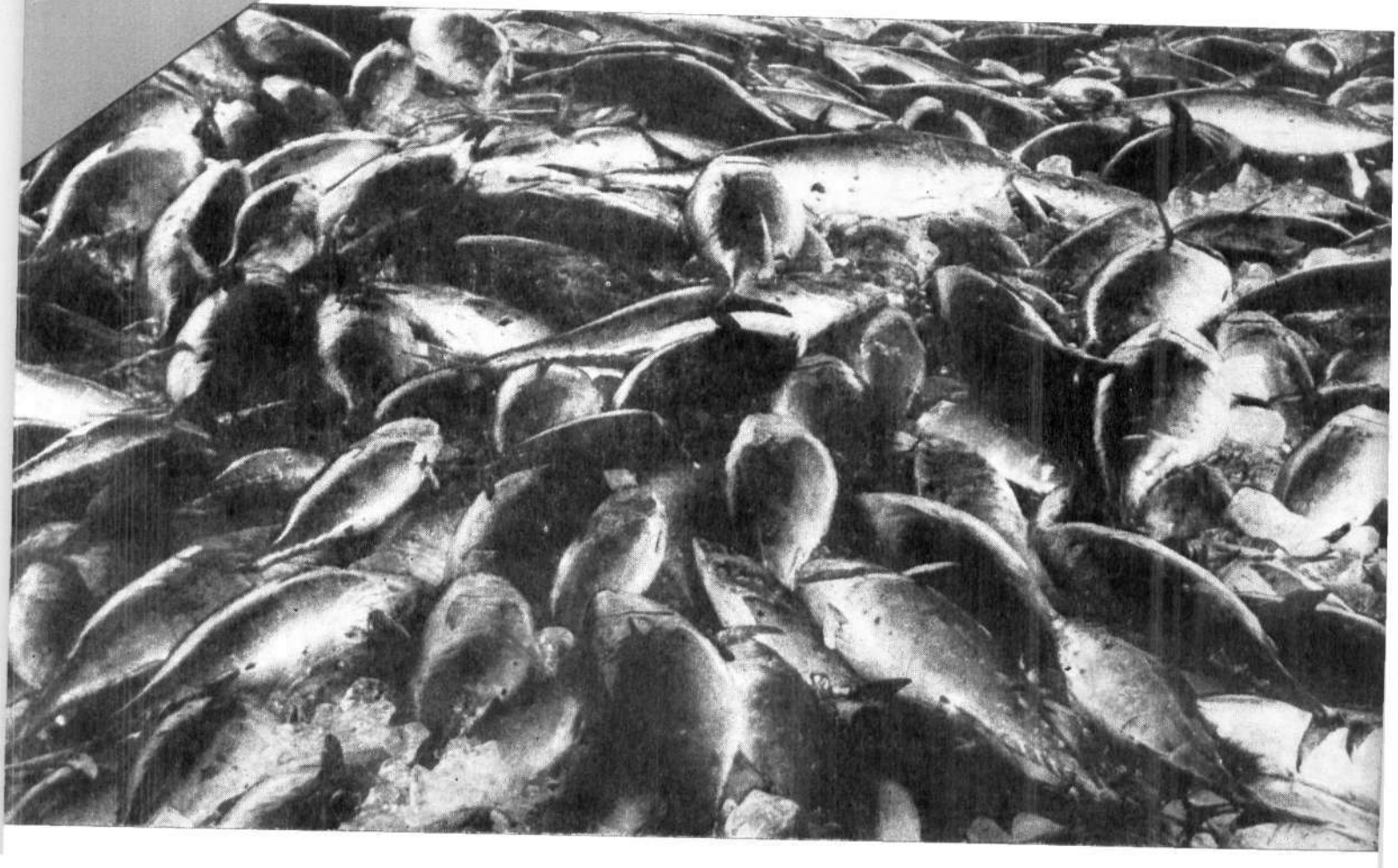
CMFRI
bulletin 36

JUNE 1985

TUNA FISHERIES OF THE EXCLUSIVE ECONOMIC ZONE OF INDIA: Biology and Stock Assessment

Edited by : E. G. SILAS



CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
P.B. No. 2704, Cochin 682 031, India

20

OBSERVATION ON THE TUNA SHOALS ASSOCIATED WITH FLOTSAM IN THE OFFSHORE WATERS OF MINICOY ISLAND DURING 1982-83 SEASON

MADAN MOHAN

Central Marine Fisheries Research Institute, Cochin, 682 031

The association of fishes with floating objects has been exploited by a number of fisheries. Tunas have long been known to aggregate around floating objects such as logs, masses of drifting seaweed, debris and other flotsam. Japanese pole-and-line fisheries and American purse seine and live-bait fisheries take advantage of the association of yellowfin tuna (*Thunnus albacares*) and oceanic skipjack (*Katsuwonus pelamis*) with logs and other flotsam (Uda 1983 ; Mc Neely 1961 ; Kimura 1954 and Inoue *et al.* 1963, 1968). The catch per set of yellowfin and other tunas in association with flotsam by purse seiners has increased in recent years.

This paper provides preliminary information on the catch pattern, ecology and behaviour of tuna species associated with floating objects in the waters around Minicoy during 1982-83 tuna fishing season.

These studies are based on data collected during 1982-83 tuna fishing season only for those fishing boats who fished on tuna shoals associated with flotsam. Distance and direction from Minicoy of flotsams and species and quantity of bait fishes used were recorded by enquiry with fishermen engaged in tuna fishing. Flotsam objects were physically examined by the author. Fork length of skipjack and yellowfin, their stomach condition, sex and maturity stages were recorded whenever it was possible.

CHARACTERISTICS AND DISTRIBUTION OF FLOTSAM OBJECTS

On most of the occasions, flotsam objects were wooden material drifting with sea currents towards Minicoy. Other objects which were associated along with tuna shoals were nylon nets, rubber pieces, nylon ropes and plastic pieces. Maximum flotsam were observed from October to December 1982 and April-May 1982. During February and March flotsam could not be observed around Minicoy waters. Distance of sightings from Minicoy varied from 2 km to 7 km and flotsam were observed in almost all the direction from the Island.

Most of the flotsam had some attached algal material and very rarely a few ascidians. Fishermen informed the author that very few small fishes were found around flotsam. When tuna fishing commenced around flotsam, these small fishes disappeared from sight. This may be the reason that tuna responded to bait fishes whenever it was thrown from the fishing boat.

BAIT FISHES USED

Chromis spp. were the main species followed by *Spratelloides delicatulus* used to attract tuna from floating objects to tuna fishing boats. Out of 75 fishing boats observed during these studies the amount of bait could be recorded only for 28 boats which used 57.5 kg of bait fishes.

Monthwise amount of bait fishes used, catches from around flotsam and catch per unit of bait are given in Table 1. The maximum CPUB was recorded during October and lowest in December.

Always more than one fishing boat approached a floating object. The first boat used bait to chum tuna and on most of the occasions it was not necessary for other boats to throw bait since tuna shoals were already feeding on bait thrown by the first boat.

TUNA CATCHES

Totally 26 nos. of flotsam were observed from November 1982 to May 1983. 75 tuna fishing boats approached

TABLE 1. *Amount of bait used and fish catch from flotsam objects*

Month	No. of Units operated	Bait used In kg.	Fish catch In kg.	Catch per unit of bait In kg.
September ..	3	14	2201.5	157.25
October ..	8	14	5706.1	407.57
November ..	11	11.5	4264.5	370.83
December ..	2	9	932.5	103.61
May ..	4	9	2776	308.44
Total for the season	28	57.5	15880.6	276.18

these shoals and caught 40,886.1 kg of fishes around them. The maximum catch was recorded from six flotsam during October when 14 fishing boats could catch 13,371.6 kg of fishes. This was followed in April when 17 boats fished 7,960.5 kg of fishes from around five flotsam and in November when 19 boats caught 7,121.5 kg of fishes from around 8 flotsams.

Specieswise, yellowfin (*Thunnus albacares*) dominated the catches and accounted for 18,875.5 kg (46.17%) of the total catches. It was followed by skipjack (*Katsuwonus pelamis*) 11,106.3 kg (27.16%), sharks 7,558 kg (18.48%), *Elagatis bipinnulatus* 2,677.8 kg (6.56%), *Coryphaena* 376.5 kg (0.93%), *Acanthocybium* 210 kg (0.52%), *Sphyraena* 10 kg (0.02%), *Euthynnus affinis* 15 kg (0.03%), *Auxis* 9 kg (0.02%), *Caranx* spp. 7.5 kg. (0.02%) and miscellaneous fishes 40.5 kg (0.09%) (Table 2).

On one occasion fishermen located a flotsam which was surrounded by sharks. When fishermen tried to catch them, they d spersed from the flotsam and did not return. Once a tuna shoal was located little away from the floating object. On some occasions biting by the tuna species was very poor and even with the help of bait fish they could not be chummed.

