SIZE-GROUPS OF *CHOODAI* TAKEN BY DIFFERENT NETS AND IN DIFFERENT LOCALITIES

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At present, the boats fishing *choodai* do not normally venture out to more than 6–8 miles off the shore. Within this zone, there are separate fishing grounds for various types of nets which differ, among other things, in mesh size. But an analysis of the size-groups taken by them shows that the catches as a whole are supported mostly by the 0-year-class. This indicates that given the indices of abundance and the corresponding rate of growth of an year-class, it should be theoretically possible, from a study of mesh-selection, to determine in advance the period at which it (the year-class) would enter the catches of a net; perhaps the approximate amount of total catches that could be expected during a particular season could also be estimated. The data collected should further be important from the point of view of evolving a proper exploitation policy. Investigation of selection has also to some extent become urgent in view of a controversy that has recently arisen in the fishery. The men who use shore-seines fish *choodai* within the coastal belt, 1–1½ miles from the shore, and they feel that the operation of gill-nets both within and outside this range is detrimental to their trade. As there are indications that the use of gill-nets is likely to increase rather than diminish in the coming years, this dispute is likely to become more serious in the future. Obviously, an important point to be clarified in this connection is whether both gill-nets and shore-seines operate on the same size-group or age-group at any time of the year.

The following points were therefore kept in mind when undertaking observations:

(*a*) At what time of the year does an year-class enter the catches of a net?

(*b*) How far is the size-composition of the catches of a net determined by its mesh-size?

(*c*) Is there any differential distribution of the size-groups in the fishing grounds exploited by the various nets?

Material and Methods

The fishery comprises mainly two species, *Sardinella albella* and *S. gibbosa*, and both are referred to in this paper. The observations reported here relate to the period 1952–55. The catches of the various nets were sampled, usually once a week, during the 1954 season. The weekly collections in respect of each boat-net combination included a minimum of two samples from two separate units. The same schedule was, to some extent, kept up during the 1955 season also, but during the years 1952 and 1953, sampling was confined mainly to the shore-seine and hand-net catches. Size-composition of the catches was studied, taking into account only the standard length of the fishes (from tip of snout to the end of the silvery area on caudal peduncle). The meshes of the nets were measured with a scale along the line of the maximum diagonal size when wet and fully stretched. For each net 15–20 meshes were measured and the average calculated. The measurements were taken at the cod-end in the case of boat-seine and both at the cod-end and the wings in the case of the shore-seine. The hand-net is a type of scoop-net attached to a circular bamboo frame about a meter in diameter, and only the meshes at the central portion were taken into account. In gill-nets meshes are of uniform size all over the net.

Buchanan-Wollaston (1927) in his theoretical treatment of net-selection has shown that the 50% release length (the length at which 50% of the fish are retained and 50% released) is a useful measure of the selective action of a net. It can be calculated from the dimensions of the mesh. In the present study, the 50% release length has been taken as that size of the fish at which the maximum body height equals the maximum diagonal size of the mesh. The height of the fishes was measured with a vernier calipers, correct to 0·5 mm. Margetts (1954), Lucas *et al.* (1954) and others regard the body- or head-girth and the circumference of the mesh as the determinative factors in selection. This procedure is perhaps essential when dealing with fishes where the body is round rather than laterally compressed. In the *Sardinella* spp. that support the Mandapam fishery, the body is very much compressed laterally and the belly is provided with sharp acutes. In the present investigation the height of the head was also measured along the line of the anterior border of the opercle in fishes above a particular size, as this factor has some importance in gill-net catches.

Season.—The *choodai* fishery is confined mainly to the Palk Bay where the season extends from March or early April to October or November. After October the Palk Bay becomes very rough and so the fishing activities are shifted to the Gulf of Mannar side where they continue until the ensuing

March. Sardine (*choodai*) catches of the Gulf of Mannar side are as a rule very poor.

Fishing Units

The following are the main types of fishing units operated for sardines. The maximum distance from the shore covered by them in the course of their normal fishing activities is also indicated.

