THE OIL SARDINE FISHERY IN THE MANGALORE ZONE DURING THE SEASONS 1963—64 AND 1967—68

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ABSTRACT

The oil sardine fishery in the Mangalore zone showed an upward trend from 1963-64 to 1966-67 when the catches increased seven-fold from 52 to 386 tonnes, which was followed by a slight decline to 243 tonnes in 1967-68. Among the gears operated for the oil sardine fishery, the highest catch-per-unit-effort values were obtained for the cast net, *chala bale* and *rampani*. The best catches of oil sardine were obtained during September-December period when temperature and salinity values ranged 25.5 to 28.6°C and 28.98 to 34.36 ‰ respectively. The length frequency studies indicate that the oil sardine attains a size of about 100-110 mm during the first year, 150-160 mm during the second year and 175-180 mm during the third year of its appearance. The fishery during the various years was supported by different year classes. One and two-year olds dominated in 1963-64, 1966-67 and 1967-68 and one-year olds in 1964-65. In 1965-66, one-year olds formed the mainstay of the fishery, although the two-year olds also contributed from December onwards. O-year class was seen entering the fishery during the months of August and September in 1964-65, 1965-66 and 1966-67, as also in October and again in January and February during 1967-68. Two or more broods have been observed to enter the fishery during certain years. Judged from the rate of growth and the size attained by the smaller size groups composing the O-year class, the interval between the entries of various broods has been observed to vary from one to three months. The estimated average rate of decrease during the five-year period worked out to 0.72, the instantaneous rate of mortality being 1.27.

INTRODUCTION

Though the oil sardine fishery is known for its fluctuations from year to year, the catches at Ullal which represent the trend of the fishery in the Mangalore zone showed a seven-fold increase, from 52 to 386 tonnes, during 1963-64 to 1966-67, followed by a slight decline in 1967-68 when the landings dropped to 243 tonnes. Among the various gears operated for oil sardine, the gill-net *chala bale* ranked first, followed by *rampani* and cast net. During the monsoon months, *kai-rampani* (shore-seine) and *koori bale* (small-meshed cast net) were the other important gears employed. The age composition and trend of the fishery in relation to hydrological conditions together with catch statistics have been presented in this account which supplements the observations on the oil sardine fishery in the Mangalore zone made

by Sekharan and Dhulkhed (1963). Considerable information on various aspects of the biology and fishery of oil sardine in respect of the Kerala coast, especially of the Kozhikode area, has been made available by Chidambaram (1950), Balan (1959, 1961), Sekharan (1962), Prabhu (1971) and Nair (1952, 1959). Besides the above, studies have also been made on the spawning behaviour (Antony Raja, 1964; Dhulkhed, 1964) and the occurrence of small-sized oil sardine (Prabhu and Dhulkhed, 1967).

MATERIAL AND METHODS

For purposes of estimation of oil sardine landings, observations were made at Ullal on all working days up to the end of January 1967 and thereafter on alternate days. About 20 - 25% of each type of gear operated for the day were observed. The catch for the day was estimated as follows:

If Y_{ij} = Yield (by weight) of the jth unit on the ith day,

E_i = No. of units on the ith day (effort on the ith day), and

e_i = No. of units sampled on the ith day

the estimated yield on the ith day (Y_i) is given:

$$Y_i = \frac{E_i \sum Y_{ij}}{e_i} .$$

The monthly yield (Y) is then calculated as:

$$Y = \frac{D}{d} \sum Y_i$$

where D = The number of fishing days in the month, and
d = the number of days of observations.

The monthly effort E is given by:

$$E = \frac{D}{d} \sum E_i .$$

The catch per unit of effort is given by Y/E.

For the length frequency studies, oil sardine samples from various gears at Ullal and also from other centres were collected, usually twice a week. The sample weight (w_i) was taken (on the ith day) in the fresh condition, after which the fish were measured for their total length and grouped in 5 mm interval size groups. The estimation of oil sardine in a particular size group and their numbers on a sampling day was made by the following method:

If n_{ij} = Number of fish of jth size group on the ith day in the sample, and

N_{ij} = estimated number of fish of the jth size group on the ith day in the catch, then,

$$N_{ij} = n_{ij} \frac{Y_i}{w_i} .$$

The estimated number of N_j of the jth size group in month is
$$N_{ij}$$

$$N_j = \frac{Y \Sigma d}{\Sigma d \, Y_i}$$

and the catch in numbers of the jth size group per unit effort is given by

$$\frac{N_j}{d}$$

FISHERY SEASONS

1963—64

At Ullal, the season's first oil sardine catch was observed on 17th September. The estimated landings of oil sardine for this centre amounted to 52 tonnes (Table 1) about 88% of which was landed in the January-March period. The gill net *chala bale* alone accounted for about 44.2 tonnes, during January-March period, whereas cast net landed only 1.6 tonnes. The annual catch per unit effort of cast net and *chala bale* for the year was 9.36 kg and 25.63 kg respectively. The contribution of these two gears to the total sardine catch was about 15% and 85% respectively.

1964—65

The oil sardine fishery started earlier, in the last week of July, with heavy catches, resulting often in a glut, at almost all the centres, particularly at the *rampani* centres in the north, till the end of the season. The occurrence of discoloured water, however, had some adverse effect on the oil sardine fishery from Bolur to Suratkal for a short while in the first week of January. At Ullal, the estimated oil sardine catch showed a three-fold increase (172 tonnes) over that of the previous year, as can be seen from Table 1. The cast net proved more effective than in the previous year, though the *chala bale*, remained the most sustained catchyielding gear, accounting for the entire catch of 36.2 tonnes landed during the April-June period. The catch per unit of effort of cast net and *chala bale* for 1964-65 was 39.89 kg and 35.11 kg respectively.

1965—66

Further improvement in the fishery over the previous seasons was witnessed during this year. Although the fishery started only by the middle of July the landings were heavy especially between Bolur and Suratkal and also in and around Hejmadi. This remarkable rise in catch this year (Table 1) was due to the three-fold increase in the landings by *chala bale* alone, which constituted about 91% of the annual catch. The interesting feature of the season was the operation of *koori bale* (small-meshed cast net) from shore for small sized oil sardine. Though *ida bale* ranked high with regard to the catch per unit of effort for the year, it has to be emphasised here that it was rarely operated. As in 1963-64, the most productive quarter was January-March when about 46.0% of the total catch was landed.

