⁻¹ would be maximized (L_{max}).

RESULT AND DISCUSSION

- *Fishing Gear*

Purse seine was the main gears to catch kawakawa in Sibolga, Western part of North Sumatera (Figure 1). The purse seine constructed by large-meshed synthetic netting with a line of float at the top and a series of iron rings at the bottom to maintain it vertical in midwater, in general, not far below the surface (Figure 2). One piece of purse seine in Sibolga has length 400 – 600 m and height 80 – 120 m. Webbing material is nylon monofilament, divided into three parts of webs with different mesh size, they are bag (diameter 4 inch), body (diameter 3 inch) and wings (diameter 1 – 2 inch). Floats are synthetic rubber diameter 5.9 inch; length 7.4 inch; distance between floats 15 - 30 cm. Iron ballast has weight 4 ounces each and the distance between were 8 12 cm. Ropes (top and down) are polyethylene with diameter 8 – 12 mm.

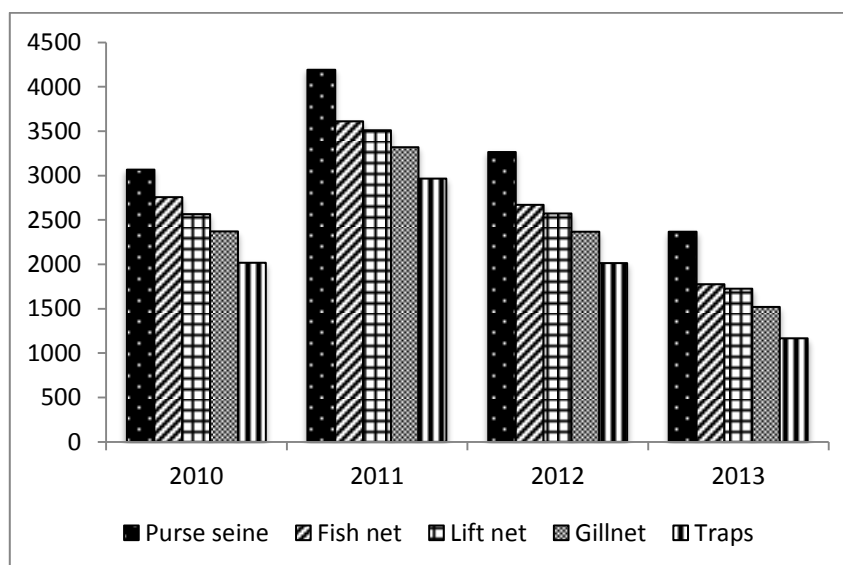
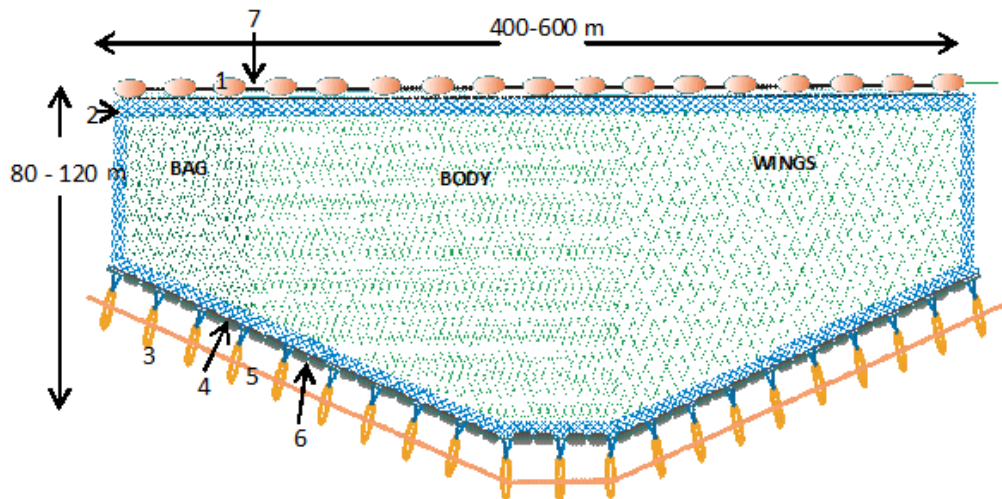


Figure 1. Vessel landing in Sibolga, Western part of North Sumatera according to the type of fishing gear



Notes :

1. Floats Ø 5.9 inch; length 7.4 inch; distance between floats 15 - 30 cm.
2. Edge nets Ø 1 inch.
3. Rings Ø 25 cm.
4. Iron ballast 4 ounces.
5. Drawstring rope Ø 3.5 cm.
6. Down rope Ø 8 – 12 mm.
7. Top rope Ø 8 – 12 mm.

