REPRODUCTIVE BIOLOGY OF THREE NERITIC TUNAS (FAMILY: SCOMBRIDAE) INHABITING THE NORTH-WESTERN COASTAL WATERS OF INDIA

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Abstract

The focus of the study was to observe reproductive biology of three neritic tunas*viz.,Thunnus tonggol, Euthynnusaffinis* and *Auxis thazard* belonging to the family Scombridae during the period 2009-2012. A total of 512 samples of *Thunnus tonggol,* 448Nos. of *Euthynnus affinis* and586 Nos. of*Auxis thazard* were analysed for the study. The development of ova from immature to maturity levelrevealed that, in IIIrdstage, the maturing ova measured between 0.039-0.068mm in *Thunnus tonggol*,0.008-0.028mm in *Euthynnusaffinis*and0.008-0.024mm in *Auxis thazard*. Two distinct spawning seasons were observed in all the three species and major spawning season for these specieswas observed during August-December. Minor spawning season was during March-May in *T. tonggol*,March to May in *E. affinis* and January-April in *A. thazard*. The size at first maturity in*T. tonggol* was recorded at 48.0cm, *E. affinis* at 42.0cm and *A. thazard* at 37.5cm.Male to female sex ratio was 1:1.3 (*T. tonggol*), 1:1.7 (*E. affinis*) and 1:1.1 (*A. thazard*). The gonado-somatic index values were in the range of 0.042-5.826 for all the three species. Fecundity of *T. tonggol* was between 1,43,230-22,30,000 ova,*E. affinis* range was 2,15,759-15,63,721 and in *A. thazard*, 89,400-15,99,528.

Keywords: Neritic tunas, reproductive biology, size at first maturity, gonado-somatic index, fecundity.

I. INTRODUCTION

The neritic tunas are the important large pelagic resources inhabiting North-west coast of India in between Lat. 18°-23°N and Long. 68°-73°E which covers two maritime states *viz.*, Gujarat and Maharashtra. The most important species occurring in the region are *Thunnus tonggol*, *Euthynnus affinis* and *Auxis thazard*. During 2016, the species,*T. tonggol* dominated the catches (4,309 tonnes) in the state of Gujarat when compared to*E. affinis* (3,533 t) and *A. thazard* (1512 t) while, in the state of Maharashtra,the neritic tuna catch was dominated by*E. affinis* (3,042 t) followed by*T. tonggol*(527 t) and *A. thazard* (119t) (CMFRI, 2017).

In order to understand the dynamics of fish population, spawning biology is crucial to predict the rate of recruitment of fish stocks. The likelihood of fluctuations in the recruitment depends on spawning habits and biology of fishes. According to Schaefer (1951), if a single population of tuna spawns over a wide area and a long season, fluctuations in environmental conditions are much less likely to give rise to large variations in survival and be reflected in the recruitment than if spawning is taken place only on one spawning ground during a short season.Somvanshi (1976) reported that,the size at which a fish matures for the first time, is essential to ensure the continuation of its race and to get sustained yield of the fish by adjusting the size of the fishing net in such a way that the small fish, which have not spawned even once may have an opportunity to escape through the net.Thusthe size at first maturity is also an essential parameter for fishery management.

Earlier many researchers across the world have contributed to derive strategies for fisheries management based on the maturation& spawning of tuna species.The contributions of Yesaki (1989a)on biological data on *Euthynnusaffinis*, Yesakiand Arce (1991) on the *Auxis* fisheries of the Philippines and some aspects of the biology of frigate and bullet tunas in the Indo-Pacific region, Yesaki (1994) on the biology and fisheries for kawakawa in the Indo-Pacific region, Yesaki (1994) on the biology and fisheries for *Thunnus tonggol* in the Indo-Pacific region,Chiou*et al.*,(2004) on reproduction and food habits of kawakawa in Taiwan waters,Mohammad and Nidal(2007) on the fishery status, growth, reproduction biology and feeding habit of two Scombrid fish from Gulf of Aqaba, Red Sea, Griffiths*et al.,* (2007) on the Feeding dynamics, consumption rates and daily ration of longtail tuna in Australian waters,Chiang *et al.,* (2011) on reproductive biology of longtail tuna from coastal waters off Taiwan, Neogroho*et al.*,(2013) on some biological aspects of*A. thazard*, *A. rochei* and*E. affinis* in West Coast Sumatera, Eastern Indian Ocean, Johnson and Tamatamah (2013)on the length frequency distribution, mortality rate and reproductive biology of *Euthynnus Affinis* from Tanzanian coastal waters,Piyawan*et al.*,(2014) on reproductive biology of longtail tuna in Thai Waters, Mohamed *et al.,* (2014) on reproductive biology of little tunny,*E. alletteratus* in the Eastern Coast of Alexandria, Egypt,Nootmorn (2015) on the status of longtail tuna resource and fisheries in Thailand andPrawira*et al.,* (2016) on size distribution and reproductive aspects of *Auxis* spp. from west coast of Sumatera, Eastern Indian Ocean, are worth to be referred.

