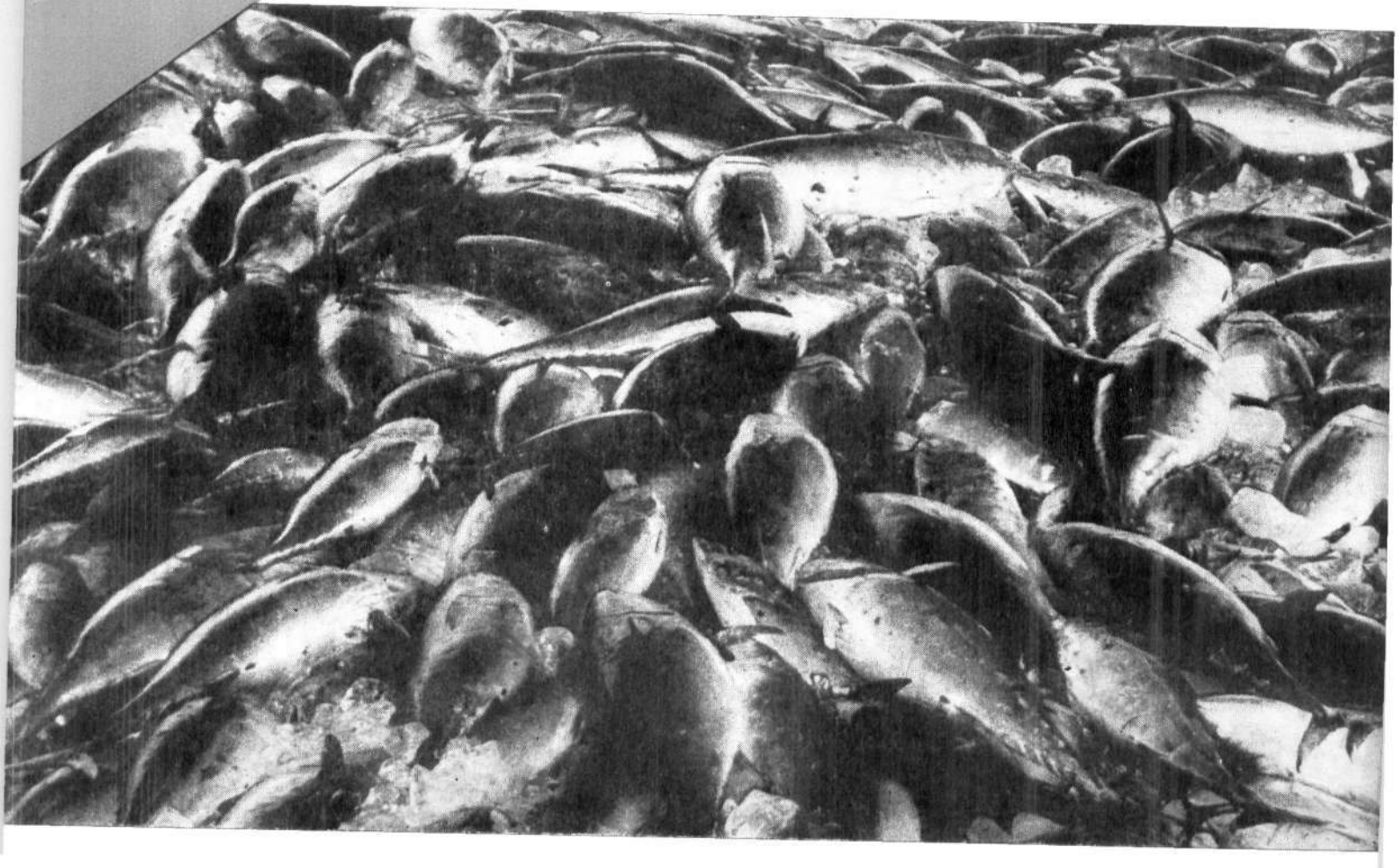
CMFRI
bulletin 36

JUNE 1985

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

Edited by : E. G. SILAS



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LENGTH-WEIGHT RELATIONSHIP OF SKIPJACK, *KATSUWONUS PELAMIS* (LINNAEUS) AND YELLOWFIN TUNA *THUNNUS ALBACARES* (BONNATERRE) FROM MINICOY WATERS

