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Status and potential of neritic tunas exploited from Indian waters

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ABSTRACT

Tuna like fishes are being exploited from the seas around India since time immemorial by coastal based fleets of varying specifications and with different craft-gear combinations. Their catch was mainly neritic tunas and small ones of oceanic tunas from shelf and adjacent oceanic areas. Tuna forms mostly an incidental catch in many gears.Major share of the catch was landed by gillnets (51.7%) and hooks and line (24.8%). Other gears, which catch tunas are pole & line, purseseines, ringseines, trawls and bagnets. Catch was supported by nine species, five neritic and four oceanic tunas. Neritic tunas represent 71% of the total tuna catch and remains the mainstay of the tuna fishery with a landing of 59,200 ton during 2011. Catch in the year registered marginal decline over 60,300 t of 2010. Fishery was supported by Kawakawa (*Euthynnus affinis*, 34,400 t), frigate tuna (*Auxis thazard*, 10,200 t), bullet tunas (*Auxis rochei*, 2,600 t), longtail tuna (*Thunnus tonggol*, 11,600 t) and bonito (*Sarda orientalis*, 400 t).

The spatial production pattern indicate that extent of fishing varies from region to region depending on the local demand and existing fishing practices. Fishery in general is restricted to selected areas with most of the catches from south and northwest coasts of the country, where fishing activity is more intense. Fishery biological observations and stock assessment of component species further indicate that exploitation of most species were either near optimum level or below it, offering scope for improved production from present grounds. Stock in general is healthy with fairly high spawning stock biomass.The assessment of fishery scenario indicate some scope for improving tuna yield from the present fishing grounds and also from less exploited areas of mainland coast and Island territories.

INTRODUCTION

Tunas in Indian waters are represented by nine species belonging to six genera, *Auxis, Euthynnus, Sarda, Katsuwonus, Gymnosarda* and *Thunnus.* Neritic tunas are represented by five species and oceanic by four species Theyare being exploited as an incidental catch in many commercial coastal fishery. Tuna fishery has a long history as that of the marine fisheries of the country. Fishing pattern and extent of exploitation varies from region to region depending on the existing fishing practices and local demand.

Tuna fishery of the country undergone several changes like modernization, , diversification, intensification and extension of fishing practices to new grounds. Accordingly tuna landing improved to the level of commercial fishery. Landings increased steadily from 848 t in I951 to 129,801 t in 2008 and thereafter showed a downward trend. Average catch of principal market tuna during the last decade (2001-10) from Indian waters was 85,000ton, which represented about 2.6% of the total marine fish production of the country.Most of these catches were taken from shelf waters and adjacent areas with neritic tunas being the major component (>60%) of the tuna fishery. Yield of neritic tuna showed same trend in productionas of total tuna.

Tuna fishery

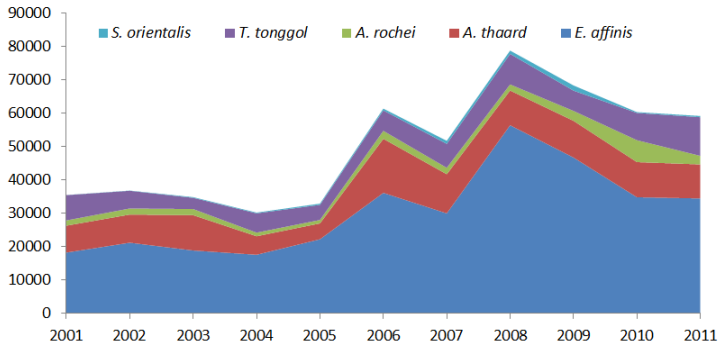
Tuna fishery was monitored systematically by Central Marine Fisheries Research Institute (CMFRI) at six geographical fishing regions, Northwest (NW), Southwest (SW), Southeast (SE), Northeast (NE),Lakshadweep and Andaman & Nicobar territories following stratified random sampling techniques. Data on effort, catch, species composition of tunas in the landings were collected and biology of the species were monitored.

