OIL SARDINE INVESTIGATION AT KARWAR

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Introduction

The clupeoid group which is composed mainly of commercially important fishes like sardines, anchovies, white baits, *Hilsa* etc., contribute to a third of the total marine fish production of our country. The analysis presented in this article is a part of the work carried out by the author under "The biological investigation of some of the important teleosts of the Kanara coast." This work was initiated in early 1955 under the guidance of Dr. N. Kesava Panikkar, the then Director of the Central Marine Fisheries Research Institute and later continued under Dr. S. Jones the present Director. The present account relates to the fishery seasons, maturity, spawning and length frequency distribution of *Sardinella longiceps* (Cuv. & Val.) during January 1955 to March 1964.

Fishery

The fishery for this fish in North Kanara has been erratic and is restricted to a narrow 8—10 mile strip of the coastal water. The season at Karwar generally commences some time in September—November and terminates in March—April with the November—January portion representing the best period of the fishery. The duration and intensity of catches varied from season to season. It has been pointed out earlier* that *Sardinella longiceps* constitutes about 8.78% of the annual catch of marine fish during 1953 at Karwar. The percentage composition of oil sardine in the total catch ranged from 2% to 28% during the years 1955 to 1963. The gears employed are the shoreseines (*Rampan & Yendi*) and cast nets (*Veechuvalae*). The oil sardine fishery is obviously one that depends upon the movement of oil sardine towards inshore waters during the season. Whenever large shoals are sighted *Rampan* nets which are usually used for mackerel fishery are operated. Drag nets (*Gorbalae*) are also operated during the years of abundance. A brief account of the different seasons commencing from 1954/1955 is given below:—

1954/1955 season: The season lasted from November 1954 to June 1955 with the peak landings in January 1955. The total quantity netted was 179.29 tons.

1955/1956 season: From July 1955 onwards, oil sardines completely disappeared from the Karwar Bay though small-sized individuals were recorded

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in September 1955. Meagre quantities were netted in November 1955. Thus, the season being a short one, the quantity landed was absolutely negligible, less than a ton.

1956/1957 season : The season was a prolonged one extending to about nine months from November 1956 to July 1957. The peak period of the fishery was noticed in December 1956. The fishery showed signs of decline during February-March 1957 but improved in April. Thereafter, oil sardine continued to occur in the catches up to July and then completely disappeared. The total quantity landed for the season was 67.61 tons.

1957/1958 season : A reappearance of oil sardine fishery was noticed during September 1957 and the fishery came to a close in October. On the other hand, fairly good landings were reported from Bingae and Kumta, the nearby fishing centres, during the months of February and March 1958. A meagre quantity of 4.67 tons were netted at Karwar during this period.

1958/1959 season : Though small quantities of oil sardines were netted towards the end of September 1958 the actual season commenced only in November 1958 and lasted up to the third week of April 1959. A prolonged season for about eight months was witnessed, the previous prolonged season being in 1956/1957. However, there were frequent breaks in the fishing activity during the current season. The shoals were encountered along with mackerel in *Rampan* nets. Generally these nets are not operated for the capture of sardine shoals but an exception occurred during the first week of December ; a net consisting of 440 pieces was operated by 55 men for sardines alone and the total quantity of 9,072 Kg. were netted. The catch of oil sardine per net varied from 680 to 9,072 Kg. The peak period of the fishery was in December, the total quantity netted for the season being 113.81 tons.

1959/1960 season : The fishery commenced during the first week of November but it was of an erratic nature, as frequent breaks were noticed in the fishing activity. Though *Rampan, Yendi* and *Veechuvalae* were employed to encounter the shoals about 98% of the catch was accounted for by the *Rampan* nets. The fishery lasted for two months *i.e.*, November and December 1959 and the total catch was 118.73 tons.

1960/1961 Season: The fishery though erratic lasted only for a short period *i.e.*, October and November 1960. A quantity of less than a ton was landed, similar to that of the 1955/56 season. Stray catches were also netted in December, 1960. The whole catch for the season was accounted for by the *Rampan* nets.

1961/1962 season: The season showed a rising tendency and the fishery proved to be a good one in the early part of the season (October to December 1961) which came to a close early in August 1962. The season's catch was 31.13 tons. *Rampan, Yendi* and *Veechuvalae* were employed. The major portion of the catch was made

in July 1962. Meagre quantities were netted in February, May and August 1962 and these were accounted for by the *Rampan* nets.

1962/1963 season: The fishery commenced in September 1962. Bumper landings were recorded during October to December 1962 which registered a ten fold increase of oil sardine landings from the corresponding period of 1961. It is to be pointed out that such an increase was witnessed during this period throughout the Kanara coast. The glut in the fishery at many centres resulted in converting part of the catch into manure. At Karwar, this season has been the highest ever recorded, the total quantity netted being 382.51 tons. The fishery lasted up to March 1963, the peak landings being in December 1962.

1963/1964 season: Immediately after the bumper crop of 1962/1963 season, the fishery showed signs of decline. 26.96 tons were netted during this season which lasted from October 1963 to March 1964. The peak landings were recorded in January 1964. *Rampan, Yendi* and *Veechuvalae* were operated during the season.

The commencement and end of the different seasons together with the peak period and the total landings of oil sardines recorded at Karwar are shown in Table I.

The average landings for the ten seasons at Karwar commencing from 1954/1955 to 1963/1964 works out to 92.52 tons. Reviewing the total catch of oil sardines for the different seasons at Karwar, we could see that the catch varied from season to season and the fishery reached disastrously low levels during 1955/1956 to 1957/1958, 1960/1961 and 1961/1962. The landings during 1954/1955, 1958/1959 and 1959/1960 were above the average. A revival of the oil sardine fishery was witnessed during 1962/1963, bringing the highest ever recorded catch at Karwar (382.51 tons). The season immediately after the bumper crop was a complete failure.