1966—67

The oil sardine fishery showed further improvement this year. The fishery started towards the end of July in the southern centres *viz.*, Kavarsad and Kumbla,

TABLE 1. *Monthly catch and effort at*

	Cast net				Chala bale				Kairampani			
	E	C	C/E	%C	E	C	C/E	%C	E	C	C/E	%C
Season: 1963-64												
Jul-Sep	418	382	0.91	5.1	—	—	—	—	—	—	—	—
Oct-Dec*	421	5,970	14.18	25.6	187	—	—	—	—	—	—	—
Jan-Mar	9	1,585	176.11	100.0	1,355	44,167	32.60	92.5	—	—	—	—
Apr-Jun	—	—	—	—	181	—	—	—	—	—	—	—
Annual Total	848	7,937	9.36	24.15	1,723	44,167	25.63	89.39	—	—	—	—
% contribution by each gear		15.23					84.77			—		
Season:1964-65												
Jul-Sep**	858	6,767	7.89	9.3	301	6,916	22.98	53.7	1	—	—	—
Oct-Dec	1,229	76,820	62.51	91.2	295	9,221	31.26	86.70	—	—	—	—
Jan-Mar	11	93	8.45	64.7	1,153	32,420	28.12	76.1	15	3,720	248.00	100.0
Apr-Jun	—	—	—	—	665	36,198	54.43	96.3	—	—	—	—
Annual Total	2,098	83,680	39.89	53.15	2,414	84,755	35.11	81.74	16	3,720	232.50	100.0
% contribution by each gear		48.61					49.23			2.16		
Season:1965-66												
Jul-Sep	917	16,323	17.80	19.2	312	15,501	49.68	87.9	—	—	—	—
Oct-Dec	270	6,848	25.36	34.0	1,190	83,082	69.82	97.3	—	—	—	—
Jan-Mar	—	—	—	—	2,575	129,530	50.30	96.9	—	—	—	—
Apr-Jun	—	—	—	—	1,051	30,350	28.88	90.4	—	—	—	—
Annual Total	1,187	23,171	19.52	22.02	5,128	258,463	50.40	95.64				
%contribution by each gear		8.18					91.23			—		

	Cast net				Rampani				Arakolli bale			
	E	C	C/E	%C	E	C	C/E	%C	E	C	C/E	%C
Season: 1966-67												
Jul-Sep	937	118,729	126.71	73.7	—	—	—	—	—	—	—	—
Oct-Dec	200	12,835	64.18	88.8	—	—	—	—	—	—	—	—
Jan-Mar	131	13,758	105.02	99.5	1	24,000	24,000	100.0	20	4,592	229.60	96.5
Apr-Jun	—	—	—	—	—	—	—	—	—	—	—	—
Annual Total	1,268	145,322	114.61	90.14	1	24,000	24,000	100.0	20	4,592	229.60	96.5
% Contribution by each gear		37.68					6.22			1.19		
Season: 1967-68												
Jul-Sep	335	27,787	82.95	98.3	—	—	—	—	—	—	—	—
Oct-Dec	155	7,965	51.39	100.0	26	102,167	3,929.50	95.3	—	—	—	—
Jan-Mar	92	—	—	—	9	18,667	2,074.11	78.3	—	—	—	—
Apr-Jun	—	—	—	—	—	—	—	—	—	—	—	—
Annual Total	582	35,752	61.43	98.69	35	120,834	3,452.40	95.25	—	—	—	—
% Contribution by each gear		14.72					49.75			—		

E - No. of Units operated; C - Catch of oil sardine in kg; C/E- Catch per-unit of effort (in kg)
* 3 Units of *kollibale* operated during the quarter but catch was nil.
** 1 Unit of *arakolli bale* was operated during the quarter but catch was nil.

Ullal during different fishing seasons

	Koori bale				Ida bale			Total	
E	C	C/E	%C	E	C	C/E	%C	C	%C
—	—	—	—	—	—	—	—	382	0.73
—	—	—	—	—	—	—	—	5,970	11.46
—	—	—	—	—	—	—	—	45,752	87.81
—	—	—	—	—	—	—	—	52,104	—
—	—	—	—	—	—	—	—	13,683	7.95
—	—	—	—	—	—	—	—	86,041	49.98
—	—	—	—	—	—	—	—	36,233	21.05
—	—	—	—	—	—	—	—	36,198	21.03
—	—	—	—	—	—	—	—	172,155	—
83	785	9.46	88.3	6	901	150.17	100.0	33,510	11.83
—	—	—	—	—	—	—	—	89,930	31.74
—	—	—	—	—	—	—	—	129,530	45.72
—	—	—	—	—	—	—	—	30,350	10.71
83	785	9.46	88.3	6	901	150.17	100.0	283,320	—
			0.28				0.32		

	Chala bale				Kantha bale				Manangu bale			Total	
E	C	C/E	%C	E	C	C/E	%C	E	C	C/E	%C	C	%C
127	4,303	33.88	91.0	—	—	—	—	30	14	0.47	0.6	123,046	31.91
1,173	60,522	51.60	95.2	957	735	0.77	0.3	—	—	—	—	74,092	19.21
985	64,739	65.36	99.7	158	—	—	—	—	—	—	—	106,729	27.68
1,048	81,751	78.01	99.0	—	—	—	—	—	—	—	—	81,751	21.20
3,333	210,955	63.29	97.91	1,115	735	0.66	0.26	30	14	0.47	0.58	385,618	—
	54.70				0.19				0.003				
226	17,080	75.58	99.8	—	—	—	—	—	—	—	—	44,867	18.47
1,054	51,934	49.27	99.6	—	—	—	—	—	—	—	—	162,066	66.73
91	5,163	56.74	98.4	—	—	—	—	—	—	—	—	23,830	9.81
405	12,104	29.89	85.7	—	—	—	—	—	—	—	—	12,104	4.98
1,776	86,281	48.58	97.31	—	—	—	—	—	—	—	—	242,867	—
	35.53		—						— —				

%C - Percentage of oil sardine in the total catch of all fishes.

as in 1964-65, and by the first week of August it had extended to Ullal and the nor-
thern centres. The catch at Ullal rose to about 386 tonnes (Table 1), the *chala bale*
catch alone accounting for more than half the annual catch. Unlike the previous
three seasons, the July-September quarter was the most preductive (31.9%) followed
by the third and fourth quarters.