Fishing units	Operational range
1. Dug-out/hand-net (along with torches)	2–3 miles from shore
2. Dug-out/Shore-seine	1–1½ miles from shore
3. Catamaran/Boat-seine	3–6 miles from shore
4. Tuticorin boat/Gill-net	Usually 5–6 miles from shore, sometimes up to about 8 miles

The methods of operation of shore-seines and hand-nets have been referred to by the author in a previous paper (Sekharan, 1955). The hand-nets fish exclusively the smaller length-groups which can be attracted to a source of light, and hence the use of this type of net is restricted to the first few months of the season. A boat-seine is a bag-type net towed between two catamarans. It must be emphasized here that boat-seines are not operated specifically for *choodai*. In fact, sardines are among the fishes most poorly represented in their landings. The Tuticorin boats sail out mainly for big-sized fishes like *Scomberomorus*, *Chirocentrus* and sharks, and their fishing grounds are situated more than 5–6 miles from shore. Before 1954 they used to go for *choodai* only on those days when, because of unfavourable weather, they could not venture out to their normal fishing localities. In 1954 and 1955, however, there was a change in this attitude to some extent, and they have now begun to devote more attention to sardines than before. Gill-nets are usually taken out of the boat only when shoals are sighted.

Mesh-size of the nets.—Shore-seines have bags with three different sizes of cod-end mesh. At the beginning of the season when the population available consists of very young fish, they are fitted with the bags of the smallest mesh-size. The intermediate type is used in May and June and the third, from July onwards.

Table I gives the mesh-size of the various nets and the periods when they are put to use.

TABLE I

Mean mesh-size of the various nets and the periods when they are used

Net	Mesh-size (diagonal)	Periods when used
Hand-net ..	8·5 mm.	April–June
Shore-seine bag	9·0 mm. (Referred to as 9 mm. bag hereafter)	April
	12·0 mm. (Referred to as 12 mm. bag hereafter)	May and June
	14·0 mm. (Referred to as 14 mm. bag hereafter)	From July onwards
Boat-seine bag ..	16·5 mm.	March–November
Gill-net	26·0 mm.	Throughout the year

Age-length relation in Sardinella *spp.*—From an analysis of the length-frequency distribution, it is seen that when about a year old, *Sardinella albella* measure 10–11 cm. and *S. gibbosa*, 10–12 cm. (Sekharan, 1955). Attempts are being made to determine the total life-span of the two species, but this is rendered difficult by the fact that though at least one type of net catches the larger sizes, there appears to be high degree of selection even there. For purposes of this study, however, this broad division of the fishes into those that are less than 1-year-old and others that are more than 1-year-old is found sufficient.

Sardinella albella

The 1952 *season.*—Boats with hand-nets showed fairly good returns in April, but after the first half of May the catches declined to an unprofitable level. The modal size they exploited at this time was 45–49 mm.; they stopped operations after May. Shore-seines were active from April to October. As shown in Fig. 1, they used the 9 mm. bag in April and the 12 mm. bag in May and June. During both the months, the modal length-group of their catches was consistently larger than that of hand-nets; but with regard to the range of size-groups taken, there was no significant difference between the two. On the other hand, the size-ranges that supported the gill-net catches were entirely separate. Reference to Fig. 1 will show

that they operated on the 1951 year-class, while shore-seines and hand-nets fished the 1952 year-class. Shore-seines used the 14 mm. bag from July to the end of the season in October and their landings continued to be supported by the underyearlings.

The 1953 *season.*—Of the four seasons considered here, that of the year 1953 was the poorest. Torch-fishing was undertaken only on very few occasions, and unfortunately no sample of their catches could be collected. Shore-seines were operated in the fishery in May and until the end of June they used the 12 mm. bag (Fig. 2). The major size-group exploited by them in May was 40–44 mm. but it stood at 65–69 mm. in July. The large gap seen between the dominant length-groups of the two months is perhaps to be explained in terms of the growth of the fish. From May to July the shore-seine catches at Dhanushkodi often contained sardines of the 1952 year-class (Fig. 2). In samples collected towards the end of May from boat-seine landings, the majority of the fish measured 60–64 mm. These, as in the case of the sardines taken by shore-seines, probably belonged to the 0-year-class. But from March to July, gill-nets landed mainly one-year olds, which conformed to the observations made in the 1952 season. From March to May the 105–09 mm. group dominated their catches, but the mode shifted to 100–114 mm. in June. After July, the gill-net operations were suspended for a few months.