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One of the major objectives of the research programme on tunas at Minicoy Island, is to collect data on length frequency distribution of skipjack, *Katsuwonus pelamis* and yellowfin tuna *Thunnus albacares* which are caught by pole and line fishing. In order to utilize these length frequency data and to convert catch data from kilograms to number of fish for the purposes of estimating average weights and the population sizes, it becomes essential to estimate the length-weight relationship of these species.

1. SKIPJACK TUNA

Data on length and weight of skipjack were collected from Minicoy fish landing centre during 1981-1982. Fish were measured and weighed in fresh condition. Fork length was measured in millimetres and weight was recorded to the nearest 50 grams. Sex and maturity stages of individual fish were also recorded.

Length-weight relationship of each fish is expressed by the formula

$$W = aL^b$$

where W = weight, L = length and a and b are constants. Logarithmic transformation of the formula gives a straight line relationship of the form

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

Log a and the regression coefficient (b) were estimated by the least square method. Through analysis of covariance procedure, the coefficient of determination r^2 and the residual mean squares or variance and M.S. were also computed for each regression equation.

A total of 440 fish, of which 220 were males were analysed for this study. Males ranged in fork length from 360 to 660 mm and the 220 females from 360 to 670 mm. The following basic statistics were estimated from the logarithmic lengths and weights for deriving the regression equations separately for the males, females and both sexes combined.

Statistics	Groups		Both sexes combined
	Males	Females	
N ..	220	220	440
sx ..	592.111743	594.437869	1186.549612
sy ..	732.061668	738.150002	1470.211670
sx^2 ..	1594.342638	1606.690249	3201.032887
sy^2 ..	2444.776084	2483.485438	4928.261522
sxy ..	1972.709421	1996.291708	3969.001129

sx, sy = Sums of x and y; sx^2, sy^2 and sxy = Sums of squares and products.

Corrected sums of squares and products as well as the estimates of regression coefficient b and standard error for males, females and both sexes combined are as follows :

Statistics	Groups		Both sexes combined
	Males	Females	
D.F. ..	219	219	438
sx^2 ..	0.72304	0.5248	1.2479
sxy ..	2.4262	1.8175	4.2437
sy^2 ..	8.8020	6.8294	15.6264
b ..	3.355656	3.462785	3.39301
D.F. ..	218	218	437
S.S. ..	0.66079	0.53057	1.19486
M.S. ..	0.0030	0.0024	0.0027
S.E. ..	0.6473	0.6804	0.0466

D.F. = Degree of freedom;
sx^2, sy^2 and sxy = Corrected sums of squares and products;
b = Regression coefficients;
S.S. = Sum of squares;
M.S. = Mean squares;
S.E. = Standard error of regression coefficients.

By using the above statistics following relationship for males and females separately was obtained.

Males $\quad \text{Log } W = -5.70392 + 3.35566 \text{ Log } L$

Females $\quad \text{Log } W = -6.00119 + 3.46279 \text{ Log } L$

which is equivalent to

Males $\quad W = 0.00000198\ L^{3.35566}$

Females $\quad W = 0.000001\ L^{3.46279}$

The value of 'r' which is a measure of the degree of association between the L and W (Correlation coefficient) for males was 0.961743 and for females 0.968386. The coefficient of determination r^2 which is the proportion of the variation in W explained by the fitted regression and square root of this quantity, for the males was 0.9249 and for females 0.92227.

The result of analysis of covariance to test the significance of differences in the regressions of y and x are presented below :

Source of variation	Degree of freedom	Sum of squares	Mean squares	Observed F	5% F
Deviation from individual regression within sexes ..	436	1.19136	0.00273	1.28208*	3.92-3.84
Differences between regression ..	1	0.00350	0.00350		
Deviation from average regression	437	1.19486	0.00273		

* Not significant.