Source : Interviews with Sibolgas fishermen

Figure 2. Technical specification of one piece purse seine based in Sibolga

- ***Fish Agregating Device (FAD)***

Fish were caught with purse seine in the Fish Aggregating Device (FAD) within 60 – 100 miles of the coast in the Indian Ocean, Western part of North Sumatera between Enggano, Mentawai, Nias island waters (FMA 572) and can be reached by fishermen about 12 – 24 hours (**Figure 3 & 4**). FADs were installed at a depth of about 500 – 1000 m. FADs construction consisting of a float/pontoon, rigging, ballast and attractor. Pontoons made of bullet-shaped iron plate coated glass fiber with length 2,5 - 3,5 m and diameter 75-80 cm. Float rope made of long polypropylene with 1500-3000 m and diameter 3-5 cm. Ballast are made of cast cement/concrete cylinders (5-10 pieces), with total weight 2-3 tons. Attractor which is used as fish collectors made from plastic/rubber tires or there is also a palm leaf.

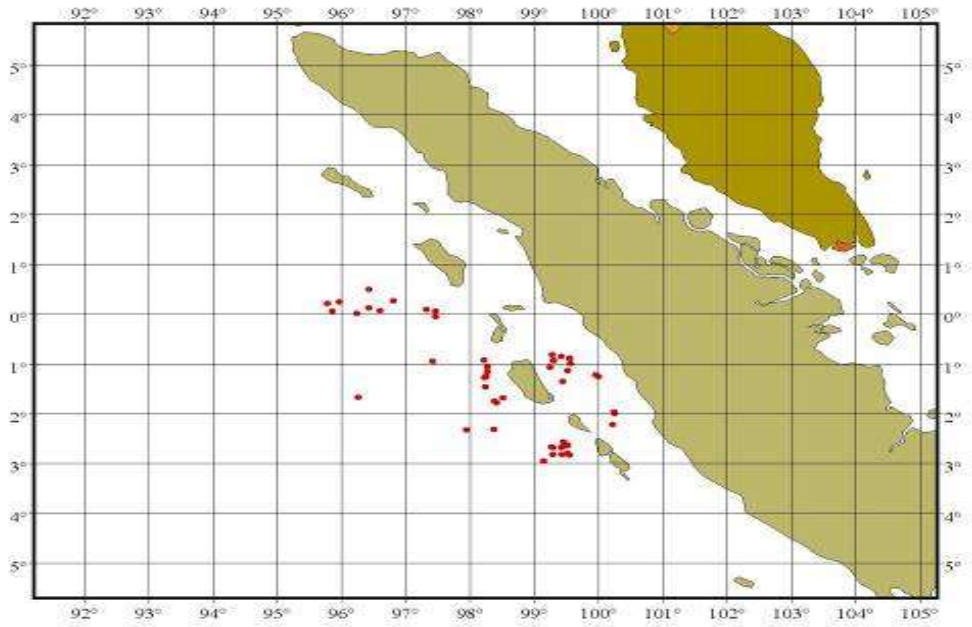
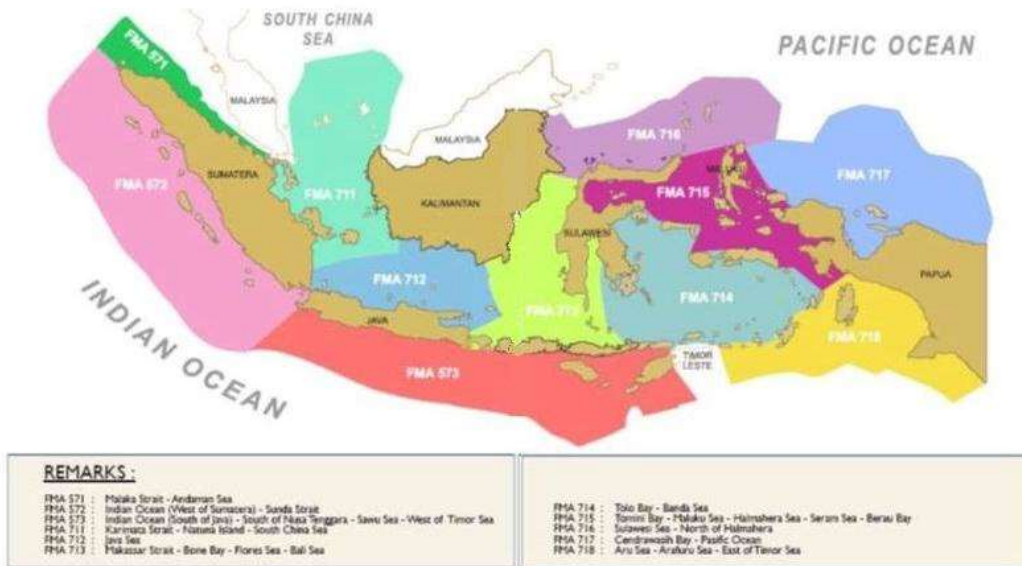


