LENGTH AND AGE COMPOSITION OF THE OIL SARDINE CATCH OFF CALICUT COAST IN 1964 AND 1965

By P. Sam Bennet

(Central Marine Fisheries Research Institute, Mandapam Camp)

The oil sardine, *Sardinella longiceps* Val., fishery has been the subject of several investigations ever since the starting of fisheries research in India. Great attention is concentrated on the fish and its biology mainly because of the tremendous variations in the yield. Catch in one area of the coast has often differed from that in other areas in the same season and periods of spectacular abundance have been followed by seasons of dramatic decline. Along the Calicut coast the oil sardine fishery has a special position, the economy of the coastal people is completely dependent upon it. Not only is fish an important food item of the ever-increasing coastal population who can rarely afford meat but it is also a satisfying substitute for the grain content of the daily food. During the so-called good oil sardine year every suitable gear is employed to get a good catch. Because the intake of oil sardine for human consumption is limited the bulk of the catch during the glut season is utilised for pickling and a small portion for manure and for extracting oil. A decline in the oil sardine fishery tells adversely on the economic situation of the coastal people as the fall in the sardine landings could not be offset by gains in catches of other fishes. In the absence of oil sardine the lower class consumers have to divert much more money to purchase much less other fish. The problem with the oil sardine is to keep the yield sustained.

An important aspect in the study of the oil sardine fishery is information about the size and age composition of the yield in "good" as well as "bad" years. To know the year-class that contributes to a successful fishing year and the year-class that is responsible for the failure in the fishery and their effect through the years, contributes an economic asset to the fisherman in addition to being an invaluable aid to the fishery administrator. To devise ways and means to meet the situation it is necessary to determine how the scarcity of oil sardine fishery during certain years has come about. It is necessary in the first instance to consider the number of fish in the different age groups caught by the fishermen. The present study of the oil sardine helps to relate the size and age composition of the sardine to fluctuations in the catch and to record the events in the fishery resulting from regular sampling of the commercial catch.

The catch analyses are based on data collected regularly at Calicut (Vellayil) fish landing centre. Nair and Chidambaram (1951) give a review of the fishing methods and general fishing conditions along this coast. Data on the "carrier"

boat landings are not included in this report. Length measurements are made in millimetres using a standard measuring board. Length frequencies for the sample days are weighted against monthly landings. Weights are taken in grammes.

THE FISHERY

The oil sardine is one of the major fisheries at Calicut and fishing for it continues all round the year. However the period from March to June is considered as the lean period for the oil sardine, the peak season being the months from September to December or even January. During 1964 the annual catch was around 5,560 tonnes. The first half of 1964 witnessed poor landings which came as low as 1.3 tonnes in May. There was no fishery for oil sardine in June. Sardines again appeared in commercial quantities in July with the landing of 223 tonnes of fish. From August there was a steady increase in the monthly landings till December when the catch reached a monthly record of 1,820 tonnes. Monthly landings are recorded in Tables I and II.

Any appreciable increase in the catch can be attributed to increased arrivals of the fish at the fishing grounds and the efficiency of the fishing gears used. Several periods of increased catch are indicated in Table I. The first increase occurred during September 1964 when 474 tonnes of fish were landed. There was a sudden increase in the oil sardine landings in October with 1,498 tonnes. The next marked increase of the commercial catch in 1964 was in December with 1,820 tonnes.

The 1965 season indicated unsteady fluctuations. There was gradual but discontinuous decline in the fishery. From 1,780 tonnes in January the catch went down to 124 tonnes in September. The period between January and September witnessed alternate rise and fall in the landings. However the situation improved with the remarkable regaining of the fishery in October with 1,177 tonnes of oil sardine landed in the commercial catches. During the next two months there was a decline in the landings though oil sardine remained the major item in the local fishery.

Boat seines and gill nets are the main implements in the oil sardine fishery at Calicut. During August 1965 when new recruits entered into the fishery cast nets were used to get the smaller size groups. A comparative account of catch and effort for the important sardine gear is given in Tables III and IV. The boat seines, 'pattankolli vala' and 'mathikolli vala', are widely used in the oil sardine fishery and they together account for over 75% of the total landings. The 'mathikolli vala' is considered as the most important gear in the sardine fishery at Calicut. In 1964 about 3,292 units were employed, for landing 2,697 tonnes of oil sardine. The catch per gear during the year came to 819 kg. of fish. The number of units operated in 1965 came to 5,097 with a record catch of 4,333 tonnes. Catch per gear in 1965 came to 851 kg.