The Palk Bay season ended in October. From November 1953 to March 1954 fishing was mainly on the Gulf of Mannar side, and during this period both shore-seines and gill-nets operated on the 1953 year-class. But the modal length of their catches differed to the extent of 10 mm. As has already been indicated the two nets vary not only in mesh-size but also with regard to the fishing grounds they exploit.

The 1954 *season.*—Of the four seasons reported on here, that of the year 1954 was the best as far as total production was concerned. The young fish first appeared in shoals in early April, and they persisted in such abundance that torch-fishing lasted from April to June, the maximum duration, so far seen, of this type of operation for *choodai*. During this period, the modal size recorded by the hand-nets shifted only to the extent of 10 mm. and once it had passed the 35–39 mm. group, torch-fishing was found to be uneconomical. Shore-seine catches were also very good during these months, the dominant size being however slightly larger than those of the hand-nets, as had been observed during the 1952 season. Shore-seine landings at Dhanushkodi included a small proportion of 1-year-olds, although at other centres, these nets concentrated exclusively on the 0-year-class.

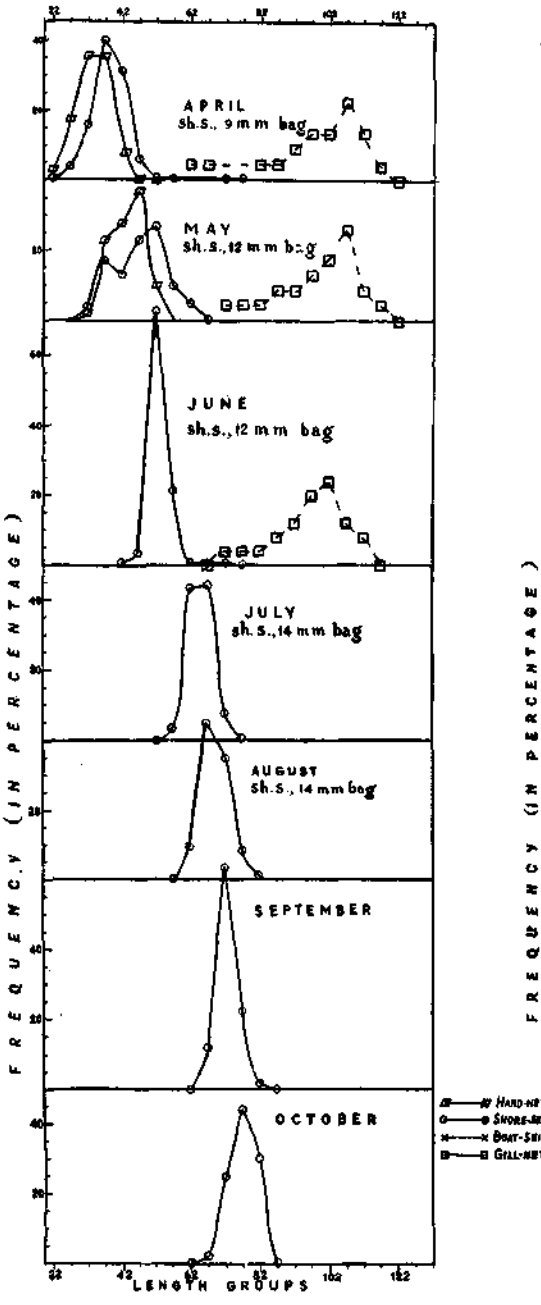

FIG. 1

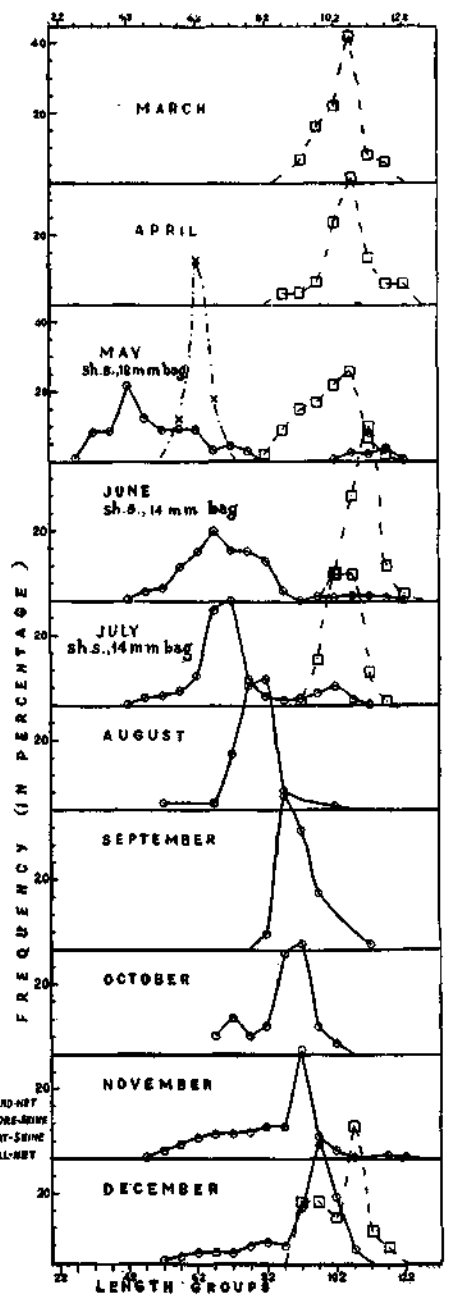

FIG. 2

FIG. 1. Size composition of the catches of *S. albella* in 1952. (sh.s. = shore-seine)
FIG. 2. Size composition of the catches of *S. albella* in 1953. (sh.s. = shore-seine)

The gill-net catches of the April to June period presented an entirely different picture with regard to size- and age-composition. As will be seen from Fig. 3, they were supported by 1-year-olds. At the same time the boat-seines brought in intermediate sizes. In July the shore-seine men used the 14 mm. bag which partly explains the rather abrupt movement of the mode from June to July. After July the dominant size-group exhibited a progressive shift to the right from month to month, which showed the growth of the 1954 year-class. On the contrary, the major size that contributed to the gill-net