1967—68

The fishery during the year was poor as compared to 1966-67, the northern
centres experiencing total failure of sardine fishery from January onwards. At
Ullal, the fishery commenced in September (Table 1). The total catch for the year,
about 243 tonnes, was better than 1963-64 and 1964-65 landings. However, but for
rampani the catch would have been nearly half of this. The cast net and the *chala
bale* were sparingly operated. It has to be mentioned here that Ullal was essentially a
cast net and gill-net centre till the end of 1966-67 season. A *rampani* was introduced
early in 1967-68. Previous records (Sekharan and Dhulkhed, 1963) show that this
gear was operated in 1961-62, much to the discomfiture of local fishermen who
feared that this may be to the disadvantage of other gears (cast net and *chala
bale*). As a matter of fact, even *arakolli bale*, a non selective boat-seine, does not
list in the gears at this centre, though fishermen from southern centres, like Man-
jeshwar, Kumbla and Kasargod operate this gear in Ullal waters with advantage.
As could be seen from the Table 1 various types of gears are operated at Ullal. Since
the nets vary in size and efficiency and since the cast net is the most widely used gear,
this net has been taken as a standard unit, the c.p.u.e. (rounded off to the nearest
whole number) of which has been treated as a factor for comparing the efficiency of
various gears. The values are given in Table 2.

OIL SARDINE FISHERY IN RELATION TO TEMPERATURE AND SALINITY

Range and average surface temperature and salinity values of the four-fathom
area off Ullal and also the catch of oil sardine against various months for the year
1963-64 through 1967-68 have been presented in Table 3. The season's major land-
ings were observed in February and March when the maximum values of temperature
and salinity were 29.5°C and 36.6‰ respectively.

The 1964-65 season had a protracted fishery. The mean temperature and
salinity during the period of better catches October-May fluctuated between 27.0°C
and 29.8°C, and 30.12‰ and 35.54‰ respectively.

In 1965-66 and 1966-67 improvement in catches coincided with the gradual
rise in temperature and salinity from October onwards. However, these values
did not show appreciable variation and were well within 30.5°C and 36‰ respect-
ively, which seem to constitute favourable limits for a successful fishery season.
Fairly good catches of oil sardine were recorded between September and January
when average temperature and salinity ranged from 25.5 - 28.6° C and 28.47 - 35.57‰
respectively. Between 24th and 27th March, about 12.1 tonnes of oil sardine were

TABLE 2. *Oil sardine catch in terms of standard effort (Cast net)*

Year \ Gear	1963—64 C	g	1964—65 C	g	1965—66 C	g	1966—67 C	g	1967—68 C	g
Cast net	7,937	848	83,680	2,098	23,170	1,190	145,322	1,268	35,752	582
Koori bale	..	..	..	..	785	41	..	..	..	..
Arakolli bale	..	..	..	..	..	..	4,592	40	..	..
Rampani	..	..	..	..	..	..	24,000	209	120,834	1,967
Kai-rampani	..	..	3,720	93	..	..	..	..	..	..
Chala bale	44,167	4,908	84,755	2,119	258,464	13,603	210,955	1,834	86,281	1,404
Ida bale	..	..	..	..	901	47	..	..	..	..
Manangu bale	..	..	..	..	..	..	14	0.1	..	..
Kantha bale	..	..	..	..	..	..	735	6	..	..

C = Catch of oil sardine in kg; g = Standard effort expressed in terms of cast net

TABLE 3. *Monthly values of surface temperature and salinity in inshore waters at Ullal for the years 1963-'64 to 1967-'68*

	1963—64					1964—65				
	Range		Average			Range		Average		
	Temperature °C	Salinity ‰	Tem. °C	Sal. ‰	Catch of sardine (in m.t.)	Temperature °C	Salinity ‰	Temp °C	Sal. ‰	Catch of Oil sardine (in m. t.)
July	.._ ..	._ ..	..	..	..	.._ ..	._ ..	..	..	0.12
August	.._ ..	._ ..	..	..	..	27.1—27.6	11.28—16.58	27.3	13.93	7.53
September	.._ ..	._ ..	..	..	0.38	23.0—27.0	17.41—32.18	25.6	29.33	6.03
October	28.2— ..	29.36— ..	28.2	29.36	4.73	26.4—27.8	22.36—34.04	27.0	30.12	60.33
November	28.7—29.2	32.10—34.29	28.9	32.57	1.24	26.0—27.8	33.86—34.97	26.9	34.42	20.40
December	27.8—29.6	32.56—34.79	28.6	33.86	..	26.7—27.7	34.74—35.12	27.2	35.07	5.31
January	26.6—28.0	34.58—35.35	27.1	34.87	1.33	27.0—27.8	33.87—33.95	27.4	33.91	13.02
February	27.5—29.0	34.67—34.83	28.3	34.75	26.73	27.2—28.3	33.69—34.25	27.8	33.99	13.88
March	28.5—29.5	34.34—36.62	29.2	34.96	17.69	28.7—29.5	34.16—35.17	29.1	34.62	9.33
April	30.9—31.2	35.44—36.85	31.0	35.96	..	29.5—30.1	35.17—35.91	29.8	35.54	17.82
May	30.1— ..	36.98— ..	30.1	36.98	..	29.1—30.2	34.72—36.11	29.7	35.30	18.17
June	.._ ..	.._ ..	..	..	..	.. ..	.._ ..	..	..	0.21
	1965—66					1966—67				
July	.._ ..	.._ ..	..	..	2.04	.. ..	.. ..	..	..	..
August	26.3— ..	25.08— ..	26.3	25.08	15.26	.. ..	..	..	..	56.57
September	25.0—27.6	25.55—30.97	26.3	28.98	16.20	24.7—26.1	27.77—33.98	25.4	30.88	66.47
October	30.4—30.6	33.80—33.89	30.5	33.85	6.85	27.9—28.5	31.98—33.19	28.2	32.47	13.99
November	28.6—30.7	33.44—34.54	29.7	33.97	54.70	27.2—27.8	33.37—34.51	27.5	33.97	23.64
December	27.9—29.0	33.98—34.54	28.5	34.36	28.38	27.0—28.5	32.14—34.60	27.8	33.65	36.45
January	27.4—28.1	33.06—34.45	27.7	33.77	73.34	27.3—27.9	31.17—32.45	27.6	31.60	10.50
February	28.3—29.8	32.84—33.60	29.9	33.24	29.43	27.2—28.7	31.69—35.44	28.0	33.81	60.75
March	29.5—30.4	33.60—34.16	30.1	33.87	27.75	29.2—29.9	54.31—35.07	29.5	34.69	35.48
April	30.1—31.0	34.54—34.81	30.3	34.69	28.47	2.7—31.3	34.88—36.20	30.5	35.45	60.00
May	28.7—29.8	33.10—35.53	29.2	34.24	1.87	30.5—30.7	34.52—..	30.6	34.52	19.17
June	.. ..	.. ..	.. ..	..	..	.. ..	.. ..	..	..	2.58

