ON THE MACKEREL FISHERY OF THE MANGALORE AREA DURING THE PERIOD 1957-61

By V. Ramamohana Rao, K. V. Sekharan and M. J. Pradhan

(Central Marine Fisheries Research Institute)

At Mangalore, studies on the mackerel fishery were initiated in 1957. The programme of work was intensified from 1958 onwards and detailed observations were made particularly at Ullal, an important fishing centre near Mangalore. This paper deals with certain interesting observations made during the years 1957–61 at Ullal and other centres in the region between Kasargod and Malpe, especially in regard to growth, maturity, and trends of catches. The von Bertalanffy growth equation has also been applied to the length-frequency data and tentative estimates of the parameters obtained. In order to study the variation in catches in relation to certain factors, the data collected by one of us (K. V. S.) at Malpe during 1954–55 have been incorporated.

Observations on the mackerel fishery of the different sections of the Mysore Coast have been published by Pradhan (1956), Sekharan (1958) and Radhakrishnan (1958). The possibility of using scales for age studies has been indicated by Seshappa (1958).

We wish to thank Dr. S. Jones and Dr. G. Seshappa for their suggestions.

Material and Methods

From October 1958 onwards observations were conducted at Ullal on all working days. The landings were first estimated on a daily basis. Usually about 20–30% of the total number of operated units of each type were sampled. The daily total catch (Y_d) in respect of each type of unit was estimated as

$$\frac{u}{n} \cdot \sum_{i=1}^{n} y_i \qquad (1)$$

where,

y_i = catch of i-th unit.

u = the total number of units operated, and

n = number of units observed.

The monthly catch (Y) was then estimated by the formula

$$\frac{D}{d} \cdot \sum Y_d \qquad (2)$$

where,

D = total number of fishing days in a month,

d = number of observation days.

Effort in man-hours was also estimated first on daily basis by the formula

$$\frac{U}{n} \cdot \sum_{i=1}^{n} m_i h_i \qquad (3)$$

where,

m_i = man-power of i-th unit,

h_i = duration of its absence from the fishing centre.

The monthly total man-hours (g) was estimated as in the case of total landings. The monthly catch-per-unit-of-effort (Y/g) was then calculated.

Length Frequency at Ullal

Samples were collected at least once a week; each sample consisted of 25–50 fish. The weight of the sample and the catch from which it was obtained were also noted. Length frequency was represented on a monthly basis in terms of the number of fish per unit-of-effort. For this purpose the following formula was used:

$$\frac{Y}{g} \cdot \frac{\sum_{i=1}^{n} y_i l_i}{\sum_{i=1}^{n} y_i} \qquad (4)$$

where,

l_i = estimated number of fish per unit weight of a particular length group in the catch of i-th unit,

y_i = weight of the catch of the i-th unit sampled for length frequency, and

n = number of fishing units sampled during the month.

Length Frequency at Other Centres

Two to three fishing centres in the region between Kasargod and Malpe were visited every week. The catches of same type of units were pooled and the size composition estimated by the following formula on a monthly basis:

$$\frac{\sum_{i=1}^{n} y_i l_i}{\sum_{i=1}^{n} m_i h_i} \quad (5)$$

During 1957–58 and 1958–59 the sample values were not raised to represent the size composition of the entire catch; only the sample values were pooled together.

While plotting Figs. 5 and 6 the catch-per-man-hour for gill-nets has been multiplied by 10.

The Mangalore wholesale fish market through which considerable part of the fresh fish catches in this zone are channellized was visited on all working days. At the market, information on the gear used, if it was *Rampani*, could be obtained. The total weight of the catch brought to the market from each centre was invariably noted and the sample values raised to obtain the size composition. The size composition for market samples has been classified as (*a*) *Rampani* and (*b*) other gear. The definitions given by Pradhan and Palekar (1956) were followed in determining the maturity stages.

The modal size did not show any marked relationship to the catch in numbers, and hence an attempt was made to correlate the catch to an average L^3 calculated for each haul by the formula

$$\frac{\Sigma n_i l_i^3}{\Sigma n_i} \quad (6)$$

where,

n_i = number of fish in i-th length group,

l_i = the mid-point of the i-th length group.

FISHERY

The types of nets that land mackerel at Ullal are shown in the following table.

	Name of the Unit	Man-power	Type of net	Area of operation
I.	Cast-net/one dug-out canoe	2–6	..	1–2 miles from shore (1–4 fthm.)
II.	*Kollibale*/two dug-out canoes	12–14	Boat-seine	2–4 miles (4–8 fthm.)
III.	*Idadale*/three dug-out canoes	20–24	Gill-net	1–5 miles (2–10 fthm.)
IV.	*Chalabale*/one dug-out canoe	3–9	Gill-net	1–2 miles (1–4 fthm.)
V.	*Kanthabale*/one dug-out canoe	3	Gill-net	3–8 miles (6–15 fthm.)
VI.	*Pattabale*/three dug-out canoes	24	Gill-net	1–5 miles (2–10 fthm.)

In centres south of Ullal, *Kollibale* and *Paithubale* (boat-seines) along with gill-nets are used for mackerel fishing, while in the villages north of Mangalore *Rampani*, *Pattabale* and *Kanthabale* are the main gear employed.

1956–57 and 1957–58

In 1956–57 fishing was poor in this region. The catches improved considerably in 1957–58 and good landings were recorded in all the fishing centres, especially from October to December. The monthly catch and effort data at Ullal from October 1958 onwards are given in Tables I–III.

1958–59

The fishery started this year rather late (in November). The total catch of mackerel at Ullal was estimated as about 114 m. tons of which about 84 m. tons were recorded in November and December by *Pattabale*. *Kanthabale* was operated only from January to June and highest c.p.u.e. for this net was recorded in March. During the same month *Pattabale* catches also showed a minor peak. Other operated nets did not catch mackerel during this year.

TABLE I

Catch and effort at Ullal (1958–59)

Months \ Nets	*Pattabale*			*Kanthabale*			*Chalabale*			Cast-net			*Kollibale*			Total catch
	g	Y	Y/*g* (kg.)	*g*	Y	Y/*g* (kg.)	*g*	Y	Y/*g* (kg.)	*g*	Y	Y/*g* (kg.)	*g*	Y	Y/*g* (kg.)	
October, 1958 ..	11,837	..	..	..	..	..	..	..	..	9,800	..	..	..	..	..	..
November „ ..	15,434	33·125	2·146	..	..	..	..	..	..	1,176	..	..	..	..	..	33·125
December „ ..	28 836	51·277	1·778	..	..	..	70	..	..	..	..	..	..	..	..	51·277
January, 1959 ..	2,160	1·121	0·519	24,690	0·636	0·025	..	..	..	..	..	..	..	..	..	1·757
February „ ..	1,361	0·059	0·043	24,458	5·679	0·232	..	..	..	..	..	..	..	..	..	5·738
March „ ..	3,513	1·031	0·293	17,813	16·358	0·918	..	..	..	..	..	..	..	..	..	17·389
April „ ..	1,690	0·790	0·470	15,048	3·740	0·250	..	..	..	..	..	..	..	..	..	4·530
May „ ..	..	–	..	1 306	0·010	0·008	..	..	..	..	..	..	..	..	..	0·010
June „ ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total ..	64,831	87·403	1·348	83,315	26·423	0·317	70	..	..	10,976	..	..	..	..	..	113·826

