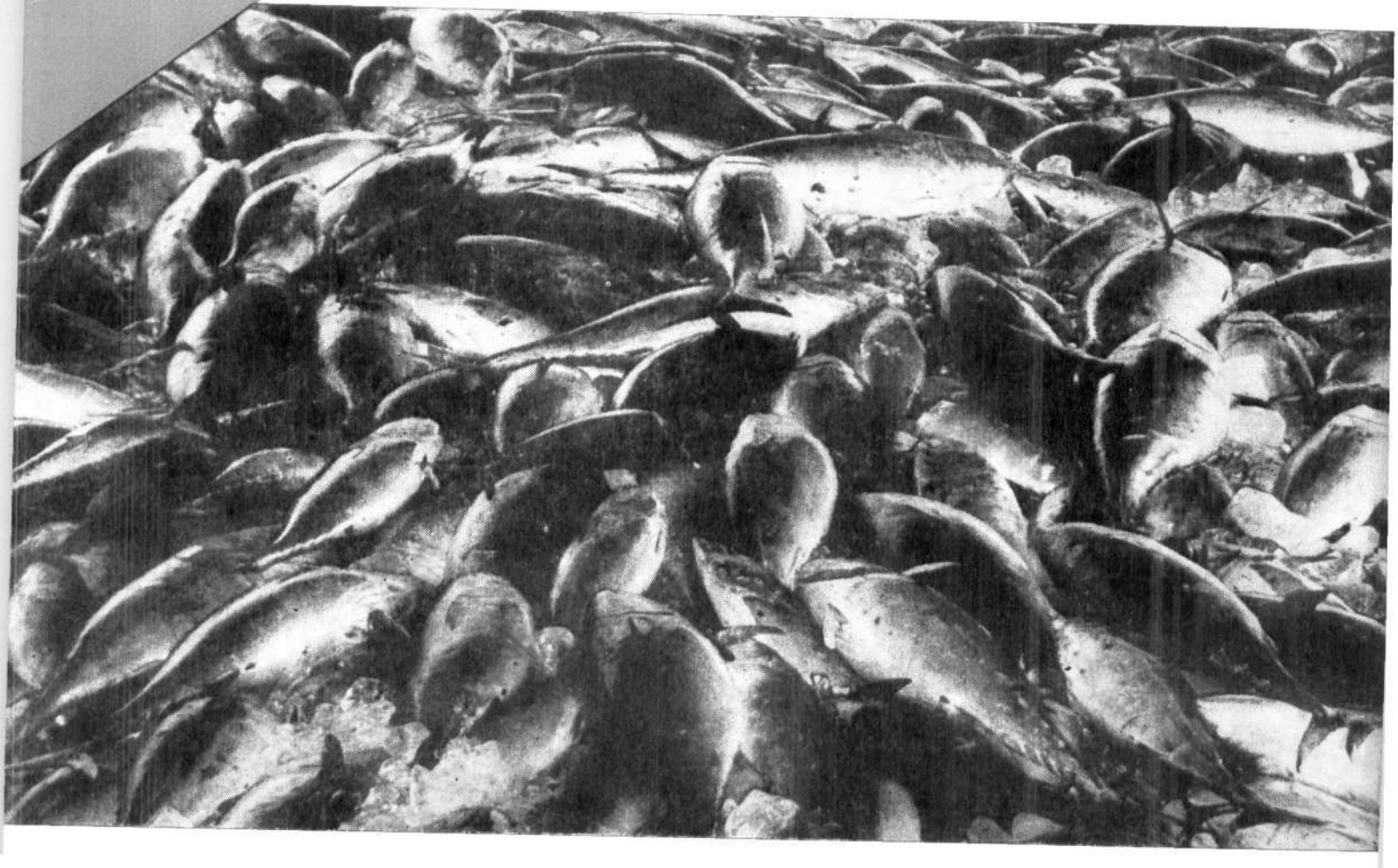
CMFRI
bulletin 36

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

6

FISHERY AND BIONOMICS OF TUNAS AT VIZHINJAM

P. P. PILLAI AND P. S. SADASIVA SARMA
Central Marine Fisheries Research Institute, Cochin-682 031

Vizhinjam (76°59'E, 8°22'N) is an important fish landing centre owing mainly to its location which affords facilities for operation of boats even during the monsoon season and accessibility to the nearby markets. With the Fisheries Harbour construction underway, the fisheries importance of this area is bound to increase further. Details of common nets employed in the centre and the modes of their operations were described earlier by Nayar (1958), Bennet (1967) and Luther *et al.* (1982). Rao (1964) described the ripe ovaries of some Indian tunas from Vizhinjam and summarised that *E. affinis*, *A. thazard* and *S. orientalis* spawn in the local waters from April to September and possibly in other months of the year. According to him, the spawn ripe individuals of the above three species indicate the existence of an important spawning ground for them off Vizhinjam.

FISHING AREA

Fishing area for tunas and allied fishes extends from Valia veli in the north to Kollengode in the south within the 40-80 m depth zone (Fig. 1). This area is influenced considerably by the SW and NE monsoons and upwelling, and the concomitant changes in the hydrographical features. Divakaran *et al.