TABLE I

The total landings and the beginning, end and peak period of the different seasons of oil sardine at Karwar

Seasons	Total landings of oil sardines at Karwar (in tons)	Beginning of the season	End of the season	Peak period
1	2	3	4	5
1954/1955	179.29	November '54	June '55	January '55
1955/1956	0.04	Landings reported for 2 months. September and November 1955.		

1	2	3	4	5
1956/1957 .	67.61	November '56	October '57	April '57
1957/1958 .	4.67	Landings reported for 2 months September and October 1957.		
1958/1959 .	113.81	September '58	April '59	January '59
1959/1960 .	118.73	Landings reported for 2 months November & December 1959.		
1960/1961 .	0.09	Landings reported for 2 months October & November 1960.		
1961/1962 .	31.13	October '61	August '62	November-December '61.
1962/1963 .	382.51	September '62	March '63	December '62
1963/1964 .	26.96	October '63	March '64	January '64

Maturity and Spawning

The mature sardine in stage IV (the fish size ranges from 147—205 mm) were observed during the 1955/1956 season. Since the fishery of 1956/1957 was mainly composed of juveniles (the modal sizes being 95 mm, 125 mm and 135 mm) the stages of maturity recorded were I and II. The appearance of immature (not beyond stage II) but large sized group (160—180 mm) contributed to the fishery from September to December during 1958/1959 season. During 1959/1960 all specimens recorded were immature (Stage I). During 1960/1961 the maturity stages recorded were in VII and II.

The fishery for 1961/1962 from October to February was constituted by oil sardine in maturity stages I and II. The stages of maturity in May were II and III, stage II predominating with 60.89%. For July the maturity recorded were IV-V, while in August IV-V and VII. During 1962/1963 from September to December the immature individuals in stage I were seen dominating the catches. Towards the close of December the individuals examined also showed maturity stages II and III. In January 1963, besides stage I, recovering spents in stage II in good proportion were also landed. For February and March, recovering spents (II) and spent ones (VII) predominated the catches. The maturity stages recorded in October during 1963/1964 were VII (100%) and for November I, II, III and VII, the dominant stage being immature I (54%). During December to February stage I again dominated with 74%, 42% and 60% respectively besides II (26%) in December, II (35%) and VII (23%) in January and II (18%) and VII (22%) in February. In March stage VII (54%) dominated.

A brief account of the spawning period of oil sardine indicated by earlier workers is given below:

Authors	Spawning period
Hornell (1910) . . .	End of June to end of August.
Hornell & Nayudu (1923) .	End of May to end of August with maximum taking place in June and July.
Devanesan (1943) . .	Collected active spawners and eggs during September and October and doubted the accuracy of Hornell and Nayudu's conclusions.
Nair (1953 & 1959) . .	Recorded spawners during June and July. Indicated that intensive spawning generally takes place during August and September.

The maturity stages with the percentages in the total together with the size range, dominant group, sex ratio during 1961/1962, 1962/1963 and 1963/1964 are shown in Tables II, III and IV.

TABLE II

Maturity stages /sex ratio/size range and dominant groups during different months at Karwar for 1961/1962 *season*

Months	Size range (mm)	Dominant groups with %	Maturity stages	Sex ratio	
				Male	Female
1	2	3	4	5	6
Oct. '61 .	94—140	105(35.71%)	Constituted by individuals in maturity stages I and II. Range of size of intra ovarian eggs were 0.051 mm to 0.102 mm.	52.0	48.0
Nov. '61 .	96—142	110(22.44%)	Do	48.15	51.85
Dec. '61 .	104—146	120(34.08%)		52.90	47.10
Jan. '62 .	111—139	115(34.86%) 125(23.40%)	Do	41.17	58.83
Feb. '62 .	104—126	115(34.86%)	Do	51.80	48.20

TABLE II (*Contd.*)

1	2	3	4	5	6
May '62	118—157	145(26.08%)	II & III	43.47	56.53
July '62	134—185	145(21.40%) 155(15.65%) 175(13.41%)	IV & V	53.34	46.66
Aug. '62	150—184	155(8.00%)	Mainly composed of spent ones, besides IV—V	44.00	56.00

TABLE III

Maturity stages/sex ratio/size range and dominant groups during different months at Karwar for 1962/1963 *season*

Months	Size range (mm)	Dominant groups with %	Maturity stages	Sex ratio	
				Male	Female
Sept. '62	87—155	95(8.79%) 105(9.25%) 135(25.46%)	I(100.00%)	40.74	59.25
Oct. '62	91—146	120(21.97%)	I(98.48%) II(1.52%)	59.05	40.94
Nov. '62	101—151	125(34.62%)	I(89.52%) II(10.48%)	56.18	43.82
Dec. '62	111—150	130(27.37%)	I(61.54%) II(35.66%) III(2.79%)	53.05	46.94
Jan. '63	110—149	135(27.91%)	I(54.69%) II*(45.30%)	56.35	43.64
Feb. '63	91—145	140(28.18%)	I(14.60%) II*(49.11%) VII(36.28%)	51.76	48.23
Mar. '63	120—149	140(38.97%)	I(1.60%) II*(44.80%) VII(53.60%)	44.80	55.20

*Recovered spents.