TABLE 3 (Continued)

	1967—'68 Range		Average		
	Temperature °C	Salinity ‰	Tem. °C	Sal. ‰	Catch of Oil sardine (in m.t.)
July	..	..	..	..	..
August	..	..	..	..	..
September	24.4 - 27.1	18.93 - 33.68	25.5	28.47	44.87
October	28.0 - 28.8	33.30 - 34.99	28.5	34.11	104.90
November	27.7 - 29.6	32.95 - 34.05	28.6	33.36	31.57
December	27.9 - 28.1	33.13 - 34.79	28.0	34.12	25.60
January	26.6 - 27.7	34.81 - 37.18	27.4	35.57	2ɔ.76
February	27.5 - 29.0	35.34 - 36.02	28.3	35.73	..
March	29.1 - 30.2	35.46 - 36.02	29.6	35.78	0.07
April	31.4 - 31.5	35.59 - 37.01	31.4	36.30	..
May	29.9 - 31.4	37.01 - 37.77	30.5	37.26	12.10
June	..	..	..	..	..

landed when salinity ranged from $37.0‰$ to $37.26‰$. This observation was a lone exception over the years considered here.

From the foregoing account it can be seen that the best catches were made during the September-December period of 1964-65 and 1967-68 when temperature and salinity values ranged from 25.5 to 28.6° C and 28.98 to $34.36‰$ respectively. During the other years, good catches were recorded in the January-March period when the temperature and salinity values ranged from 27.1 to 30.1° C and 31.60 to $34.92‰$ respectively.

LENGTH FREQUENCY AND RATE OF GROWTH

Length frequency data based on samples from the non-selective gears cast net, koori bale, arakolli bale, paithu bale, kai-rampani, rampani and trawl nets are presented in Figs. 1-5 separately for Ullal and other centres in the Mangalore zone. In the figures frequencies in percentages in respect of c.p.u.e., have been given for facilitating the presentation of frequency data. In this connection, it may be mentioned that while most of the gears operated at Ullal were selective, these at other centres were mostly non-selective.

