

MACKEREL FISHERY OF KARWAR

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I. INTRODUCTION

KARWAR (Lat. 14° 50' N and Long. 74° 03' E, North Kanara, Bombay State) is one of the major mackerel fishing centres of India. The Kanara Coast, which is 76 miles long, runs in a straight line except for the shallow Karwar and Belikeri bays in the north. The coast-line extending from Majali, on the southern boundary of Goa to Bhatkal, the southernmost limit of Bombay State, is of a varied character with rocky islands and capes, stretches of sandy beach and narrow river mouths. There are no major rivers opening into the sea on the Kanara Coast, but there are four main streams, Kalinadi

or Sadashivgad river about 4 miles from the extreme north; Gangavali or Bedti river 20 miles to the south of Kalinadi; the Tadri or Mirjan river 6 miles to the south of Gangavali, and the Sharavati or Gersappa river about 16 miles to the south of Tadri. The mouths of these rivers are generally narrow and barred with sand, but they are spread into wide estuaries and form navigable tidal rivers for 12 to 20 miles from the river mouth. The northern half of the coast-line extending from Majali to Gangavali has shallow inshore waters, where shoaling fishes like the mackerel and the sardines congregate. The southern half from Gangavali to Bhatkal is surf-beaten, rocky and with deep inshore waters.

Topography of Karwar

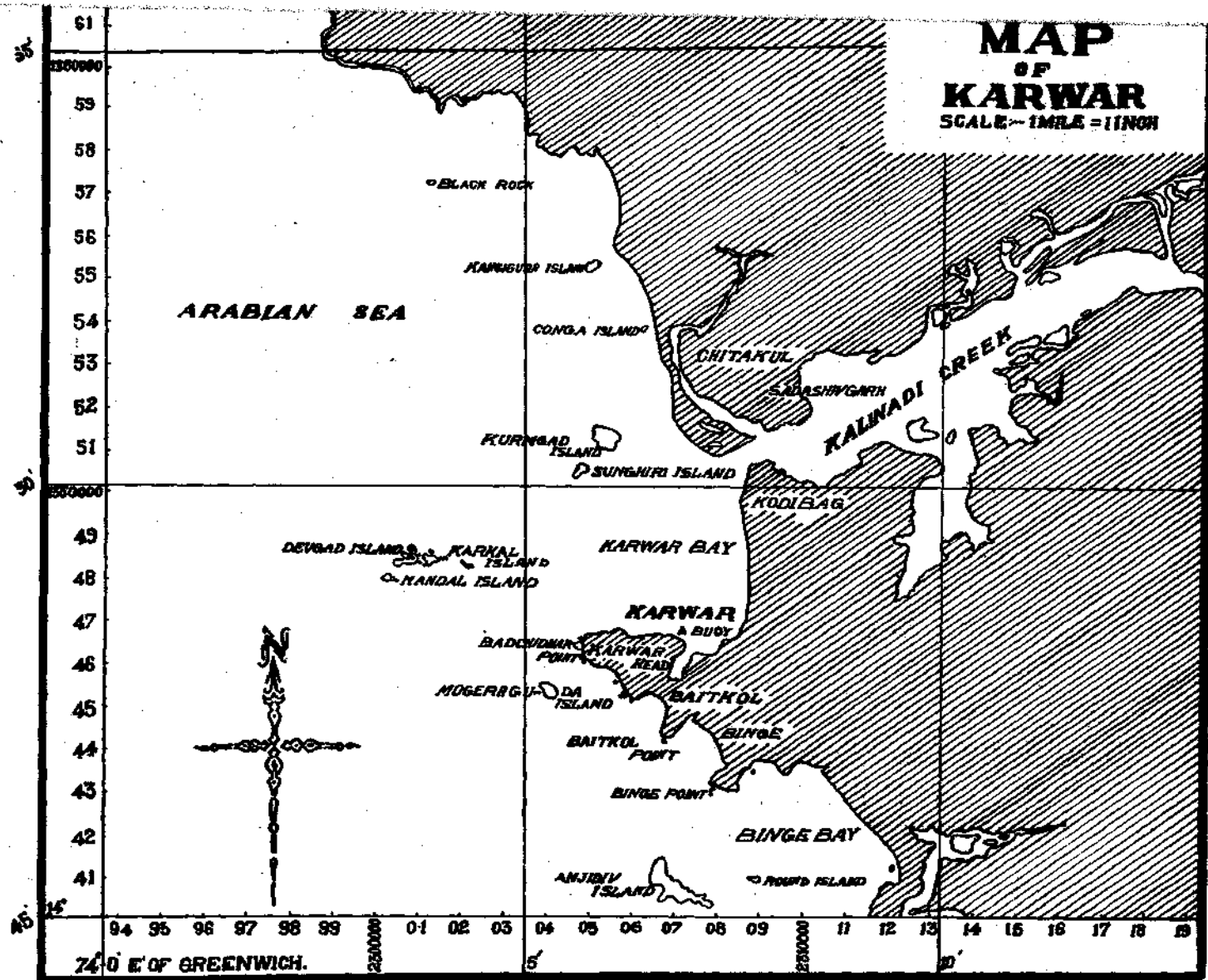
The Karwar Bay, 7 miles long and 2 miles broad, extends from the steep woody rock of Liolola in Goa, 300 feet high, to the Karwar Head with a height of 650 feet. An extension of Karwar Bay between the Karwar Head and the mainland is known as Baitkol Cove, one-fourth of which is exposed at low tide. There is a cluster of islands in the Karwar Bay, the largest of these being known as Deogad Island, on which is situated the Oyster Rocks light-house. This island is $4\frac{1}{2}$ miles from the Karwar beach and 218 feet above the sea-level. The other two islands to the north-east of Deogad Island are Sunghiri or Madlingad and Kurumgad, about 120 and 180 feet respectively above the sea-level. The depth of water at Baitkol Cove at high tide is about 2 to 3 fathoms and that at the buoy about 33 feet (*vide* Map). The depth at anchorage, about $1\frac{1}{2}$ miles from the shore, is about 6 fathoms at low tide and $6\frac{1}{2}$ fathoms at high tide. Around the Deogad Island, it varies from 7 to 10 fathoms. The depth of the jetty is about 15 feet at high tide. The sea-bed up to about 2 miles from the shore is sandy and further up to Deogad Island and beyond it, is muddy. The Karwar Beach is about 3 miles long extending from the mouth of the Kali River to Coney port light.

Meteorological and hydrological conditions

The meteorological and hydrological conditions in the Karwar harbour during the seasons 1948-49 to 1952-53 are shown in Table I. The salinity of the harbour waters is subject to marked fluctuations due to the influx of fresh-water from the Kali River. During the rainy season low salinity, even down to 2.04‰, has been noted. The current in Karwar waters is feeble. Latham describes it as "a sluggish surface current with a velocity of half a mile and not forming any part of any main periodical currents outside the bar".

Fishing grounds

The 100-fathom line is about 45 miles off the Kanara Coast. The fishing grounds exploited at present cover an area of about 800 square miles, and the catch per square mile on the basis of total annual landing of all



Adapted from Survey Map of India

TABLE I

General Meteorological and Hydrological Conditions in Karwar Harbour Area during the Mackerel Seasons—1948-52

Month	Temperature of sea-water °C.		Salinity of sea-water ‰		Temperature of air °F.		Barometer reading in inches		Direction of wind and force of wind
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
October ..	26	28	23.2	37.8	78	90	29.81	29.94	E. N. NW. W.
November ..	26	29	31.7	38.0	78	92	29.80	29.94	E. N. NW. W. NE. SE. SW.
December ..	25	29	34.6	38.7	72	90	29.84	30.6	E. N. NW.
January ..	28	30	35.2	38.4	74	92	29.84	30.6	E. N. NW. NE.
February ..	28	30	35.2	40.8	72	90	29.84	30.4	E. N. NW. W.
March ..	27	28	35.3	37.9	78	92	29.83	29.94	E. N. NW. W. Light to moderate

types of fishes in the district, works out to about 22.5 tons. At Karwar, fishing is carried out usually within 10 miles from the shore and in 1 to 10 fathoms of water. During the mackerel season, lasting from October to February, fishing operations are restricted to within a range of about 1½ miles from the shore. From April onwards to the commencement of the rainy season in June, wider and distant fishing grounds are exploited. In the rainy season, however, mackerel are occasionally caught very close to the shore in 2 to 3 fathoms of water. The chief mackerel fishing centres of Kanara District are Majali, Karwar, Binge, Sankarubag, Chendia, Kodar, Bellikeri, Bellambar, Kumta, Honavar, Murdeshwar, Shirali and Bhatkal. The fish curing yards attached to important fishing centres are at Majali, Karwar, Binge, Sankarubag, Chendia, Kodar, Harwada, Keni, Gangavali, Kumta, Mullukurva, Manki, Murdeshwar, Shirali and Bhatkal.

Fishing season

The mackerel season at Karwar and along the Kanara Coast is from October to February and may, at times, extend to March. The mackerel shoals subsequently break up, resulting in poor catches in April, and practically disappear from the shores of Karwar during May. In the rainy season, June to end of September, they are occasionally caught in small numbers in inshore waters within a range of about half a mile from the shore.

Magnitude of Fishing Industry

In 1933, Sorley estimated a total catch of 7,775 tons of sea-fish for the Kanara District. During the last 22 years there has occurred a marked improvement in the fish trade in general, and by about 1952, the total fish landings in the district approximated to 18,000 tons valued at Rs. 40,00,000. Mackerel alone contribute more than two-thirds of the total landings of fish in the district, the average annual catch of mackerel being 13,000 tons. About 90,000 maunds (27 Bengal maunds—1 ton) of salted mackerel, worth Rs. 4,50,000, are exported annually from the Kanara District.

The mackerel fishery of Karwar alone accounts for an average annual output of 1,500 tons, valued at Rs. 2,25,000. It is estimated that about 7,000 maunds of common salt are utilized for curing mackerel during the season. The export value of both wet unprocessed mackerel and the cured product may roughly be computed as Rs. 2,75,000. Of this, 25,000 maunds of cured mackerel worth Rs. 1,50,000 are exported annually from Karwar.

There are 8 *Rampan* nets at Karwar and 600 fishermen are engaged in *Rampan* operations. The earnings of each fisherman during the season vary between Rs. 300 and 350. In the fish curing yard, 50 to 75 fisher-women are engaged either on daily wages or on piece-work basis, each woman earning about Rs. 125 to 175 in the mackerel season.

In the Karwar fish market, about 80 to 83 tons of wet unprocessed mackerel are sold during the season. The daily average consumption of fresh mackerel at Karwar may roughly be computed as about 5,500.

II. FISHING METHODS

The types of boats and nets used in mackerel fishery at Karwar and other fishing centres in North Kanara District are:—

Boats

These are of outrigger type and of two sizes, namely the *Pandi* or *Rampan* boat and the *Doni*.

Pandi.—This is used for carrying only the *Rampan* net and is manned by a crew of 16 to 20. This type of boat is propelled with oars only. Its size is 45×10×4 feet. Approximate cost Rs. 1,500. There are 16 boats of this type at Karwar.

Doni.—This is a smaller boat used as a scout boat for sighting mackerel shoals or for removing mackerel from an impounded area. It is manned by a crew of 6 to 8 and propelled with both oars and sail. Its size is 24×3×2 feet. Approximate cost Rs. 500. These number 40.

Nets

These are chiefly of three types, namely, the shore-seine *Rampan* net, the *Payawada* or *Yendi*, the gill-net *Pattebale* or *Bangada jal*, and the cast net *Pag*.

(i) Fishing by *Rampan* net

The shore seine is one of the oldest nets in operation on the west coast of India. But about 80 to 85 years ago, it is believed, a Portuguese priest called Father Rampani or Rampini introduced into South Kanara a very large shore-seine capable of encompassing large shoals of fish in inshore waters, and this net has been named after him. It was introduced at Chendia and Binge by about 1926 and two years later in Karwar waters. This net is operated at Karwar exclusively for catching shoaling fishes like mackerel and sardines.

The net, made of hemp or cotton, consists of a number of pieces joined end to end. The number of these pieces varies from place to place. In Karwar and other neighbouring fishing villages the net consists of 400 to 600 pieces, while in the southern half of the district the number is reduced to 100 to 200. In a *Rampan* net, two parts can be distinguished. The central part is called *Chikkanbale* or *Mand* and the side pieces *Allibale* or *Shellabale*. In a net of 500 pieces, there are about 100 pieces as *Chikkanbale* and 200 as *Allibales* on either side. The dimensions are:

Chikkanbale— $6 \times 35' \frac{1}{2}''$; *Allibale*— $16 \times 37' \frac{1}{4}'' - 1 \frac{1}{2}''$. The end pieces, where the hauling ropes are attached, measure $16 \times 16' \frac{1}{4}'' - 1 \frac{1}{2}''$. The average area per piece of *Rampan* net is 324 square feet.

