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Age, growth and population structure of the yellowfin tuna *Thunnus albacares* (Bonnaterre, 1788) exploited along the east coast of India

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ABSTRACT

Lengths measurements of 6,758 yellowfin tuna (*Thunnus albacares*), landed by hook and line operators off eastern Indian coast were taken (20–185 cm FL) from 2003 to 2009. Age and growth were estimated using length based methods. The von Bertalanffy growth parameters estimated were L_∞ = 197.42 cm, annual K= 0.30 and t_0= -0.1157. Mortality estimates were M= 0.48 and Z= 0.71 and F= 0.23 with the exploitation ratio E= 0.32. Growth was rapid during the initial years when the annual growth increment was as high as 36.6 cm during the first year which declined to as low as 3.3 cm in the tenth year. The fish attained a fork length of 56.2 cm at the end of one year. Size at maturity (87.5 cm) corresponded to an age of 1.7 years and the oldest individual in the sample was 9+ years (186 cm). The annual mean lengths varied from 80.6 cm to 115.3 cm with an average mean length of 101.9 cm. The fishery comprised of mostly adults with 64% comprising of fishes larger than size at first maturity.

Keywords: Age, Growth, India, Mortality, *Thunnus albacares*, Yellowfin tuna

Introduction

Yellowfin tuna (*Thunnus albacares*) inhabits the surface layer of all warm seas of the world and is extensively fished using seines, gillnets as well as hooks and line. Along the Indian coast, the yellowfin tuna is mainly exploited by longlines. Gillnets and the larger meshed purse seines too land this oceanic species occasionally. Hooks and line form the only mode of exploitation for yellowfin tuna along Andhra coast and the traditional, motorized as well as the mechanized sectors participate actively in exploiting the available tuna population. Though the potential estimates for oceanic resources in the Indian seas from subsurface and surface fishery has been estimated as 2,46,000 t (Sudarsan, *et al*., 1991) and that of yellowfin tuna along the Indian coast is about 1,08,900 t (Somvanshi *et al*., 2003), the present production is only around 15,086 t (CMFRI, 2010), a mere 13.8 % of the available potential. Exploitation of yellowfin tuna resources from the oceanic waters was initiated by the chartered longliners in the late eighties but, actual commercial exploitation of large pelagics from the oceanic waters by Indian fishermen commenced only by the late nineties. The age and growth of yellowfin tuna has been studied extensively in the Pacific and Atlantic waters. The recent studies include those of Wild (1986); Lehodey and Leroy (1999); Kikkawa and Cushing (2002) Sun *et al*. (2003) and Lessa and Duarte-Neto (2004). Marsac and Lablanche (1985) reported on the growth of yellowfin tuna caught from the western Indian Ocean. Studies so far on the age and growth of yellowfin tunas landed along the Indian coast is mainly based on the catches made by the experimental and exploratory survey vessels and based on catches made in the island systems of India (Mohan and Kunhikoya, 1985; John and Reddy, 1989; Pillai *et al*., 1993; John, 1995. John (1998). Somvanshi *et al*. (2003) have made a synoptic review of the studies carried out on the yellowfin tuna in the Indian seas. The present study on the age and growth is based on length measurements of yellowfin tuna collected from commercial crafts operating along the east coast of India and landing the catch at Andhra Pradesh.

Materials and methods

The fork length (cm) and wet weight (kg) of yellowfin tuna were collected on a weekly basis from the landings made by the commercial hook and line and long-line operators of Andhra Pradesh during 2003-2009. The large longliners operate throughout the east coast of India and land the catch at major Fishing Harbours. The length-weight relationship was calculated as in Le Cren (1951). Growth parameters *viz*., asymptotic length (L_∞) and growth coefficient (K) were estimated using the ELEFAN I module of FiSAT software and the Powell-Wetherall plot (Gayanilo *et al*., 1996). The length based growth performance index Ø = Log K +2* Log L_∞ was calculated as in Pauly and Munro (1984) and the age at zero length (t_0) from Pauly's (1979) empirical equation. Longevity was estimated from $t_{max} = 3/K+t_0$ (Pauly, 1983a). Natural mortality (M) was calculated by Pauly's empirical formula (Pauly, 1980) and total Mortality (Z) from length converted catch curve (Pauly, 1983 b). Exploitation ratio was estimated from the equation, E= F/Z and exploitation rate from $U=F/Z (1-e^{-z})$; where F is the fishing mortality rate.