landings showed a backward movement from July onwards until it coincided with that taken by shore-seines in October. It is, of course, difficult to fix the age of the fish caught by the gill-nets in July and August; perhaps they were a mixture of the 1954 and 1953 year-classes. The major length-groups taken by them in September and October evidently belonged to the 1954 year-class; the same year-classes entered the boat-seine catches of these months.

The 1955 *season.*—Torch and hand-net boats started fishing *choodai* in April, but samples of their catches could not be obtained in that month. In May, the modal length-group exploited by them stood at 35–39 mm. after which torch-fishing came to a stop. An interesting deviation from the usual time-table for changing the shore-seine bags was also witnessed during this season, in that the 14 mm. bag was used from June onwards. The fishermen were perhaps aware that the fish had shown a better growth rate during the April to June period of this season than during the corresponding period of the 1954 season. A small percentage of the shore-seine catches at Dhanushkodi in May included the 1954 year-class. By September, the differences with regard to the mode and range of length-groups caught by the various nets narrowed down considerably; it was apparent that from that month onwards, all types of gear were capturing only the 1955 year-class (Fig. 4).

The foregoing observations may be summed up as follows: only very young fish below a modal length of 50–54 mm. are caught by the torch and handnet boats. Shore-seine catches are mainly of the 0-year-class throughout the season, although a small proportion of their catches at Dhanushkodi, which is not a very important *choodai* centre, consists of 1-year-olds as well. From March to about August, gill-nets capture 1-year-old fish, and during the other months, the 0-year-class. The catches of boat-seines also consist mainly of the 0-year-class and, to some extent, of older fish, the modal sizes of their catches being intermediate between those of shore-seine catches and gill-net catches, especially during the April to August period.