Cost.—A net consisting of 500 pieces of cotton or hemp Rs. 37,000; of coir ropes, Rs. 10,000.

A complete set, consisting of 2 *pandi*, 4 *doni* and a *Rampan* net of 500 pieces, including coir ropes, would now cost Rs. 55,000.

Mode of operation.—A full complement of requirements for fishing with a *Rampan* net consists of 60 to 80 men, one *Pandi* for carrying *Rampan* net, 3 or 4 *Doni*, one of which is used as a scout boat, and the net comprising 400 to 600 pieces. The net is piled in 'V' layers in the *Pandi* which is kept ready in shallow water of a depth of 3 to 4 feet. As soon as the mackerel shoal is sighted by the crew of the scout boat, stationed at distance of 2 or 3 miles from the shore, the fishermen waiting on the shore are alerted by a signal indicating the direction in which the shoals are moving. The shore staff of about 16 to 20 men at once put out to sea in the *doni* and board the mother boat or *Pandi*. The free end of lead rope is then taken to the shore in a sister boat, and *Pandi* is rowed out to sea in a direction perpendicular to the shore. As it proceeds, the rope is paid out, and, on reaching the other end of the rope, the boat is steered in a semicircle. The free end of the lead rope, which was taken to the shore at the commencement of the operation, is taken in hand and some 20 to 25 men, depending on the size of the net, start pulling the rope to the shore. This preliminary dragging of the first rope is necessary to keep the net open and stretched breadth-wise, as there is every chance of the net rolling upon itself which would allow the entire shoal of fish

to escape. The *Pandi* completes a semicircle by the time the whole net is paid and it is now steered towards the shore in a line parallel to the first lead rope. It comes very close to the shore and after the lead rope at the other end of the net is handed over to another batch of fishermen stationed there, the *Pandi* is rowed in a reverse direction and is anchored at the centre of the circumscribed net (Fig. 1). The net is then dragged shorewards.

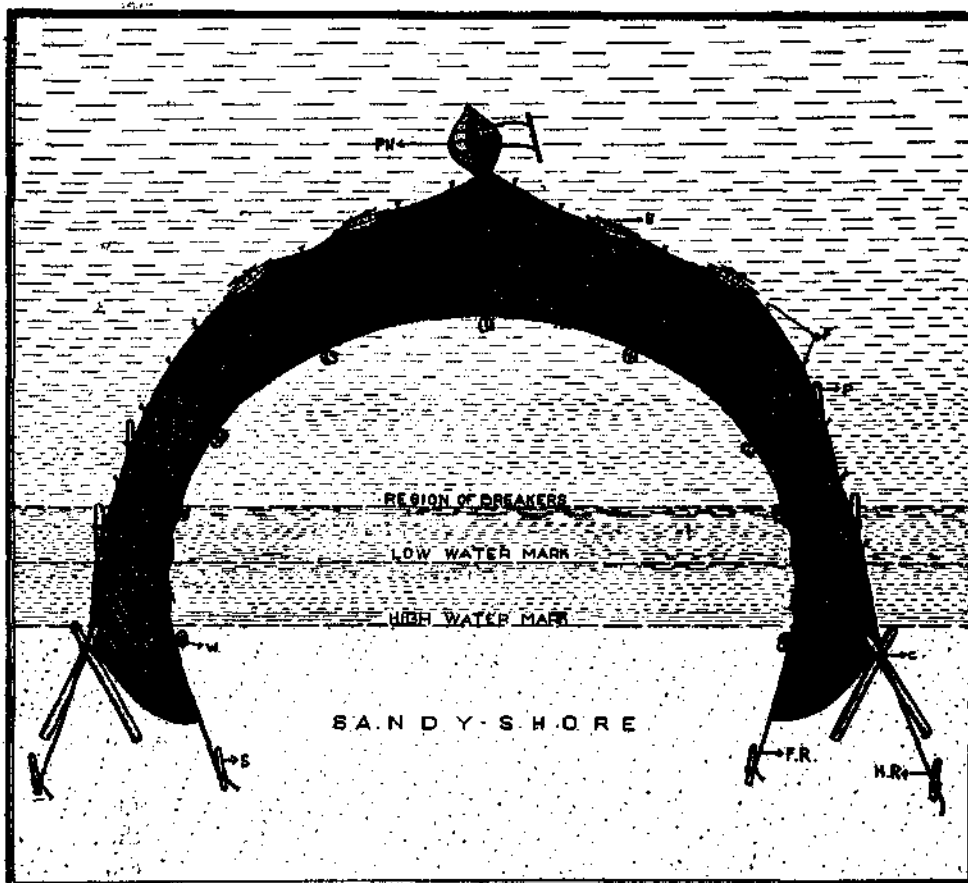


FIG. 1. Impounding of Mackerel Shoals with *Rampan* Net.

B, Boat; C, Crutch; F, Floats; F.R., Foot-rope; H.R., Head-rope; P, Pole; PN, Pandi; S, Stake; W, Weight.

The dragging of the net is done by a team of 25 to 30 men on each side, arranged in pairs one behind the other. As the net portion comes out of water, it is rolled around the lead rope and the drag poles are lashed to the rolled-up portion of the net. The men at both ends gradually approach each other as the dragging operations continue, and, when the two ends are some 500 to 600 feet apart, dragging is stopped and the net tethered, pending the arrival of fish carrier

launches from Bombay or the settlement of price of the fish and completion of the sale transactions.

Tethering or impounding by Rampan net.—This is a very ingenious method devised by local fishermen to keep fish alive even up to eight days after they are caught, to meet the preference shown for fresh mackerel, for which the owners of fish transport launches are able to offer higher prices. The practice of impounding the mackerel, and loading the fish directly into launches, came into vogue by about 1940. Prior to this the *Rampan* net was completely hauled out of water and the entire catch heaped on the sandy shore and auctioned. The operations for impounding the fish are briefly described below:—

As stated above, the dragging of the net ashore is stopped when the two ends are some 500 to 600 feet apart. The head-rope is raised up to a height of 4 or 5 feet by means of crutches fixed in the sand beyond the high water-mark (Fig. 1). That part of the net lying submerged within the range of breakers is tied on each side to 5 or 6 poles driven firmly in the ground. The head-rope is tied to the poles in such a way that it always remains above the level of water even during the highest tide. The head-rope beyond the range of breakers is tied to the prows of 5 or 6 *Donies* anchored at regular intervals on either side of the *Pandi*, which usually occupies a central position. The foot-rope, where the waves break, is weighted down with heavy stones to prevent the rolling of net, as it is not tied to poles like the head-ropes. Beyond the breakers, the foot-rope is suspended to trail on the ground. The free ends of the head- and foot-ropes on each side are tied to stout stakes driven firmly in dry sand, the foot-rope taken 2 or 3 feet on the inner side of the circle making a portion of the net trail on the ground. The extra pieces of net beyond the stakes are disconnected, dried or, if necessary, mended.

Removal of Mackerel from impounded area.—For removing mackerel from the impounded area, a small shore seine, the *Yendi*, is employed. This is plied within the circumference of the *Rampan* net and, like the latter, is hauled towards the shore but not completely pulled out of the water. Some 4 or 5 men on each side come closer to form a circle and, when the foot-ropes of both ends overlap, they are lifted up to make an artificial bag, as in a purse-seine net. Thus, a part of the catch is separated from the entire impounded stock and emptied into a small boat lying close by. The process is repeated till the boat is filled up and the fish are taken either to the launches or to the fish-curing yards.

It may be mentioned here that the impounding of mackerel causes at times a high mortality of the fish captured due to their struggle to escape or to asphyxiation from overcrowding. The rate of mortality for impounded mackerel is usually 2 to 4% but may be even as high as 12% when an unusually large stock of mackerel is impounded.

(i) *Payawada or Yendi*

The net consists of 50 to 60 pieces, each piece measuring $13 \times 13\frac{1}{4}$ " and costing Rs. 26 when made of hemp. It is operated within a range of 2 furlongs

from the shore, during the rainy season (from June to end of September), and also after the mackerel season (March to May). About 8 to 12 men are required to operate this net. The same net is also used in combination with the *Rampan* net for removing a part of the catch from the impounded area.

(ii) *Pattebole or Bangada Jal*

The total number of pieces in this gill-net varies from 20 to 30, each piece measuring $25 \times 26'$ - $27'/1\frac{1}{2}''$ - $1\frac{3}{4}''$ and costing Rs. 50 if made of cotton. It is used for catching mackerel from March to May.

(iii) *Pag*

This net is of various sizes and is operated practically all the year round. Mackerel are usually caught in this net during the months, March to May. Cost of a large net, $14' \times 36'$, is Rs. 175.

III. METHODS OF CURING

The salt used in curing fish in this district is from the Sanikatta salt pans situated about 30 miles south of Karwar. It is of muddy colour but has good preservative property and contains about 95% sodium chloride with traces of magnesium and calcium chloride.

The various processes of curing mackerel, with the required proportion of salt, are given below:—

1. *Wet Process or Ratnagiri Method*

Proportion of salt.—One part of salt to three parts of fish.

In this process the loss in weight is about 25%. One maund of wet cured mackerel would comprise 550 in number as against 400 before curing. Mackerel, cured by this process, can remain in good condition for 4 to 6 months, depending on the humidity and atmospheric temperature of the place. In coastal places, on account of excessive moisture content in the atmosphere, the fish spoils sooner.

2. *Dry Process*

(i) *Mackerel slit on the abdomen, gutted and gills removed*

Proportion of salt.—One part of salt to five parts of fish. One maund of 'dry cured' mackerel would number 800 to 900. Mackerel cured by this process can remain in good condition for about three months. Those, cured during the first half of the season, remain in good condition at the most for three months on account of their high fat content. Mackerels, cured late in January or February, last longer, up to six months, till the commencement of the next season.

(ii) *Mona process—Pulling out guts and gills through the mouth*

Proportion of salt.—One part of salt to five parts of fish. One maund of dry 'mona' mackerel would number 980 to 1,000.

Mackerel cured by this process remain in good condition for about three months.

(iii) *Dry process—Fish slit on abdomen, and viscera removed*

Proportion of salt.—One part of salt to nine parts of fish.

Mackerel cured by this process can remain in good condition for 3 to 4 months.

3. *Tamarind Process or Colombo Method*

Proportion of salt.—One maund of salt (Bengal maund) to three maunds of mackerel. Turmeric powder 1/8 lb.; Tamarind (Korka), 5 lb.

This type of curing is common at Bhatkal. Mackerel, cured by this process, can be kept in good condition for about a year.

IV. DISPOSAL OF CATCH, DISTRIBUTION AND MARKETING

Although large quantities of mackerel are landed every year at Karwar and other fishing centres, only a small fraction of the catch is consumed in the fresh state. Mackerel is a fish that taints rapidly and has to be preserved in ice until it reaches the distributing centres in inland places. In the whole of Kanara District there are only three ice factories, each of 2 tons production capacity. These are located to the south of Karwar at Chendiye, Ankola and Kumta, at a distance of 5, 20 and 40 miles respectively. The ice supply is inadequate and, with the existing transport facilities, fresh fish cannot be supplied to distant areas. During the season, about 100 tons of wet unprocessed mackerel in ice are supplied to inland places within a radius of about 150 miles. The Fisheries Department of Bombay State, in 1936, introduced, as an experimental measure, fish carrier launches for quick transport of fish from distant fishing areas, along the Konkan and Kanara coasts, to Bombay markets. The experiment proved a success and by 1950 there were 40 fish carrier launches plying between Bombay and Karwar. These bring from Bombay enough ice for the preservation of fish. Each launch carries 2 to 3 lakhs (18 to 27 tons) of mackerel. The quantity of mackerel brought to Bombay markets by these launches is shown in Table II. About 2,000 tons of wet mackerel are supplied to Bombay from Karwar and other neighbouring fishing villages. The bulk of the mackerel catch, about 60%, is cured by 'Wet' or 'Ratnagiri' process and exported to interior towns like Kolhapur, Belgaum, Satara, etc. In fact mackerel forms 80 to 90% of the total quantity of fish brought to the fish-curing yards in the districts. Large quantities of 'dry' cured mackerel are sent to Ratnagiri, Bombay, Malabar and Colombo. Mackerel cured by the 'Colombo' method is exported to Ceylon.