TABLE II

Catch and effort at Ullal (1959–60)

Months \ Nets	*Pattabale*			*Kanthabale*			*Chalabale*			Cast-net			*Kollitale*			Total catch
	g	Y	Y/*g* (kg.)	*g*	Y	Y/*g* (kg.)	*g*	Y	Y/*g* (kg.)	*g*	Y	Y/*g* (kg.)	*g*	Y	Y/*g* (kg.)	
July, 1959 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
August ,, ..	..	..	..	..	..	..	..	..	..	..	..	..	53	0·006	0·110	0·006
September ,, ..	8424	4·570	0·54	..	..	..	..	..	..	..	..	..	2233	0·064	0·029	4·634
October ,, ..	1088	8·510	7·82	..	..	..	..	..	..	200	0·013	0·065	233	0·020	0·090	8·543
November ,, ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
December ,, ..	..	..	..	1,039	0·034	0·033	698	0·530	0·759	..	..	..	..	..	..	0·564
January, 1960 ..	8146	0·600	0·074	13,318	0·470	0·035	..	..	..	..	..	..	..	..	..	1·070
February ,, ..	..	..	..	13,240	0·086	0·006	..	..	..	..	..	..	..	..	..	0·086
March ,, ..	..	..	..	24,598	2·180	0·089	..	..	..	..	..	..	..	..	..	2·180
April ..	165	..	..	15,019	1·940	0·130	..	..	..	..	..	..	..	..	..	1·940
May ,, ..	4664	0·060	0·013	871	..	..	..	..	..	..	..	..	..	..	..	0·060
June ,, ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total ..	22487	13·740	0·611	68,085	4·710	0·069	698	0·530	0·759	200	0·013	0·065	2519	0·090	0·036	19·083

g, Effort in man-hours; Y, Catch of mackerel in metric tons; Y/*g*, Catch of mackerel per man-hour in kg.

TABLE III

Catch and effort at Ullal during 1960–61

Months \ Nets	*Pattabale*					*Kanthabale*					*Chalabale*				
	g	Y	Y/*g*	Total all fish	% mackerel	*g*	Y	Y/*g*	Total all fish	% mackerel	*g*	Y	Y/*g*	Total all fish	% mackerel
July, 1960 ..	..	..	..	..	..	..	..	..	..	..	917	..	..	0·730	..
August ,, ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
September ..	3,271	0·263	0·080	0·397	66·20	..	..	..	..	..	576	..	..	..	..
October ,, ..	16,099	21·480	1·334	24·640	87·18	..	..	..	..	..	..	..	..	..	..
November ,, ..	11,597	5·700	0·500	5·700	100	3,763	2·260	0·600	4·750	47·50	1,107	..	..	1·782	..
December ,, ..	17,225	2·800	0·160	2·800	100	672	0·230	0·340	0·530	43·39	5,155	..	..	14·809	..
January, 1961 ..	204	..	..	..	..	15,033	0·600	0·040	15·510	3·86	4,564	..	..	17·070	..
February ,, ..	..	..	..	..	..	18,861	3·423	0·181	22·150	15·00	..	..	..	..	..
March ,, ..	..	..	..	..	..	18,384	1·060	0·058	12·220	8·67	1,052	..	..	3·001	..
April ,, ..	10,581	4·190	0·396	5·460	76·74	14,738	1·008	0·068	15·695	6·42	1,875	..	..	16·074	..
May ,, ..	10,084	3·030	0·300	3·030	100	4,352	..	..	4·570	..	..	..	..	..	..
June ,, ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	69,061	37·463	0·542	42·027	89·14	75,803	8·581	0·113	75·425	11·38	15,246	..	..	53·486	..

TABLE III—*Contd.*

Months \ Nets	*Idabale*					Cast-net					*Kollibale*					Total catch of	
	g	Y	Y/*g*	Total all fish	% mackerel	*g*	Y	Y/*g*	Total all fish	% mackerel	*g*	Y	Y/*g*	Total all fish	% mackerel	Mackerel	All fish
July, 1960 ..	..	..	..	..	..	3,245	..	..	5·380	..	..	..	..	..	..	..	6·130
August ,, ..	..	..	..	..	..	7,078	15·569	2·200	27·069	57·50	..	..	..	..	..	40·350	56·277
September ,, ..	5,893	24·781	4·210	29·208	83·80	7948	0·420	0·053	13·650	3·2	..	..	..	..	..	4·123	20·007
October ,, ..	7,825	3·440	0·440	5·960	57·80	11,151	0·619	0·056	24·117	2·57	..	..	..	..	..	22·099	48·757
November ,, ..	..	..	..	..	..	470	..	..	0·112	..	..	..	..	..	..	7·960	12·344
December ,, ..	..	..	..	..	..	291	..	..	3·399	..	105	..	..	0·049	..	3·030	21·587
January, 1961 ..	..	..	..	..	..	441	..	..	0·789	..	..	..	..	..	..	0·600	33·369
February ,, ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3·423	22·150
March ,, ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1·060	15·221
April ,, ..	..	..	..	..	..	..	..	..		..	..	..	..	..	..	5·198	37·229
May ,, ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3·030	7·600
June ,, ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	13,718	28·221	2·057	35·168	80·25	30,624	16·608	0·542	74·516	22·29	105	..	..	0·049	..	90·873	280·671

g, Effort in man-hours; Y, Catch of mackerel in metric tons; Y/*g*, Catch of mackerel per man-hour in kg.

1959–60

Mackerel fishery was a complete failure in this zone during this year. The total catch at Ullal was only about 19 m. tons, although five types of nets landed mackerel as against only two in the previous year. *Pattabale* retained its dominant position having contributed about 13 m. tons in September and October. *Kanthabale* had its best catch-per-man-hour in April.

1960–61

The fishery showed significant improvement during this year and good catches were recorded both at the southern and the northern centres from October to December. At Ullal about 91 m. tons of mackerel were landed by four types of nets. In regard to the total catch *Pattabale* ranked first as in the previous years and was followed by *Idabale* and *Kanthabale*. *Kanthabale* had the best c.p.u.e. in February, when the other two nets were not operated.

It will be apparent from Tables I–III that *Pattabale* was the most important gear used for mackerel fishing at Ullal during the years referred to here. It is operated when shoals are sighted and the best catches are made during October to December, although a secondary but minor peak is observed in the months March to May. *Kanthabale*, which is another important gear, is usually operated at Ullal from December onwards, when *Pattabale* catches are declining. The c.p.u.e. of the two nets have been plotted in Fig. 1, from which it will be evident that the periods of the best catches of the two nets are different. What is of significance here is that *Kanthabale* is a bottom drift gill-net with a height of only about 7′. The fact that mackerel are landed by this bottom net at a time when the catches of *Pattabale* are on the decline, is a clear indication of their availability on or near the bottom. It will also be of interest to add that the fishermen gradually extend the depth of operation from 6–15 fathoms as the season advances.