Figure 3. Fish Aggregating Device location indicated the fishing ground



Source : Fisheries Improvement Indonesia, 2014.

Figure 4. Fisheries Management Area in Indonesia

- **Indonesia Marine Capture Fisheries Production**

The growth of capture fisheries production increase about 3.53% in the last 5 years (2008 – 2013). The increasing of fisheries production data, essentially driven by the obedience and the quality of fisheries statistics data collection, as well as several activities in order restoration of fish resources and the environment (**Working Group of Marine and Fisheries Data Arrangement, 2013**). Indonesia marine capture fisheries production by major commodities shown in **Table 1**.

The unit of Fisheries Management Area regulated by the Minister of Marine and Fisheries Regulations No. 1/2009 on Regional Fisheries Management Area (FMA). Fisheries Management Area in Indonesia divided into 11 regions stretching from the Straits of Malacca to the Arafura Sea (**Budhiman et al., 2011**). **Table 2** shown the marine capture fisheries production by Fisheries Management Area.

Table 1. Indonesia marine capture fisheries production by major commodities (ton)

Commodities	2008	2009	2010	2011	2012	2013
Tunas	194,173	203,269	213,796	241,364	275,778	269,530
Skipjack	296,769	338,034	329,949	372,211	429,024	381,070
Eastern little tunas	421,905	404,283	367,320	415,331	432,138	419,490

Source : Working Group of Marine and Fisheries Data Arrangement, 2013.

Table 2. Marine capture fisheries production by Fisheries Management Area (ton)

FMA	2008	2009	2010	2011	2012	2013
571	384,276	350,130	316,833	461,848	509,171	475,489
572	510,215	545,108	541,476	558,592	576,632	575,091
573	404,192	481,361	436,613	506,882	406,224	521,853

Source : Working Group of Marine and Fisheries Data Arrangement, 2013.

- **Length frequency distributions**

Length frequency distributions of kawakawa ranging from 23.5 – 61.5 cm captured during July 2012 to December 2013 were examined. A total 4,225 measured specimens of kawakawa were examined with fork length (FL). Length frequency for kawakawa pooled into groups with 2 cm length intervals (**Figure 5**). **IGFA (2011) in Collete et al. (2011)**, mentioned that Maximum Size is 100 cm fork length (FL) fish caught off Isla Clarion, Revillagigedo Islands, Mexico, in the eastern Pacific outside the usual range of this Indo-West Pacific species.

