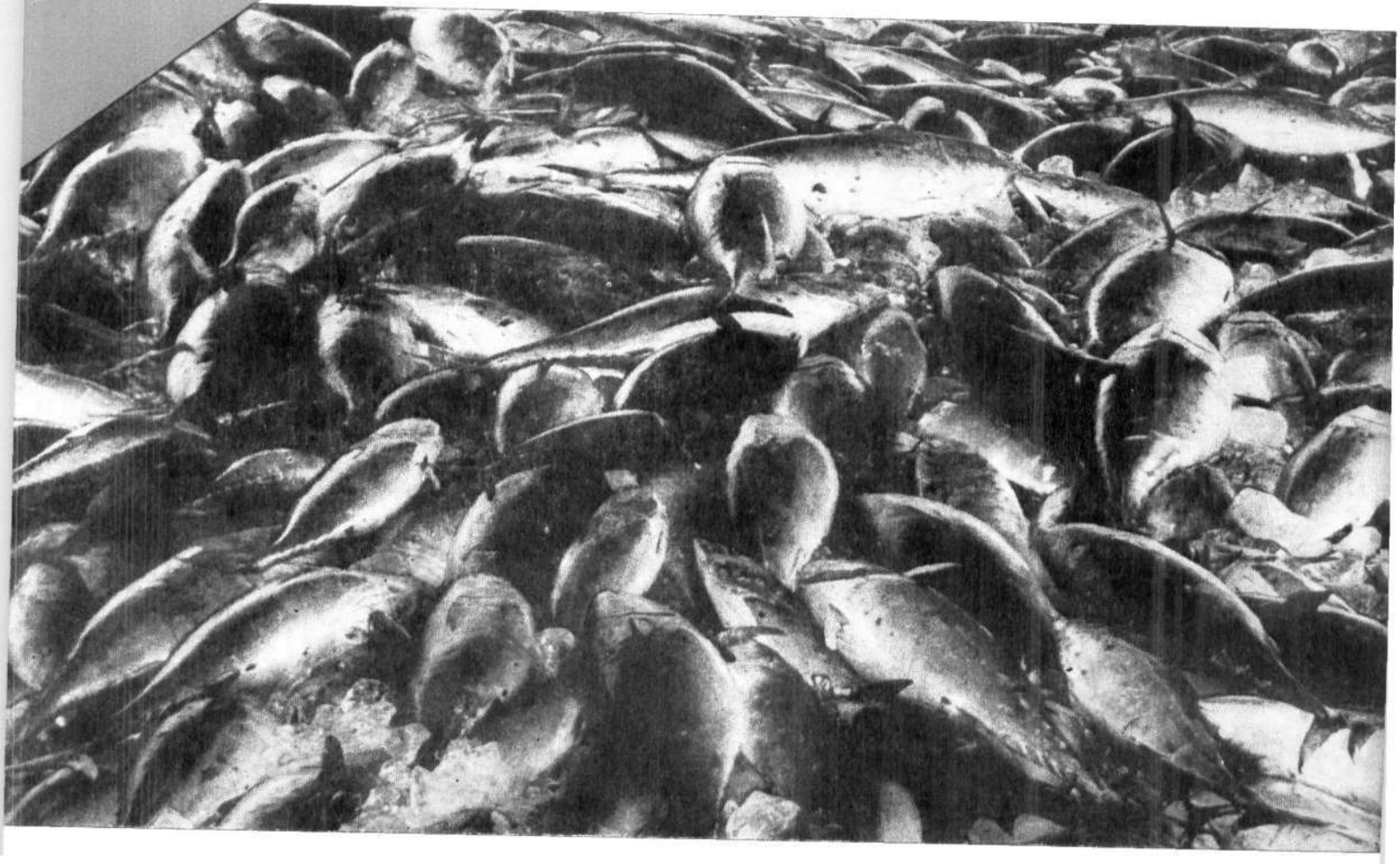
CMFRI
bulletin 36

JUNE 1985

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

Edited by : E. G. SILAS



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SPAWNING BIOLOGY OF THE SKIPJACK, *KATSUWONUS PELAMIS* (LINNAEUS) FROM MINICOY WATERS

