Journal of the Andaman Science Association Vol. 24(1):70-76 (2019)
ISSN 0970-4183, Printed in India

Fishery, Growth and Stock Status of Little Tuna, *Euthynnus Affinis* (Cantor, 1849) from Andaman Waters

***[1]K. Lohith Kumar, [2] R Kiruba-Sankar, A.K.O Ratheesh, [2] K Saravanan, [3]Monalisha Devi S and [1]S. Dam Roy**

[1]*Kolkata Centre of ICAR-CIFRI, CGO Complex, DF Block Salt Lake, Kolkata – 64, India*
[2]*Division of Fisheries Science, ICAR-Central Island Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands, 744105*
[3]*Fishing Technology Division, ICAR-Central Institute of Fishing Technology, Kochi-682029*
**lohith318@gmail.com*

Abstract

Euthynnus affinis, also known as little tuna or kawakawa, is one of the important coastal tuna species contributing significantly to the tuna fisheries in Andaman and Nicobar Islands. In this study; fishery, growth parameters and the stock status of *E. affinis* from Andaman waters was investigated. The major gears exploiting this resource were drift gill net followed by hook and lines. The fishes in the length class of 33-48 cm contributed more than 50% to the little tuna fishery. This species predominantly feeds on fishes followed by crustaceans and molluscs. The length-weight relation was found as $W=0.196\ L^{2.913}$. The von Bertalanffy growth parameters estimated were $L\infty=74.03$ cm, K=0.41/ year and $t_0=-0.025$ years. Mortality parameters estimated were M=0.77, Z=1.09 and F=0.32 with the exploitation ratio E=0.294 and exploitation rate U=0.195. The M/K ratio was 1.87. The estimated maximum sustainable yield was 3535 tons which is higher than the average annual catch indicating the stocks of *E. affinis* are not fully exploited.

Key words: Andaman, *Euthynnus affinis*, little tuna, fishery, growth parameters, stock status

Introduction

The archipelago of Andaman & Nicobar Islands (ANI) is a group of 572 islands, islets and rocks, lying in the South Eastern part of the Bay of Bengal. The aggregate coastline of ANI is 1912 km. The continental shelf area is very limited with an estimated area of 16000 km^2 and the sea is very deep within a few kilometers from the shore. The Exclusive Economic Zone (EEZ) around the Islands encompasses around 0.6 million km^2, which is about 30% of the Indian EEZ (Pillai and Abdussamad, 2009). Marine fishery resources of ANI are vast and abundant with estimated fishery potential of 1.48 lakh tons (John *et al.*, 2005). Andaman & Nicobar waters are known to harbour rich tuna resources to the tune of 64500 tons (Anrose *et al.*, 2009). Of the total tuna potential, oceanic tunas (skipjack, yellowfin and bigeye tuna) forms 46500 tons and the remaining 18000 tons is of the neretic tunas. Out of 6 genera of tuna, 3 genera are reported from oceanic region of ANI viz *Thunnus albacores* (yellowfin tuna), *T. obsesus* (big eye tuna), *Katsuwonus pelamis* (skipjack tuna) and *Gymnosarda unicolor* (dogtooth tuna). The other four genera represented by the coastal tunas include *Euthynnus affinis* (little tuna), *Thunnus tonggol* (longtail tuna), *Sarda orientalis* (oriental bonito), *Auxis thazard* (frigate tuna) and *Auxis rochei*(Bullet tuna) (Anrose *et al.*, 2009).

Euthynnus affinis, also known as little tuna or kawakawa, is one of the coastal tuna species which has a wide distribution in tropical and sub tropical waters of Indo-pacific region. This species is reported from Cape St. Francis, South Africa along the coasts of east Africa, Arabian Peninsula, Indian sub continent, Islands of Indian Ocean including Andaman and Nicobar Islands, Malaysian peninsula to southern china, off southern Japan up to Australia and is dominant in narrow shelves such as Sri Lanka and Philippines (Mitsuo, 1989). Genetic studies on the stocks of *E.affinis* in South-East Asia have revealed that it is a pan-mixing stock (Mudjekeewis *et al.*, 2010) and in Indian waters (including both islands) it is a single stock (Girish *et al.*, 2012). *E. affinis,* being a coastal species, is widely exploited all along the Indian coast to the tune of 35,446 tons forming about 40% of the total tuna landings of India in 2016 (CMFRI, 2017). The combined landing of tuna species in ANI during the year 2016-17 was 2208 tons (Unpublished data, 2018). Coastal tunas contributed 2008 tons (99%) to the total tuna production whereas the contribution of oceanic tunas was 200 tons only. *Euthynnus affinis* contributed significantly to the tuna production in ANI.