TABLE I

Year-class composition of the Sardinella longiceps *catch at Calicut in 1964.*

Months	Catch		Number of fish by year-class				
	Kg.	Numbers	1964	1963	1962	1961	1960
January	48088	1348614				714762	633852
February	21247	774307			30972	743335	
March	4042	128817			2629	99900	26288
April	22328	740185			5787	727643	6755
May	1341	41880				41880	
June	00	00			00	00	00
July	223386	4047940				4047940	
August	203452	10256377		10174326		82051	
September	473874	27026771		26197600		829171	
October	1498239	82004679		81203908		800771	
November	1243581	86172758		86172758			
December	1820013	98670118		91200692		7469426	
Total	5559591	311212446	00	294949284	39388	15556879	666895

TABLE II

Year-class composition of the Sardinella longiceps *catch at Calicut in 1965.*

Months	Catch		Number of fish by year-class				
	Kg.	Numbers	1965	1964	1963	1962	1961
January	1779770	93931253			86874332		7056921
February	804351	49798881			49798881		
March	397568	24250359			24250359		
April	199364	12533611			12533611		
May	361137	27070906			26707781	363125	
June	235680	19449346			18957293	492053	
July	266200	10036001			9823179	212822	
August	439195	44061074	18930573	4730321	20400180		
September	123965	4479436		1167733	3311703		
October	1176775	43075210		11746355	31328855		
November	449183	34088523		28608972	5479551		
December	401380	17487497		16109746	1354719	23032	
Total	6634568	380262097	18930573	62363127	290820444	1091032	7056921

TABLE III

Catch and effort for Sardinella longiceps *at Calicut.*

Months	1964			1965		
	Landings in Kg.	Total units operated	Catch per unit	Landings in Kg.	Total units operated	Catch per unit
Pattankolli vala						
Jan	33,178	251	132·2	00	00	00
Feb	21,247	161	131·9	00	00	00
Mar	4,042	44	91·9	00	00	00
Apr	11,356	57	199·2	00	00	00
May	00	00	00	1,349	14	96·3
June	00	00	00	1,56,399	492	317·8
July	00	00	00	2,65,787	1,042	255·0
August	00	00	00	3,84,356	1,094	351·3
Sep	1,01,122	425	237·9	1,19,116	324	367·6
Oct	00	00	00	7,62,450	661	1,153·4
Nov	00	00	00	2,10,703	294	716·6
Dec	00	00	00	88,495	105	850·9
Total	1,70,945	1,083	157·8	19,88,655	4,039	492·4
Mathikolli vala						
Jan	4,618	26	177·6	17,78,070	1,642	1,082·9
Feb	00	00	00	8,04,351	897	896·7
Mar	00	00	00	3,97,555	416	955·6
Apr	00	00	00	1,99,251	227	877·7
May	00	00	00	3,59,788	418	860·7
Jun	00	00	00	2,53,764	209	1,214·1
Jul	2,23,386	515	433·7	00	00	00
Aug	1,809	7	258·4	00	00	00
Sep	13,424	16	839·0	00	00	00
Oct	62,498	77	811·6	00	00	00
Nov	5,71,559	864	661·5	2,34,296	560	418·3
Dec	18,20,013	1,787	1,018·5	3,08,355	728	423·5
Total	26,97,307	3,292	819·3	43,35,430	5,097	850·6

TABLE IV

Catch and effort for Sardinella longiceps *at Calicut.*

Months	1964			1965		
	Landings in Kg.	Total units operated	Catch per unit	Landings in Kg.	Total units operated	Catch per unit
Mathichala vala						
Jan	13,203	317	41·6	1,700	10	170·0
Mar	00	00	00	13	1	13·0
Apr	10,972	602	40·2	111	4	28·2
May	1,341	300	4·5	00	00	00
Jun	00	00	00	6	2	3·0
Sep	53	4	14·0	00	00	00
Nov	00	00	00	4,184	57	73·4
Dec	00	00	00	4,530	89	50·9
Total	25,569	1,726	14·8	10,544	163	64·7
Thattum vala						
Aug	1,32 584	332	399·3	00	00	00
Sep	3,59,275	799	449·6	925	368	2·5
Oct	14,35,741	2,541	565·0	4,14,325	859	482·3
Nov	6,72,022	1,013	663·3	00	00	00
Total	25,99,622	4,685	554·9	4,15,250	1,227	338·4
Nethal vala						
Aug	68,032	237	287·0	47,559	229	207·6
Sep	00	00	00	3,924	14	280·2
Total	68,032	237	287·0	51,483	243	211·9

The next important gear in the sardine fishery is the 'thattum vala', also a boat seine. Its use is restricted to the months, August to November, mainly to catch medium-sized sardines. In 1964 a total of 4,685 'thattum vala' units was employed in the fishery for landing 2,600 tonnes. But in 1965 only 1,227 units were used with a landing of 415 tonnes. The catch per unit for the two years were 555 kg. and 338 kg. for 1964 and 1965 respectively.

During 1964 altogether 1,083 units of 'pattankolli vala' were employed in the fishery with a total landing of 171 tonnes of oil sardine. The mean catch per unit during the year came to 158 kg. In 1965 'pattankolli vala' landed 1,989 tonnes of fish with 4,039 units. The catch per gear in 1965 was appreciably higher than in 1964, with 492 kg. of oil sardine.