* (1983) described the plankton production in the Vizhinjam inshore waters and indicated the availability and abundance of different groups of zooplankton groups in this area.

CRAFTS AND GEARS

At Vizhinjam tunas are mainly caught in the drift gillnets, and hooks and lines. In certain months, shoals of coastal species of tunas come so close to the shore that they are captured in the shore seines operated in the fore-shore waters.

About 60% of the total tuna landings is by the drift gillnets and the rest by the hooks and lines. Both mechanised and non-mechanised crafts are engaged in the operation of both the gears. The tuna landings by other gears such as shore seines and Konchuvala (gillnet) are insignificant.

The crafts used are catamarans and dugout canoes. Four pieces of logs of 6.3 m length are tied together

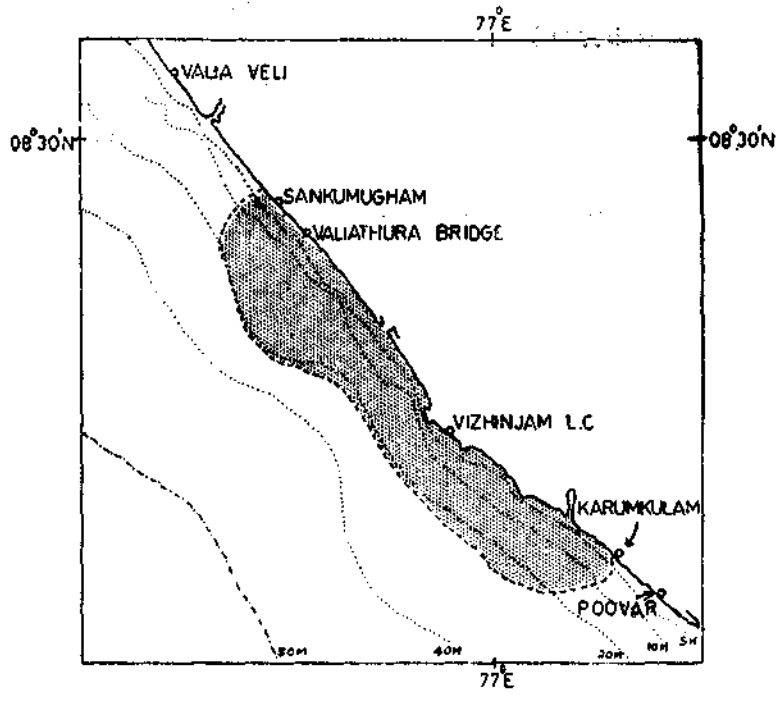


Fig. 1. Operational core area of drift gillnetters and hooks and line fishery at Vizhinjam.

to form one catamaran unit and three fishermen operate one unit. The canoes are dugout, carved from a single log and it has a length of 8 m and depth of 1 m and 3-4 fishermen operate these canoes. Usually drift gillnet operation is suspended during the monsoon months. Of late, mechanised boats of 7.9 m OAL and 16-40 HP are also employed in the fishery.