Studies on distribution, abundance and various aspects of biology had been conducted from different regions of the world. Biology of Indo-Pacific tunas was studied in detail and compiled as synopsis (Mitsuo, 1989). From Sri Lankan waters biology of exploited stocks (Sivasubramaniam, 1970) and stock assessment (Pauline *et al.*, 1991) of *E. affinis* was studied. Distribution of *E. affinis* in western Thailand was studied (Chamchang and Chayakul, 1988). Stock assessment of *E.affinis* for entire Indian Ocean was done (Rishi *et al.*, 2012). Length frequency distribution and population parameters for little tuna of northwestern Sumatran waters were studied (Ririk *et al.*, 2014) while biological studies were also conducted for tuna and tuna like species from Malaysian waters and Gulf of Thailand (Chiampreecha, 1978). From Indian waters, stock assessment studies of various tuna species including *E. affinis* was done (Silas *et al.*, 1985). Various authors have studied the fishery, biology and stock assessment of tunas (James et al., 1993; Pillai and Gopakumar, 2013). Distribution, abundance, exploitation and biology of tunas from Andaman and Nicobar waters were studied earlier by Madhu *et al.*, (2002), Pandian et al., (2007) Pradeep et al., (2017). But these studies are mostly for oceanic tunas such as *Thunnus albacores* and *Katsuwonus pelamis*. There is no information on the biology and stock status of *E.affinis* from Andaman waters. Studies on the fishery, biology and growth of *E. affinis* in different parts of globe including India are limited (Prathiba *et al.*, 2012). In this context, an effort was taken to study the fishery, growth parameters and stock status of *E. affinis* from Andaman waters.

Materials and Methods

Euthynnus affinis were sampled to record fork length (cm) and weight (gm) from April 2015 to March 2017 at commercial landing centers around Port Blair and at the fish processing plants in Port Blair who receive fish from other parts of Andaman Islands. Fish samples were collected randomly and brought to laboratory for conducting biological studies. The length weight relation was calculated using the formula ($W=aL^b$). Stomachs were analyzed for fullness by visual method and prey was identified up to genus level wherever possible. ELEFAN I module of FiSAT II software was used to estimate the von Bertalanffy's growth parameters ($L\infty$ and K). 't_0'was estimated using the formula Log_{10}-t_0=-0.3922-0.2752*$Log_{10}L_\infty$-1.038 log_{10} K. The growth performance index was estimated using the formula $log_{10}(K) + 2Log_{10}(L_\infty)$. Longevity was estimated from $t_{max}=3/K + t_0$. Natural mortality (M) was estimated using Paulys empirical formula. Length converted catch curve method in FiSAT II software was used to estimate total mortality (Z). Fishing mortality (F) was calculated by F=Z-M. Exploitation ratio (E) was estimated using the formula E=F/Z, where F is fishing mortality rate and Z is total mortality rate. To calculate Exploitation rate (U) formula $U=F/Z*(1-e^{-z})$ was used. Length based Virtual Population Analysis (VPA) was performed in the FiSAT II software to obtain length class wise fishing mortalities. Total stock (P) was estimated by the ratio of Y/U, where Y is the annual average yield. Biomass or standing stock (B) was estimated from the ratio Y/F. Maximum sustainable yield (MSY) was calculated by the equation MSY=Z×0.5×B for exploited fish stocks.

The data on fish catch and effort was obtained from the Department of Fisheries, A&N Administration. The Department of Fisheries, A&N Administration collects catch data of tunas in two categories; one is oceanic tuna and the other is coastal tuna. Under the category of oceanic tuna, catch data of three species (*Thunnus albacores, T. obsesus* and *Katsuwonus pelamis*) is collected separately whereas under the category of coastal tunas, species wise catch data is not collected. Therefore, on the basis of our observations in fish landing centers and fish markets, interactions with the staff of Department of Fisheries, A&N Administration and fishermen, it was assumed that 70-90%of the coastal tuna catch is comprised of *E. affinis.* Hence, an average of 80% (1608 tons) of average coastal tuna catch of last five years (2010 tons) was used for the estimation of total stock (P), standing stock (B) and MSY.

