ON THE SOUTH KANARA COASTAL FISHERY FOR MACKEREL, *RASTRELLIGER CANAGURTA* (CUVIER) TOGETHER WITH NOTES ON THE BIOLOGY OF THE FISH

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North of Mangalore, the South Kanara fishery for the Indian mackerel, *Rastrelliger canagurta* (Cuvier), is confined mostly to coastal waters. The gear used is the *Rampani* net, a large shore-seine which exploits only a narrow belt of the sea 1–1½ miles from shore [see Pradhan (1956) for description and figure of the net]. The use of other gear for mackerel during the season has traditionally been under a social ban in many of the fishing villages; but even in other places, where the ban does not exist, no serious attempts are made to extend the area of operations. Nevertheless, the output at these centres of coastal fishing forms a major contribution to the total mackerel catch in India. As in other sections of the coast, the best catches are obtained during the October–December period, though the season, as a rule, begins in October and lasts until March or April. During other months, small quantities of mackerel are caught in gill-nets (*Pattavala*) and small shore-seines (*Kairampanis*); the gill-net boats venture to a distance of about 6 miles offshore, while '*Kairampanis*' are operated within a zone of only about half a mile from the shore. Panikkar (1949, 1952) has summed up the present state of our knowledge regarding the life-history and movements of mackerel, and has further indicated the lines of investigation that have to be undertaken for a fuller understanding of the fluctuations in catches. Recently Pradhan (1956) has published the results of his study of the mackerel fishery of Karwar. This paper deals with the coastal fishery* of the region between Baikampady and Tarapathy in the South Kanara District, with special reference to that of Malpe, one of most important mackerel centres on the West Coast.

Material and Methods

The fishing centres between Baikampady and Tarapathy were visited twice, first during the 1954–55 season and again during the following year, when a total enumeration was made of the boats, gear and men engaged in the fishery. (The

* 'Coastal fishery' as referred to in this paper means a fishery confined to a narrow belt of the sea 1 to 1½ miles from shore.

distance between the two centres is about 50 miles.) Detailed studies were conducted at Malpe during the 1954–55 season, when 18 *Rampanis*, confined to a 6-mile-long section of the coastline, were kept under observation. This has been supplemented by data collected for the 1955–56 season, when trips were made to Malpe in the months of December and April. Particular emphasis has been placed on the catch statistics as well as length-frequency and maturity of the mackerel. As the mackerel of every haul are invariably counted at the landing place itself and the fishermen and merchants were very helpful there was no difficulty in getting reliable data of catches. According to local custom if a catch consists of more than 50,000 mackerel it is divided among the merchants who control the net; otherwise it is auctioned. Hence the merchants are in a position to supply the relevant statistics, at least with regard to the larger hauls. It may be mentioned in this connection that the production figures presented here for the 1955–56 season are based mainly on details given by them. The data collected from them refer to the day-to-day hauls of 12 out of the 18 *Rampanis* operated in the Malpe area during that season. These figures are complete and reliable as far as hauls of more than 50,000 mackerel are concerned. The merchants were also able to give data on poorer catches which they had purchased in auctions, but it was found impossible to trace all such transactions. There is, however, reason to believe that the number of hauls on which information is lacking would not be more than 2–3 per net per month. Initially there was some difficulty in defining a convenient measure of abundance of mackerel; after some trials, the 'catch-per-man-hour'† was found suitable for the purpose.

The catch statistics maintained by the Madras Government Fish Curing Yards have also been utilized here. Being based on information elicited by the staff mainly through enquiries, these estimates probably involve a certain degree of error. But it may be pointed out that only a limited number of hauls are undertaken by the *Rampani* fishermen every day (at Malpe this varied from 1–10), and that the news of a catch, especially if it is a large one, gets a wide local publicity. Hence, it is probable that the yard data on *Rampani* catches are subject to a smaller margin of error than their estimates pertaining to other gear. Thus the difference between the data collected by the author himself and those recorded by the Malpe Fish Curing Yard, concerning the operations of the *Rampani* nets in the Malpe zone for a short period in December 1955, was about 20%; but for the period from 26th November 1954 to 19th March 1955 the difference was less than 7%. Undoubtedly, the yard data give a rough indication of the annual trends of production. They have also been analysed here with a view to confirming some of the observations made by the author during the 1954–55 season.

For purposes of the study of the size-composition of catches, only the total length (from tip of snout to the end of the longest caudal ray) has been taken into

† If n men operate a net for h hours and catch c pounds, the catch-per-man-hour is given by the formula c/nh.

account. An analysis has also been carried out of the data published by the Madras Fisheries Department on the length-frequency of mackerel of the West Hill area. The gonad stages referred to are based on the conventions laid down by the International Council for the Exploration of the Sea. The diameter of ova from fishes of the early and advanced maturity stages was measured.

Fishing centres.—Because of the difficulties of transport and disposal of the catches the industry has tended to concentrate near centres where communications are better developed; this has to some extent brought about an uneven distribution of the intensity of fishing. Thus the coastal waters are probably fished more at Malpe, Hangarcutta and Padathonse than at other centres. The following table gives the names of the important mackerel centres north of Mangalore along with the number of nets and man-power employed.

Centres	Number of *Rampani* nets in use	Number of men required to operate each net
Baikampady ..	2	65–70
Hosubet ..	2	65–70
Moolky ..	7	65–75
Kaup ..	2	75–80
Pollippu ..	6	60–65
Udyavar ..	6	70–80
Malpe ..	18	70–80
Padathonse ..	11	70–80
Hangarcutta ..	11	70–75
Manoor ..	6	60–70
Gangolli ..	13	70–75
Maravanthe ..	9	50–60
Tarapathy ..	5	60–70

Trends of production.—The details of the catch statistics of the West Coast for the years 1925–26 to 1930–31 have been published by Raj (1927, 1931, 1933 and 1939) and for the years 1931–32 to 1949–50, by Chacko (1954 & 1955). In the following table data are given of the *Rampani* landings of the seasons 1944–45 to 1955–56; they are based on the reports of the Fish Curing Yards which maintain rough estimates of the landings recorded by the *Rampanis* in areas under their jurisdiction.

The catches of the 1954–55 season were the lowest for the 12-year period considered here. According to experienced fishermen, such a poor annual yield had seldom been witnessed on the South Kanara Coast.

The Fishery in 1954–55

The detailed observations conducted on the fishery during the 1954–55 season were confined to a 6 mile-long section of the coastline, of which

Seasons	Catch (in maunds‡)
1944–45 ..	396,040
1945–46 ..	1,700,850
1946–47 ..	649,200
1947–48 ..	333,790
1948–49 ..	481,250
1949–50 ..	641,730
1950–51 ..	1,491,810
1951–52 ..	953,980
1952–53 ..	265,760
1953–54 ..	303,580
1954–55 ..	164,070
1955–56 ..	418,510

‡ 1 Maund = 82·28 lb.

Malpe formed the centre; this sector also coincided with the area of jurisdiction of the Malpe Fish Curing Yard. Here altogether 18 *Rampanis* took part in fishing, out of which 3 operated only for part of the season and later migrated elsewhere, owing to the dearth of catches. As stated before, catch-per-man-hour was regarded as the index of abundance of the fish in coastal waters.

The fishery started in October, but except for a few good catches the hauls gave disappointingly poor returns. There was a better concentration of the shoals in November, which registered the maximum monthly catch of the season. This was followed by a marked fall in the yield in December. In January, mackerel appeared in the coastal waters in shoals only on rare occasions. February and March registered a slight increase. The following table summarises the monthly data.

Months	Total catch (in lb.)	Catch-per-man-hour (in lb.)
November ..	1,821,000	47·3
December ..	374,040	22·5
January ..	5,840	1·2
February ..	14,040	2·5
March ..	9,230	1·9
TOTAL ..	2,224,150	

The average catch-per-man-hour for the whole season was 14·9 lb. but the values of abundance for different months exhibited considerable variations, as can be seen from Fig. 1, which gives the percentage deviations from the seasonal average. In November, the month of the highest yield, the catch-per-man-hour was 47·3 lb.; but even this represented a poor level of stock density, for months of peak productivity at Malpe had recorded a catch-per-man-hour of 200 lb. or even more in some of the previous years.