The Distribution of *Rampani* Catches at Malpe

From 20th November 1954 to 20th March 1955 there were 393 *Rampani* hauls at Malpe of which 115 landed mackerel. The catches in numbers were grouped into convenient classes every month; the frequency distribution thus obtained is shown in Fig. 2. The wide variation in the range of catches during different months necessitated the adoption of different class intervals in different months. It will be seen that the distribution of the frequencies in almost all the months was roughly positively skewed.

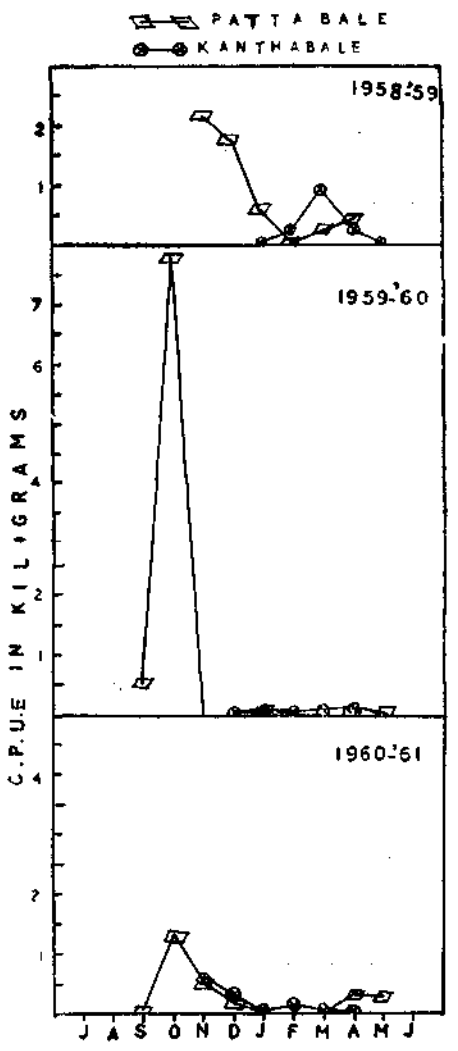


FIG. 1

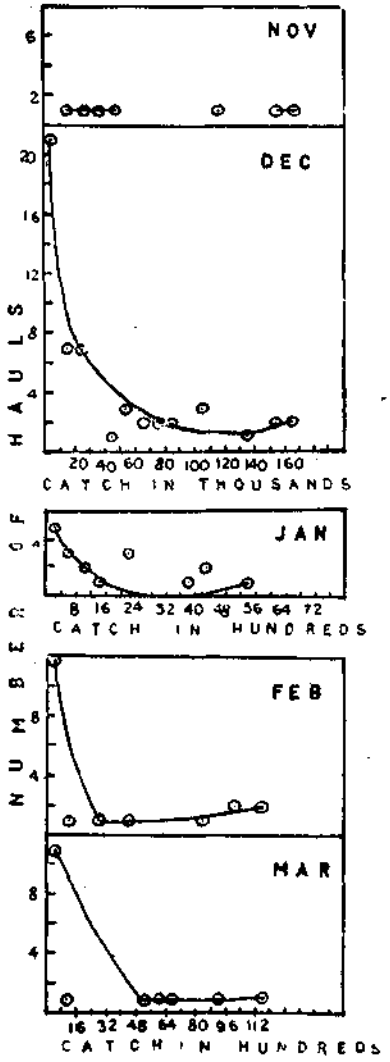


FIG. 2

FIGS. 1–2. Fig. 1. Catch-per-unit of effort of *Kanthabale* and *Pattabale*. Fig. 2. Distribution of *Rampani* catches at Malpe during 1954–55. (A freehand curve is drawn joining the point.)

Catch and Time of Operation

At Malpe in 1954–55, the time of paying the net was noted for each haul; fishing was conducted only between sunrise and sunset. The catch-per-haul (in numbers) at one-hour intervals in different months is shown in Table IV. The period of better catches was after 12 o'clock in December, February and March, and before 12 o'clock in January. Thus there

appeared to be no consistent relation between the catch and the time of commencement of the haul.

TABLE IV

Average catch per haul in relation to time of commencement of haul at Malpe in 1954–55

Time	December	January	February	March
6– 7	2,000	..	..	..
7– 8	34,000	..	550	308
8– 9	17,500	1,856	837	200
9–10	25,000	1,633	200	..
10–11	5,500	2,000	..	..
11–12	38,625	..	9,550	..
12–13	51,250	200	..	15,000
13–14	73,750	..	200	3,400
14–15	36,667	500	..	..
15–16	7,167	..	..	9,000
16–17	22,500	..	7,750	..
17–18	67,286	..	..	5,500
18–19	100,000	..	..	7,000
19–20	..	..	..	..

BIOLOGICAL STUDIES

Maturity

The data collected during the period July 1957 to October 1961, as regards different stages of maturity and range of ova-diameter are pooled and summarised in Table V. It will be seen that mackerel in Stage IV of maturity are usually recorded in most of the months with the exception of November, December and January. The higher stages of maturity (V–VII) were common during the period March to October. These data and the range of ova-diameter in different months suggest that spawning takes place from March to October. Earlier workers have indicated the spawning season as March to September. Our observations during 1957–60 were in agreement with this. However, during October 1961, mackerel in size range 210–259 were invariably either in Stage VI or VII and contributed considerably to the

TABLE V

Maturity stages and range of ova-diameter of Rastrelliger canagurta *during different months*
(Data pooled for 1957–1961)

	Range of ova-diameter	Length groups										Different stages of maturity
		180–89	190–99	200–09	210–19	220–29	230–3 9	240–49	250–59	260–69	270–79	
July ..	0·04–0·80	..	..	V	..	IV	IV	..	..	..	..	IV, V
August ..	0·04–0·86	I	..	..	IV, VI *b*	II, VI *a*, VI *b*	III, IV, V VI *b*	..	..	..	..	I, II, III, IV, V, VI *a*, VI *b*
September ..	0·04–0·80	I, II	I	I, II	II, IV, VI *b*, VII	III, V, VI *b*, VI *a*	II, III, VI *b*	VI *a*, VI *b*	..	..	..	I, II, III, IV, V, VI *a*, VI *b*
October ..	0·04–0·95	I	I, II	I, II	VI *b*	V, VI *b*, VII	VI *b*, VI *a*	II, III, VI *b*	III	..	..	I, II, III, IV, V, VI *a* VII, VI *b*
November ..	0·04–0·43	I, II	I, II	I, II	I, II	..	..	II, III	II	..	..	I, II, III
December ..	0·04–0·43	..	I, II	I, II, III	I, II, III	II	..	..	..	..	..	I, II, III
January ..	0·04–0·45	..	II	II	II, III	II, III	I, II	I, II	I, II	I II	..	I, II, III
February ..	0·04–0·60	II	II	I, II, III	I, II, III, IV	I, II, III, II *a*	II, III, IV, VII, II *a*	II, III II *a*	IV, II *a*	II, II *a*	..	I, II, III, IV, VII, II *a*
March ..	0·04–0·87	..	..	II, III	II, III, IV	II, III, IV	I, II, III, IV	II, III	II, III	II, III, VII	II *a*	I, II, III, IV VII, II *a*
April ..	0·04–0·60	..	..	II, III, IV	II, III. IV	II, III, IV	II, III	III, IV, V	IV	IV	..	II, III, IV, V
May ..	0·04–0·72	..	..	..	II, IV	III, IV, V	IV	III	III	..	..	III, IV, V
June ..	0·04–0·76	..	..	..	..	IV, V	..	..	..	..	..	IV, V

