OBSERVATIONS ON THE INDIAN MACKEREL, *RASTRELLIGER CANAGURTA* (CUVIER) FROM THE TRAWL CATCHES ALONG THE BOMBAY COAST

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Referring to the distribution of the Indian mackerel, Panikkar and Jayaraman (1956) mention that there is a distinct and unmistakable gap in the distribution of the major fisheries to the north of Ratnagiri and that north of this place shoals of mackerel are not known, but the species is widely distributed having been found in the Persian Gulf and the Bay of Bengal and stray specimens have also been taken in the trawls operated off Kathiawar. That the mackerel met with in the offshore catches are of importance is known from the statement that "a full picture of the distribution will depend on the location of the spawning grounds and the discovery whether there is any deep sea mackerel existing in offshore regions of the coast" (Panikkar, 1949). Mackerel in small numbers have been recorded on many occasions from the catches of the trawlers fishing along the Bombay coast. In one instance a dense shoal of mackerel was also encountered while the vessel M.F.V. 'Jheenga' was trawling about 32 kilometres off Bombay at depth of 35 metres, when about half a ton of mackerel was caught in a single haul. An attempt is made here to summarise the observations made on the catches of mackerel from trawlers working along the Bombay coast. The common occurrence of mackerel, though usually in small numbers, in the trawl catches prompts one to infer that the fish may at least occasionally move to the deeper waters.

The materials for the present study were collected either while on board the vessels of the Deep Sea Fishing Station, Bombay* or at Sassoon Docks, Bombay, when the catches of the trawlers were landed.

From the seasonal records of mackerel in the trawl catches given in Table I, it is evident that most of the mackerel catches were recorded during the period November–December, which happens to be the peak season for mackerel fishery in the west coast of India.

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* The vessels M.F.V. 'Jheenga', M.F.V. 'Bangada' and M.F.V. 'Bumili' referred to in this paper are the trawlers of the Deep Sea Fishing Station, Bombay.

TABLE 1

Records of mackerel from trawl catches along the Bombay Coast

Date	Locality	Number	Length range in cm
February 1952	Off Saurashtra (Taiyo Maru—No. 17)	22*	22·1–27·7
24–11–1958	Off Bombay—23 metres (M.F.V. 'Bangada')	21	18·4–26·2
5–12–1958	Off Bombay (M.F.V. 'Bangada')	3	17·3, 18·0 and 21·5
15–5–1959	Off Porbandar (M.F.V. 'Jheenga')	4	24·0–24·5
1–12–1959	Off Bombay (M.F.V. 'Bangada')	1	15·8
3–12–1959	Off Mangrol (M.F.V. 'Jheenga')	2‡	19·5 and 19·8
2–12–1960	Off Bombay—35 metres (M.F.V. 'Jheenga')	265	17·5–24·5
3–12–1960	Off Bombay—38 metres (M.F.V. 'Jheenga')	93	18·8–24·3
3–12–1960	Off Bombay—34 metres (M.F.V. 'Jheenga')	175	17·5–24·5
14–12–1960	Off Jaigarh—37 metres (M.F.V. 'Jheenga')	66**	20·0–23·7
15–12–1960	Off Dhabol—25 metres (M.F.V. 'Jheenga')	30**	21·0–23·5
2– 6–1961	Off Cutch (Bull Trawlers of New India Fisheries Ltd.)	1*	28·5
28–11–1961	Off Bombay—29–54 metres (M.F.V. 'Bumili')	38	18·5–24·0
30–11–1961	Off Bombay—24–31 metres (M.F.V. 'Bumili')	3	19·5, 19·5 and 20·9
8–12–1961	Off Tarapore and Arnala (M.F.V. 'Jheenga')	29	18·5–23·5

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Details of five hauls in which mackerel appeared in fairly good numbers are given in Table II. All these hauls were taken on board M.F.V. 'Jheenga' in December, 1960.