The Fishery in 1955–56

Rampanis started operation in October. The best monthly returns were recorded in October in the Malpe area, but in November in the southern centres. In Malpe the catches were better in December than in November. In January and February the landings were very low in all the centres, though a slight recovery was witnessed in March. The following

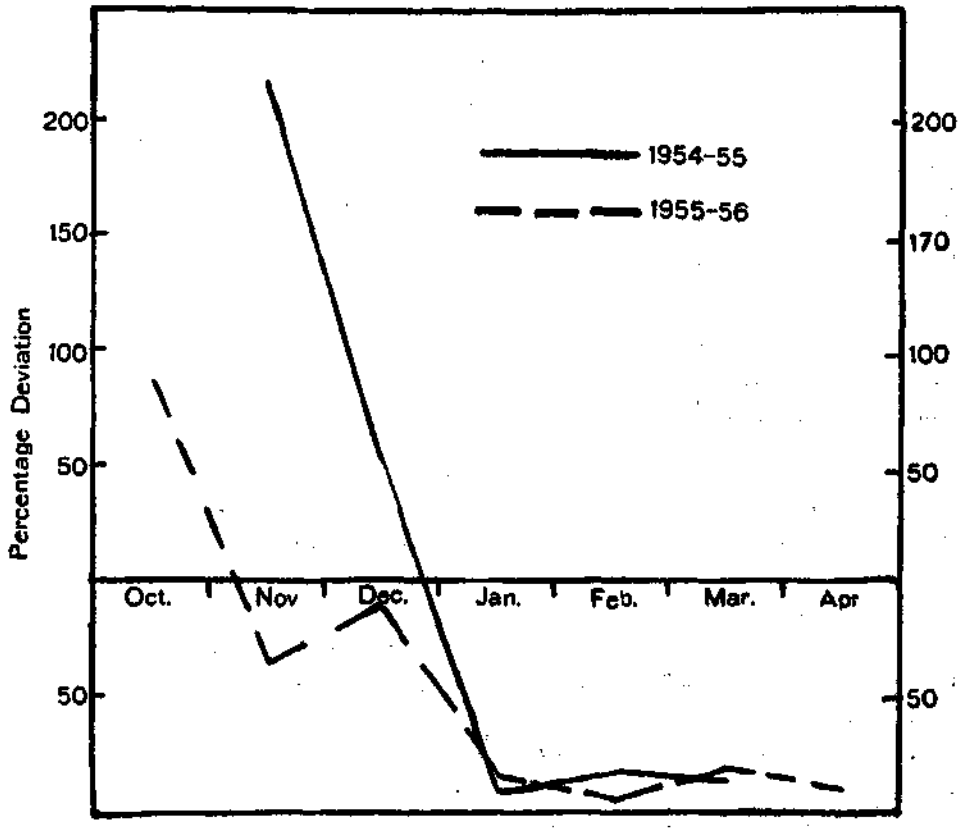


Fig. 1

table gives the approximate total catches of 12 out of 18 *Rampanis* that were operating in the Malpe zone, together with the average monthly catch-per-man-hour (see also Fig. 1).

Months	Total catch of 12 nets (in lb.)	Catch-per-man-hour (in lb.)
October ..	1,878,220	65·8
November ..	672,580	22·7
December ..	1,145,520	33·4
January ..	13,800	5·5
February ..	3,860	2·4
March ..	43,800	6·0
April (up to 18th) ..	4,000	3·4

The gill-net operations commenced in April; catch-per-boat-per-trip varied from 150–500 lb., and the catch-per-man-hour was 3·4 lb. for that month. As mentioned earlier, the boats with gill-nets fish in areas beyond the operational range of the *Rampanis*.

Madras fisheries data.—The data collected from the Fish Curing Yards for the years 1944–45 to 1955–56 lend support to the above observations regarding the pattern of monthly variations in the abundance of the fish. These are shown in Table I.

The rates of increase and decrease in monthly landings are most striking. It is also evident that the catches of the months July to September bear no relation to the yield of the October-December period. In other words, there seems to be an almost sudden concentration of shoals in the coastal waters in October and November; a high level of abundance is maintained for one month, or at the most two, and this is followed by an abrupt fall in the returns. However, there would appear to be a secondary, though minor, rise in abundance normally during the February–March period. As the production statistics of almost all the seasons considered here denote this trend, a secondary peak in yield is probably the rule rather than the exception. (In 1951–52 the first peak was noticed in October and the second in December.) In the table given below, the data are further

TABLE I

Catch statistics of the Fish Curing Yards in the region between Baikampady and Tarapathy (in maunds) (27·22 maunds = 1 ton)

Month	Year											
	1944-45	1945-46	1946-47	1947-48	1948-49	1949-50	1950-51	1951-52	1952-53	1953-54	1954-55	1955-56
July ..	..	197	..	..	..	..	..	..	..	..	..	..
August ..	70	800	..	126	175	341	1,465	435	897	3,687	140	3
September ..	2,731	2,008	2,913	195	1,781	130	10,478	3,865	6,720	1,720	327	450
October ..	86,922	465,673	266,152	4,078	34,062	130,645	392,685	310,897	125,450	43,935	18,790	138,341
November ..	143,581	843,407	185,085	186,730	234,165	469,135	681,200	136,975	76,660	133,215	134,714	180,135
December ..	123,385	45,751	63,977	97,895	120,841	35,014	117,035	199,400	15,415	105,895	7,850	87,960
January ..	25,393	66,618	36,865	1,446	77,120	4,095	70,258	163,610	30,060	9,365	506	6,607
February ..	8,855	149,793	84,306	4,263	1,396	1,158	113,769	83,385	1,750	1,499	675	437
March ..	812	91,246	1,205	16,910	2,208	238	111,440	33,190	6,515	325	420	4,574
April ..	60	12,986	..	1,320	745	860	1,270	3,330	140	50	100	..
May ..	..	1,117	11	442	159	37	780	177	650	20	..	..
June ..	..	..	..	237	35	20	..	..	495	57	..	..
Total ..	391,809	1,679,596	640,515	313,642	472,687	641,673	1,500,380	935,264	264,752	299,768	163,522	418,507

analysed with reference to the number of yards that showed a secondary increase in the landings during the seasons 1944-45 to 1955-56.

Seasons	Number of yards for which data are available	Number of yards which showed a secondary peak in production in February–April period
1944–45 ..	8	1
1945–46 ..	10	10
1946–47 ..	11	9
1947–48 ..	11	10
1948–49 ..	11	5
1949–50 ..	9	6
1950–51 ..	11	10
1951–52 ..	11	5
1952–53 ..	11	10
1953–54 ..	11	3
1954–55 ..	11	6
1955–56 ..	11	6

The data in col. 3 do not include the yards where the secondary peak was noticed earlier, or later, than the February–April period. The 1951–52 season particularly illustrates this point. During that season the first peak was witnessed in October, and in 5 of the yards the secondary peak fell within the December–January period (see also Table I).

As mentioned earlier, the catch statistics of the Malabar and South Kanara coasts have been published by Raj (1927, 1931, 1933 and 1939) for the years 1925-26 to 1930–31 and by Chacko (1954 and 1955) for the years 1931–32 to 1949–50. Details with regard to the individual fishing centres are available only for the period 1926–27 to 1935-36, but a dissection of these data also shows that the Baikampady-Tarapathy section recorded two peaks during certain years, November and February in 1927–28 and 1928–29, November and January in 1929–30, and November and May in 1934–35. During the 1934–35 season, it would appear the catches were more or less uniform in the months November, December and January. Again, if the production figures are summed up for the whole West Coast (*i.e.*, South Kanara and Malabar), it can be shown that two peaks in monthly totals had usually been recorded during past seasons. This is indicated in the following table (see also Appendix).

Season	Months of peak catches
1925–26 ..	November and January
1926–27 ..	November only
1927–28 ..	November and May
1928–29 ..	November and March
1929–30 ..	November, January and March
1930–31 ..	November only
1931–32 ..	November and January
1932–33 ..	November only
1933–34 ..	December and April
1934–35 ..	November only (catches fairly uniform from November to February)
1935–36 ..	December only (catches fairly uniform in November, December and January)
1936–37 ..	December and May
1937–38 ..	October and April
1938–39 ...	One peak in October; a minor peak in April
1939–40 ..	November and April
1940–41 ..	November only
1941–42 ..	November and January
1942–43 ..	January only
1943–44 ..	November only
1944–45 ..	November only
1945–46 ..	November and February
1946–47 ..	October and February
1947–48 ..	December and March
1948–49 ..	November and April
1949–50 ..	November and April

At Karwar.—Pradhan (1956) has given the statistics of mackerel landings at Karwar for the period 1948–49 to 1952–53. An examination of his Table VI (pp. 163–64) shows that at Karwar also, two peaks in monthly totals have been recorded during certain years: in November and March during the 1950–51 season, and in December and February during the 1951–52 season. As far as the average catch-per-piece-per-month was concerned, there were two peaks during the seasons 1950–51, 1951–52 and 1952–53. But, what is more interesting is that during the 1951–52 season the best monthly total was registered at the time of the second peak—a reversal of the usual trend.

At West Hill.—Chidambaram and Menon (1945) have observed that there are two peaks of total fish landings in the West Hill area, the first during the September-December period, and the other in the March-May period. They have not, however, split the data with reference to different species.

Time of fishing.—Night fishing by *Rampanis* is socially prohibited in the South Kanara District. The reason for this remains obscure; the most common explanation given by the fishermen was that the phosphorescence created when the water is disturbed at night would scare away the mackerel shoals from coastal waters.