Tuna fishery involved fleets of varying specifications with different craft-gear combinations, with no fleets specifically designed for tuna fishing. The major gears harvesting tunas are gillnet, hooks and line (handlines, longlines, troll lines, pole and lines etc.), purse-seine, ring seine and trawl. In the beginning of last decade, traditional fishers introduced thousands of artisanal crafts for exploiting smaller yellowfin tunas and associated resources congregating around shelf break areasusing small handlines, longlines, trolllines, pole & line and gillnets. During the same period several small to medium mechanized trawlers were modified and introduced for longlining. They operate mostly in

shelf edge and adjacent oceanic waters. All fishing units generally carry multiple gears and operate different gears depending on the ground condition and time of operation.

Fleet Category	**Fleet strength (in number)**
Traditional crafts (motorised& non-motorised)- multiple gears	5,000-6,000
Small long liners (converted trawlers-<24 m OAL) -multiple gears	840
Medium long liners (converted trawlers >24 m OAL) multiple gears	48

Fleet strength (in numbers) involved in tuna fishery in Indian seas



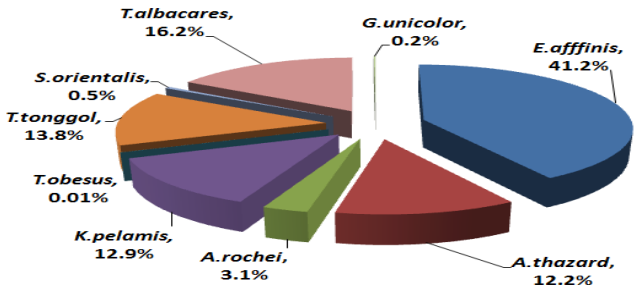
Growth in neritic tuna landings in tons from Indian EEZ

Tuna fishery was supported by nine species; five neritic and four oceanic species. Neritic tunas remained the mainstay of traditional tuna fishery throughout the period. Total tuna production was 848 t in 1951. It registered steady increase to 129,801 t in 2008 and thereafter shown a downtrend.The average total tuna landings during 2006-'11was 107,575 t and formed 2.5 % of the total marine fish production of the country.The tuna yield in 2011 declined to 83,580 t from 95,370 t of 2010. Neritic tuna landing during 2006-'11 varied between 51,666 t and 78,678 t with an average of 63,217 t represent 59 % of total tuna catch. After the peak in 2008, landing registered continuous decline. Their yield in 2011 declined to 59,100 t from 60,300 t of 2010. They represent 71% of the total tuna catch in 2011 and was supported by Kawakawa (*Euthynnus affinis*, 41.2%), frigate tuna (*Auxis thazard*,12.2%), bullet tuna (*Auxis rochei*, 3.5%), longtail tuna (*Thunnus tonggol*, 13.8%) and bonito (*Sarda orientalis*, 0.5%).Oceanic species represent 29% of the total landings with production of 48,335 t. Yellowfin tuna (*Thunnus albacares*, 16.2 %),

skipjack tuna (*Katsuwonus pelamis*, 12.9 %*)* and small proportions of dogtooth tuna (*Gymnosarda unicolor*) and bigeye tuna (*Thunnus obesus*) supported the fishery.

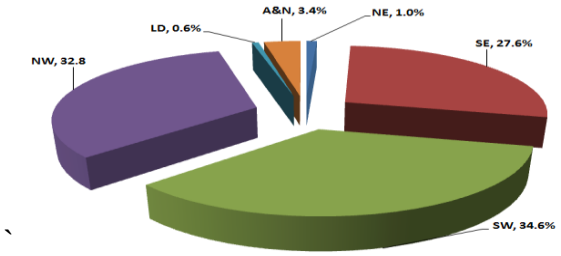
Species	2006	2007	2008	2009	2010	2011	Average
E.afffinis	36085	29939	56322	46664	34775	34425	39702
A.thazard	16184	11735	10400	11000	10527	10173	11670
A.rochei	2389	1912	1835	2963	6556	2566	3037
T.tonggol	6115	7173	9140	6073	8159	11563	8037
S.orientalis	550	907	981	1551	257	383	771
Total	61323	51666	78678	68251	60274	59110	63217