The length-frequency distributions of mackerel from the trawl catches in November–December appear to be very much similar to those recorded

TABLE II

Details of five hauls sampled for mackerel studies on board M.F.V. 'Jheenga' in December 1960

Particulars of hauls				Particulars of mackerel in each haul				
Date, time and duration in hrs.	Location	Depth in metres	Quantity in kg. (Estimated no. given in brackets)	Percentage (in weight)	Number measured	Size range (total length in cm.)	Dominant size grop in cm.	Other fishes in the haul (wt. in kg. given in brackets)
1. 2-12-1960 11-50 to 13-40 hrs. 1-50 hrs..	Area 5D: 18-72 (Lat. 18° 40′ N. to 18° 50′ N. Long. 72° 30′ E to 72° 40′ E.)	35	440 (4,400)	39·82	265	17·5 to 22·9	20·5	Perches (576) Carangids ('Narvi') (50) Cat-fish (40)
2. 3-12-1960 7-45 to 9-15 hrs. 1-30 hrs.	Area 6D: 18-72 (Lat. 18° 50′ N. to 19° 00′ N. Long. 72° 30′ E. to 72° 40′ E.)	38	20 (200)	2·71	93	18·8 to 24·3	21·5	Elasmobranchs (420) Cat-fish (161) Sciaenids (40) Perches (18)
3. 3-12-1960 10-10 to 11-40 hrs. 1-30 hrs.	Area 5D: 18-72 (Lat. 18° 40′ N. to 18° 50′ N. Long. 72° 30′ E. to 72° 40′ E.)	34	40 (400)	7·50	175	17·5 to 24·5	20·5	Cat-fish (160) Perches (158) Elasmobranchs (100) Carangids ('Narvi') (60) Sciaenids (40)
4. 14-12-1960 12-00 to 14-30 hrs. 2-30 hrs.	Area 3F: 17-72 (Lat. 17° 20′ N. to 17° 30′ N. Long. 72° 50′ E. to 73° 00′ E.)	37	10 (100)	2·00	66	20·0 to 23·7	22·5	Pomfret (200) Cat-fish (80) Perches (30) Sciaenids (80) Carangids ('Narvi') (80)
5. 15-12-1960 7-00 to 8-30 hrs. 1-00 hrs.	Area 4F: 17-72 (Lat. 17° 30′ N. to 17° 40′ N. Long. 72° 50′ E. to 73° 30′ E.	25	3 (30)	2·03	30	21·0 to 23·5	22·5	Synagris (80) Cat-fish (20) Rays (25) Sciaenids (20)

at Karwar, Malpe, and West Hill at this period of the year. It is likely that the length frequency of mackerel as judged from some samples of smaller numbers of fish are not very reliable. The dominant size group is almost always represented by modes between 18·5 and 22·5 cm., and this is quite evident in cases where larger numbers of mackerel have been measured for the samples (Fig. 1). However, a feature of significance noted is the presence of a second mode in the frequency curves at 23·5 or 24·5 cm. This mode is present at 24·5 cm. without any prominence in curves given in Figs. 1 A and 1 D, but is quite prominent in Figs. 1 G and 1 H. This mode may be of significance with reference to the statements on age made by Sekharan (1958) and Pradhan (1956).

24 mackerel caught in the 'dol' nets at Versova on 25–11–1961 ranged in size* from 16·2–20·9 cm., and had the dominant size group at 17·5 cm., and a minor group at 20·5 cm. Comparing this with the frequency curve of mackerel taken in the same week from the catches of the trawler M.F.V. 'Bumili' (Fig. 1 G) it is seen that the 17·5 cm. group is completely unrepresented in the trawler catch. Though it cannot be said that the 'dol' net and the trawl are operated in the same place, their areas of operation in this instance with reference to depth is almost the same. (In both cases the fishing operations take place generally at depths beyond 15 metres. For details of 'dol' net operations refer to Setna, 1949.) The absence of smaller size mackerel in the trawl catches, it would appear, is possibly due to the selectivity of the gear. (The mesh size of the cod end of the trawl nets used by the Deep Sea Fishing Station vessels is generally about 6 cm. and that of the 'dol' net about 1·5 cm.) This will have to be verified from further studies.