TABLE II

Quantity of Mackerel from Konkan and Kanara Coasts brought by fish carrier launches to Bombay Markets

(Figures quoted from the Reports of the Fisheries Department of Bombay State)

Year	Number of Fish Carrier Launches	Quantity of Mackerel (in lb.)
1936-37	3	2,34,411
1937-38	4	3,56,522
1938-39	9	12,22,303
1939-40	9	19,60,036
1940-41	9	15,27,037
1941-42	10	20,82,690
1942-43	8	27,08,171
1943-44	?	27,06,171
1944-45	11	10,85,282
1945-46	15	28,39,286
1946-47	23	30,08,764
1947-48	16	33,92,502
1948-49	40	55,64,283
1949-50	41	44,64,366
1950-51	40	60,87,996
1951-52	20	55,85,214
1952-53	18	47,73,405

Wholesale and Retail Price of Mackerel

The wholesale and retail price of wet unprocessed mackerel fluctuates markedly from month to month during the mackerel season. At the commencement of the fishing season, that is in October, the wholesale price of wet mackerel is usually Rs. 5 to 8 per thousand. This price rises steadily with the growing demand for fish both from the fish curers and the owners of fish carrier launches. If the fishing season is fairly good and the supplies are not too small, there is less competition among the fish curing merchants, who normally do not raise the wholesale price of mackerel above Rs. 20 to 30 per thousand. This price index remains steady for the next 2 or 3 months. It is only towards the close of the season when catches are poor that the price of mackerel occasionally rises again as high as Rs. 40 to 60 per thousand. In past years when the mackerel season had been of short duration and the landings poor as in 1949-50, the wholesale price of mackerel had shot up to Rs. 60 per thousand. The bidders were the owners of fish carrier launches who could afford to pay high prices at the

production centre and still sell the fish in the Bombay market with a fair margin of profit.

At the commencement of the season, the retail price of mackerel is 6 annas a dozen. During the peak period of fishing (December or January) mackerel are sold in Karwar market at 1 anna for 12 and very rarely, as in February 1952, at 1 anna per 24.

The wholesale price of mackerel, cured by the 'wet' process, is Rs. 15 to 20 per thousand during the season and that of 'dry cured' product Rs. 15 to 35 per thousand, depending on the current price of fresh mackerel in the market. The off-season retail price of dry cured mackerel is Rs. 2-8-0 to Rs. 3 per hundred.

V. MACKEREL FISHERY OF KARWAR: 1948-53

The general features of the fishery such as the duration of the season, the total landings, the dominant size classes and the monthly average lengths of mackerel during different months of the seasons, 1948-49 to 1952-53, are shown in Table III.

1948-49

The season was fairly good, but there were frequent interruptions attributed by the local fishermen to the unprecedented weather conditions like cyclones and heavy rains. Another noticeable feature was that comparatively large shoals of mackerel appeared in Malvan waters and more mackerel was exported to Bombay market from Malvan than from Karwar. Consequently large quantities of mackerel were cured at Karwar and the neighbouring fishing centres. The season ended abruptly by the end of February 1949.

1949-50

The *Rampan* fishing commenced in the first week of October 1949 and continued till the middle of January 1950, when the mackerel shoals practically disappeared from Karwar waters. The intensity of fishing was low and the local fishermen were confronted with the bleak prospect of a bad season. Actually, *Rampan* nets were operated along the Kanara Coast just for two months, October and November 1949. By about the middle of December, mackerel shoals disappeared from most of the fishing centres in the district. The weather too was unfavourable, for in the first half of January the sea was so rough, with the strong northerly winds sweeping over the harbour area, that fishing operations had to be suspended temporarily for about a fortnight. The shoals did not return to the Kanara during the season. The factors which affected the fishery in 1949-50 were: (1) rough sea and unfavourable weather conditions, particularly in the first week of January; (2) irregularity of the appearance of mackerel shoals in inshore waters and the gradual fall in their numbers; and (3) the sudden disappearance of shoals from Karwar waters. In that year too, comparatively large quantities of mackerel were supplied to Bombay market from Malvan.

1950-51

The salient features of this season were that it was fairly good, extending up to the 3rd week of March 1951, and the size of fish entering the fishery was comparatively large. The number of non-fishing days was small compared with the last two years, for the corresponding period.

1951-52

The season was characterised by the erratic appearance of shoals in inshore waters of Karwar. The total landings of mackerel by the end of December 1951 were far below the average, for the corresponding period of the previous year. This may be attributed to the small size of shoals entering harbour waters. The average catch per *Rampan* haul was 2,00,000 as against 3,00,000 to 4,00,000 (11,200 mackerel = 1 long ton) in the previous year. In the latter half of the season, particularly from the 3rd week of January to the middle of February, there was intensive fishing. In fact, the total quantity of mackerel landed during the season was better than in the previous season. Another notable feature was the appearance of medium-sized fish of 18 cm. to 20 cm. (total length) throughout the season. At Malvan, where the fishery flourished during the last two seasons, the fishes dwindled considerably, yielding only 9.4 tons during the season, October to December 1951.

1952-53

There was only one *Rampan* haul during October and a miscellaneous catch of small fish was landed. The intensity of fishing was the greatest during November, particularly in the 1st week, when on the same day 3 or 4 *Rampan* nets were operated simultaneously. In the succeeding months there was a gradual decline in the fishery, due to the erratic appearance of mackerel shoals.

Size-groups appearing at Karwar during different months of the year

October to March.—This is the mackerel season on the West Coast of India. At its beginning in October, mackerel ranging between 12 cm. and 24 cm. are caught in *Rampan* nets, the average size being from 17.5 cm. to 18.5 cm. This wide range in the length of fish in commercial catches is inconsistent with the range in a shoal and may be due to several mackerel shoals being encompassed in the same *Rampan* net. It has been observed that, in single mackerel shoal, the range of size is very small and the individuals collectively present a striking uniformity of size (Panikkar, 1952). The percentage of small-sized fish falls in November and by December mackerel below 16 cm. do not enter the fishery. In December and January the fishery is constituted by fishes of length 19.5 cm. to 20.5 cm. which form the dominant size-class, and towards the close of the season, in February or March, the fishery consists of 19.5 cm., 20.5 cm., 21.5 cm. or 22.5 cm., depending on the dominant size-class in these months.

TABLE III

Duration of mackerel season, the total landings during the seasons, the dominant size-groups and the monthly average length of Mackerel caught during 1948-49 to 1952-53 seasons

Mackerel season	Duration of Mackerel season		Total landing of Mackerel during the season (in tons)	Dominant size-groups and monthly average length of Mackerel caught during different months of the season		
	Beginning of season	End of season		Month	Dominant size-group	Monthly average length (T.L.)
1948-49	First week of October 1948	End of February 1949	1,726	October	..	..
				November	..	..
				December	20.5	20.67
				January	20.5	20.29
				February	20.5	19.77
				March	20.5	20.04
1949-50	First week of October 1949	Middle of January 1950	950.0	October	17.5	16.12
				November	19.5	18.95
				December	18.5	18.27
				January	19.5	19.60
				February	19.5	19.12
				March	19.5	19.60

1950-51	Middle of October 1950	Third week of March 1951	2,035	October	19-5	18-76
				November	20-5	19-83
				December	20-5	20-76
				January	21-5	21-10
				February	22-5	21-85
				March	22-5	22-20
1951-52	Third week of October 1951	First week of March 1952	2,250	October	19-5	19-01
				November	20-5	19-92
				December	20-5	20-18
				January	20-5	20-12
				February	20-5	20-46
				March	20-5	20-37
1952-53	Third week of October 1952	Middle of March 1953	1,125	October	17-5	18-57
				November	19-5	19-83
				December	19-5	19-89
				January	19-5	19-26
				February	19-5	19-51
				March	19-5	19-26

April and May.—By April, a further increase in size from 20 to 25 cm. is registered, although mackerel 19 cm. long are occasionally caught in small numbers. The percentage of large-sized fish (21 to 22 cm.) is comparatively high, as this group forms the dominant size-class of the month. In May, the mackerel shoals disappear from inshore waters and it becomes difficult to estimate the size-range in this month. It may be inferred from a few records of the occurrence of mackerel that the size-group in May is 19 to 24 cm., with a dominant size-class of 22.5 cm.

June to end of September.—This period coincides with the spawning season of mackerel, and occasionally, a small number is caught in inshore waters. The size-range during these months is 20 to 26 cm. In the first half of September, juvenile mackerel, ranging between 12 and 16 cm., are common and this group is succeeded immediately in October by a larger size-group.

The above account gives a general picture of the various size-groups of mackerel appearing in different months of the year and indicates the progressive growth in length from the fishing season, October to March, to the spawning period, June to September. But occasionally, some stray specimens of sizes other than normal are encountered in fishermen's catches. For example, on the 17th June 1949, two specimens, 8.3 and 9.5 cm. long, were recorded and on the 23rd August 1953, mackerel ranging between 13 and 17 cm., were caught in inshore waters of Karwar. On the 24th April 1953 mackerel measuring from 14.4 to 15.4 cm. and on the 28th of the same month, two specimens, 14.0 and 15.4 cm. long, were recorded for the first time from Karwar waters. On the 7th May 1953 also, 12 mackerel ranging from 17.2 to 18.8 cm., were secured from the catch.

In regard to the sizes of mackerel caught in the Arabian Sea, there appears to be a wide range in different localities. For example, mackerel caught off Porbandar were definitely large, the largest specimen measuring 27.7 cm. Mackerel of this size have not been recorded so far either from the Konkan, Kanara or Malabar coasts. The following information relates to mackerel obtained in offshore catches made by the Trawler *Taiyo Maru* No. 17 on February 22, 1952, off Porbandar. In Haul No. 19 there were 6 specimens varying in length from 22.1 to 27.7 cm. (total length) and the size-range of 18 mackerel, obtained in Haul No. 20, was 22.2 to 26.3 cm.

Length-frequency distribution of mackerel

As practically nothing is known of the mackerel population from which are drawn the commercial catches on the Kanara Coast, a study of the length-frequency distributions of mackerel during the successive seasons wa

undertaken. From a random sample from each *Rampan* haul, 100 fish were measured to find the length-frequency distribution during each month of the mackerel season. The length-frequencies for each month were calculated by summing up all the sample frequencies, and the resulting frequencies at each centimetre length interval were expressed as percentages to facilitate comparison (Table IV). On the basis of these figures the monthly graphs were drawn (Fig. 2). During the remaining months of the year, April to September, records of measurements were maintained and the appearance of size-groups and their fluctuations from year to year were noted (Table V).

During the mackerel season 1948-49, 4,023 mackerel were measured; in 1949-50, 3,116; in 1950-51, 10,088; in 1951-52, 8,794; and in 1952-53, 6,113.

For the 1948-49 season, data are available from December onwards. The dominant size-class during December 1948 was 20.5 cm. and this group persisted throughout the season till March 1949. The history of dominant classes in the preceding 2 months is, however, not known.

During the next mackerel season 1949-50, three dominant classes, namely, 17.5 cm.; 18.5 cm.; and 19.5 cm., constituted the fishery at various intervals. Of these, only the 19.5 cm. group persisted throughout the season, with the exception of October and December.

At the commencement of the 1950-51 season, that is, in October 1950, only one dominant size-group, 19.5 cm., entered the fishery. In November, the dominant size-group of October had increased to 20.5 cm. and disappeared from the fishery in December. The second group entered the fishery in November 1950 and the dominant size-class was then 17.5 cm. This increased to 20.5 cm. in December, 21.5 cm. in January 1951 and 22.5 cm. in February and March.

The season of 1951-52 showed less variation in the dominant size-classes from month to month. The dominant size in October 1951 was 19.5 cm. and it increased to 20.5 cm. in the following month and, thereafter, the same group persisted throughout the season.

The length-frequency distribution of mackerel during the season 1952-53 indicates that the dominant size-group in October was 17.5 cm. and this increased to 19.5 cm. in the next month, and that the same group persisted throughout the season till March 1953. The larger group 22.5 cm. which also entered the fishery in October, increased to 23.5 cm. in November and persisted in small numbers in December also. This group, however, disappeared from the fishery in the succeeding months of the mackerel season.