From the table it becomes clear that there is no significant difference in the regression coefficient between males and females. Even in the adjusted means also, no significant difference could be observed. Therefore, the data for both males and females were pooled together and a common length-weight relationship was fitted.

$$\text{Log } W = -5.80855 + 3.39301 \text{ Log } L$$

which is equivalent to

$$W = 0.00000155\ L^{3.39301}$$

The regression lines for males and females and for both sexes combined are shown in Fig. 1 & 2.

In the report by Chatwin (1959) a very low exponential value of 2.626 was obtained for skipjack from off northern Chile area. It was pointed out by him that the estimate was based on two samples of fish with a very narrow range of total lengths which was not representative of the range in the catch. He emphasized that it would be desirable to obtain a further estimate based on a larger range of total length. Hennemuth (1959) calculated regression coefficient value from 3.144 to 3.555 based on 1280 fish with length range from 414 to 697 mm in different areas of the Eastern Pacific Ocean north of the equator. The total pooled regression equation by him was :

$$Y = -8.250 + 3.336\ X$$

Nakamura and Uchiyama (1966) found the value of b to be 3.36836 from the Central Pacific Ocean. Batts (1972) calculated the length-weight relationship for 644 skipjack from North Carolina waters. Fish length in his studies ranged from 263 to 757 mm while weights were from 0.29 to 9.73 kg. He calculated the value of regression coefficient to be 3.3533 and noticed that this value agreed well with length-weight relationship of skipjack reported by Nakamura and Uchiyama (1966).

Blackburn and Servanty (1981) measured 607 skipjack with length range of 410 to 645 mm from east coast of Australia and calculated the following relationship.

$$\text{Log } W = -6.0762 + 3.5202 \text{ Log } L$$

The coefficient of determination r^2 was 0.856 and standard error of the first and second constant in the equation were 0.1595 and 0.0586. Their equation was equivalent to

$$W = 0.000000839\ L^{3.5202}$$

They found that regression from east Australia and eastern Pacific are significantly different at the 5% level of probability. They reported that the two groups of skipjack tuna probably belong to different populations.

In the present study regression equation was calculated for males and females separately and the value of b for males was 3.35566 and for females 3.46279. Testing for significant difference between the two regression equations was performed. The F value in testing for equal slopes was found to be non-significant. Thus the two regression lines were found coincidental and therefore no significant difference is present between the length-weight relationship of male and female fish. So it is appropriate to pool all the data and the common value for regression coefficient was found as 3.39301.

Similar studies on the length-weight relationship of skipjack tuna have been conducted during the period