The gill net 'mathichala vala' was used many times during the season. However, it landed only small quantities of oil sardine. 1,726 'mathichala vala' units were employed in 1964 with 26 tonnes of fish landed. In 1965 only 163 units were operated with 10 tonnes of fish landed. 'Nethal vala' or *Anchoviella* net was used mainly to catch small oil sardines during August and September and landed 68 tonnes in 1964 and 51 tonnes in 1965. Small quantities of oil sardine were also landed by cast net and 'paithu vala'.

Age and Length Composition

Regular samples from the commercial catches were analysed for size frequency studies. The size groups were analysed irrespective of the gear and mode of catch. While analysing the total landings of different size groups in the commercial fishery the samples were weighted with the monthly total landings. Figs. 1 and 2 represent the length frequency curve for the two seasons. During 1964 sardines from 7.0 cm. to 19.5 cm. were represented in the landings. Relative contributions of the different size groups to the fishery as a whole are graphically represented in the figures. Four year-classes of sardines were identified in the catches. Because new recruits enter the fishery after July with an accompanying age change, the fish are described for convenience by year-classes instead of age groups. The 1960 year-class, which was three years old, occurred during January, March and April of 1964. In January the total length of the 1960 year-class ranged from 16.5 cm. to 19.0 cm. and the year class contributed to over 50% of the total landings during the month. During March the total length of this group had shifted to 17.0 cm. — 19.0 cm. and contributed to about 25% of the sardine landings. In April the 1960 year-class virtually disappeared from the catches and was represented by fish of 19.0 cm.

During the year the 1961 year-class contributed a greater part in the year's fishery than the 1960 year-class. It occurred in all the months except June and November. At the beginning of the year, in January, the length range of the group was 13.0 cm. to 16.0 cm. and the size range gradually shifted to 17.0 cm. to 19.5 cm. in December. The 1961 year-class played a dominant role between January and July 1964 mainly because of the failure of the other year-classes. After July its role had been eclipsed by the on-rush of the 1963 year-class.

Failure was writ large on the 1962 year-class during 1964. This year class sardines were never abundant and occurred only in February, March and April

of 1964, rather in small quantities. The size of the 1962 year-class sardines was 12.5 cm. in February and 13.0 cm. in March and April 1964. This generation of sardines did not occur in large quantities to show any range in their size composition.

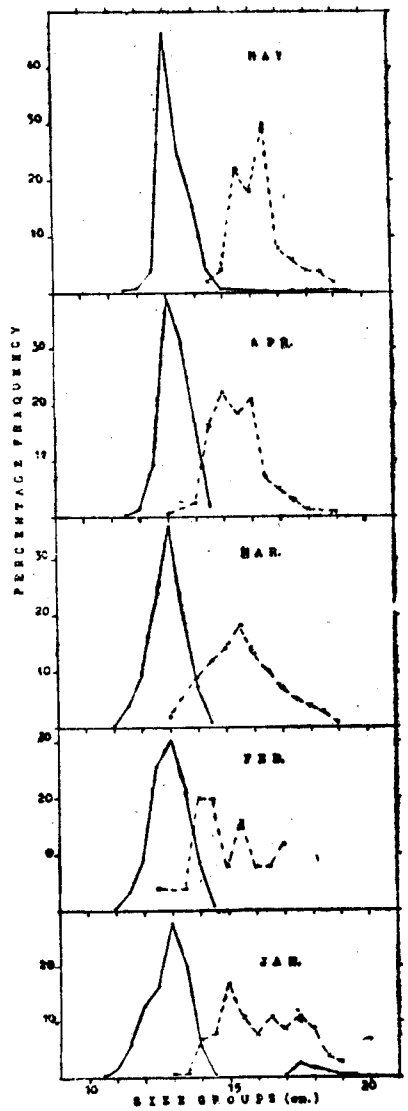

Fig 1. Percentage length composition of oil Sardine catch at Calicut (× – – – – ×) 1964 and (● – – – – ●) 1965.