TABLE
Length-frequency distribution of Mackerel

Year	1949						1950					
Month	April	May	June	July	Aug.	Sept.	April	May	June	July	Aug.	Sept.
Size Range in cm. (T.L.)												
8- ..	..	..	1 (0.89)	..	..	..	..	..	..	..	..	..
9- ..	..	..	1 (0.89)	..	..	..	..	..	..	..	..	..
10- ..	..	..	..	..	..	..	..	..	..	..	..	..
11- ..	..	..	..	..	..	..	..	..	..	..	..	1 (0.90)
12- ..	..	..	..	..	..	..	..	..	..	..	..	1 (0.90)
13- ..	..	..	..	..	..	..	..	..	..	..	..	13 (11.81)
14- ..	..	..	..	..	..	32 (21.47)	..	..	..	..	..	25 (23.73)
15- ..	..	..	..	..	..	60 (40.26)	..	..	..	..	..	16 (14.54)
16- ..	..	..	..	..	..	..	..	..	..	..	..	29 (26.36)
17- ..	..	..	..	..	..	23 (15.43)	..	..	..	..	..	15 (13.63)
18- ..	..	..	..	..	..	..	..	..	..	..	..	..
19- ..	..	..	..	..	..	..	12 (2.36)	..	..	..	..	..
20- ..	13 (7.02)	..	..	8 (15.68)	7 (13.72)	8 (5.36)	90 (17.75)	..	..	..	2 (11.76)	..
21- ..	28 (15.13)	..	48 (42.85)	12 (23.52)	15 (29.41)	10 (6.71)	302 (59.56)	..	8 (40.00)	5 (38.46)	8 (47.05)	..
22- ..	112 (60.54)	..	62 (55.39)	10 (19.60)	18 (35.29)	12 (8.05)	65 (12.82)	..	12 (60.00)	8 (61.53)	7 (41.17)	6 (5.45)
23- ..	16 (8.64)	..	..	18 (35.29)	9 (17.64)	3 (2.01)	20 (3.94)	..	..	..	..	4 (3.63)
24- ..	10 (5.40)	..	..	3 (5.86)	2 (3.92)	1 (0.67)	14 (2.76)	..	..	..	..	..
25- ..	6 (3.24)	..	..	..	..	..	3 (0.59)	..	..	..	..	..
26- ..	..	..	..	..	..	..	1 (0.19)	..	..	..	..	..
Total	185 (99.97)	..	112 (100.20)	51 (99.97)	51 (99.99)	149 (99.96)	507 (99.97)	..	20 (100.00)	13 (99.99)	17 (99.96)	110 (99.84)

V

during other months of the year

1951						1952					
April	May	June	July	Aug.	Sept.	April	May	June	July	Aug.	Sept.
..
..
..	..	..	..	..	..	..	..	..	..	..	1
..	..	..	..	..	..	..	..	..	..	..	(0-15)
..	..	..	..	..	..	..	..	..	..	..	3
..	..	..	..	..	..	..	..	..	..	..	(0-45)
..	..	..	..	..	..	..	..	..	..	..	133
..	..	..	..	..	..	..	..	..	..	..	(19-94)
..	..	..	..	..	5	..	..	..	..	..	254
..	..	..	..	..	(2-31)	..	..	..	..	..	(33-34)
..	..	..	..	..	29	..	..	..	..	..	176
..	..	..	..	..	(13-42)	..	..	..	..	..	(26-50)
..	..	..	..	..	61	..	..	..	..	..	56
..	..	..	..	..	(38-24)	..	..	..	..	..	(8-46)
..	..	..	..	..	58	..	..	..	..	..	17
..	..	..	..	..	(25-92)	..	..	..	..	..	(2-67)
..	..	..	..	..	23	..	..	..	..	..	18
..	..	..	..	..	(10-64)	..	..	..	..	..	(2-73)
..	..	..	..	..	..	..	..	..	..	..	5
..	..	..	..	..	..	..	..	..	..	..	(0-75)
..	68	..	..	..	..	..	..	..	..	..	..
..	(17-39)	..	..	..	..	..	..	..	..	..	..
98	53	..	..	..	..	..	..	..	..	..	..
(13-00)	(13-55)	..	..	..	..	..	..	..	..	..	..
76	29	..	..	..	..	50	One spe.	..	..	..	..
(9-31)	(7-41)	..	..	..	..	(27-17)	(20-8)	..	..	..	..
401	128	..	47	39	24	80	..	..	..	..	..
(49-14)	(32-73)	..	(59-49)	(59-09)	(11-11)	(43-48)	..	..	..	..	..
193	63	..	32	27	18	36	..	..	..	..	..
(23-65)	(16-11)	..	(40-50)	(40-90)	(8-33)	(19-56)	..	..	..	..	..
40	43	..	..	..	..	18	..	..	..	..	..
(4-90)	(10-99)	..	..	..	..	(9-78)	..	..	..	..	..
8	7	..	..	..	..	..	..	..	..	..	..
(0-98)	(1-79)	..	..	..	..	..	..	..	..	..	..
..
816	391	..	79	66	218	184	..	..	..	..	862
(99-98)	(99-97)	..	(99-99)	(99-99)	(99-97)	(99-99)	..	..	..	..	(99-99)

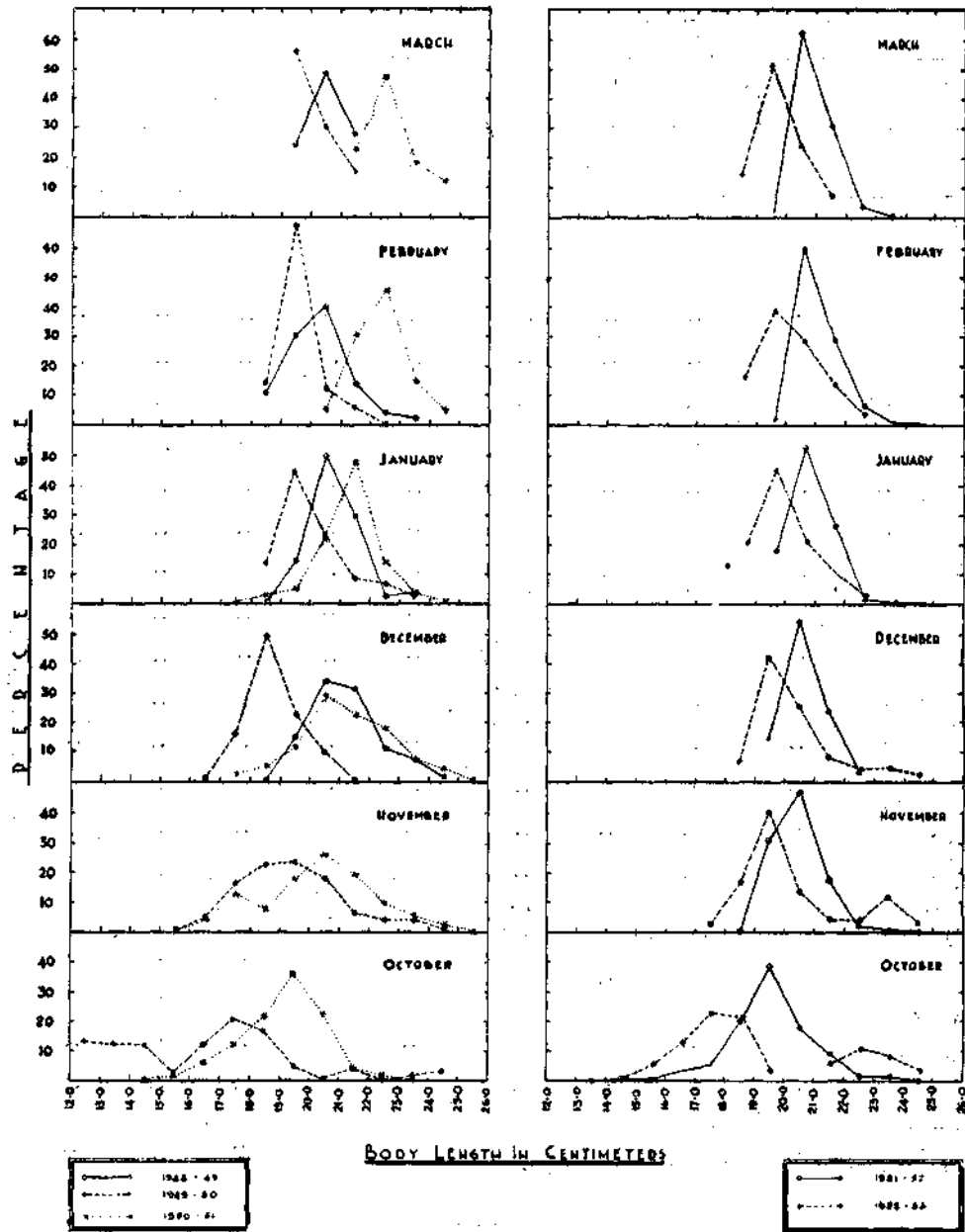


FIG. 2. Length-frequency polygons showing sizes of Mackerel taken each month during the Mackerel season at Karwar (1948-49 to 1952-53).

It may be seen from the above account of the length-frequency distributions that during a period of five years 5 dominant size-groups entered the fishery in different years and that the same dominant size appeared at certain intervals. For example, the 20.5 cm. group, constituting the fishery of 1948-49 season, also contributed to the fishery of 1951-52 season. Likewise, the 19.5 cm. group, entering the fishery of 1949-50 mackerel season, also appeared in 1952-53 and persisted throughout the season. It may be that the same size-classes reappear after a lapse of two years. One noteworthy point is that at the commencement of the season in October a smaller size-class enters the fishery and increases to a larger class which persists throughout the season. The juvenile mackerel, in the maturity Stage I and II, constitute the fishery and the percentage of immature adult fish above the minimum size at maturity (22.4 cm.) entering the fishery is insignificantly small.

Effect of dominant size-groups on the fishery

It was observed that, when the dominant size-class was small and persisted throughout the season, the total landings during the mackerel season were also comparatively small, as can be seen from the results of 1949-50 and 1952-53 seasons. The dominant size-group in both the seasons was 19.5 cm.; the seasonal catch in 1949-50 and 1952-53 was 950 tons and 1,125 tons respectively. The season was good when a large dominant size group of 20.5 cm. was registered in 1948-49 and 1951-52 seasons. The quantity of mackerel landed in these two seasons was above the average figure of 1,500 tons, being 1,726 tons and 2,250 tons respectively. The 1950-51 season was also good, the total landings in that season being 2,035 tons. But the direct relation of catch to dominant size-group cannot be applied to this season as the fishery was contributed by two dominant size-classes increasing to different sizes in different months. It appears that the direct relation of catch to dominant size-group holds good only when the fishery is contributed by one size-group persisting throughout the season.

The rate of growth

The monthly average lengths of mackerel for different months are given in Table III and shown graphically in Fig. 3. A progressive growth in the length of mackerel, from the fishing season (October to March) to the spawning period (June to September) has been noted in the size-groups. The monthly average length trends, in the mackerel season and other months of the year, indicate not only changes in the size of fish from year to year but also the lengths of fish in the corresponding months of different mackerel seasons. It will be seen (from Table III) that the monthly average length

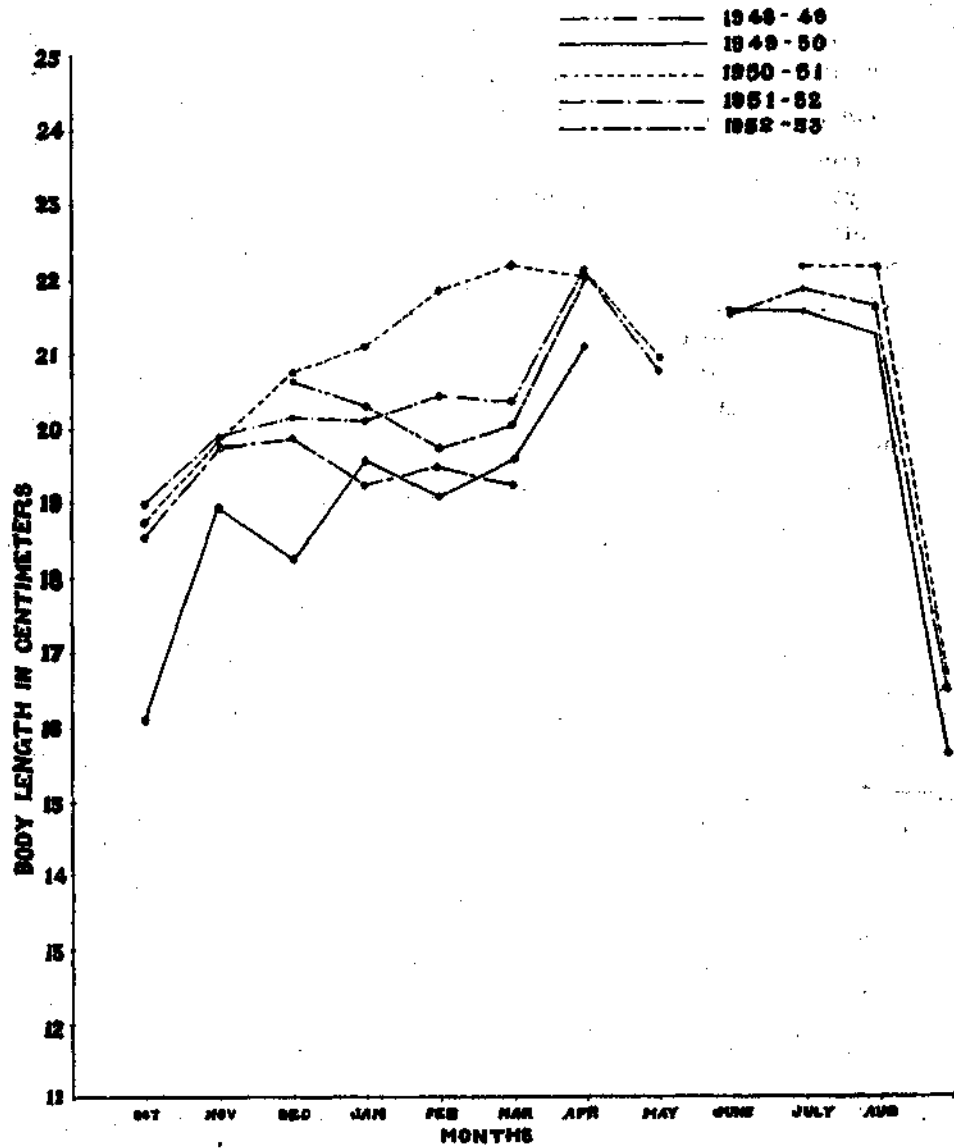


FIG. 3. Monthly average length-frequency polygons showing sizes of Mackerel occurring at Karwar during 1948-49 to 1952-53.