Results

Euthynnus affinis formed the dominant species in landing among the coastal tuna. Drift gill net was the single major gear exploiting the *E.affinis* by using plank built boat with inboard engines locally known as '*bongadongi*' and fibre reinforced plastc (FRP) boats of varying size. Other gears harvesting tunas were hook and line, troll lines and ring seine.Gill nets with mesh size 100-120 mm were mostly used. For trolling fish hooks of size 1-6 were used. Annual landings of coastal tuna from 2012-13 to 2016-17 is shown in figure 1. The annual landings varied from 1972 tons in 2015-16 to 2200 tons in 2014-15.The average catch of coastal tuna during the last 5 years was 2010 tons forming about 11% of the estimated coastal tuna potential of ANI. Though the fish is caught round the year, the peak fishing season is from December to April. Most of the tuna catch is exported to mainland India due to low demand in the local market.

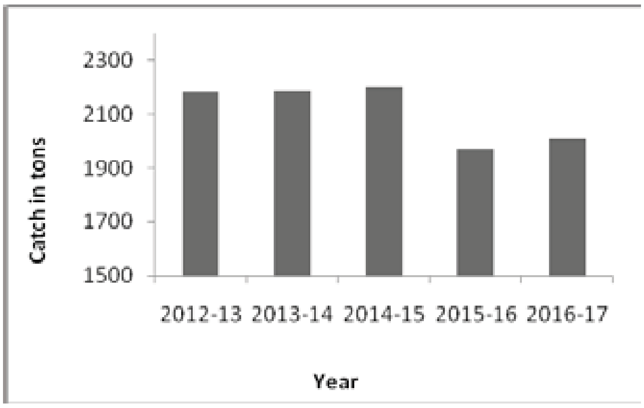

Fig. 1 Annual landings of coastal tuna during 2012-13 and 2016-17 in ANI.

The length-weight data was collected from a total of 1935 fish samples. The fork length of the observed fishwas in the range of 15 to 72cm. The figure 2 shows the length frequency distribution of little tuna in Andaman waters. More than 53% of the little tuna catch was contributed by fishes falling in the length range of 33 to 48cm making it the modal class. The stomachs of the little tuna were analyzed to study feeding intensity and feeding habits. 52% of the fishes had half full stomachs. Stomachs with one forth fullness constituted about 30% and little with empty stomachs constituted 18% (figure 3). None of the fishes had full stomach. The prey of little tuna included fishes, molluscs and crustaceans. Fish formed the dominant group (>90%) of diet such as horse mackerel, lesser sardines, white baits, threadfin breams etc.

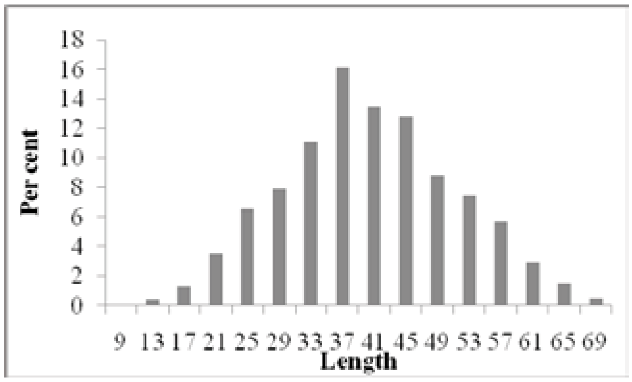

Fig. 2 Length frequency distribution of little tuna from Andaman waters.