As per the literature upto 1990, inIndian waters, the investigations on reproductive biology of neritic tunas were carried out by Rao (1964) on the ripe ovaries of some Indian tunas, Muthiah (1985) on maturation spawning of neritic tunas in the Mangalore coast, Pillai and Ganga (1985) on fishery and biology of tunas in the Indian seasand Siraimeetan(1985) on fishery and bioeconomics of tunas along Tuticorin waters.In recent years, such studies are very limited, rather scanty, except the works of Rohit*et al.,* (2012) on fisheries bionomics of little tuna from Indian waters, Kumar*et al.*,(2012) on stock status based on the genetic variation,Deepti and Sujatha (2012) on fishery and some aspects of reproductive biology of *A. thazard* and *E. affinis* off north Andhra Pradesh,Ghosh*et al.,* (2012) on Fishery, Population dynamics and Stock Structure of *A. thazard* exploited from Indian waters,Abdussamad *et al.,* (2013) on neritic tuna fishery, biology and population characteristics of longtail and frigate tuna along the Indian coast, Masani (2015) on some aspects of biology of little tuna,*E. affinis* from Veraval Coast, Gujaratand Nissar*et al.,* (2015) on reproductive biology of little tunain the Arabian Sea.

As the demand for food is being increased at regional, national and global level due to increase of population, it is very much essential to conduct periodic evaluation of the spawning biology of fishery resources occurring in various regions. Therefore, this study is an attempt to investigate and understand the reproductive biology of neritic tunas inhabiting the North-west coast of India in order to derive strategies for better management of this fishery.

II. MATERIAL AND METHODS

For investigating maturation and spawning of neritic tunas, 512 specimens of *Thunnus tonggol*, 448 specimens of *Euthynnus affinis* and586 specimens of *Auxis thazard*collected from the landings centres of Porbandar in Gujarat and Sassoon Dock &New Ferry Wharf in Mumbai, Maharashtra during 2009-2012, were considered for this study (Figure 1). To determine the spawning season, percentage occurrence of maturity stages (I-Vstages) were plottedmonth-wise and pooled for one year. Observation of maturity and spawning was carried out based on the mature eggs in the ovary. Ovaries of mature fishes of known length and weight were dissected out, weighed and immersed into Gilson's fluid (Simpson,1951) for easy separation of ova and estimationof fecundity.Gonado-somatic Index was calculated to see the progression of maturation and spawning. Size at first maturity was calculated for females from stage III to V. The proportion of male to female sex ratio was calculated based on the length group and Chi square test (χ^2) was applied with the formula in order to determine the differences in frequency of occurrence of male and female specimens. (1) $$\chi^2_c = \sum \frac{(O_i - E_i)^2}{E_i}$$