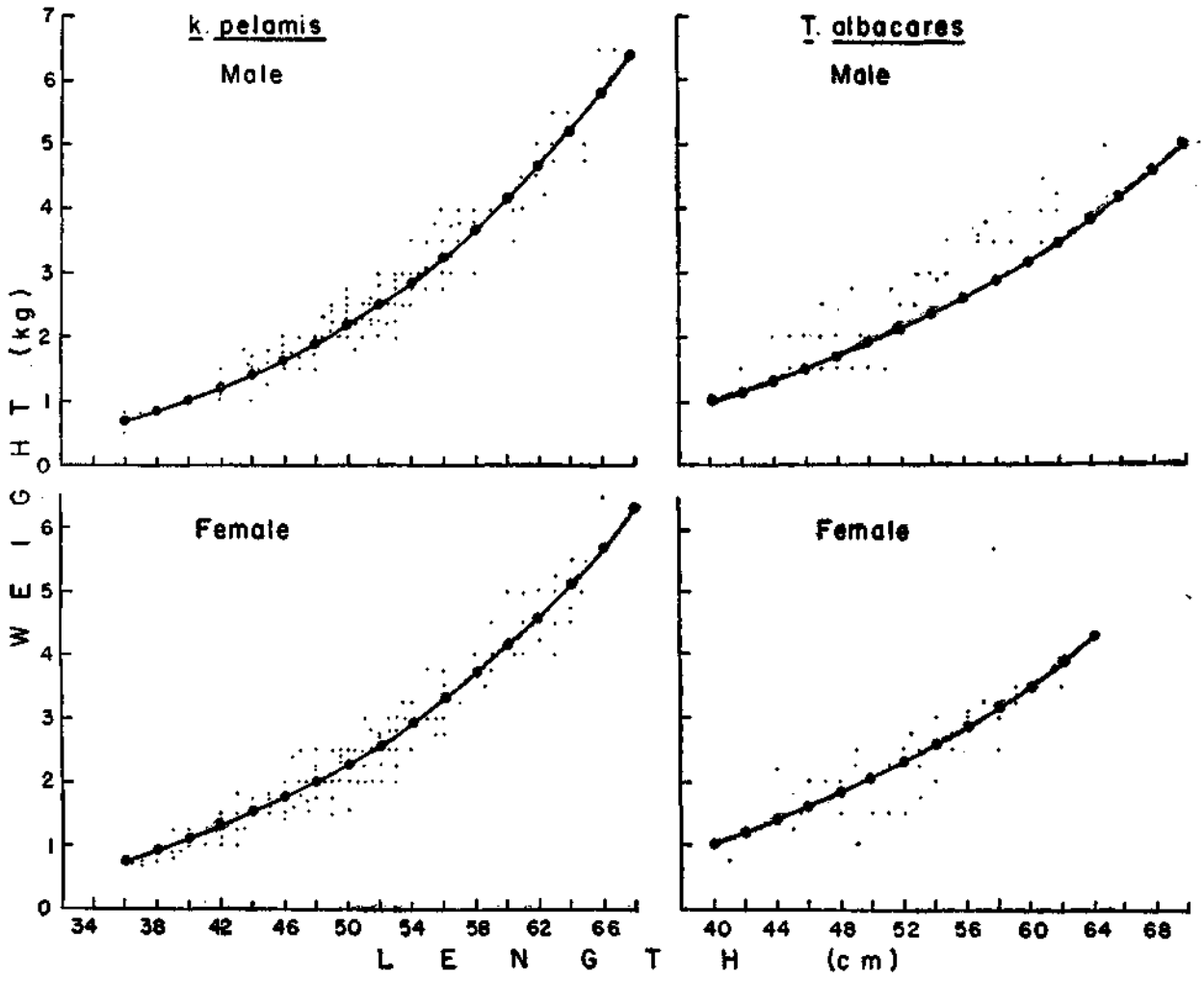

Fig. 1. Length-weight relationship of males and females of *K. pelamis* and *T. albacares* at Minicoy 1980-'82.

1978-80 and the relationship emerged was with 'r' value of 0.9615.

$$W = 0.000000002093\ L^{3.30212}$$

The standard error of common regression coefficient in the equation is 0.04669 and the value of coefficient of determination r^2 as 0.9235.

There is no previous published information on length-weight relationship of skipjack from Indian waters for comparison with the results of the present study. However, Marcille and Stequert (1976) have examined 848 specimens of skipjack taken by bait boats from Madagascar within the size range 41-62 cm and according to them the value of constant 'b' is 1.131×10^{-5} and the coefficient of allometry 'a' was 3.158. They arrived at the conclusion that the calculated weight of 55 cm fish is 3.54 kg.

2. Yellowfin tuna

The length-weight relationship of yellowfin tuna, *Thunnus albacares* from several fishing areas of the Eastern Tropical Pacific Ocean been published by Chatwin (1959). But there is no published information on this aspect from Minicoy waters, where yellowfin forms 5 to 20 % of the total tuna catch every year.