Stomach contents of 20 fish taken from the trawls were analysed with a view to find whether they had fed on bottom organisms, in case the fish were actually in the bottom waters while the trawling operations were in progress. Volumetric analysis of the stomach contents was done by taking their 'settlement volume'. The volume of the contents varied between 0·2–4·0 c.c.

Analyses of food and feeding of mackerel by previous workers have shown that the mackerel is a plankton feeder (Chidambaram, 1944; Bhimachar and George, 1952; Pradhan, 1956; and Kuthalingam, 1956). Table III gives the details of the stomach contents of the fish analysed at

* Size measurements of mackerel given in this paper refer to total length, *i.e.*, from tip of the snout to the tip of the upper caudal fluke.

TABLE III

Stomach contents of mackerel taken in the trawl catches

Serial No.	Date	Locality	Total length of fish in cm.	Sex and Stage of maturity	Settlement volume in c.c.	Food Items (given in order of abundance)
1	5-12-1958	Off Bombay (M.F.V. 'Bangada')	17·3	Female—Immature	2·3	Sand grains; foraminiferans; copepods; crustacean appendages; *Coscinodiscus*; fish eggs; digested matter
2	do.	do.	21·5	Male—Immature	0·5	Copepods; fish eggs; *Coscinodiscus*; digested matter
3	do.	do.	18·0	do.	0·7	Copepods (mostly *Microsetella*); crustacean appendages; digested matter
4	1-12-1959	do.	15·8	?	1·8	Copepods; Ostracods; Gastropod larvæ; *Coscinodiscus* and other diatoms; foraminiferans and sand grains; fish eggs; digested matter
5	3-12-1959	Off Mangrol (M.F.V. 'Jheenga')	19·5	Male—Immature	1·0	Copepods; Diatoms; crustacean appendages; digested matter
6	do.	do.	19·8	do.	..	Copepods; *Coscinodiscus*; foraminiferans and sand grains; Cypris larvae; fish eggs
7	2-12-1960	Off Bombay-35 metres (M.F.V. 'Jheenga')	23·4	Female—Immature	2·0	Ostracods (*Pyrocypris*); copepods; fish eggs; crustacean appendages; digested matter
8	do.	do.	23·7	Male—Immature	4·0	Foraminiferans; sand particles; molluscan shell bits; ostracods; copepods (mainly *Temora*)
9	do.	do.	17·5 (standard length)	?	2·0	Copepods; tintinnids; *Coscinodiscus*; *Ceratium*; gastropod larvae; sand grains and foraminiferans

10	2-12-1960	Off Bombay-35 metres (M.F.V. 'Jheenga')	21·0	Male—Immature	1·0	Digested matter; copepods; ostracods; *Coscinodiscus*; fish eggs; crustacean appendages
11	do.	do.	23·0	do.	1·5	Foraminiferans and sand grains; ostracods; copepods; fish eggs; digested matter
12	do.	do.	20·5	Female—Immature	1·1	Copepods; crustacean eggs; *Coscinodiscus*; and tintinnids; debris
13	28-11-1961	Off Bombay (M.F.V. 'Bumili')	18·8	Male—Immature	1·0	Copepods; foraminiferans and sand grains; decaying tissue of jelly-like consistency; fish eggs
14	do.	do.	20·3	do.	3·5	Decaying tissue of jelly-like consistency; sand grains and foraminiferans; copepods; fish scales
15	do.	do.	19·5	do.	2·0	Decaying jelly-like tissue; sand grains and foraminiferans; copepods
16	do.	do.	22·8	do.	0·2	Copepods; crustacean appendages; diatoms
17	do.	do.	23·7	do.	3·7	Sand grains; foraminiferans; crustacean appendages; copepods; *Coscinodiscus*; fish eggs
18	30-11-1961	Off Bombay-24-31 metres (M.F.V. 'Bumili')	20·0	Female—Immature	1·5	Copepods; sand grains and foraminiferans; fish scales; gastropod larvae
19	do.	do.	19·5	do.	1·7	Alima larvae (carapace length 18 mm.); sand grains; foraminiferans; copepods
20	do.	do.	19·5	Male—Immature	0·5	Copepods; *Coscinodiscus*; digested matter

