FISHERY AND BIOLOGY OF THE OIL-SARDINE, *SARDINELLA LONGICEPS* VAL., OFF THE COCHIN COAST

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ABSTRACT

The oil-sardine catches at Cochin showed wide fluctuations during the years of this study. Relatively higher catches were obtained in 1960-61, 1966-67 and 1967-68, the highest being in the 1964-65 season. Poor fishery was recorded during the seasons 1959-60, 1962-63 and 1963-64. The highest catch per gear for 'thangu vala' (boat seine) was made in 1964-65. Studies on length frequency distribution indicated that the juvenile fish grew very fast during the first 12 months. The fishery was supported largely by the dominant 0-year and 1-year classes; the 2-year and 3-year old ones were less abundant. During each year, commencing from 1959-60 through 1968-69, the bulk of the sardine catch was contributed by the 135, 140, 125, 45,100, 130, 150, 135, 130 and 115 mm modal lengths respectively. Ova diameter studies revealed a short period of spawning, ova being released in a single batch. The peak season of spawning extends from June to August.

INTRODUCTION

The oil-sardine fishery has shown remarkable fluctuations in the past several decades. Most of the earlier investigations on the biology and fishery of the oil sardine has been along the Calicut coast and north of it (Hornell and Nayudu, 1923; Chidambaram, 1950; Nair, 1952, 1960; Balan, 1961; Antony Raja. 1964; Sekharan, 1965; and Sekharan and Dhulkhed, 1968 to mention only a few). The present paper is an attempt at describing the fluctuations of the oil-sardine fishery at Cochin during the period 1959-69 together with observations on the biology of the species.

MATERIAL AND METHODS

The oil-sardine landing data and length frequency data were collected from Cochin thrice a week (generally each sample consisted of 50 numbers), from January 1959 to June 1969. The weight of the individual sardine, in fresh condition, was recorded correct to 0.5 g in the laboratory. Total length[2] of each fish was noted correct to 1 mm. Based on the estimates made from the samples taken on alternate days, the monthly distributions of the length frequencies were estimated in the case of the boat-seine

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2. Total length measured from tip of snout to tip of ventral caudal fluke.

(thangu vala) catches. If n_{jj} is the number of fish in I-th size group on any sampling day j, the estimate of number of fish of i-th size group caught on that day is

$$N_{ij} = n_{ij} \times \frac{WJ}{wj}$$

where WJ = estimated catch on the J-th day and wj=weight of the sample on the J-th day. The number of fish N_i of size in the whole month is then estimated as

$$N_i = \frac{D}{d} \Sigma N_{ij}$$

where d is the number of sampling days and D the number of fishing days in the month.

While collecting the material for the biological studies, data on the sardine landings and the sardine catch per gear at Cochin (Manassery, about 6 km south of Cochin Harbour mouth) were collected on the basis of random sampling (by eye estimation, checking with actual weighing) throghout the period of this work. Monthly estimates were made based on each day's total catch estimations, with a view to study the trends of fluctuations in the landings.

For studying the phases of gonadal maturation and spawning of oil-sardine, ovaries preserved in 4% formalin were utilised. The individual ova did not show any shrinkage or distortion even several months after preservation and the material was found quite suitable for this study.

Fishing craft and gear

The fishing crafts employed at Cochin consist of two types of canoes and dug-outs. The large-sized one used for the operation of the boat-seine is 12-13 m long and the medium-sized one which is usually used for the operation of gill nets is 9-10m in length.

The nets used for the capture of the sardine along the Cochin coast are the one-boat boat-seines, 'thangu vala' and 'nona vala', and the gill net, 'chala vala'; 'nona vala' is employed mainly for the capture of young sardines and white baits. Of these gear, 'thangu vala' is the most commonly operated one and is quite efficacious. The extent of operation of these gear normally ranges from 1/4 to 10 Km from the sea shore, the depth of fishing ranging from 5 to 30 m. (For details of boat-seines see Kuriyan *et al.*, 1962 and for details of 'chala vala', Satyanarayana and Sadanandan, 1962).