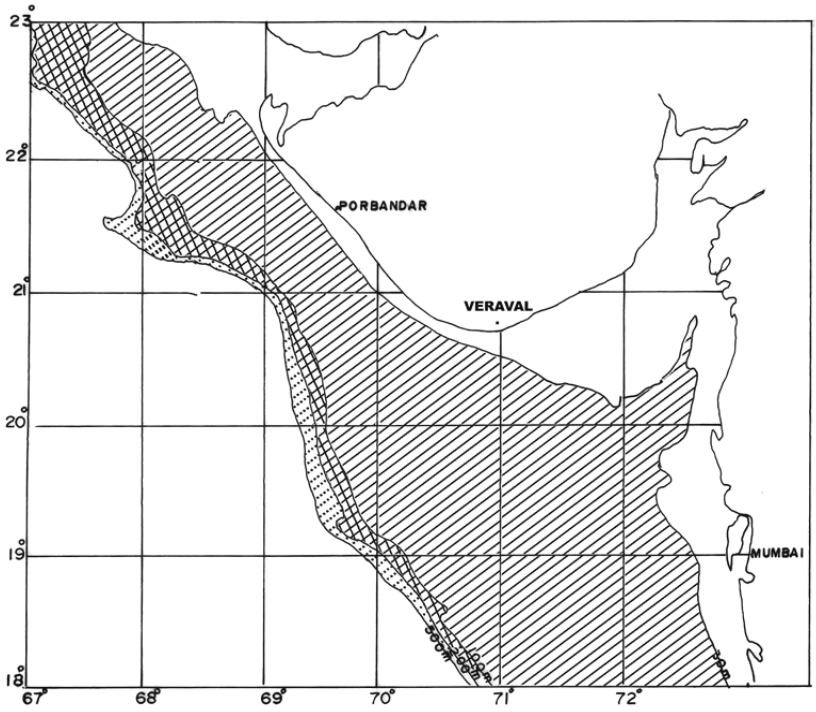

Fig. 1. Study area: North west coast of India

III. RESULTS AND DISCUSSION

3.1 Development of ova to maturity

The ovaries at different stages of maturity were examined to understand the development of ova to maturity. The oocytes of immature ovary (stage I) may be termed as the general egg stock which were observed to be present in the ovaries of all stages of maturity in all three speciesunder study. In *Thunnus tonggol*, at developing stage (stage II), ova measured between 0.002 and 0.027mm, in *Euthynnus affinis*, between 0.004 and 0.019mm and in *Auxis thazard*, between 0.005 and 0.011mm diameter. The maturing ova at stage III measured between 0.039 and 0.068mm in *T. tonggol*, 0.008 and 0.028mm in *E. affinis* and in *A. thazard*, it was between 0.008 and 0.024mm diameter. In stage IV, early mature ova increased in diameter between 0.072 and 0.081mm in *T. tonggol* with a mode at 0.076mm, in *E. affinis*, 0.012 and 0.044mm with a mode at 0.032mm and in *A. thazard*, it was observed between 0.011 and 0.034mm with a mode at 0.029mm. In stage V, fully matured ova showed slight

increase in size with therange between 0.078 and 0.091 in *T. tonggol*, 0.016 and 0.049mm in *E.affinis*and 0.009 and 0.039mm in *A. thazard*.

3.2 Spawning Season

In *T. tonggol*, two distinct spawning seasons were observed during the period of study. The major spawning season was during August to December with a peak in November and minor was from March to May with a peak in March (fig.2). The length-wise maturity stages revealed that,in *T. tonggol*,the ovaries starts maturing from 38cm onwards and at a length of 48cm with nearly 70% matured ovaries were seen. From 48-74cm length range, the maximum matured and spent stage female specimens were observed. (fig. 3).