of mackerel during the season appears to fluctuate by 2 or 3 cm., indicating growth in length during the season. A further increase of 1 or 2 cm. is seen in the succeeding months to August. Thus from November to August when the size range of fish is from 18 to 25 cm., the monthly average length of mackerel has been found to increase from 18.95 to 21.60 cm.

in 1949-50, or from 19.83 to 22.41 cm. in 1950-51 or 19.92 to 22.11 cm. as in 1951-52. The month of October has been omitted here, as the monthly average length of fish is likely to be influenced by the small-sized fish appearing in fluctuating numbers in that month.

Fluctuation in abundance and yield per unit of effort of fishing

For comparing the seasonal fluctuation in the abundance of catch for different years, the total catch and the total number of pieces of *Rampan* net operated during different months of each mackerel season, are taken into account irrespective of the number of days, men or time spent on fishing. The catch per month per piece of net with an average area of 324 square feet, is taken as the unit of effort of fishing and on this basis the relative intensity of fishing is noted for different months of the season. The total catch in number of mackerel, the unit of effort of fishing and the relative intensity for different months of the mackerel season are given in Table VI.

TABLE VI

Unit of effort of fishing and relative intensity of fishing during different months of the Mackerel season—1948-49 to 1952-53

Mackerel season	Total number of Mackerel caught during the month	Unit of effort of fishing (Number of Mackerel per piece, per month) $N/P = x$	Relative intensity of fishing $N/x = y$
(1948-49)			
October	8,16,400	441	1,851
November	62,94,480	740	8,506
December	1,01,02,400	1,110	9,101
January	20,49,600	256	8,006
February	39,200	5	7,840
March .. .. .	.. .. .	..	..
(1949-50)			
October	44,800	52	861
November	66,41,600	729	9,110

TABLE VI—Contd.

Mackerel season	Total number of Mackerel caught during the month	Unit of effort of fishing (Number of Mackerel per piece, per month) $N/P = x$	Relative intensity of fishing $N/x = y$
December ..	36,96,000	450	8,213
January ..	63,000	52	1,211
February ..	..	..	..
March ..	..	..	..
(1950-51)			
October ..	28,56,000	476	6,000
November ..	90,16,000	1,001	9,006
December ..	47,04,000	563	8,355
January ..	44,24,000	549	7,594
February ..	4,48,000	59	8,058
March ..	13,44,000	244	5,508
(1951-52)			
October ..	3,53,600	505	700
November ..	35,92,000	389	9,233
December ..	36,70,000	469	7,825
January ..	7,59,000	132	5,750
February ..	43,28,000	417	10,378
March ..	8,52,000	378	2,253
(1952-53)			
October ..	..	..	..
November ..	56,89,000	552	10,306
December ..	13,15,000	122	1,077
January ..	5,38,000	65	8,276
February ..	4,78,000	58	8,241
March ..	2,20,000	69	3,188

1948-49 Season.—In this season, the intensity of fishing was the greatest in December, as, in this month, both the total landings of mackerel (1,01,02,400) and the catch per piece of net (1,110) reached the maximum value for the season. The relative intensity of fishing was almost the same in November, January and February though there were marked fluctuations in the monthly total catch from 39,200 to 62,94,480 and the catch per piece from 5 to 740 mackerel. The intensity of fishing was lowest in October, but the unit of effort of fishing was comparatively higher than that of January and February. The total landing of mackerel during the month was 8,16,400. Thus in 1948-49 season, November-December 1948 and January 1949 may be considered the peak period of fishing with a maximum yield in December.

1949-50 Season.—The 1949-50 season was one of short duration and the total landings fell below the average figure of 1,500 tons. The highest monthly catch of 66,41,600 and also the catch per piece of net—729—were recorded in November. The intensity of fishing was also the highest during the season. In December a total of 36,96,000 mackerel with a yield of 450 per piece was registered. These figures appear to be low considering the intensity of fishing which was slightly less than that of the previous month. The fishery was poor in October and January and the monthly landing of fish was as low as 44,800 in October. The catch per piece of *Rampan* net was also the lowest, being 52 in both the months. The intensity of fishing was slightly greater in January and a comparatively high total of 63,000 mackerel was recorded in that month. In the 1949-50 season, the fishery was at its best in November and December as in the previous season.

1950-51 Season.—In the 1950-51 season, marked fluctuations both in the number of mackerel per piece of net and the monthly total landings, were noticed, although there was no appreciable difference in the intensity of fishing in successive months. The minimum and maximum catches of the season were 4,48,000 and 90,16,000, in February and November respectively. In these months, also the lowest—59—and the highest—1,001—figures were recorded for each piece of net. In December and January the fishery was on the decline and the monthly landings approximated to half the quantity registered in November. A total of 47,04,000 and 44,24,000 mackerel were recorded in these months. The catch per piece fell from 563 in December to 549 in January, the intensity of fishing being practically the same in both months. There was a sudden set-back in the fishery in February when the lowest quantity of the season was landed but in the next month, the fishery improved considerably and the comparatively high figure 13,44,000 mackerel was recorded. The catch per piece worked out at 244 mackerel. At the beginning of the season in October, the intensity of fishing was not so great, a total of only 28,56,000 mackerel being landed, and the catch per piece was 476. The peak period of the fishery in the 1950-51 season was during November and January.

1951-52 Season.—In contrast to the last two seasons, the intensity of fishing was greatest towards the end of season, in February 1952. A total of 43,28,000

mackerel were landed during the month, with a yield of 417 mackerel per piece of *Rampan* net. November and December was next best period of the season in which 35,92,000 and 36,70,000 mackerel were caught in the respective months. The relative intensity was greater in November but the yield per piece was rather low giving only 378 mackerel, as against 469 in December. In March and January the fishery was on the decline, the total landing of mackerel being 8,52,000 in March and 7,59,000 in January. The relative intensity was greater in January than in March but the catch per piece was in the reverse order, being 378 in March and 132 in January. In October, the intensity of fishing was poor as in the past but the catch per piece was the highest—505—of the season. The total landing for this month was 3,53,600.

1952-53 Season.—In the 1952-53 season, October is shown blank, not because there was no fishing, but because the single *Rampan* haul did not land mackerel as the entire shoal escaped before the net was dragged ashore. In this season a gradual decline in the fishery was seen from November to March, the fall in the monthly landing of mackerel was from 56,89,000 to 2,20,000. The intensity of fishing was greatest in November and so also the total monthly catch, and the catch per piece of net, which worked out at 552 mackerel. The relative intensity of fishing was lowest in December, with a yield of 122 mackerel per piece of net: the monthly landings of fish was computed at 13,15,000. In the next two months the fishing operations were of almost uniform intensity and gave similar results. The monthly landings in January and February were 5,38,000 and 4,78,000 respectively and the catch per piece, 65 and 59. In March, the catch per piece was higher—69—than in the previous two months though the quantity of mackerel—2,20,000—landed was less than half the number recorded either in January or February.

From the foregoing analysis of the catch statistics of successive mackerel seasons certain deductions can be made. These may be stated briefly as follows:—

1. In general, the mackerel fishery is poor in October—the beginning of the season at Karwar. The total number of pieces of *Rampan* net in operation and the number of hauls too are comparatively fewer, with the result that the total quantity of mackerel during October is the lowest of the season.
2. The peak period of mackerel fishery at Karwar is generally in November to December, but this may be shifted towards the end of the season, as in February of the 1951-52 season.
3. The total number of pieces of *Rampan* net operated during the month may vary between 8,000 and 9,000 during the peak period, but the catch per piece and the total monthly landings of mackerel show marked fluctuations in the sponding months of successive seasons.

4. The relative intensity of fishing during the peak period of successive mackerel seasons does not vary much, though the catch per piece of net may show marked fluctuations.

5. The monthly total catch of mackerel appears to be more influenced or governed by the dominant size-class or classes, as shown previously, than by the actual number of pieces of *Rampan* net in operation during the month. In other words, the frequency of appearance of mackerel shoals in inshore waters and probably the size of a shoal itself, appear to be related in some unknown manner to the dominant size-class of the month or season.

6. In Karwar or wherever the *Rampan* net is operated in inshore waters, the fishing conditions—the area of fishing, the fishing gear, the number of men operating the net, etc.—being almost uniform in successive years, the fluctuation in the seasonal catch may be attributed more to the quality of the size-composition of a mackerel shoal than to meteorological and hydrological changes in the fishing area.

7. In the case of *Rampan* fishing, the unit of effort of fishing or even the relative intensity of fishing does not explain satisfactorily the fluctuations in the abundance of fish in inshore waters.

8. The fluctuations in the seasonal catches are not so pronounced as in the case of the oil sardine. It is observed that at an interval of two years, that is, in the 3rd year, the fishery reaches its lowest ebb, the total landings in that season falling below the average figure of 1,500 tons.

VI. BIOLOGY OF MACKEREL

All along the west coast of India, from Ratnagiri in Bombay State to Ceylon in the south, the mackerel fishery appears to be based only on one species, namely *Rastrelliger canagurta* (Cuv.).

Mackerel of all sizes from different fishing centres in Kanara District were examined for morphological variations. The various body proportions, and the counts of fin-rays, gill-rakers and the vertebral count conformed to the description of *Rastrelliger canagurta* (Cuv.) by Beaufort (1951). The various body proportions and their standard deviations for mackerel from Karwar Bay are shown in Table VII.