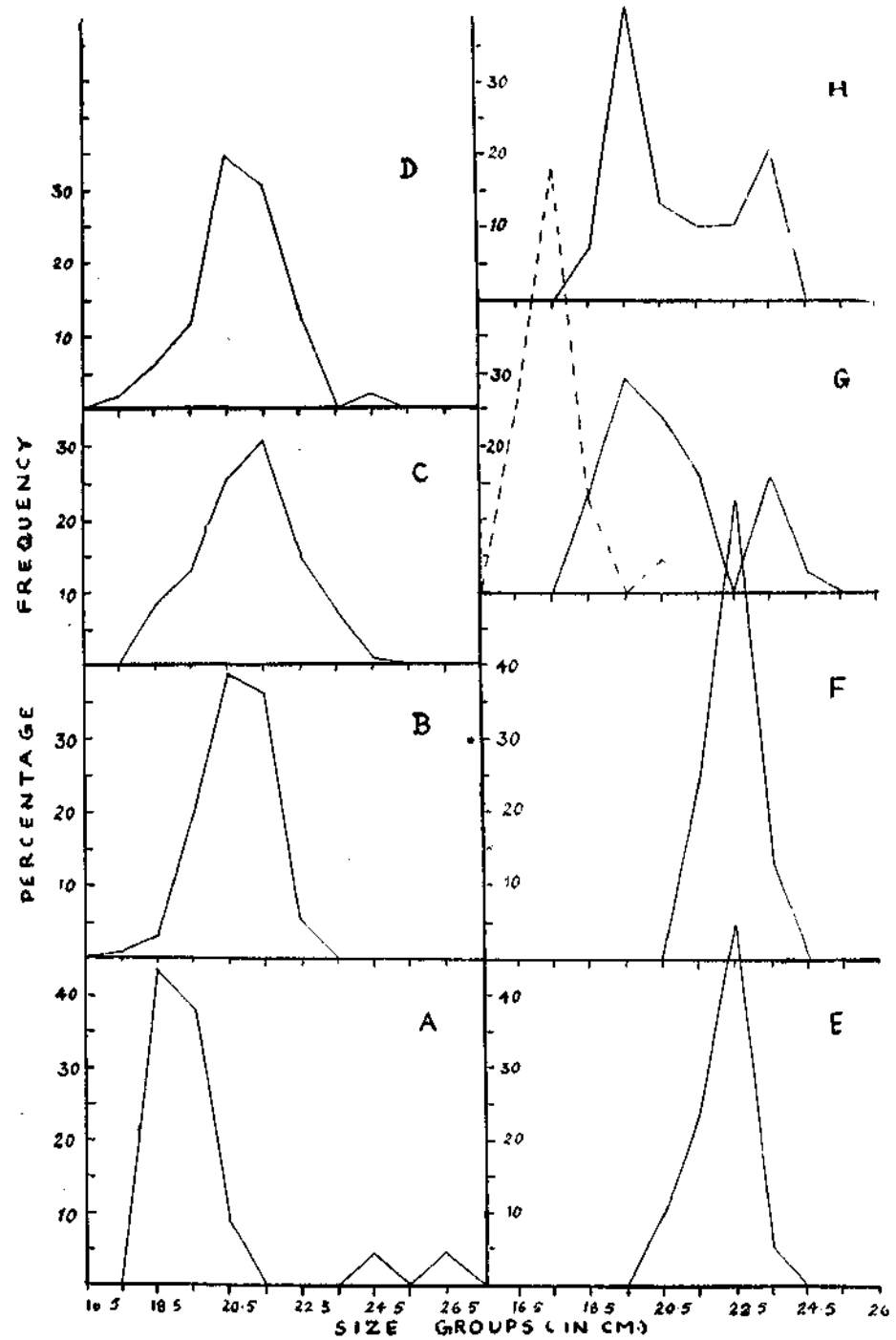

FIG. 1.