The Fishery

The oil-sardine fishery has been the single largest fishery of the Cochin coast. The fishing season here usually commences towards the end of the south-west monsoon, i.e. end of August or early September, generally with the occurrence of juveniles. The fishery continues even beyond March, the peak of landings being from October to January.

It may be seen from Table 1 that there had been remarkable fluctuations in the oil-sardine landings at Cochin during the 1958-69 period. During the different seasons the best catches were made in the following months: 1959-60—August; 1960-61—December; 1961-62—October; 1962-63—December; 1963-64—August; 1964-65—October; 1965-66 — October; 1966-67 — January; 1967-68 — December; 1968-69 — October. The highest oil sardine catch of 4724.4 tonnes as well as the highest number of gear used was in the 1964-65 season (Table 1). Good catches were made also in 1960-61, 1966-67 and 1967-68. In all these years catches were very poor between February and August.

The heavy and indiscriminate fishing of the young sardine (mode 45 mm) since the beginning of 1962-63 season may probably be the cause for the marked decline in the quantum of the catches during the entire 1962-63 and 1963-64 seasons. Even though the landings of big-sized sardine were unusually poor during 1964-65, the over-abundant recruitment of small age-groups made the fishery extremely rich. The general fall in the landings of 1965-66 season may be due to extremely heavy fishing of the younger age-groups in the preceding year. The heavy impact of fishing on juvenile sardine (55-80 mm length) early in 1965-66 has resulted in marked reduction of the catches during the latter half of that season; probably this also caused a considerable drop in recruitment of juveniles in the succeeding year. In 1967-68 season, the 120-130 mm group (nearing 12 months) was better represented and hence a rise in the landings. A partial revival of the juvenile fishery was noticed only in the early part of the 1968-69 season after 1965-66. From these observations it is resonable to infer that heavy fishing on the young fish (below 100 mm length) in the beginning of the season reduces the landings to some extent in the latter half of the season.

The gill net catches at Cochin were relatively small during the period of this investigation (*vide* Table 1).

The number of gear (thangu vala) operated at Cochin showed considerable variations in the different years, the highest numbers (378 to 2587) being generally from July to September excepting for the maximum of 1463 in December 1960 and 1,668 in October 1961. The increase in the number of gear during July-September was not solely due to the increase in sardine fishing activity, but also on account of fishing operation being confined to the shallow inshore waters for the exploitation of other fishes.

The catch per gear of 'thangu vala' and the gill net is given in Table 2. The highest catch per gear during this investigation was made in 1964-65 while it was below average during 1968-69 season.

LENGTH COMPOSITION

Ages of various size groups of the oil-sardine have been determined by a study of the scales (Balan, 1968). The length data are presented in Table 3. During the

TABLE 1. *Oil-sardine landings by boat seine at Manassery (Cochin) in tonnes, from 1958-59 to 1968-69. (Gill net catches whenever observed are given in brackets).*