Food of Mackerel

It is well known that the mackerel feeds both on phytoplankton and zooplankton. The chief planktonic organisms constituting the food of mackerel are:—

<i>Phytoplankton</i>	<i>Zooplankton</i>
Coscinodiscus	Copepods
Rhizosolenia	Acartia
	Oithona
Biddulphia	Pseudocalanus
Ceratium	Harpacticoids
Peridinium	Euterpina
	Corycaeus
	Temora
Pleurosigma	Cypris
Dinophysis	Mysis
Nitzschia	Lamellibranch and Gastropod Larvæ
Thalassiothrix	Lucifers
Fragilaria	Prawn larvæ
Ornithocercus	Zœa larvæ (Brachiura)

The observations of various workers in India are at variance in points of detail. Devanesen (1942) observed that the mackerel normally feed on fish eggs and this was subsequently confirmed by Chidambaram (1942) and Devanesen and Chidambaram (1948). John and Menon (1942) assert that fish eggs were never encountered in the stomach of mackerel caught on the Trivandrum Coast. The analysis of the stomach contents of mackerel caught in Karwar waters indicates that occasionally a few eggs, up to a dozen, may be encountered, though, on the 12th August 1950, about 275 eggs were recorded from one mackerel. Devanesen and Chidambaram (1948) are also of opinion that mackerel supplements its diet of planktonic organisms by occasionally feeding at the bottom on dead decaying fishes; these authors have also recorded fish scales and sand grains from the stomachs of mackerel. In regard to the inclusion of sand grains in the stomach of mackerel, certain interesting observations were made at Karwar. It was noted that the percentage of sand particles in the stomach of mackerel caught in different nets varied markedly, particularly in those caught in *Rampan* nets and impounded for varying intervals of time. It was thought that the inclusion of sand might be due to the particular mode of fishing and the impounding of mackerel for shorter or longer periods of time. In order to elucidate this point, the stomach contents of mackerel caught in different nets and hauled after varying intervals of time were examined throughout the year and the results analysed (Table VIII). It will be seen from Table VIII that sand particles contributed about 80 to 90% of the stomach contents of mackerel caught in a *Rampan* net. The amount of sand varied with the period of impounding of fish; the longer the period of impounding the greater the amount of sand in the stomach. This may be attributed to the large population of mackerel confined to a limited shallow area which is sandy. In

TABLE VII

*Body proportions, their standard deviation and fin counts of Rastrelliger canagurta (C.)
caught in Karwar waters*

Body proportion	1	2	3	4	5	6	7	8	9	10
	Standard L.	Body depth	Head L.	Head depth	Snout	Maxillary	Eye diameter	Snout to insertion of :		
								Dorsal fin	Ventral fin	Anal fin
Total L.	Total L.	Total L.	Total L.	Total L.	Total L.	Total L.	Total L.	Total L.	Total L.	Total L.
Mean body proportion ..	0.8583	0.2190	0.2543	0.1989	0.0719	0.1288	0.0586	0.3148	0.3061	0.5336
Standard deviation of body proportion	0.0304	0.0107	0.0121	0.0101	0.0063	0.0095	0.0142	0.0128	0.0229	0.0242
	Fin Ray Count					Gill Raker Count		Gill Raker (Largest) Length	Vertebral Count	
	1st	Dorsal 2nd	Anal	Pectoral	Ventral	Lower Branch	Upper Branch			
	9 to 10	11+5 to 12+5	11+5 to 12+5	2/16-18	1/5	32 to 38	12 to 21	18-24 mm.	36	

All measurements for length-frequency distribution are in total length. By total length is meant the distance from the tip of the snout to the tip of the longest ray of the caudal fin. The standard length measures from the tip of the snout to the end of the vertebral column marked by a point in line with the posterior ends of the two ridges or keels on either side of the root of the caudal fin. The terms 'body length' and 'standard length' are used in this paper as synonyms. The length of the head measures from the tip of the snout to the end of the opercle and the height of the fish is the maximum height, usually at the commencement of the first dorsal fin. The length of the snout is the distance between the tip of the snout and the pre-orbital, and the length of the maxilla extends from the mid-point of upper jaws to the posterior broad end of the maxillary bone. The diameter of the eye is the maximum width across the eye.

TABLE VIII

The proportion of sand in the stomach of Mackerel caught in the Ramapan net in comparison with other nets

Period	Locality	Type of Net	Time interval of paying and hauling net in hours	Number and Range of size of Mackerel (Total length) in cm.	AMOUNT OF FEED (Dry volume)			Amount of sand (%)	REMARKS
					Minimum	Maximum	In majority specimens		
March to May	Karwar	Rampan	6-12	(4) 21-22.6	0.2 c.c.	1.8 c.c.	0.2-1 c.c.	80-90	Very poor feed: debris—3-8%. Digested food—50-88%
	Karwar	Yendi	1-2	(12) 19.2-24.5	0.03 c.c.	2.6 c.c.	0.5-1.2 c.c.	Usually nil (90% noted in one specimen only)	Moderately well-fed occasionally starved debris—2-5%. Digested food—5-10%
	Binge Arge	Pattebale	4-6	(6) 20.1-22.1	1.3 c.c.	3.5 c.c.	1-3 c.c.	Nil	Relatively well-fed—5-20% debris, with muddy content in some digested food—1-5%
	Kadwad	Stake Net	4	(1) 26		4 c.c.	..	Nil	Muddy content (well-fed)
June to September	Karwar Arge	Yendi	1-2	(19) (a) 10-12 (b) 21.6-23.5	(a) On average 0.9 c.c.	4.2 c.c.	0.26 c.c.	Usually nil (Noted in one specimen only)	(a) Poorly fed (b) Relatively well-fed Digested food—2-5% Specimens well-fed (Little debris and digested food noticed)
	Binge Arge Chandiyee	Pattebale	4-6	(14) 21.7-23.7	0.3 c.c.	4 c.c.	1.2-2.8 c.c.	No sand	Well-fed—3-6%. Digested food, debris—2-10% (Occasionally muddy content)
	Majali Karwar	Cast Net	..	(5) 21.7-23.7	1.7 c.c.	3.6 c.c.	1.8	No sand	
October to February	Karwar Arge Chandiyee	Rampan	12-36	(68) 17.1-24.5	0.1 c.c.	3.8 c.c.	0.5-2.5 c.c.	90-95%	Stomach gorged with sand; debris—5-10%. Actual food—0.5-2%. Digested food—50-90%
	Karwar	Yendi	1-2	(20) 20-24.3	0.3 c.c.	7.2 c.c.	1-2.5 c.c.	Nil (Rarely small amount present)	Muddy content with some debris found in majority specimens Moderately fed; digested food—30-50%. Debris and mud—10-25%
	Karwar Arge	Cast Net	..	(6) 16.1-19.5	0.2 c.c.	3 c.c.	0.5-0.8 c.c.	Usually nil (Only once encountered)	Relatively well-fed; digested food—20-50%. Debris—3-5%

the stomachs of mackerel caught in a cast net, or drift net, or *Ailakolli* net, the sand particles were entirely absent or, when present, their percentage was negligibly small.

Seasonal variations in the food of Mackerel.—The analyses of stomach contents of mackerel throughout the year reveal that there is no marked variation in the food of mackerel during the mackerel season and other periods of the year, the same forms in varying numbers being encountered according to the seasonal fluctuations of various planktonic groups. Observations of Bhimachar and George (1952) indicate that the composition of the food of mackerel varies from season to season depending upon the fluctuations in the occurrence of various planktonic elements.

According to Chidambaram *et al.* (1952) the intensity of feeding varies from season to season. These authors have shown that there are two periods of intense feeding, one from October to December and the other from March to April.

Food of Mackerel in relation to seasonal fluctuation of plankton.—Studies on food and feeding habits of mackerel at Karwar indicate that planktonic forms recorded from the stomach of mackerel are also encountered in inshore plankton with this difference, that the order of abundance of various planktonic organisms is not always the same in corresponding analyses. A close correlation between the food constituents and the planktonic organisms of the inshore area was noted by Bhimachar and George (1952). The studies reported here have been confined to inshore material—both plankton and fish—and until new material from offshore waters is available for analysis and comparison, the shoreward migration of mackerel during October to March should not be linked with the food and feeding habits of the species from an apparent similarity of food constituents and inshore plankton.

Selectivity in Feeding.—Certain forms like *Sagitta*, stomatopods and spionid larvæ, hydromedusæ, ctenophores and salps, though common in plankton samples, have been rarely recorded from the stomach of mackerel. Of particular interest is *Noctiluca* which is conspicuous by its absence; only on one occasion in a single specimen 6 *Noctiluca* were noticed by Bhimachar and George (1952). It is evident that a certain amount of selectivity in feeding, by eliminating some planktonic groups or individual forms abounding in plankton samples, is shown by mackerel.

Maturity and the amount of feed.—Information on the intensity of feeding in relation to the state of maturity of Indian mackerel is scanty. Bhimachar and George (1952), in their studies on food and feeding habits of mackerel,

have noted a distinct correlation between the state of maturity and the intensity of feeding. According to these authors, the intensity of feeding is high during February and middle of April when mackerel are maturing. It is low from April to June when the fish is in an advanced state of sexual maturity, in Stage V. They observed that the fish feeds less during the spawning season and this is in agreement with the findings of other workers. The feeding is also comparatively poor in juvenile fish entering coastal waters during July and August.

There is no marked difference between the food constituents of the young and adult mackerel. The variations in their food are also in accordance with the seasonal abundance and fluctuation of plankton.

Maturity and spawning season

Stages of sexual maturity of Mackerel during different months of the year.— There appears to be some difference in the stages of sexual maturity of mackerel caught at different fishing centres on the west coast of India at the same time. According to Devanesen and Chidambaram (1948), the reproductive elements are fully ripe by the end of May and the spawning season is a protracted one, extending from June to September. Again, Chidambaram *et al.* (1952) state that mackerel with ripening gonads are caught in the months of March, April and May. The maturity of mackerel studied at Karwar has given rather different results. It was noted that the stages of sexual maturity during different months of the year differ slightly from those recorded by workers on the Malabar Coast. In this connection, it must be made clear at the outset, that the maturity stages as fixed by the International Council for the Exploration of the Sea for the Herring Scheme can be applied to the mackerel ovary up to and including the Stage V. The Stage VI, as will be explained in the discussion of spawning of mackerel, cannot be rigidly applied for the advanced stage of a maturing ovary. The last, Stage VII, designated for the spent ovary, can be adopted for mackerel ovary. In assigning different stages of maturity during different months, the general appearance of the ovary, the relative length of the ovary to the abdominal cavity, the cytological changes as seen in the deposition and nature of yolk and the oil globules in the developing ovum and ova diameter measurements have been taken into consideration. All observations were made on fresh ovaries. The results are summarised in the following table:—

Stages of sexual maturity of Rastrelliger canagurta (C.) in different months of the year at Karwar

Duration	Range of ova diameter in mm.	Stages of maturity	
		Female	Male
October to January (<i>Im</i>)	0.03 to 0.27	I	I
February (<i>m</i>)	.. 0.28 to 0.37	II	II
March (<i>m</i>) ..	.. 0.28 to 0.37	II	II
April (<i>m</i>) ..	.. 0.37 to 0.46	III	III
May (<i>m</i>) ..	.. 0.37 to 0.46	III	IV
June	.. 0.46 to 0.56	IV, V	IV, V
July	.. 0.57 to 0.76 0.81	IV, V, VI, VII	IV, V, VI
August	(<i>M</i>) .. 0.57 to 0.76 0.81	"	"
September	.. 0.57 to 0.76 0.81	"	"
October (<i>m</i>)	.. 0.03 to 0.27	I	I

Im = Immature; *m* = Maturing; *M* = Mature.

Spawning of Mackerel.—The spawning of mackerel, as indicated by size-frequency distributions of mature ova during different months, appears to be from June to September. The Indian mackerel *Rastrelliger canagurta* (C.), like the European species *Scomber scombrus* L., spawns in succession over a prolonged period and only a small percentage of ova mature each time, giving that stage a speckled appearance aptly described as 'plum pudding' stage (Le Danois, 1937). The spawning of mackerel between June and September has also been indicated by Devanesen and John (1940), but Chidambaram and Venkatraman (1946) put it between May and September increasing the range of spawning period by a month.

It must be pointed out here that the spawning period (either May to September or June to September) has been fixed by various workers based on studies on ovarian ova or occurrence of spent fish in inshore waters. Neither planktonic eggs nor mackerel actually spawning have been encountered

in inshore waters so far. This evidently indicates that the spawning grounds of Indian mackerel are beyond the present fishing area. Devanesen and John (1942) reported that at Chaliyam—a place 5 miles off Calicut—they collected about 405 mackerel eggs in various stages of development. It is by a process of elimination, general appearance and diameter measurements of the mature ovarian ova that these authors have identified this mass of eggs as belonging to *Rastrelliger canagurta* (C.). They, however, admit that in the absence of artificially fertilized eggs, the inference cannot be conclusive.

We do not know the time interval between the discharge of successive batches of ripe ova nor the number of batches involved in a spawning season. It thus becomes increasingly difficult to enumerate the total number of mature eggs that would have spawned during a season, though Devanesen and John (1940) estimate an average of 94,000 eggs in the Indian mackerel.

Sex composition.—The sex composition of the commercial catches during the mackerel season can be stated roughly as 45% male and 55% female. Sex differentiation is possible in specimens above 12 cm. in length. There are no external indications of sex.

Minimum size at maturity.—The minimum size at maturity as determined by the mature ovarian ova in Stage VI *a* or VI *b* and the length of the spent fish was found to be 22.4 cm.