Biological Studies

Age-composition of the catches.—Studies on the age-composition of the catches were based on length-frequency. As there were marked oscillations in weekly catches, the availability of samples also fluctuated considerably, which rendered it difficult to keep to a programme of measuring the fish at regular intervals. Attempts were made, therefore, to measure as many fish as possible, especially during the periods of low yield. Altogether 53 samples, comprising 4,160 mackerel, were collected between November 1954 and March 1955; and in December 1955 and March 1956, 20 samples, totalling 1,400 mackerel were examined. The collections made in April 1956 included three lots from gill-net (*Pattavala*) catches. Each sample consisted usually of 100 mackerel.

Mackerel landed by *Rampani* nets varied from 162–256 mm. in total length. Figs. 2 and 3 give the monthly frequencies in 1 cm. size-groups. It will be apparent that the fishery draws its support mainly from a single age-group. The contribution made by the 18–, 19– and 21-cm. groups during the two years may also be noted. During the 1954–55 season the monthly modal frequencies showed a progressive shift, in contrast to what was seen during the subsequent year, when the same size-group dominated the *Rampani* catches of the months of December and April. The difference in the size-composition of the landings of *Rampanis* and *Pattavala* is to be explained in terms of mesh-selection. At Karwar, according to Pradhan (1956), the monthly modal length-groups of the various seasons ranged from 17–22 cm.

The data on the length-frequency of mackerel in the West Hill area published by the Madras Fisheries Department (Administration Reports for the years 1935-36 to 1940–41) provide further information on the problem of age-composition. They relate to a continuous series of years 1934–35 to 1940–41, and are presented in Figs. 4–10, in which the modes are

marked alphabetically. A study of the major size-groups of the various years with reference to their progression through successive months would indicate that the West Hill fishery, as that of Malpe, is dependent mainly on a single age-group.

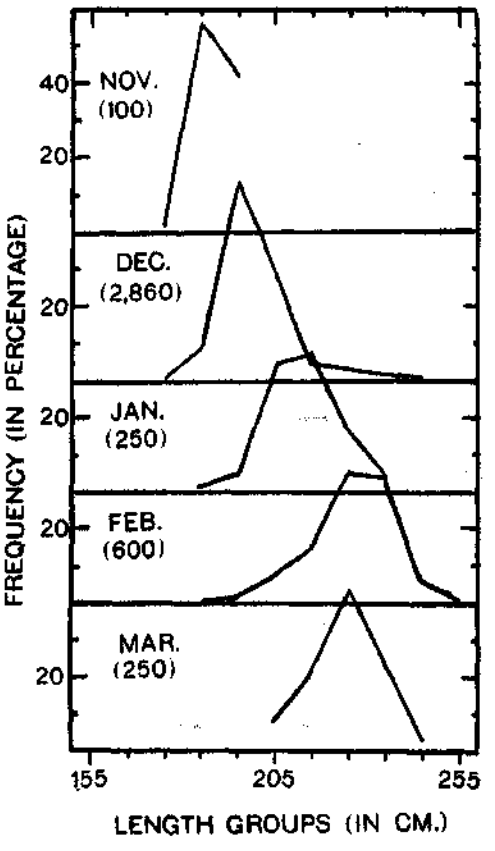


FIG. 2

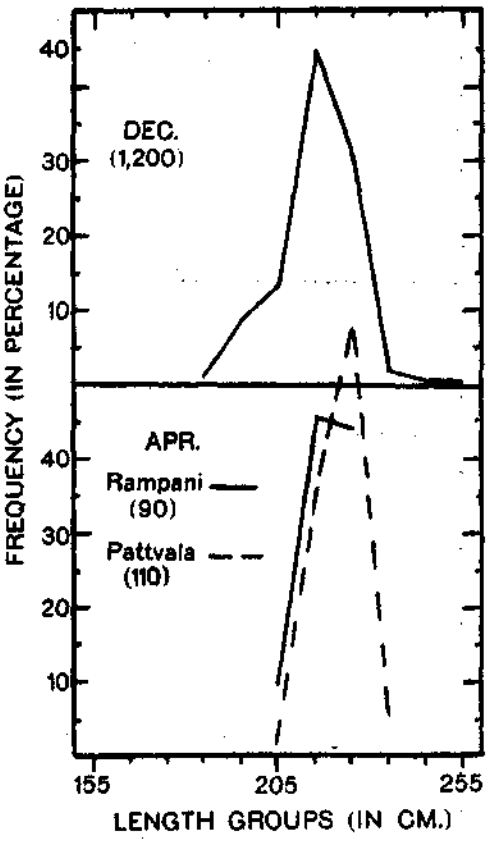
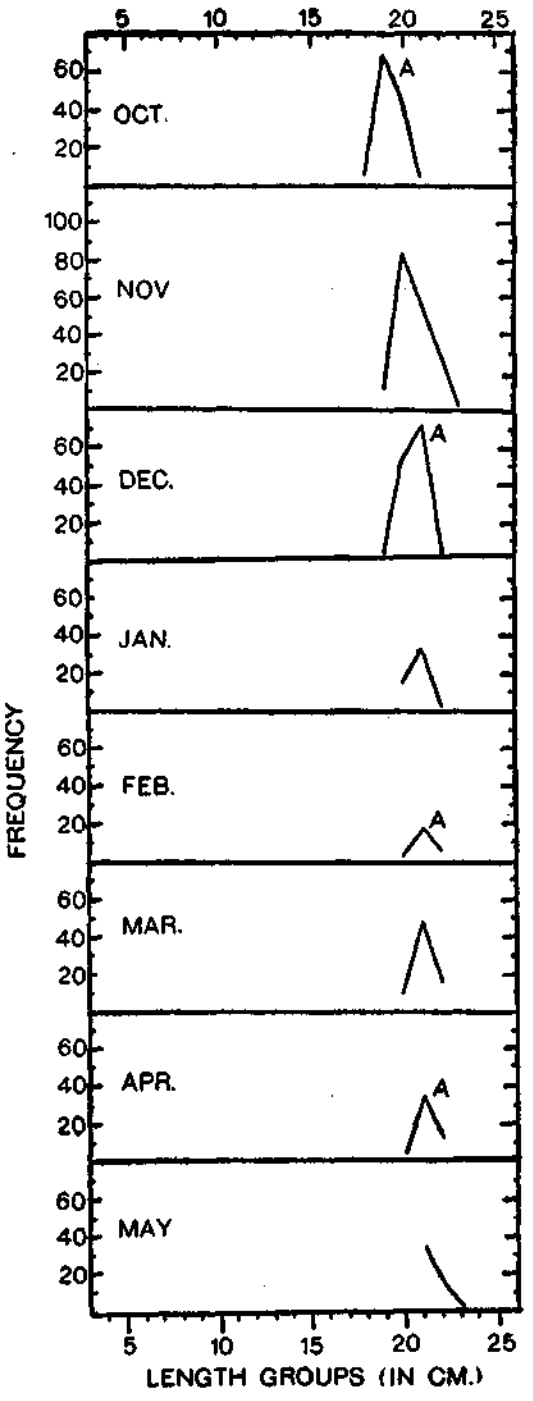


FIG. 3

The modes, B, D, E and F, representing the year-classes that formed the mainstay of the seasons in 1935–36, 1937–38, 1938–39 and 1939–40 respectively, were first recorded in the month of July, when they measured 12 cm., 12 cm., 12–14 cm. and 12 cm. in the order mentioned. On the other hand, the year-classes that corresponded to the modes A and C stood at 19 cm. at the time of their first appearance, which fell within the August–October period; the mode G was at 17 cm. in August 1940. But, during the August-October period, the modes B, D, E and F also fluctuated between 16 cm. and 20 cm. It will be evident from this that the modes A, B, C, D, E, F and G, when they form the major element of the catches, represent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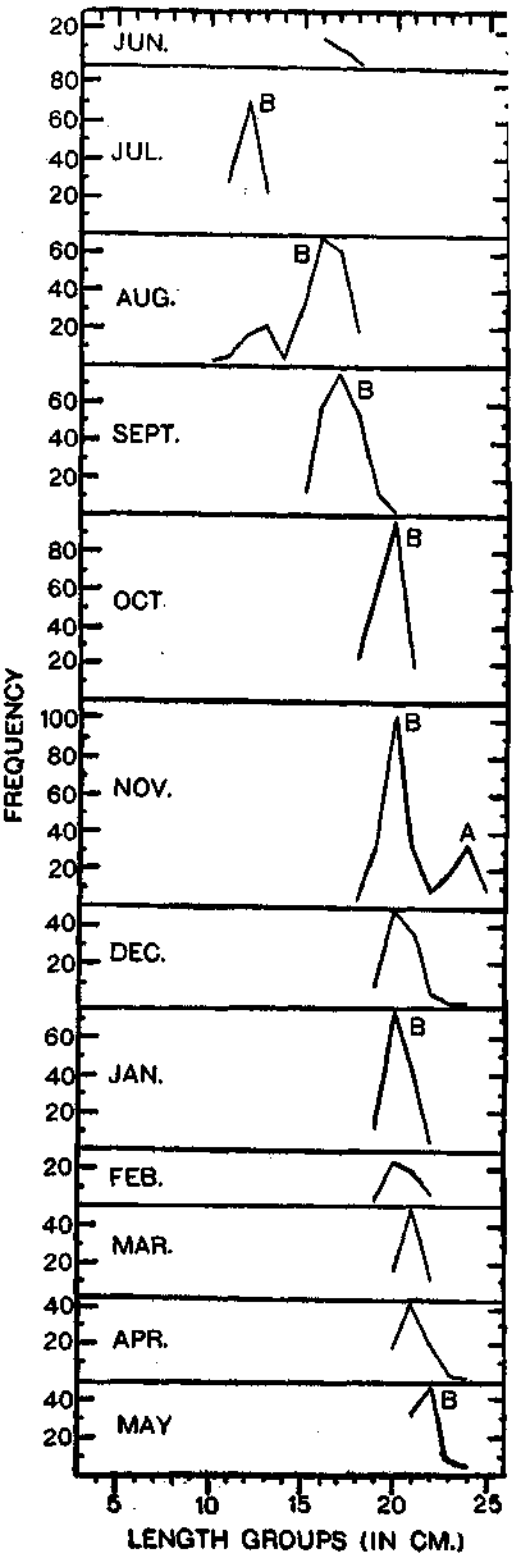
A
LENGTH GROUPS (IN CM.)