Stage II *a* is spent recovering.

fishery, while during the earlier years in October, mackerel in the same size range were in Stage II or III of maturity.

The data on the distribution of maturity stages in relation to length groups in different months (Table V) indicates that mackerel below 200 mm. are immature. Spawning and spent specimens are first observed in the 210–219 mm. group, though not in large numbers. These stages were more common in sizes above 220 mm. Seshappa (1958) observed growth checks in the scales of mackerel above 221 mm. which he indicated to be spawning checks and Pradhan (1956) has shown that the size at first maturity is 224 mm.

From November to January very few fish above 229 mm. were available for gonadial studies and the absence of higher stages of maturity during these months as indicated in Table V may also be partly due to the fact the samples collected during this period did not include larger fish. It is therefore even possible that spawning may be taking place throughout the year, with peaks at certain intervals.

Length Frequency

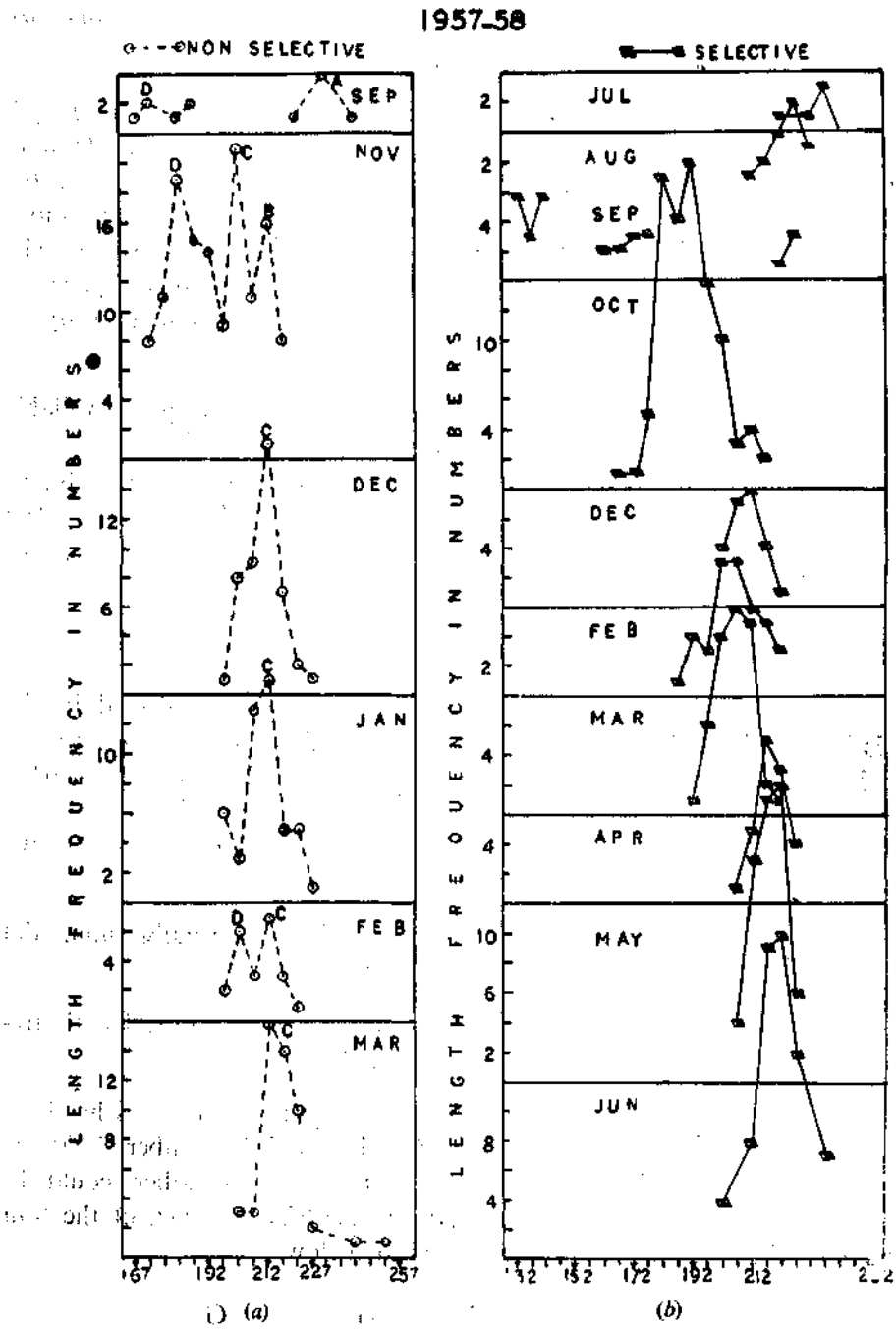
The length-frequency distribution based on samples collected in the field is indicated in Figs. 3–6. The range and mode of market samples are given in Table VI. The data on *Rampani* catches collected from market and from field centres showed very close agreement especially in regard to modal size. As noted by earlier workers the monthly length-frequency distribution shows the following features:

(1) During November to May the frequencies are usually unimodal and the modes are either stationary or shift at a slow rate.

(2) From July to October, when mackerel fishery is poor, length frequencies have wider range and are multimodal.

In Figs. 3–6 the progression of modes through different months has been indicated. In this connection data for October and November 1960 are interesting. The four modes (G, H, I and J) seen in October could be traced in the subsequent month also. An average size for each of the four groups seen during these two months is given below.

J	I	H	G
187	210	230	245



FIGS. 3 (*a*) and 3 (*b*). Fig. 3 (*a*). Length-frequency distribution of the catches of non-selective gear during 1957-58. Fig. 3 (*b*). Length-frequency distribution of the catches of the selective year for 1957–58.