Results

A total of 6,758 tuna in the size range of 20-185 cm were measured for their fork length. The major modes were at 90 cm and 130 cm with the mean length at 101.9 cm (Fig.1).The 'a' and 'b' parameters of the length weight relationship $W= aL^b$ was estimated as a=0.017077 and b=2.976, where 'W' is the weight of fish in grams and 'L' the fork length of fish in cm.

Pooled length frequency distribution of yellowfin tuna was developed from the landings of commercial hook and line and longline operators. The modes within each monthly size group were tracked from time of recruitment to near asymptotic size. The data was analyzed and the growth parameters in the von Bertalanffy equation were obtained (Fig. 2). The average parameter values of L_∞ and *K* were 197.42 cm fork length and 0.30 yr^{-1} respectively. The t_0 estimated was -0.1157. Growth was observed to be rapid during the initial two years and then the growth rate declined during the later years (Fig. 3). The fork length attained during different months of growth for a period of 10 years is given in Table 1. Yellowfin tuna attained a fork length of 56.2 cm during the first year, attained maturity in the second year and reached the maximum length (fork length) during the 10^{th} year of growth. The growth performance index (Ø) was 4.0 and longevity (t_{max}) was estimated as 10.1 years.

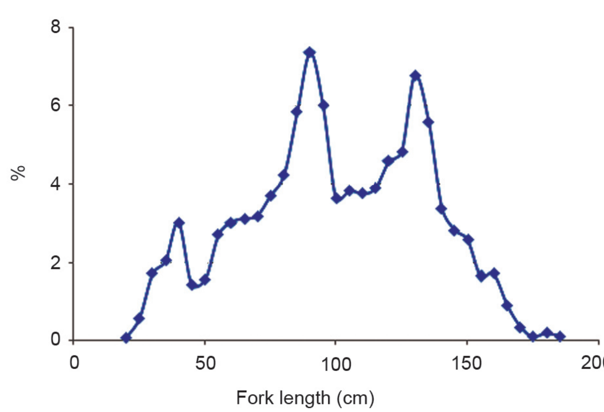

Fig. 1. Length frequency distribution of *T. albacares* in commercial landings along east coast of India.

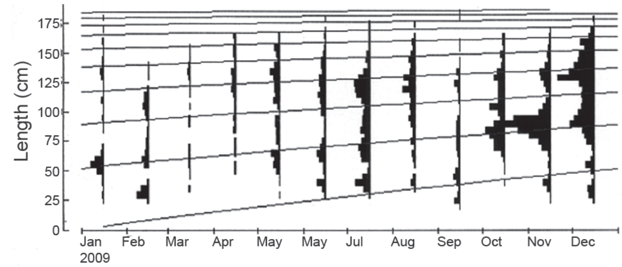

Fig. 2. von Bertalanffy growth plot of *T. albacares* (L_∞ = 197.42 cm , K=0.3 yr^{-1})

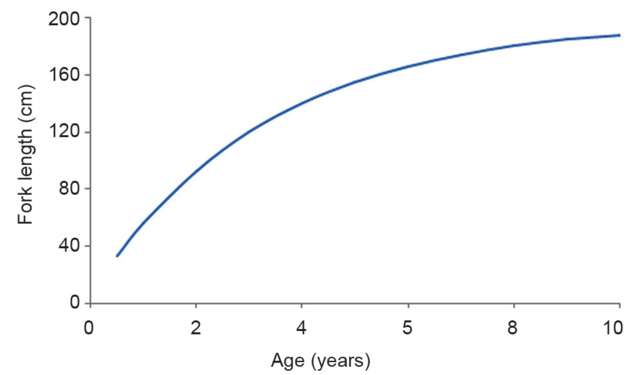

Fig. 3. Estimated growth curve of *T. albacares* exploited along east coast of India.

Natural mortality (M) was estimated at 0.4, total mortality (Z) at 0.71, fishing mortality (F) at 0.23. The exploitation ratio (E) was 0.32 and exploitation rate (U) 0.162.