TABLE IV

Maturity stages/sex ratio/size range and dominant groups during different months at Karwar for 1963/1964 *season*

Months	Size range (mm)	Dominant groups with %	Maturity stages	Sex Ratio	
				Male	Female
Oct. '63	156—164	160(60.00%)	VII(100.00%)	70.00	30.00
Nov. '63	81—157	90(11.74%) 100(37.3%) 130(1.70%)	I(54.00%) II*(26.00%) III(6.00%) VII(14.00%)	60.00	40.00
Dec. '63	101—142	110(37.50%)	I(74.35%) II*(25.64%)	43.58	56.41
Jan. '64	101—154	115(25.93%) 140(6.25%)	I(41.66%) II*(35.41%) VII(22.92%)	43.75	56.25
Feb. '64	114—144	125(37:21%)	I(60.00%) II*(18.00%) VII(22.00%)	62.00	38.00
Mar. '64	125—186	130(14.54%) 160(14.54%)	I(21.81%) II*(23.62%) VII(54.54%)	40.00	60.00

*Recovered spents.

The overall seasonal percentages of males and females for the different seasons at Karwar are shown below:

Seasons	Percentage of males in the total	Percentage of females in the total
1959/1960	51.74	48.25
1960/1961	48.57	51.42
1961/1962	50.93	49.06
1962/1963	54.27	45.72
1963/1964	52.00	48.00

During most of the seasons except 1960/1961 males slightly dominated over females. Hornell and Nayudu (1923) has shown that "males predominated slightly

over the females in the case of spent sardines" and this was attributed by them to a considerably higher rate of mortality of the females than the males after spawning. They further pointed out that the females predominate among juveniles till they become mature and move off to the spawning grounds." It is seen from the available records at Karwar that males were relatively numerous among the immature group but among the spent fishes females outnumbered males. Thus these conclusions on sex composition remain to be further checked from the data from different centres.

Viewing the data collected for the last few years, it is gathered that empty adults were obtained in April during 1958/1959 and October to November during 1960/61. The prominence of spent and recovering individuals during the months of January to March 1963 for 1962/1963 season, and during October 1963 to March 1964 for 1963/1964 season were noticed. Neither spawning individuals in stage VI nor free eggs have been recorded at Karwar. The occurrence of mature individuals in stage IV-V in the inshore area at Karwar during January to August 1962 were witnessed. Because of the mature individuals in stage IV-V during July-August and the predominance of spent ones during August, February and March besides recovering ones in January to March in the inshore area at Karwar, it is concluded that the spawning of this species along this coast is much prolonged than hitherto believed.

Hornell and Nayudu (1923), Devanesan (1943), Chidambaran and Venkataraman (1946) have stated that the oil sardine attains a size of 15 cm at first maturity. The estimate given by the above mentioned authors appear to be rather high as during the 1962/1963 and 1963/1964 seasons, spent individuals were obtained from January to March in the size groups ranging from 120—139 mm. The occurrence of spent gonads in this size range which confirms the onset of maturity may probably be the first record from our coast.

According to Nair (1953) oil sardines spawn only once as shown by the simultaneous maturation and extrusion of almost all the mature ovarian eggs and also by the scarcity of partly spent and recovered spent forms. Since it has been indicated that the spawning season of this species appear to be a prolonged one it seems possible that one or more additional batches could mature successively in the same season as an early spawning. Further, the minimum size at maturity around this group (120-139 mm) indicate the possibility of individual fishes entering the spawning season more than once in their life time. Reference may be made here about the occurrence of an unusually larger size group (160-180 mm) in comparatively earlier stages of gonadial development (Stage II) during 1958/1959 season at Karwar. Such a phenomenon was also reported from Mangalore during the same season. This obviously suggests that these shoals may come from a different stock altogether and the related possibility that they belong to a different spawning generation.

Because of the notable absence of individuals with fully ripe gonads along the coastal waters at Karwar and the reappearance of spent and recovering fishes along the coast, it seems reasonable to suppose that this species migrates into offshore regions beyond the existing fishing limit for the purpose of spawning. This conclusion is further supported by the fact that so far neither the eggs nor the larvae have been collected from the coastal plankton samples.

Length-Frequency Distribution

Since there are not much of difference in sizes netted by different gears, the data have been pooled together, and graphs drawn accordingly.

1954/1955 season: The size ranges recorded for February March, April, May and June 1955 respectively were 110—156, 112—153, 111—158, 120—161 and 121-162 mm. For February 1955, mode "I" at 120 mm. (23.15%) is noticed This has moved to 130 mm (42.29%) in March '55. Mode "2" at 120 mm (14.66%) in March has moved to 130 mm (32.72%) in April and to 150 mm (10.65%) in June '55. A third mode "3" seen at 120 mm (16.25%) in April has shifted to 130 mm (27.76%) in May and by June showed a further increase, the modal size remaining at 140 mm (31.52%). The seasonal length frequency analysis has shown that about 32% of the commercial catch were composed of individuals in 130 mm size group.

1955/1956 season: The 130 mm size group which contributed mainly to the 1954/1955 season disappeared from the fishing grounds altogether in June '55 and a new stock composed of small ones (55—72 mm) was observed in September. But since the catch was negligible the length frequency analysis for this month has not been taken into consideration except to state that the dominant group for September was 60 mm. In November '55 the individuals with size range 147—205 mm were netted, the fishery being dominated by three modes, *i.e.*, "4" at 155 mm (12.98%), "5" at 165 mm (9.13%) and "6" at 185 mm (20.19%). During 1955/1956, Balan (1959) has also indicated three distinct modes, *i.e.*, 120 mm, 160 mm and 180 mm in the length frequency distribution of this species at Calicut.

1956-1957 & 1957-1958 seasons: For November, December and January '57 the size groups recorded were 81—126 mm 81—146 mm and 81—126 mm respectively. The size ranges recorded for other months were as follows:

March '57	100—135 mm
April	91—146 mm
May	90—135 mm
June	101—156 mm
July	92—140 mm
September '57*	121—149 mm
October*	121—146 mm

* This relates to1957/1958 season.