SEASONAL VARIATION IN OCCURRENCE OF DIFFERENT SPECIES

During the course of these investigations both the species of tunas i.e. *Katsuwonus pelamis* and *Thunnus albacares*, Sharks (*Carcharias* spp.) and *Elagatis bipinnulatus* were available from September to May. Other species such as *Caranx* spp., *Coryphaena* spp., *Auxis*, *Euthynnus affinis* and *Acanthocybium* were caught occasionally. The percentage occurrence of different species is given in Table 2 from which it can be seen that yellowfin dominated in flotsam catches during September to November and April, while skipjack dominated during December, January and May. Sharks supported the catches substantially during November, December and April. Catches of *Elagatis bipinnulates* were good during September, October and December.

Catch per unit effort ; Average catch per unit of effort for the season as a whole from flotsam associated catches was 908.58 kg. The maximum cpue as can be seen from Table-3 was recorded during October being 1593.05 kg which was followed during December 1,150.5 kg, September 1,040.33 kg, April 780.44 kg, May 722.83 kg, November 624.70 kg and lowest during January 507.67 kg.

It is interesting to note here that the average cpue from flotsam catches was about three times higher than the average cpue for pole-and-line catches during 1982-83 tuna fishing season. The main reason for the higher cpue for flotsam associated catches is, the availability of fishes in good numbers around these floating objects

TABLE 2. *Percentage contribution of different species of fish from flotsam associated catches*

Month	*Katsuwonus pelamis*	*Thunnus albacares*	Shark	*Elagates bipinnulatus*	*Acantho-cybium* sp.	*Sphyraena* sp.	*Coryphaena* sp.	*Auxis* sp.	*Caranx* sp.	*Euthynnus affinis*	Misc.	Total in kg.
September ..	21.87	61.73	6.45	9.45							0.50	3,121
October	11.46	59.81	16.65	11.33	0.45		0.14				0.16	13,371.6
November ..	30.33	37.84	24.40	5.40	0.08	0.14	1.49	0.11		0.21		7,121.5
December ..	35.94	19.62	22.72	10.60	3.82		7.30					3,451.5
January ..	78.04	6.70	14.18	0.10	0.78			0.10			0.10	1,532
February ..	..	..	..	..	..	..	..	..	..	..	..	..
March ..	..	..	..	..	..	..	..	..	..	..	..	..
April ..	24.90	49.44	24.62	0.94					0.10			7,960.5
May ..	43.49	35.55	10.01	0.95								4,337
Total ..	11,106.3	18,875.5	7,558	2,677.8	210	10	376.5	9	7.5	15	40.5	40,886.1
Percentage ..	27.16	46.17	18.48	6.56	0.52	0.02	0.93	0.02	0.02	0.03	0.09	

TABLE 3. *Monthwise total effort, nos of flotsams, total fish catch and catch per unit of effort for flotsam associated fish landings during* 1982-83 *tuna fishing season*

Months	Effort	Flotsam nos.	Total fish catch In kg.	Catch per unit of effort in kg.
September ..	3	1	3121	1040.33
October ..	8.4	6	13371.6	1593.05
November ..	11.4	8	7121.5	624.70
December ..	3	1	3451.5	1150.5
January ..	3	2	1523	507.67
April ..	10.2	5	7960.5	780.44
May ..	6	3	4337	722.83

Catch per flotsam object ; As can be seen from Fig. 1 the maximum catch per flotsam was recorded during December being 3,451.5 kg which was followed in September 3 121 kg, October 2,228.6 kg, April 1,592.10 kg, May 1445.67 kg, November 890.91 kg and January 761.50 kg. The average catch per flotsam object for the season as a whole was 1,572.54 kg.

Length frequency distribution of tunas ; The fork length of two main species of tunas namely skipjack (*Katsuwonus pelamis*) and yellowfin (*Thunnus albacares*) were recorded and analysed.

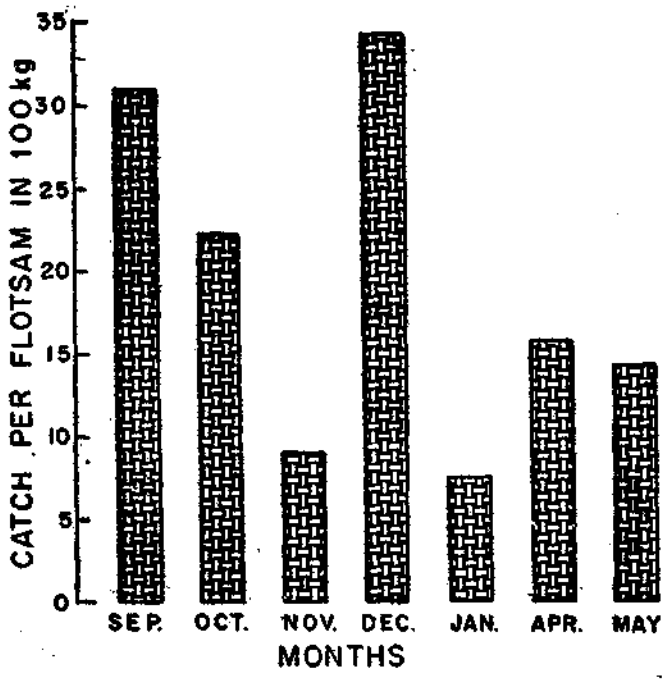


Fig. 1. Total catch of tunas from around flotsam at Minicoy, 1982-'83.

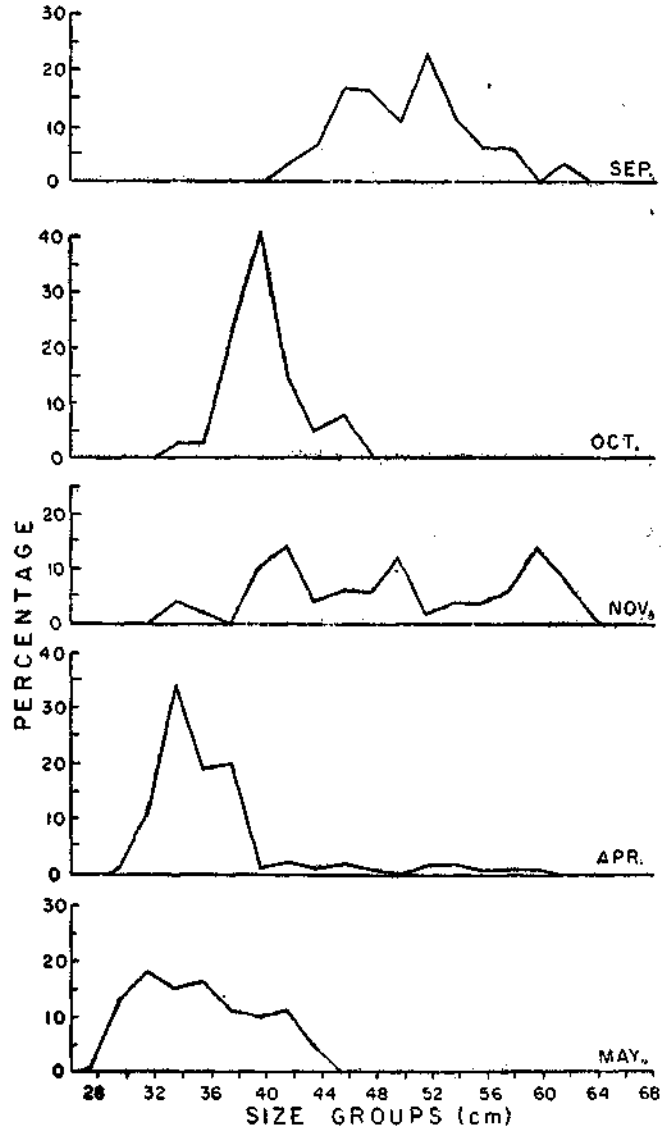


Fig. 2. Length frequency distribution of *K. pelamis* taken from around flotsam at Minicoy, 1982-'83 (Sept.-Nov. 1982 and April-May 1983)

Katsuwonus pelamis ; As can be seen from Fig. 2, during September the length of the fish ranged from 400 mm to 620 mm and size group 440-540 mm dominated. The next month, the length ranged between 340 to 560 mm. During November it ranged from 320 to 640 mm with 3 size groups 380-420 mm, 480-500 mm and 580-600 mm dominating. During April it ranged from 280 to 600 mm when the size range 300 to 380 mm was dominant. Next month the range was 260 to 440 mm with size group 280-420 mm showing dominance.