Years	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total for each gear	Combined total
1958-59	—	—	—	—	—	—	53.633	42.153 (51.666)	22.813 (52.685)	55.350	7.874 (22.164)	— (20.415)	181.823 (146.930)	328.753
1959-60	*	152.320 (48.262)	86.995 (35.180)	46.916 (19.074)	79.398 (28.576)	37.793	17.922 (7.880)	2.173 (8.033)	*	13.893 (20.074)	20.463 (3.979)	23.586	481.459 (171.058)	652.517
1960-61	2.722	233.240	157.896	409.592	561.584	578.873	401.027 (43.835)	192.630 (34.296)	99.728	181.444	65.414 (42.547)	17.059 (0.459)	2901.209 (121.137)	3022.346
1961-62	66.438 (4.082)	67.522	25.944	829.001	152.891	433.250 (6.803)	110.583 (2.383)	286.601 (0.456)	148.048	179.358 (3.592)	266.967 (16.126)	46.977	2613.580 (33.442)	2647.022
1962-63	15.758	14.046	28.819	127.396	201.442	215.700	25.166	58.770	46.528	169.795	44.953	16.248	964.621	964.621
1963-64	44.716	207.852	48.111	11.300	4.460 (37.170)	157.571 (12.990)	12.403 (3.369)	1.313	0.867 (0.061)	2.090 (0.600)	11.326 (7.200)	51.738 (2.100)	553.747 (63.490)	617.237
1964-65	93.206	213.382	941.244	1025.298	637.608	635.502 (1.708)	307.117	336.578	201.251	103.468	188.160	39.842	4722.656 (1.708)	4724.364
1965-66	182.769	136.522	277.231	429.273	187.300	208.083	129.553	23.259	58.143	93.825	74.707	109.512	1910.177	1910.177
1966-67	331.908	248.558	278.625	105.798 (0.607)	261.567	572.726	719.916	375.153	428.015	171.025	168.279 (2.181)	42.424	3703.949 (2.788)	3706.782
1967-68	36.430	129.253	253.420	720.067	363.159	962.288	290.545	116.488	147.446	138.225	229.546	22.468	3409.335	3409.335
1968-69	138.355	2.429	155.373	343.497	190.274 (0.105)	191.300 (0.240)	235.119	144.829	37.078	85.277	45.333	51.705	1620.569 (0.345)	1620.914

* No oil-sardine landing.

TABLE 2. *Oil-sardine catch per gear ('thangu vala') in kg at Cochin (Gill net catch per gear in brackets)*

Years.	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1958-59	—	—	—	—	—	—	111.3	169.3 (95.7)	146.2 (112.6)	164.7	96.0 (76.4)	(107.4)
1959-60	*	298.6 (209.8)	114.3 (228.4)	212.2 (149.0)	143.3 (204.1)	99.7	56.4 (52.5)	51.7 (191.3)	*	108.5 (59.4)	163.7 (90.4)	37.6
1960-61	37.3	457.3	207.4	413.7	428.7	395.6	437.3 (113.9)	332.1 (95.3)	285.7	245.8	227.1 (144.2)	36.9 (30.6)
1961-62	80.5 (177.5)	173.1	139.4	497.0	180.9	495.1 (206.2)	170.1 (47.7)	386.2 (17.5)	242.3	275.9 (143.7)	282.5 (337.1)	242.5
1962-63	14.8	12.1	47.2	140.4	206.8	268.0 (136.6)	157.3 (29.5)	175.0	156.0	205.8	79.8	13.6
1963-64	18.6	80.3	38.2	18.8	64.5 (74.8)	357.6 (124.9)	49.8 (43.8)	15.0	17.3 (0.5)	149.3 (100.0)	41.9 (81.8)	49.4 (52.5)
1964-65	33.6	228.5	756.6	750.6	586.6	1166.4 (61.0)	432.4	530.0	372.7	207.8	270.3	56.8
1965-66	78.4	81.3	195.1	357.7	216.8	374.2	183.8	58.1	140.8	322.4	134.1	193.5
1966-67	232.1	179.3	335.7	178.7 (17.3)	401.2	548.6	546.6	451.4	372.8	289.4	234.7 (87.2)	168.3
1967-68	27.6	68.8	318.7	1128.6	392.6	511.0	390.0	282.1	356.1	245.5	372.0.	33.0
1968-69	91.3	1.7	232.6	477.7	291.8 (17.5)	283.4 (26.7)	388.6	268.2	180.0	262.4	144.4	54.2

* No oil-sardine landing.