The occurrence of small-sized oil sardine (Prabhu and Dhulkhed, 1967) close to the shore was an interesting feature in some years. In 1965-66 these were caught mainly by small-meshed cast net, koori bale. In August '65 the koori bale catches ranged in size from 37 to 97 mm with mode K_3 at 47 mm which was not seen during the rest of the year. In September '65 two other groups viz., K_1 at 107 mm and K_2
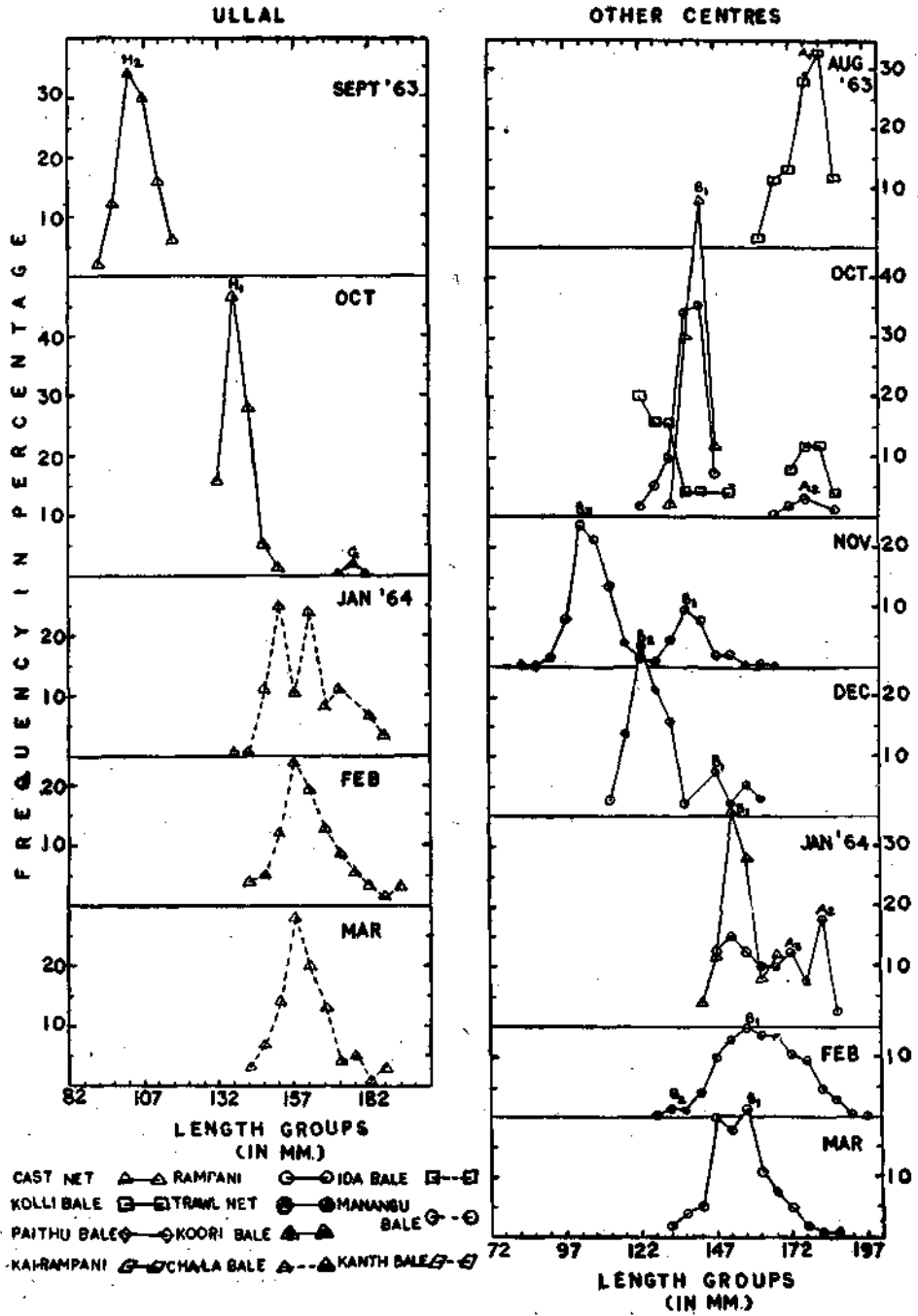
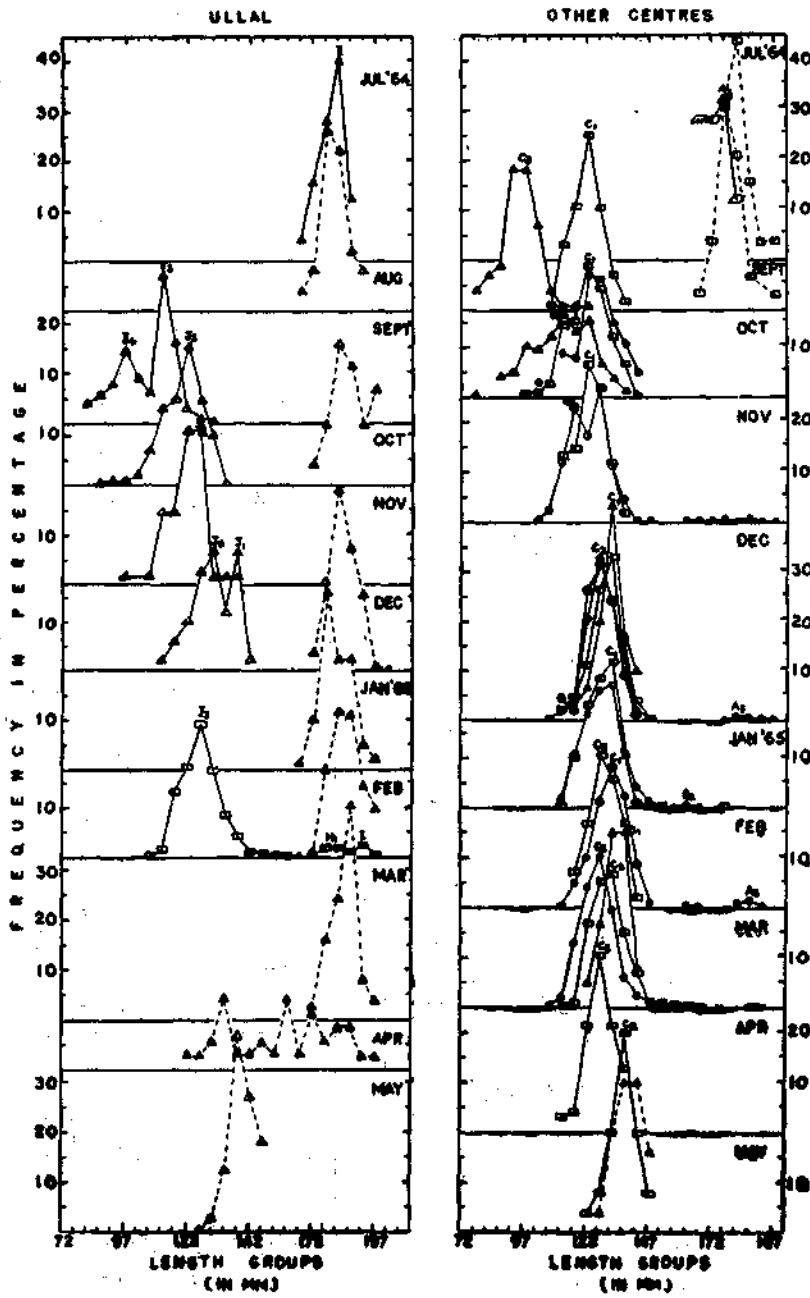Fig. 1.   Length frequency of oil sardine in 1963-64

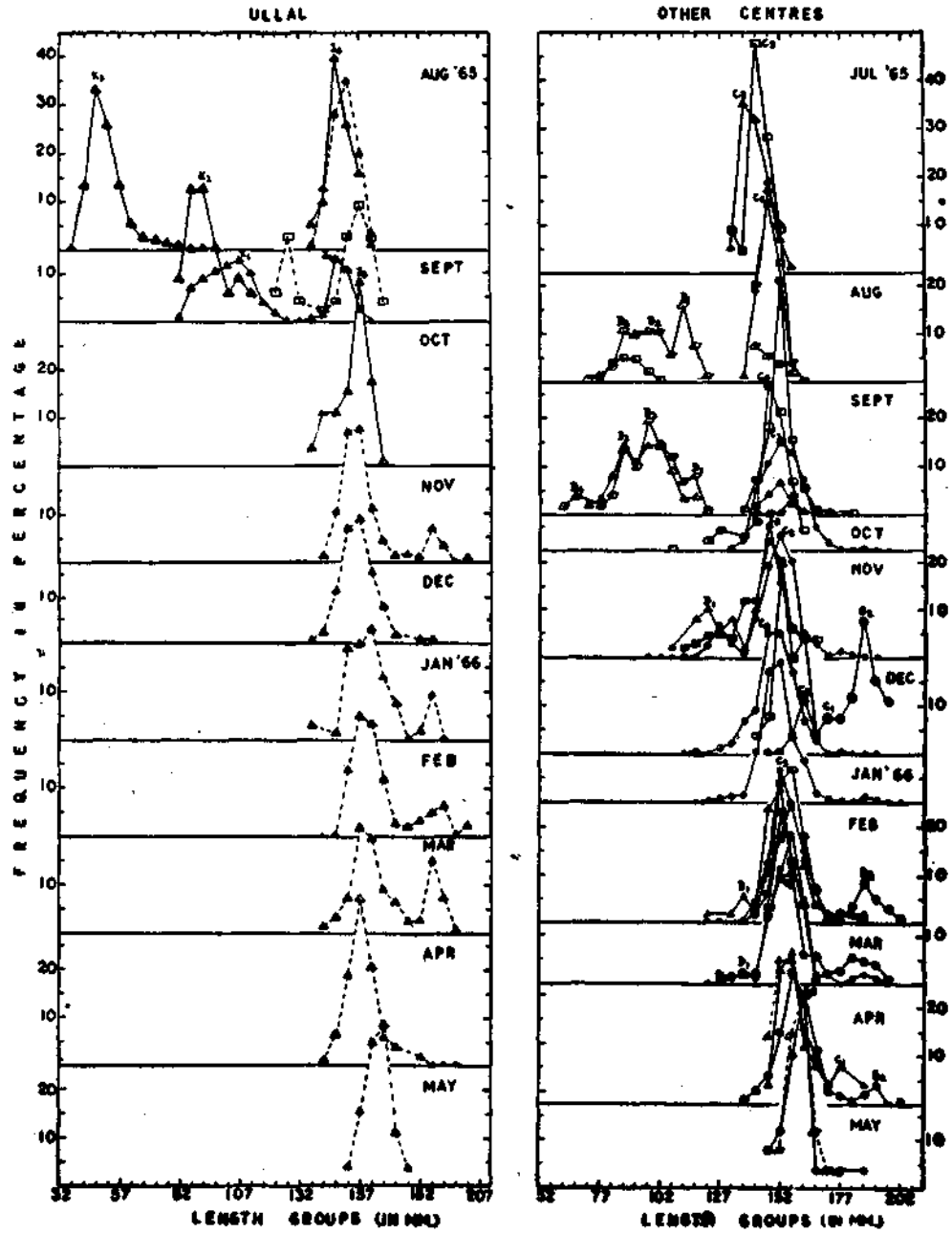FIG. 2. Length frequency of oil sardine in 1964-65