Thunnus albacares ; As can be seen from the Fig. 3, during September the length of yellowfin ranged from 420 to 640 mm and size group 520 to 560 mm

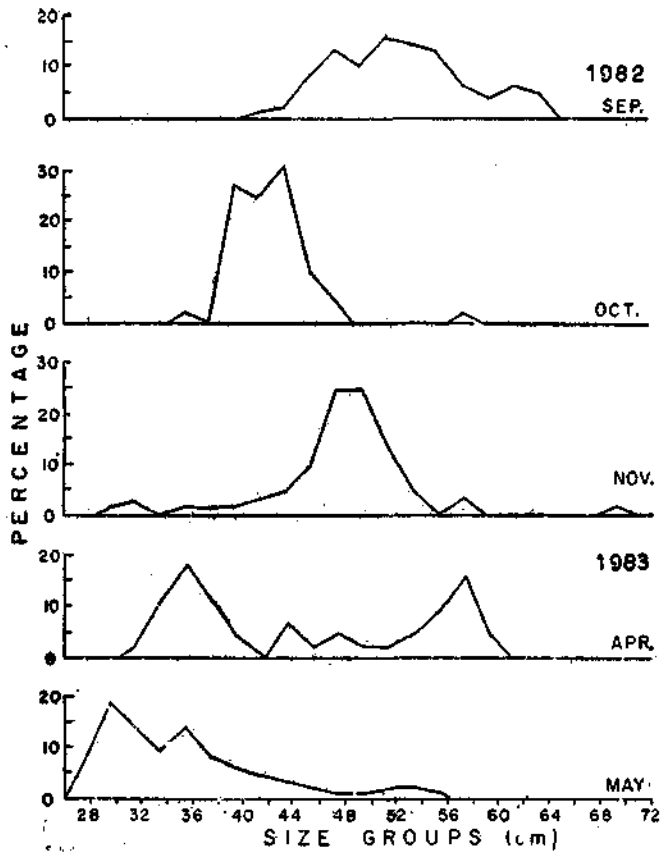


Fig. 3. Length frequency distribution of *T. albacares* taken from around flotsam at Minicoy, 1982-'83.

dominated. But next month catches were dominated by young fish with modal size range from 400-440 mm. In November length ranged from 300-700 mm and size group 480-500 mm dominated. During April length of fish ranged from 320 to 600 mm, but two modal sizes 340-380 mm and 560 to 580 mm were dominant. During May, yellowfin catches from flotsam were dominated by small fishes, *i.e.*, from 300 to 360 mm while the total range was 280 to 560 mm.

From July to November, wind and upwelling cause both clockwise and anticlockwise surface sea currents in Lakshadweep and Maldives region (Silas and Pillai, 1982). Every year it is seen during August to October period that large number of Coelenterates specially pelagic Siphonophores (*Porpita* spp., and *Physalia physalis*) are washed ashore along the western shore of Minicoy. During September 1982, an unusual invasion of Minicoy lagoon by *Ctenochaetus strigosus* in large profusion was observed for the first time in the history of Minicoy Island. Schools of this species almost covered the Minicoy lagoon, stock of which certainly originated elsewhere but reached Minicoy alongwith strong sea water currents. This clearly indicates a strong sea surface current towards Minicoy bringing alongwith it flotsam objects. Strong wind also plays an important role in the floating and drifting of wooden objects. So the occurrence of flotsam objects around Minicoy from September to December and again during April and May may be because of mixed processes of strong sea surface current and strong winds towards Minicoy.

The occurrence of very young skipjack ranging from 30 to 40 cm associated with flotsam objects during October and again during April-May is significant. Shoals of such small skipjack may be available far away from Minicoy, but they are reaching Minicoy only when they are associated with flotaing objects. Generally length of the skipjack at recruitment to the commercial catches at Minicoy is more than 40 cm.

But in the case of yellowfin, young fishes between 30 to 50 cm were found associated mostly with flotsam. Even in commercial catches at Minicoy, yellowfin available is more than 50 cm in length. Big yellowfin of more than 70 cm long are caught only by the troll line gear during the monsoon season. So it can be said that in one way floating objects help in the recruitment of young tunas to commercial pole-and-line tuna fishing.

Hypothesis

Several hypothesis have been proposed to explain the association of fishes with floating objects, but the reasons for the attraction of fishes to floating objects have not been fully substantiated. Some of them are :

1. Fish are attracted to the object to feed on associated forage organisms, algae or decaying matter.
2. Fish seek shade under the object.
3. The object provides shelter from predators.
4. The object is used as a substrate on which the fish lay their eggs.
5. The object functions as a cleaning station where pelagic fishes congregate to have their parasites removed by other fishes.

Gooding and Magnuson (1967) and Hunter and Mitchell (1967) have examined these hypothesis. While the former authors concluded that shelter from predators was probably the most significant drawing force in attracting fish to a floating object, Hunter and Mitchell, on the other hand, found no evidence in support of the hypothesis. They concluded :

1. Fishes associate with floating objects because the object serve as a schooling companion and,

2. In the case of non-pelagic species and others undergoing a change from pelagic to other modes of existance and object may function as a substitute for a reef or some other type of substrate.

As far as hypothesis with regard to feeding is concerned the floating objects examined during these studies, did not contain much food except some algal encrustation. On one occasion one small plastic piece served as floating object and nothing was attached to it. More over, for juvenile and non-piscivorous adult fishes this hypothesis would not apply. Food content analysis of tunas revealed that mostly bait fish used for chumming tuna were present. The only possibility of food may be the visible macro-plankton under the shadow of the object. But it is not clear how a small floating object can provide plankton aggregation for large shoals of fish.

As for the hypothesis regarding laying of eggs, most of the species caught from flotsam such as skipjack, yellowfin, *Elagatis bipinnulatus* and *Coryphaena* spp. are pelagic in nature and they shed their eggs in open sea.

During these studies floating objects such as nylon rope or nylon nets were also encountered which cannot give shelter to even very small school of fishes.

Most of the species caught from the floating objects generally school at the surface and some of them occur together. At Minicoy skipjack and yellowfin are found schooling together. On most of the occasions *Elagates bipinnulatus* and dolphin fish are also caught along with tunas. Tuna schools are found sometimes with shoals of sharks and dolphins.

After examining all the above hypothesis it appears that association of tunas with floating objects is nothing but merely a coincidence. Since almost all the species are found at one time or other schooling together their occurrence with floating objects does not show any change in their schooling pattern. Whenever a tuna shoal with other species of fish move with the sea water currents incidentally they observe a floating object as reference point and aggregate around it. In short, floating objects appear to serve only as companions drifting in the same direction with tuna shoals. It helps tuna fishermen in locating tuna shoals and makes their task easier for scouting of tuna schools.

REFERENCES

AIKAWA, H. 1937. Notes on the shoal of bonito (Skipjack *Katsuwonus pelamis*) along the Pacific coast of Japan. (In Jpn., Engl. summ.) *Bull. Jpn. Soc. Sci. Fish.* 61: 13-21. (Engl, transl. by W. G. Van Campen, 1952. In *U. S. Fish Wildl. Serv., Spec. Sci. Rep. Fish.* 83 ; 32-50).

AIKAWA, H., AND M. KATO. 1938. Age determination of fish (Preliminary Report I). (In Jpn., Engl. synop.) *Bull. Jpn. Soc. Sci. Fish.* 7 ; 79-88. (Engl. transl. by W. G. Van Campen, 1950. *In U. S. Fish Wildl. Serv., Spec. Sci. Rep. Fish.* 21, 22 p.

ALAGARAJA, K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. *Indian J. Fish.* 31(2) : 177-208.

ALVERSON, F. G. 1963. The food of yellowfin and skipjack tunas in the eastern tropical Pacific Ocean. (In Engl. and Span.) *Inter-Am. Trop. Tuna Comm. Bull.* 7 ; 293-296.

ANON. 1978. General description of marine fisheries—Karnataka, India. Working paper under FAO/UNDP small scale fisheries promotion in South Asia, RAS/77/044—WP No. 22: 1-40.

APPUKUTTAN, K. K., P. N. RADHAKRISHNAN NAIR, AND K. K. KUNHIKOYA. 1977. Studies on the fishery and growth rate of oceanic skipjack, *Katsuwonus pelamis* (Linnaeus), at Minicoy Island from 1966 to 1969. *Indian J. Fish.* 24 (1&2) : 31-47.

BALDWIN, W. J. 1977. A review on the use of live baitfishes to capture Sipjack tuna, *Katsuwonus pelamis*, in the tropical Pacific Ocean with emphasis on their behaviour, survival and availability. *In* R. S. Shomura (Editor), *Collection of tuna baitfish papers*, p. 8-35. U. S. Dep. Commer., NOAA Tech. Rep. NMFS Circ. 408.

BATTS, B. S. 1972a. Age and growth of the skipjack tuna, *Katsuwouns pelamis* (Linnaeus), in North Carolina waters. *Chesapeake science*, 13(4) : 237-244.

BATTS, B. S. 1972b. Sexual maturity, fecundity and sex ratios of the skipjack tuna, *Katsuwonus pelamis* (Linnaeus), in North Carolina waters. *Trans. Am. Fish. Soc.* 101 : 626-637.

BAYLIFF, W. H. 1973. Observations on the growth of yellowfin tuna in the eastern Pacific Ocean derived from tagging experiments. *Inter-Am. Trop. Tuna Comm. Internal Rep.* 7 ; 26p.

BENNET, P. SAM. 1967. Kachal, a tackle for filefish (Family Balistidae : Pisces) *J. Bombay Nat. Hist. Soc.*, 64(2) : 377-380.

BERTALANFFY, L. VON. 1938. A quantitative theory of organic growth (Inquiries on growth laws, I). *Human Biology*, 10(2) : 181-213.

BEVERTON, R. J. H., AND S. J. HOLT. 1957. On the dynamics of exploited fish populations. *Min. Agric. Fish. and Food (U.K. Fish. Investing. Ser.* II, 19 : 1-533.

BLACKBURN, M., AND D. L. SERVENTY. 1971. Observations on distribution and life history of skipjack tuna, *Katsuwonus pelamis*, in Australian waters. *Fish. Bull., U. S.* 79 ; 85-94.