present. The stomachs examined in most cases showed that they had fed on their normal food like copepods, cladocerans, diatoms, etc. However in the stomachs of 12 out of 20 fish were found sand grains and foraminiferan shells (mainly textualarids, rotalids, nonionids and lituolids). In a few, the stomachs were gorged with these items of food. Fish scales and molluscan shell bits were also met with in the stomach contents. Another feature of interest is the presence of macroscopic organisms in the stomach of mackerel. In one instance a full grown alima larva of *Squilla*, the carapace of which was 18 mm. in length, was found. While analysing the stomach contents of 3 fish recorded from Sassoon Dock landing place on 17–10–1958 it was observed that these three had taken in macroscopic organisms, besides mud from the sea floor. (It is not known whether these fish had come from the trawl catches or the local 'dol' net catches, and hence the data on these are not included in Table III.) The stomach of one fish (17·5 cm.) with 4·2 c.c. of contents was found to contain the anterior portion of the body of the fish, *Trypauchen vagina*, head of *Acetes* and prawn appendages. In another, six entire *Acetes indicus* of size 2–3 cm. were found.

The presence of sand grains and fish scales in mackerel stomach has been recorded by other workers. Devanesan and Chidambaram (1948) mention that the mackerel "supplements its diet of planktonic organisms by occasionally feeding at the bottom on dead and decaying fishes, for, in the stomach at times fish scales and sand grains without any trace of fish bones are found". Bhimachar and George (1952) say that "on a few occasions sand grains and fish scales were noticed in the stomach contents". Pradhan (1956) finds that in mackerel impounded in the 'rampan' nets at Karwar sand particles contributed about 80–90% of the stomach contents. The presence of sand grains, foraminiferans, fish scales and molluscan shell bits in the stomachs analysed suggests that the fish have in all probability fed on the bottom ooze in the sea.

Chidambaram (1944) and Devanesan and Chidambaram (1948) observed young mackerel feeding on the fish *Stolephorus* and mention that this indicates the carnivorous habit of the young fish. In the present analysis the occurrence of *Trypauchen vagina* in mackerel stomach is of interest with reference to this. The occurrence of *Acetes indicus* in the stomach contents also suggests that mackerel have fed on these macroscopic forms, probably selecting them by sight. Referring to the feeding habits of this fish John and Menon (1942) state that "mackerels of this coast are often found to feed on macroplankton organisms such as lucifers, mysids, *Acetes* and other crustaceans, besides polychaetes and fish fry". That the mackerel do adopt

selectivity in feeding is stated by Bhimachar and George (1942) and depending on that they have divided plankton into two kinds, edible and non-edible. They found that mackerel avoid non-edible plankton such as salps, medusae, ctenophores, stomatopod larvae, chaetognaths and noctilucae. Pradhan (1956) is also of the opinion that in the mackerel there is a certain amount of selectivity in feeding. When it is evident that mackerel feed on plankton by "filtration" one is unable to guess how exactly the process of selective feeding takes place. Regarding the manner by which the mackerel avoid the non-edible plankton Bhimachar and George (1952) state that practically all the non-edible elements, especially noctilucae, are surface living forms and that at the regions of their concentration mackerel prefer to feed below the surface layers of waters. In the case of *Scomber scombrus* it is said that the fish obtain smaller organisms of their diet by filtration and the larger organisms by selective visual feeding (Bullen, 1912; Steven, 1949). Mackerel kept in Plymouth aquarium were observed to have fed on the fragments of squids as they sink through the water by obvious visual feeding. It is possible that the larger organisms in the food of the Indian mackerel are also taken in by visual selection.