Drift gillnets are made of nylon yarn. The stretched mesh size is 5-10 cm. The nylon twine has completely replaced cotton and hemp twine as net making materials. The net is preserved by dipping it in a concoction prepared by boiling tamarind in water.

The drift gillnet fishermen leave the shore for fishing by 1600 hrs and they sail in a north by north-west direction. They take 2-3hrs to reach the fishing ground. Generally two hauls are made and the soaking time vary between 2-3 hrs. They return to the shore by about 0600-0800 hrs the next day. The fish catches are auctioned and taken to different markets.

Hooks and line fishery employ longline (choonda) and small hooks (achil). In the longline, fishermen use hooks of size No. 4 and 9 in varying numbers and the line used is nylon (Kangoos). Achil has hooks of size No. 16 and no bait is used. The area of operation is the same for the drift gillnet fishery in a little farther off. The craft used in this fishery is catamaran and manned generally by two fishermen. They leave the shore by 0600 hrs and return at about 1400-1800 hrs. Now a days, catamarans fitted with *Yamaha* outboard engines (8 HP) are popular among the fishermen. The fuel used is diesel and kerosine mixed in equal proportions.

Effort, catch and CPSE

The average standard effort for the period 1979-1982 was 3060 units and the average catch was 258 tonnes of tunas (Fig. 2).

In 1979, maximum standard effort expended was in May (10120 units) and minimum in July. The catch recorded a maximum of 122 tonnes in October with CPSE at 44.50 kg, although during April and July, it was 12.2 kg and 17.0 kg respectively. In 1980, the effort expended was maximum (11,647 units) in June and catch was also highest in that month (207 tonnes) As in the case in 1979, the CPSE in 1980 was highest in October (44.5 kg). In 1981, maximum effort put in was in September (6667 units), but the catch was at its peak in May (147 tonnes), and maximum CPSE was also in May (33.2 kg) with a secondary maximum in November (13.8 kg). In 1982, 12,864 units were in operation in October and the maximum catch recorded was in May (64 tonnes) and maximum CPSE of 27.1 kg was recorded in September.

Based on the pattern of fluctuations in CPSE in the tuna fishery at Vizhinjam, it is observed to be irregular, showing peaks in the monsoon, pre-monsoon and post-monsoon months during the period under report.

Species composition

E. affinis and *A. thazard* were represented in the catches throughout the year. But for *A. rochei, S. orientalis, T. albacares* and billfishes definite periodicity was observed. *A. rochei* appeared in the fishery during pre-monsoon months, *S. orientalis* during pre-and post-monsoon months and *T. albacares* and billfishes during the pre-monsoon months.

In 1979, *E. affinis* contributed to 51.6% and *S. orientalis* and *A. thazard* 27.5% and 14.8% respectively of the total catch (Fig. 3). The percentage composition of *E. affinis* increased during the years 1980, '81 and '82 (55.0%, 68% and 71.6%) while that of *S. orientalis* showed a decreasing trend in these years, their share being 9.8%, 3.1% and 1.2% respectively of the total catch. *A. thazard* constituted 18-20% and billfishes 3-4% of the total catch in all these years.

Length distribution

The data on Length frequency distribution is available for *E. affinis* and *A. thazard* for the years 1981 and 1982 (Figs. 4 & 5).

Annual pooled length distribution of *E. affinis* indicate that in 1981 the major modes were at 26, 38 and 50 cm. A minor mode was present at 58 cm. In 1982, the major modes were at 30, 34, 50 and 58 cm. With regard to *A. thazard* the annual pooled length distribution evinced a biomodal peak in 1981 and 1982 at 30 and 34 cm (Fig. 6).