BLUNT, C. E. Jr., AND J. D. MESSERSMITH. 1960. Tuna tagging, in the eastern tropical Pacific, 1952-1959. *Calif. Fish Game* 46 (3) : 310-369.

Bobp. 1983. Marine small scale fisheries of India : A general description. BOBP/INF/3 (GCP/RAS/040/SWE), 69p.

———1985. Tuna fishery in the EEZs of Sri Lanka. UNDP/FAO, Bay of Bengal Programme, BOBP/WP/31, 90 p.

BOY, R. L. AND B. R. SMITH. 1984. Design improvements to Fish Aggregating Devices (FAD) mooring systems in general use in Pacific island countries *SPC Handbook* No. 24, 77p.

BROCK, V. E. 1954. Some aspects of the biology of the aku, *Katsuwonus pelamis*, in the Hawaiian Islands. *Pac. Sci.* 8 ; 94-104.

BRYAN, P. G. 1978. On the efficiency of mollies (*Poecilia mexicana*) as live bait for pole and line Skipjack fishery : Fishing trials in the tropical central Pacific. *Technical report on project No. 4-35-D, American Samoa Baitfish programme, Pago Pago, American Samoa.*

BUNAG, D. M. 1956. Spawning habits of some Philippine tuna based on diameter measurements of the ovarian ova. *Philipp. J. Fish.*, 1958, 4 : 145-177.

CHATWIN, B. M. 1959. The relationships between length and weight of yellowfin tuna (*Neothunnus macropterus*) and skipjack tuna (*Katsuwonus pelamis*) from the eastern tropical Pacific Ocean. (In Engl. and Span.) *Inter-Am. Trop. Tuna. Comm. Bull.* 3 ; 307-352.

CHRISTY, F. T. JR. L. C. CHRISTY, W. P. ALLEN AND R. NAIR. 1981. Maldives—Management of Fisheries in the Exclusive Economic Zone. Rep. FI : GCP/INT/334/NOR, GCP/RAS/087/NOR. *FAO/Norway Co-operative Programme*, 99 p. FAO, Rome.

CLARK, F. N. 1934. Maturity of the California sardine (*Sardina caerulea*), determined by ova diameter measurements. *Calif. Div. Fish Game, Fish Bull.* 42, 49p.

CLEAVER, F. C., AND B. M. SHIMADA. 1950. Japanese Skipjack (*Katsuwonus pelamis*) fishing methods. *Commer. Fish. Rev.* 12 (11) : 1-27.

COLE, J. S. 1980. Synopsis of biological data on the yellowfin tuna, *Thunnus albacares* (Bonnaterre, 1788), in the Pacific Ocean. *Inter-Am. Trop. Tuna Comm., Spec. Rep.* (2) : 71-150.

COLLETTE, B. B., AND L. N. CHAO. 1975. Systematics and morphology of the bonitos (*Sarda*) and their relatives (Scombridae, Sardini). *Fish. Bull., U. S.* 73 ; 516-625.

CMFRI. 1980. Trends in total marine fish production in India, 1979. *Mar. Fish. Infor. Serv. T & E Ser.*, 22 ; 1-19.

———1981. All India census of marine fishermen, crafts and gear, 1980. *Mar. Fish. Infor. Serv. T & E Ser.*, 30 : 33p.

———1981. Trends in total marine fish production in India, 1980. *Mar. Fish. Infor. Serv. T & E Ser.*, 32 : 1-6.

———1982. Trends in total marine fish production in India, 1981. *Mar. Fish. Infor. Serv. T & E Ser.*, 42 : 1-33.

———1983. Trends in marine fish production in India, 1982-83. *Mar. Fish. Infor. Serv. T & E Ser.*, 52 : 21p.

———1983. A code list of common marine living resources of Indian seas. CMFRI Special Publ., 12 : 150p.

DAVIDOFF, E. B. 1963. Size and year class composition of catch, age and growth of yellowfin tuna in the eastern tropical Pacific Ocean, 1951-1961, *Inter-Am. Trop. Tuna Comm. Bull.* 8(4) 201-251.

DE JONG, J. K. 1939. A preliminary investigation on the spawning habits of some fishes of Java Sea. *Treubia*, 17 ; 307-330.

DHULKHED, M. H., C. MUTHIAH, G. SYDA RAO, AND N. S. RADHAKRISHNAN. 1982. The purse seine fishery of Mangalore (Karnataka). *Mar. Fish. Infor. Serv. T & E Ser.*, 37 : 1-7.

DIAZ, E. L. 1963. An increment technique for estimating growth parameters of tropical tunas as applied to yellowfin tuna (*Thunnus albacares*). *Inter. Am. Trop. Tuna Comm. Bull.* 8(7) : 383-416.

DIVAKARAN, O., M. ARUNACHALAM, N. B. NAIR AND K. G. PADMANABAN. 1980. Studies on the zooplankton of the Vizhinjam inshore waters, south-west coast of India. *Mahasagar*, Bull. Nat. Inst. Oceanogr., 13(4) : 335-341.

ELLIS, R. H. 1924. A short account of the Laccadive Island and Minicoy. *Govt. Press, Madras*, 30p.

FISHER, R. A. 1970. Statistical methods for research workers 14th Ed.

GEORGE, P. C., B. T. ANTONY RAJA, AND K. C. GEORGE. 1977, Fishery resources of the Indian Economic Zone. *Silver Jubilee Souvenir, IFP*, Oct. 1977, 79-116.

GEORGE, M. S. 1981. Role of small scale fisheries in Karnataka and its impact on rural economy. *CMFRI Bull.*, 30-B : 22-29.

GODSIL, H. C. 1954. A descriptive study of certain tuna-like fishes. *Calif. Dep. Fish Game, Fish Bull.* 97, 185p.

GOODING, R. M., AND J. J. MAGNUSON. 1967. Ecological Significance of a drifting object to pelagic fishes. *Pac. Sci.* 21(4) : 486-497.

GNANAMUTHU, J. C. 1966. On the occurrence of the oriental bonito, *Sarda orientalis* (Temminck and Schlegel) along the Madras coast. *J. Mar. Biol. Assoc. India.* 8 : 365.

HAMADA, H., M. MORITA, Y. ISHIDA, AND Y. TAKEZAGA. 1973. Investigation of long-corseletted frigate mackerels (*Auxis rochei*). (*In Jpn.*) *Rep. Kochi Pref. Fish. Exp. Stn.* 69 ; 1-12. (Unedited Engl. transl. infiles of Southwest Fish. Cent., Natl. Mar. Fish. Serv.., NOAA, Honolulu, HI 96812.)

HENNEMUTH, R. C. 1959. Additional information on the length-weight relationship of skipjack tuna from the eastern tropical Pacific Ocean. (In Engl. and Span.) *Inter-Am. Trop. Tuna Comm. Bull.* 4 : 25-37.

HENNEMUTH, R. C. 1961. Size and year class composition of catch, age and growth of yellowfin tuna in the eastern tropical Pacific Ocean for the years 1954-1958. *Inter-Am. Trop. Tuna Comm. Bull.* 5(1) : 112.

HICKLING, C. F., AND R. AUTENBERG. 1936. The ovary as an indicator of spawning period in fishes. *J. Mar. Biol. Assoc.* U. K. 21 : 311-317.

HIDA, T. S. 1971. Baitfish scouting in the Trust Territory. *Commer. Fish. Rev.* 33 (11-12) : 31-33.

HIDA, T. S., AND J. A. WETHERALL. 1977. Estimates of the amount of nehu, *Stolephorus purpureus*, per bucket of bait in the Hawaiian fishery for skipjack tuna, *katsuwonus pelamis*. *In* R. S. Shomura (editor), *Collection of tuna baitfish papers*, p. 55-56. U. S. Dep. Commer., NOAA Tech. Rep. NMFC Circ. 408.

HONMA, M., AND Z. SUZUKI. 1978. Japanese tuna purse seine fishery in the Western Pacific. (In Jph., Engl. summ.) *Far Seas Fish. Res. Lab. S Ser.*, 10, 66p.

HORNELL, J. 1910. Report on the results of a fishery cruise along the Malabar Coast and the Laccadive Islands in 1908. *Madras Fish. Bull.*, 4 : 71 126.

HOTTA, H., AND T. OGAWA. 1955. On the stomach contents of the skipjack, *Katsuwonus pelamis*. (In Jpn., Engl. summ.) *Bull. Tohoku Reg. Fish. Res. Lab.* 4 ; 62-82.

HUNTER, J. R., AND C. T. MITCHELL. 1967. Association of fishes with flotsam in the offshore waters of Central America. *U. S. Fish Wildl. Serv., Fish. Bull.* 66(1) : 13-29.

IKEHARA, I. I. 1953. Live-bait fishery for tuna in the central Pacific. *U. S. Fish Wildl. Serv. Spec. Sci.* Rep *Fish.* 107, 20p.

INOUE, M., R. AMANO, AND Y. IWASAKI. 1963. Studies on environments alluring skipjack and other tunas—1. On the oceanographical condition of Japan adjacent waters and the drifting substances accompanied by Skipjack and other tunas. (In Jpn., Engl. summ.) *Rep. Fish. Res. Lab., Tokai Univ.* 1(1) 12-23.