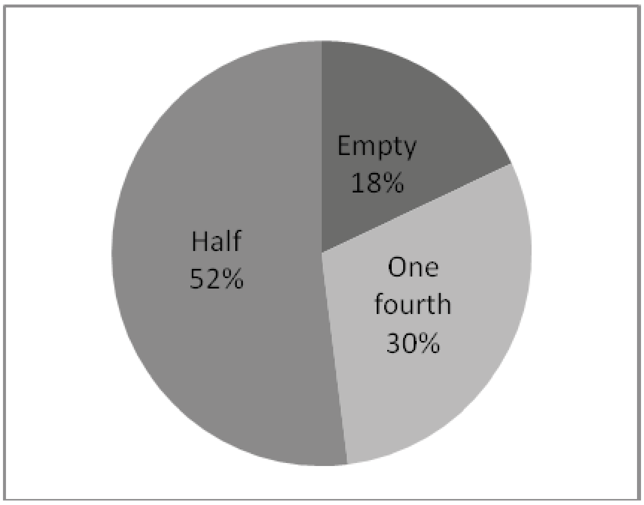

Fig. 3 Stomach condition of little tuna during the study period

Length weight relationship of little tuna was $W=0.196\ L^{2.913}$ where W is the weight of the fish in grams and L is the fork length of the fish in centimeters. The growth parameters in von Bertalanffy's growth equation $Lt=L_{\infty}[1-(e^{-K(t-t0)})]$estimated were $Lt=74.03[1-(e^{-0.410(t+0.025)})]$.The growth performance index (Ø) was 3.351. The estimated longevity of the *E.affinis* was 7.10 years and the length attained after 1st, 2nd and 3rd year was 25, 41 and 52 cm respectively. The M/K ratio estimated was 1.87 which is within thenormal range of 1 to 2.5. The natural mortality rate (N), fishing mortality rate (F) and total mortality rate (Z) estimated were0.77, 0.32 and 1.09 respectively. Exploitation ratio (E) and exploitation rate (U) estimated was0.294 and 0.195 respectively. Virtual Population

Analysis (VPA) indicated that major loss in the little tuna stock upto 30.5 cm was due to natural reasons (figure 4). Mortality due to fishing increased after this point but the fishing mortality remained more or less low. The estimated total stock (P) was 8662 tons and standing stock (B) was 5275 tons. The estimated value of maximum sustainable yield (MSY) corresponded to 2639 tons which is higher than the annual average yield indicating that little tuna stocks are underexploited.

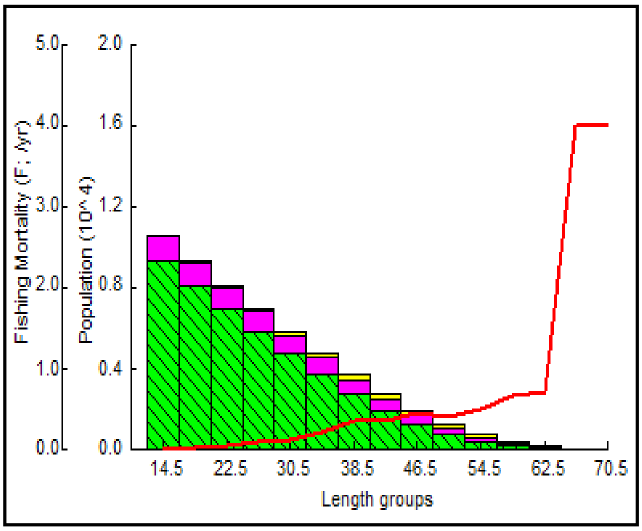

Fig. 4 Virtual Population Analysis of *Euthynnusaffinis.*

Discussion

Andaman Nicobar waters have a fishery potential of 1.48 lakh tons and are known as one of the best fishing grounds for tunas with a potential of 64500 tons/year against their harvest of only 2208 tons during 2016-17. Out of 64500 tons of potentially harvestable tuna, 46500 tons is constituted by oceanic tunas whereas the annual harvest was 200 tons in 2016-17. The remaining 18000 tons in the potential catch is constituted by coastal tunas which are harvested to the tune of around 2000 tons. This indicates that though the potential of oceanic tunas is more, the fishing pressure is more on the coastal tunas. This may be due to the status of present fishing fleet who fish mostly within 200m depth zone (Pillai and Abdussamad, 2009), limited tradition of tuna fishery, low market price of tuna in relation to other pelagic resources such as barracudas and seer fishes making tuna fisheries less attractive etc. There is no species specific catch data for the coastal tunas from Andaman waters but we observed that *E. affinis* is the major contributor to the catch of coastal tunas. Also, studies on the fishery and biology of this species were not undertaken earlier. Understanding the biological characteristics of fished stocks and their assessment is imperative for the management of fishery. Growth characteristics of fishes are important part of population dynamics and essential parameters to take serious decision on the management issues of any fishery (DeVries and Frie, 1996).