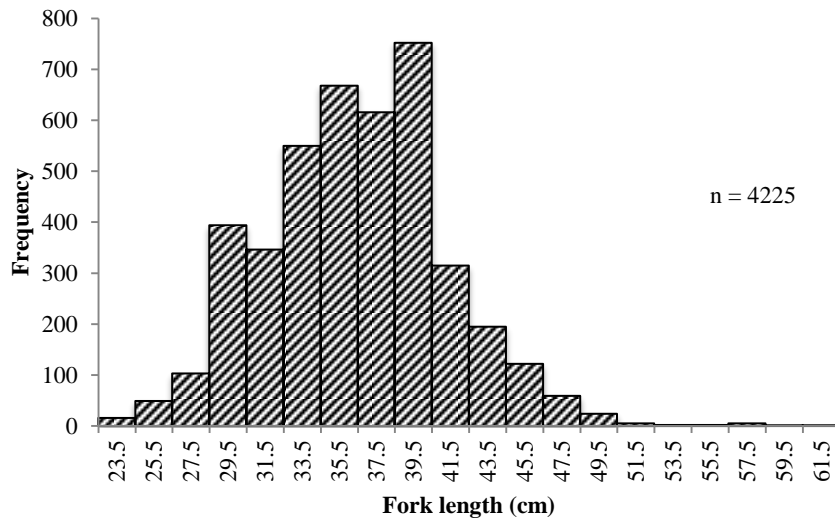


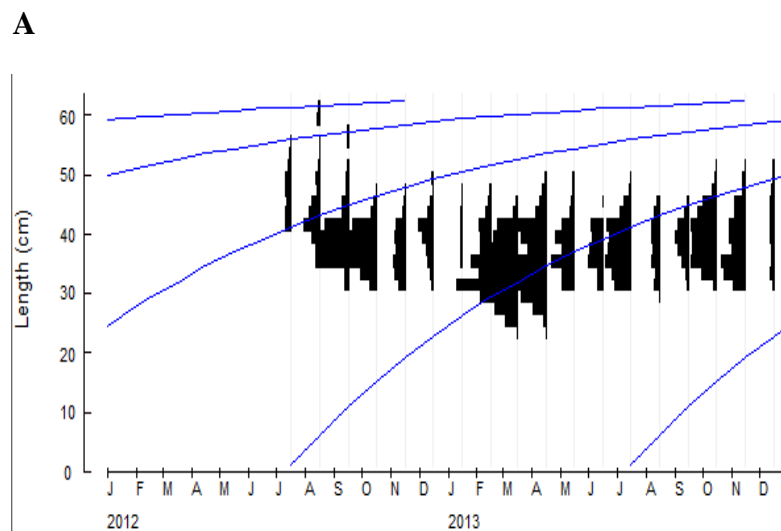
Figure 5. Length frequency for kawakawa pooled into groups with 2 cm length intervals

The morphological and reproductive characteristics, population sizes and genetic frequencies of species are adjusted to their environments by natural selection and species inhabiting different environments show different patterns of life history characteristics (Adams, 1980). In the present study length infinity of *E. affinis* were 64.58 cm which indicated higher infinity length. Different L_{∞} and K , might be associated with sampling error or variation in fishing intensity or environmental conditions. The L_{∞} obtained in this study for the kawakawa was lower than the estimate given by some previous studied (Yesaki, 1989; Rohit, *et al.*, 2012; Johnson & Tamatamah, 2013; Kaymaran & Darvishi, 2012) but higher than that by Chodrijah, *et al.*, 2013; Joseph, *et al.*, 1987 and Jatmiko, *et al.*, 2013. In this study K value was higher than the estimate given by some previous studied (Table 3). Growth comparison of fish based on a single parameter K or L_{∞} is misleading (Pauly, 1979).

Table 3. Estimates of growth parameters from various studies for kawakawa in Indian Ocean.

Location	L_{∞}	K	Reference
Gulf of Thailand	76	0.96	Yesaki, 1989
Java Sea, Indonesia	59.63	0.91	Chodrijah, <i>et al.</i> , 2013
Sri Lanka	63	0.61	Joseph, <i>et al.</i> , 1987
Northwest Sumatera, Indonesia	63.53	0.63	Jatmiko, <i>et al.</i> , 2013
India	81.92	0.56	Rohit, <i>et al.</i> , 2012
Tanzania	89.25	0.78	Johnson & Tamatamah, 2013
Iran	95.06	0.67	Kaymaran & Darvishi, 2012
Northwest Sumatera, Indonesia	64.58	1	Present study

The result of seasonalized von Bertalanffy growth curves shows that there are five cohorts from July 2012 to December 2013 (**Figure 6. A**). The majority of the captured fish was within the size from 23.5 to 61.5 cm. The estimated von Bertalanffy growth parameters for this species are $L_{\infty} = 64.58$ cm, $K = 1$ yr⁻¹ and $t_0 = -0.12872$ yr⁻¹ (**Figure 6. B**). The growth curves were plotted from raw data and considered for other analyses.