The observation of Bhimachar and George (1952), that there is no period of the year when mackerel abstain from food and that similarly there is also no time of the year when the planktonic organisms which form the food of the mackerel are altogether absent, is of interest. In the European mackerel, starving fish were recorded quite commonly both in the pelagic and demersal shoals and regarding the former, most of which starve in winter, it is said that they gorge in the pelagic fish, *Maurolicus pennanti*, whenever they get an opportunity (Steven, 1959). In the absence of forage and other environmental data the cause for the change in the food habits of the Indian mackerel cannot be known. However, it is possible the fish take in less familiar food when their normal planktonic food is not readily available. With reference to this the statement made by Steven (1949) that "mackerel obtain their food by the most profitable method depending upon the size and kind of food organisms and that at any time of the year wherever they may be they fast only if there is nothing for them to feed on" is significant. Pradhan (1956) finds that mackerel impounded in the 'rampan' net had 80–90% of sand grains in their stomach. This is perhaps an instance where mackerel change to the diet of bottom elements due to the absence of planktonic food inside the crowded enclosure. Whether the fish go to the sea bottom at such times when their normal planktonic food is not readily available in the surface is not known.

Except for a collection from the catches of the bull-trawlers of the New India Fisheries Limited in 1956 no other sample examined showed mackerel of advanced stage of maturity, but unfortunately the exact date of this catch is not known. (The fish were kindly sent to us by Dr. S. B. Setna.) The catches were presumably made off Gujarat. 7 fish in this collection included two immature males, four mature males and one mature female with the ovary in late Stage IV of the maturity scale and with the majority of ova ranging in size between 0·52 and 0·70 mm. Several specimens were examined on board M.F.V. 'Jheenga' on 2nd and 3rd December 1960, from catches taken off Bombay and here all the fish examined were found to be immature (Stage I). In all the other collections also, where gonads were examined, the fish were found to be immature, most of the catches having been made in November and December, when elsewhere in the West Coast also mackerel were found to be in the same stage of maturity.

While examining the catches taken off Veraval and Porbunder by M.F.V. 'Bumili' on 26-11-1960 a mackerel measuring 20·5 cm. in length was found entire in the stomach of an adult 'dara' (*Polydactylus indicus*) which is generally taken as a demersal fish. Other items present in the food of the 'dara' examined were *Sciaena* spp., *Polydactylus heptadactylus*, *Coilia dussumieri*, *Parapenaeopsis* sp., and *Solenocera indica*, all of which are usually found in the menu of trawl-caught 'dara'.

Discussion

Records of mackerel from the trawl catches along the Bombay coast given in Table I suggest that but for a single record in 1952 all the others were made between 1958 and 1961. While it is known that trawlers were fishing off Bombay before 1958 one is unable to guess why mackerel records were so scarce in the trawl catches during the period. Even though it was not possible to procure the details on mackerel recorded from the catches of the trawlers prior to 1958 it is known that stray specimens were caught in the trawls operated in the Gujarat coast (Panikkar and Jayaraman, 1956; Pradhan, 1956). It is also possible that mackerel were reported more frequently since 1958 because of the more intensive exploratory fishing operations by the trawlers of the Deep Sea Fishing Station towards the later period. It was, however, noted that the details of the catches given in the reports of these vessels tended to ignore the stray occurrence of mackerel owing to the smaller size of the catches and therefore these catch records were not of much help in this study.

Most of the mackerel catches from the trawlers working in the Bombay coast were obtained during November–December. This period almost coincides with the peak of the mackerel fishery in the West Coast of India, South of Ratnagiri. The size composition and observations on the gonadial condition are almost in line with the observations recorded in these areas during this period. However, in some samples, the length-frequency distribution shows two prominent modes of which the second mode may or may not be significant as in most of the samples the number of individuals measured are limited. In a few instances where fairly good numbers of mackerel were sampled for length frequency the second mode is either absent or insignificant. If this mode is true it would mean that there are two year classes represented in these catches, unlike the inshore mackerel catches of the coast.