TABLE 3. *Monthly length range and modal length (in parentheses) in mm during the seasons 1958-'69 at Cochin*

	1958-59	1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69
July	—	*	90-120 (110)	145-185 (155)	135-175 (145)	145-195 (175)	165-190 (170)	135-195 (145)	80-195 (100)	140-180 (155)	130-185 (145)
August	—	105-195 (120)	105-185 (120)	150-190 (160)	140-190 (155)&(160)	90-190 (130)	80-125 (105)	55-190 (150)	90-195 (120)&(165)	65-180 (80)&(155)	50-170 (145)
September	—	70-145 (135)	130-175 (145)	90-120 (115)	40-175 (45)&(160)	115-145 (135)	95-145 (115)	85-195 (130)	90-180 (130)&(165)	90-145 (110)	55-160 (135)
October	125-175 (140)	120-170 (130)	130-180 (145)	105-140 (120)	85-180 (105)	125-140 (135)	110-155 (130)	85-190 (150)	90-180 (135)&(165)	90-165 (120)	100-170 (115)
November	130-170 (160)	120-185 (135)	130-185 (145)	105-140 (120)&(125)	105-160 (120)	*	95-150 (130)	100-165 (110)	110-180 (140)	90-185 (125)	100-185 (115)
December	125-175 (140)	125-175 (135)	130-190 (145)	105-170 (125)	105-190 (120)	120-190 (140)	105-160 (130)	105-160 (110)	105-180 (140)	90-180 (130)	95-180 (115)
January	130-180 (140)	130-195 (135)	130-185 (145)	105-140 (120) (125)	115-185 (170)	130-190 (140)	100-160 (125)	105-190 (115)	110-185 (135)	90-175 (100)	100-185 (120)
February	120-180 (145)	125-180 (145)	135-165 (145)	110-190 (125)	110-190 (165)	125-165 (135)	105-145 (130)	100-160 (140)	100-195 (135)	90-175 (100)	100-175 (120)
March	140-185 (150)&(170)	*	135-175 (145)	105-195 (120)&(125)	120-170 (130)	125-170 (145)	100-145 (125)	110-175 (150)	110-195 (135)	85-185 (100)	105-175 (130)
April	135-185 (155)	130-170 (145)	130-165 (145)	105-145 (125)	120-190 (130)	150-180 (165)	105-145 (120)	110-180 (155)	120-180 (140)	90-175 (105)	105-175 (120)
May	140-185 (150)	140-185 (150)&(165)	135-190 (150)	110-180 (135)	125-190 (140)	145-190 (165)	110-180 (130)	115-190 (155)	120-190 (145)&(170)	95-185 (140)	115-180 (130)
June	*	155-185 (160)	135-180 (155)	125-190 (135)	125-195 (170)	155-200 (175)	115-150 (125)	135-200 (160)	120-180 (150)	125-185 (135)	125-180 (140)

* Nil catch

1958-59 season, the modal length of the one-year old sardine was 140mm in October which remained static up to end of January 1959, and progressed to 145mm, 150 mm and 155 mm from February through April. In November a mode at 160 mm representing the 2-year olds appeared which moved to 170 mm in March.

During the 1959-60 season the mode at 120 mm in August progressed to 135 mm in September when it was one year old; and after a static period up to January, the mode moved to 145 mm in February and 150mm in May when it was nearing two years. In May, another mode at 165 mm which was two year old was also noticed. The influx of 2-year old mature fish (mode 160 mm) into the fishing area is seen in June synchronous with the onset of spawning period.

In July of 1960-61, juveniles of O year (mode 110mm) appeared in abundance. The mode progressed to 145 mm in September which represented the one year old fish. It is remarkable that the same mode persisted till the end of April.

In 1961-62, July and August recorded 155 mm and 160mm modes indicating the presence of 2-year old fish. However, from September onwards, the O-year juveniles with modes ranging from 115 to 125mm dominated the catches up to April. By May/June, this group advanced to 135 mm indicating that their growth was slow though they just completed one year.

In 1962-63, the one year olds (mode 145mm) dominated in July, and the mature, two year olds (modes 155 and 160mm) in August. The unusual preponderance of the 45mm mode in September may be due to comparatively delayed or prolonged spawning and/or heavy recruitment and availability of very young juveniles. Two-year old fish (160mm mode) were also noticed in September. A mode at 105 mm appeared in October whose growth can be traced to 140 mm in May when the fish completes one year. In January, February and May the 2-year old fish (modes 165-170 mm) appeared.