Present investigations are based on 134 yellowfin tuna taken in the pole and line fishery out of which 67 were males and 67 females. Males ranged in fork

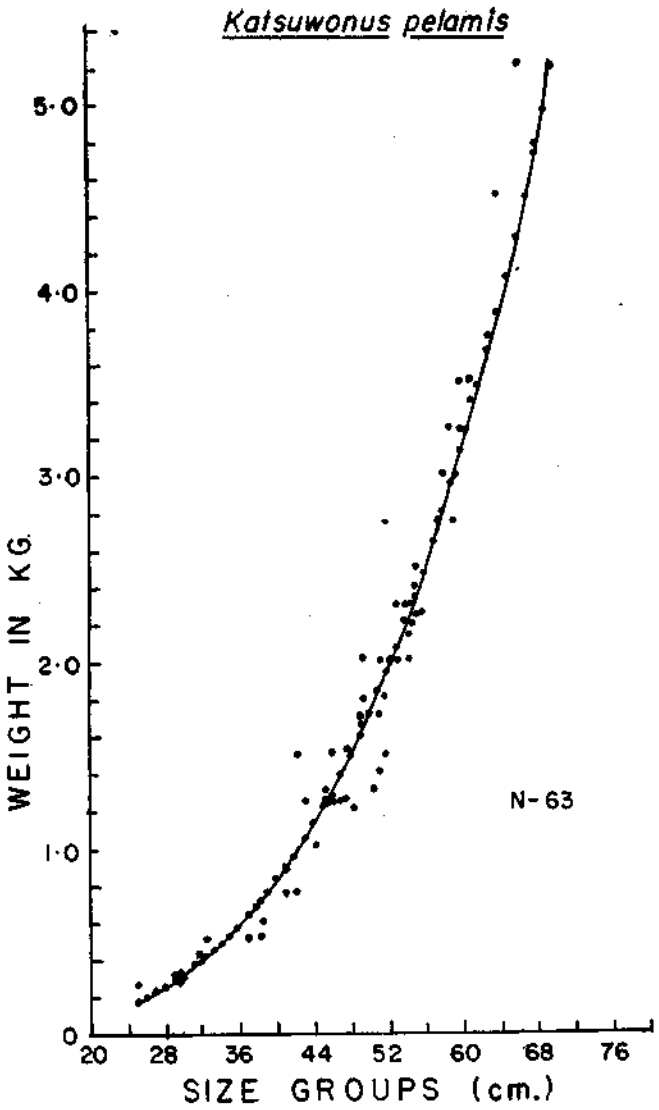

Fig. 2. Length-weight relationship of *K. pelamis* at Minicoy (pooled), 1980-'82.

length from 420 mm to 680 mm and females between 410 mm and 620 mm. Fork length in millimetres, total weight in grams, sex and maturity stages of individual fish were recorded in fresh condition.

The following basic statistics were estimated from the logarithms of length and weight for deriving the regression equations separately for the males, females and both sexes combined.

Statistics	Groups		Both sexes combined
	Males	Females	
N ..	67	67	134
sx ..	417.727836	417.150184	834.878020
sx^2 ..	2605.167765	2597.768107	5202.935872
sy ..	516.945556	509.704716	1026.650272
sy^2 ..	3997.080792	3884.822076	7881.902868
sxy ..	3225.220016	3175.109956	6400.329972

sx, sy = Sum of x and y :

sx^2, sy^2 and sxy = Sums of squares and products.

Corrected sums of squares and products as well as the estimates of regression coefficient *b* for males, females and for both sexes combined are as follows :

Statistics	Males	Females	Both sexes combined
D.F. ..	66	66	132
sx^2 ..	2.196905	1.626134	3.823039
sxy ..	0.741721	0.540107	1.281828
sy^2 ..	8.532913	7.226591	15.759504
b ..	2.961902	3.010763	3.001012
D.F. ..	65	65	131
D.D. ..	8.2829	7.0472	15.3297
M.S. ..	0.1274	0.0358	0.0810

D.F. = Degree of freedom :

xy, x^2, y^2 = Corrected sums of products and squares :

b = Regression coefficient :

S.S. = Sum of squares :

M.S. = Mean squares.