Various authors have reported the length range of *E. affinis* such as 10-78cm (Pillai *et al.*, 2002) and 14-80cm (Prathibha *et al.*, 2012) for Indian waters. Little tuna fishery in the northwestern Sumatran waters was supported by fishes in the length range of 23.5 – 61.5 cm (Ririk *et al.*, 2014). The length range recorded in this study (15-72cm) is within the range of values of earlier studies. This study recorded 33-48cm as modal length class supporting fishery which was close to the observations (34-58 cm) made for Indian waters (Prathibha *et al.*, 2012). *Euthynnus affinis* is a highly opportunistic predator and feeds on small fishes, squids, crustaceans and zooplankton indiscriminately (Collette, 2001). Studies from Indian waters also observed that the major component of *E.affinis* diet is fish followed by crustaceans and mollusks. In this study, we recorded small carangids, clupeoids and stolephorus (whitebaits) as major component among the fish followed by crustaceans and mollusks. The length-weight relationship ($W=a L^b$) explains the exponent ‘b’ in the parabolic equation. The value of ‘b’ usuallylies between 2.5 and 4.0, and for an ideal fish which maintains constant shape, b=3. The ‘b’ values from various region of Indian waters [16-20,22&40-42] and from Indian Ocean[43-45] were reported where the value of ‘b’ ranges from 2.5 (Silas et al., 1985) to 3.2 (Siraimeetan, 1985). The estimated ‘b’ value in this study was 2.91 which isalmost closer to 3 indicating the isometric growth.

Growth parameters L_∞, K and $t_0$were estimated by various workers. The value of L_∞ ranges from 72.5 in the Saurashtra coast (Shubhadeep *et al.*, 2010) to 87.5 in the east coast (Kasim and Abdussamad, 2003). The value of K showed wider range from 0.365/year (Silas *et al.,* 1985) to 1.5/year (Kasim and Abdussamad, 2003). The values obtained in this study were within the range of earlier studies indicating *E. affinis* as a fast growing fish with longevity of 7.10 years. The exploitation ratio (E) is an index used to assess if a stock is overfished, on the assumption that optimal value of E is equal to 0.50. The 'E' of 0.83 is reported along east coast (Kasim and Abdussamad, 2003) indicating over exploitation of *E. affinis* stocks whereas the reports from Veravel coast (Shubhadeep *et al.*, 2010) and Indian waters (Prathibha *et al.*, 2012) indicates that the *E. affinis* stocks are under exploited with value of 'E' being around 0.36. In the present study the value of 'E' estimated was 0.294 which is less than 0.5 indicating that the *E.affinis* stocks in Andaman waters are underexploited. A similar value of 'E' was reported from Sri Lankan waters (Pauline and Janaka, 1970) who inferred that the *E affinis* stocks were not fully exploited. In the present study fishing mortality (0.32) is lesser than the natural mortality (0.77) which indicates the stocks of *E.affinis* are not under the pressure of biological overfishing. The estimated MSY for *E. affinis* was 2639 tons which is higher than the average annual landings of 1608 tons (80% of the average annual production), indicating that the stocks are within the safe limits. The stock assessment studies of *E affinis* for Indian Ocean shows that the stocks are approaching overfishing levels (Rishi *et al.*, 2012) though the author cautions about the reliability of the results due to lack of quality input data. Of the 600 fish stocks monitored by FAO globally, 52% are fully exploited, 17% are overexploited 7% are depleted and 1% are recovering from depletion (FAO, 2011) and in contrast, fish stocks in the EEZ of ANI are underexploited. In ANI the present harvest is only 25% of the potential. The results of this study indicate that the MSY of *E. affinis* is higher than the present harvest indicating that stocks are within safer limits. Any attempt of increasing the production of this species should be done judiciously due to the nature of multi gear multi species fishery. Another important aspect is that the average annual landing of oceanic tunas is about 200 tons, which is less than 0.5% of its potential. The fishery managers may consider focusing on exploiting the oceanic tuna resources to reduce the fishing pressure on coastal tuna stocks.

Conclusion

Tuna is the most dominant and internationally demanded resource. Since the Andaman Nicobar waters are blessed with rich tuna resources, any development of fisheries program in the islands should be centered on it. The reliability of output of any study greatly relies on the quality of input data and is applicable for this study also. One shortcoming in this study was the unavailability of species specific catch and effort data which we have tried address by certain assumption based on regular observations and interactions with fishermen. Scattered landing centers in the remote and distant islands, unsure landing times and unavailability of tunas in the catch all the days as it is not a prime target for fishermen are some other issues in performing stock assessment studies in the bay islands. This study indicates that the present exploitation level of little tuna stock is below MSY and scope is available to increase the fishing pressure. Collection of species specific fish catch and effort data employing standard statistical methods and conducting similar studies on the other species of coastal and oceanic tunas will help in better understanding of the dynamics and stock status of tunas in Andaman and Nicobar waters. The information generated in this study will help the fishery managers in the islands to plan the future course of actions for the development of island fisheries in a sustainable way.