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One of the important technical approaches to investigate the resource characteristics of oceanic species of tunas is to study the phases of its life history. Subsequent to the results of investigations on spawning of skipjack in Minicoy waters by Raju (1964), there is no further information available on this aspect from the area. The present paper deals with the spawning of skipjack, *Katsuwonus pelamis* in Minicoy waters with particular reference to the reproductive process. Ova diameter measurements have been used to demonstrate the developmental changes that take place in the female gonads during the breeding season.

Material for these investigations was obtained from the fish landed by commercial pole and line tuna fishing boats at Minicoy during 1981 and 1982. The fork length in millimetre and weight in kg of the fish were recorded. The body cavity was opened and sex and maturity stage was determined by visual examination. The ovaries along with attached peritonial and vascular tissues were carefully removed from the fish and were preserved in 5% formalin. Ovaries from immature to spent stages were collected for ova diameter measurement studies. For the fecundity studies only mature ovaries were collected.

For ova diameter examination, samples were collected from anterior, middle and posterior part of the ovary. Ova were teased out under a binocular microscope to ensure complete separation from the follicles. For immature ovaries, measurements of 200 ova were taken but for maturing, mature and spent ovaries 300 ova were measured. Measurements were made by an ocular micrometer in a compound monocular microscope and later micrometer divisions were calibrated into millimetres. Almost majority of ova were spherical, even then measurements were made on whatever axis ova fell parallel to the micrometer divisions.

June (1953), Yuen (1955), Otsu and Uchida (1959), Joseph (1963), Raju (1964) and Batts (1972) could not detect any difference in the frequencies of ova diameters selected from different part of the same lobe of the ovary and from right or left ovary. Thus all these workers concluded that ova develop uniformly throughout the ovary and in both ovary lobes of tunas. Therefore, during these present investigations, for fecundity studies ova samples were taken from the middle of either lobe of the mature ovary randomly and all the mature ova were counted. Fecundity was calculated by using the following formula :

$$\text{Fecundity} = \frac{\text{Number of ova in sample X weight of paired ovaries}}{\text{Weight of ova samples}}$$

For determining maturity stages and spawning season 638 specimens of skipjack were examined.

Maturity

Ova diameter of 200 ova for stage I and stage II and 300 ova for stage III and above were taken at random and they were grouped into four ocular micrometer division groups. Ocular micrometer divisions were converted in millimetres and frequency polygons of ova showed typically seven maturity stages (Fig. 1).

Only immature ova with diameter upto 0.14 mm with mode at 0.09 mm are present in stage I. As a matter of fact this group of ova should be called as the 'General Immature Egg Stock' since they are available throughout the year in the ovaries of all stages of maturity.

In stage II one batch of ova is seen separated from the immature ova with a mode at 0.28 mm with the maximum ova diameter of 0.37 mm. This group of

ova can be termed as 'Intermediate Group'. At this stage of maturation yolk deposition has started in ova.

In stage III the maturing group of ova which is observed as 'Intermediate Group' in stage II showed