Discussion

Yellowfin tunas for the present study were collected from major landing centres located in Andhra Pradesh. All types of units (non-mechanized, motorized and mechanized) operating the trolls and the longlines land at these centres. Collections were made during all months spanning over a period of six years (2003-2009). The length measurements thus have taken into account all size groups caught by commercial yellowfin tuna operators.

Growth in yellowfin tunas is isometric and followed the typical length - weight relationship of $W= aL^b$ with the weight increasing 3 times that of length. The 'b' value of 2.976 obtained for *T. albacares* in the present study agrees with the above mentioned growth pattern. The length-weight relationship has been studied in detail by earlier workers and reviewed by Rohit *et al*. (2008).

The estimated maximum length (L_∞) of 197.42 cm for *T. albacares* exploited along the east coast of India in the present study is much larger than that reported by earlier workers from India. Probably as suggested by John (1998), the earlier studies especially from Lakshadweep waters, might have covered smaller young individuals collected from surface and coastal waters thus resulting in smaller estimates. While Lessa and Duarte-Neto (2004) arrived at a much larger L_∞ of 230.7 cm for *T. albacares* caught from the western equatorial Atlantic, Sun *et al*. (2003) estimate was smaller at 175 cm for *T. albacares* caught from the western Pacific region. The parameters were estimated by studying the growth rings on the dorsal fin spines and length based MULTIFAN method respectively. However, Huang *et al*. (1973) Huang and Yang (1974) and Lehodey and Leroy (1999) studied the scales and otolith rings of *T. albacares* and reported L_∞ values of greater than 190 cm for *T. albacares* from the western Pacific region. In fact, the L_∞ estimates in the western Pacific by different workers ranged from 166 to 199.6 cm (Table 2). *T. albacares* having a fork length of >180 cm are not rare in the catches made by longliners operating along the east coast of India (John, 1995; 1998; John *et al*., 1998, Rao and Rohit, 2007; Rohit *et al*., 2008 and Rohit and Rammohan, 2009). So the estimated L_∞ of 197.42 cm along the east coast of India in the present study is well within the expected range. Earlier estimates of growth parameters of *T. albacares* from Indian as well as other major ocean systems are given in Table 2.

The growth coefficient (K) values of *T. albacares* ranged from 0.12 yr^{-1} to 0.45 yr^{-1} for tunas collected from various regions (Table 2). Growth coefficient 'K' and the L_∞ have an inverse relationship and gives an idea of the longevity of the fish. The 'K' value of 0.30 obtained in the present study with a life span of 10.2 years is comparable to the values obtained by earlier workers in the Indian region as well as those from other parts of the world (Table 2). The fork length at the end of year 1, 2, 3 and 4 in the present study was 56.2, 92.8, 119.9 and 140 cm respectively (Table 1). This is similar and comparable to the length at age of *T. albacares* studied from Western Pacific (Sun *et al.*, 2003) and estimate made by John (1995) for fishes collected from the Andaman and Nicobar islands. However, growth studies of *T. albacares* collected from other regions in Indian waters have given a smaller annual mean length (Table 3). The reason for this disparity may once again be attributed to sampling of smaller young individuals collected from surface and coastal waters thus resulting in smaller estimates.

The use of length frequency data for estimation of growth parameters of yellowfin tuna is often criticized as there is an overlap of length modes leading to underestimation of age, spawning is generally throughout the year and not discrete, the development of cohorts are influenced by different growth rates under different environmental conditions, possibility of size-frequency deficiencies where year classes may be absent or under represented (Everhart and Younge, 1992; Driggers *et al.*,

Table 1. Estimated fork length attained by *T. albacares* during different months