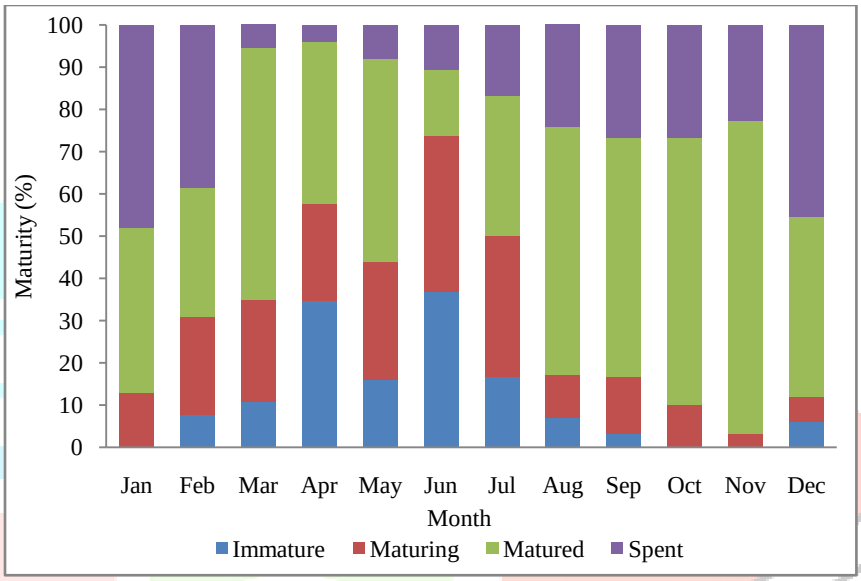

Fig. 2.Month-wise maturity pattern of*T. tonggol*

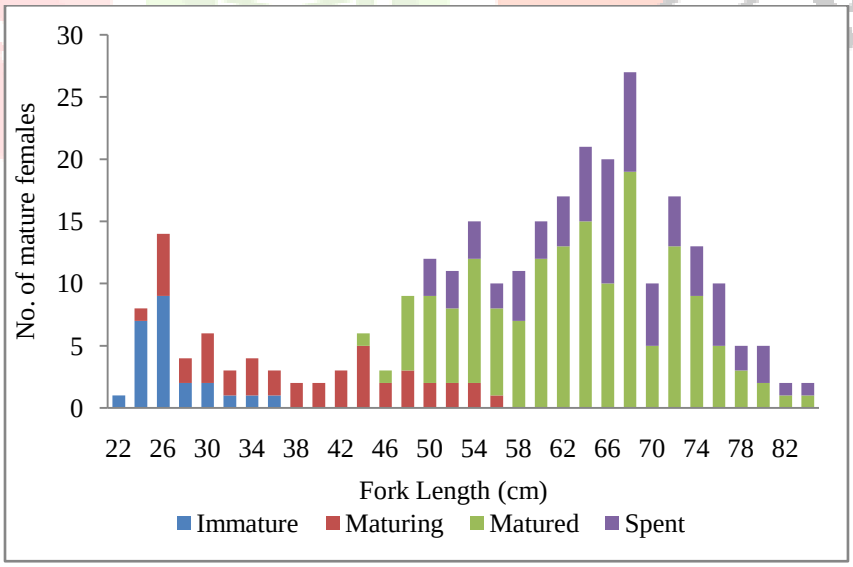

Fig. 3. Length-wise maturity pattern of*T. tonggol*

In *E. affinis*, the spawning season was observed twice in a year, major during August-December, with a peak in October and minor during March to May with a peak in April. In the months of April, September and October, dominance of ripe

gonads were found in the samples (fig. 4). The length-wise maturity stages indicated that, in*E. affinis*, maturation of ovaries began at 34cm length onwards and 50% matured ovaries were observed at a length of 42cm where.The matured and spent females were foundfrom 43-62cm length range. (fig. 5).