Neritic tuna landings in ton by coastal based fleets



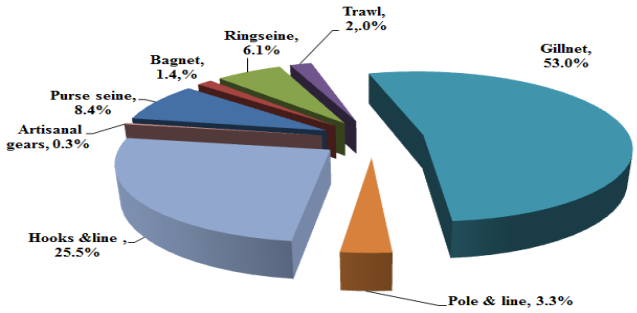
Component species in the tuna catch (%)

West coast is more productive and contributing 68 % to the neritic tuna production. Fishing activity is relatively high along this coast for many resources. Fishing activity and yield from areas like northeast, Andaman and Lakshadweep waters were very low.



Region-by contribution to total tuna production

Tunas were caught by a variety of gears either as incidental catch or as targeted resource. They are caught mostly by gillnets and hooks and lines. Nearly 53% of the tuna catch is realized by gillnets and 29% by hooks and line (long-lines, hand-lines, pole & and lines and troll lines). Other gears landing tuna include the purseseines, ringseines, trawls and bagnets.



Contribution (%) by different gears to total tuna production

Species	Trawl	Gillnet	Hooks & Line	Pole & line	Bagnet	Ring-seine	Purse-seine	Artisanal
E. affinis	2.0	52.3	23.0	5.0	1.6	8.4	7.4	0.2
A. thazard	0.6	45.9	35.4	0.2	1.6	2.3	13.8	0.2
A.rochei	2.7	27.1	67.6	0.0	0.0	0.4	2.3	0.0
T. tonggol	5.7	77.7	13.2	0.0	0.0	0.1	3.3	0.0
S.orientalis	5.5	42.3	51.1	0.0	0.0	0.0	1.1	0.0

Gear-by landings of (%) coastal/neritic tunas

Kawakawa

Most dominant commercial species, widely distributed and exploited along the Indian coast including island territories with large contribution from the southern coasts, especially from southwestcoast. Southern coast contribute 79.5% of their total landings. They are caught mainly by gillnets (52.3%) and hooks & lines (28%). They are also landed occasionally by ringseines, purseseines and trawls. Their annual catch ranged between 29,939 t (2007) and 56,322 t (2008) with an average catch of 39,702 t and represent 63% of the neritic tuna catch. Production declined continuously after the peak in 2008 and again improved during 2011 to 39,700 t.They support fishery round the year with peak during June-October.

Frigate tuna

The second dominant species with fishery mainly from southern coast, contributing 86.4% in the landings.Caught by gillnets (46%), hooks and line (35 %), purseseines (14 %) ring seines and trawl. Their annual catch ranged between 10173 t (2010) and 16184 t (2006) with an average catch of 11,670 and formed 18.5% of the neritic tuna catch.Yield after continuous decline since 2006, improved in 2011.Fishery occurred round the year

with peak during June to September. Rich abundance is noticed around knolls, Chagos-Laccadive ridges and outer shelf waters mainland and Island systems.

Bullet tuna

Major fishery is restricted to the southernmost part of Indian waters with nearly 96% of the landings from the region. Target fishing for bullet tuna by longlines and handlines, driven by local demands, prevails along the southern districts of Kerala. They together land 68% of their landings. They are also landed trawls (27 %), purse seines and ring seines. Average annual production was 3,037 tforming around 5 % of the neritic tuna catch. Landings after peak in 2010 registered down trend 2011. They are landed throughout the year with major peak during June and the second peak in November.

Striped bonito

They are caught from around coral reefs and knolls along the coasts of mainland and island territories.They are caught mainly by hooks and line (51%), gillnets(42%) and trawls (6%). Major areas of their fishery are southwest and north west coast of mainland and Andaman & Nicobar waters. They support an emerging fishery after the extension of fishing activities to deeper waters and presently contribute nominally (1.2%) to the neritic tuna catch. Yield exhibiting an uptrend with an average annual landings of 771 t. They formed round the year fishery along southwest coast and seasonal fishery at other areas with peak during July-December.