Fig. 4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B
A
LENGTH GROUPS (IN CM.)

Fig. 5

mackerel of roughly the same age. This is confirmed by the fact that there was little variation in the sizes registered by the different modes when they passed through the May–July period following their respective seasons of abundance in the fishery. Their sizes at that time fell within a narrow range of 21–23 cm. (see Table II). It may be noted also that the modes shift at a more rapid rate during the July–September period than during the other months.

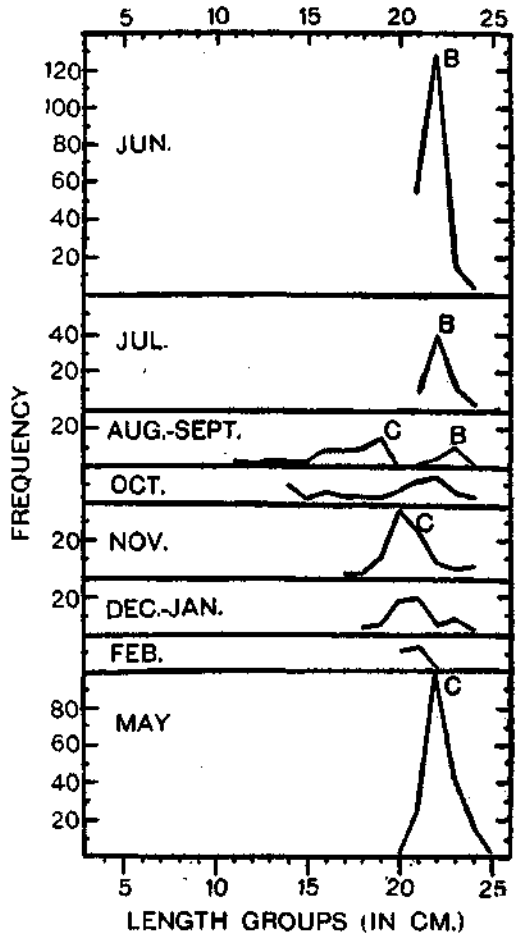
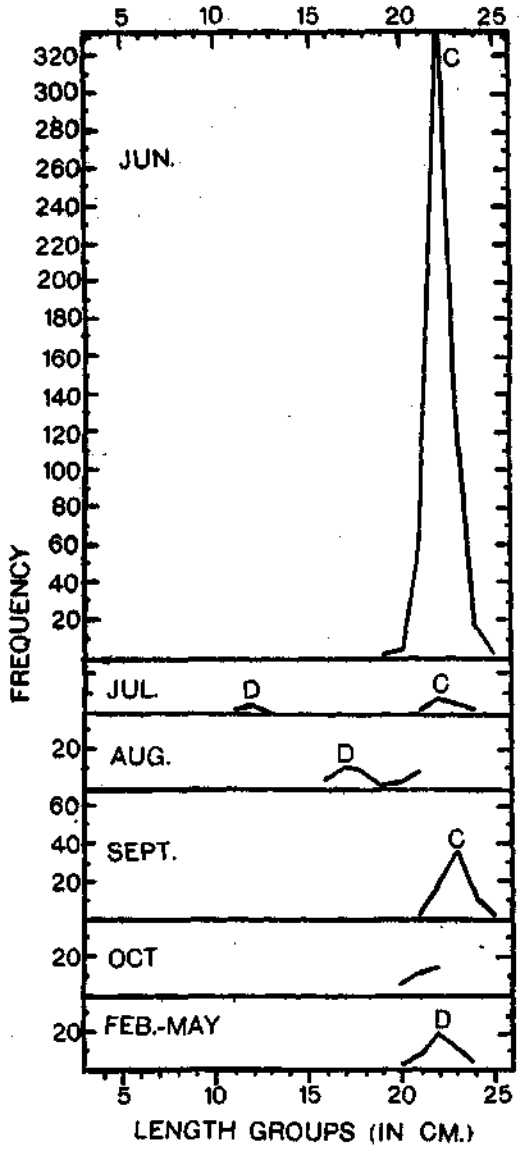


Fig. 6

Fig. 10 shows that young mackerel measuring 4–7 cm. in total length and with a modal size of 6 cm. were noticed in June 1940 (mode H). They obviously belonged to the 0-year-class, since in this species spawning activity is at its maximum during the South-West Monsoon period or some time prior to it. It would then follow that the modes B, D, E and F,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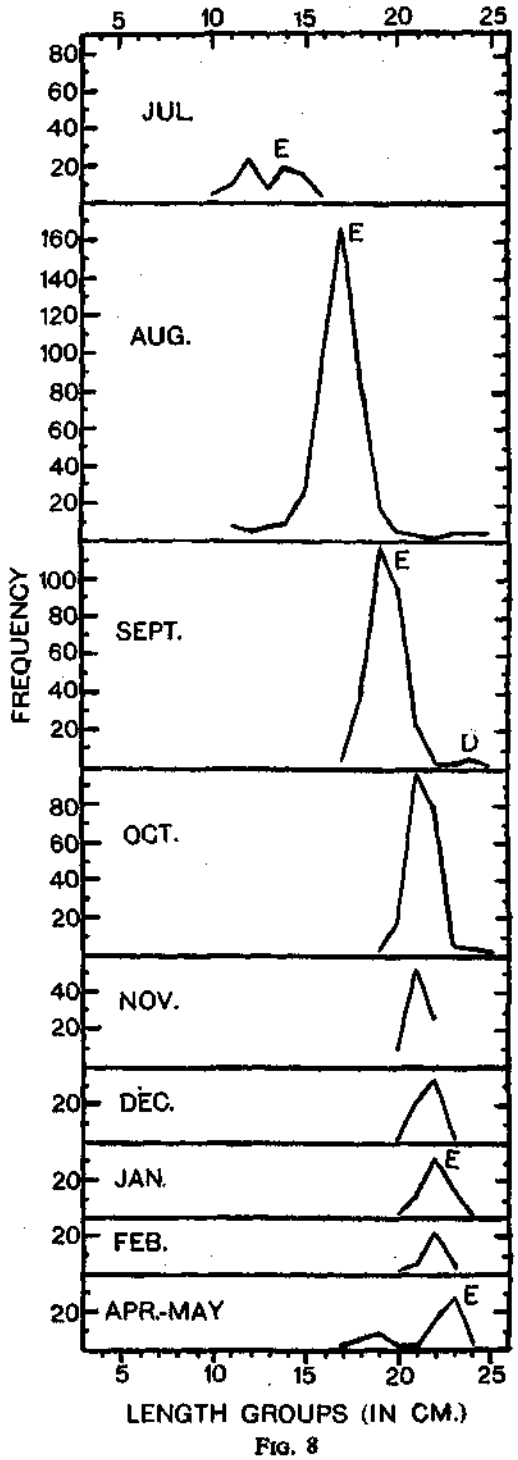
D
LENGTH GROUPS (IN CM.)

Fig. 7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E
D
LENGTH GROUPS (IN CM.)