The smallest group "7" recorded in November '56 at 90 mm (29.31%) relates to that year's spawn. This mode can be further traced at 100 mm (22.93%) in December, 110 mm (8.13%) in January, and 120 mm (29.94%) in March. This mode remained constant at 120 mm (21.37%) in April. Mode "8" seen in November at 100 mm (24.38%) can be noticed at 110 mm (25.63%) in December, 130 mm (19.61%) in March, 135 mm (14.59%) in April and 145 mm (7.08%) in June. Mode "9" at 110 mm (10.68%) seen in November '56 has shifted to 120 mm (7.23%) in December and January '57.

Mode "10" at 90 mm (16.42%) in December '56 can be further traced at 100 mm (35.88%) in January, 110 mm (19.28%) in March, 110 mm (21.37%) in April, 120 mm (19.06%) in May, 130 mm (20.41%) in June, 135 mm (41.36%) in September and 140 mm (17.64%) in October '57. In January '57, another mode "11" appeared at 90 mm (32.05%) 100 mm (8.56%) in April, 110 mm (16.53%) in May, 120 mm (18.66%) in June and 130 mm (10.21%) in July '57. In May, a new mode "12" at 100 mm (11.45%) is noticed which has shifted to 110 mm (7.53%) in June, 120 mm (35.03%) in July and 130 mm (31.76%) in October '57. A new mode "13" appeared at 90 mm (6.20%) in May has shifted to 110 mm (11.68%) in July. Another mode "14" is also noticed at 100 mm (8.75%) in July. The seasonal length frequency analysis has shown that 90 mm (9.60%), 110 mm (15.99%) and 120 mm (13.38%) contributed to the fishery. Balan (1959) has recorded three modes at Calicut for 1956/1957 season *i.e.*, 120 mm, 170 mm and 190 mm. The bigger size groups at 170 mm and 190 mm recorded at Calicut were absent at Karwar.

1958/1959 season: The monthly size ranges recorded during the season are as follows:

September '58	144—157 mm
November	151—189 mm
December	151—186 mm
January '59	151—186 mm
February	145—199 mm
March	150—189 mm
April	130—197 mm

The 150 mm group mode "14(1)" dominated with 33.33% for September. During the subsequent months from November '58 to April '59 two dominant modes, *i.e.*, at 160 mm (mode "14(1)") and at 170 mm (mode "15") are witnessed, the modes remaining constant throughout. For February '59 a new mode "16" is seen at 150 mm (3.33%). The annual length frequency distribution has shown that 150 mm (5.68%), 160 mm (29.32%) and 170 mm (29.32%) were the three important groups which contributed to the fishery.