Months	1	2	3	4	5	6	7	8	9	10	11	12
FL (cm)	11.4	16.0	20.5	24.9	29.1	33.3	37.3	41.3	45.2	48.9	52.6	56.2
Months	13	14	15	16	17	18	19	20	21	22	23	24
FL (cm)	59.6	63.0	66.4	69.6	72.8	75.8	78.8	81.8	84.6	87.4	90.1	92.8
Months	25	26	27	28	29	30	31	32	33	34	35	36
FL (cm)	95.4	97.9	100.3	102.7	105.1	107.3	109.6	111.7	113.9	115.9	117.9	119.9
Months	37	38	39	40	41	42	43	44	45	46	47	48
FL (cm)	121.8	123.7	125.5	127.3	129.0	130.7	132.3	133.9	135.5	137.0	138.5	140.0
Months	49	50	51	52	53	54	55	56	57	58	59	60
FL (cm)	141.4	142.8	144.1	145.5	146.7	148.0	149.2	150.4	151.6	152.7	153.8	154.9
Months	61	62	63	64	65	66	67	68	69	70	71	72
FL (cm)	155.9	156.9	157.9	158.9	159.9	160.8	161.7	162.6	163.4	164.3	165.1	165.9
Months	73	74	75	76	77	78	79	80	81	82	83	84
FL (cm)	166.7	167.4	168.2	168.9	169.6	170.3	171.0	171.6	172.3	172.9	173.5	174.1
Months	85	86	87	88	89	90	91	92	93	94	95	96
FL (cm)	174.6	175.2	175.8	176.3	176.8	177.3	177.8	178.3	178.8	179.2	179.7	180.1
Months	97	98	99	100	101	102	103	104	105	106	107	108
FL (cm)	180.5	181.0	181.4	181.8	182.2	182.5	182.9	183.3	183.6	183.9	184.3	184.6
Months	109	110	111	112	113	114	115	116	117	118	119	120
FL (cm)	184.9	185.2	185.5	185.8	186.1	186.4	186.7	186.9	187.2	187.4	187.7	187.9

Growth parameters used L_α = 197.4, K = 0.3 yr^{-1} and t_0 = - 0.1157

Table 2. Estimates of growth parameters of *T. albacares* from different regions

Author	Area	Growth parameters			
		L_∞ (cm)	K yr^{-1}	t_0	Ø
Present study	East coast of India	197.42	0.30	-0.1157	4.00
Kaymaram (2010)	Oman Sea	183	0.45		
Shono *et al*. (2007)	Indian Ocean	166.07	0.38		
Hampton and Fournier (2001)	WC Pacific	184	0.395		
Lessa and Duarte-Neto (2004)	W Equatorial Atlantic	230.7	0.267	-0.081	
Somvanshi *et al.* (2003)	Indian EEZ	193.0	0.20		3.88
Sun *et al.* (2003)	Western pacific	175.0	0.392	0.00306	4.08
Hampton (2000)	Western pacific	166.0	0.250		3.84
Lehodey and Leroy (1999)	Western Pacific	199.6	0.390		4.19
Li *et al*. (1995)	Western Pacific	1787.6	0.129		3.62
John (1995)	Andaman and Nicobar, India	171.5	0.316	-0.305	
Pillai *et al*. (1993)	Minicoy and south-west coast of India	144.06	0.44	-0.448	
Marsac (1991)	Indian Ocean	173.1	0.65	-1.03	
John and Reddy (1989)	West coast of India	175.0	0.29		3.94
Mohan and Kunhikoya (1985)	Minicoy, India	145.0	0.32	-0.34	
Huang and Yang (1974)	Western Pacific	174.9	0.386		4.07
Huang *et al.* (1973)	Western Pacific	192.8	0.333		4.09
Yang *et al.* (1969)	Western Pacific	195.2	0.360		4.14
Yabuta *et al*. (1960)	Western pacific	190.1	0.330		4.08
Yabuta and Yukinawa (1959)	Western pacific	175.0	0.392		4.08

1999) and influence of gear selectivity and seasonal sampling (Fonteneau, 1980). However, Lessa and Duarte-Neto (2004) found coherent and compatible results for yellowfin tuna while using length frequency data as well as growth bands on the dorsal spines, and concluded that it is proper to assess age and growth using length frequencies collected over a period of time. Further, doubts have been expressed, if the yellowfin tuna growth follows a classical von Bertalanffy model or if there are two different growth periods with a slow down period for young fish (FL < 60 cm). Studies from modal analysis for small yellowfin tuna in the Eastern Atlantic (Fonteneau, 1980; Bard, 1984), in the south-western Pacific (Brouard *et al*., 1984) and the western Indian Ocean (Marsac and Lablanche, 1985) indicate a period of slow growth rate during the juvenile phase. On the other hand, in the eastern Pacific, the growth rate of tagged yellowfin in the length range from 25 to 100 cm does not show an apparent period of decrease (Wild and Foreman, 1980). Therefore there seems to be variations in the growth rate of juvenile yellowfin tuna occurring in different regions. Anderson (1988) reviewed various estimations based on length frequency studies as well as otolith observations and suggested that a growth rate of 2.9 + 0.4 cm per month would be nearest to the true rate for yellowfin tuna. Somvanshi *et al*. (2003) observed slower growth rate for yellowfin tuna juveniles in Indian waters as growth increments during the second and third year of growth was 2.4 cm per month and 1.97 cm per month respectively. In the present study, the growth rate ranged between 3.6 cm per month and 2 cm per month during the first three years of growth.