INOUE, M., R. AMANO, Y. IWASAKI, AND M. YAMAUTI. 1968a. Studies on the environments alluring skipjack and other tunas—II. On the driftwoods accompanied by skipjack and tunas. *Bull. Jpn. Soc. Sci. Fish.* 34 ; 283-287.

ISA, J. 1972. The skipjack fishery in the Ryukyu Islands. *In* K. Sugawara (editor), The Kuroshio II. *Proceedings of the second symposium on the results of the cooperative study of the Kuroshio and adjacent regions*, Tokyo, Japan, September 28—October 1, 1970, pp. 385-410. Saikon Publ. Co., Ltd., Tokyo.

JONES, R. 1981. The use of length composition data in fish stock assessment (with notes on VPA and cohort analysis). *FAO Fish. Circ.* 734 FIRM/C 743.

JONES, S. 1958. The tuna live-bait fishery of Minicoy Island. *Indian J. Fish.* 5(2) : 300-307.

JONES, S. 1959. Notes on eggs, larvae and juveniles of fishes from Indian waters. III, *Katsuwonus pelamis* (Linnaeus) and IV. *Neothunnus macropterus* (Temminck and Schlegel). *Indian J. Fish.* 6(2) : 360-373.

JONES, S. 1960a. Notes on eggs, larvae and juveniles of fishes from Indian waters. V. *Euthynnus affinis* (Cantor). *Indian J. Fish.* 7(1) : 101 106.

JONES, S. 1960b. Further notes on *Spratelloides delicatulus* (Bennett) as a tuna live-bait with a record of *S. japonicus* (Houtuyn) from the Laccadive Sea. *J. Mar. Biol. Assoc. India.* 2(2) : 267-268.

JONES, S. 1964. A preliminary survey of the common tuna baitfishes of Minicoy and their distribution in the Laccadive Archipelago. *Proc. Symp. Scombroid Fishes, Mar. Biol. Assoc. India, Symb. Ser.* I, Pt. 2 : 643-680.

JONES, S., M. KUMARAN. 1959. The fishing industry of Minicoy Island with special reference to the tuna fishery. *Indian J. Fish.* 6 (1) : 30-57.

JONES, S., M. KMUARAN. 1963. Distribution of larval tuna collected by the Carlsberg Foundation's *Dana* Expedition (1928-30) from the Indian Ocean. (In Engl., Fr. resume.) *FAO Fish. Rep.* 6 (3) : 1753-1774.

JONES, S., AND E. G. SILAS. 1960. Indian tunas—a preliminary review with a key for their identification. *Indian J. Fish.* 7(2) : 369-393.

JONES, S., AND E. G. SILAS. 1963a. Synopsis of biological data on skipjack, *Katsuwonus pelamis* (Linnaeus) 1758 (Indian Ocean) *FAO Fish. Rep.* 6(2) : 663-694.

JOSEPH, K. M. 1984. Salient observations on the results of fishery resource survey during 1983-'84. FSI/BULL/13/84, p. 1-11.

JOSEPH, J. 1963. Fecundity of yellowfin tuna (*Thunnus albacares*) and skipjack (*Katsuwonus pelamis*) from the Pacific Ocean. (In Engl., and Span.) *Inter-Am. Trop. Tuna Comm. Bull.* 7 ; 257-292.

JOSEPH, J., AND T. P. CALKINS. 1969. Population dynamics of the skipjack tuna (*Katsuwonus pelamis*) of the eastern Pacific Ocean. (In Engl., and Span.) *Inter-Am. Trop. Tuna Comm. Bull.* 13 : 1-273.

JOSSE, E., J. C. LE GUEN, R. KEARNEY, A. LEWIS, A. SMITH, L. MAREC, AND P. K. TOMLINSON. 1979. Growth of skipjack. *South Pac. Comm. Occas. Pap.* 11, 83 p.

JUNE, F. C. 1951. Preliminary fisheries survey of the Hawaiian-Line Islands area. Part II. Notes on the tuna and bait resources of the Hawaiian, Leeward and Line Islands. *Commer. Fish. Rev.* 13(1) : 1-22.

JUNE, F. C. 1953. Spawning of yellowfin tuna in Hawaiian waters. *U. S. Fish Wildl. Serv., Fish. Bull.* 54 : 47-64.

JUNE, F. C., AND J. W. REINTJES. 1953. Common tuna-baitfishes of the central Pacific. *U. S. Fish Wildl. Serv., Res. Rep.* 34, 54p.

KAWAGUCHI, K. 1967. Report to the Government of India on the exploratory tuna longline fishing off the south-west coast of India. *UNDP Rep. No. TA* 2274, *FAO*, 31 p,

KAWASAKI, T. 1955a. On the migration and the growh of the skipjack, *Katsuwonus pelamis* (Linnaeus), in the south-western sea area of Japan. (In Jpn., Engl. summ.) *Bull. Tohoku Reg. Fish. Res. Lab.* 4 : 83-100.

KAWAKAI, T. 1955b. On the migration and the growth of the skipjack, *Katsuwonus pelamis* (Linnaeus), in the Izu and Bonins Sea areas and the north-eastern sea area along the Pacific coast of Japan. (In Jpn., Engl. summ.) *Bull. Tohoku Reg. Fish. Res. Lab.* 4 : 101-119.

KAWAKAI, T. 1963. The growth of skipjack on the north-eastern Sea of Japan. (In Jpn., Eng . summ.) *Bull. Tohoku Res. Fish. Res. Lab.* 23 : 44-60.

KAWAKAI, T. 1964. Population structure and dynamics of skipjack in the North Pacific and its adjacent waters. (In Jpn., Engl. summ.) *Bull. Tohoku Reg. Fish. Res. Lab.* 24 ; 28-47.

KAWASAI, T. 1965. Ecology and dynamics of the skipjack population. II. Resources and fishing conditions. (In Jpn.) *Jpn. Fish. Resour. Prot. Assoc.*, Stud. Ser. 8 ; 49-108. (Engl. transl. 1967, 79 : U. S. Joint Publ. Res. Serv.).

KEARNEY, R. E. 1975. Some hypotheses on skipjack (*Katsuwonus pelamis*) in the Pacific Ocean. *South Pac. Comm.*, Occas. Pap. 7, 23p.

KEARNEY, R. E. 1980. Skipjack survey and assessment programme annual report for the year ending 31st December 1979. *South Pacific Comm.*, 18p.

KEARNEY, R. E., A. D. LEWIS AND B. R. SMITH. 1972. Cruise report *TAGULA* 71-1. Survey of Skipjack tuna and bait resources in Papua New Guinea waters. *Dep. Agric., Stock Fish., Res Bull.* 8, 145 p. Port Moresby.

KIKAWA, S. 1977 Japanese skipjack tuna, *Katsuwonus pelamis*, baitfish surveys in the western and southwestern Pacific Ocean. *in* R. S. Shomura (Editor), *Collection of Tuna Baitfish Papers.* p. 81-88. *U. S. Dep. Commer.* NOAA Tech. Rep. NMFS CIRC. 408.

KIKAWA, S., AND I. WARASHINA. 1972. The catch of the young yellowfin tuna by the skipjack pole-and-line fishery in the southern area of the Western Pacific Ocean. *Far Seas Fish. Res. Lab. Bull.*, 6 : 39-49.

KIKAWA, S., AND STAFF OF THE NANKAI REGIONAL FISHERIES RESEARCH LABORATORY. 1963. Synopsis of biological data on bonito *Sarda orientalis* Temminck and Schlegel 1842. *FAO Fish Rep.* 6, 2 : 147-156.

KIMURA, K. 1954. Analysis of skipjack (*Katsuwonus pelamis*) shoals in the water of " Tohoku Kaiku " by its association with other animals and objects based on the records by fishing boats. (In Jph., Eng . summ.) *Bull. Tohoku Reg. Fish. Res. Lab.* 3, 87 p.

KIMURA, K. 1932. Growth curves of bluefin tuna and yellowfin tuna based on the catches near Sigedera, on the West Coast of Province Izu. *Jap. Soc. Sci. Fish., Bull.*, 1(1) : 1-4.

KING, J. E., AND I. I. IKEHARA. 1956. Comparative study of food of bigeye and yellowfin tuna in the central Pacific. *U. S. Fish Wildl. Serv., Fish. Bull.* 57 : 61-85.

KISHNOUYE, K. 1895. The food of the tunas and skipjack. *Doubtsugaku zasshi*, 7 : 111.

KLAWE, W. L. 1961. Notes on larvae, juveniles, and spawning of bonito (*Sarda*) from the eastern Pacific Ocean. *Pac. Sci.* 15 : 487-493.

KUMARAN, M. 1964. Studies on the food of *Euthynnus affinis* (Cantor), *Auxis thazard* (Lacepede), *Auxis thynnoides* Bleeker and *Sarda orientalis* (Temminck and *Schlegel*). *Proc. Symp. Scombroid Fishes, Part* 2. *Mar. Biol. Assoc. India, Symp. Ser.* 599-606.

LEE, R. 1973. Live-bait research. Skipjack tuna fishing project in Fiji. *South Pac. Isl. Fish Newsl.* 9 : 26-30.

LECREN, 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.

LEWIS, A. D., B. R. SMITH, AND R. E. KEARNEY. 1974. Studies on tunas and bsitfish in Papua New Guinea waters II. *Dep. Agric. Stock Fish., Res. Bull.* **11**, 112 p.