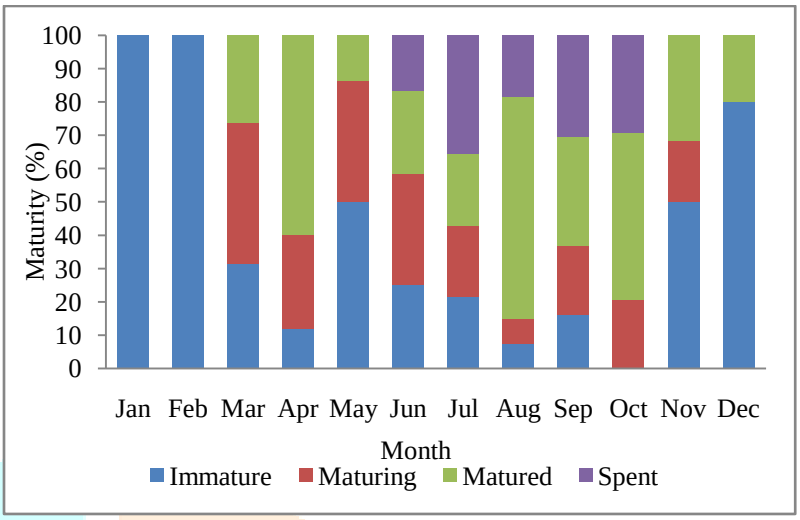

Fig. 4.Month-wise maturity pattern of*E. affinis*

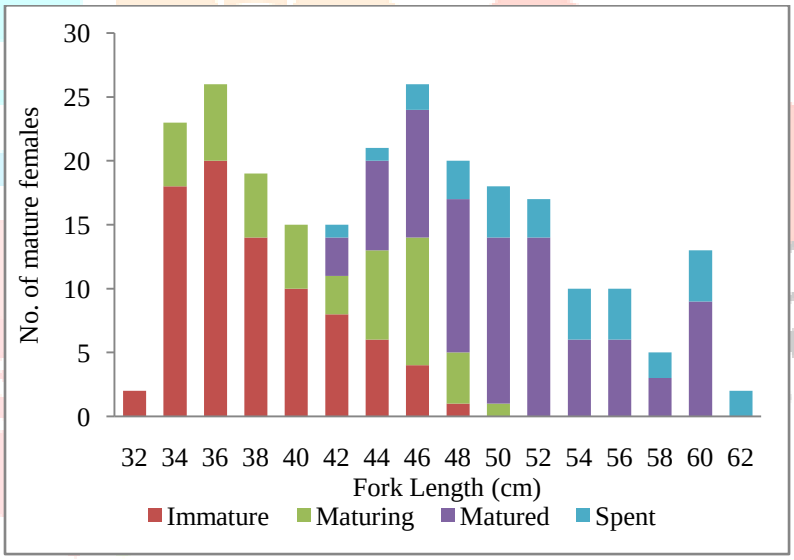

Fig. 5.Length-wise maturity patternof *E. affinis*

In*A. thazard*, two spawning seasons were observed,major during August to December with a peak in September and minor during January-April with a peak in March (fig. 6). Maturing, matured and spent gonads were observedduring both the periods of spawning.Maturing individuals were noticed at 32cm length, thereafter, matured and spent individuals were seen between 34cm and 44cm length (fig. 7).

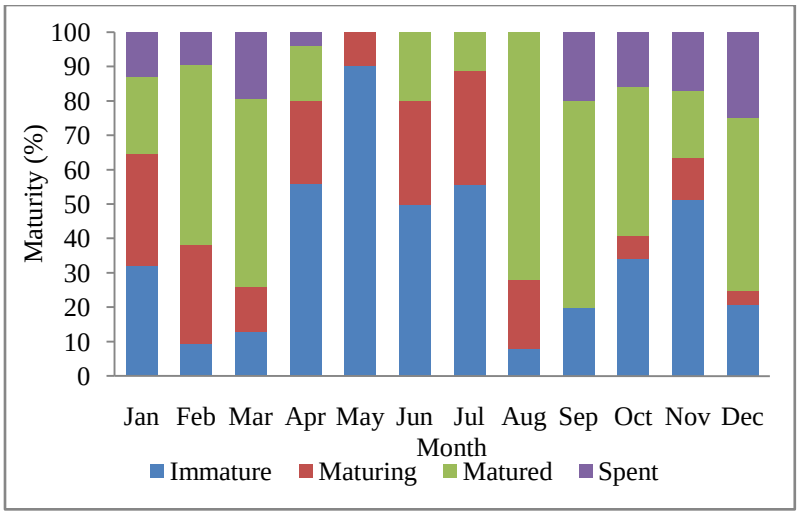

Fig. 6.Month-wise maturity pattern of*A. thazard*

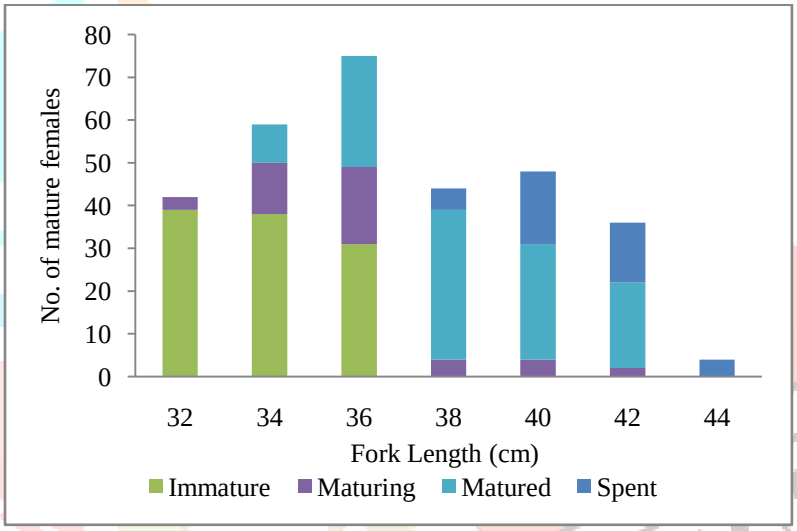

Fig. 7.Length-wise maturity patternof*A. thazard*

3.3 Size at First Maturity

From the study, it is inferred that the species *T. tonggol* attained maturity at 48cm, *E.affinis* at 42cm and *A. thazard*at37.5cm and the specimen wereobservedto be in III and IV stages of maturity(fig. 8 -10).