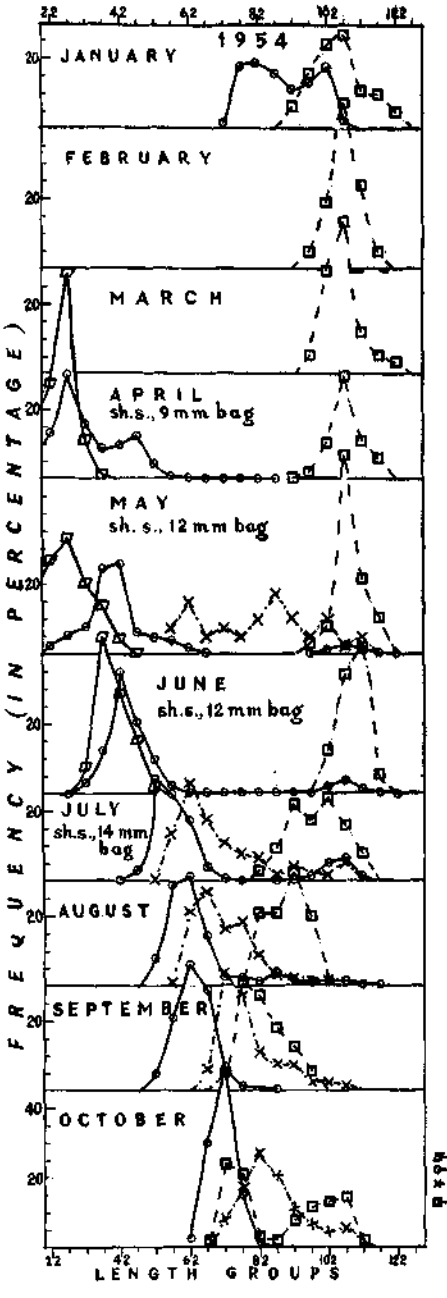

FIG. 3

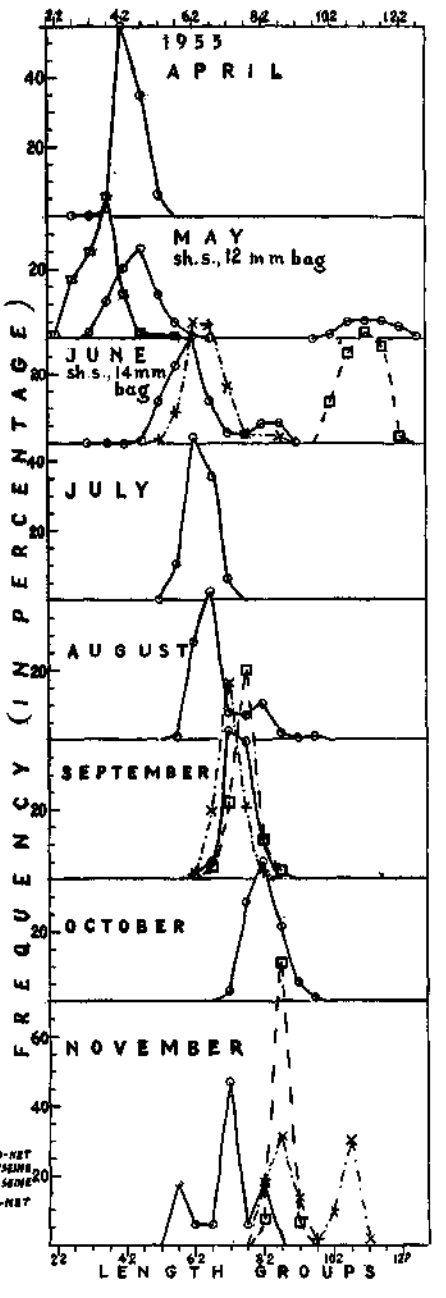

FIG. 4

FIG. 3. Size composition of the catches of *S. albella in* 1954. (sh .s. = shore-seine)

FIG. 4. Size composition of the catches of *S. albella* in 1955. (sh.s. = shore-seine)

Sardinella gibbosa

The 1952 *season.*—Boats with torches and hand-nets commenced operations in April, their landings showing a modal size of 35–39 mm. The succeeding length-groups were present in smaller numbers, but the fishermen continued fishing until the 60–64 mm. group also was caught to some extent. It must, however, be explained that *S. albella* was the major species represented in the catches at this time, and it is doubtful whether *S. gibbosa* alone could have sustained economical torch-fishing up to the 60–64 mm. stage. Shore-seines were dependent on the same modal sizes as the hand-nets in April, when they were using the 9 mm. bag. In May and June they were fitted with the 12 mm. bag. During these months both hand-nets and shore-seines were concentrating on the 0-year-class unlike the gill-nets which were taking 1-year-olds, represented by the modal size of 105–109 mm. in Fig. 5. The November and March samples were collected from the Gulf of Mannar coast and it will be seen that the gap between the major size-groups of the landings of shore-seines and gill-nets was considerably reduced during this period.