LUTHER, G., P. N. RADHAKRSHNAN NAIR, G. GOPAKUMAR, AND K. PRABHAKARAN NAIR. 1982. The present status of small-scale traditional fishery at Vizhinjam. *Mar. Fish. Infor. Serv. T & E Ser.*, **38** : 17p.

MC NEELY, R. L. 1961. Purse seine revolution in tuna fishing, *Pac. Fisherman* **59**(7) : 27-58.

MANGUSON, J. J., AND J. G. HEITZ. 1971. Gill raker apparatus and food selectivity among mackerels, tunas, and dolphins. *Fish. Bull., U. S.* **69** ; 361-370.

MARCILE, J. AND B. STEQERT. 1976. Etude preliminaire de la croissance du lisato (*Katsuwonus pelamis*), *dens louert de l'ocean* Indian Tropical. *Cah. O.R.S.T.O.M. Ser. Oceanogr.*, **14**(2) : 139-151.

MATHEW, M. J. AND T. B. RAMACHANDRAN. 1956. Notes on the survey of fishing industry of the Laccadive and Aminidivi islands. *Fisheries Station Reports and Year Book*, Madras, 1954-55 : 125-137.

MATSUMOTO, T. 1937. An investigation of the skipjack fishery in the waters of Woleai, with notes on the bait situation at Lamotrek and Puluwat Is. (In Jap.) *S. Sea Fish. News* (Nanyo Suisan Joho) 3 : 2-6. (Engl. transl. *In* W. G. Van Campen (translator), 1951, Exploratory tuna fishing in the Caroline Islands. *U. S. Fish Wildl. Serv., Spec. Sci. Rep. Fish.* 46 : 35-42.

MATSUMOTO, W. M., R. A. SKILLMAN. 1984. Synopsis of biological data on skipjack tuna, *Katsuwonus pelamis* (Linnaeus). *U. S. Nat. Mar. Fish. Serv. NOAA Tech. Rep. NMFS SSRF*, 451, p 92.

MATSUMOTO, W. M. 1959. Descriptions of *Euthynnus* and *Auxis* larvae from the Pacific and Atlantic Oceans and adjacent seas. *Dana-Rep., Carlsberg Found.* 50, 34 p.

MATSUMOTO, W. M., T. K. KAZAMA AND D. C. AASHAD 1981. Anchored Fish Aggregating devices in Hawaiian waters. *Mar. Fish. Rev.*, **43** (9) : 1—13.

MOORE, H. L. 1951. Estimation of age and growth of yellowfin tuna (*Neothunnus macropterus*) in Hawaiian waters by size frequencies. U. S. Fish & Wildl. Serv., Fish. Bull., 52 : 133-149.

MORROW, J. E. 1954. Data on dolphins, yellowfin tuna and little tuna from East Africa. *Copeia*, 14-16 p.

MUNRO, I. S. R. 1955. *The Marine and Fresh Water Fishes of Ceylon.* Department of External Affairs, Canberra.

MUTHIAH, C. 1982. Drift gillnet fishery of Dakshina Kannada coast. *Mar. Fish. Infor. T. & E Ser.* No. 37 : 8-15.

MURDY, E. O. 1980. The commercial harvesting of tuna attracting Payayos : A possible boon for small scale fishermen. *ICLARM News letter*, 3(1) : 10-13.

NAKAMURA, H. 1936. The food habits of yellowfin tuna *Neothunnus macropterus* (Schlegel), from the Celebes Sea. *U. S. Fish and Wildlife Service, Spec. Sci. Rept. Fisheries*, **23** ; 1-8.

NAKAMURA, E. L., AND J. H. UCHIYAMA. 1966. Length-weight relations of Pacific tunas. *In* T. A. Manar (Editor), *Proceedings of the Governor's Conference on Central Pacific Fishery Resourecs*, pp. 197-201. State of Hawaii, Honolulu.

NAKAMURA, E. L., AND W. M. MATSUMOTO. 1967. Distribution of larval tunas in Marquesan waters. *U. S. Fish Wildl. Serv. Fish. Bull.* **66** : 1-12.

NAYAR, G. 1958. A preliminary account of the fisheries of Vizhinjam. *Indian J. Fish.*, **5** (1) : 32-55.

NOSE, Y., S. TOMOMATSU., K. MIMMARA, AND Y. HIYAMA. 1955. A method to determine the time of ring formation in hard tissues of fishes, especially for the age determination of Pacific tunas. *Rec. of Oceanog. Works, Japan*, n.s., **2**(3) : 9-18.

OMMANNE , F. D. 1953. The pelagic fishes. Note on tow nettings : Distribution of macroplankton, fish eggs and young fish. *In* Report on the Mauritius-Seychelles fisheries survey 1948-49. Part II. *G. B. Colon. Off. Fish. Publ.* **1**(3) : 58-104,

ORANGE, C. J. 1961. Spawning of yellowfin tuna and skipjack in the Eastern Tropical Pacific, as inferred from studies of gonad development. *Inter-Am. Trop. Tuna Comm., Bull* **5**(6) : 459-526.

OTSU, T., AND R. N. UCHIDA. 1959. Sexual maturity and spawning of albacore in the Pacific Ocean. *Fish. Bull.* U. *S.* **59**(148) : 287-305.

PAULY, D., AND N. DAVID. 1981. ELEFAN I. A basic program for the objective extraction of growth parameters from length-frequency data. *Meeres orschun.* **28**(4) : 205-211.

PINKAS, L., M. S. OLIPHANT, AND I. L. KEVARSON. 1971. Food habits of albacore, bluefin tuna and bonito in Colifornia waters.

PINKAS, L., M. S. OLIPHANT, AND I. L. KEVERSON. 1971. Food habits of albacore, bluefin tuna and bonito in California waters. *Calif. Dep. Fish Game, Fish Bull.* 152, 105 p.

PILLAI, P. P. 1981. Report on the analysis and evaluation of the fishery and biological data collected by the scientists from the CMFR Institute, Cochin, on board 'M. V. Prashikshani during Feb.-June, 1981. *News Letter, CIFNET*, I (2) : 6p.

PRESTON, G. 1982. The Fijian experience in the utilisation of fish aggregating devices. *Working Paper* 25, *Fourteen Regional Teehnical Meeting on Fisheries*, 64 p.

PRABHU, M. S. 1956. Maturation of intra-ovarian eggs and spawning periodicities in some fishes, *Indian J. Fish.* 3(1) : 59-90.

PRINDLE, B. 1981. Factors correlated with incidence of fish-bite on deepsea mooring lines. *WHOI*-81--57, Woods Hole, Massachusetts.

PRINDLE, B. AND R. G. WALDEN. 1976. Deep-sea line fishbite manual. *NOAA, National Data Bouy Office, Bay St. Louis, Mississipi.*

PUTHRAN, V. A. AND V. N. PILLAI. 1972. Pole and line fishing for tuna in the Minicoy waters. *Seafood Exp. Jour.*, 4 : 11-18.

RAJU, G. 1964a. Observations on the food and feeding habit of the oceanic skipjack, *Katsuwonus pelamis* (Linnaeus) of the Laccadive Sea during the year 1958-59. *Proc. Symp. Scombroid Fishes*, Part 2. *Mar. Biol. Assoc. India, Symp. Ser.* 1 : 607-625.

RAJU G. 1964b. Studies on the spawning of the oceanic skipjack, *Katsuwonus pelamis* (Linnaeus)in Minicoy waters. *Proc. Symp. Scombroid Fishes*, Part 2. *Mar Biol. Assoc. India. Symp. Ser.* 1 : 744/768.

RANADAE. M. R. 1961. Notes on the tuna and frigate mackerel from Ratnagiri. *J. Bombay Nat. Hist. Soc.*, 58 (2) : 351-354.

RAO, K. V. NARAYANA. 1964. An account of the ripe ovaries of some Indian tunas. *Prof. Symp. Scombroid Fishes*, Part 2. *Mar. Biol. Assoc. India., Symp. Ser.* 1 : 733-743.

RAO. K. V. NARAYANA., G. SYDA RAO., G. LUTHER, M. N. KESAVAN ELAYATHU. 1982. The emerging purse-seine fishery for anchovy (white bait) resources of the west coast of India. *Mar. Fish. Infor. Serv. T & E.* Ser. 36.

REINTJES, J. W., AND J. E. KING. 1953. Food of yellowfin tuna in the Central Pacific. U. *S. Fish Wildl. Serv., Fish. Bull.* 54 : 91/110.

ROBERT, W. H., AND V. E. BROCK. 1948. On the herding of prey and schooling of the black skipjack, *Euthynnus yaito* Kishinouye. *Pacific Science*, 2(4) : 297-298.

RODRIGUEZ-RODA, J. 1966. Estudio de la bacoreta, *Euthynnus alleteratus* (Raf.), bonito, *Sarda sarda* (Bloch) y melva, *Auxis thazard* (Lac.). capturados por las almadrabas espanolas (In Span, Eng. Summ.) *Inves. Pesq.* 30 ; 247/292.

RONQUILLO, I. A 1953. Food habits of tunas and dolphins based upon the examination of their stomach contents. *Philipp. J. Fish.* 2(1) : 71-83.