In the 1963-64 season, the two-year old sardine (175mm mode) were dominant in July. In August, one-year old juveniles (130mm mode) which were the slow-growing fish, recorded the start of the fishery for that season. In January and February, the modes at 140 and 135mm were of the 1-year old fish. The 145mm mode in March also was 1-year old. In April and May, the 2-year old fish (165mm mode) dominated. In June, the 3-year olds (175 mm) were observed.

In 1964-65, a brood having 170mm mode (2-year olds) entered the fishery in July. The O-year juveniles (105 mm mode) occurred in August; they were born during the commencement of spawning season, *i.e.* in May, and got recruited in August and during the time interval the fast growth resulting in 105 mm mode had taken place. This mode advanced to 115 mm in September. From October to February (except in January when mode was 125 mm) it was noticed that the mode persisted at 130 mm. In March and April, the modes declined further. In May

and June, modes were at 130 and 125 mm; they were the one-year group which had slow growth after September. Further, the occurrence of lesser modal length in January, March, April and June may be due to recruitment of separate 'slow-growing, broods.

In 1965-66 July, the one-year olds having 145 mm mode appeared. The modal length progressed to 150 mm next month. The 110 mm mode in November-December belonged to O-year group recruited in the same year. In January and February the modes were at 115 and 140 mm. The mode regained 150 mm during next month and this I-year fish sustained the fishery.

In July and August of 1966-67 the new recruits formed modes at 100 and 120mm. The 130 mm mode in September progressed to 135 mm next month; they represented the 1-year olds. It was followed by 140 mm mode in November and December. As the rate of growth was rather slow, the fish in June which completed 2 years were only 150 mm in modal length. Besides in May the fish having 170 mm mode appeared which by then were nearing three years.

In 1967-68, the 155 mm mode belonging to the 2-year old fish occurred in July and August. Recruitment of the juveniles (80 mm mode) in these months indicated the early starting of the fishery during that year. In September, the bigger fish disappeared and the 110 mm mode occurred which progressed to 120, 125 and 130 mm in October, November and December. A brood of O-year group (100 mm mode) appeared in January and persisted till April.

In 1968-69 from July to September, I-year old fish whose modal lengths were 145, 145 and 135mm respectively were dominant. The O-year group (115 mm mode) continued to occur from October to December which progressed to 120 mm in January, February and April. The fish nearly I-year old whose mode ranged from 130 to 140 mm supported the fishery in March, May and June. The higher age groups were remarkably poor between February and June.

Annual modal length distribution

The yearly estimates of numerical abundance of sardine catches can be seen from Table 4.

During those eleven years, the very heavy catches of 1964-65, showed the overall abundance in the numerical strength, being largely contributed by 130 mm length group which was nearly one-year old. The 3-year olds were extremely poor from 1960-61 to 1962-63, in 1964-65 and also from 1966-67 to 1968-69 season.

Ova Diameter Studies

The material for this study was collected at Cochin mostly between May and September from 1959 to 1965. Fifty-two ovaries, preserved in formalin and belonging to stages III to V, were examined (*vide* Balan, 1971). From the anterior,

TABLE 4. *Distribution frequency (in per cent) of the different size groups in the 'thangu vala' landing of the seasons 1959-60 through 1968-69 at Cochin*