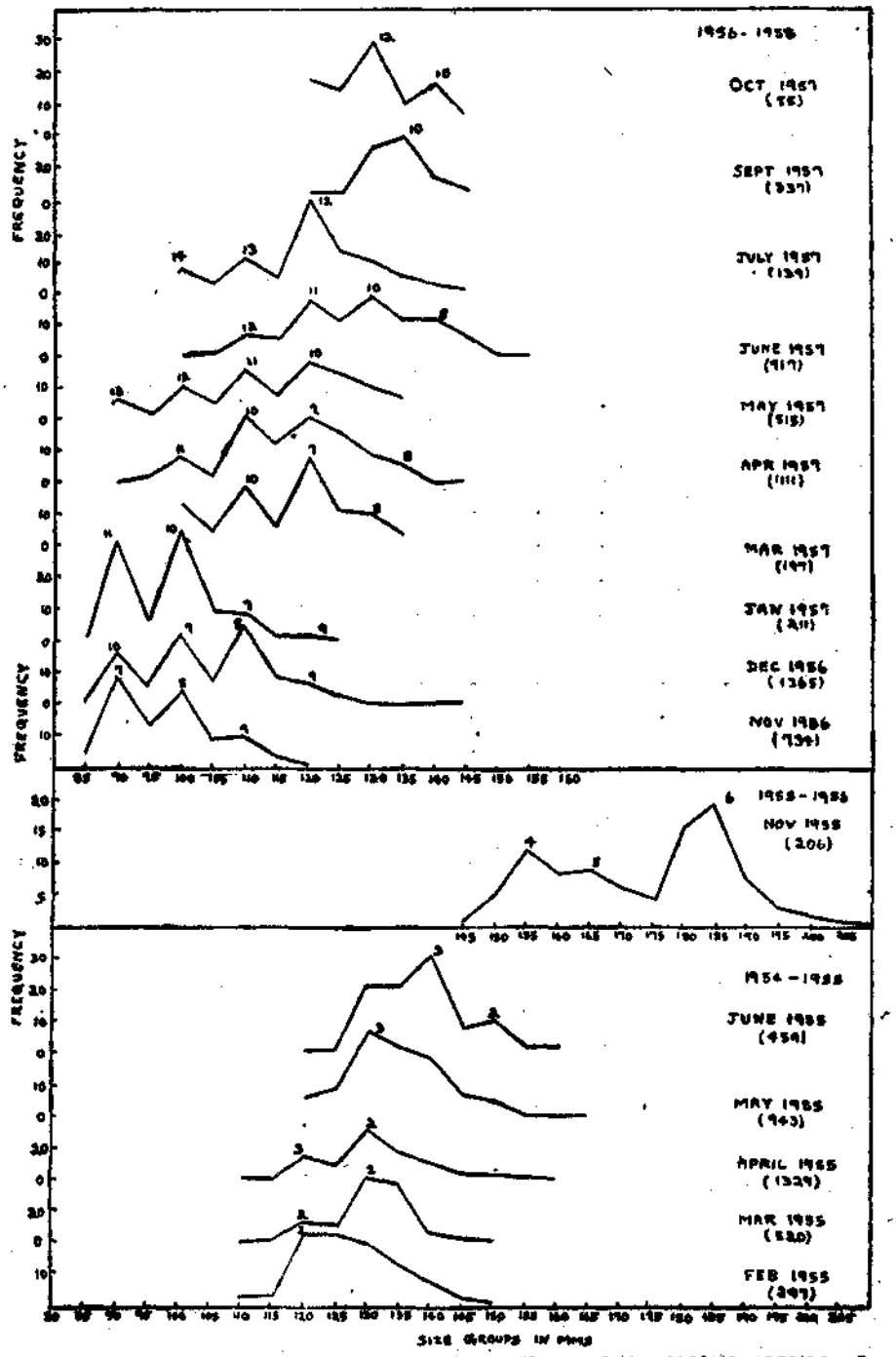

FIG. 1 Length-frequency distribution of oil sardine at Karwar during 1954/55, 1955/56 and 1956/58 seasons.

1959/1960 season: The range of size for November and December respectively were 121—168 mm and 121—148 mm. It is seen that 135 mm (26.48%) and 140 mm (27.14%) contributed much to the fishery during the season. For November 1959, the modal size of mode "17" was 135 mm (26.19%) and for December it showed an increase of 5 mm the size being 140 mm (8.42%).

1960/1961 season: The size ranges recorded for October and November respectively were 154—175 mm and 142—205 mm. The 165 mm. group (mode "18") dominated the catches for October with 64.55%. For November this mode remained at the same place where it was for the previous month. Other modes noticed for November were: Mode "19" at 150 mm (3.96%), mode "20" at 185 mm (11.88%) and Mode "21" at 195 mm (5.44%).

1961/1962 season: The size ranges recorded from October '61 to August '62 are shown below. During March, April and June Oil sardine landings were not reported.

October '61	94—141 mm
November	96—142 mm
December	104—146 mm
January '62	111—139 mm
February	104—126 mm
May	118—157 mm
July	134—185 mm
August	150—184 mm

Since the number measured was too small in August, the data have been omitted for detailed analysis. Mode "22" recorded in October '61 at 105 mm (35.71%) can be further traced at 110 mm (22.44%) in November, 120 mm (34.08%) in December, 125 mm (23.40%) in January '57, 145 mm (26.08%) in May. This mode remained at the same position in July also. In January and February, the 115 mm group (mode "23") dominated the catches with 34.86% and 48.21% respectively. Mode "24" at 155 mm (15.65%) and mode "25" at 175 mm (13.41%) were noticed in July. The bulk of the landings for the entire season came from the 120 mm (26.15%) size group.

1962/1963 season: The range of size noted for September '62 were 87—155 mm with peaks: Mode "26" at 95 mm (8.79%) mode "27" at 105 mm (9.25%), mode "28" at 120 mm (4.16%) and mode "29" at 135 mm (25.46%). The last mode predominated the catch. It is seen that younger generation (a new batch of small-sized sardines) entering the fishery was noted during this month and the same was reported from almost all the centres of the west coast. In October the catches included individuals ranging in size from as small as 52 mm up to 146 mm the 120—125 mm (42.17%) group predominated. (Mode "28"). The occurrence of such small-sized individuals in the month of October was recorded for the first