The 1953 *season.*—The first modal size-group taken by shore-seines during this season was 40–44 mm.; this was in May when they were fitted with the 12 mm. bag. Samples of boat-seine catches obtained during this month contained a mixture of yearlings and underyearlings. Another notable feature of this season was the use of gill-nets in the fishery in September (Fig. 6). However, gill-net fishing was very irregular, and their landings could not be sampled in October and November. The data for the period, December 1953 to March 1954, represent *choodai* from the Gulf of Mannar fishing grounds. A study of the curves in Figs. 6 and 7 will show that from September onwards, both gill-nets and shore-seines were fishing sardines of the 1953 year-class. Here again, as in the case of *S. albella*, a distinct, though minor, difference is seen in the major size-groups taken by the two types of gear, which cannot be explained entirely in terms of mesh-selection, but is perhaps also attributable to an uneven distribution of the length-groups in the coastal and offshore fishing grounds.

The 1954 *season.*—During this year young sardines occurred in such abundance as to support torch-fishing for the first three months of the season, *viz.*, April, May and June. At the time when the hand-net activities came to a close, *S. gibbosa* had a modal size of 45–49 mm. At Dhanushkodi the 1953 year-class made a minor contribution to the catches of shore-seines during the April to June period, but at other centres their landings were composed entirely of the 1954 year-class. It was perhaps