Length intervals (mm)	1959—60	60—61	61—62	62—63	63—64	64—65	65—66	66—67	67—68	68—69
40 - 44				10.24						
45 - 49				15.36						
50 - 54				8.53						0.00
55 - 59				8.53			0.21			0.01
60 - 64				—			0.58			0.49
65 - 69				—			0.46		0.10	1.22
70 - 74	0.01			—			0.70		0.67	1.91
75 - 79	0.55			—			0.70		1.04	0.63
80 - 84	0.96			—		0.04	0.21	0.37	1.97	0.04
85 - 89	0.45			0.10		0.05	0.18	0.41	0.80	0.08
90 - 94	0.07	0.01	0.06	0.23	0.90	0.22	0.36	1.67	0.75	0.08
95 - 99	1.88	0.01	0.40	0.18	6.93	1.54	1.72	2.50	3.95	0.09
100 - 104	4.70	0.01	0.23	1.50	10.42	4.36	2.40	3.65	8.93	0.31
105 - 109	3.29	0.10	1.41	2.47	10.16	5.01	3.20	2.90	7.32	2.50
110 - 114	1.41	0.15	4.22	2.37	5.53	7.68	5.33	3.64	7.21	9.29
115 - 119	0.26	0.25	13.71	4.98	1.79	8.96	6.72	4.17	7.07	17.63
120 - 124	1.28	1.00	21.18	8.53	4.14	12.42	5.46	5.31	10.21	15.40
125 - 129	4.25	1.22	21.67	7.25	8.66	17.95	5.08	6.10	12.82	8.91

TABLE 4. (*Contd.*)

Length intervals (mm)	1959—60	60—61	61—62	62—63	63—64	64—65	65—66	66—67	67—68	68—69
130 - 134	17.31	1.25	18.50	6.89	9.93	21.99	8.60	10.79	14.94	9.22
135 - 139	22.20	8.07	9.62	3.42	9.36	12.43	9.51	16.38	8.53	9.83
140 - 144	12.25	40.28	3.50	5.09	6.39	5.42	10.97	15.07	5.39	6.38
145 - 149	7.71	24.55	0.79	1.50	3.93	0.95	10.27	7.65	2.69	4.48
150 - 154	3.69	13.41	0.38	1.17	3.54	0.27	11.82	3.90	1.39	3.33
155 - 159	2.21	4.59	0.73	1.22	2.74	0.09	8.34	1.01	1.66	2.61
160 - 164	1.92	2.07	1.33	1.71	3.49	0.05	4.74	2.34	1.01	2.89
165 - 169	3.52	0.79	1.10	2.99	1.89	0.04	1.39	4.90	0.63	1.23
170 - 174	3.92	0.54	0.67	3.10	2.74	0.16	0.24	4.28	0.43	0.86
175 - 179	2.13	1.19	0.30	1.89	2.78	0.16	0.10	2.24	0.21	0.34
180 - 184	2.17	0.24	0.10	0.56	2.54	0.11	0.06	0.60	0.26	0.21
185 - 189	1.64	0.20	0.05	0.09	1.24	0.08	0.22	0.04	0.02	0.03
190 - 194	0.08	0.07	0.05	0.10	0.79	0.02	0.30	0.05	—	—
195 - 199	0.14	—	—	0.00	0.06	—	0.13	0.03	—	—
200 - 204	—	—	—	—	0.05	—	—	—	—	—
Total Nos. in (thousands)	16261	145276	165274	80302	25807	282991	87771	177781	236947	98083

middle and posterior parts of ovaries, 200 ova each were measured at a magnification of 16.3μ to a micrometer division. Ova below 10 m.d. were abundant in all the ovaries. Ova diameters have been pooled into 5 m.d. groups for plotting frequencies (Fig. 1). There is only one group of maturing eggs, apart from immature oocytes, a compact group of limited size range, the prominent mode constituting 45 to 55%.