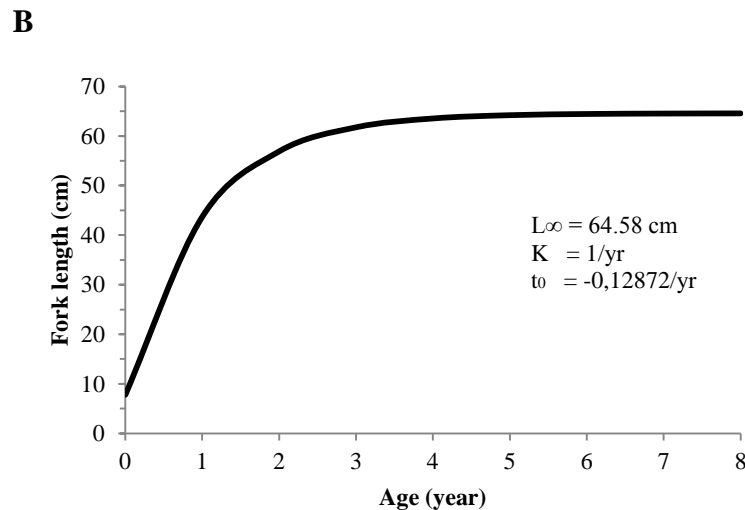


Figure 6. Seasonalized von Bertalanffy growth curve ($L_{\infty} = 64.58 \text{ cm}$, $K = 1 \text{ yr}^{-1}$ and $t_0 = -0.12872 \text{ yr}^{-1}$) based on the length frequencies histograms (A) and growth of *Euthynnus affinis* in Indian Ocean (B).

Indian Ocean Tuna Commission/IOTC (2006) reported that *Euthynnus affinis*, inhabits coastal water and has preference staying in relatively warm water 18°- 29°C. This species forms school that appears down to 400 m depth. Oceanography parameters commonly influencing the distribution of *Euthynnus affinis* are temperature, current, and salinity (Hela & Laevastu, 1970).

As age at zero length (t_0) was calculated to be -0.12872 year, which means juveniles *E. affinis* grow more quickly than adults (King, 2007). The natural mortality coefficient (M) for kawakawa were 1.44 per year, which different with the estimates reported by earlier studies in Northwest Sumatera and Java Sea and Value of Z and F obtained in this study were marginally higher than that in earlier works in Northwest Sumatera and Java Sea. According to Gulland (1971, 1979), the yield is optimized when $F = M$; therefore, when E is more than 0.5, the stock is over fished. The fishing mortality rate of 5.03 year^{-1} . These results are important for fisheries management authorities as they suggest that the resource is fully exploited and in addition to a revision of mesh size regulations, a substantial reduction in fishing effort would also be required if management objectives are to be achieved. Patterson (1992) observed that the fishing rate satisfying optimal E level of 0.5 tended to reduce pelagic fish stock abundance, and hence, the former author suggested that E should be maintained at 0.4 for optimal exploitation of those stocks. Increase in the size at first capture to that which would

maximize yield per recruit would be associated with an increase in yield at the existing fishing mortality rate. However, the existing fishing mortality rate in this study was 5.03 year⁻¹ (Figure 7). The relative biomass per recruit at the estimated fishing mortality rate was particularly low at less than 15% of the unexploited level. If the critical spawning stock biomass is between 20 and 50% of the unexploited level, as suggested by King (2007), recruitment over fishing is also likely to be occurring for *E. affinis*. Again, this demonstrates that growth over fishing is occurring and in combination with the results of the yield per recruit analyses shows that substantial effort reductions are also required as target reference points cannot be achieved by modification of the gear selectivity characteristics alone. As the size at first capture (36.46 cm) was considerably smaller than the size at which yield per recruit would be maximized (64.58 cm FL), an increase in the mesh size for fishery should be considered by management authorities.