Fig. 8

in so far as they occur first in the month of July at sizes varying from 12–14 cm., signify the length attained by mackerel at about the end of the first year of their life, and that they complete the second year of their life-cycle after supporting the fishery of the months October–March. More conclusive evidence regarding the age of mackerel is afforded by the mode G (see Figs. 9 and 10). Occurring first in September 1939 at 10 cm., it moved to 14 cm. by February 1940; its commercial abundance was recorded some time afterwards. Since the shifting of the modes is most rapid during the July–September period, G would most probably have measured 6 cm. or even less in June 1939. (Compare also the progression of the mode F between the months of July and September 1939.) This would mean that until the May–June period of the year 1940, the mode G would be included in the category of the 0-year-class. G appears next in August 1940 at 17 cm. Taking into account the rate of progression of the modes during the periods April–June and July–September, it could legitimately be concluded that the mode G would have stood at about 15 cm. in July 1940, which compares favourably with the size of one-year-olds as derived from the study of the modes A–F. Thus, when G is commercially prominent, the mackerel it represents are in the second year of their life. That the modes A, B, C, D, E, F and G, at the time of their abundance in the catches, indicate mackerel of roughly the same age has been demonstrated above. The inference follows that the mackerel fishery of the West Hill and Malpe areas is dependent mostly on one-year-olds. This conforms to the view expressed by Panikkar (1952) that "it is the second year-class that comprise the fishery". The following table showing the year-classes represented by the modes A–H is drawn up on the basis of this premise; it also sums up the main points mentioned above.

Rate of growth.—In the light of the available data, the normal modal size of one-year-olds could be assumed to be 12–15 cm. When an year-class passes through the May–July period immediately following the season of its abundance in the catches it appears to complete its second year; a reference to Table II will show that the dominant size-group at this time is 21–23 cm. As prosecuted at present, the fishery draws little support from mackerel measuring more than 25 cm. in total length. Hence it is difficult to decide the question of the total life-span of the fish by an analysis of the commercial size-groups alone. However, the existence in the population of other age-groups besides the one- and two-year-olds remains a distinct possibility. Thus, though 25 cm. is the maximum length of mackerel recorded by Day (1889) from India, specimens of greater

TABLE II

Modal sizes of the year-classes at different periods

Mode and the corresponding year-class	Season of abundance of the year-class	Month of first appearance of the mode (year-class)	Size of mode at time of first appearance	Size of mode (year-class) in the May-July period following its season of commercial abundance
A—1933 year-class	1934–35	October 1934	19 cm.	21 cm.
B—1934 ,,	1935–36	July 1935	12 ,,	22 ,,
C—1935 ,,	1936–37	Aug.–Sept. 1936	19 ,,	22 ,,
D—1936 ,,	1937–38	July 1937	12 ,,	22 ,,
E—1937 ,,	1938–39	July 1938	12–14 cm.	23 ,,
F—1938 ,,	1939–40	July 1939	12 ,,	23 ,,
G—1939 ,,	1940–41	September 1939	10 ,,	21 ,,
H—1940 ,,	..	June 1940	6 ,,	.. ,,

length have frequently been landed both on the West Coast and the East Coast. The author had collected a 29 cm. mackerel from the Mandapam area in 1952. Specimens measuring 22–28 cm. have been recorded in trawler catches (Pradhan, 1955). The maximum size attained by the species, according to Beaufort (1953), is 39 cm. It would also be important to remember in this connection that " the very narrow range of size variation in a second year-class is so pronounced as to throw suspicion on their age " (Panikkar, 1952).

Pradhan (1956) believes that " the Indian mackerel attains a length of 10 cm. in one year and that when it enters the fishery in October, it is 18 cm. or more, completing its second year ". According to him, therefore, when mackerel support the fishery of the months October–March, they are in the third year of their life. He has given the data of length-groups recorded at Karwar during the years 1948–49 to 1952–53. From these it is seen that the monthly modal sizes of the October–March period varied between 17·5 cm. and 22·5 cm. The following points brought out in his data will also be of interest in this connection: (1) In September 1949, the

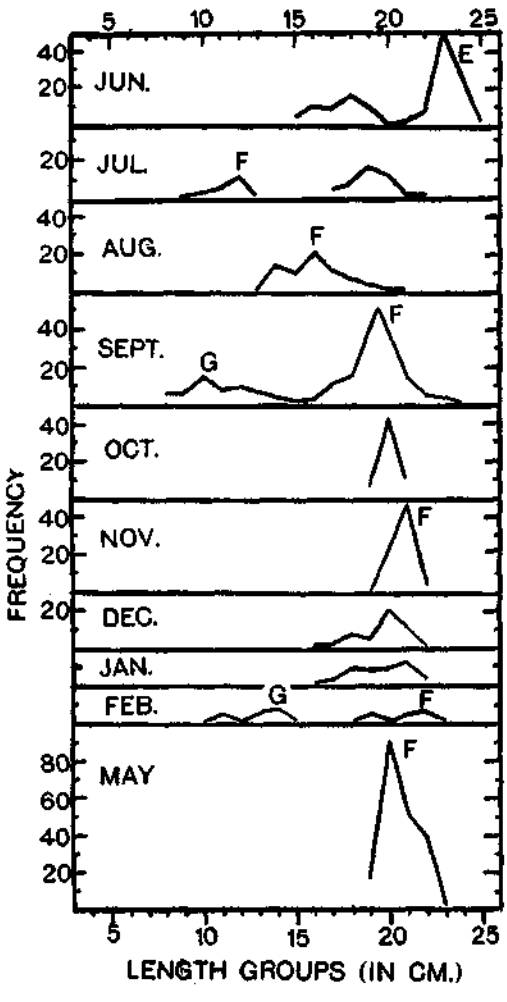

FIG. 9

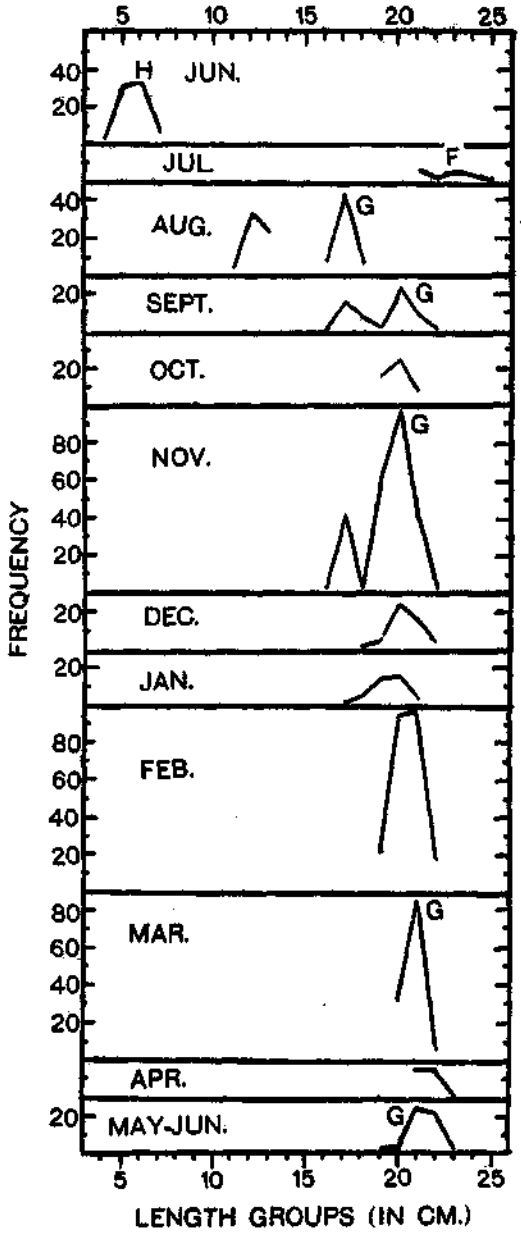

FIG. 10

major size-group stood at 15·5 cm.; this moved to 17·5 cm. and 19·5 cm. in October and November respectively. (2) In September 1950, there was a mode at 16·5 cm. (3) In September 1952, the dominant size-group was

13·5 cm. (4) In the March–April period the modal frequencies varied between 19·5 cm. and 22·5 cm.