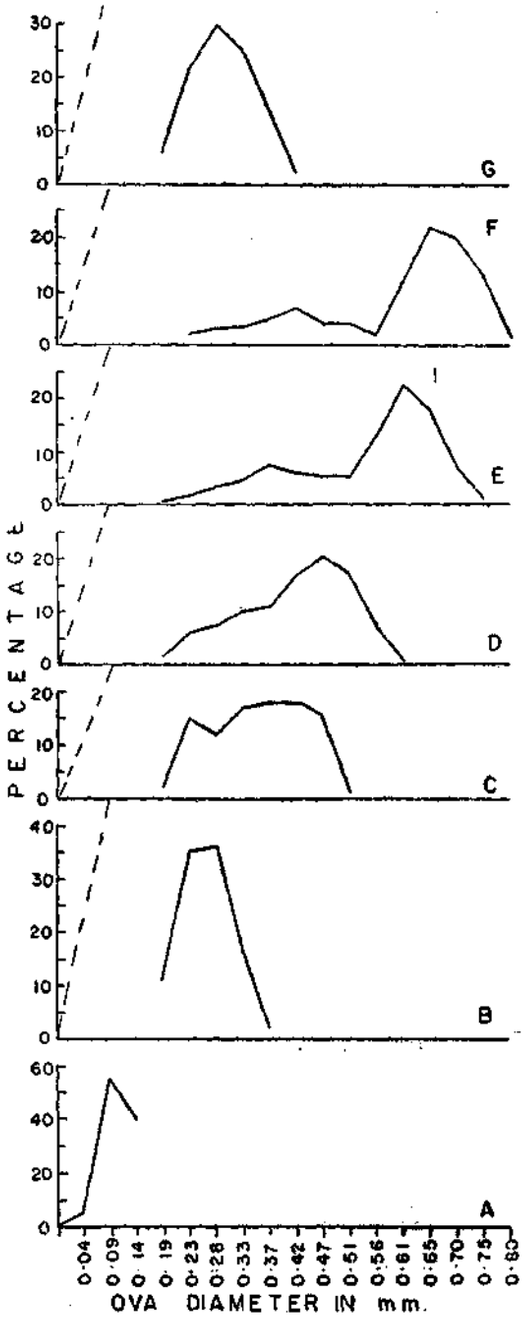

Fig. 1. Ova diameter frequency polygons of *K. pelamis* at Minicoy.

progress in diameter with mode at 0.42 mm with maximum diameter of 0.51 mm. Ova at this stage show thick deposition of yolk.

In stage IV maturing ova showed further increase in size and become mature with mode at 0.47 mm and with maximum diameter of 0.61 mm. The ova are opaque at this stage.

In stage V in addition to the immature stock of ova, two groups of ova *i.e.*, maturing and mature ova show prominent separate modes. While maturing ova did not show much growth, mature ova has grown at a faster rate. The mode at 0.61 mm of ripe ova is evidently the group of eggs which would spawn in near future.

In stage VI range of ripe group of ova diameter was from 0.56 mm to 0.80 mm with mode at 0.65 mm. Although ova at this stage did not show much growth, but they changed from yellowish to orange in colour and also started to become transparent. The one ovary which was examined during these studies did not contain ova with oil globule. Mature ova are easily separated from the follicles and some loose ova were found in the lumina of the ovary.

In the spent ovary stage VII diameter of ova is almost similar to those of in stage II. Very few residual eggs were observed in this ovary. While the absence of the the residual eggs in the ovaries cannot be accepted as proof that the fish has never spawned, their presence shows good evidence that spawning has definitely occurred.

SEX RATIO

Ratio of males to females was found to be 1 : 1.18 for the year 1981 and 1 : 0.98 for the year 1982. The ratio for the pooled data for both the years of observations was male 1 : female 1.07. The percentage occurrence of sexes in different months during both the years are given in Table 1. From this it can be seen that during 1981, while the females dominated over males during January, February, April, June, November and December, males dominated in March, May and September. During 1982 females dominated over males in January, February, September and October, while males dominated during the remaining months except November when both the sexes were equally distributed.

SPAWNING SEASON AND FREQUENCY

A comparison of the data on the maturity of skipjack over two successive years (1981, 1982) reveals that fish of various maturity stages may be present in any month of the year. For example, fish of maturity stage II to IV were recorded throughout the year.