Monthly variation in size distribution is presented in Figs. 5 and 6, for the two species for the years 1981 and 1982. In 1981 *E. affinis* occurred in the 22-72 cm size group. The major modes increased from January and during August smaller individuals with a peak at 26 cm was recorded. Further increase in the modal classes was evident from September onwards, In 1982, major modes were around 34 and 50 cm. *A. thazard* occurred in the size range 22-50 cm in 1981 and their major modes were around 28, 34, 40 and 42 cm. In 1982, from February to May, modal progress was clearly perceptible and during September, November and December their modes were at 30-32 cm size group.

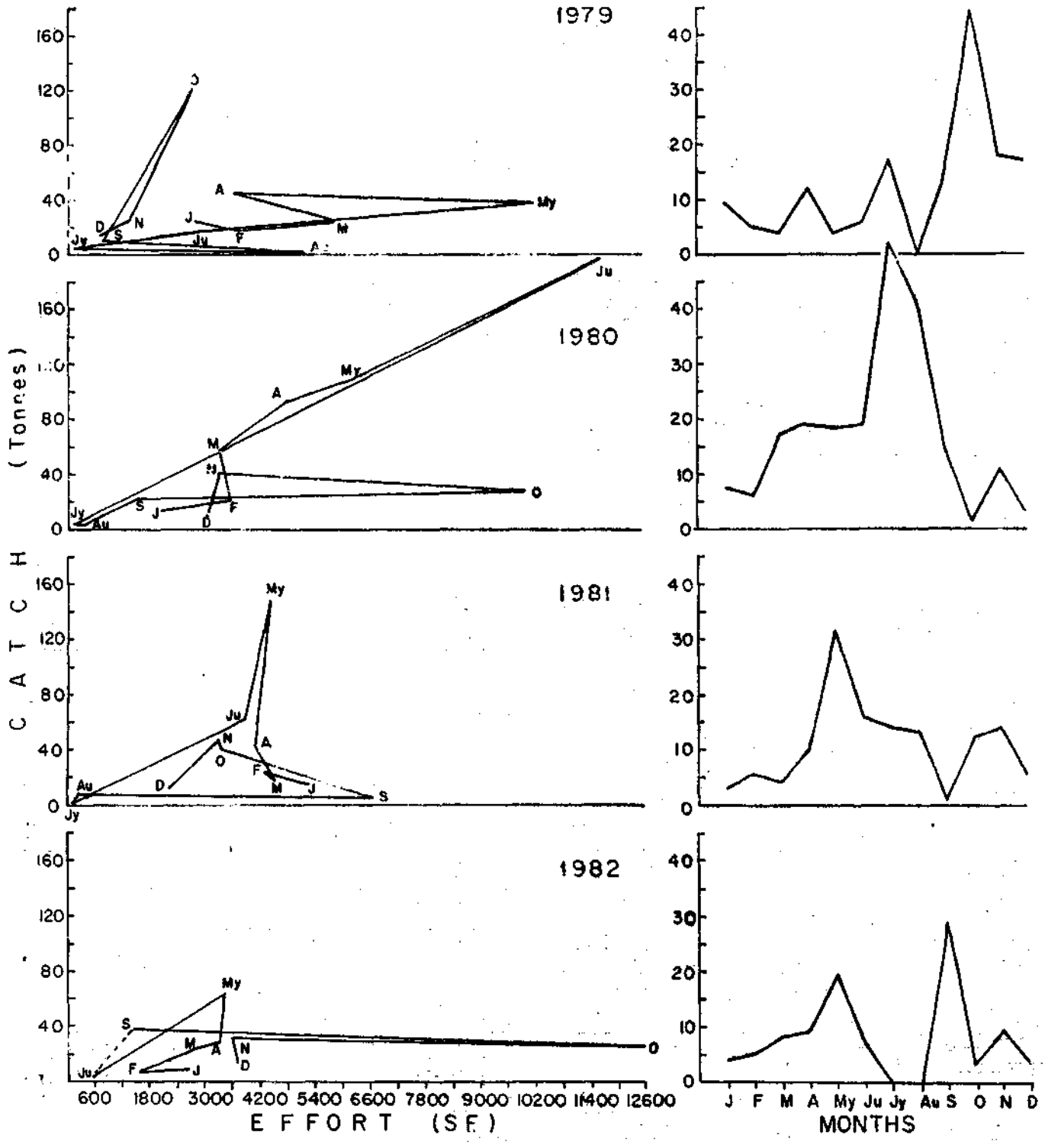


Fig. 2. Catch-standardized effort relationship of tunas at Vizhinjam, 1979-'82.