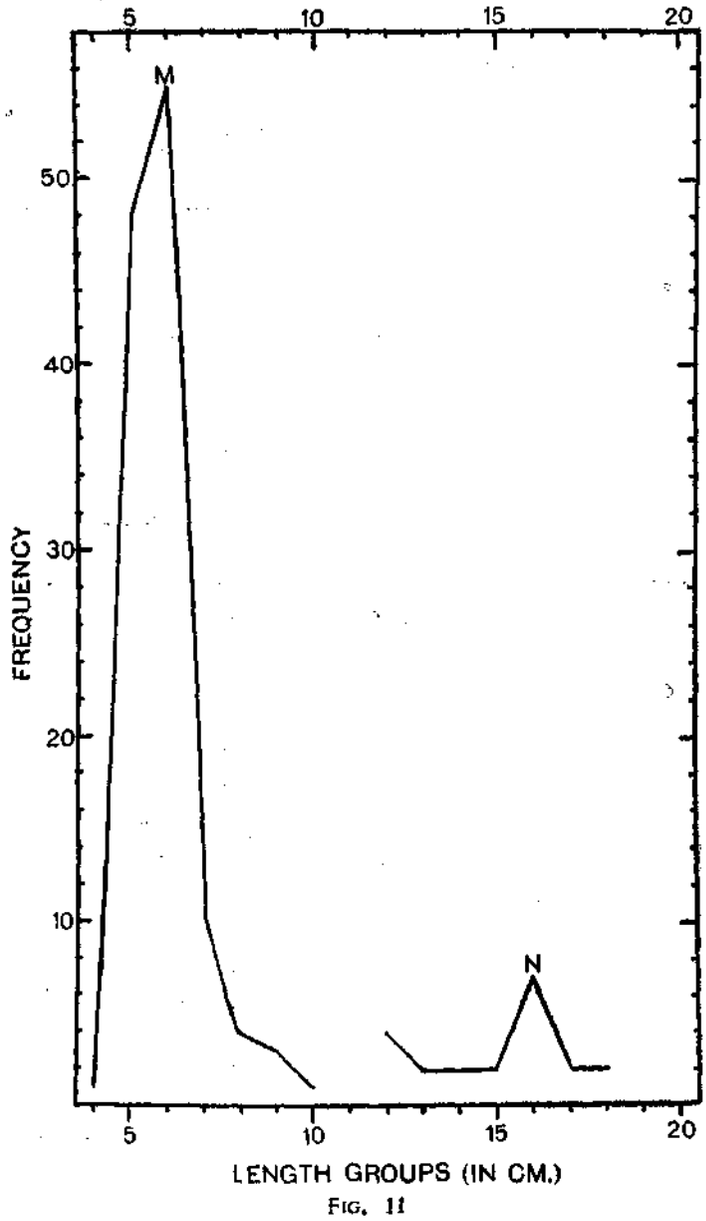

FIG. 11

The size-composition of the mackerel catches of the West Hill area has been discussed by Chidambaram *et al.* (1952), who have also drawn attention to the periodic fluctuations exhibited by the same. In the length-

frequency diagram given by them for the month of August 1949, two principal modes can be recognised—one at 8 cm. and the other at 13–15 cm. If allowance is made for a month's growth, the second mode would probably have been at 12–14 cm. in July 1949—the length of one-year-old mackerel as estimated in the present paper. In the diagram for April 1950, the mode stands at 21 cm., thereby describing the growth of the year-class concerned for a nine-month period beginning in August. According to the same authors, the range of sizes available in the months of April and May was 21–24 cm. In June 1948, only larger sizes measuring 22–25 cm., were observed.

Panikkar (1952) has observed that mackerel measuring 9–11 cm. and 6–11 cm. occur in Karwar and Calicut respectively, in the August–September period. Rao and Basheerruddin (1953) have commented on the size-frequency of the commercial mackerel population off the Madras Coast. Their data refer to the March–April period and indicate four dominant size-groups at that time, at 8–9 cm., 13–14 cm., 20–21 cm. and 23–24 cm. respectively. During the months May–July 1954, Shri A. V. V. Satyanarayana, Survey Assistant, C.M.F.R.S., collected three samples of mackerel from Vizagapatnam and they could be arranged around two modal size-groups, namely, 6 cm. and 16 cm. (*see* Fig. 11). This roughly corresponds to Fig. 10, wherein the first two dominant size-classes are 6–7 cm. and 17–18 cm. respectively during the June–August period.

There appears to be a well-marked periodicity in the rate of growth of the year-classes, as shown by the checks in the movements exhibited by the modes in certain months of the year. In the following table, the year is divided into four periods, and the increment in length attained by the different year-classes during the different periods shown. (This is based on Figs. 4–10).

	July–Sept.	Oct.–Dec.	Jan.–Mar.	April–June
1933 year-class ..	..	2 cm.	..	..
1934 ,, ..	5 cm.	3 ,,	1 cm.	1 cm.
1935 ,, ..	..	2 ,,	..	1 ,,
1937 ,, ..	5 cm.	3 ,,	1 cm.	..
1938 ,, ..	7 ,,	2 ,,	1 ,,	..
1939* ,, ..	3 ,,	..	1 ,,	..

* The growth of this year-class is considered only as it relates to the year 1940–41.

It is evident that growth is most rapid during the July–September period. The increase in length witnessed during the months January–June is negligible. However, this observation on the periodicity in the growth phenomenon applies only to the commercially valuable age-group; only further investigations will show to what extent this trend is shown by the other age-groups also.

Maturity and Spawning Season.—During the 1954–55 season, samples were collected at fortnightly intervals for determining the state of maturity of the fish. In addition, hundreds could be examined in the field, as mackerel are gutted at the landing place itself. The majority of specimens in the November and December samples were immature (stages I and II). In the following months the *Rampani* landings were seen to depend on an increasing percentage of maturing fish (stage III and above). Thus, out of 100 mackerel examined in February, 52 were in stage III, 8 in stage IV and the rest in stages I and II. In March 1955, one sample of 25 fish was available. The fish of that lot were in a very advanced stage of maturity (probably late stage V), and although the ovaries contained only a few transparent eggs, milt and ova oozed out in small quantities on the application of moderate pressure on the abdomen. This shows that spawning would commence in March or at least in April, though the height of the breeding activity might occur sometime later. It will also be apparent that the minimum age of mackerel at the time of first spawning is about 2 years. Devanesan and Chidambaram (1948) and Pradhan (1956) believe that spawning of mackerel occurs during the June–September period. This aspect has also been discussed by Chidambaram *et al.*, (1952), and they state that the months April–September should be regarded as the spawning season of mackerel.

During the 1955–56 season, maturity studies were continued in greater detail. Ova from mackerel in the early and advanced stages of maturity were measured, following the procedure adopted by Clark (1934).

Fig. 12 gives the size-frequency of samples of ova from 5 mackerel in stages II–III. They were collected in December 1955. Though the specimens ranged from 201–222 mm. in total length, they differed little with regard to ova diameter. The curves for ova size show two peaks, but this is only to be expected in the early stages of maturation.

Eight samples totalling 200 mackerel were collected in April; they consisted of specimens in late stage V (stages V–VI), and as was noted in March 1955, ova and milt oozed out in moderate quantities when the abdomen was pressed. But samples of the ovary, when examined under

the microscope, showed only very few completely transparent eggs. In the ovaries of many individuals, ova that were getting transparent were confined to certain regions; even within such regions, it could clearly be made out from external appearance alone, that some ova were getting transparent very much ahead of others (*see* Plate I, Figs. 1 and 2). There was, in other words, an intermingling of opaque white patches and translucent spots, which to some extent resembled the "plum-pudding" stage of the Atlantic mackerel, as seen from the photograph given by Steven (1949). The "plum-pudding" appearance, according to Steven (1949), is shown by an ovary in stage VI. In the Malpe material, however, the condition shown in Photographs 1 and 2 was caused by translucent ova and others that were in various stages of transparency. In fact, in the April samples only very few completely transparent ova could be seen. Pradhan (1956) has also described a "plum-pudding" stage in the Indian mackerel.

Seven mackerel representatives of various size-groups were selected for the study of the ovaries of stages V–VI. Since all opaque ova do not become transparent simultaneously, it was decided to measure the two groups separately. Also, samples from the anterior, middle and posterior parts of the ovary were treated separately, as it was found that ova from different regions exhibited slight differences in size and appearance; the frequencies were pooled when plotting the curve for each individual. Each sample consisted usually of 100 ova.

When the measurements for all ova were combined, irrespective of whether they were opaque or transparent, the curves for all except one mackerel (curve G in Fig. 13) showed only two peaks—one for the immature group and the other for the maturing group (*see* curves C and E in Fig. 13). It must be emphasised here that ova less than 0·15 mm. in diameter have not been included in the data in proportion to their true numerical abundance, as the aim was to concentrate on the maturing group. This explains the fact that in some the first peak was seen at 0·045 mm. and in others at 0·120 mm. Within the maturing group of ova, those that were opaque and others that were in various stages of transparency showed different modal sizes. This can be interpreted as showing that the mackerel eggs are ripened and released in batches. But the possibility cannot be ruled out that after the first batch is shed, the others undergo degeneration. In some samples taken from certain regions of the ovary another peak was seen at 0·27 mm., but in all mackerel except one this was masked when the readings for all the three regions of the ovary were combined.