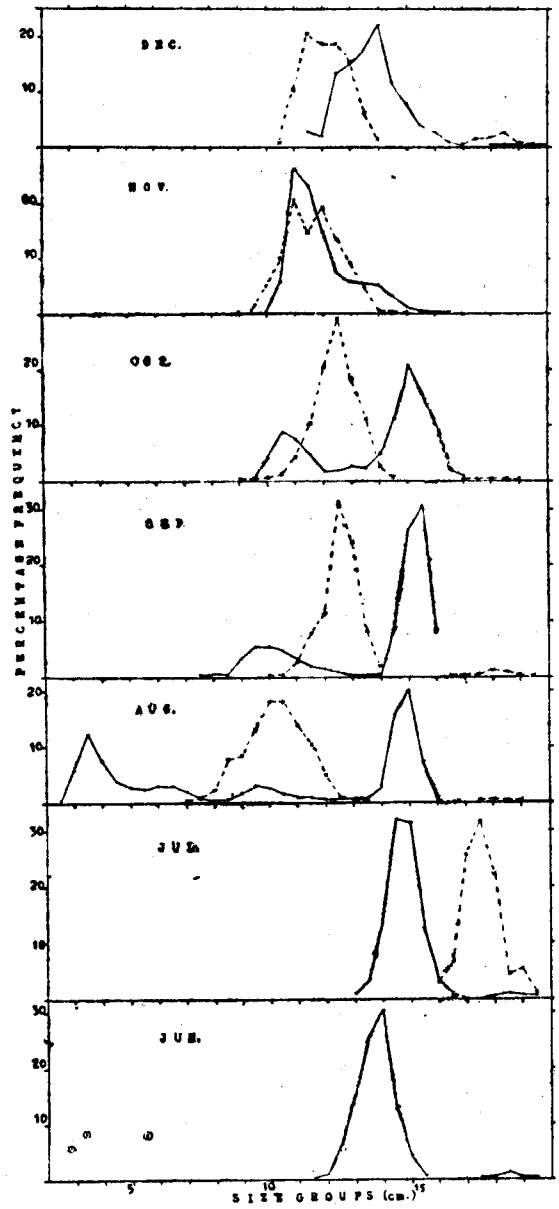

Fig 2. Percentage length composition of oil Sardine catch at Calicut. (× – – – – ×) 1964 and (● – – – – ●) 1965.

TABLE V

Length composition of age and year-classes in Sardinella longiceps *samples from the Calicut commercial catch during 1964.*

Total length cm.	Year-classes 1964	1963	1962	1961	1960	Total	age groups 0	1	2	3	Total
7·0		2				2		2			2
7·5		15				15		15			15
8·0		28				28		28			28
8·5		50				50		50			50
9·0		56				56		56			56
9·5		65				65		65			65
10·0		153				153		153			153
10·5		200				200		200			200
11·0		578				578		578			578
11·5		568				568		568			568
12·0		755				755		755			755
12·5		792	2			794		794			794
13·0		586	3	1		590		589	1		590
13·5		267		3		270		267	3		270
14·0		64		29		93		64	29		93
14·5		8		55		63		8	55		63
15·0		1		72		73		1	72		73
15·5				78		78			78		73
16·0				69		69			65	4	69
16·5				49	11	60			40	20	60
17·0				73	16	89			19	70	89
17·5				98	16	114			8	106	114
18·0				97	13	110			4	106	110
18·5				73	8	81			2	79	81
19·0				25	5	30			2	28	30
19·5				3		3				3	3
Totals	00	4188	5	725	69	4987	00	4193	378	416	4987

TABLE VI

Length composition of age and year-classes in Sardinella longiceps *samples from the commercial catch during 1965*

Total length cm.	Year-classes 1965	1964	1963	1962	1961	Total	Age groups 0	1	2	3	Total
2·5	1					1	1				1
3·0	39					39	39				39
3·5	93					93	93				93
4·0	77					77	77				77
4·5	56					56	56				56
5·0	61					61	61				61
5·5	77					77	77				77
6·0	114					114	114				114
6·5	100					100	100				100
7·0	68					68	68				68
7·5	36	23				59	36	23			59
8·0		119				119		119			119
8·5		99				99		99			99
9·0		88				88		88			88
9·5		140				140		140			
10·0		161				161		161			161
10·5		171	3			174		174			174
11·0		255	28			283		283			283
11·5		280	134			414		414			414
12·0		230	298			528		528			528
12·5		175	635			810		788	22		810
13·0		143	1,160			1,303		1,263	40		1,303
13·5		65	1,083			1,148		988	160		1,148
14·0		90	614			704		592	112		704
14·5		74	603			677		239	438		677
15·0		64	1,208			1,272		104	1,168		1,272
15·5			360			360		9	351		360
16·0			115			115			115		115
16·5			17	1		18			18		18
17·0			5	0	9	14			10	4	14
17·5				7	46	53			5	48	53
18·0				34	35	69			19	50	69
18·5				54	25	79			19	60	79
19·0				28	8	36			6	30	36
19·5				12	2	14			2	12	14
20·0				1		1				1	1
Totals	722	2177	6263	137	125	9424	722	6012	2485	205	9424

An young group of one year old sardines of the 1963 year-class entered into the fishery in August 1964. This group entered as the dominant group in August and continued its dominance through December of the year. Entering into the fishery as late as August the 1963 year-class sardines became the major group responsible for the bumper crop of sardines during the season. The season's fishery depended mainly on this year-class of juveniles. The length range of the 1963 group was 7.0 cm. to 13.5 cm. in August with the mode at 10.0 cm. The length range gradually improved and came to 9.0 cm. — 15.0 cm. in November and 10.5 cm. — 14.0 cm. in December 1964. New recruits of the 1964 year-class were not available for observations.