Growth performance index (Ø) value is similar for a particular species even if it is collected from different regions (Pauly and Munro, 1984). It is also an index of the accuracy and reliability of the growth parameters estimated for a species collected from different regions and growth parameters calculated using different methods (Bellido *et al*., 2000). The Ø value obtained in the present study using length frequency data is similar to the values of other studies (Table 2) and comparable to the values obtained from scales (Yabuta *et al*., 1960, Yang *et al*., 1969, Huang *et al*., 1973, Huang and Yang, 1974), from otoliths (Lehodey and Leroy, 1999) and MULTIFAN (Sun *et al*., 2003). Therefore, it may be stated that the growth parameters estimated in the present study using the length frequency distribution method is reliable.

The mortality parameters estimated in the present study seem to be reasonable. Though, huge potential for yellowfin tuna is available in the Indian waters, only a small part of it is being exploited presently. The exploitation level as

Table 3. Comparison of estimated length attained by *T. albacares* during different years from various studies

Author	Method used	Study area	Fork length attained				
			1	2	3	4	5
Present study	Length	East coast of India	56.2	92.8	119.9	140.0	154.9
Lessa and Duarte-Neto (2004)	Dorsal fin spine	North-eastern Brazil	48.4	95.1	133.9	155.6	172.0
Somvanshi *et al*. (2003)	Length	Indian EEZ	35.1	63.9	87.5	106.8	122.6
Sun *et al*. (2003)	Length	W.Pacific	56.2	95.0	121.0	138.5	
Lehodey and Leroy (1999)	Otolith	C. W. Pacific	73.5	114.2	141.8	160.5	
John (1995)	Length	Andaman and Nicobar Islands	57.9	88.7	111.2	127.5	139.4
John and Reddy (1989)	Length	Indian waters	77.0	101.7	120.1	134.0	144.3
Huang and Yang (1973)	Scale	W. Pacific	48.9	89.7	118.4	139.8	
Huang *et al*. (1974)	Scale	W. Pacific	53.9	93.2	1178	136.5	
Huang (1971)	Scale	W. Pacific	53.8	93.1	118.2	138.4	
Yang, *et al*. (1969)	Scale	W. Pacific	45.9	90.0	123.5		
Yabuta *et al*. (1960)	Scale	W. Pacific	54.3	92.7	120.8		
Yabuta and Yakinawa (1959)	Length	W. Pacific	51.0	100.0	125.0	137.0	

well as fishing mortality level is low as compared to exploitation of other resources available in the region. Diversification and targeted fishing for the available oceanic tunas is required in order to optimally harvest the available stock of yellowfin tuna in the region.

References

Anderson, R. C. 1988. Growth and migration of juvenile yellowfin tuna (*Thunnus albacares*) in the central Indian Ocean. *COU. Vol. Work Doc, IPTP, TWS/88*/21:28-39.

Bard, F. X. 1984. Aspects de la croissance de l'albacore est Atlantique (*Thunnus albacares*) a partir de marquages. *Coll.Vol. Sci. Pap. ICCAT* 21:108-114.

Bellido, J. M., Pierce, G. J., Romero, J. L. and Millan, M. 2000. Use of frequency analysis methods to estimate growth of anchovy (*Engraulis encrasicolus* l., 1758) in the Gulf of Cadiz (SW Spain). *Fish. Res*., 48: 107-115.

Brouard, F., Grandperrin, R. and Cillaurren, E.1984. Croissance des jeunes thons jaunes (*Thunnus albacares*) et des bonites (*Katsuwonus pelamis*) dans le Pacifique tropical occidental. ORSTOM. *Notes et Documents d'Oceanographies*. 10: 1-23.