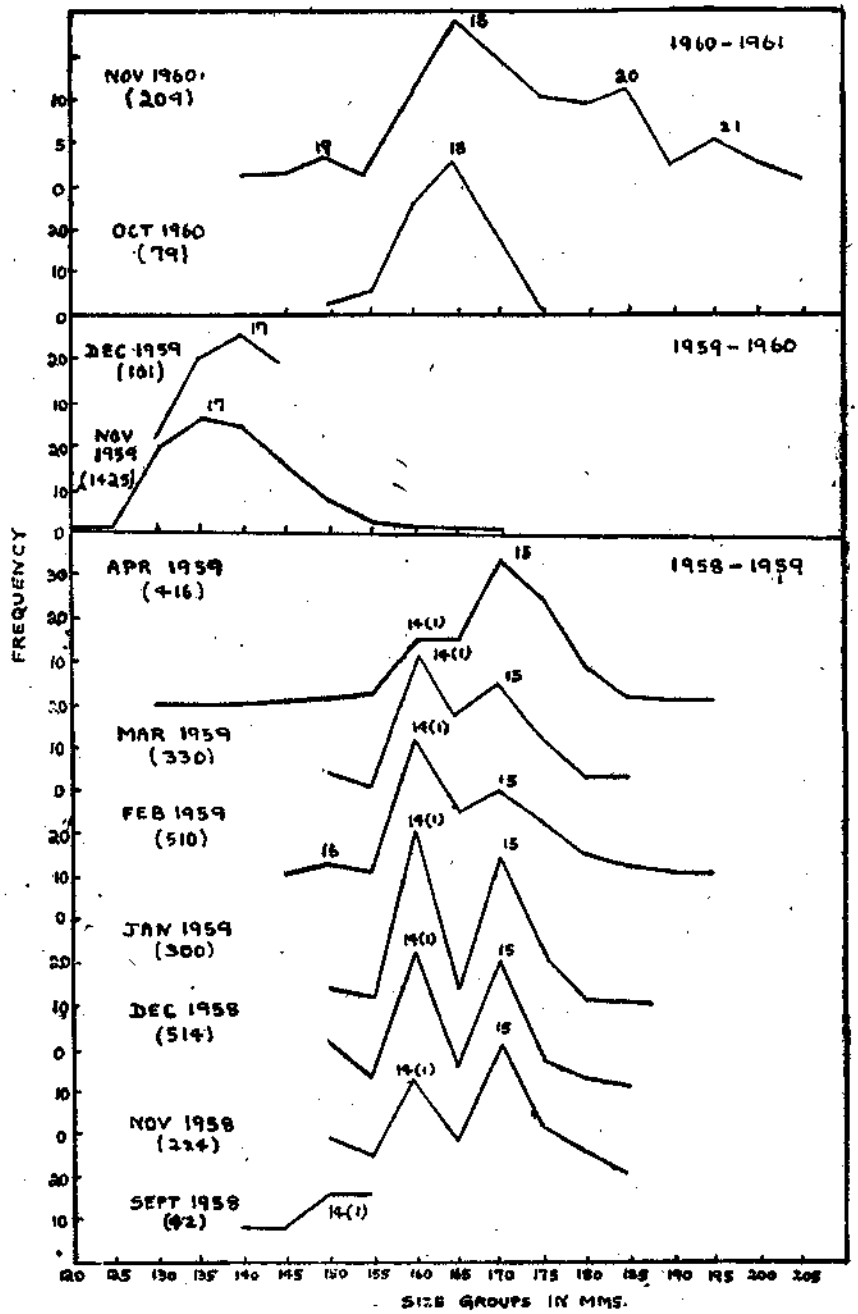

FIG. 2. Length-frequency distribution of oil sardine at Karwar during 1958/59, 1959/60 and 1960/61 seasons.

time at Karwar. The range of size noted for November and December were 101—151 mm and 115—150 mm respectively with dominant sizes at 125 mm (34.62%) and 130 mm (29.37%) for the different months. These were the continuation of mode "28". For January '63, the mode at 130 mm seen for the previous month remained at the same position with 27.91% along with another mode "30" at 120 mm (22.01%), the size range recorded for that month being 110—149 mm.

For February and March the 135 mm group (mode "28") predominated the catches, the size range for these months being 91—147 and 120—149 mm respectively. The seasonal length frequency analysis has shown that the bulk of the catch was composed of 130 mm individuals with 24.09%.

1963/1964 season: The range of sizes recorded for October, November and December were 156—164, 81—157 and 101—142 mm respectively. Landings were absolutely poor in October as only a meagre quantity were netted with 160 mm group dominating the catch. Since the samples were too small, this was not taken into consideration for detailed analysis.

The younger generation belonging to the O-year class appeared to have entered the fishery in fairly large numbers during November 1963 at Karwar. The 100 mm group (mode "32") dominated the fishery with 37.31% besides minor modes at 90 mm (11.74%) and at 130 mm (1.70%). In December, the 110 mm was found to be dominant with 37.50%. The size ranges recorded for January, February and March were 101—154 mm, 114—144 mm and 125—186 mm respectively. The continuation of mode "32" seen in November-December months at 100 mm and 110 mm respectively were again traced at 115 mm (25.93%) in January, 125 mm (37.21%) in February and 130 mm (14.54%) in March, thus showing the growth trend of the species. Mode "33" was further traced in January at 140 mm (6.25%) and in March at 160—165 mm (27.28%). The seasonal length frequency analysis revealed that the bulk of the catch was composed of 110-115 mm group individuals forming 26.92%.

Viewing the data as a whole we find that the fishery showed the usual changes in the age composition during the different years. The monthly progression of modes for the different seasons were traced to illustrate the rate of growth of the species to the possible extend. Hornell and Nayudu (1923) have concluded that oil sardine attains a length of 15 cm (SL) at the age of one year and growth during the second year is extremely slow, and amounts to only 1 cm in length. The oldest sardine examined by them was approximately 2½ years, which was believed to be the ordinary limit of life. Devanesan (1943) suggested that the life span extends over 14 years. Nair (1949) indicated that the average life span is about 3-4 years. Chidambaram's (1950) findings lend support to Nair's conclusions. He also inferred that the life span is between 3-4 years, and estimated the average length as 100, 145, 185, and 205 mm at the end of 1, 2, 3, and 4 years respectively.