The year 1965 was a very good year for the oil sardine fishery at Calicut. Five year-classes entered into the commercial landings. Fish from 2.5 cm. to 20.0 cm. total length were noticed in the catches. The 1961 year-class sardines, which were the oldest to enter the fishery in the year, were caught in January only and contributed to a small percentage of the month's catch. The size range of the 1961 group in 1965 January was 17.0 cm. to 19.5 cm. After January this year-class practically disappeared from the fishery.

As in the previous year the 1962 year-class of sardines were never abundant during 1965 and occurred in small numbers during May, June, July and December. In May this group was between 16.5 cm. and 19.5 cm. in total length. During June the size range was from 17.5 cm. to 19.5 cm. and in July it was from 18.0 cm. to 19.5 cm. Fish of the 1962 group had grown to a size range of 18.0 cm. to 20.0 cm. in December 1965.

The 1963 year-class sardines were by far the most prosperous group and occurred in all the months of 1965. In fact the fishery of 1965 depended mainly on this group of sardines. In January 1965 the size range of the 1963 year-class was from 10.5 cm. to 14.5 cm. The size range had shifted continuously and had attained 15.5 cm. to 17.0 cm. at the close of the year.

The 1964 year-class fish for the first time entered into the fishery during August 1965 at the age of one year. It continued till the end of the year. In August the length range of the 1964 group was from 8.0 cm. to 12.0. Length of fish in the 1964 year-class was from 11.5 cm. to 15.0 cm. in December 1965.

The new recruits of 1965, the 1965 year-class, entered into the fishery at the beginning of August and appeared for a few days before moving away from the fishing grounds. The smallest size recorded for this group was 2.5 cm. and occurred on 5 August 1965. The size range of the 1965 group was from 2.5 cm. to 7.5 cm. It is apparent that variations in the length composition are matched by similar variations in the year-class composition of the catches. The 1963 year-class was the most abundant in the fishery during the two years. It contributed almost two-thirds of the total number of oil sardine landed at Calicut

during 1964 and 1965. Fish older than three years made up of only a fraction of the total landings and occurred during January to April in 1964 and in January 1965.

TABLE VII

Monthly mean total length and weight of Sardinella longiceps *at Calicut during 1964 and 1965*

Months	Year-classes 1960		1961		1962		1963		1964		1965	
	L	W	L	W	L	W	L	W	L	W	L	W
1964												
Jan	17·6	43·6	15·2	28·8								
Feb.			15·3	27·9	12·7	15·0						
Mar.	17·8	41·2	15·4	29·2	13·3	20·0						
Apr.	19·0	44·0	15·7	29·3	13·3	19·0						
May.			16·6	32·0								
Jun.	No landings.											
Jul.			17·7	55·8								
Aug.			18·2	60·8			10·4	9·4				
Sep.			18·3	56·1			12·6	15·9				
Oct.			18·2	56·9			12·4	17·2				
Nov.							12·0	15·9				
Dec.			18·3	48·4			12·5	15·8				
1965												
Jan.			18·1	47·6			12·8	15·9				
Feb.							13·1	16·3				
Mar.							13·1	16·5				
Apr.							13·5	16·1				
May.					18·5	43·0	13·6	17·9				
Jun.					18·7	53·4	13·9	21·8				
Jul.					18·9	54·2	14·9	25·5				
Aug.							15·1	28·4	10·4	7·7	5·7	1·5
Sep.							15·4	33·4	9·7	7·5		
Oct							14·9	30·0	11·1	12·2		
Nov.							14·3	22·2	11·9	13·5		
Dec.					19·1	48·3	15·9	35·0	13·6	20.5		

WEIGHT COMPOSITION

Lengths and weights of different year-class sardines are given in Tables VII, VIII and IX. The data relating to the comparison of the average total lengths and weights for the different months show that the mean weight for corresponding length groups vary between year-classes. Slight variations in the mean length and weight pattern result from the variations in number of fish represented in the different age groups. Also certain length groups appeared in the samples at varying times in both years and hence their weights are not strictly comparable. However, the data relating to weight points out the differences in the weight of the fish in the same length range but belonging to different year-classes.