From the habitat point of view, the occurrence of mackerel in trawl catches is significant. As the fish, from their known habits, at present, are presumed to be of the pelagic group, their occurrence in these catches is often overlooked. It is quite likely that stray individuals or even larger numbers of mackerel get into the trawl net from the upper layers of water while the net is being hauled in. However, the occurrence of sand grains, foraminiferan shells, fish scales and molluscan shell bits in the stomach contents of 12 out of 20 mackerel sampled at different locations, the catch of about half a ton of mackerel in one haul and their appearance in lesser quantities in almost all the other hauls of a three-day voyage of one of the trawlers fishing off Bombay, the occurrence of the fish in the catches of the 'dol' net which is a bottom-operated stationary bag net and their common occurrence, though in small numbers, in trawl catches as noted in the past few years tend to show that mackerel adopt a bottom habitat occasionally. The occurrence of macroscopic organisms such as *Trypauchen vagina* and *Acetes indicus*, which are generally taken as demersal forms, in the food of mackerel and the single record of mackerel forming the food of *Polydactylus indicus*, which is a prime trawl fish of the coast, can also be mentioned as evidence for the bottom habitat of the fish even though these can be treated as accidental. Future study should throw more light on this important phase in the ecology of the Indian mackerel.

That the mackerel do adopt a bottom habitat is suggested by Chidambaram (1944) and Devanesan and Chidambaram (1948). In the life-history of Indian mackerel it is not known what happens to the shoals of mackerel when they leave the coast at the advent of the monsoon. In his detailed study of mackerel migrations in the English Channel and Celtic Sea, Steven (1948) found that the adult mackerel has in the course of one full

year two main periods, a demersal period and a pelagic period and that during the 'deployment phase' of the demersal period the fish perform small diurnal vertical movements, rising from the sea floor during the night and descending during the day. It is not known whether it is any change in the environment in the surface or a habit of the fish, as yet unknown, which, as it appears, induces the Indian mackerel to adopt a bottom habitat. It is presumed that more data on the offshore environs and the shoaling behaviour of mackerel would aid in the better understanding of this complex problem.

Summary

On many occasions mackerel have been caught in small numbers in the trawlers fiishing along the Bombay Coast and in a single instance about half a ton of this fish was taken in one haul. It is found that most of these catches were made in the period November–December, when the peak season for the mackerel fishery exists in the West Coast of India, South of Ratnagiri. The size composition and gonadial condition noted in these fish are almost similar to those recorded during this period in mackerel occurring elsewhere in the West Coast.

The food of 12 out of 20 trawler-caught mackerel, as revealed from examining the stomach contents of specimens sampled at different locations, consisted, besides planktonic organisms, of bottom elements such as sand grains, foraminiferan shells, fish scales and demersal organisms. It is felt that the bottom elements in the food were taken in while the fish were feeding near the sea floor. It is possible that the larger organisms found in the stomach of some of the fish were taken in by visual selection.

The common occurrence of the mackerel in the catches of the trawlers as well as the bottom-operated 'dol' nets and the presence of the deep water elements in the food of mackerel are possible indications of the occasional sojourn of the mackerel to the deeper waters. More data on the offshore environs and the shoaling behaviour of mackerel are required for a fuller understanding of the problem.

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EXPLANATION OF FIGURES

FIG. 1 A–H. A. Length-frequency distribution of mackerel taken on board M.F.V. 'Bangada' off Bombay at 23 metres on 24-11-1958. B. Length-frequency distribution of

mackerel taken on board M.F.V. 'Jheenga' off Bombay at 35 metres on 2–12–1960. C. Length frequency distribution of mackerel taken on board M.F.V. 'Jheenga' off Bombay at 38 metres on 3–12–1960. D. Length-frequency distribution of mackerel taken on board M.F.V. 'Jheenga' off Bombay at 34 metres on 3–12–1960. E. Length-frequency distribution of mackerel taken on board M.F.V. 'Jheenga' off Jaigarh at 37 metres on 14–12–1960. F. Length-frequency distribution of mackerel taken on board M.F.V. 'Jheenga' off Dhabol at 25 metres on 15–12–1960. G. Length frequency distribution of mackerel taken on board M.F.V. 'Bumili' off Bombay at 29–54 metres on 28–11–1961. Broken line indicates distribution of mackeral from 'dol' net catches, yersova, see text. H. Length-frequency distribution of mackerel taken on board M.F.V. 'Jheenga' off Tarapore and Arnala on 8–12–1961.