Longtail tuna

They are caught mainly from the west coast of mainland coast and Andaman waters with major abundance and fishery share of the catch from northwest coast. They are caught mainly by gillnets(78 %), hooks and line (13 %) and trawls (6%). Their young ones and sub-adults are available in appreciable numbers over and around knolls and seamounts of west coast and Andaman ridges. Nearly 93% of their catch was from the west coast with major contribution (83%)from northwest coast. Recent observations indicated the presence of large concentration of small and medium sized longtail tunas on seamounts off the west coast. Catch is maintaining an uptrend with an average yield of 8,037 t during 2006-‘11 and

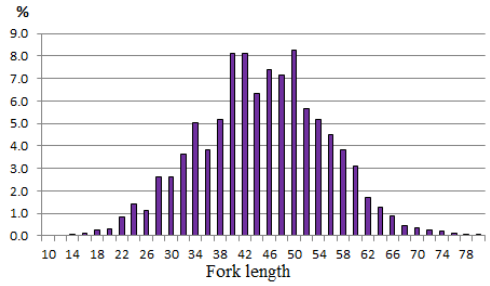
contributed 13 % to the neritic tuna catch. Their yield peaked with 11,563 t in 2011. Fishery is round the year with peak during September-February.

BIOLOGY STOCK ASSESSMENT

Kawakawa (*Euthynnus affinis*)

Length composition

Catch was supported by 14 to 80 cm(FL) fishes. Fishery was sustained mainly by 34 to 58 cmsize groups, which constitute 70% of the catch. Major modes were at 40 and 52 cm and the annual mean length ranged between 42.6 and 50.2 with mean of 45.9 cm. Catch in tralws was supported mainly small juveniles and sub-adults of 14-30 cm size. In hooks and lines and gillnets relatively larger fishes support fishery.



Length composition of E. affinis in the catch

Growth

Their length-weight relationship was derived as $W = 0.0254\ L^{2.889}$; where 'W' is the weight of fish in grams 'L' is fork length in cm. The von Bertalanffy growth parameters were estimated and their growth can be described as, $Lt = L_\infty\ [1 - e^{k\ (t\ -t_0)}]$ was $Lt = 81.92\ [1\text{-}e^{-0.56(t-0.0317)}]$.They attain 42.7 cm and 59.5 cm, respectively at the end of 1st year and 2nd year.Their growth performance index is 3.340, indicating relatively fast growth.The length frequency showed that fishery was sustained mainly by the 1+ to 2 yr old fishes. The longevity of *E.affinis* was 9.03 years and asymptotic weight was 8563 g.

The size at first capture (L_c) in gillnet was 41.4 cm at an age of (t_c) of 0.97year.

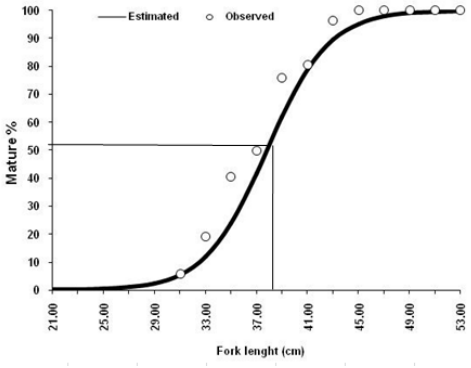
Food and feeding

They feed mainly on crustaceans, cephalopods and finfishes. Crustaceans were dominated by the non-penaeid prawn *Acetes* spp. and crabs. Cephalopods were dominated by the squid, *Loligo duvaucelli*. Finfishes were dominated by sardines, anchovies,

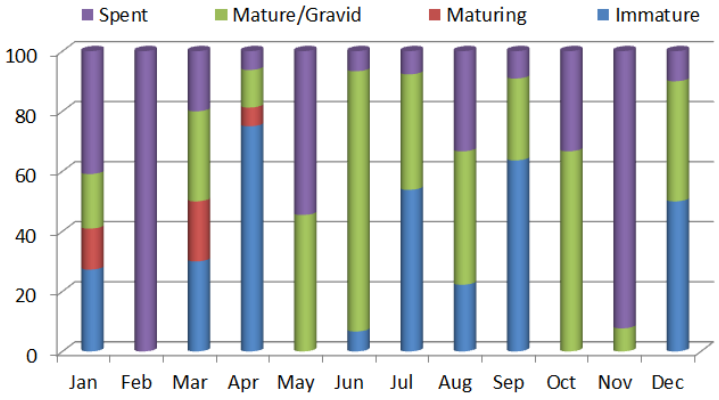
mackerels, scads and tuna juveniles. The feeding intensity was more in the months of March, April, June and December.