TABLE 1. *Percentage of males and females of* Katsuwonus pelamis *during* 1981 *and* 1982

Month	1981 Total number of fish	1981 Percentage of Males	1981 Percentage of Females	1982 Total number of fish	1982 Percentage of Males	1982 Percentage of Females
January	40	37.50	62.50	51	43.14	56.86
February	49	38.78	61.22	32	46.88	53.12
March	31	54.84	45.16	30	60.00	40.00
April	32	40.63	59.37	67	53.73	46.27
May	31	51.61	48.39	..	..	..
June	41	46.33	53.67	..	..	..
July	..	..	..	..	..	..
August	..	..	..	..	..	..
September	..	..	..	50	46.00	54.00
October	13	69.23	30.77	16	43.75	56.25
November	33	45.45	54.55	30	50.00	50.00
December	57	47.37	52.63	35	60.00	40.00

Further, females were divided into three major categories based on maturity stages *i.e.*, immature (stage I and II), Maturing (Stage III) and mature (Stage IV and above). The results are given in Tables 2—4 It can be seen from these tables that mature fish occurred almost throughout the commercial pole and line tuna fishing period. During 1981 peak occurrence of mature fish was in January to May. But in 1982 mature fish dominated during all the months except in October.

TABLE 2. *Percentage occurrence of gonads of* Katsuwonus pelamis *in different stages of maturity*
(From January 1981 to December 1981)

Month	No. of	Sex	Stages of maturity I	II	III	IV	V	VI	VII
January	15	M	..	20.00	40.00	33.33	6.67	..	..
	25	F	..	16.00	36.00	32.00	16.00	..	..
February	19	M	..	21.05	47.37	26.32	5.26	..	..
	30	F	..	6.67	43.33	36.67	13.33	..	..
March	17	M	..	29.41	17.65	41.18	11.76	..	..
	14	F	..	28.57	21.43	42.86	6.14	..	..
April	13	M	..	38.46	46.16	15.38	..	..	..
	19	F	..	36.84	42.11	21.05	..	..	..
May	16	M	..	18.75	43.75	31.25	6.25	..	..
	15	F	..	13.33	33.33	33.34	20.00	..	..
June	19	M	5.26	36.84	42.11	15.79	..	..	..
	22	F	..	54.55	36.36	9.09	..	..	..
July	..	M	..	..	..	..	..	..	..
	..	F	..	..	..	..	..	..	..
August	..	M	..	..	..	..	..	..	..
	..	F	..	..	..	..	..	..	..
September	..	M	..	..	..	..	..	..	..
	..	F	..	..	..	..	..	..	..
October	9	M	44.44	44.45	11.11	..	..	..	..
	4	F	25.00	25.00	50.00	..	..	..	..
November	49	Ind.	..	..	..	..	..	..	..
	15	M	26.67	20.00	46.67	6.66	..	..	..
	18	F	11.11	16.67	66.67	5.55	..	..	..
December	27	M	..	3.70	62.97	33.33	..	..	..
	30	F	..	10.00	60.00	30.00	..	..	..

M = Male, F = Female, Ind. = Indeterminate

TABLE 3. *Percentage occurrence of gonads of* Katsuwonus pelamis *in different stages of maturity* (From January 1982 to December 1982)

Month	Number of fish	Sex	Stages of maturity						
			I	II	III	VI	V	VI	VII
January	22	M	..	..	59.09	36.36	4.55	..	..
	29	F	..	..	31.03	58.62	10.35	..	..
February	15	M	..	33.33	66.67	..	..	..	..
	17	F	..	58.82	17.65	5.88	..	..	..
March	18	M	..	27.78	27.78	44.44	..	..	..
	12	F	..	8.33	50.00	41.67	..	..	..
April	36	M	..	..	11.11	19.44	50.00	13.89	5.56
	31	F	..	..	19.35	32.26	38.71	9.68	..
May	..	M	..	..	..	..	..	..	.
	..	F	..	..	..	..	..	..	..
June	..	M	..	..	..	..	..	..	..
	..	F	..	..	..	..	..	..	..
July	..	M	..	..	..	..	..	..	..
	..	F	..	..	..	..	..	..	..
August	..	M	..	..	..	..	..	..	..
	..	F	..	..	..	..	..	..	..
September	23	M	..	8.69	21.74	43.48	26.09	..	..
	27	F	..	..	29.63	44.44	25.93	..	..
October	7	M	28.57	42.86	28.57	..	..	..	..
	9	F	..	22.22	55.56	22.22	..	..	..
November	15	M	..	..	46.67	20.00	26.67	6.66	..
	15	F	..	..	40.00	33.33	26.67	..	..
December	21	M	..	9.52	9.52	23.81	38.10	19.05	..
	14	F	..	..	28.57	28.57	28.57	14.29	..