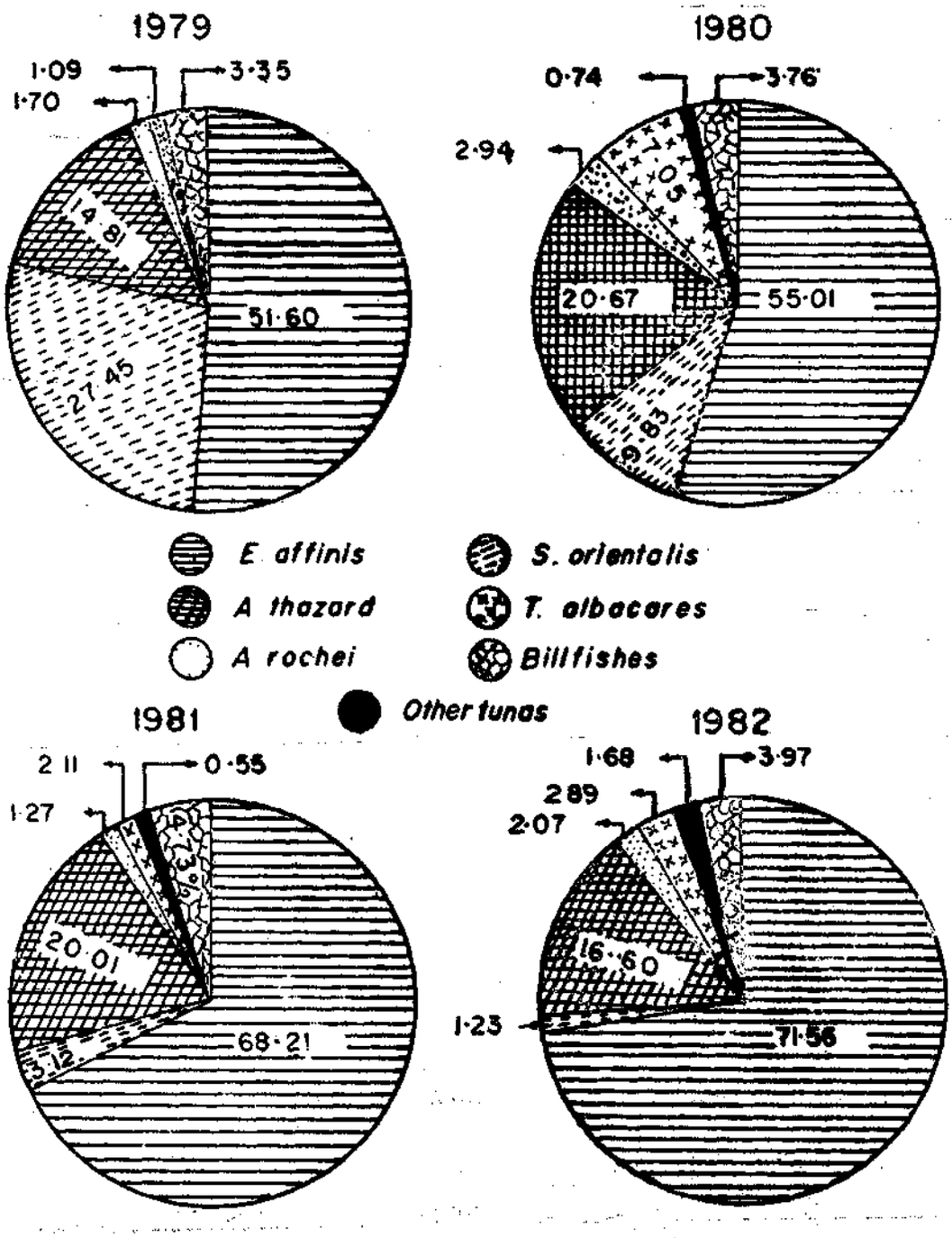


Fig. 3. Percentage composition of different species of tunas and bill-fishes at Vizhinjam, 1981-'82.