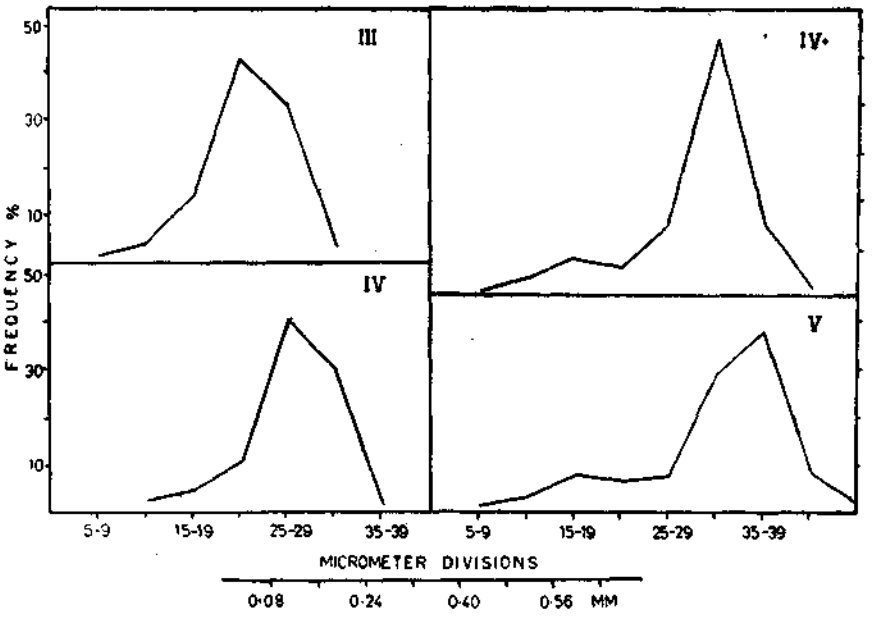

FIG. 1 Ova-diameter frequencies of oil-sardine in stages III, IV, IV+and V of maturity, measuring 15.6, 16.0, 16.9 and 18.9 cm. in total length respectively.

As the frequency curves for the maturing group of eggs are unimodal, a short period of spawning of ova in a single batch is indicated in an individual sardine. Though it differs from the findings of Dhulkhed (1964), it is in general agreement with the observations of Nair (1960) and Antony Raja (1964).

Maturation and spawning period

During the present investigation, fish above stage III of maturation were met with in length groups 140-190 mm. The 150-154 mm length group formed about 50% among those fish in stages III-V maturation range. This length (150-154 mm) of fish at first maturity agrees with the observations of Antony Raja (1964) and Hornell and Nayudu (1923.) The fish in stage V had an average length of 160 mm. The smallest maturing fish (stage IV) observed was 148 mm in total-length. No sardine with gonad oozing or 'running' was observed during this investigation in the Cochin area.

Fish in maturity stages III to V occurred from May to June regularly. In June of 1959 and 1960, all the fish sampled belonged to this category.

Partly spent fish having narrow and flabby gonads were met with in good numbers in August. Occurrence of spent fish was observed from September onwards; their proportion generally increased during October and November. Fish in spent recovering condition were observed after November, though their number in the catches was generally small then. Usually, spent recovering fish were remarkably lean also.

On the evidence obtained from sequence of maturation, occurrence of spent fish, the fish in stage V and the young ones, the peak period of spawning of the sardine may be inferred as from June to August, essentially agreeing with the observations of Antony Raja (1964).

General Remarks

Very fast growth has been observed in the oil-sardine before completion of the first 12 months of life (Balan, 1968). It is during this phase of their growth that the sardine become vulnerable to heavy fishing and predation. These mortalities, however, are compensated mostly by prolific breeding and large-scale recruitment. Simultaneous with the progression of the main modes the occurrence of smaller modal lengths in the catches (especially as in 1964-65), changing the pattern of length distribution, is significant, as it may either indicate the presence of separate broods, or the entry of the progeny from belated spawning. This is also in line with the observations of Prabhu and Dhulkhed (1967).

Fluctuations in growth rate of the O-year class fish is also a major aspect to be considered here; it is possible that this growth variation may be responsible for the presence of such length modes as at 60, 90, 100 and even 120 mm during the first six months following the May-July spawning.

Recruitment generally depends more upon the variability of mortality than on number of eggs produced (fecundity). The O-year recruits had marked decline in 1959-60, 1960-61, 1966-67 and 1967-68 seasons off Cochin. But their recruitment was heavy in 1962-63, 1963-64 and 1968-69 seasons. However, the regular and almost uninterrupted recruitment of various size-classes was often found supporting the catches at a nearly stable level, at a time when the sardine catches were feared declining.

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