TABLE VI

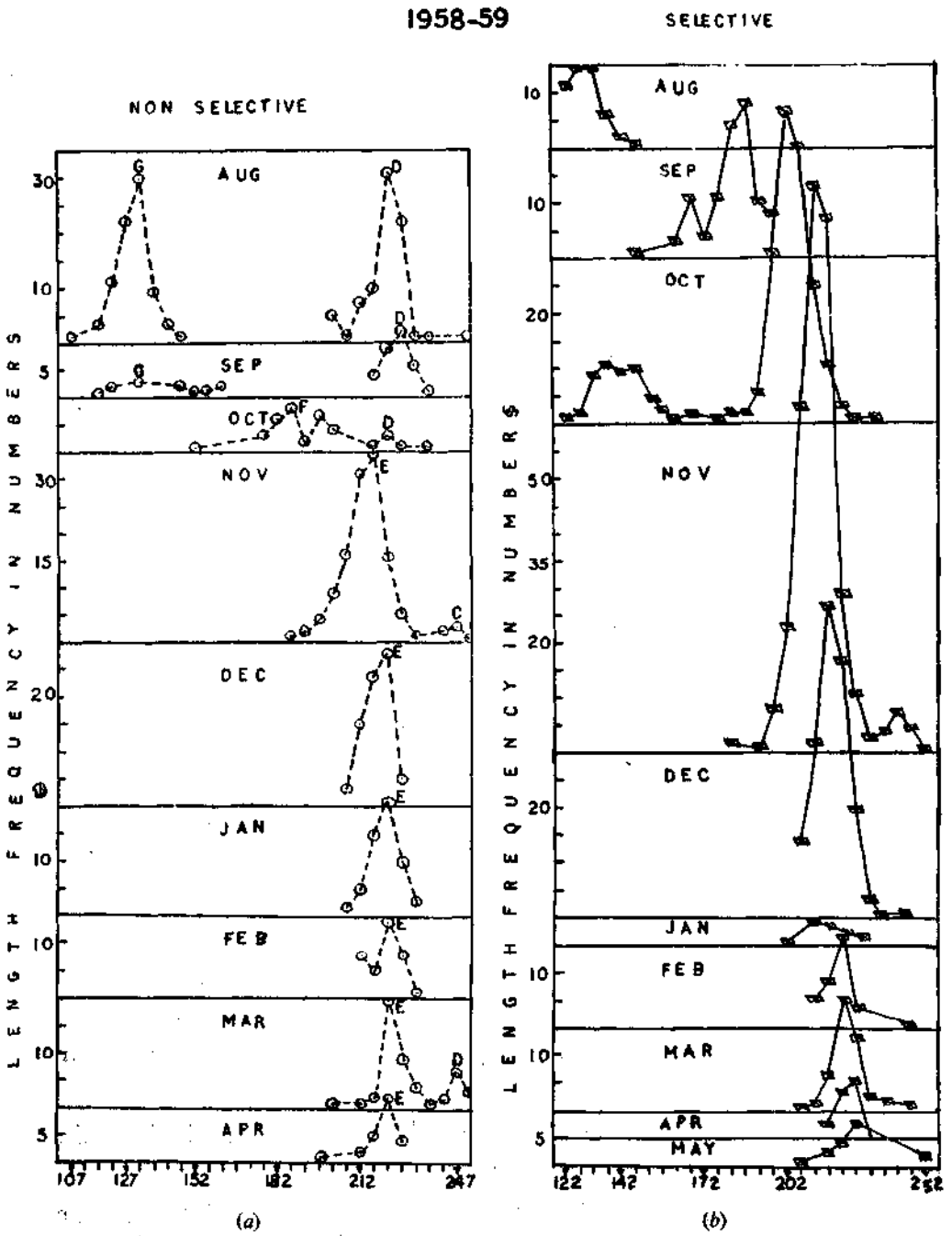
Range and mode of market samples (in mm.)

Year / Month	1959–60				1960–61			
	Rampani		Other gear		*Rampani*		Other gear	
	Range	Mode	Range	Mode	Range	Mode	Range	Mode
July	..	..	..	..	..	..	95–134	102, 127
August	..	..	120–159	132, 152	..	..	120–159	137
September	..	..	120–249	132, 182, 212, and 232	..	..	145–179	152, 167
October	..	..	..	..	165–234	182, 202 and 227	..	..
November	175–229	202	195–229	207	180–239	197, 237	190–219	212
December	195–224	207	..	..	200–224	212	190–229	212, 222
January	200–239	217	..	..	200–229	217	..	..
February	200–259	212, 242	205–234	217	..	..	..	..
March	..	..	..	..	190–224	212	..	..
April	..	..	..	..	..	..	205–229	217
May	..	..	..	..	..	..	215–239	222
June	..	..	..	..	..	..	..	..

It is apparent that the difference between the relative ages of successive groups is less than one year.

The approximate time interval has been estimated on the basis of the progression of the modes as indicated below.

(1) In November 1957, the mode D is at 182 mm. and within nine months is seen at 222 mm. (*i.e.*, in August 1958). Hence it is probable that a mode at 187 mm. will shift to 230 mm. in about the same time.



FIGS. 4 (*a*) and 4 (*b*). Fig. 4 (*a*). Length-frequency distribution of the catches of non-selective gear during 1958–59. Fig. 4 (*b*). Length-frequency distribution of the catches of selective gear (gill-nets) during 1958–59.

(2) The mode G which was at 217 mm. in February 1960 progresses to 247 mm. in 8 months, *i.e.*, it moves by 30 mm. The time interval between modes G and I should also be almost the same.

(3) The mode C which was at 212 mm. in February 1958 shifts to 247 mm. in November 1958 (*i.e*, in about 9 months' time).

(4) During 1958-59, the time lag between the modes C and D when they reach 247 mm. is four months.

The time interval between the successive modes can be regarded as approximately four months. Taking four months as one unit of time and age of 187 mm. as t, the age of the other groups will be $t + 1$, $t + 2$ and $t + 3$. Applying the von Bertlanffy equation for growth in length (*see* Beverton and Holt, 1957) the following estimates of the parameters are obtained:

$$L_\infty = 316 \text{ mm.}$$
$$K = 0{\cdot}2$$

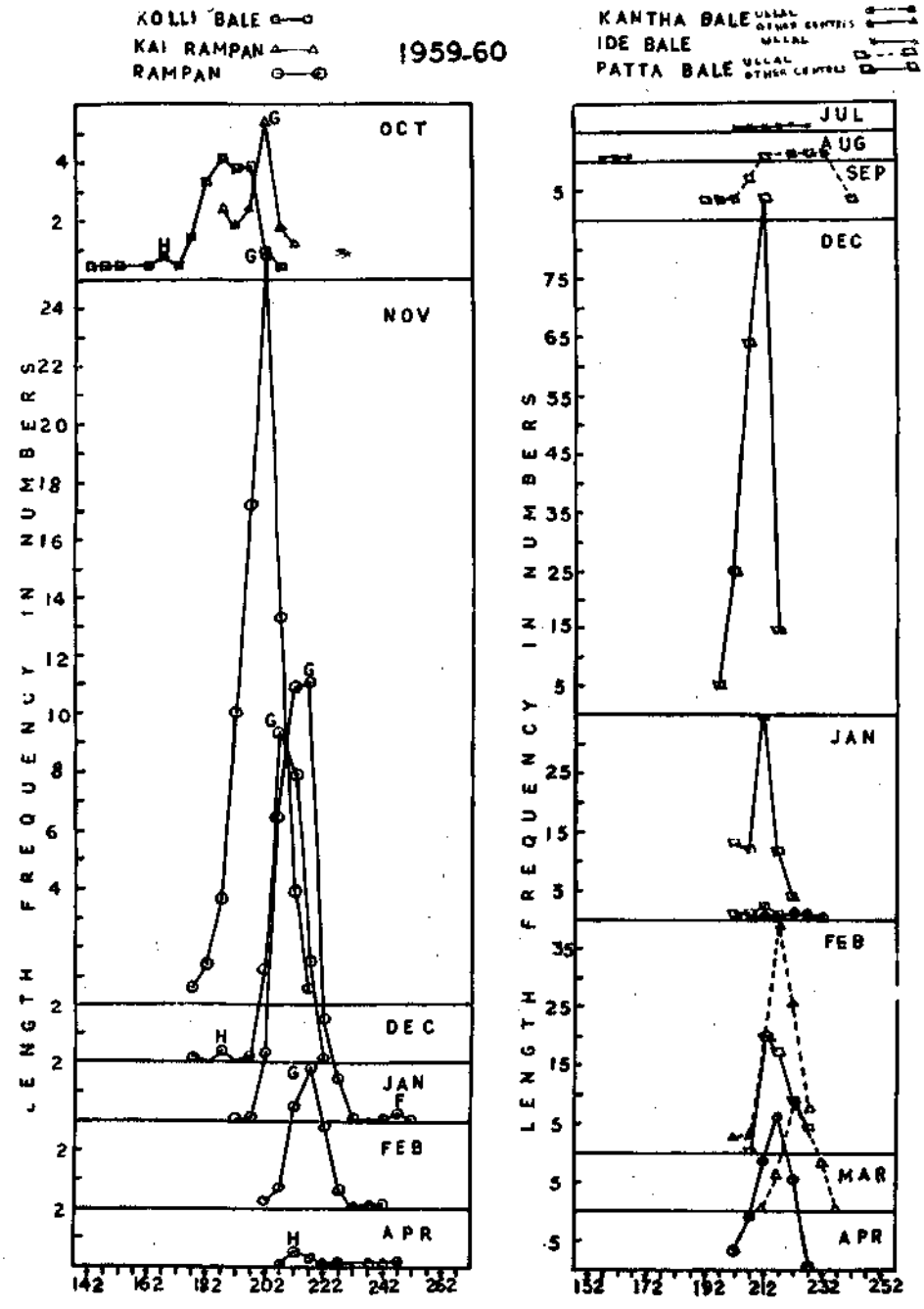
The age of 12-15 cm. fish in June according to the estimate made by Sekharan (1958) is about one year. On this basis, the age of 187 mm. fish in November should be about 4·25 units, the unit of time being four months. The approximate age of the other groups will, therefore, be 5·25, 6·25 and 7·25. These approximations are supported by the following estimates of t_0:

$t_0 = t_1 - 4{\cdot}46$ Based on J.
$t_0 = t_2 - 5{\cdot}39$ Based on I.
$t_0 = t_3 - 6{\cdot}55$ Based on H.
$t_0 = t_4 - 7{\cdot}57$ Based on G.

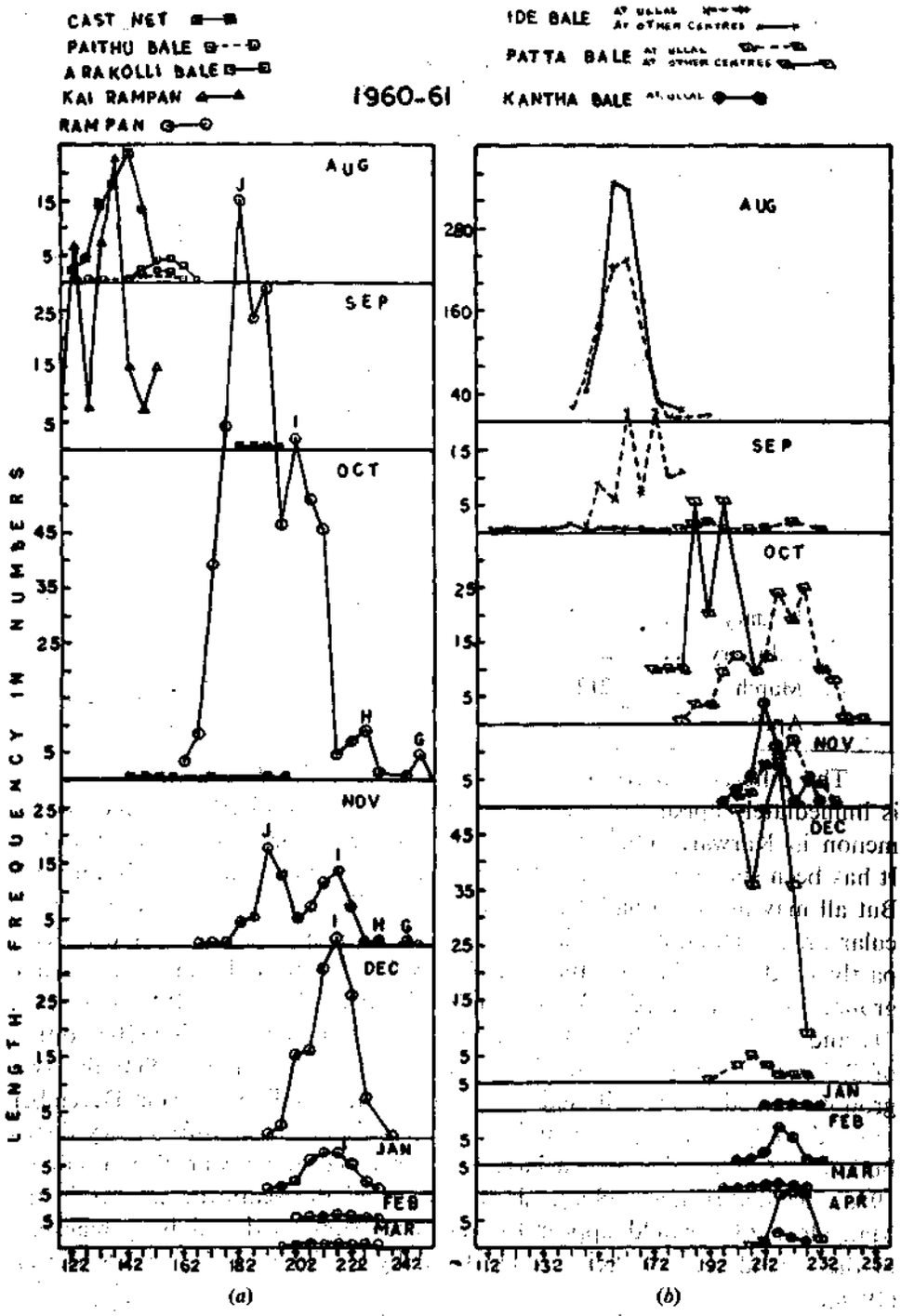
Substituting the values 4·25, 5·25, 6·25 and 7·25 for t_1, t_2, t_3 and t_4 respectively we obtain an average t_0 of $-0{\cdot}24$, which is quite reasonable.