Acknowledgements

We whole heartedly thank the Director, ICAR-CIARI, Port Blair for his support during the entire course of study. We are also thankful to the Department of Fisheries, A&N Administration and fishermen of ANI for their support and cooperation for this study.

References

Anrose, A. Sinha, M. K. & Kar, A. B. (2009). Oceanic Tuna Resources Potential in Andaman & Nicobar Waters. *In*: *Proceedings of Brainstorming session on Development of Island Fisheries,* edited by Dam Roy S, Krishnan P, Kamal Sharma & Grinson George, Central Agricultural Research Institute. 5-22.

Chamchang, C. & Chayakul, R. (1988). Distribution of longtail (*Thunnustonggol*, Bleeker), kawakawa (*Euthynnusaffinis*, Cantor) and frigate tuna (*Auxisthazard*, Lacepede) in the western coast of the Gulf of Thailand. *Indo - Pac. Tuna Dev. Mgt. Programme,*IPTP/87/GEN/13. 80–88.

Chiampreecha, B. (1978). Biological studies on tuna and tuna-like fishes in the west of the Gulf of Thailand and off east coast of Peninsular Malaysia. *Pelagic Fish. Rep.,* (Marine Fisheries Division, Department of Fisheries, Bangkok). 25.

CMFRI. (2017). Annual Report 2016-17. Central Marine Fisheries Research Institute, 292.

Collette, B. B. (2001). Scombridae. Tunas (also, albacore, bonitos, mackerels, seerfishes, and wahoo), *In*: *FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific*, edited by Carpenter, K. E. & Niem, V. (Vol. 6. Bony fishes part 4 (Labridae to Latimeriidae), estuarine crocodiles. FAO, Rome) 3721-3756.

De Vries, D. R. & Frie, R. V. (1996). Determination of age and growth. *In*: Fisheries techniques (2nd edition), edited by Murphy, B. R. & Willis, D. W. (American Fisheries Society, Bethesda, Maryland) 483-512.

FAO. (2011). Review of the state of world marine fishery resources, FAO Fisheries and Aquaculture Technical Paper No. 569 (FAO, Rome) 334.

Girish,K., Kunal, S. P. & Menezes, M. R. (2012). Low genetic variation suggest single stock of kawakawa, *Euthynnusaffinis*(Cantor, 1849) along the Indian Coast. *Turk. J. Fish. Aquat. Sc.*, 12: 371-380.

James, P. S. B. R., Pillai, P. P., Jayaprakash, A. A., Pillai, N. G. K., Gopakumar, G., Kasim, H. M., Sivadas, M. & Said Koya, K. P. (1993) Fishery, biology and stock assessment of small tunas, *In*: *Tuna research in India*, edited by Sudarsan, D. & John, M. E. (Fishery Survey of India, Bombay, India) 123-148.

John, M. E., Bhargava, A. K., Varghese, S., Gulathi, D. K., Ashok, S. K. & Dwivedi, S. K. (2005) Fishery Resources of the Indian EEZ around Andaman and Nicobar Islands, *Bull. Fish. Surv. India.,*28.

Kasim, H. M. & Abdussamad, E. M. (2003) Stock assessment of coastal tunas along the east coast of India, *In*: *Proc. Tuna Meet,* edited by Somvanshi, V. S., Varghese, S. & Bhargava, A. K. 42-53.

Madhu, K., Rema, M., Ahlawat, S. P. S., Raveendran, E. K. & Dam Roy S. (2002). Status of exploitation of tuna, mackerel and seerfish in Andaman and Nicobar Islands. *In*: *Management of scombroid fisheries,* edited by Pillai, N. G. K., Menon, N. G., Pillai, P.P. & Ganga, U. (CMFRI, Kochi, India) 49-55.

Mitsuo,Y. (1989) Synopsis of biological data on kawakawa, *Euthynnus affinis. Indo-Pac.Tuna Dev. Mgt.Programme,* (IPTP/89/WP/19) 55.