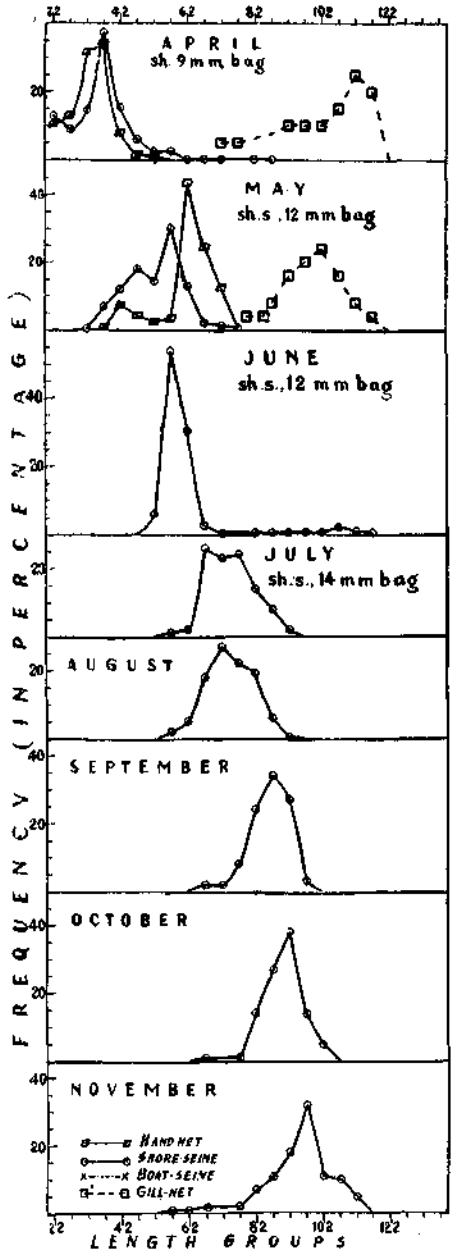

FIG. 5

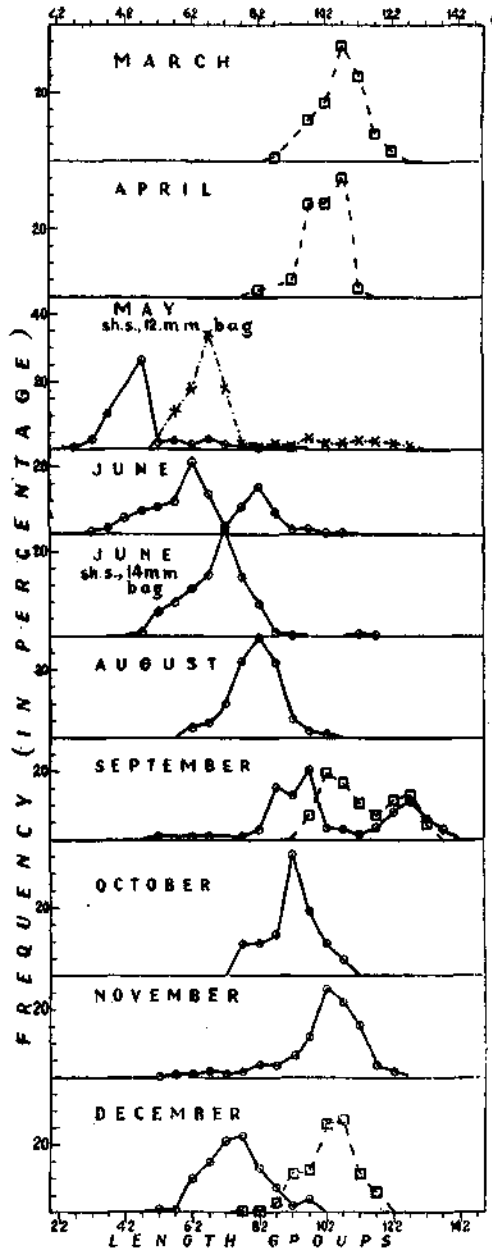

FIG. 6

FIG. 5. Size composition of the catches of *S. gibbosa* in 1952. (sh.s. = shore-seine)

FIG. 6. Size composition of the catches of *S. gibbosa* in 1953. (sh.s. = shore-seine)

the same year-class that was taken by the boat-seines in April, with this difference that the principal length-group caught by them was a longer sized group than that collected by shore-seines. From April to June, gill-nets were fishing 1-year-old sardines. From July onwards, all the three types of gear were operating on the 1954 year-class, though on different modal sizes. (Fig. 7).

The 1955 *season.*—In torch-fishing, the 35–39 mm. group dominated in the first half of May and the 50–54 mm. group in the second half. After the last week of May torch and hand-net boats did not go out to fish, as the returns were unprofitable. For about a week prior to the 15th of May and for another week after that date, fishing by shore-seines and hand-nets was practically at a standstill, which partly explains the occurrence of two modes for the 1954 year-class in that month (Fig. 8). The third mode noticed in the sizes taken by shore-seines was due to the presence of the 1954 year-class in the Dhanushkodi catches. From September onwards the catches of the shore-seines, boat-seines and gill-nets were composed mainly of the 0-year-class.

From a critical study of the data presented above, it will be apparent that the age-composition of the catches of *S. gibbosa* follows the same pattern as in *S. albella.* In *S. gibbosa*, however, the maximum modal size represented in the landings at the close of torch-fishing was 60–64 mm., while for *S. albella*, it was 45–49 mm. But this, of course, does not mean that *S. gibbosa* by itself would support torch-fishing on a commercial scale up to its 60–64 mm. stage, as the major proportion of the catches is contributed by the other species. Shore-seines, the main gear operated for *choodai*, catch mainly the 0-year-class, although a minor proportion of their landings at Dhanushkodi is contributed by 1-year-olds. From about March to July or August, the gill-nets take only 1-year-olds, but from September onwards they take the 0-year-class. Boat-seine landings consist of a mixture of 0-year-olds and 1-year-olds, the former being more abundant.

Height of Sardinella *spp. in relation to length.*—As has been mentioned earlier, the assumption here is that the 50% release length is that particular size of the fish at which its maximum body height equals the maximum diagonal measurement of the mesh. This rule, of course, would not always apply, as will be shown later. However, from the point of the theory of mesh-selection it is important to know the relation between the height and length. Table II gives the values for height corresponding to the various size-groups entering the fishery.