M = Male, F = Female.

TABLE 4. *Percentage occurrence of female fish in immature, maturing and mature stages during* 1981 *and* 1982

Month		Immature	Maturing	Mature
January	1981 ..	16.00	36.00	48.00
	1982 ..	..	31.03	68.97
February	1981 ..	6.67	143.33	50.00
	1982 ..	17.65	58.82	23.53
March	1981 ..	28.57	21.43	50.00
	1982 ..	8.33	50.00	41.67
April	1981 ..	36.84	42.11	21.05
	1982 ..	..	19.35	80.65
May	1981 ..	13.33	33.33	53.53
	1982 ..	..	..	..
June	1981 ..	54.55	36.66	9.09
	1982 ..	..	..	..
July	1981 ..	..	..	..
	1982 ..	..	..	..
August	1981 ..	..	..	..
	1982 ..	..	..	..
September	1981 ..	..	..	..
	1982 ..	..	29.63	70.37
October	1981 ..	50.00	50.00	..
	1982 ..	22.22	55.56	22.22
November	1981 ..	27.78	66.67	5.58
	1982 ..	..	40.00	60.00
December	1981 ..	10.00	60.00	30.00
	1982 ..	..	28.57	71.43

Fish in spawning stage of maturity (ripe running) and spent condition were very rare in the catches. Here it becomes necessary to point out that scarcity of spawning females in commercial catches at Minicoy does not mean that skipjack is not spawning in Minicoy waters. This has already been shown by Jones (1959) based on skipjack larval collections from Laccadive Sea. The predominance of stage III (maturing) may be because of the entry of fishes in the catches in their recovering stage after spawning. Moreover the assumption about the females moving into deeper waters for spawning and be away from the reach of pole and line fishing cannot be ruled out.

According to Matsumoto and Skillman (1984) 'Gonadial studies in the Pacific Ocean indicated that skipjack tuna spawn throughout the year in tropical waters near the equator and from spring to early fall in subtropical waters with the spawning period becoming shorter with increasing distance from the equator.'

Therefore, the occurrence of mature females throughout the pole and line fishing season and occurrence of young fishes of about 30 cm during January to May and September to December, period clearly indicates

that in Minicoy waters also skipjack spawn throughout the year.

The frequency distribution of ova diameter measurements from a ripe and spawning ovary (Stage V and VI) of skipjack reveals that there are three groups of ova *i.e.*, immature, maturing and mature which are clearly separated from each other. It is understood that as the ripe group of ova is spawned out, its place is soon taken up by the maturing group of ova which have already completed more than half of the maturation process. It is clear from the Fig. 1 that mature ova grow at a faster rate than maturing ova. Therefore, when mature ova are spawned out, maturing ova will grow at a faster rate and may be ready for spawning soon, thus having more than one spawning in a year (Brock 1954 ; Bunag 1956 ; and Raju 1964).

FECUNDITY

An examination of the mature ovaries of *K. pelamis* reveals that they contain three groups of ova *i.e.*, immature, maturing and mature. The number of mature eggs was taken to be the fecundity of each individual fish. A total of 23 mature individuals was examined. The length and weight of fish, total number of mature ova and ova per kg of fish body weight are given in the Table 5. Results of other studies on skipjack from different world oceans are given in the Table 5.