Mudjekeewis, D. S., Grace, V. L. & Noel, C. B.(2010). A Pilot Study on the Genetic Variation of Eastern Little Tuna (*Euthynnus affinis)* in Southeast Asia. *Philipp J Sci.,* 139: 43-50.

Paul Pandian, P., Kar, A. B., Sinha, M. K., & Pattnayak, S. K. (2007). Observation on the distribution and abundance of tuna resources in the exclusive economic Zone (EEZ) of Andaman &Nicobar Islands. *In*: *National Symposium on Conservation and Valuation of Marine Biodiversity,*edited by the Director (Zoological Survey of India, Kolkata) 287-299.

Pauline, D. & Janaka, D. S. (1991). An assessment of Kawakawa (*Euthynnus affinis*) stock on the west coast of Sri Lanka. *Asian Fish. Sci.,*4: 219-226.

Pillai, N. G. K. & Abdussamad, E. M. (2009). Development of Tuna Fisheries in Andaman and Nicobar Islands. *In*:*Proceedings of Brainstorming session on Development of Island Fisheries,* edited by Dam Roy, S., Krishnan, P., Sharma, K. & George, G. Central Agricultural Research Institute, 23-34.

Pillai, P. P. & Gopakumar, G. (2003). Tunas. *In*: *Status of exploited marine fishery resources of India,* edited by Mohan, J. M. & Jayaprakash, A. A. (CMFRI, Kochi, India), 51-59.

Pillai, P. P., Pillai, N. G. K., Muthiah, C., Yohannan, T., Kasim, H. M., Gopakumar, G., Koya, K. P. S., Manojkumar, B., Sivadas, M., Nasser, A. K. V., Ganga, U., Dhokia, H. K., Kemparaju,S., Bhaskaran, M. M., Elayathu, M. N. K., Balasubramanian, T. S., Manimaran, C., Kunhikoya, V. A. & Ajith Kumar, T. T. (2002). Status of exploitation of coastal tunas in the Indian seas. *In*: *Management of Scombroid fisheries,* edited by Pillai, N. G. K., Menon, N. G., Pillai, P. P. & Ganga, U. (CMFRI, Kochi) 56-61.

Pradeep, H. D., Swapnil, S. S. & Kar, A. B. (2017) Estimates of length-based population parameters of the skipjack tuna, *Katsuwonus pelamis* (Linnaeus, 1758) in the Andaman waters. *Journal of Fisheries*. 5: 477–482.

Prathibha, R., Anulekshmi, C., Abdusssamad, E. M., Joshi, K. K., Said Koya, P., Sivadas, M., Shubhadeep, G., Margaret, M. R. A., Kemparaju, S., Dhokia, H. K., Prakasan, D. & Beni. N. Fishery and bionomics of the little tuna, *Euthynnus affinis* (cantor, 1849) exploited from Indian Waters. *Indian J. Fish.* 59: 33-42.

Ririk, K. S., Irwan, J. & Arief, W. (2014). 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). *IOTC* 04-20.

Rishi, S., Miguel, H. & Julien, M. (2012). Indian Ocean Neritic Tuna Stock Assessments (Kawakawa and Longtail): Using Surplus Production Models with Effort: An Observation Error Based Approach. *Second Working Party on Neritic Tunas, Penang, Malaysia, IOTC* 1-16.

Shubhadeep, G., Pillai, N. G. K. & Dhokia, H. K. (2010). Fishery, population characteristics and yield estimates of coastal tunas at Veraval. *Indian J. Fish*., 57: 7-13.

Silas, E.G. (1985). *Tuna fisheries of the exclusive economic zone of India: biology and stock assessment.* (CMFRI Bull., 36).

Siraimeetan, P. (1985). Fishery and Bionomics of tunas at Tuticorin. *In*: *Tuna fisheries of the exclusive economic zone of India:biology and stock assessment*, edited by Silas, E. G., (CMFRI Bulltin 36) 86-103.

Sivasubramaniam, K. (1970). Biology of the exploited stock of mackerel tuna *E. affinis* (Cantor) off the south-west region of Ceylon. *Bull. Fish. Res. Stn. Ceylon*, 21: 7-16.

Unpublished data. Directorate of Fisheries, A&N Administration, 2018.

Received : 07th January, 2018 Accepted : 16th January, 2019