RONQUILLO I .A. 1963. A contribution to the biology of Philippine tunas *FAO Fish. Rep.* 6 : 1683-1752.

ROTHSCHILD, B. J. 1963. Skipjack ecology. *In* W. G. Van Campen (Editor), Progress in 1961-62. p 13-17. *U. S. Fish Wildl. Serv. Circ.* 163.

ROTHSCHILD B. J. 1967. Estimates of the growth of skipjack tuna (*Katsuwonus pelamis*) in the Hawaiian Islands. *Proc. Indo-Pac. Fish Counc.* 12 (Sect. 2) : 100-111.

SCHAEFER, M. B. 1948. Size composition of catches of yellowfin tuna (*Neothunnus macropterus*) from Central America, and their significance in the determination of growth, age, and schooling habits, *U. S. Fish Wildl. Serv. Fish. Bull.* 51 : 197-200.

SCHAEFER, M. B. 1961. Appendix A. Report on the investigations of the Inter-American Tropical Tuna Commissionn for the year 1960. (In Engl. and Span.) *Inter-Am. Trop. Tuna Comm. Bull Annu. Rep.* 1960 : 40-183.

SCHAEFER, M. B., B. M. CHATWIN, AND G. C. BROADHEAD. 1961. sTagging and recovery of tropical tunas, 1955-1959. *Inter-Am. Trop. Tuna Comm. Bull.* 5(5) : 343-416.

SCHAEFER, M. B., G. C. BROADHEAD, AND C. J. ORANGE. 1963. Synopsis on the biology of yellowfin tuna, *Thunnus albacares* (Bonnaterre), 1788 (Pacific Ocean). *FAO Fish. Rep.* 6(2) : 538-561.

SCHAEFER, M. B., AND J. C. MARR. 1948. Juvenile (*Euthynnus lineatus* and *Auxis thazard* from the Pacific Ocean off Central America. *Pac. Sci.* 2 : 262-271.

SERVENTY, D. L. 1956. Additional observations on the biology on the northern bluefin tuna, *Kishinoella tonggol* (Bleeker) in Australia. *Aust. J. Mar. Freshwat. Res.*, 7(1) : 44-63.

SHABOTINIETS, E. I. 1968. Opredelenie vozrasta tuntsov Indiiskogo okeana (Age determination of Indian Ocean tunas). (In Russ., *Tr. VNIRO* 64, *Tr. Azeher NIRO* 28 : 374-376. (Engl. transl) by W. L. Klawe. 1968. 5 p., *Inter-Am. Trop. Tuna Comm.*, La Jolla. Calif.)

SILAS, E. G. 1963. Synopsis of biological data on oriental bonito *Sarda orientalis* (Temminck and Schlegel) 1842 (Indian Ocean), *FAO Fish. Rep.* 6, 2 : 834-861.

SILAS E. G. 1964. Aspects of the taxonomy and biology of the oriental bonito *Sarda orientalis* (Temminck and Schlegel). *Proc. Symp. Scombroid Fishes*, Part 1. *Mar. Biol. Assoc. India. Symp. Ser.* 1 : 283-308.

SILAS, E. G. 1967. Tuna fishery of the Tinnevelly Coast, Gulf of Mannar. *Proc. Symp. Scombroid Fishes*, Part 3. *Mar. Biol. Assoc. India. Symp. Ser.* 1 : 1083-1118.

SILAS, E. G. 1969. Exploratory fishing by R. V. *Varuna*. *Bull. Cent. Mar. Fish. Res. Inst.* 12, 86 p.

SILAS, E. G. 1982. With rising energy cost, is there a future for deep sea operations in India ? or, would it be more prudent for us to concentrate on Aquaculture ? (Mim. Rep.) Key Note address, *International conference on deep sea fishing*, New Delhi, June 1982, 32 p.

SILAS, E. G., M. S. RAJAGOPALAN, AND P. PARAMESWARAN PILLAI, 1979. Tuna fisheries in India : recent trends. *Mar. Fish. Infor. Ser. T & E Ser.*, 13 ; 12 p.

SILAS, E. G. AND P. P. PILLAI, 1982. Resources of tunas and related species and their fisheries in the Indian Ocean. *CMFRI Bull.*, 32, 174 p.

SILAS, E. G., AND P. P. PILLAI, 1983. Tuna resources of the Indian seas—an overview. *Proc. Sympos. Harvest and Post-harvest Technol. Fish., Fish Technol.*, pp. 20-27 Cochin, India,

SILAS, E. G., AND P. P. PILLAI, 1984. Recent developments in National Tuna Fishery, an update for India. Proc. Ad-hoc Workshop on the *stock assessment of tuna in the Indo-Pacific Region*, IPTP, Jakarta, Aug., 1984, 18 p.

SILAS, E. G., P. PARAMESWARAN PILLAI, A. A. JAYAPRAKASH, AND M. AYYAPPAN PILLAI, 1984. Focus on small scale fisheries : Drift gillnet fishery off Cochin, 1981 and 1982. *Mar. Fish. Infor Ser. T & E Ser.*, 55 : pp. 1-12.

SIMMONS, D. C. 1969. Maturity and spawning of skipjack tuna (*Katsuwonus pelamis*) in the Atlantic Ocean, with comments on nematode infestation of the ovaries. *U. S. Fish Wildl. Serv. Spec. Sci. Rep. Fish.* 580, 17 p.

SIVASUBRAMANIAN, K. 1966. Distribution and length-weight relationship of tunas and tuna-like fishes around Ceylon. *Bull. Fish. Res. Stn. Ceylon* 19(1-2 : 27-46.

SIVASUBRAMANIAN, K. 1969. Occurrence of oriental bonito (*Sarda orientalis* Temminck and Schlegel) in the inshore waters of Ceylon. *Bull. Fish. Res. Stn. Ceylon*, 20(1) : 73-77.

SIVASUBRAMANIAN, K. 1973. Co-occurrence and the relative abundance of narrow and broad corseletted frigate mackerels *Auxis thazard* (Lacepede) and *Auxis rochei* (Risso), around Ceylon. *In Proceedings of the Symposium on Living Resources of the Seas Around India*, p. 537-547. Cent. Mar. Fish. Res. Inst., Cochin.

SIVASUBRAMANIAN, K. 1985. The tuna fishery in the EEZs of India, Maldives and Sri Lanka. BOBP/WP/31, 19-47.

SKILLMAN, R. A. (MS). Estimates of von Bertalanffy growth parameters for skipjack tuna, *Katsuwonus pelamis* from capture-recapture experiments in the Hawaiian Islands. *South-west Fish. Centre, Honolulu Lab.*, NMFS, NOAA, Honolulu.

SMITH, B. R. 1977. Appraisal of the live-bait potential and handling characteristics of the common tuna bait species in Papua New Guinea. *In* R. S. Shomura (Editor), *Collection of Tuna Baitfish Papers*, p. 95-103. *U. S. Dep Commer.* NOAA Tech. Rep. NMFS CIRC. 408.

SRINATH, M. 1986. Handbook of working methods for estimating mortality rates of exploited fish stocks (MS.)

STEQUERT, B. 1976. Estude de la maturite sexuelle, de la ponte et de la fecendite du listao (*Katsuwonus pelamis*) de la cote nord-ouest de Madagascar. (A study of sexual maturity, the fertility and spawning of the skipjack (*Katsuwonus pelamis*) of the north-west coast of Madagascar.) (*In Fr., Engl.*, abstr.) Cah. O.R.S.T.O.M., Ser. Oceanogr. **14** : 227-247.

SUDA, AKIRA, S. KUME, AND T. SHIOHAMA. 1969. An indicative note on the role of thermocline as a factor controlling the long-line fishery ground for bigeye tuna. *Bull. Far seas Fish. Res Lab.*, **1** ; 99-114.

SURESH, K., AND M. P. M. REDDY 1980. Variations in oceanographic factors and the possible relation to fluctuations in oil sardine and mackerel catches off Mangalore. *Indian J. Fish.* **27**(1&2) : 1-9.

SUZUKI, Z. 1971. Comparison of growth parameters estimated for the yellowfin tuna in the Pacific Ocean. *Far. Seas Fish. Res. Lab., Bull.*, **5** : 89-105.

TAN, H., Y. NOES, AND Y. HIYAMA. 1965. Age determination and growth of yellowfin tuna, *Thunnus albacares*, Bonnaterre. *Bull. Jap. Soc. Sci. Fish.*, **31**(6) : 414-422.

TESTER, A. L., AND I. NAKAMURA. 1957. Catch rate, size, sex, and food of tunas and other pelagic fishes taken by trolling off Oahu, Hawaii, 1951-55. *U. S. Fish Wildl Serv., Spec. Sci. Rep. Fish.*, **250**, 25 p .

THOMAS, P. T. 1964a. Food of *Katsuwonus pelamis* (Linnaeus) and *Neothunnus macropterus* (Temminck and Schlegel) from Minicoy waters during the season 1961-62. *Proc. Symp. Scombroid Fishes.*, Part II. *Mar. Biol. Assoc. India, Symp. Ser*, **1** : 626-630.