Growth of Mackerel

A combined study of the length-frequency distributions throughout the year and the maturity and spawning of mackerel indicates that their rate of growth in the seas of India is rather slow. It is known that mackerel of small size, ranging between 6 and 11 cm., are occasionally landed from July to September. The next larger group of 12 to 16 cm. is recorded in the first half of September. It has also been observed that juvenile mackerel below the size 16 cm. never enter inshore waters in very large numbers to form a fishery. The 12 cm. to 16 cm. group is succeeded immediately in the next month—October—by a larger size-group, 18 to 20 cm., and in the succeeding months February to March, higher figures 21 to 22 cm., are registered. There is a progressive increase in size from 22 to 25 cm. during the spawning season and the whole cycle is repeated from the commencement of the next mackerel season.*

* I was fortunate in obtaining in April and May 1953, some intermediate sizes not recorded previously from Karwar waters. On the 24th April 1953, only 5 mackerel, of 14.4 to 15.4 cm. and 14.8 and 15.4 and cm., on the 28th of the same month 2 specimens measuring 14.0 and 15.4 cm. in length, were recorded. Again on the 7th May, 12 mackerel with a range of 17.2 to 18.8 cm. were encountered in the fishermen's catch at Baitkol-Karwar.

The growth of Indian mackerel can be reviewed as follows:

The spawning season lasts from June to September. The juvenile mackerel ranging between 6 and 11 cm., recorded occasionally during July to September, are presumably the offspring of fish which has spawned in the previous season. The difference in size-range may be attributed to the intermittent spawning over a prolonged season, the average length of a year old fish being about 10 cm. This group does not contribute to the fishery of the succeeding months of the mackerel season but leaves inshore waters. It is reasonable to believe that this group may have grown to about 14 to 16 cm. by about April and that it enters the fishery the following season, when the fish are 2-year old, and probably have attained a size of 18 cm. or more.

The larger group, 12 to 16 cm., common in the first half of September in Karwar waters are obviously more than one year old and it is possible they mature and spawn in the next spawning season when they may have attained a length of about 22 cm. or above, the minimum size for maturity. The 12 to 16 cm. group also does not contribute to the fishery of the next month—October—the beginning of mackerel season.

It may be concluded that the Indian mackerel attains a length of 10 cm. in one year and when it enters the fishery in October, it is 18 cm. or more completing its second year. The rate of growth of Indian mackerel is not so fast as that of the European species *Scomber scombrus* L., which attains a length of about 20 cm. or above in the course of the first year of its life.

Weight-length relationship in Mackerel

For determining the weight-length relationship in mackerel, 1,250 specimens ranging between 12 and 26 cm. total length were arranged in 10 mm. groups and the weight of each individual fish recorded. The average length and weight of each group of observations was calculated and the general equation $W = AL^a$ (where W = weight of fish; L = length of fish and A and a the constants whose values are to be determined) was fitted to them. The calculated values are: $A = 0.005978$ and $a = 3.1737$. Substituting these values for A and a , the weight of a fish of given length was calculated. The observed and calculated weights of the fish were plotted against the average weight of each size-group and two curves following an almost parallel course obtained (Fig. 4).

The weight-length relationships in the male and female mackerel obtained during the mackerel seasons 1949-50 to 1951-52 were noted separately. The average lengths and weights of 768 males and 1,023 females ranging from 15 to 26 cm. are shown graphically in Fig. 5.

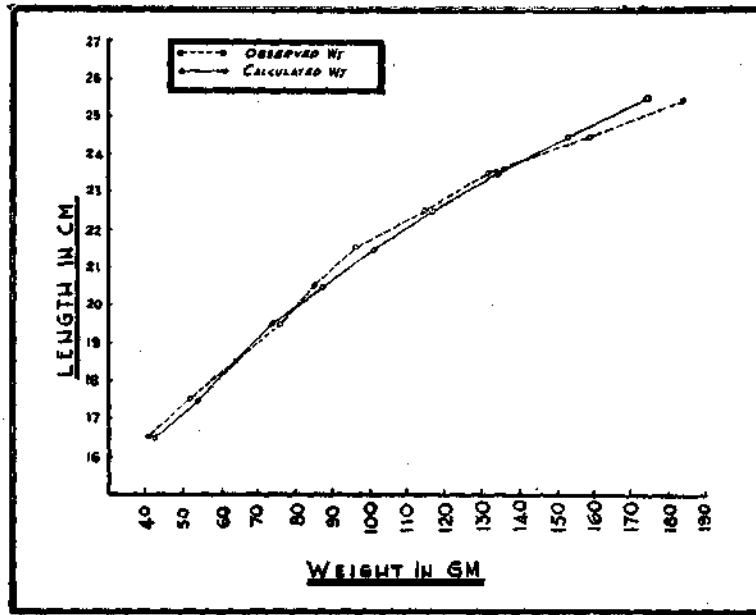


FIG. 4. Length-weight relationship of *Rastrelliger canagurta* (C.)

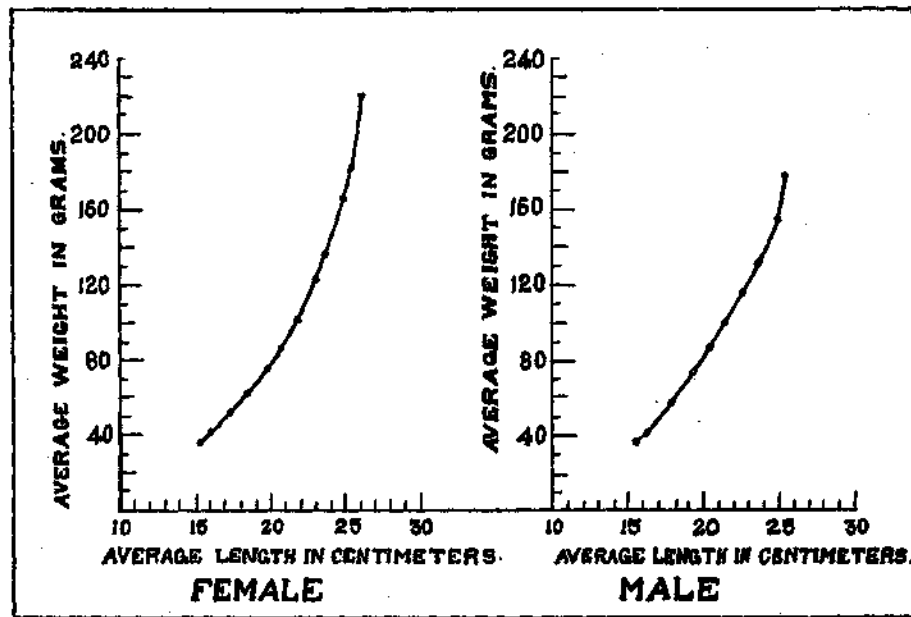


FIG. 5. Average observed length and weight of *Rastrelliger canagurta* (C.) during 1949-50, 1950-51, 1951-52 seasons.

Relationship between standard and total length of Mackerel

In order to establish an equation for the conversion of total length to standard length or *vice versa* the allometric curve of Huxley, viz., $y = Cx^a$ (where y represents the total length and x standard length and C and a constants to be determined) was fitted, when a was found to be 0.94 and C , 1.406. The relation thus becomes $y = Cx^a = 1.406 \times .94 x$.

A conversion table from standard length to total length of fish between the range 10 to 23 cm. is also given (Table IX).

TABLE IX

A. conversion table from standard length to total length between the range 10 and 23 cm.

Standard length in cm.	Log of st. length	Log of Calculated total length	Total length in cm.	
			Calculated	Observed
10	1.0000	1.0784	11.98	11.90
11	1.0414	1.1173	13.10	13.40
12	1.0792	1.1528	14.22	14.30
13	1.1139	1.1854	15.32	15.80
14	1.1461	1.2157	16.44	16.45
15	1.1761	1.2439	17.54	17.60
16	1.2041	1.2702	18.63	18.73
17	1.2304	1.2949	19.72	19.64
18	1.2553	1.3183	20.81	20.95
19	1.2788	1.3404	21.90	21.86
20	1.3010	1.3613	22.98	23.55
21	1.3222	1.3812	24.05	24.28
22	1.3424	1.4002	25.13	25.7
23	1.3617	1.4183	26.20	..
24	1.3802	1.4357	27.27	..

VIII. OBSERVATIONS OF MACKEREL SHOALS

Mackerel shoals can be spotted from a distance as dark patches with ripples. At night, shoals are located by phosphorescent patches.

The range of size in a single mackerel shoal is very small and the individuals collectively present a striking uniformity of size. It was noted on several occasions, and, to quote a particular instance, on the 25th September 1952, that mackerel which were caught in 'pattebale'—gill nets—at a distance of 4 miles north of Karwar, were of larger size, ranging from 21 to 23.5 cm. (with 22 cm. as the over-all size in one case) and 21 to 22.5 cm. with a dominant size-group of 22 cm. in the other. Those caught in 'Yendi'—shore-seine—on the same day at a distance of 1 furlong from the shore were decidedly smaller, ranging from 12 to 15.7 cm. with a majority size of 14 cm. This suggests that mackerel of different size-groups move in shoals separately and the range of size in the same shoal is not significantly large. Thus if one encounters mackerel of various sizes with a wide range in a catch the conclusion is that the catch is comprised of more than one shoal, as can be seen in *Rampan* catches.

Salinity and occurrence of Mackerel

It is observed that the occurrence of mackerel in Karwar Bay is influenced to some extent by low salinity during the rainy season when mackerel are not so frequently caught as in the neighbouring fishing centres like Binge, Chendia or Majali. The influx of fresh water from the mouth of Kali river lowers the salinity which may occasionally be as low as 2.04‰. Records of the occurrence of mackerel in Karwar Bay and the salinity of water samples from the site of the operation of *Yendi* showed that mackerel can withstand the low salinities even down to 2.04‰. The occurrence of mackerel in relation to fluctuations in the salinity of water samples from Karwar Bay are shown in the following table:—

Type of net	Number of mackerel caught	Range of size (T.L.) in cm.	Salinity ‰	Range of salinity ‰ during the month	
				Min.	Max.
<i>Yendi</i> ..	6	21-23.00	18.15	..	..
" ..	5	22-25.00	15.07	..	..
" ..	25	21-23.00	12.18	5.25	22.26
" ..	12	20.4-23.6	12.75	..	..
" ..	26	13.6-23.5	9.55	..	..
" ..	25	12.0-15.3	6.65	..	..
<i>Yendi</i> ..	3	22.0-23.0	2.15	2.04	20.59
" ..	8	15.1-17.5	2.04	..	..
<i>Yendi</i> ..	3	16.2-19.2	20.08	..	..
" ..	25	13.3-19.2	8.35	3.45	25.38
" ..	500	13.1-20.1	13.00	..	..
" ..	300	14.0-16.0	18.52	..	..

Mackerel are known to enter estuarine waters of the Kali river and ascend along the tidal current up to a distance of about $1\frac{1}{2}$ miles during April and May when the range of salinity of river water is between 29.73 and 34.6 ‰. In the mackerel season, fishermen avoid as far as possible using the *Rampar* net at the northern end of the shore, that is, near the mouth of the river. They have learnt from experience that the entire stock of impounded mackerel is apt to die from a sudden fall in salinity occurring in that area due to the influx of fresh water from the river.

Movement of Mackerel

1. *Shoreward migration of shoals.*—When there is wind in north-easterly direction, mackerel shoals enter inshore waters. Shoals usually move along the current of water at high tide. When there is a strong wind in easterly direction mackerel shoals come close to the shore through deeper layers of waters.

2. *When chased by larger fish.*—Mackerel shoals scatter when attacked by seer fish. But when the shoals are chased by sharks or porpoises, the mackerel submerge with the head downwards into a compact mass. The indication that the shoals have dived at a particular spot is that there is invariably a patch of muddy water due to the churning of water by a large mass of fish.

3. *Pattern of mackerel shoal and the velocity of movement.*—It was observed that mackerel shoals move in semicircular or arrow-head formations. It was also noted that the time taken by a mackerel shoal to travel from the Oyster Rocks light-house to Karwar shore, a distance of about $4\frac{1}{2}$ miles, is roughly half an hour. It may be inferred that mackerel shoals move at a speed of about 8 to 10 miles per hour.

Enemies of Mackerel

Sharks, seer fish, ribbon fish, and porpoises.

VII. ACKNOWLEDGEMENTS

My grateful thanks are due to Dr. N. Kesava Panikkar, for his helpful criticism and suggestions. My thanks are also due to Shri K. H. Mohamed, Fishery Survey Assistant at Bombay, for supplying me with information on size-groups of mackerel caught off Porbunder, by the Japanese Trawler *Taiyo Maru* No. 17.

IX. SUMMARY

The present paper deals with a general account of the mackerel fishery of Karwar, with observations on the dominant size-groups contributing to the fishery during the period 1948-49 to 1952-53 and their effect on the fluctuations in the seasonal catches. The fishing grounds, exploited at present around the North Kanara Coast, cover an area of about 800 square miles. The catch per square mile is about 22.5 tons, giving an annual total for the

district of 18,000 tons, valued at Rs. 40,00,000. The annual mackerel catch for the district is about 13,000 tons. At Karwar the average annual catch of mackerel is about 1,500 tons valued at Rs. 2,25,000. The total landings of mackerel during the seasons, 1948-49 to 1952-53, were 1,726; 950; 2,035; 2,250; and 1,125 tons respectively.