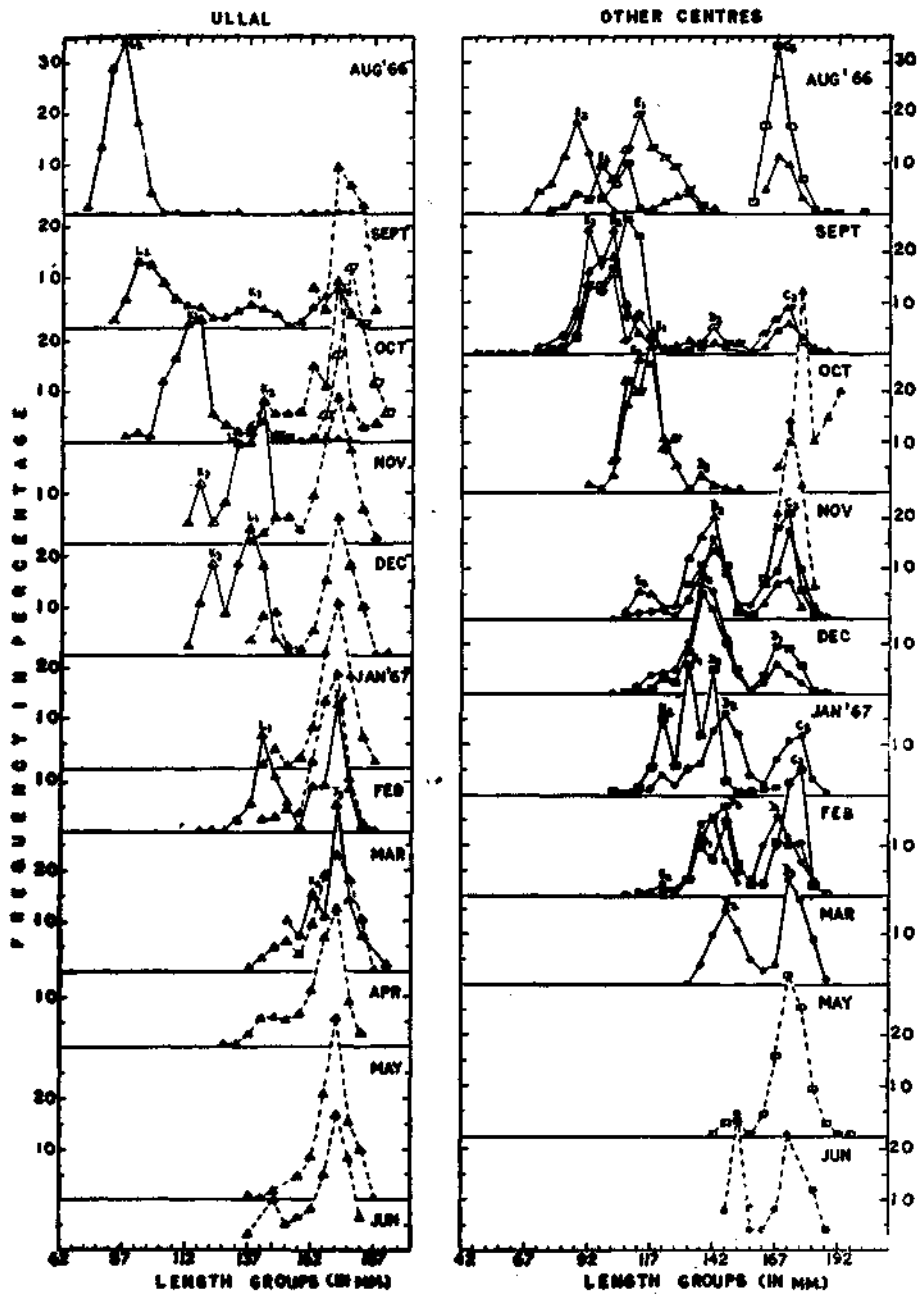Fig. 3.   Length frequency of oil sardine in 1965-66
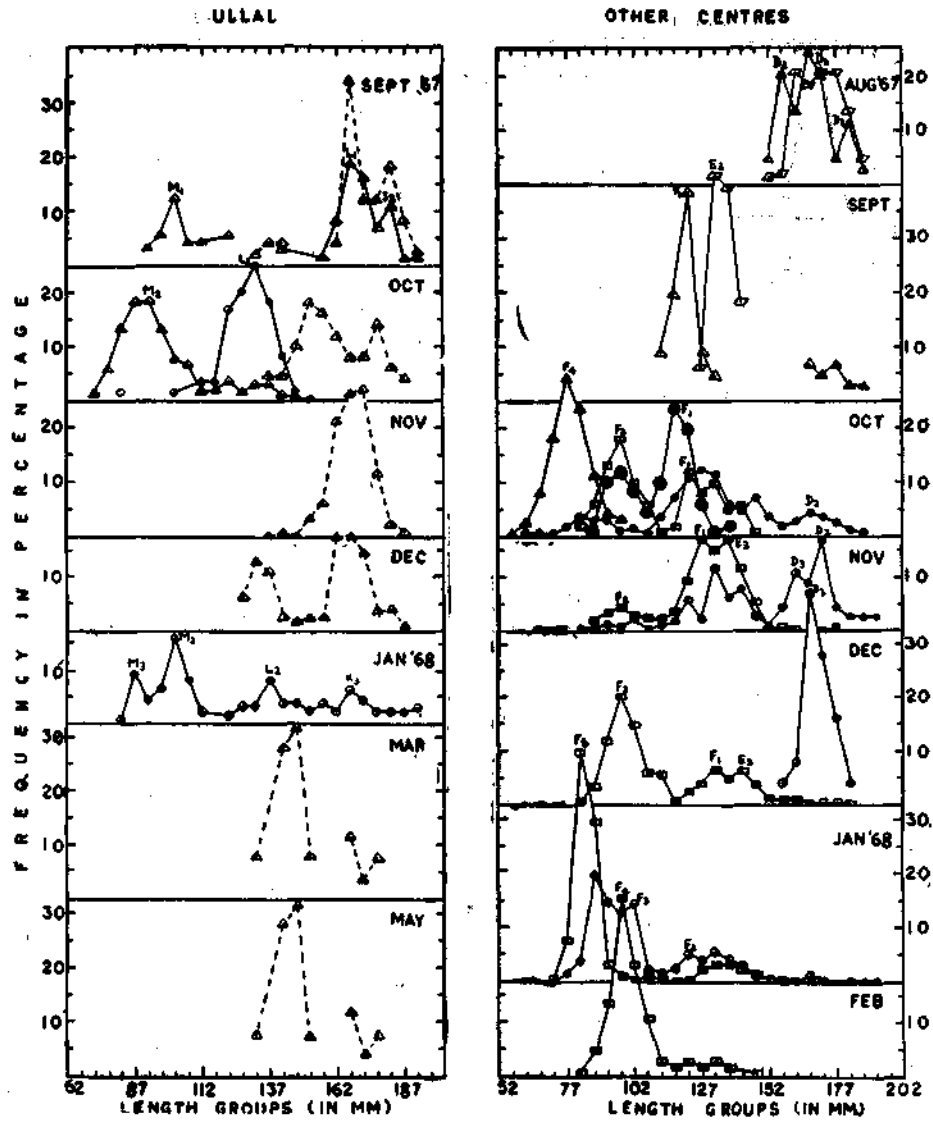
FIG. 4. Length frequency of oil sardine in 1966-67