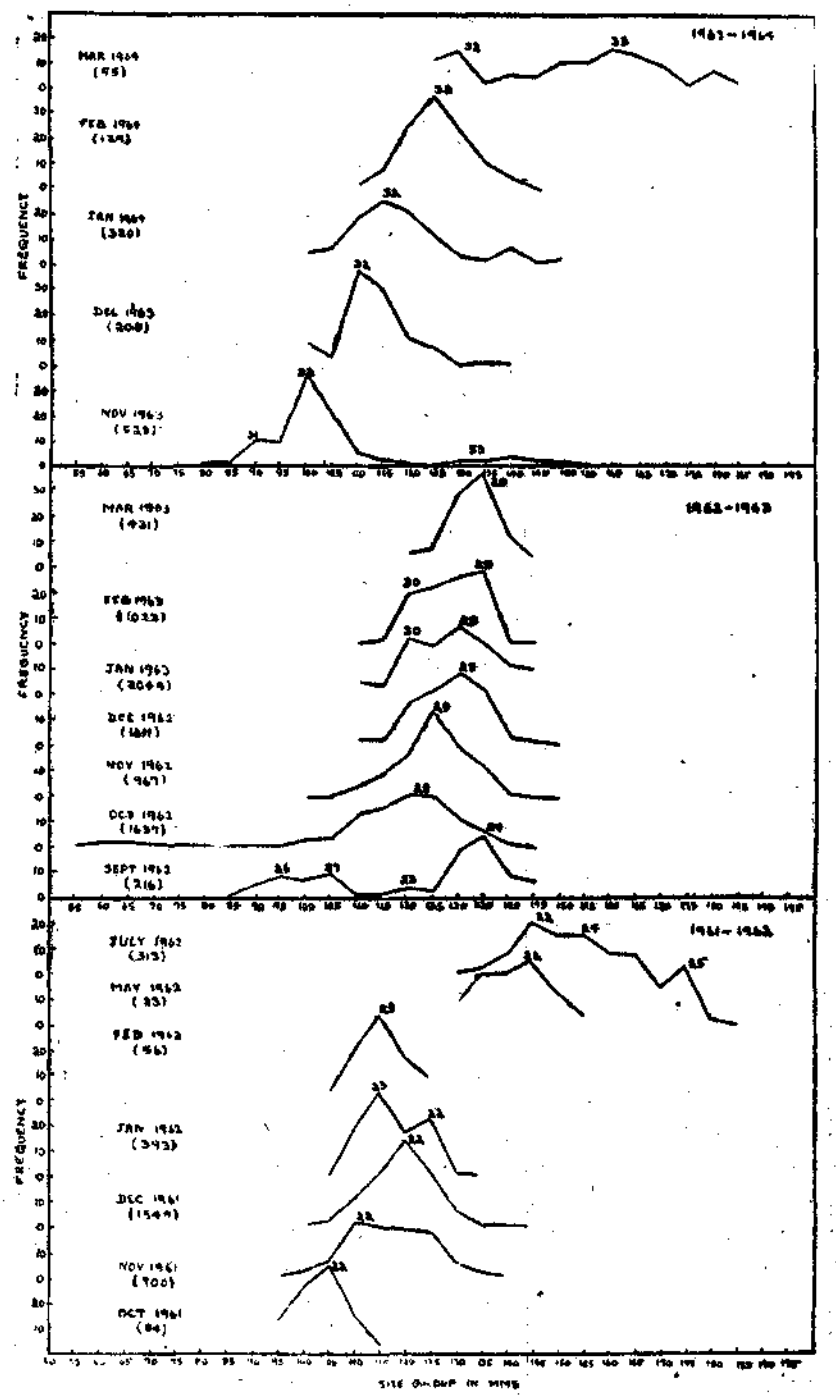

FIG. 3. Length-frequency distribution of oil sardine at Karwar during 1961/62, 1962/63 and 1963/64 seasons.

Nair (1953) stated that the new stock recruited every year during the short spawning season grows to a length of 10 cm and enters the fishery in a very immature condition during the subsequent year. At the end of the second year when the gonads are in the early stages of maturity the fish matures at 15 cm. They attain the adult spawning size at 19 cm at the end of the 3rd year. A small percentage of population alone reaches the maximum size of 210 mm and above during the 4th year. The recent study of Sekharan (1962) on oil sardine fishery of Calicut area during 1955-1959 has also shown that the size of 1 and 2 year olds as about 10 and 15 cm respectively. Based on the data collected at Karwar, it is seen that this species grows to a length of 90-100 mm during the 5-6 months period and that the modal size of one year old fishes appear to be in the size range from 135-145 mm and that during the second year it ranges from 160-165 mm. Studies have also shown that this species in the earlier stages of its life grows at a faster rate, and when it enters the second year, it slows down considerably.

No true understanding of the sardine fishery and its population can be reached until the size fluctuations occurring within each fishing season are clearly set forth. It is seen that the products of 1954 spawn contributed much to the 1954/1955 season from February '55 and that the fishery draws its support mostly from O-year group, along with I+ year class to some extent towards the close of the season. And when the fishery for 1955/56 season commenced from November 1955 at modes 155 mm and above, it might obviously have completed one year or more and hence reasonable to assume that the 1955/1956 fishery was mainly composed of individuals in I+ and II+ year class. While examining the data for 1956/1957, it is presumed that the individuals recorded at 90 mm in November 1956 to January 1957 must be the products of spawned individuals during July-September of that year (1956). Later the progression of different modes was traced and when it showed a modal size of 135-140 mm in September and October, it obviously has completed one year. Thus we see that the 1956/1957 and 1957/1958 seasons were mainly composed of O-year and I+ year class respectively. During 1958/1959 season the older generation I+ and II+ contributed to the fishery whereas for 1959/1960 the products of early 1959 spawn entered the fishery after completing just or about one year with the size range at 135-140 mm. During 1960/1961 the presence of different modes between 150 mm to 195 mm might probably be due to the slight shifting of the period of spawning, the fishery being dominated by II+ year class. For 1961/1962 the bulk of the landings were composed of individuals in the O year group. Towards the close of the season, May and August fishes belonging to I+ and II+ individuals seem to have contributed to the fishery. Since the group (120 mm in September to 135 mm in March) can be steadily traced throughout all the months during 1962/1963 after its entry into the fishery, it is possible that these are recruits from the 1962 stock. Thus, we conclude that the O year class formed the bulk of the fishery during 1962/1963. Another interesting feature noticed during the said season was that the 135 mm group seen in September 1962 (mode "29")

failed to form an appreciable percentage of the catches at Karwar after September. There is every likelihood of this group being the recruits from the earlier spawners probably belonging to the older generation which entered the spawning season for the second time. Since the spawning class formed only a minor percentage during the spawning season, it is likely that their contribution to the recruitment would have been of lesser magnitude and hence the immature stock mentioned above failed to form the mainstay. It is of interest to note that big-sized sardines belonging to II+ and above were landed in March '64 for 1963/64 season. The bulk was chiefly supported by O and I+ year class, the abundance of which was very consistent.

To sum up the data it is seen that during 1954/1955, 1956/57, 1959/1960, 1961/1962 and 1962/1963 the fishery depended on the availability of 120-149 mm group individuals and the seasonal catch during the above-mentioned seasons appear to be above average for Karwar. The dominance of bigger size groups in the fishery occurred during 1955/1956, 1958/1959 and 1960/1961, the seasonal catch except for 1958/1959 was just negligible. It is obvious that the O and I+ year classes form the recruit age group and the fishery depended mainly on their abundance in the inshore waters at Karwar. There appears to be a correlation between the dominant size group occurring in the fishery and the seasonal catch for oil sardine. The possibility has been indicated but more data from other centres are required before any positive conclusion is put forward.