It will be seen from the foregoing account that there may be three broods in an year; this can be indicated even on consideration of maturity data alone. We have shown that spawning takes place from March to end of October; in this period three broods at about four-month intervals are quite possible (in March, July and end of October). On the other hand, all the broods may not be sufficiently numerous to be apparent in the length-frequency distributions in all years.

Our estimate of $K = 0{\cdot}2$ is for a period of four months. On an annual basis it should be 0·6 which compares favourably with the value of 0·65



FIGS. 5 (*a*) and 5 (*b*). Fig. 5 (*a*). Length-frequency distribution per c.p.u.e. of *Kollibale*, *Kairampan* and *Rampan* nets during 1959–60. Fig. 5 (*b*). Length-frequency distribution per catch-per-$\frac{1}{4}$10 man-hours of the selective gear (gill-nets) during 1959–60.



FIGS. 6 (*a*) and 6 (*b*). Fig. 6 (*a*). Length-frequency distribution per c.p.u.e. of cast-net *Paithubale*, *Kairampan* and *Rampan* during 1960–61. Fig. 6 (*b*). Length-frequency distribution per catch per 10 man-hours of selective gear (gill-nets) during 1960–61.

obtained by Holt (1959) on other considerations. Holt (1959) has estimated L_∞ as 30–33 cm. Our estimate of the same is 31·6 cm.

Following Taylor (1958) life span can be regarded as equal to the time taken to attain 0·95 L_∞. The effective life span of mackerel then is about 4·91 years. The calculated lengths at age I, II, III and IV years are 150·7, 225·3, 266·2 and 288·9 mm. respectively.

It has to be emphasised here that the estimates given above of the parameters and the growth rates should be regarded as tentative.

Age Composition of the *Rampani* Catches

The following table gives the modal sizes which constituted the bulk of the catches from October to April in different years:

Month	1957–58	1958–59	1959–60	1960–61
October ..	..	..	..	182, 202
November ..	202	217	202	192, 217
December ..	212	222	207	217 ..
January ..	212	222	217	217 ..
February ..	212	222	217	217 ..
March ..	212	222	..	217 ..
April ..	..	222	..	.. ..

The difference between the modal sizes of 1958–59 and the other years is immediately apparent. Pradhan (1956) has also noticed the same phenomenon in Karwar. Our results give at least a partial explanation for this. It has been shown above that there may be more than one brood in an year. But all may not be equally successful or contribute to the catches of a particular area. The difference in the modal sizes between years would at least partly be due to the fact that the fishery is supported by an early or late group. Thus the modes for November in 1957, 1958 and 1959 were 202, 217 and 202 respectively. The calculated age of 202 mm. fish is 1·70 and that of 217 mm. 1·95 years. Again in October and November 1960 the two groups 'I' and 'J' contributed to the bulk of the landings. From December onwards only the group 'I' could be recognised in the length-frequency distributions. Similar phenomena have been observed at Karwar also (Pradhan, 1956; Radhakrishnan, 1958). However, in all the years the catches in the Mangalore zone would appear to have been supported mainly by mackerel in the second year of their life as stated by Panikkar (1952) and Sekharan (1958).

Gill-Net Catches

The modal sizes recorded from October to March in gill-net and *Rampani* were usually either the same or differed to the extent of 5–10 mm. only. It would therefore appear that the same group or groups contributed the catches of both types of nets. Data for October 1960 will be of some interest here. In *Pattabale* at Ullal group 'H' was dominant, while in the same type of net operated at other centres 'J' occurred as the main group. If all *Pattabale* data are pooled, it will be seen that 'J' is more abundant than 'H' which is of course to be expected. In *Rampani* catches also, the group 'J' was better represented than 'H'. Although the modes of operation of *Pattabale* and *Kanthabale* are different, they have the same mesh size and, as would be expected, the size-groups caught by both the nets are almost the same.

Rate of Decrease per Month

An average rate of decrease per month was estimated by the formula

$$D = 1 - \frac{N_{t+1} + N_{t+2} + N_{t+3} \ldots N_{t+n}}{N_t + N_{t+1} \ldots N_{t+n-1}} \qquad (7)$$

where, D = average rate of decrease per month and N_t, N_{t+1}, etc., the catch-per-unit of effort in numbers in months t, $t + 1$, etc. The month of peak catch-per-unit of effort was selected for N_t. The analysis was done for the *Rampani* catches of October–March period, at Karwar, Malpe and Mangalore zones. The relevant data for Malpe for 1954–55 and for Mangalore zone from 1959–61 are given below.

	Catch per man-hour		
	At Malpe 1954–55	Mangalore zone	
		1959–60	1960–61
October ..	..	..	626·00
November ..	283	76·40	86·30
December ..	135	28·73	143·22
January ..	6	48·80	33·30
February ..	13	13·60	1·71
March ..	10	1·70	0·66
April ..	..	..	..

For Karwar the data are taken from Pradhan (1956) and Radhakrishnan (1958). The following table gives the values of D:

	Karwar	Malpe	Mangalore area
1949–50 ..	0·57	..	..
1950–51 ..	0·35	..	..
1951–52 ..	0·07	..	..
1952–53	0·61	..	..
1954–55 ..	0·75	0·62	..
1955–56 ..	0·53	..	..
1959–60 ..	..	..	0·41
1960–61 ..	..	..	0·71