CMFRI 2010. *Annual Report* 2009-10. Central Marine Fisheries Research Institute, Cochin, 169 pp.

Driggers III, W. B., Grego, J. M. and Dean, J. M. 1999. Age and growth of yellowfin tuna (*Thunnus albacares*) in the western north Atlantic Ocean. *Coll. Vol. Sci. Pap. ICCAT* 123: 374-383.

Everhart, H. M. and Younge, W. D. 1992. *Principles of fishery science*, 2nd edn., Cornell University Press, Ithaca, 263 pp.

Fonteneau, A. 1980. Croissance de l'albacore (*Thunnus albacares*) de l'Atlantique est. ICCAT. *Coll.Vol. Sci. Pap*., 9: 152-168.

Gayanilo, F. C. Jr., Sparre, P. and Pauly, D. 1996. The FAO-ICLARM Stock Assessment Tools (FiSAT) *User's Guide*. FAO computerized series (Fisheries). No. 8. Rome, FAO, 126 pp.

Hampton, J. and Fournier, D. A. 2001. A spatially-disaggregated, length-based, age-structured population model of yellowfin tuna (*Thunnus albacares*) in the western and central Pacific Ocean. *Mar. Freshw. Res*., 52: 937-963.

Huang, C. C., Sun, L. and Yang, R. T. 1973. Age growth and population structure of the Indian yellowfin tuna. *J. Fish. Soc. Taiwan*, 2 (1): 16-30.

Huang, C. C. and Yang, R. T. 1974. Age and growth of yellowfin tuna in the waters around the southern part of Taiwan. *J. Fish. Soc. Taiwan*, 3(2) : 51-60

John, M. E. 1995. *Studies on yellowfin tuna, Thunnus albacares (Bonnaterre, 1788) in the Indian seas*, Ph. D. thesis submitted to Bombay University, 225 pp.

John, M. E. 1998. *A synoptic review of the biological studies on yellowfin tuna (Thunnus albacares) in the Indian seas*. 7th expert Consulttion on Indian Ocean Tunas, Victoria Seychelles, 9-14 November 1998, p. 211-215.

John, M. E., Neelakandan, M., Shivaji, V., Premchand, Parasuraman, P. S., Sanjeevan, M. K. and Sivaraj, P. 1998. Some aspects on the reproductive biology of yellowfin tuna (*Thunnus albacares*) in the Bay of Bengal. *Bull. Fish. Surv. India*, 26: 42-50.

John, M. E. and Reddy, K. S. N. 1989. Some considerations on the population dynamics of yellowfin tuna, *Thunnus albacares* (Bonnaterre) in the Indian seas. Studies on fish stock assessment in Indian waters. *FSI Spl. Pub*., 2: 33-54.

Kaymaram, F. 2010. The study of population dynamic parameters of yellowfin tuna in the Oman Sea. *IOTC-2010- WPTT*-39.

Kikkawa S. Bert and James W. Cushing 2002. Growth of yellowfin tuna (*Thunnus albacares*) in the equatorial western Pacific Ocean. *Working paper YFT-4. 15th meeting of the standing committee on tuna and billfishes,* SCTB 15, Honolulu, Hawai, 22-27 July 2002, 12 pp.

Lehoday, P. and Leroy, B. 1999. Age and growth of yellowfin tuna (*Thunnus albacares*) from the western and central Pacific Ocean as indicated by daily growth increments and tagging data. *SCTB12 working paper. YFT-2*. 12th Standing committee on tuna and billfish.

Lessa Rosangela and Paulo Duarte-Neto. 2004. Age and growth of yellowfin tuna (*Thunnus albacares*) in the western equatorial Atlantic, using dorsal fin spines. *Fish. Res.*, 69: 157-170.

Le Cren, E. D. 1951. The length weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *J. Anim. Ecol*., 20: 201-219.

Mohan Madan and Kunhikoya, K. K. 1985. Age and growth of *Katsuwonus pelamis* (Linnaeus) and *Thunnus albacares* (Bonnaterre) from Minicoy waters. *Bull. Cent. Mar. fish. Res. Inst*., 36: 143-148.