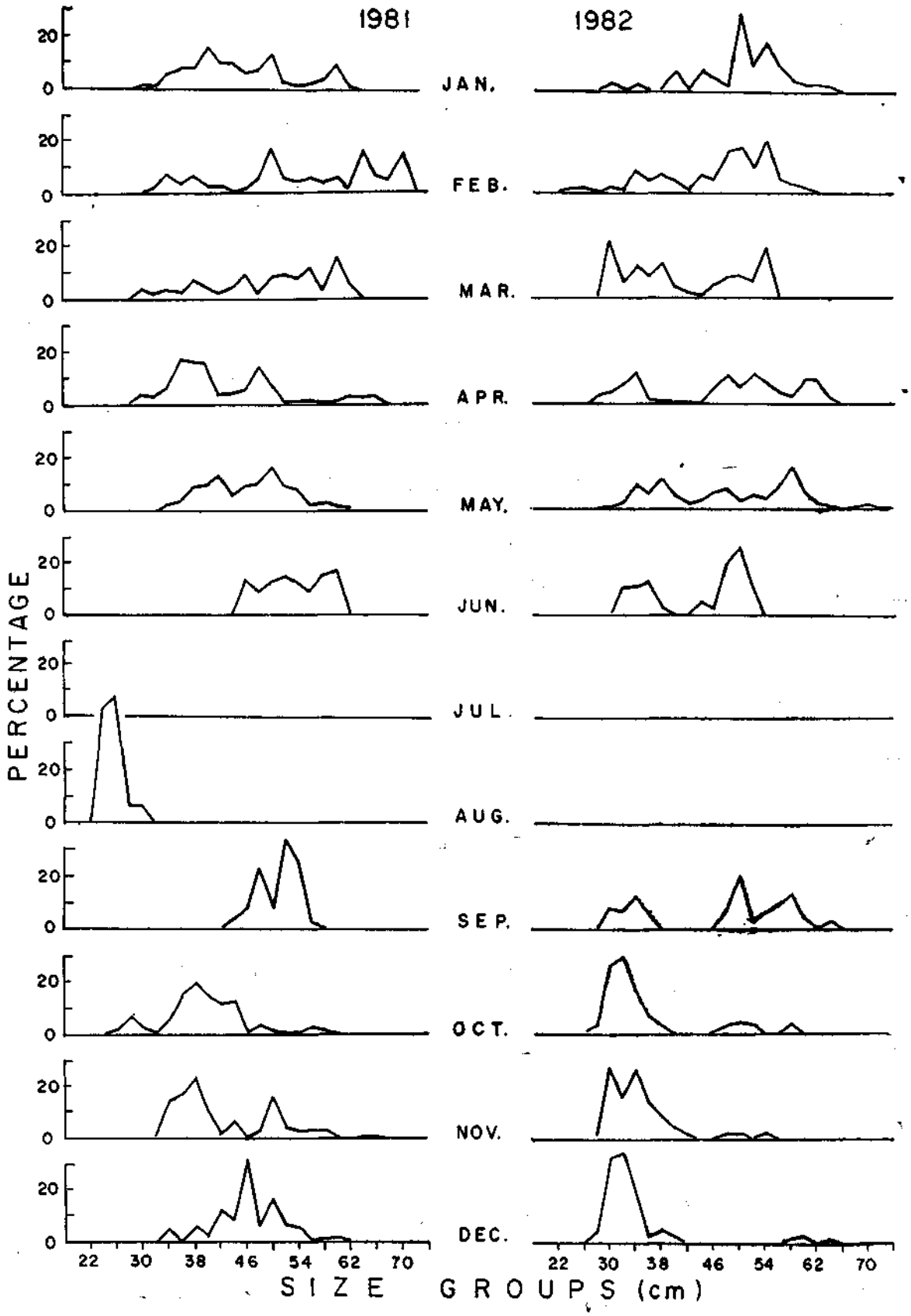


Fig. 4. Monthly length frequency distribution of *E. affinis* at Vizhinjam, 1981-'82.