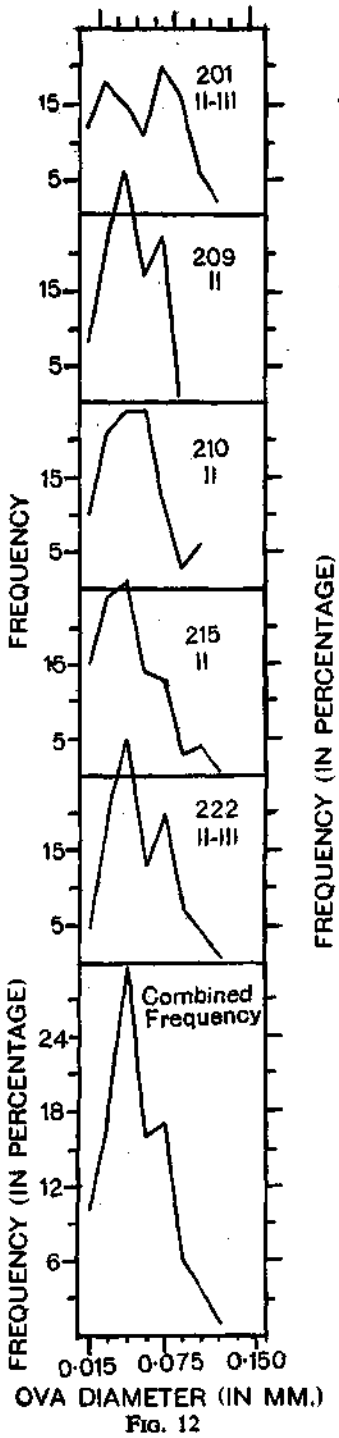

FIG. 12

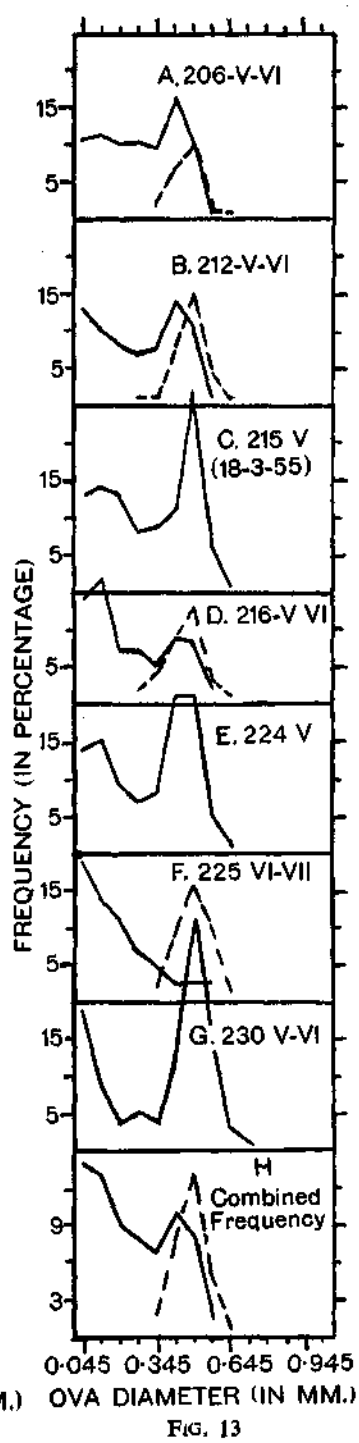

FIG. 13

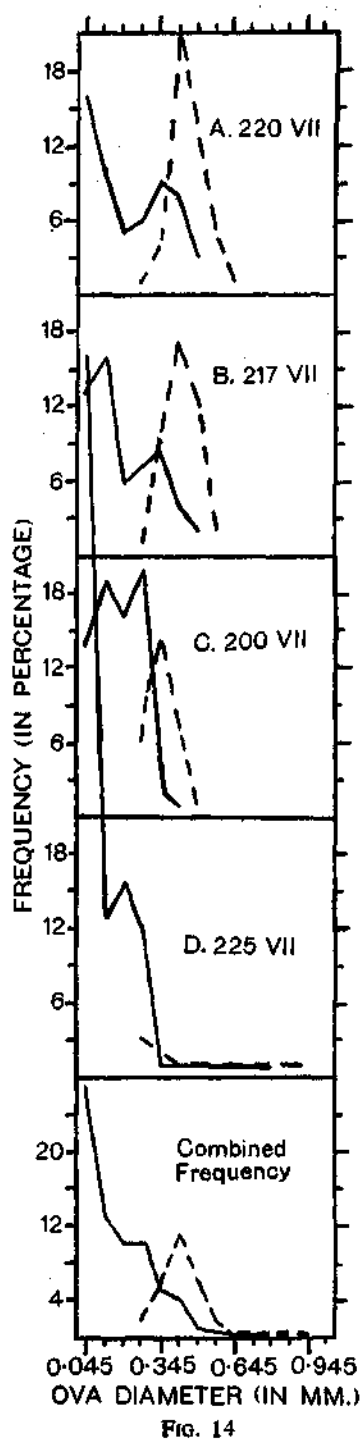

FIG. 14

A few partly and fully spent individuals were also collected in April 1956. The ova measurements of four fish of this stage are represented in Fig. 13. Those that were immature and opaque and the others that were transparent and undergoing degeneration were recorded separately. In Fig. 13, the curves A, B and C are for partly spent specimens. It will be seen that as spawning nears completion, the mode for opaque ova instead of remaining at the same point shifts towards the left. Only future studies will show whether this group ripens during the same season or undergoes degeneration.

It has been generally held that in the Indian mackerel, as in the Atlantic species *Scomber scombrus*, ova are ripened and released in batches. No convincing proof has hitherto been adduced in support of this view. The present investigation has served only to show that the occurrence of such a phenomenon in the Indian mackerel is a possibility. It is evident that the question can be settled only after the ovaries of the May-September period are examined in detail.

Devanesan and John (1940) have given an account of what they believed to be mackerel eggs; but neither detailed descriptions nor figures have been published.

Discussion

A critical study of the catch statistics would seem to reveal that the rates of increase and decrease in production during the October–January period are probably too great to be accounted for by the growth of the fish or by changes in fishing intensity. In effect, there appears to be a rather sudden rise followed by an equally sudden fall in the abundance of the exploitable stock in the coastal waters during the main part of the season. It may be suggested therefore that the fishery north of Mangalore is based on a population which touches the coastal waters in the course of its seasonal movements. Panikkar (1952), referring to the fishery of the whole West Coast, states that "both sardines and mackerel appear earlier in the south and slowly extend northwards and their disappearance from north to south also follows a similar pattern". In this context, the secondary peak in the yield of the coastal fishery noted during the February–April period will be of some interest, although the abundance of mackerel at this time seldom attains the earlier level. The full significance of this trend, however, might not become apparent until at least the salient features of the life-history of mackerel are understood; it is also essential to analyse these data in relation to what happens on other sections of the coast. Only an integrated programme covering the entire West Coast would show whether the secondary peak in production in the South Kanara District is only a phenomenon of local significance

affecting small local groups or whether it portrays the normal character of the movement of the main body of a population.

As the stock maintains a high level of abundance only for a short while, a full exploitation policy demands the application of the maximum fishing pressure, at that time, at least in the coastal waters. On this point, if not on any other, the wisdom of the social ban on night fishing and on the use of other gear may be questioned. Little evidence is forthcoming at present which would show that mackerel do not enter coastal waters at night or that they would react adversely to night operations. On the contrary, Rounsefell and Everhart (1953) state that many species of fishes approach the coastal waters at night. Moreover, in the North Kanara and Ratnagiri Districts there is no social ban on night operations by *Rampanis*, and good catches are landed not only during daytime but also at night. Hence there is reason to believe that the *Rampanis* of the South Kanara District at present take only about 50% of their potential catch. Probably, this traditionally imposed restriction had an economic aspect as well. In the former days, disposal was a problem because of difficulties of transport, and an unmanageable catch could easily have resulted in a glut in the market. To a certain extent these conditions exist even now.

As prosecuted at present, the fishery seems to be concentrated on one-year-old mackerel both in the West Hill and in the Malpe areas. But there is practically no coastal fishery in Malabar and South Kanara, south of Mangalore, at least of the type that obtains north of Mangalore where mackerel congregate in dense shoals. The reasons for this have probably to be sought in the differences of the environment, unless it is held that mackerel occurring at these places belong to different populations with different habits. The sea off Malpe is 3–4 fathoms deep at less than a mile from the shore; off West Hill the 3–4 fathom line is more than 2 miles offshore. Fleming (1948) observed that a classification of nearshore environments has to take into account, among other things, the type of coastline. According to him, " one author recognises eleven major types (of coastline) ranging from steep mountainous areas to river deltas and coral reefs. The reason for emphasising the type of coastline is that it makes it possible to estimate many of the physical features of the regions from land maps and charts. These will not only be the general sub-surface terrain but also the type of bottom, the amount of local run-off, the probable amount of suspended material and its character, exposure to storms, and the type of current". The coastal region north of Mangalore is featured by mountainous tracts; added to this is the large number of rivers that cut up the coastline.