THOMAS, P. T. 1964b. A study on the fluctuations in the occurrence of major tuna live-bait fishes of Minicoy. *Proc. Symp. Scombroid Fishes.* Part II. *Mar. Biol. Assoc. India.* pp. 681-690.

UCHIDA, R. N., AND R. F. SUMIDA. 1971. Analysis of the operations of seven Hawaiian skipjack tuna fishing vessels, June-August 1967. *U. S. Dep. Commer., Natl. Mar. Fish. Serv. Spec. Sci. Rep. Fish.* 629, 25 p.

UCHIYAMA, J H., AND P. STRUHSAKER. 1981. Age and growth of skipjack tuna, *Katsuwonus pelamis*, and yellowfin tuna *Thunnus albacares*, as indicated by daily growth increments of sagittae. *Fish. Bull.*, U. S. **79** ; 151-162.

UDA, M. 1983. Types of Skipjack schools and their fishing qualities. *Bull. Jap. Soc. Sci. Fish.*, **2** : 107-111.

VAN PEL, H. 1960. Report on the sea fisheries of Western Samoa. *South Pac. Comm.*, Noumea, New Caledonia, 24 p.

VARGHESE, G. 1970. Comparative merits of mechanised boats over non-mechanised boats on oceanic skipjack tuna live-bait fishery. *Seafood Exp. Jour.*, **3** ; 115-121.

VARGHESE, G. 1982. Tuna rich Lakshadweep. *Fishing chimes*, Ann. Number, 1982, 70-72.

VARGHESE, K. K., M. E. JOHN, AND V. SIVAJI, 1984. Some observations on the tuna resources of the Indian Ocean. *Fishery Survey of India, Bull.*, **13** : 30-33.

WADE, C. B. 1950. Juvenile forms of *Neothunnus macropterus*, *Katsuwonus pelamis* and *Euthynnus yaito* from Philippine seas. *U. S. Fish Wildl. Serv., Fish. Bull.* **51** : 398-404.

WALDRON, K. D. 1963. Synopsis of biological data on skipjack *Katsuwonus pelamis* (Linnaeus) 1758 (Pacific Ocean), *FAO Fish. Rep.* 6(2) : 695-748.

WANKOWSKI, J. W. J. 1981. Estimated growth of surface-schooling skipjack tuna, *Katsuwonus pelamis* and yellowfin tuna. *Thunnus albacares*, from the Papua New Guinea region. *Fish. Bull., U. S.* **79**(3) : 517-531.

WATANABE H. 1958. On the difference of stomach contents of the yellowfin and bigeye tunas from the western equatorial Pacific, *Rept. Nankai Rep. Fish. Lab.*, **7** ; 72-81.

WATANABE, H. 1960. Regional differences in food composition of the tunas and marlins from several oceanic areas. *Rept. Nankai Reg. Fish. Lab.*, **12** ; 75-84.

WEBER, M., AND L. F. DE BEAUFORT. 1951. *The Fishes of the Indo-Australian Archipelago*. 9. Leiden, 484. p. 89 figs.

WELSH, J. P. 1949. A preliminary study of food and feeding habits of Hawaiian Kawakawa, mahimahi, ono, aku and ahi, *Hawaii Div. Fish and Game, Fish. Prog. Rept.* 1(2) : 1-26 (*In* Fish and game, Spec. Bull., **2**. 1950.

WELSH J.P. 1950. A preliminary report of the Division of Fish and Game bait program. Part I. Summary of field work with special reference to Hilo Harbor nehu scarcity. *Spec. Bull.* 2 *Hawaii Div. Fish Game, Board Agric. For., Fish. Prop. Rep.* 1(0), November 15th 1949, 25 p.

WHITE, T., AND M. YESAI, 1982. The status of tuna fisheries in Indonesia and Philippines. FAO Indo-Pacific Tuna development and Management Programme. IPTP/82/WP/3. SCS/82/WP/112 : 62 p.

WHITLEY, G. P. 1964. Scombroid fishes of Australia and New Zealand. *Proc. Symp. Scombroid Fishes*, Part I. *Mar. Biol. Assoc. India. Symp. Ser.***1** ; 221-253.

WILD, A., AND T. J. FORBMAN. 1980. The relationship between otolith increments and time for yellowfin and Skipjack tuna marked with tetracycline. (In Engl., and Span.) *Inter-Am. Trop. Tuna Comm. Bull.* **17** ; 509-560.

WILLIAMS, F. 1956. Preliminary survey of the pelagic fishes of East Africa. G. B. Colon. Off. Fish. Publ. 8, 68 p.

WILLIAMS, F. 1963. Synopsis of biological data on little tuna *Euthynnus affinis* (Cantor) 1850 (Indian Ocean). *FAO Fish Rep.* 6 : 167-179.

WILLIAMSON, G. R. 1970. Little tuan *Euthynnus affinis* in the Hongkong area. *Bull. Jpn. Soc. Fish.* 36 ; 9-18.

WILSON, P. T. 1963. The past, present and future status of the tuna resources of the Trust Territory of the Pacific Islands. *In* H. Rosa, Jr. (Editor), *Proc. World. Sci. Meet. Biol. Tunas Related species*. La Jolla, Calif., U.S.A., 2-14 July 1962, p. 1633-1638. FAO Fish. Rep. 6,3.

WILSON P. T. 1971. Truk live bait survey. *U. S. Dep. Commer., NOAA, Tech. NMFS* CIRC—353, 10 p

WILSON P.T. 1977. Observations on the various tuna bait species and their habitats in the Palau Islands. *In* R. S. Shomura (editor) *Collection of tuna baitfish papers*, p. 69-74. *D. S. Dep. Commer., NOAA Tech Rep. NMFS CIRC*, 408.

WOOD, H. 1930. Scottish herring shoals. Prespawning and spawning movements. *Scotland Fish. Bd. Sci. Investt* ; 1-71.

YABE, H. 1954. A study on spawning of skipjack in the Satsunan Sea area. *In* General view of fishery science, Tokyo (In Jpn.) Jpn. Assco. Adv. Sci. 181-199. (Engl. transl. by G. Y. Beard, 1959, 9 p. : in files of *Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu*, HI 96812)

YABE, H., S. UEYANAGI., S. KIKAWA, AND K. WATANABE. 1958, Young tunas found in the stomach contents. *Rept Nankai Res Fish Res. Lab.*, 8 ; 31-48.

YABUTA, Y., AND M. YUKINAWA. 1957. Age and growth of yellowfin tuna (*Neothunnus macropterus*) in Japanese waters by size frequencies. *Rept. Nankai Rep. Fish. Res. Lab.*, 5 : 127-133.

YABUTA Y., AND M. YUKINAWA 1959. Growth and age of yellowfin tuna (*Neothunnus macropterus*) in the equatorial Pacific. Study of length frequency distribution—I. *Nankai Reg. Fish. Res. Lab. Res.*, 11 ; 77-87.

YABUTA, Y., M. YUKINAWA, AND Y. WARASHINA. 1960. Growth and age of yellowfin tuna. Age determination (Scale method), *Rept Nankai Reg. Fish. Res. Lab.*, 12 ; 63-74.

YASUI M. 1975. Some observations on the frigate mackerel which migrates into Japanese coastal waters. (In Jpn.) Proceedings of the 1974 Tuna Research Conference, Shimizu, Japan, February 4-6, 1975, p. 219-225. Fish Agency, Far Seas Fish. Res. Lab.

YESAKI, M. 1983. Observations on the biology of yellow in (*Thunnus albacares*) and skipjack (*Katsuwonus pelamis*) tuna in the Philippine waters. IPTP/83/WP/7. SCS/83/WP/119. 66 p.

YOIOIA, T., M. TORITAYA, F. KANA, AND S. NOFFRA 1961 Studies on the feeding habit of fishes. (In Jpn.) *Rep. Nankai Reg. Fish. Res Lab.* 14 ; 1-234.

YOSHIDA H. O., AND E.L. NAMIALURA. 1965. Notes on schooling behaviour, spawning and morphology of Hawaiian frigate mackerels, *Auxis thazard* and *Auxis rochei. Copeia*, 1965 : 111-114.

YOSHIDA, H. O. 1966. Skipjack tuna spawning in the Marquesas Islands and Tuamotu Archipelago. *U. S. Fish Wildl. Serv., Fish. Bull.* 65 ; 479-488.

YOSHIDA, H O. 1971. The early life history of skipjack tuna, *Katsuwonus pelamis*, in the Pacific Ocean. *Fish. Bull., U.S.* 69 ; 545-554.

YOSHIDA, H. O., N. UCHIDA, AND T. OTSU. 1977. The Pacific tuna pole and line and live bait fisheries *In* R. S. Shomura (Editor) *Collection of tuna bait fish papers*. p. 36-51. *U. S. Dep. Commer. NOAA Tech. Rep.* NMFS CIRC. 408.

YUEN, H. S. H. 1955. Maturity and fecundity of bigeye tuna in the Pacific. *U. S. Fish Wildl. Serv. Spec. Sci. Rep.*, 150, 30 p,

YUEN, H. S. H. 1977. Desired characteristics of a bait for skipjack tuna, *Katsuwonus pelamis*. *In* R. S. Shomura (Editor), Collection of tuna bait-fish papers, p. 52-54. *U.S. Dep. Commer., NOAA Tech. Rep.* NMFS CIRC. 408.