Maturity, fecundity, spawning and recruitment

Size at first maturity was estimated using logistic curve as 37.7 cm. Spawning and recruitment was observed round the year with peak spawning during May-June and October-December.Two peaks were observed in recruitment, the major during May-June and the minor during November-December. The first pulse contributed 59.3% and the second 22.9% of recruits. The fecundity was estimated at 3,08,150 eggs/kg body weight.



Logistic curve estimating size at maturity



Seasonal pattern of maturity along the Indian coast

Mortality, exploitation and VPA

The estimates of natural mortality (M), fishing mortality (F) and total mortality (Z) are 0.93, 0.75 and 1.68, respectively. The exploitation rate was 0.45 and exploitation ratio was 0.36. This showed that the present exploitation rate is well within limits with a healthy stock condition.

E_{max} is 0.811 which is much higher than the present exploitation, indicating further scope for exploitation of this species.

VPA indicated that main loss from the population up to 32 cm size was due to natural causes.They became more vulnerable to the gear after this size and mortality due to fishing increased. However, loss due to fishing still remains very low.

Stock and MSY

The annual total standing stock, biomass and MSY of *E.affinis*in the present fishing grounds were estimated at 1,12,208 t,54,342t and 45,647 t, respectively. The average annual yield is 40,757.

Yield/recruit

The yield and biomass/recruit and yield and biomass curves showed that the maximum yield and yield/recruit could be obtained by increasing the present level of fishing 1 to 2.2. The maximum yield and yield per recruit obtained by increasing the present fishing effort by 2.2 timesis 47,966 t and 509.31 g, whereas at the present level of fishing, it is 40757 t and 432.76 g. The increase in relative yield at the increased effort would be 117.7 %.

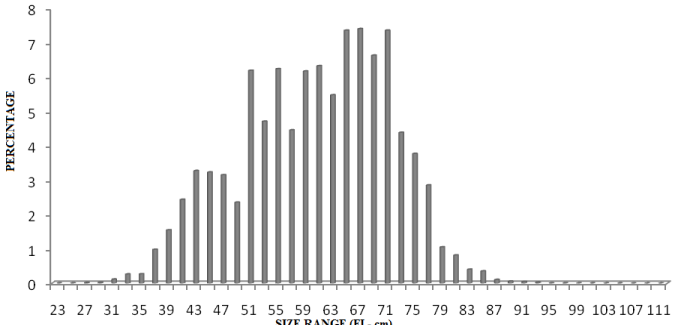
The yield per recruit analysis indicated substantial increase in yield with increase in effort. Therefore an increase in effort may be considered to increase the present yield at least to the limit of estimated MSY. However, in a multi-fishery scenario the impact of increase in effort on the resources will have to be carefully examined and increase in effort as a management strategy for increasing *E.affinis* production will have to be done cautiously.

Longtail tuna (*Thunnus tonggol*)

Length distribution in the catch

Small to medium sized fishes supported the fishery with larger ones less frequent in the fishery. Catch was supported by 23-111 cm fishes with 60.5 cm as mean. Major share, accounting 72.8% of the catch in number was represented by 51-73 cm size groups. Catch in gillnet was supported by relatively smaller fishes (23-90 cm) and in hooks and line by larger size groups (42-111cm). Along the southern coast catch was supported by relatively

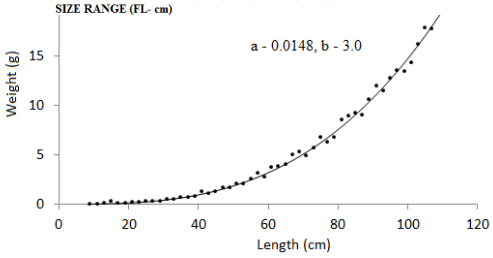
smaller fishes of 23-97cm size with 50 cm as mean size compared to those caught from northwest coast, 23-111 cm with 61.9 cm as mean. Fishery was sustained mainly by 41-73 cm fishes, which respectively represent 84.2 and 75.6% of the catch in numbers along south and north. It is clear from that there is an obvious increase in their size towards northern latitude.