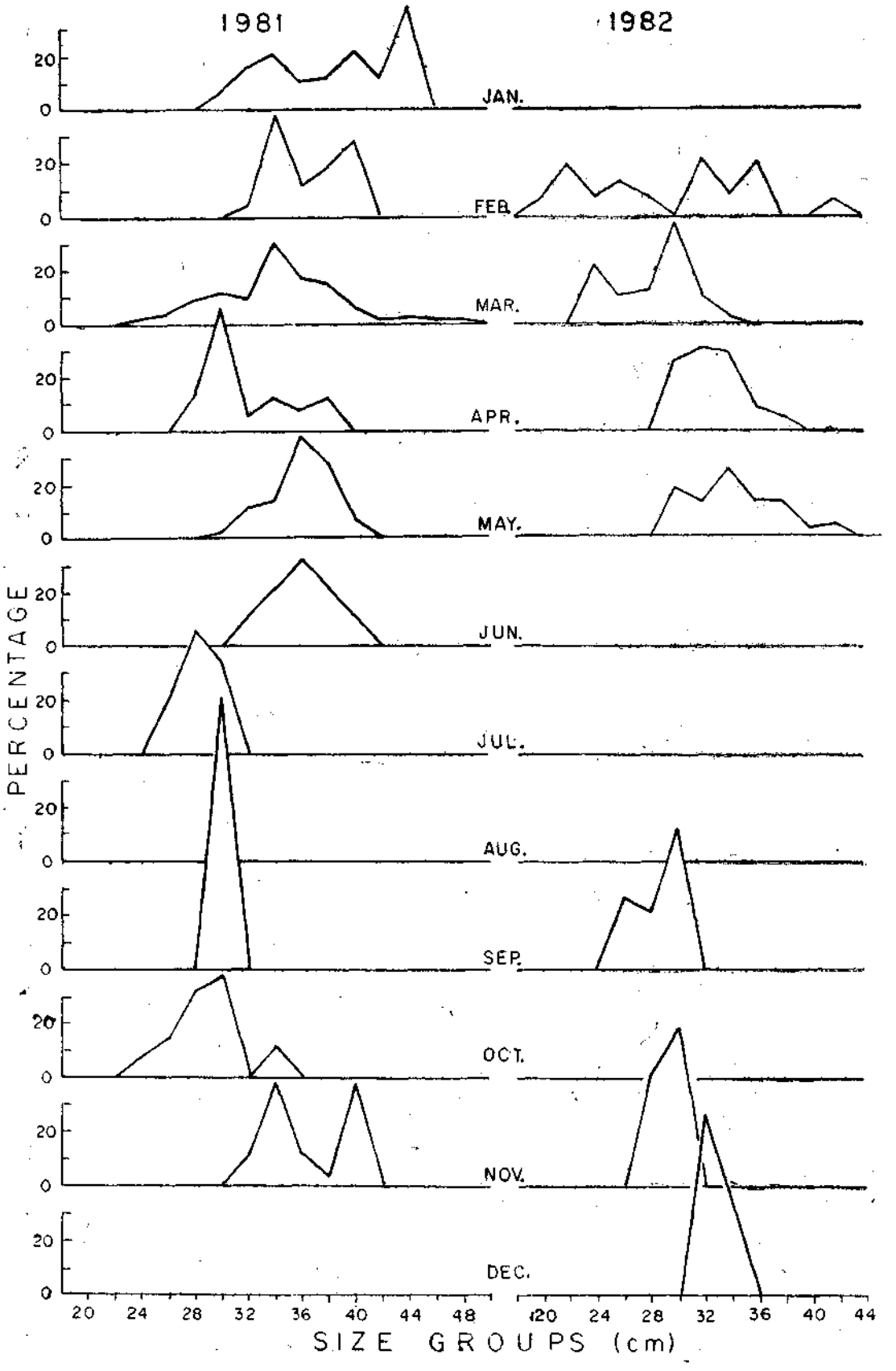


Fig. 5. Monthly length frequency distribution of *A. thazard* at Vizhinjam, 1981-'82.

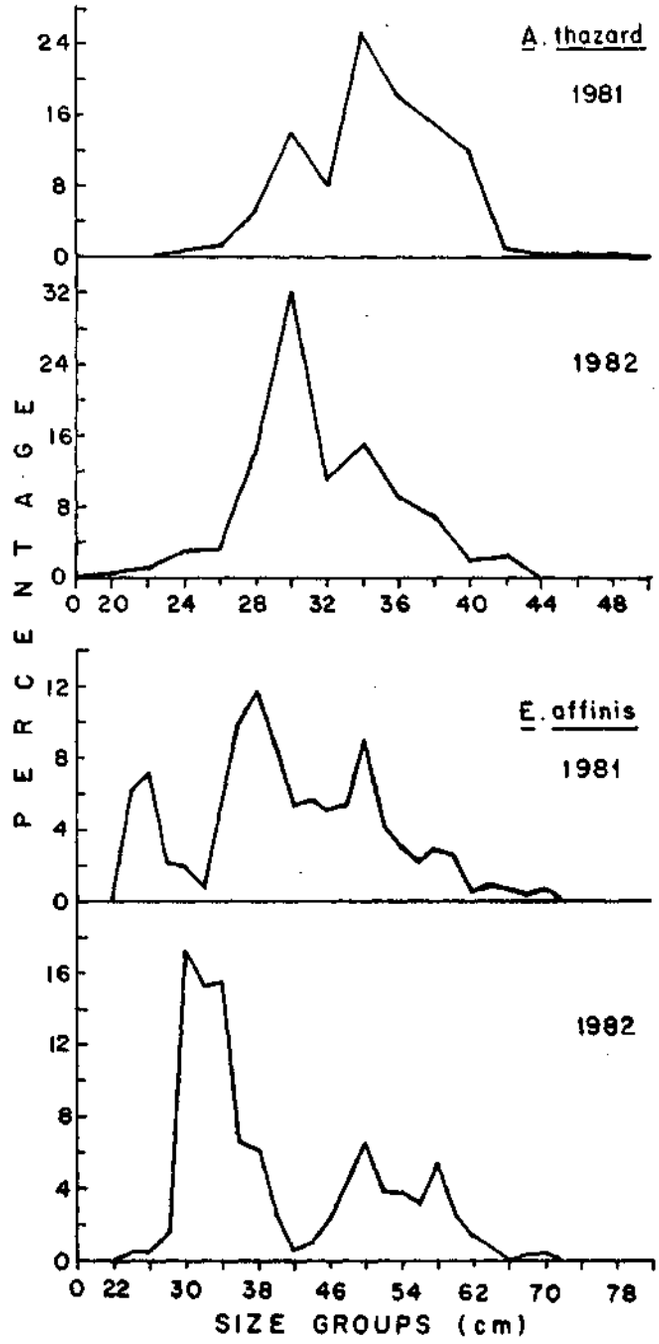


Fig. 6. Pooled annual length frequency distribution of *A. thazard* and *E. affinis* at Vizhinjam, 1981-'82.

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.