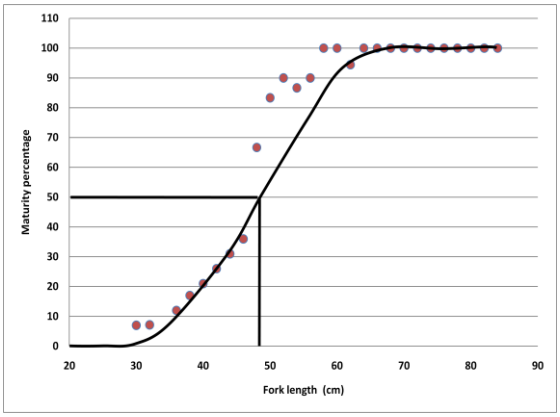

Fig. 8.Size at first maturity of*T. tonggol*

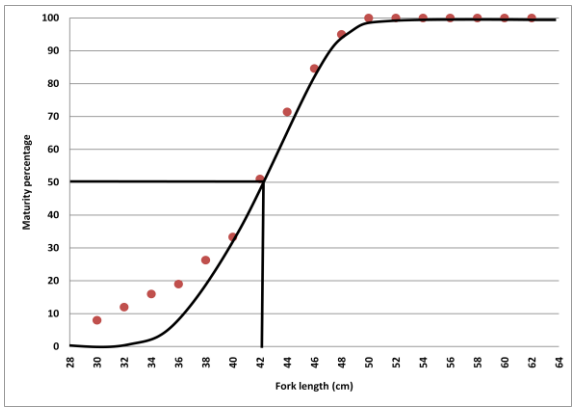

Fig. 9. Size at first maturity of *E. affinis*

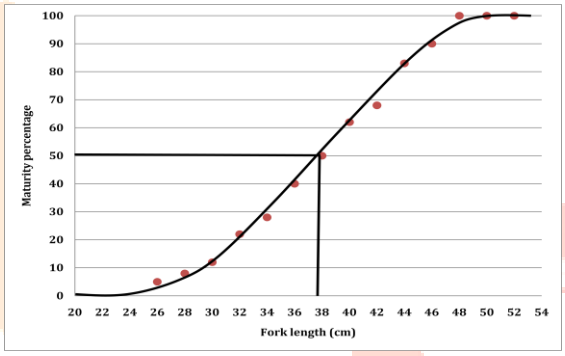

Fig. 10. Size at first maturity of *A. thazard*

3.4 Sex ratio

The male to female sex ratio observed in*T. tonggol* was 1:1.3, derived Chi square value (χ^2) was 9.57 while in *E.affinis,*the ratio was 1:1.7 with the χ^2 value 2.89 and in case of *Auxis thazard,* it was 1:1.1 with the χ^2 value 1.53.The Chi square values derived for each of the species are given in Tables 1-3. In all the species, the p value calculated as p>0.05 therefore, significant difference between male to female sex ratio was indicated.

Table 1.Chi-square analysis for *T. tonggol*

	Male	Female	Total
Observed Frequency	221	291	512
Expected Frequency	256	256	512

X^2 **(Cal),** X^2=9.57

X^2 **(Tab),** $X^2_{(0.05,\ 1)}$ = 0.479

Table 2.Chi-square analysis for *E. affinis*

	Male	Female	Total
Observed Frequency	206	242	448
Expected Frequency	224	224	448

X^2 **(Cal),** X^2=2.89

X^2 **(Tab),** $X^2_{(0.05,\ 1)}$ = 0.145

Table 3.Chi-square analysis for *A. thazard*

	Male	Female	Total
Observed Frequency	278	308	586
Expected Frequency	293	293	586

X^2 **(Cal),** X^2=1.53
X^2 **(Tab),** $X^2_{(0.05,\ 1)}$ = 0.070

As calculated value is greater than the table value of X^2 ,H_o **is rejected**
i.e. there is no equality among males and females
H_o= There is equality among males and females
H_1= There is no equality among males and females

In all three species, the critical values of χ^2, with one degree of freedom, were less than the calculated values. Therefore,during the study period, the occurence of females was higher than the males in each speciesat 5% level of significance.

3.5 Gonado-Somatic Index

The spawning season of the species under study was determined using the gonado-somatic index(GSI)values. The female specimens from stagesIIIto Vwere considered for deriving the GSI values. The GSI values obtained for *T.tonggol* were in the range of 0.04 to 0.573; for *E.affinis*the values were between0.218 to 5.199 and for*A.thazard*, rangedfrom 1.841 and 5.826. Higher values of GSI in *T.tonggol*were observed in the range of 0.417 to 0.573 during August to December, which coincided with the spawning season. In*E.affinis*, the higher GSI values were observed in the range of 2.641 to 4.84between September to Decemberwhich corroborated with peak spawning season observed during September and October. The higher GSI values in case of *A.thazard* were in the range of 3.739 to 5.826 found between August and December, which also confirmedthe peak spawning season of this species(fig. 11 -13).