Length frequency distribution of longtail tuna in the catch

Length-weight relationship

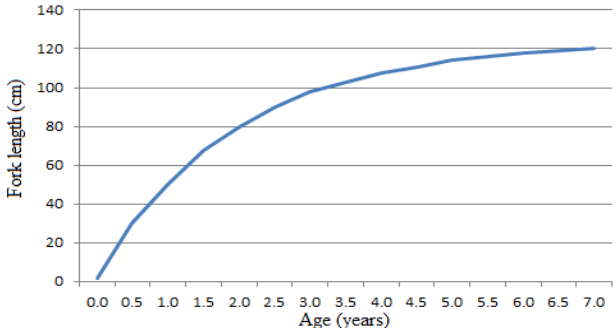
The estimate of length weight relationship of unsexed population indicated that species follow perfect isometric growth. The relationship can be expressed as $W = 0.0148 * L^{3.0}$



Length-weight plot of longtail tuna

Age, growth and longevity

Growth parameters; asymptotic length ($L\infty$), growth constant (K) and age at zero length (t_o) were respectively estimated as 123.5 cm, 0.51/year and -0.0319 years. Growth was described by the von Bertalanffy model and it shows that the species grow relatively fast in length. They attain 29.4, 50.6, 79.7, 97.2, and 107.7 cm by the end of 0.5, 1, 2, 3 and 4 years. However, growth in weight is slow compared to other species of the genera. Their longevity (t_{max}) in Indian waters was estimated as 4.5 years.



Growth curve of longtail tuna

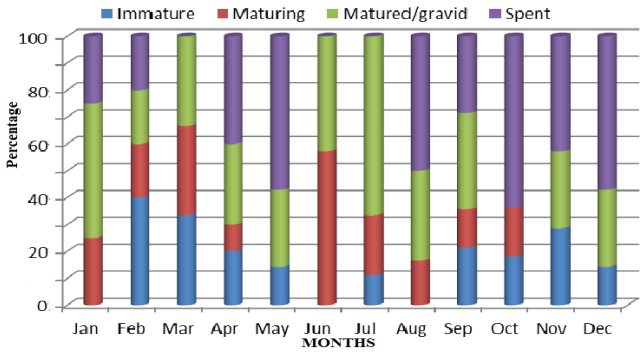
The age length data shows that minimum age of the fish in the catch is 4.5 months and maximum 4.5 years. Major share of the catch was supported by 12 to 20 month age groups (51-73 cm) with 1.3 year as mean age. However, along the southwest coast relatively small fishes of 9 to 15 month old with a mean age of one year supported the fishery.

Food and feeding

They are non-selective in feeding habit and feeds mainly on teleost fishes (82%), crustaceans (4.6 %) and molluscs (13.4%). Sardines (*Sardinella* sp.), anchovies (*Thryssa* sp.), scads (*Decapterus* sp. and *Selar* sp.), ribbonfishes (*Trichiurus* sp.), flying fish, hemiramphids, small tuna (*Auxis rochei*), threadfin breams and small perches (*Lethrinus* sp) dominated the food. Crustaceans represented in the food are penaeid prawns, *Acetes* sp., pelagic crabs and stomatopods. Squid, octopus and gastropods represented the molluscan component. Considerable variation was observed in the gut content over space and time indicating them as a highly opportunistic feeder, feeding on the available prey.