Marsac, F. 1991. Growth of Indian Ocean yellowfin tuna estimated from size frequencies data collected on French purseiners. Workshop on stock assessment of yellowfin tuna in the Indian Ocean, Colombo, Sri Lanka, 7 – 12 October 1991), *TWS/91/17*.

Marsac, F. and Lablanche, G. 1985. Preliminary study of the growth of yellowfin (*Thunnus albacares*) estimated from purse seine data in the western Indian Ocean. Indo-Pacific Tuna Development and Management Programme. *Expert Consultation on the Stock Assessment of Tunas in the Indian Ocean,* 31: 1-13.

Pauly, D. 1979. Theory and management of tropical multi-species stocks. A review with emphasis on the South-east Asian demersal fisheries. *ICLARM Studies and Reviews*, 1: 35 pp.

Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 stocks. *L. Cons. Ciem*., 39(2): 175-192.

Pauly, D. 1983a. Some simple methods for the assessment of tropical fish stocks. *FAO Fisheries Technical Paper*, No. 243, 52 pp.

Pauly, D. 1983b. Length converted catch curves. A powerful tool for the fisheries research in tropics (Part-I). *ICLARM Fishbyte,* 1(2): 9-13.

Pauly, D. and Munro, J. L. 1984. Once more on the composition of growth in fish and invertebrates. *Fishbyte*, 2(1): 21.

Pillai, P. P., Said Koya, K. P., Pillai, N. G. K. and Jayaprakash, A. A.. 1993. Fishery and biology of yellowfin tuna occurring in the coastal fishery in Indian seas. In: Sudarshan, D. and John, M. E. (Eds.), *Tuna research in India*, p. 23-38.

Rao, G. S. and Prathibha Rohit 2007. Small scale yellowfin tuna fishery of western Bay of Bengal region, India. *INFOFISH International*, 2/2008, p. 65-68.

Rohit Prathibha, Syda Rao, G. and Rammohan, K. 2008. Yellowfin tuna fishery by traditional fishermen at Visakhapatnam, Andhra Pradesh with notes on its biology. *J. Mar. Biol. Ass. India*, 50(1): 62-68.

Rohit Prathibha and Rammohan, K. 2009. Fishery and biological aspects of yellowfin tuna *Thunnus albacares* along Andhra coast, India. *Asian Fish. Sci.,* 22(1): 235-244.

Shono, H., Satoh, K. and Okamoto, H. 2007. Preliminary stock assessment for yellowfin tuna in the Indian Ocean using stock synthesis II (SS2). *IOTC-2007-WPTT*-11, 12 pp.

Somvanshi, V. S., Bhargava, A. K., Gulati, D. K., Varghese, S. and Sijo P. Varghese. 2003. Growth parameters estimated for yellowfin tuna occurring in the Indian EEZ. *WPTT-03-21. IOTC Proceedings*, 6: 191-193.

Sudarshan, D., John, M. E. and Nair, K. N. V. 1991. Some biological considerations of the yellowfin tuna, *Thunnus albacares* (Bonnaterre) taken by longline gear in the Indian EEZ. *IATTC Bull*.TWS/91/11:18-26.

Sun Chi-Lu, Nan-Jay Su and Su-Zan Yeh 2003. Estimation of growth parameters and age composition for yellowfin tuna, *Thunnus albacares*, in the Western Pacific using the Length-Based MULTIFAN method. *SCTB16 working paper,* Standing committee on tuna and billfish, Qld, Australia 9-16 July 2003.

Wild, A. 1986. Growth of yellowfin tuna, *Thunnus albacares*, in the eastern Pacific Ocean based on otolith increments. *IATTC Bull*., 18(6): 423-482.

Wild, A. and Foreman, T. J. 1980. The relationship between otolith increments and time for yellowfin and skipjack tunas marked with tetracycline. *Inter-Amer. Trop. Tuna Comm. Bull.,* 17(7): 509-560

Yabuta, Y., Yukinawa, M. and Warashima, Y. 1960. Growth and age of yellowfin tuna, 2: age determination (scale method). *Rep. Nankai Reg. Fish. Res. Lab*., 12: 63-74.

Yang, R., Nose, Y. and Hiyama, Y. 1969. A comparative study on the growth of yellowfin tuna from the Pacific and Atlantic Ocean. *Bull. Far Seas Fish. Res. Lab*., 2: 1-21.

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