TABLE VIII

Weight frequency distribution of

Size groups cm.	Weight in														
	18	20	22	24	26	28	30	32	34	36	38	40	42	44
1960 *year-class*														
16·5										2	1	6		1
17·0									1	2	3	3	2	2
17·5												1	3	5
18·0												1		
18·5													1	4
19·0														1
1961 *year-class*														
13·0	1													
13·5	3													
14·0		1	5	13	6									
14·5		3	3	18	17	5	3							
15·0			2	1	12	23	15	6	2					
15·5				1	5	16	32	16	4	3				
16·0					4	4	14	12	15	6				3
16·5							2	13	11	9	2		1	
17·0								1	2	5	2	6	4	3
17·5										1	2	2	2	6
18·0													2	2
18·5													1	2
19·0														
19·5														
1962 *year-class*														
16·5										1				
17·0														
17·5											2		1	4
18·0										1	1	5	8	8
18·5												3	8	
19·0														1
19·5														
20·0														

Sardinella longiceps *samples from Calicut during* 1964 *and* 1965

grammes														
46	48	50	52	54	56	58	60	62	64	66	68	70	72	74
2														
2	1	1												
2	1													
	3			3										
	1	1	1											
1														
1	1	4						1						
2	3	13	12	6	6		1							
7	5	7	10	13	21	13	7	4	1	1				
6	6	8	5	13	16	20	16	15	3	2	1			1
1	5	3	3	4	10	3	13	6	6	5	2	2	1	
1		1	2	4	1	1	2	4	3	2	2	1	2	1
				1				1		1				
	1													
1	2	4	6	2										
11	2	6	3	9	6	1	2							
3	1	9	2	2	3	4		1	1					
1		3			3	2	1	2						
					1									

TABLE IX

Weight frequency distribution of

Size groups cm.	4	6	8	10	12	14	16	18	20	22	24	26	Weight in 28
1963 *year-class*													
9·5			1	1									
10·0		1	5	3	1			1					
10·5			2	29	7			2					
11·0				42	68	16	1	4	2				
11·5				13	108	139	44	5	5	1			
12·0				2	26	153	235	64	8	1	1		
12·5				2	8	97	262	249	101	9		1	
13·0				2	7	23	218	230	215	53	4		
13·5				1			53	169	179	134	62	11	
14·0							7	27	82	67	86	88	21
14·5						1			8	22	33	125	112
15·0											3	26	68
15·5												3	4
16·0													
16·5													
17·0													
1964 *year-class*													
7·5	1												
8·0	4	7											
8·5		5	2										
9·0		10	4										
9·5		7	15										
10·0		1	14	10									
10·5			6	30	4								
11·0				43	23	16	1						
11·5				3	32	70	19	1					
12·0					3	24	90	13					
12·5							38	59	11				
13·0							2	29	28	6			
13·5								8	35	15	3		
14·0								1	9	32	24	11	
14·5										6	20	21	12
15·0											3	7	17

Sardinella longiceps *samples from Calicut during 1964 and 1965*

grammes 30	32	34	36	38	40	42	44	46	48	50	52	54	56
1													
4		1	1										
93	17	4											
184	114	51	25	3	1								
26	77	81	69	25	12	5	3						
1	4	13	27	15	13	6	9	6	1	1			
		1	2	5	1	1	1		3	1			
					1		1	1	1				1
8													
19	8	6	1										

DISCUSSION

After a period of low yield the *Sardinella longiceps* fishery at Calicut experienced remarkable increase in yield during 1964 and 1965. The vicissitudes experienced by the fishery during these two years are described. Nair and Chidambaram (1951) and Nair (1958) extensively reviewed the capricious nature of the fishery and its bearing on the economic fluctuations on the fishing industry of the South Kanara and Malabar coasts. Sekharan (1962) points out the importance of year-class strength in the fluctuations of the oil sardine fishery. The most interesting feature of the fishery during the two years was the dominant role played by the 1963 year-class of oil sardines. This year-class entered into the fishery in August 1964 at the age of one year. Continuous bumper crop of this year-class was recorded throughout 1965 also. Estimated total landings during the 1964-65 sardine year, ie. between August 1964 and July 1965 came to 9,283 tonnes, one of the highest after the 1957-58 landings of about 8,424 tonnes. The appearance of the 1963 year-class in such large quantities was surprising because of the total failure of the 1962 year-class. Again it is only a matter of conjecture how far the 1964 generation will contribute to the success of the fishery during the succeeding years.

Various theories have been put forward to explain the influx of shoals of oil sardine into the fishing grounds and their acute scarcity during certain years. It is seen that the oil sardine fishery at Calicut is supported mainly by one year old sardines with average length of 10.0 cm. to 15.0 cm. When the one year olds appear in great numbers the fishery become prosperous and successful. Their effect on the local fishery has been discussed by Nair (1952) and Sekharan (1962). Early workers on oil sardine at Calicut, Devanesan (1943) and Devanesan and Chidambaram (1948), suggested overfishing of spawners, migration and mortality of larvae as reasons for the fluctuations in the sardine fishery. Nair and Subrahmanyan (1955) suggested the availability of *Fragilaria oceanica*, a favourite food of the oil sardine as a major factor governing the fluctuations. Chidambaram (1950) advocated the theory of depletion by persistent exploitation of immature sardines during the preceding years thereby resulting in a corresponding deficiency of spawners in the succeeding years.