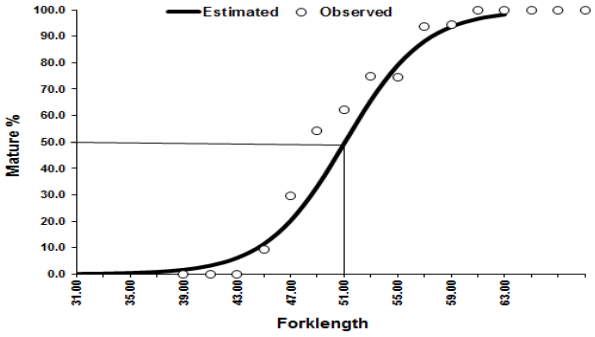
Sexual maturity and spawning

Seasonal pattern of maturity along the Indian coast



Males and females are represented almost equally in the population and no indication of any sexual dimorphism in growth and maturity. Gonads at different stages of development were observed throughout the year. As evidenced by the presence of fishes with matured and spent gonads in the catch, they spawn round the year with two peaks in spawning; during August-December and April-May. In the present study, fishes with gravid gonads were observed only less frequently in the catch, indicating probable seasonal migration of fishes to spawning grounds after attaining full gonadal development.

Full sexual maturity and spawning was observed from 48 cm onwards. Estimate of their size at maturity by logistic curve is 51.1cm. Age of the fish at this size was 12.2 months. Two to three distinct batches of eggs were observed in the matured ovary indicating batch spawning in the species.



Logistic curve estimating size at maturity of longtail tuna (females)

Fecundity

Fecundity estimate varied between 227,364 and 1092,891 eggs per fishes measuring 53.7 and 79.4 cm. The relative fecundity (number of eggs/kg body weight)found to increase with the size of the fish and it varied between 103,347 and 147,688 respectively in the smallest and largest fish studied with a mean of 132,840.

Optimum size for exploitation and size at capture:

Based on the size at maturity, the optimum size (Lopt) and age for exploitation of longtail is estimated respectively as 55.3 cm and 1.13 years. This may provide nearly 80% of the recruit at-least a chance to mature and spawn before being caught. Their length and age first capture in gillnet was 51.24 cm and 1.02 years respectively. The size at capture is small, compared to L_{opt}, and this condition allow only less than 50% of the recruit to mature and spawn before being caught

Recruitment pattern

Recruitment is bimodal with young ones being recruited into the fishery round the year with major pulse in recruitment during May-June and minor pulse in August-September. The size of the species at recruitment is 28 cm during May-June and 23 cm during August September. The growth rate of the species shows that May–June recruit derived from the post monsoon spawning and the August recruits from pre-monsoon months.

Mortality and Exploitation

Natural mortality was estimated as 0.77, fishing mortality 3.08 and total mortality, 3.82. Fishing mortality was more than three times of the natural mortality.Exploitation rate was $0.79y^{-1}$. The exploitation rate, which will provide maximum yield (E_{max}) of the species, was estimated as 0.485.The larger value for fishing mortality and exploitation rate can be attributed to the presence of large proportion of smaller fishes in the gillnet catch.

Yield per recruit and biomass

Under the present fishing scenario, the relative yield per recruit (Y/R) increases steadily till the exploitation rate reach 0.63 and thereafter decline with increasing exploitation. At this point, relative biomass per recruit decline to 32.5% of the pre-exploitation level and further low of 9.4% at the present level of exploitation. If the exploitation maintains at the E_{max} level the biomass/recruit will remain around 75% of the pre-exploitation level and give the highest yield and yield per recruit.

Estimates of standing and spawning stock biomass shows the availability of large proportion (65.4%)of spawning stock biomass, sufficient to ensure successful reproduction and recruitment for sustaining the stock.

Though the resource was available in good numbers along the seamounts off west coast, presently they are not targeted as they are less lucrative for fishers. This provides a natural retrieve for the species along the region.Despite large fishing mortality and exploitation rate the study demonstrated that longtail tuna are currently being fished at biologically sustainable levels, with considerable scope for increasing their yield. For sustaining the resource and fishery exploitation of the species from seamounts off the west coast, where relatively smaller fishes predominate should be regularly monitored and fishing pressure be maintained at the present level. At the same time measures may be made to minimize the capture of smaller fishes.

Conclusion

The fishery biological observations and stock assessment of component species indicate that neritic tuna stock in general is healthy with exploitation of most species below optimum level, offering some scope for improved production from present grounds. The

present fishing pattern indicate that coastal based fishery restricted to limited areas of the coast. Presently, fishery is concentrated mainly along the southern and northwest coast and hence have scope for increasing the production from less exploited areas of the coast.

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