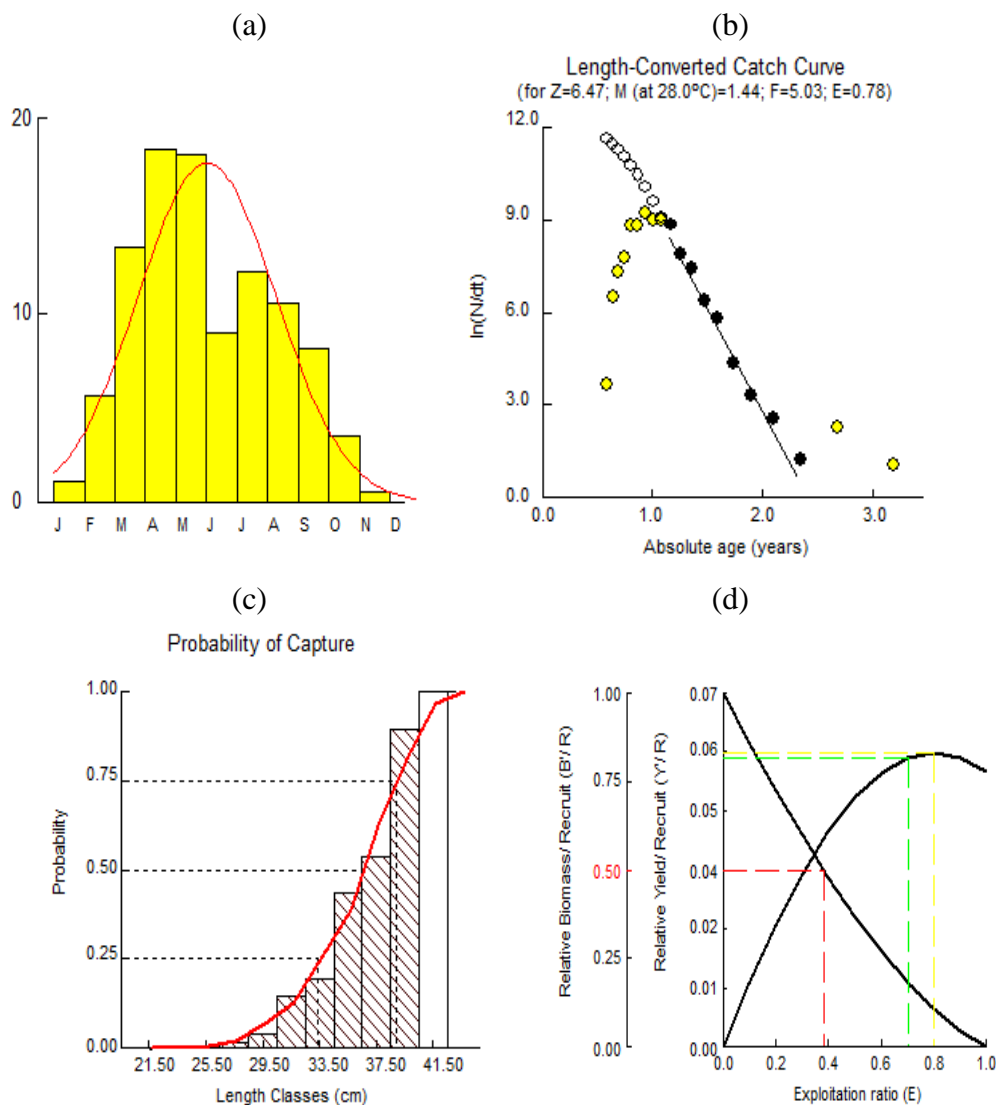


Figure 7. (a) Recruitment pattern; (b) Length-converted catch curve $Z = 6.47 \text{ yr}^{-1}$; M (at 28.0°C) = 1.44 yr^{-1} ; $F = 5.03 \text{ yr}^{-1}$; (c) Length at first capture, shown by the red line, is $L_c = 36.46 \text{ cm}$; and (d) Relative yield-per-recruit (Y'/R) and relative biomass-per-recruit (B'/R) as calculated using the selection ogive method ($E_{max} = 0.799$; $E_{0.1} = 0.705$; $E_{0.5} = 0.382$).

The results indicated that the stock of *E. affinis* is fully exploited. Any increase in the existing fishing level/exploitation will most likely result in a reduction in the yield per recruit and thereby hamper the optimum level. It is necessary to immediately impose fishing regulation on the stock and this can be done by gradually increasing the mesh size of the gears or by restricting fishing for certain seasons or declaring fish sanctuaries in certain areas, especially in spawning grounds.

CONCLUSION

From 4,225 fish were collected with ranged from 23.5 – 61.5 cm, the Von Bertalanffy growth function estimates were $L_\infty = 64.58 \text{ cm}$, $K = 1 \text{ year}^{-1}$ and $t_0 = -0.12872 \text{ year}^{-1}$. The annual instantaneous rate of total mortality (Z) was 6.47 year^{-1} , the natural mortality (M) was 1.44 year^{-1} and the fishing mortality (F) was 5.03 year^{-1} . The exploitation rate ($E = 0.78$) was more than 0.5 indicating that *Euthynnus affinis* was fully exploited in the Indian Ocean.

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