According to Nair and Subrahmanyan (1955) optimum temperature, salinity conditions and the availability of *Fragilaria oceanica* are the causative factors which influence the movements of the juveniles on the abundance of which depends the success or failure of the fishery every year. Whether the theory put forward by Nair and Subrahmanyan (1955) applies to the other parts of the Indian coast is a point which only collaborated investigation will clarify, since there appears to be no correlation between oil sardine landings and bloom of *F. oceanica* at Karwar. Chidambaram (1950) while discussing environmental factors responsible for the fluctuations in the fishery suggested that temperature, salinity and availability of food, control the spawning and survival of the larvae and fry. Since the occurrence of oil sardine was sporadic and erratic at Karwar, no conclusion could be drawn, so as to show correlation existing between oil sardine landings and hydrological conditions.

Summary

A detailed account relating to the fishery seasons, maturity and length frequency distribution of *Sardinella longiceps* (Cuv. & Val.) at Karwar during January 1955 to March 1964 is presented.

The season at Karwar generally commences some time in September-November and terminates in March-April with the November-January portion representing

the best period of the fishery. The fishing gears employed in the fishery and a brief account of the different seasons from 1954/1955 to 1963/1964 are given. The average landings at Karwar works out to 92.52 tons. The fishery reached disastrously low levels during 1955/1956, 1956/1957, 1957/1958, 1960/1961 and 1961/1962. The landings during 1954/1955, 1958/1959 and 1959/1960 were above the average figure. A revival of the oil sardine fishery was witnessed during 1962/1963 season, bringing the highest ever recorded catch at Karwar (382.51 tons) The season immediately after the bumper crop was a complete failure.

The maturity stages recorded during the different seasons have been dealt with. Because of the occurrence of mature individuals in stage IV/V during July/August and the predominance of spent ones during August, February and March besides recovering individuals in January-March in the inshore area at Karwar, it is concluded that the spawning of this species is much prolonged than hitherto believed. Further, the minimum size at maturity around 120-139 mm indicate the possibility of individual fishes entering the spawning season more than once in their life time. Because of the notable absence of individuals with fully ripe gonads along the coastal waters at Karwar and the reappearance of spent and recovering fishes along the coast, it seems reasonable to suppose that this species migrates into offshore regions beyond the existing fishing limit for the purpose of spawning. Most of the seasons except 1960/1961 males slightly dominated over the females. It is also noticed that males were relatively numerous among the immature group but among the spent fishes females outnumbered males.

Length frequency distribution of oil sardine at Karwar from 1954/1955 to 1963/1964 has been analysed. It is seen that the rate of growth in the different year classes varies owing to the shifting of the time of recruitment and the period of spawning of this species. Studies have shown that in the early stages of its life, this species grows at a faster rate and that when it enters the second year it slows down considerably. The modal size of one year old fish appear to be in the size range between 135-145 mm and that of the second year 160-165 mm. The shoals at Karwar were mainly composed of O and 1+year old sardines and the small sized sardines have contributed largely to the success of the fishery in the years of abundance.

Since the occurrence of oil sardines at Karwar was erratic, no conclusion could be derived, so as to show correlation, if any between the landings of oil sardine and hydrological conditions.

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REFERENCES

Balan, V. 1959 — Age determination of the Indian oil sardine, *Sardinella longiceps* Val by means of scales. *Curr. Sci.*, **29**(3) : 122-23.

Chidambaram, K. 1950 — Studies on length frequency of the oil sardine, *Sardinella longiceps* (Cuv. & Val.) and certain factors influencing their appearance on the Calicut coast of Madras Presidency. *Proc. Indian Acad. Sci.* **31** (5) : 252-86.

Chidambaram, K. and Venkataraman, R. S. 1946. — *Tabular statements on the natural history of certain marine food fishes of the Madras Presidency West coast.* Government press, Madras, 26 pp.

Devanesan, D. W. 1943 — A brief investigation into the causes of the fluctuation of the annual fishery of the oil sardine of Malabar, *Sardinella longiceps* (Cuv. & Val.) Determination of its age and an account of the discovery of its eggs and spawning ground. *Madras Fish. Bull.* **28**(1) : 1-38.

Hornell, J. 1910 — Report on the results of a fishery cruise along the Malabar coast and to the Laccadive Islands in 1908 *Madras Fish. Bull.* **4**(4) : 71-126.

Hornell, J. and Nayudu, M. R. 1923 — A contribution to the life history of the Indian sardine with notes on the plankton of the Madras coast. *Madras Fish. Bull.*, **17**(5) : 129-97.

Nair, R. V. 1949 — The growth rings on the otoliths of the oil sardine *Sardinella longiceps* (Cuv. & Val.) *Curr. Sci.*, 18(1): 9-11.

Nair, R. V. 1953 — Studies on the revival of the Indian oil sardine fishery. *Proc. Indo-Pac.. Fish. Coun.*, 115-29.

Nair, R. V. 1959 — Notes on the spawning habits and early life history of the oil sardine, *Sardinella longiceps* (Cuv. & Val.) *Indian J. Fish.* **6**(6), 342-59.

Subrahmanyan, R. 1955 — The diatom, *Fragilaria oceanica* Cleve, an indicator of abundance of the oil sardine, *Sardinella longiceps* (Cuv. & Val.) *Curr. Sci.*, 24(2), 41-2.

Sekharan, K. V. 1962 — On the Oil sardine fishery of the Calicut area during the years 1955-56 to 1958-59. *Indian J. Fish.* **9**(2), A : 679-700.