By using the above statistics the following equations for males and females separately were obtained.

Males $\quad \text{Log } W = -10.751095 + 2.961902 \text{ Log } L$

Females $\quad \text{Log } W = -11.137845 + 3.010763 \text{ Log } L$

The results of analysis of covariance to test the significance of differences in the regressions of x and y are presented in the following table :

Source of variation	Degree of freedom	Sums of squares	Mean squares	Observed F	5% F
Deviation from individual regression within sexes ..	130	15.3301	0.1179	0.0034 *	3.92-3.84
Differences between regressions ..	1	0.0004	0.0004		
Deviation from average regression	131	15.3297	0.1046		

* Not significance.

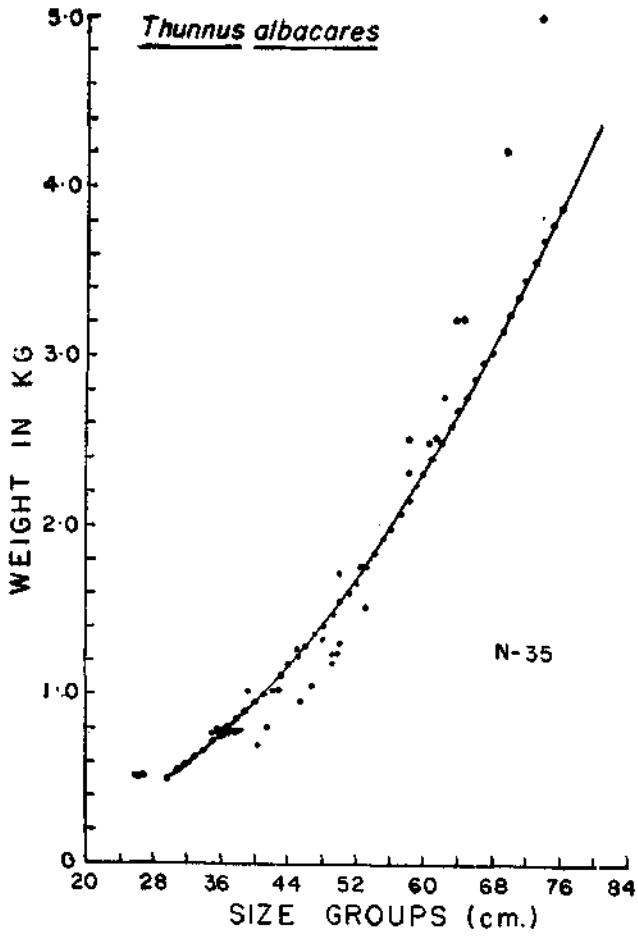

Fig. 3. Length-weight relationship of *T. albacares* at Minicoy (pooled), 1980-'82.

As is clear from the table there is no significant difference in the regression coefficient between males and females (Fig. 1). Therefore, the data for both males and females were pooled together and a common length-weight relationship equation was fitted as below (Fig. 3).

$$\text{Log } W = -11.036032 + 3.001012 \text{ Log } L$$

The value of '*r*' which is a measure of the degree of association between the length and weight (Correlation coefficient '*r*') for the males was 0.8732 and for females 0.8230.

Studies on the similar lines have been conducted to find out the length-weight relationship of yellowfin tuna during 1978-80. The relationship obtained was

$$W = 0.000001655\ L^{3.21150}$$

and the '*r*' value was 0.9139.

Chatwin (1959) calculated the length-weight relationship of yellowfin tuna, *Thunnus albacares* from the Eastern Pacific Ocean. He estimated the value of regression coefficient to be 3.020 from all the areas he sampled.

The results of the present study reveal that there is no significant difference in the regression coefficient between males and females. Therefore data are pooled together and common equation is fitted. The value of regression coefficient for the pooled data is 3.001012 which is almost equal to the value given by Chatwin (1959).

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.