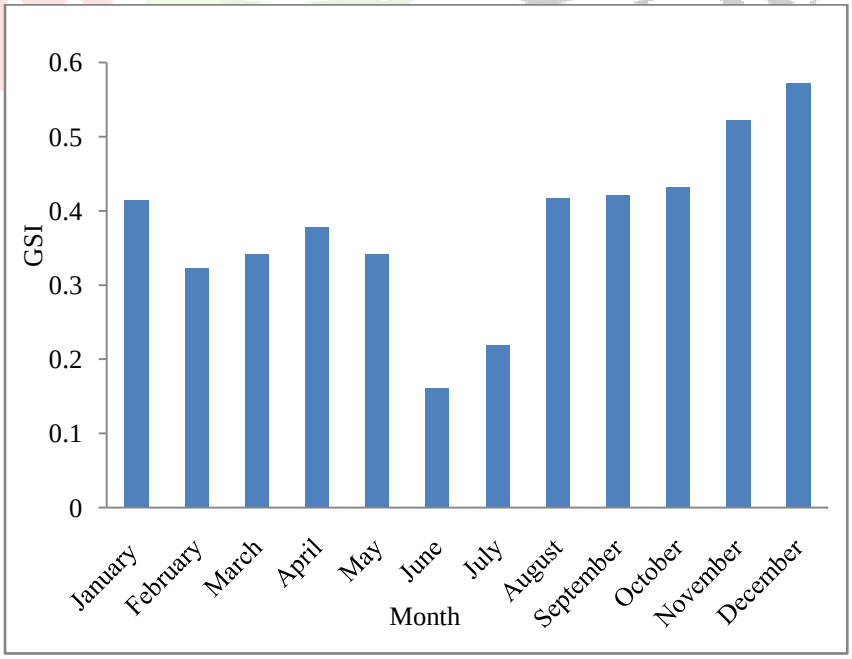

Fig. 11.Gonadosomatic Index of*T. tonggol*

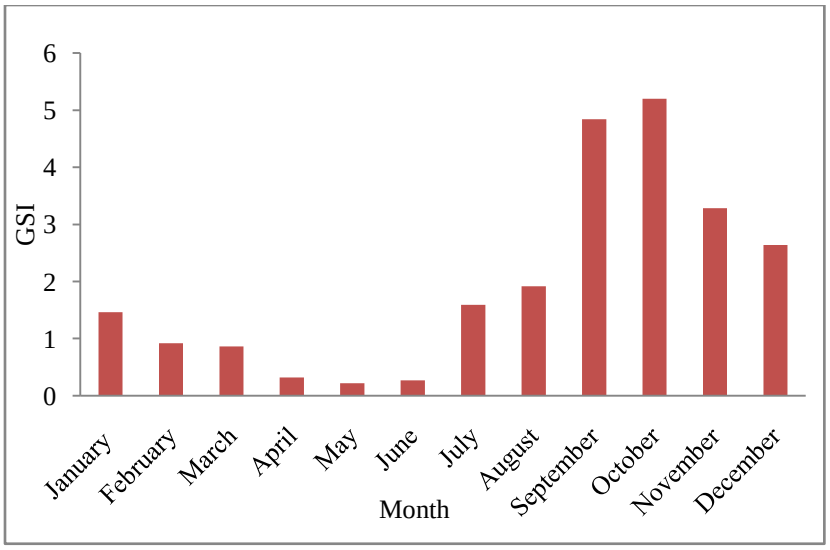

Fig. 12.Gonadosomatic Index of*E. affinis*

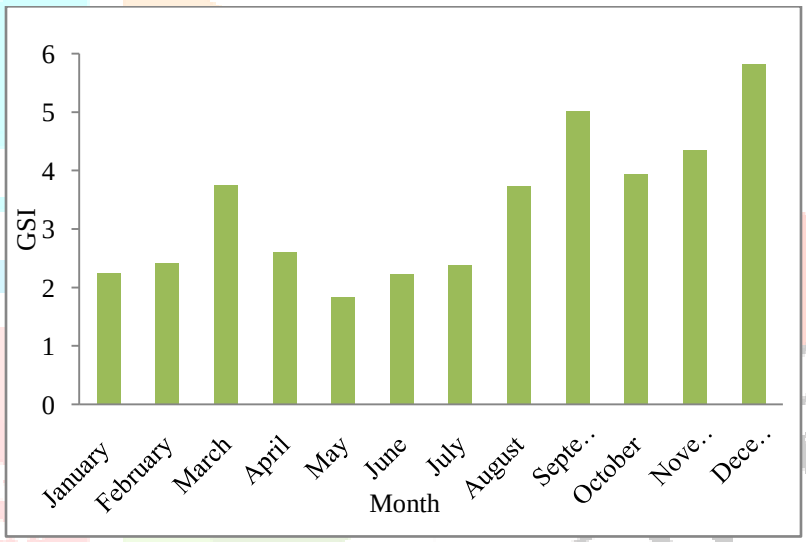

Fig. 13.Gonadosomatic Index of*A. thazard*

3.6 Fecundity

The mature specimens of *T.tonggol*, in the size range of 45-72cm, *E.affinis* with the size between 46-54 cm and *A.thazard* within 35-38cm size range were considered for the study. The fecundity of *T.tonggol* was observed in the range 1,43,000-22,30,000, *E.affinis*was 2,15,760–15,63,720 and *A.thazard*was 89,400-16,00,000. Fecundity estimated from the study revealed that the ovagm^{-1} body weight ranged between 110gm^{-1} and 600gm^{-1}in *T. tonggol*, 125g$m^{-1}$and 600gm^{-1}in *E. affinis* and120g$m^{-1}$and 1400gm^{-1}in *A. thazard*.

3.7*Thunnus tonggol*

Seasonal pattern of maturity in longtail tuna revealed that the gonads of all the stages were observed during the whole year. Occurrence of mature and spent gonads during August to December indicated the spawning period of this species. This observation is in confirmity with the results obtained by Abdussamad *et al.*, (2012). Size at first maturity derived through logistic curve was 48cm and at this length, the age of the fish was 21 months.Variations in size at first maturity were observed in the literature, which might be due to different food and feeding habits, ecosystem where the species occurs and the fluctuations in environmental parameters. The sex ratio for this species was 1:1.3 and the chi-square value derived was 9.57which indicated significant variation ($p>0.05$), where the females were found to be dominant in the samples. The sex ratio

varying from region to region and ocean to ocean(Ref).The GSI value for this species was in the range of 0.04 to 0.573and coincided with the spawning season(August to December). The fecundity ranged (between 14,43,000 and 22,30,000), values werecloser to the values of Muthiah (1985) and Rao (1964).

3.8*Euthynnus affinis*

The matured gonads in this species were observed twice in a year, onceduring August-December and later during March to May confirming the spawning season. The studies of Collate and Nauen (1983) inferred that, this species show different spawning seasons whichvary from region to region. They observed the spawning season from March to May in Philipine waters and from October to November & April to May from Seychelles, and August to October off Indonesian Waters. The