The fact that the fishery is supported mainly by a single age-group cannot be explained in terms of selective action of the gear, at least as far as the *Rompanis* are concerned. These nets touch the bottom of the area fished, and their catches include young forms of other species measuring 3–4 cm. and even less; similarly, larger specimens having a length of 100 cm. or even more have also been recorded from their catches. As there is little intermingling of the age-groups within the range of waters fished during the months October–March, the average catch-per-unit-of-effort of a season would perhaps form an index of the relative numerical strength of the year-class concerned. But the availability of the fish in the normal fishing grounds, especially in those situated very near the shore, might be limited by a number of factors. Hence, estimates of the relative numerical abundance of year-classes based on the statistics of the coastal fishery, are, as likely as not, to be correct. On the other hand, the more offshore fishery off Malabar which samples the population more evenly might yield useful data on this point.

It has been shown above that at the time they first spawn, mackerel are about two years old. Since the industry is at present rarely supported by mackerel when they are actively breeding, there is little information on the age-composition of spawning shoals, so essential in understanding the dynamics of recruitment. This is also closely linked with the question of the total life-span of the species, but as has been pointed out earlier, the total life-span cannot be determined from an analysis of the size-composition of the catches, unless it can be assumed that a very high mortality rate occurs after spawning. However, the possibility of the existence, in the population, of older age-groups, at least in depleted strength, cannot be excluded. In that case, the appearance of one-year-olds in the fishery will have to be regarded as a differential migration.

Normally, it is possible to recognise, even in July, the particular age-group that would dominate the catches from October onwards; but the landings during the period July–August are usually very poor. The shoaling of the main body of the year-class concerned, near the coastline, occurs at a time when there is rich plankton production (Panikkar, 1952 and Bhimachar & George, 1952).

That the mackerel is essentially a plankton feeder has been established by many workers. Bhimachar and George (1952) observed that on an average, about 50% of the food of mackerel consists of copepods, the other major elements being Cladocerans, Decapods and some items of phytoplankton. Chidambaram *et al.* (1952) have also observed that mackerel feed mainly on plankton (*see* also Pradhan, 1956). As regards the intensity of

feeding, there are roughly two maxima (Chidambaram *et al.*, 1952; Bhimachar & George, 1952): one occurring during the September-December period and the other during February–May.

According to Chidambaram and Menon (1945) the total fish production in the West Hill area is directly proportional to the quantity of plankton. George (1953) demarcates plankton species into edible and non-edible forms and shows that the edible fraction is highest from September–December (*i.e.*, the period of the first peak in the feeding intensity of mackerel) and he correlates this with the main pelagic fisheries of the area. The fat content of mackerel with reference to its periodic variations has been studied by Chidambaram *et al.* (1952). Their data indicate that there are two peaks of fat formation in a year—the first in October–November and the other during the March–April period. They attribute this to feeding activity.

There is thus strong evidence in favour of correlating the mackerel fishery of the West Coast with plankton production. But this relation does not become very apparent when the rate of growth of the fish is taken into account. As has been mentioned before, the growth of the commercial age-group during the October-December period appears to be very slow, despite the fact that feeding activity and the edible fraction of plankton are at their maximum level at this time. It can readily be admitted that the increase in length of the fish might be dependent on other factors as well. Nevertheless, if the amount of food taken is any criterion, it would appear that mackerel grow too slowly during the period of October-December. The peak in fat formation noted at this time confirms this point. Again, Bhimachar & George (1952) have mentioned the fact that the food of the 0-year-class does not differ radically from that of the mackerel of the commercial age-group. Yet, the 0-year-class is practically absent from the landings at a time when plankton of the coastal waters is richest in edible forms. Therefore, the question, whether the concentration of mackerel in the inshore waters is entirely a direct response to plankton production, still remains to be verified.

SUMMARY

1. The paper deals with the coastal fishery of the region between Baikampady and Tarapathy in the South Kanara District. Special reference is made to the Malpe sector, where detailed observations were conducted during the 1954–55 and 1955–56 seasons.

2. The *Rampani* net whose operational range is 1–1½ miles from shore is the main gear employed. Details are given regarding the centres of fishing, manpower and the number of nets employed.

3. Mackerel gave an exceptionally poor yield during the 1954–55 season. This is indicated by the catch statistics relating to a 12-year period beginning from 1944–45.

4. Normally, there are two peaks of production, the first in October–November and the other during the February–March period. Sometimes deviations from this trend occur.

5. As the *Rampani* nets of the South Kanara District are not operated at night, it is probable that they take only about 50% of a potential catch at present.

6. The normal modal size of one-year-old mackerel appears to be 12–15 cm. At the end of the second year of their life, the fish probably measure 21–23 cm. The possibility is indicated that the population contains other age-groups as well. The length-frequency studies do not, however, reveal the total life-span of the species.

7. The fishery off West Hill and Malpe appears to be concentrated on one-year-olds (*i.e.*, mackerel in the second year of their life). Catch statistics show that the stock that supports the fishery touches the coastal waters only for a short period while in the course of its seasonal movements.

8. At the time of first spawning, mackerel are about two years old. Spawning starts in April.

9. At the time when the mackerel shoal in coastal waters plankton is rich with edible forms. There is, however, reason to believe that the coastward movement of the fish may not entirely be a direct response to plankton production.

Acknowledgments

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Explanation of Figures

Fig. 1. Percentage deviation of monthly catch-per-man-hour from the average catch-per-man-hour of the season.

Fig. 2. Size-composition of mackerel catches in 1954–55. (The figures in brackets indicate the number of fish examined.)

Fig. 3. Size-composition of mackerel catches in 1955–56. (The figures in brackets indicate the number of fish examined.)

Fig. 4. Length-frequency of mackerel in the West Hill area in 1934–35.

Fig. 5. Length-frequency of mackerel in the West Hill area in 1935–36.

Fig. 6. Length-frequency of mackerel in the West Hill area in 1936–37.

Fig. 7. Length-frequency of mackerel in the West Hill area in 1937–38.

Fig. 8. Length-frequency of mackerel in the West Hill area in 1938–39.

Fig. 9. Length-frequency of mackerel in the West Hill area in 1939–40.

Fig. 10. Length-frequency of mackerel in the West Hill area in 1940–41.

Fig. 11. Length-frequency of mackerel collected during the period, May-July 1954, from Vizagapatam.

Figs. 12–14. Fig. 12. Ova diameter frequency of makerel in stages II and III (collected in December 1955). Fig. 13. Ova diameter frequency of mature mackerel (all except C collected in April 1956). In Curves A, B, D, F and H the continuous line represents the group of immature and opaque ova and the broken line, the ova that were in various stages of transparency. Fig. 14. Ova diameter frequency of spent fish. The continuous line represents the immature and opaque ova and the broken line, ova that were either degenerating or in various stages of transparency. (The total length of mackerel and the maturity stage are given with reference to each curve.)

APPENDIX I

Months when peak catches were landed by some of the gear operated for mackerel on the West Coast of Madras State (Malabar and South Kanara) during the seasons 1936-37 *to* 1949–50 (*Based on Chacko,* 1954 *and* 1955)

Name of net seasons	1936–37	1937–38	1938–39	1939–40	1940–41	1941–42	1942–43	1943–44	1944–45	1945–46	1946–47	1947–48	1948–49	1949–50
Ailakkollivala	Dec.	..	Aug. Nov. Apr.	Dec. Feb.	Nov. Jan. Apr.	Nov. Feb. Apr.	Oct. Dec. Jan. Mar.	Dec.	Nov.	Oct. Feb. May	Dec. Mar.	..	Dec. Apr.	Oct. Mar
Ailavala	..	..	Nov. Apr.	Oct. Apr.	Nov. Jan. Mar.	Sep. Dec. Feb.	Oct. Dec. Mar.	Oct. Dec.	Sep.? Dec.	Oct. Feb.	Jan. Mar.	Sep. Nov. Jan. Mar.	Oct. Jan.	Oct. Jan.
Ailachalavala	Jan.	..	Oct. Jan.	..	Dec. Apr.	Oct. Mar.	Jan. May	Oct. Dec. Apr.	Oct.	Dec. Feb.	Sep. (catches very poor)	Sep.	Apr.	catches very poor

'*Aila*' is the Malayalam name for mackerel; '*vala*' means net. See Chacko (1954 and 1955) for further information regarding the types to which these nets conform and the area of their operations.

FIG. 1. Ovary of mackerel in Stages V–VI.

FIG. 2. Magnified view of the portion between the dotted lines in Fig. 1.

APPENDIX II

Total mackerel catches of the two periods September–December and January–April on the West Coast of the Madras State during the seasons 1944–45 *to* 1947–48 (*Based on Chacko,* 1954 *and* 1955)

Periods Seasons	September–December	January–April
	maunds*	maunds
1944–45 ..	1,169,053	429,375
1945–46 ..	1,955,287	1,256,358
1946–47 ..	1,248,798	1,369,150
1947–48 ..	597,716	227,408

* 27·22 Maunds = 1 ton.