It is seen that the oil sardine follow a two year cycle from recruitment to maturity. A newly recruited group normally is available for large scale fishing at the end of one year. From then on it is exploited continuously till it is extinct from the fishing grounds at the fourth year. Success or failure of a year-class, it may be assumed, depends upon the following factors: (1) the number of one year old fish available for spawning, and (2) the number of 0-year fish surviving. Sardine fishery of 1964 and 1965 brings out the spectacular success of the 1963 year-class and the dismal failure of the 1962 year-class. Considering the moderate contribution of the 1961 year-class throughout the

1964 season it may safely be assumed that this year-class entered into the fishery in 1962 as one year old fish and at its second year spawned so many eggs to give rise to the 1963 year-class. Additional recruitment also came from the 3-year old 1960 year-class. Mortality during the first year might have been very light.

Conversely the 1962 year-class was very weak all throughout. Very little is known about the 1960 year-class as it was at the point of extinction at the start of this investigation. With comparatively few spawners the 1962 year-class produced only a weak generation of 1964 year-class sardines. The 1961 year-class was fairly strong to augment this poor supply of young ones. As a result it may be expected that the 1964 year-class will be one of moderate size only. A comparison of the landings for the first five months, from August to December, for the 1963 and 1964 year-classes is a pointer to justify this view. During August to December 1964 about 295 million sardines of 1963 year-class were landed whereas only 62 million fish of the 1964 year-class were landed for the same period in 1965.

Applying the biannual cycle theory to the future the spectacular 1963 year-class in association with a little supplement from the 1962 year-class sardines should produce a fascinating 1965 year-class of sardines. In spite of the known infant mortality during August 1965, when about 19 million fry were caught by cast net in Calicut alone, it is expected that the 1965 year-class would be sufficiently strong to give a good sardine season in 1966. However a pinch of caution is cast due to the less investigated reasons discussed below. It is difficult to explain as to how an year-class which has disappeared completely or almost completely, becomes all of a sudden, as numerous as the strongest year-class and at the same time an year-class which was very strong all of a sudden dwindles and becomes weak. Predictions based on this theory tend to be correct only when the periodicity of the fluctuations is preserved. It seems highly probable that two definite generations are present in the fishery, one of which is abundant and the other depleted or weakened. Sometimes, all of a sudden unusually large quantities of one year old sardines appear in a poor year, but the situation is soon restored. The only difference being that very often former poor year-classes become abundant or the abundant year-classes become poor.

When the phenomenon of the fluctuations is examined it becomes apparent that the cause of the fluctuations may be attributed to one or the other of the following. Pritchard (1938) attributes the cause of fluctuations in the Canadian Pink Salmon to some catastrophe which exterminated one of the generations. A similar calamity may be attached to the oil sardine fishery. During certain years it either destroys large portion of the eggs or young fry on the spawning grounds, thus exterminating one or two generations. The catastrophe strikes in all regions

bringing an overall reduction of particular year-classes. However, the basic instinct for self-preservation plays a leading part and the depleted generation afterwards grows in abundance. Johnson (1966) while discussing self-regulation of population abundance in *Oncorhynchus nerka* states that "although populations of *O. nerka* fluctuate rather widely in abundance, show a tendency to maintain their abundance about some level in a manner indicating the operation of density-dependent self-regulating mechanisms".

Chidambaram (1950) favours the view that continuous exploitation of younger sardines gradually depletes the fishery. If it is admitted that fishing depletes one or the other generation a question arises why do the fishing not diminish all the generations. How is it that one or other year-class escaped unscathed to give a bumper fishery? As it is the fishery is prosecuted in such a way, that no distinction is shown about the year-classes. All available size groups and year-classes are fished by using different varieties of gear. It is this essential point which compels one to admit, in spite of apparent facts on the contrary, that fishing is not the cause of fluctuations. Yet, the decline in strength of the sardine catches starts with the period of the most intensive exploitation of the stock. The unsuccessful attempt of the Madras Government to improve the oil sardine stock, by restricting the fishery during 1943 to 1947 proves that the fishery exerts little influence in improving the stock strength. In fact, the fishery was a dismal failure during and soon after the period of the legislative restriction. Protective measures against extensive fishing of one generation of oil sardine do not help to any extent to restore it. On the other hand under-fishing of any particular abundant year-class does great harm to both the abundant generation and the weaker generation that succeeds it by over stocking the available area. When an year-class is unusually abundant it exerts such a great stress on the weaker generation that the weaker generation slowly fades away from the fishery. Under-fishing of stronger year-classes also causes over-crowding of spawning grounds and subsequent competition for food between the parent and fry. In the process when the parent is extremely agile and numerous the young ones are eliminated or become greatly reduced in numbers. Thus an abundant year-class of sardines produces a weaker generation which causes an unexpected failure in the fishery in addition to confusing the biannual cycle theory.