TABLE 5. *Fecundity estimates of* Katsuwonus pelamis, *during* 1981-'82

S. No.	Length of fish (cm)	Weight of fish (kg)	Length of ovary (cm)	Weight of ovary (g)	Total number of mature ova	Ova per kg of fish weight
1 ..	46.5	1.8	12.7	46.0	2,12,566	1,18,092
2 ..	48.0	2.0	12.2	42.5	2,21,297	1,10,648
3 ..	48.5	2.0	12.9	38.0	1,82,856	91,428
4 ..	49.0	2.5	11.5	35.0	1,70,555	68,222
5 ..	50.0	2.3	13.0	33.0	1,89,024	82,184
6 ..	50.0	2.6	13.2	53.0	2,94,097	1,13,114
7 ..	50.0	2.5	14.1	52.0	3,29,628	1,31,851
8 ..	51.0	2.3	13.1	53.0	2,74,858	119,503
9 ..	51.5	2.5	13.4	47.0	2,48,988	99,555
10 ..	51.5	2.7	13.3	54.5	2,98,933	1,10,715
11 ..	52.0	2.5	12.2	43.0	2,53,442	1,01,376
12 ..	52.5	2.8	12.7	46.5	3,31,824	1,18,508
13 ..	53.0	3.0	13.8	50.5	3,26,987	1 08,995
14 ..	53.0	2.5	14.4	58.8	3,26,826	1,30,730
15 ..	53.0	3.2	14.6	47.5	2,73,980	85,628
16 ..	53.0	3.0	14.3	46.0	3,05,762	1,01,920
17 ..	53.0	2.8	13.6	51.5	3,06,013	1,09,290
18 ..	54.0	2.5	14.5	5.10	3,74,595	1,49,838
19 ..	54.0	3.5	13.0	52.0	2,67,904	76,544
20 ..	54.0	3.3	14.5	53.5	3,53,742	1 07,194
21 ..	59.0	4.0	13.5	66.0	4,34,412	1,08,603
22 ..	62.0	4.5	14.0	76.0	4,79,484	1,06,552
23 ..	66.0	6.5	15.3	930	6,82,899	1,05,061

TABLE 6. *Observed fecundity estimates for skipjack tuna*

Source & Area	Locality	Number of fish	Fish length range (mm)	Total ova range
Pacific Ocean				
Yabe (1954)	Ryuku Islands	5	460-610	113,364-859,897
Rothschild (1963)	Hawaii	3	440-870	280,000-900,000
Joseph (1963)	Eastern Pacific	42	614-715	210,000-1190,000
Yoshida (1966)	Marquesas Islands	4	430-750	100,000-2000,000
Atlantic Ocean				
Simmons (1969)	Caribbean Sea	13	465-809	262,000-331,000
Batts (1972)	North Carolina	31	498-704	141,000-1200,000
Indian Ocean				
Raju (1964)	Minicoy	63	418-703	151,900-1977,000
Stequert (1976)	Madagascar	64	441-565	87,000-824,000
Present study	Minicoy	23	465-660	170,555-682,899

Relation between fecundity and length and weight of fish

The fecundity observations of 23 skipjack are plotted against the length (Fig. 3). The number of mature eggs increased with the length of the fish. However, it can also be seen that the fecundity of the individual fish of the same length varied considerably.

The regression line is fitted by least square method by applying the following formula :

$$Y = a + bL$$

Where Y is the number of mature ova in thousands, L is the length of fish in mm and *a* and b are constants. The values of *a* and b were estimated and the following equation was obtained. The value of '*r*' was 0.92707.

$$Y = -918.57049 + 23.27525\ L$$

In order to find whether any relation exists between the weight of the fish and fecundity, fecundity estimates of 23 individual fish are plotted against their respective fish weight (Fig. 2). By the least square method, relation between fecundity and weight of the fish was determined and the following equation was obtained :

$$Y = -20.00365 + 99.48753\ W$$

where Y = fecundity of the fish and W = weight of fish in kg. The value of '*r*' was 0.90004.