FIG. 5.   Length frequency of oil sardine in 1967-68

at 92 mm were observed. These two groups also, as in the case of K_3 were absent in the catches during the rest of the year. During the next year, small-sized oil-sardine were present in the catches by *kai-rampani* in September, with sizes ranging from 47 mm onwards. In 1967-68 the smaller size groups ranging from 57 mm onwards, entered the fishery in October with two distinct modes F_4 and F_2 at 77 mm and 97mm.

Taking into consideration the progression of modes during the different years it could be seen from Figs. 1-5 that the mode B_2 at 122 mm in December '63 had shifted to 162 mm in January '65 recording a growth of 40 mm in one year. A further growth of 25 mm in the same size group was observed in the course of next one year since the mode B_2 was traced at 187 mm in December '65. The modes C_1 and C_3 seen at 122 and 97 mm in September and C_2 at 112 mm in October 1964 were observed again after one year at 157 mm, 147 mm and 152 mm in September, showing a growth of 35, 50 and 40 mm respectively. The mode C_3 again shifted to 172 mm in September '66, indicating a growth of 25 mm and 5 mm in the next four months. The group D_1 appearing at 112 mm in August '65 recorded a growth of 25 mm in six months and 35 mm during the next 12 months. The same group reappeared in the fishery in the 1967-68 season at 182 mm in August '67 recording a further growth of 10 mm. The group D_2 at 97 mm in September '65, shifted to 142 mm in exactly twelve months, recording a growth of 45 mm. This group continued to support the fishery in the next season also and showed a growth of 25 mm from September '66 to August '67. Another group D_3, is seen at 87 mm in September '65 also showed growth of 50 mm in the course of the first year of its appearance in the fishery and 30 mm during the second year. A growth of 45 mm was seen in the group E_3 which shifted from 87 mm in August '66 to 132 mm in September '67. The studies undertaken at Ullal also revealed almost identical growth pattern. This is evident from the progression of the modes J_3, J_4 and L_2 at Ullal which agrees with that of C_2, C_3 and E_3 of other centres. Among the modes at other centres, it is interesting to point out here that the growth pattern of C_3 is similar to that of D_2, D_3 and E_3. Taking into account the spawning season and the entry of various size groups into the fishery, it is reasonable to consider the groups K_3 and D_4 of 1965-66 and F_4 and F_5 of 1967-68, ranging from 47 to 82 mm, as the products of the respective year's spawning, and the modes, particularly those at C_1, C_2, D_1 and E_1, falling within a modal range of 112 to 122 mm during August-October period as being one-year old.

From the progression of various modes, the oil sardine appears to attain a size of about 100-110 mm during the first year, 150-160 mm during the second year and 175-180 mm during the third year of their appearance. Thus, it can be said that the growth recorded between the first and second year as seen from the progression of modes C_1, C_2, D_1, D_2, D_3, and E_3 is about 40 to 50 mm and between the second and third year 25 to 30 mm.