Rastrelliger canagurta (C.) is the only species entering the commercial catches of Kanara District. The juvenile mackerel in the maturity stages I and II constitute the fishery. The percentage of immature adult fish above the minimum size at maturity, namely 22.4 cm., is insignificant.

There appears to be some relation between the dominant size-class and the seasonal catch. When the dominant size-class was small, the seasonal catch was also comparatively poor, being below the average catch. When the dominant size-class was large the seasonal catch was also above the average figure.

Mackerel are plankton feeders. It was noted that the planktonic forms recorded from the stomach of mackerel were also encountered in inshore plankton with this difference that the order of abundance was not always the same. Certain forms like *Sagitta*, stomatopod and spionid larvæ; hydromedusæ, ctenophores, though common in plankton samples, were only occasionally recorded from the stomach of mackerel. *Noctiluca* was conspicuously absent from the stomach of mackerel.

The male and female mackerel are in maturity Stage I during October to January, in Stage II in February to March, and in Stage III in April. In May, male mackerel attain Stage IV, while the female is in Stage III. From June to September both are encountered in stages ranging from IV to VII. Spawning of mackerel takes place from June to September. The spawning is intermittent and extends over a prolonged period.

The sex composition of commercial catches in the fishing season may be stated as 45% male, 55% female. Sex differentiation takes place in specimens above 12 cm. The minimum size at maturity is 22.4 cm. From the records of the occurrence of juvenile mackerel it may be inferred that the Indian mackerel *Rastrelliger canagurta* (C.) attains a length of about 10 cm. in the first year and enters the commercial catches during the season when 2 years old, measuring 18 cm. or more in length.

It was observed that mackerel can withstand low salinity even down to 2.04 ‰ and that it enters estuarine waters of the Kali river, ascending along the tidal current up to a distance of about 1½ miles during April to May, when the range of salinity is between 29.73 and 34.6‰.

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APPENDIX I

Key to the Stages of Sexual Maturity of *Rastrelliger canagurta* (C.)

BY L. B. PRADHAN AND V. C. PALEKAR

(Mackerel Research Unit of Central Marine Fisheries Research Station, Karwar)

Rastrelliger canagurta (C.) is a very important food fish on the west coast of India and has attracted the attention of several workers. In order to avoid confusion in the interpretation of the stages of maturity and for the correct assignment of the phase of development of the gonads to the various stages, the following key has been prepared for general use at the suggestion of Dr. N. K. Panikkar, based on the experience of examining a very large amount of material at Karwar. It is hoped that this would help in achieving uniformity of reporting results of observations on the mackerel in the various centres of India and the Indo-Pacific. The maturity scales adopted by the International Council for the Exploration of the Sea in the Herring Scheme have been followed up to and including Stage V. The Stage VI has been subdivided into Stage VI (a) and VI (b), owing to the peculiar mode of the ripening of ova in batches, the ovary giving a speckled appearance, aptly described as 'plum-pudding stage'. The range of ova-diameters is given from fresh ovaries, and all other observations are also recorded from fresh material.

Key to the stages of sexual maturity of the Indian Mackerel—Rastrelliger canagurta (C.) (Female)

Extent of ovary in the body cavity	General appearance of the ovary	Range of ova diameters (in mm.)	Appearance of ova (under the microscope)	State of maturity	Maturity stage
Ovary less than half the length of the body cavity	Reddish to pinkish in colour; ova invisible to the naked eye	0.038-0.13 0.14-0.27	Yolkless, transparent ova. Semi transparent ova, with traces of yolk along the periphery of the cell-wall and very minute oil globules surrounding the centrally placed nucleus	<i>Im</i>	I
Ovary slightly more than half the length of the body cavity	Pinkish in colour; ova visible to the naked eye; ovary slightly granular in appearance	0.28-0.37	Small opaque ova, white in appearance	<i>m</i>	II
Ovary extending to about $\frac{3}{8}$ the length of the body cavity	Pinkish creamy to yellowish in colour; distinctly granular in appearance	0.37-0.46	Medium-sized, whitish, opaque ova	<i>m</i>	III
Ovary extending a little over $\frac{3}{8}$ the length of the body cavity	Creamy to yellowish in colour; granular in appearance	0.46-0.56	Large-sized, white, opaque ova	<i>m</i>	IV
Ovary extending over the entire length of the body cavity	Yellowish in colour; superficial blood vessels conspicuous; distinctly granular but without transparent eggs	0.57-0.81	Some slightly translucent ova. loosely attached to the ovary wall; one to three oil globules with diameters varying from 0.17 to 0.23 mm.	M	V
Do.	Yellowish colour with "plum-pudding" appearance, translucent eggs scattered through the entire mass of ovary, but not in the lumen. External appearance of ovary same as in the previous stage, but the lumen contains ripe transparent eggs	Do.	Transparent, mature ova, usually with a large oil globule measuring up to 0.23 mm. in diameter	M	VI (a)
Do.		Do.	Do.	M	VI (b)
Shrunk ovary about $\frac{1}{2}$ the length of abdominal cavity	Ovary blood-red in appearance with remnants of mature ova as unhealthy opaque masses	..	..	S	VII

Im = Immature; *m* = Maturing; M = Mature; S = Spent fish.

Key to the stages of sexual maturity of the Indian Mackerel—Rastrelliger canagartha (C.) (Male)

Extent of testes in the body cavity	General appearance of testes	State of maturity	Maturity stage
Testes less than half the length of the body cavity	<ol style="list-style-type: none"> 1 Testes very small, whitish in colour; in most cases exhibit asymmetrical development in that the one on the right or left side may be :— <ol style="list-style-type: none"> (i) irregularly lobed (ii) in the form of a small nodule (iii) in the form of a thin strip 2 In majority cases the left testes is larger and flattened into a wedge-shaped mass 3 The vas deferens usually distinct 	<i>Im</i>	I
Testes slightly more than half the length of the body cavity	Testes whitish in appearance, more or less symmetrical; lobed or unlobed	<i>m</i>	II
Testes extending to about $\frac{3}{4}$ the length of the body cavity	<ol style="list-style-type: none"> 1 Testes whitish in colour, unlobed and symmetrical, or lobed and asymmetrical 2 Left testis flattened and more extensively developed than the right one which is feebly developed. In rare cases the reverse condition noted 3 Vas deferens mostly covered by the substance of the testes 	<i>m</i>	III
Testes more than $\frac{3}{4}$ of the length of the body cavity	<ol style="list-style-type: none"> 1 Testes whitish to creamy in appearance 2 They become extensively flattened massive, showing irregular growth and may or may not be fused posteriorly 3 When not fused, they generally appear lobed and irregularly flattened, the left testis being distinctly more flattened and extensive than the right. In rare cases the reverse condition noted 	<i>m</i>	IV
Testes extending over the entire length of the body cavity	In advanced stages of maturity the testes become soft and are of whitish colour; spermatids visible under microscope	<i>M</i>	V
Do.	The general appearance same as in the previous stage. On a slight pressure spermatic fluid can be extruded	<i>M</i>	VI
Testes comparatively much reduced in size	Texture flabby and bloodshot in appearance	<i>S</i>	VII

Im = Immature; *m* = Maturing; *M* = Mature; *S* = Spent fish.

TABLE IV. Length-frequency distribution of Mackerel during different months of the season

N.B.—Figures in brackets indicate percentage. All measurements are in total length.

Year	1948-49						1949-50						1950-51						1951-52						1952-53					
Month	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Oct.	Nov.	Dec.	Jan.		
Size Range in cm. (T.L.)																														
12-13	30 (12.65)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
13-	28 (11.81)	2 (0.01)	..	..	..	..	..	..	..	..	..	..	3 (0.33)	..	..	..	..	..	..	..	..	..	..	..
14-	27 (11.39)	..	..	..	..	..	3 (0.15)	..	..	..	..	..	7 (0.78)	..	..	..	..	..	9 (1.41)	..	..	..	..	..
15-	6 (2.53)	6 (0.04)	..	..	..	..	7 (0.25)	2 (0.06)	..	..	..	..	7 (0.78)	..	..	..	..	..	9 (1.52)	..	..	..	..	..
16-	27 (11.39)	62 (4.34)	4 (1.33)	..	..	..	96 (4.81)	102 (3.19)	..	..	..	..	22 (2.48)	..	..	..	..	..	69 (13.89)	..	..	..	..	..
17-	48 (20.25)	228 (15.96)	45 (16.00)	..	..	..	221 (11.08)	367 (11.47)	29 (1.92)	12 (0.39)	..	..	46 (5.41)	..	..	..	..	..	148 (23.27)	91 (3.37)	..	..	..	..
18-	9 (0.41)	7 (0.72)	56 (10.81)	..	39 (16.45)	317 (22.19)	147 (49.00)	49 (13.17)	17 (1.72)	..	414 (20.75)	232 (7.25)	73 (4.83)	96 (3.11)	..	..	180 (20.92)	10 (0.40)	..	..	..	..	137 (21.54)	446 (16.50)	94 (8.17)	142 (20.00)	..	..
19-	310 (14.29)	137 (14.13)	154 (29.72)	88 (23.97)	11 (4.64)	398 (23.66)	68 (22.66)	167 (44.89)	301 (66.15)	178 (54.93)	705 (35.34)	541 (16.90)	171 (11.32)	166 (5.38)	..	..	344 (38.78)	789 (31.72)	292 (15.79)	221 (18.32)	42 (3.41)	14 (3.21)	27 (4.24)	1099 (40.68)	499 (43.35)	312 (45.00)	..	..
20-	729 (33.60)	482 (49.74)	203 (39.57)	177 (48.22)	1 (0.42)	254 (17.78)	30 (10.00)	86 (23.11)	55 (12.08)	97 (29.93)	439 (22.00)	810 (25.31)	435 (28.81)	644 (22.59)	10 (5.00)	..	162 (18.26)	1176 (47.30)	1013 (54.76)	640 (53.06)	1042 (50.16)	395 (62.40)	..	330 (14.06)	298 (25.89)	147 (21.00)	..	..
21-	681 (31.39)	284 (29.30)	70 (13.51)	102 (27.79)	9 (3.79)	90 (6.30)	3 (1.00)	33 (8.87)	28 (6.15)	49 (15.12)	74 (3.71)	614 (19.19)	336 (22.25)	1493 (48.40)	60 (30.00)	33 (22.29)	86 (9.69)	435 (17.49)	455 (24.56)	323 (23.78)	501 (48.92)	199 (31.42)	42 (6.6)	123 (4.55)	95 (8.25)	71 (10.30)	..	..
22-	244 (11.24)	25 (2.57)	21 (4.05)	..	..	56 (3.92)	..	26 (6.98)	4 (0.87)	..	30 (1.50)	299 (9.34)	277 (18.34)	455 (14.75)	90 (45.00)	70 (47.29)	14 (1.57)	60 (2.40)	90 (4.86)	19 (1.58)	121 (6.98)	23 (3.63)	71 (11.16)	120 (4.44)	58 (5.04)	12 (1.70)	..	..
23-	161 (7.42)	34 (3.50)	12 (2.31)	..	4 (1.68)	56 (3.92)	..	11 (2.95)	..	..	6 (0.30)	157 (4.90)	111 (7.35)	119 (3.86)	29 (14.50)	27 (18.24)	12 (1.35)	9 (0.36)	..	2 (0.16)	12 (0.59)	2 (0.31)	54 (8.49)	338 (12.51)	67 (5.82)	..	..	..
24-	35 (1.61)	..	..	..	7 (2.95)	19 (1.33)	..	..	..	..	..	67 (2.09)	65 (4.30)	50 (1.62)	11 (5.50)	18 (12.16)	2 (0.22)	7 (0.28)	..	1 (0.08)	14 (0.80)	..	22 (3.46)	105 (3.89)	40 (3.47)	..	..	..
25-	9 (0.28)	13 (0.86)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total	2169 (99.96)	969 (99.96)	518 (99.97)	367 (99.98)	237 (99.95)	1428 (99.45)	300 (99.99)	372 (99.97)	455 (99.97)	324 (99.98)	1995 (99.99)	3290 (100.00)	1510 (99.98)	3035 (100.10)	200 (100.00)	148 (99.98)	887 (100.94)	2486 (99.95)	1850 (99.97)	1206 (100.58)	1732 (99.96)	53 (99.97)	636 (99.98)	2702 (100.00)	1151 (99.99)	68 (99.90)	..	..