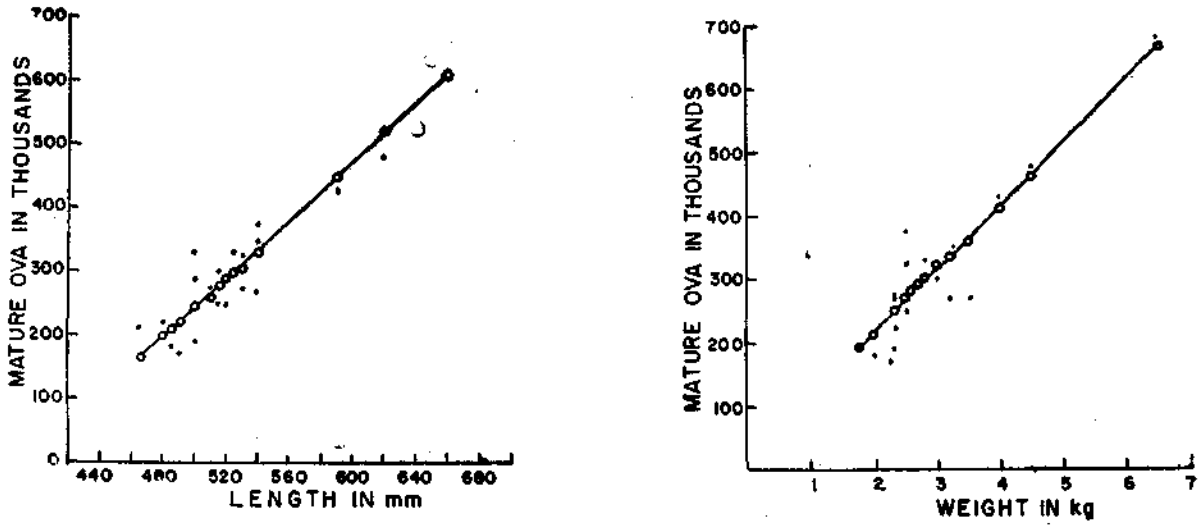

Fig. 2. Fecundity in relation to the length and weight of *K. pelamis* at Minicoy.

Discussion

A number of investigations have been conducted on the spawning of skipjack from the Pacific Ocean and elsewhere. These studies were based on the presence of skipjack larvae, young fishes or on the stage of gonad maturity in the adult fish. Waldron (1963) stated that in the equatorial waters in the Pacific, spawning occurs throughout the year, although there may be identifiable peak periods. According ot him in increasing distances from the equator, the season becomes progressively shorter and spawning occurs during the summer months.

Jones and Silas (1963) stated that no definite range of spawning has been established in any area in the Indian Ocean except that from the Laccadive Archipelago. Based on larval collections by Jones (1959) and gonadial examination by Raju (1964), Jones and Silas (1963) concluded that spawning of skipjack takes place over an extended period from January to April and then from June to early September with the peaks in January and June respectively.

Waldron (1963) opined that the presence of larval skipjack in plankton collection probably provides a more precise estimate of spawning season than does the presence of mature ovaries in the adults. After the studies on skipjack larvae from Laccadive sea by Jones (1959), there is no published accounts on this aspect from this area. Perhaps regular plankton collection throughout the year from the Laccadive sea and Minicoy area may give a better picture.

Since mature fishes are available throughout the pole and line fishing season and regular occurrence of fish below 30 cm clearly indicates that around Minicoy waters spawning of skipjack is protracted and most probably occurs throughout the year.

Waldron (1963) while reviewing the literature on the biology of skipjack stated that the sex ratio of skipjack may depart significantly from 1 : 1 at certain times of the year. Jones and Silas (1963) have also reported in the same way about sex ratio of skipjack from Minicoy area. Orange (1961) reported that in Eastern Tropical Pacific, percentage of males below the length of 75 cm is close to 50 per cent, but percentage of males increases with the length of the fish.

Results of present investigations reveal that during 1981 and 1982 together, females dominated over males but not significantly. Monthly variation in sex ratio was observed during both the years.

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