spawning observed in the present study corroborated with these observations. The size at first maturity for this species was observed at 42cm where, the fish was at the age of 18 months.The size at first maturity observed by Masani (2015) from Veraval coast was 46.21 cm which is close to the value of the present study. The sex ratio obtained was 1:1.7 and the chi-square value derived was 2.89, whichshowed significant variation($p>0.05$)as dominance of females than males. The GSI values ranged between 0.218 and 5.199 for this species. The higher GSI values during September to December correlated with the spawning season. The fecundity values were also within the range (2,15,760 to 15,63,720) of the estimates made by Muthiah (1985) and close to the observatons of Deepti and Sujatha (2012).

3.9*Auxis thazard*

The size at first maturity for this species was observed at 37.5cm (19 months), which is similar to the value obtained by Deepti and Sujatha (2012) from north Andhra Pradesh coast of India and very close to the values of Yesaki (1993) from west coast of Thailand (38cm), Chiampreecha (1978) from east coast of PeninsularMalaysia (37cm) and Klinmuang (1978) from the Gulf of Thailand (39cm). The sex ratio derived for this species was 1:1.1 and the Chi-square value was 1.65 ($p>0.05$), showing significant difference between the frequency of males to females sex ratio.The GSI values estimated for the species were in the range of 3.739 to 5.826, with higher values observedbetween August and December, which coincided with the peak spawning season.

The results on the reproductive biology under thisstudy revealed that in all the three species, the spawning season was twice in a year with varying periods in the north west coast of India. The sex ratio also showed significant variations. Size at first maturity provided the understanding at which stage, these species started maturing. Fecundity indices derived to understand how many younger ones can be recruited into the wild. For better management studies, the spawning seasons, harvesting of these resources could be brought to a sustainable level as the exploitation levels of these neritic tuna stocks are seen as over exploitation. Regular investigations on reproduction studies are required to understand the changes in the population biology and will be helpful in drawing the strategies for conservationand management of these species.

IV. ACKNOWLEDGEMENT

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