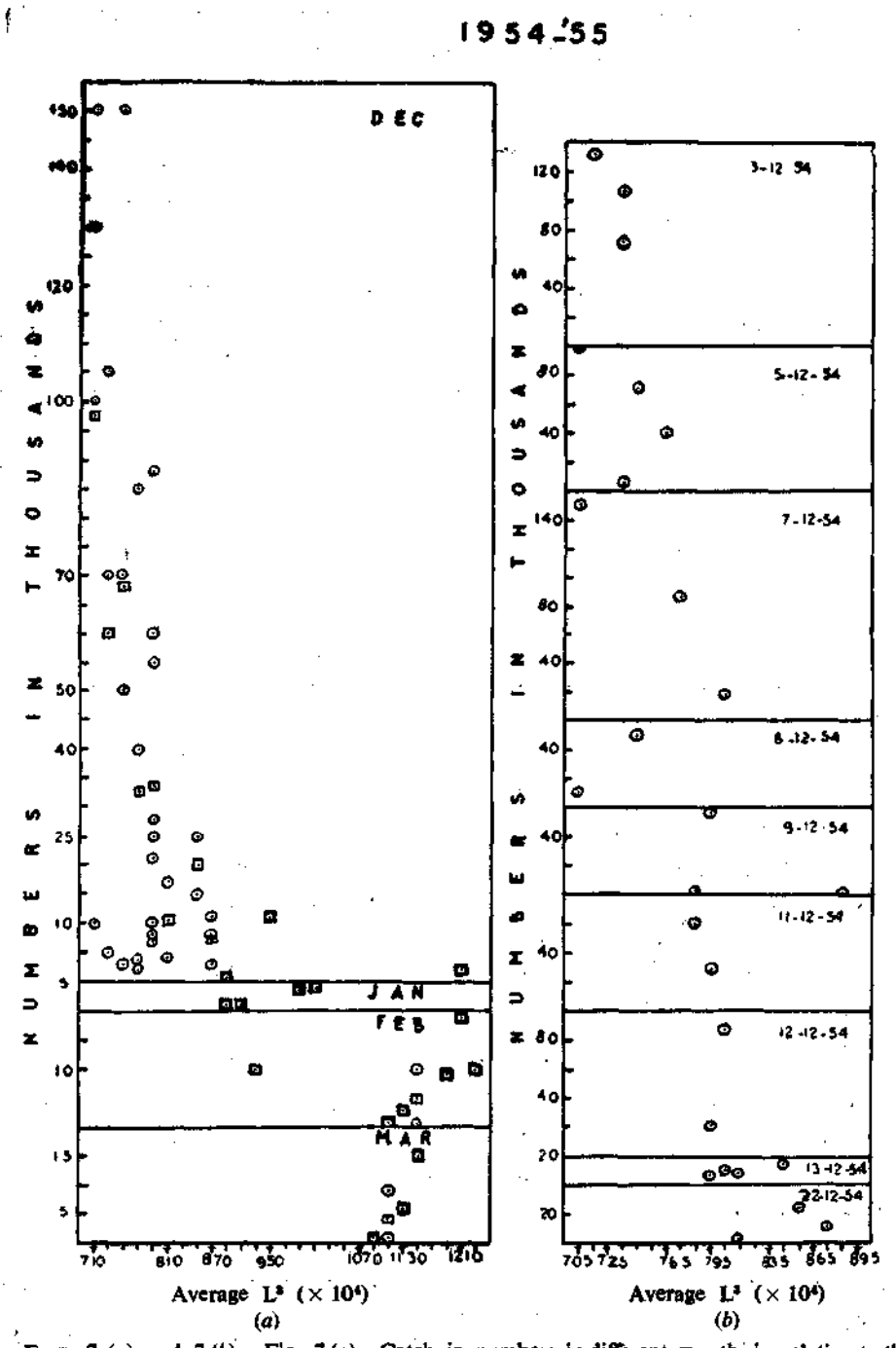
Except for 1951-52 the values in all the regions fell within the range of 0·35-0·75.

Relation between Catch and Cube of Length

At Malpe in 1954–55 there were wide differences in regard to the number of mackerel landed from haul to haul even on the same day. This could not be explained in terms of their modal sizes. Hence, an average L^3 for each haul was calculated. The values obtained were grouped into convenient classes. The individual catches and their averages are indicated in Fig. 7 *a*. It is seen from there that with the increase in L^3 the catch showed a decline. This was particularly marked in December when the data were available for 34 hauls. However, this trend was not seen in February and March which perhaps may be partly due to the fact that data for these months were inadequate. The analysis for the days in December 1954 when there were more than one haul is indicated in Fig. 7 *b*. On most of the days the catches tended to fall with increase in average L^3.

Discussion

It has been shown that the landings of *Kanthabale*, a bottom gill-net operated in the Mangalore area, generally include mackerel. The best



FIGS. 7 (*a*) and 7 (*b*). Fig. 7 (*a*) Catch in numbers in different months in relation to the average L^3. ⊙ denotes individual hauls and ⊡ the average catch per haul. Fig. 7 (*b*). Catch and average L^3 on the different days during December 1954.

catches are recorded from January to April and during this period the fishermen gradually extend the depth of operations from 6–15 fathoms. After May this net is not operated, owing to monsoon. Stray specimens of mackerel have also been observed occasionally in the trawl nets operated off Mangalore in the 6–20 fathom area. Again Pradhan (1956) has reported the occurrence of mackerel in the trawl catches off Porbunder. Munro (1955) has reported mackerel from the trawling grounds off Ceylon. Thus all the available evidence seems to indicate that mackerel may be available on or near the bottom during certain periods. In the Mangalore area this period includes the months January to May, when the landings of *Rampani* and *Pattabale* are not of the same magnitude as in earlier months. Whether this indicates the possibility of a dispersed and demersal phase in the life-history of the mackerel as reported in the case of the Atlantic mackerel (Steven, 1948), will have to be examined when more data on bottom nets are available for other sections of the coast.

The observations on length frequency and maturity have shown not only that there may be more than one brood in an year but also that the period, and perhaps the region, of peak spawning may vary from year to year. All the resultant broods may not be equally numerous as to be traceable in the length-frequency distributions of the October–March period. This is also suggested by the fact that the modal sizes in different years show variations. Our estimates of the time interval between broods and of L_∞ and K are tentative. Obviously it is not necessary that broods should be equally spaced during all the years.

The estimates of D given here are, of course, not equal to total mortality. But it is interesting to note that the values for different regions in respect of various seasons fell within the range of 0·35–0·75 except for 1951–52.

Summary

Observations were conducted on the fishery and biology of mackerel in the Mangalore area from 1957 to 1961. The fishery was a failure in 1959–60 but during the other years the catches were better.

The monthly catch-per-unit of effort for various types of units operated at Ullal is given for the years 1958–61. *Pattabale*, a gill-net, is the most important gear used for mackerel at this place. It is operated when shoals are sighted and the best catches are made during October–December, although a secondary but minor peak is observed in the months March to May. Another important gear is *Kanthabale*, a bottom gill-net employed

usually from December onwards. The fact that mackerel are landed by this bottom net when the catches of *Pattabale* and other nets are on the decline is a clear indication of their availability on or near the bottom. North of Mangalore bulk of the catches were landed by *Rampani.*

Maturity studies indicate that the spawning period may be March to October.

The length-frequency distribution indicated the probability of there being more than one brood in an year, although all broods may not be equally successful or contribute to the catches of a particular area. The von Bertalanffy growth equation was fitted to length-frequency data and estimates of $L_\infty = 316$ mm. and K (on annual basis) = 0·6 obtained. The catches appear to be supported by fish in the second year of their life.

The frequency distribution of *Rampani* catches on monthly basis at Malpe in 1954–55 was positively skewed. The catches in December 1954 tended to fall in relation to average L^3. During the other months the total number of hauls was small and this trend was not noted.

At Malpe in 1954–55, no consistent relationship could be seen between catch and the time of commencement of the haul.

An average rate of decrease per month was calculated from the available data for Karwar, Malpe and Mangalore areas. Except for 1951–52, the values fell within the range of 0·35–0·75.

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