It will be seen that the monthly growth curve is sigmoid with growth being generally more rapid during August-November/December period than during other months. The progression of modes in the period following the month of their appearance is also shown in Table 4. Since the pattern of growth being as mentioned above, strictly speaking the von Bertalanffy equation (see Beverton and Holt, 1957) for growth in length cannot be applied to these data. Nevertheless, the equation was fitted to obtain at least the tentative estimates of the constants, L_∞, K and t_0. K and L_∞ are estimated by the method of least squares (by plotting $Lt+1$ against Lt, t being

TABLE 4. Showing the position of modes (values in mm) in successive months of different broods

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Brood and month of first appearance																			
F_1 (Sep 67)								122	..	127	132								
F_2 (Oct 67)					97	..	..	122											
F_3 (Nov 67)					97	..	102												
F_4 (Oct 67)	77	..	..	..	97														
E_1 (Aug 66)	..	..	..	..	..	..	112	..	117	..	..	132	137						
E_2 (Aug 66)					97	102	107	112		122	122								
E_3 (Aug 66)			87	92	..	..	..	..	..	..	..	..	..	..	132	..	137	142	
D_1 (Aug 65)							112	117	..	122	..	..	137	137	..	..	..	..	..
D_2 (Aug 65)					97	97	..	..	..	..	..	..	..	..	..	..	..	142	..
D_3 (Aug 65)			87	87	..	..	..	..	..	..	..	..	..	..	..	..	137	..	..
C_1 (Sep 64)								122	122	122	132	132	132	137	..	..	..	..	..
C_2 (Oct 64)							112	112	..	..	..	..	..	137	..	142	147	152	..
C_3 (Sept 64)					97	..	..	..	..	..	127	127	..	..	137	..	147	..	147
B_1 (Oct 63)																142	..	..	152
B_2 (Dec 63)								122	..	132	..	..	..	..	..	..	..	..	..
Average	77.0	87.0	86.0	97.0	99.5	109.0	118.4	119.5	124.5	127.0	130.3	135.3	137.0	134.5	142.0	142.0	142.0	145.3	149.5

	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
D_1 (Aug 65)	..	..	..	167	..	167	172	..	..	..	..	182							
D_2 (Aug 65)	142	..	..	147	..	..	..	..	..	167	..	177							
D_3 (Aug 65)	142	..	..	..	..	..	..	..	..	..	..	167							
C_1 (Sep 64)	157	..	..	..	..	..	..	177	..										
C_2 (Oct 64)	..	162																	
C_3 (Sep 64)	147	..	152	..	..	162	..	..	167	172	..	172	..	177	177				
B_1 (Oct 63)	157	157	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
B_2 (Dec 63)	..	162	..	..	..	..	..	..	..	..	..	..	187	..	187	..	..	..	192
Average	149.0	160.3	152.0	157.0	..	164.5	172.0	177.0	167.0	169.5	..	174.5	187.0	177.0	182.0	..	..	..	192

counted in months). For purposes of this study the average values of the modes as shown in the last row of Table 4 have been taken into consideration. If the observed value of a mode of an age-group was less than its value in the preceding month it was omitted from calculations. Thus 21 values of Lt+1 were available which were either same as, or more than Lt. The value of t_o was estimated by using the method proposed by Beverton (1954) *i.e.*,

$$\log (L_{oo}-L_t) = (\log L_{oo}+Kt_o)-Kt.$$

The estimates are given below:

$$L_{oo} = 244.5$$
$$K = 0.04$$
$$t_o = 0.26$$

In this connection it is of interest to refer to the growth parameters for oil sardine as given in the Annual Report of the Central Marine Fisheries Research Institute (1958) which are given below:

	West Coast	Calicut
L_{oo}	207 mm	207 mm
K	0.53 (on yearly basis)	0.50 mm (on yearly basi.)
t_o	1.33 years	1.26 years.

It has to be mentioned that the value of L_{oo} is higher than the maximum size recorded for the fish. But this is only to be expected in view of the fact that the monthly growth curve is sigmoid in shape as mentioned earlier. On the basis of above data the estimates of length at age one, two, three and four are 9.2, 15.0, 18.6 and 20.8 cm respectively.

From Figs. 1 to 5 it is seen that the fishery during the various years was of a multi-modal nature. In 1963-64, one and two-year olds supported the fishery whereas in 1964-65, one-year olds dominated the catches. In 1965-66 one-year olds formed the mainstay of the fishery though the two-year olds contributed to a lesser extent from December onwards. A significant feature was the entry of O-year class in August-September. Incidentally it may be pointed out that it was this year-class

TABLE 5. *Estimates of 1-and 2-year olds (in nos.) in the catches*

Years	Cast net I+	Cast net II+	Kolli bale I+	Kolli bale II+	Kai-rampani I+	Kai-rampani II+	Rampani I+	Rampani II+
1963-'64	19,614	..	1,210	51,921	..	..	887,399	653,311
1964-'65	97,978	9	542,137	355	..	..	3,294,061	26,186
1965-'66	13,689	16,439	3,715	65,868	38,097	7,621	1,199,017	1,081,114
1966-'67	25,616	7.922	20,327	19,123	17,461	5,880	1,569,661	794,111
1967-'68	2,529	2,131	21,451	3,927	161	..	3,263,655	960,384

which was mainly responsible for a bumper fishery in 1966-67. As in the previous years, the fishery in 1967-68 was mainly composed of one-and two-year olds.

Another interesting feature of the oil sardine fishery during the five-year period was the entry of two or more broods during certain years. Judged from the rate of growth and the size attained by the different groups, it can be inferred that the interval between the entry of different broods comprising 0-year class into the fishery may vary from one to three months.

Since the oil sardine fishery is supported mainly by one-and two-year olds, the relative strength of these two year-classes in the various non-selective gears has been estimated based on the c.p.u.e. in numbers for the year 1963-64 through 1967-68. For purposes of this study, the lowest point between two successive modes for each monthly frequency curve was taken into consideration. The values thus obtained for one- and two-year olds were added separately for each year and are shown in Table 5. It may be stated here that *rampani, kolli bale* and cast net are operated during the major part of the fishing season whereas *kai-rampani* is operated from July to September only. This is apparent from the data presented in Table 5 from which it can also be made out that the fishery is supported by 1-year olds during all the years, though in the cast net catches of 1965-66 they were available only during August and September. The annual rate of decrease during the 5-year period varied from 0.54 to 0.88 and the average for the entire period worked out to 0.72, the instantaneous rate of mortality being 1.27 (Table 6). The above findings have their own limitations since data from more centres at closer intervales as well as by other methods for this purpose were not available.

TABLE 6. *Annual rates of decrease during the years 1963-'68*

Years	Cast net	*Kolli bale*	*Kai-rampani*	*Rampani*	Average for the zone.
1963-64/64-65	..	0.80	..	0.97	0.88
1964-65/65-66	0.83	0.88	..	0.67	0.79
1965-66/66-67	0.42	..	0.85	0.34	0.54
1966-67/67-68	0.92	0.81	..	0.39	0.71

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