All that has been said above shows that the sardine fishery may be predicted to a certain extent by applying the biannual cycle theory. Certain reservations have to be applied also. One is the catastrophic annihilation of the eggs or young ones in the spawning grounds due to unknown causes. Second is the adverse cyclic changes of the environment. Its effect has to be discounted largely, for, there seems to occur no great and sudden changes in the environmental conditions. Year in and year out the environmental conditions remain same. The most important cause for a breach in the biannual cycle periodicity rests with the under-fishing of abundant year-classes. It is seen that the 1963 year-class was

strong and abundant. Apparently it exerted great stress on the 1964 year-class fry causing it to diminish in numbers. However the 1963 year-class at its second year produced a good amount of 1965 year-class sardines. The "carry over" in large numbers of the 1963 year-class beyond the second year should exert a great pressure on the 1965 year-class. How much this pressure of the 1963 year-class on the 1965 year-class may be seen only when the 1965 year-class sardines enter into the fishery during August 1966. Nair (1959) gives the fecundity of the oil sardine as 78000 eggs. Based on this it should not be surprising when the offspring of the depleted 1962 year-class suddenly comes back in greater abundance when the stress of the 1963 year-class is diminished. By reducing the abundance of one generation to the minimum a re-distribution of abundance is effected between two sets of generations. It is this re-distribution which is observed after a period of unforeseen fluctuations.

It is natural that one year-class of juvenile sardines at a certain stage of fishing intensity suffer greater losses than another. Assuming that the 1962 year-class suffered greater loss in numbers by uncontrolled fishing its abundance is lowered in the fishery. Let it be called year-class 'A'. Year-class 'B' recruited in 1963 was not weakened by the fishery. Since year-class 'A' was poor in abundance it could not consume all the food resources in the feeding area it would have consumed had it not been reduced in numbers. Because of this year-class 'B' has a better environment for growth and after the first year this generation will appear in greater numbers in the fishery. The 1964 year-class 'C' resulting mainly from the spawning of the weakened year-class 'A' will be in a most unfavourable and hostile environment. In the second year year-class 'B' will consume most of the available food causing a food shortage. The unfavourable conditions will have little effect on the grown up and strong fish of year-class 'B', whereas the weak and young fish of year-class 'C' will suffer most because of its inability to compete with larger fish. This will invariably decrease the number in year-class 'C'. Year-class 'D' of 1965 originating from the larger number of spawning fish of the year-class 'B' will have less competition from the weakened 'A' and 'C'. This would expect an accurate prediction of the fishery. But the large number of "carry over" from the year-class 'B' after the spawning causes an upset in predictions. Already most of the food depleted by the super numerous generation 'B' and the hungry generation 'C' the generation 'D' will have a tough time to survive. Competition with the older fish of 'B' and 'C' will be only disadvantageous to the young fry of generation 'D'. It is this condition which is seen after one or two years of bumper fishery. All the year-classes become weak and the fishery becomes well nigh barren. Weak year-classes are further weakened by the continued fishery. With the decrease in numbers of fish the food resources increase. Other plankton feeders like the mackerel also utilise this situation and increase in numbers. The lucky year-class of sardines which appears just at this period finds the conditions favourable for survival and increases enormously in numbers giving rise to an unpredictable bumper fishery.

Thus it is seen that owing to great many factors, some known and many unknown, one or other year-class enters into the fishery in great numbers. The stress caused by the increased number of larger fish causes deterioration in the subsequent year-classes immediately following it. Unless fishing reduces the prominent year-class to the minimum required for an average spawning at the second year there is bound to be great pressure on the food resources by the "carry over" of the abundant year-class. Indiscriminate fishing further weakens the weaker year-classes. The decisive factor which causes the fluctuations in abundance is not the quantity of eggs produced and shed or the fry hatched out but the stress caused by the abundant year-class over the subsequent year-classes. Prohibition by legislation, to fish during certain years produce results only if at the time of legislation, exploitation of the abundant year-class was considerably increased. This would help ease the stress on the weaker year-classes and there would be no suppressed year-classes. The rate of survival of poor generations will increase. If only a general prohibition is imposed it will further aggravate the situation by protecting the aggressive year-classes also.

Summary

Observations on the age, size and weight composition of the 1964 and 1965 oil sardine catch at Calicut are recorded. The 1963 year-class contributed to a bumper fishery during the two years.

Reasons for the fluctuations in the annual oil sardine landings are discussed. There appears to be a bi-annual cycle in the life history of the oil sardine. Stress exerted by the over-abundant year-class seems to be the cause for unpredictable fluctuations.

Acknowledgements

Grateful thanks are due to Dr. S. Jones, Director, Central Marine Fisheries Research Institute for his keen interest and to Dr. G. Seshappa for his kind encouragement in this study.

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