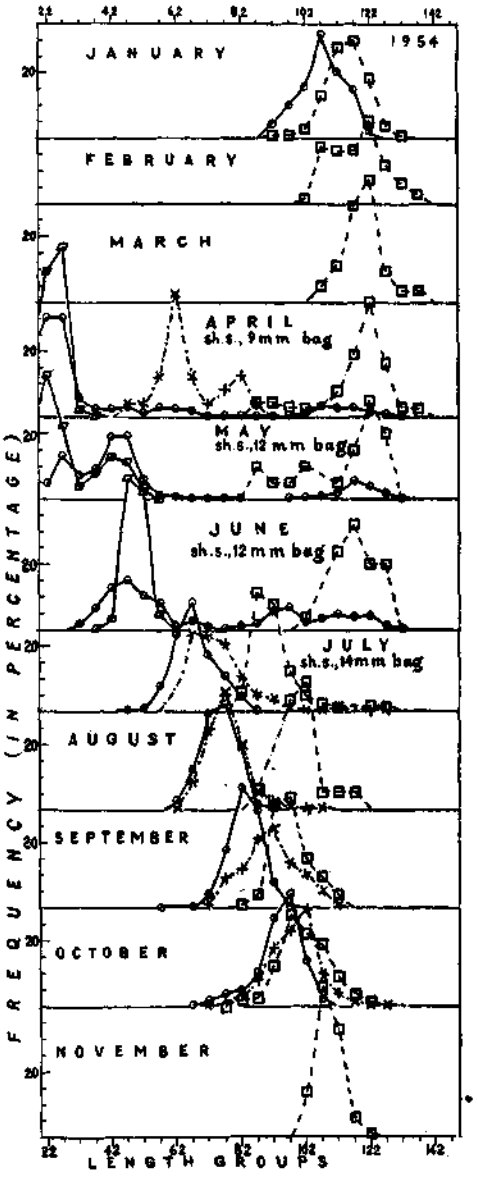

FIG. 7

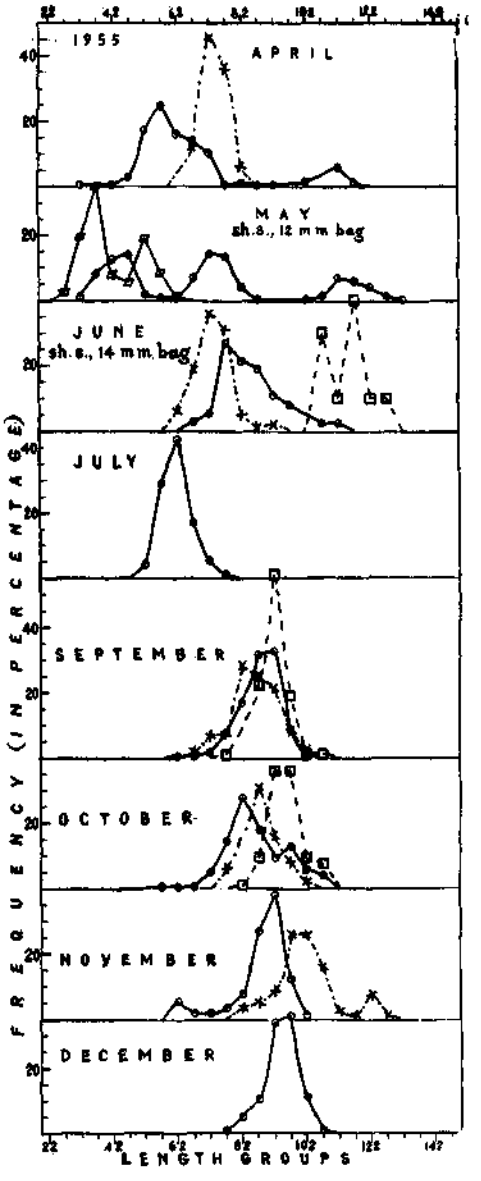

FIG. 8

HAND-NET
SHORE-SEINE
BOAT-SEINE
GILL-NET

FIG. 7. Size composition of the catches of *S. gibbosa* in 1954. (sh.s. = shore-seine)

FIG. 8. Size compo sition of the catches of *S. gibbosa* in 1955. (sh.s. = shore-seine)

TABLE II

Length-height relation in Sardinella *spp.*

Size-groups (in mm.)	*S. albella*			*S. gibbosa*		
	No. of fish examined	Average length (in mm.)	Average height (in mm.)	No. of fish examined	Average length (in mm.)	Average height (in mm.)
20– 24	71	23·2	5·5	86	22·6	4·6
25– 29	287	27·0	6·8	136	27·1	6·0
30– 34	454	31·9	8·2	316	32·9	7·6
35– 39	436	36·8	9·5	566	36·8	8·7
40– 44	244	41·9	11·3	263	41·7	10·1
45– 49	196	46·7	12·7	161	46·5	11·5
50– 54	132	51·8	14·2	93	52·1	12·8
55– 59	138	57·4	15·8	231	57·3	13·8
60– 64	351	62·4	17·1	161	61·4	14·9
65– 69	631	67·1	18·7	50	67·0	16·8
70– 74	434	71·6	20·3	52	72·0	18·1
75– 79	88	76·1	21·8	69	77·1	19·3
80– 84	20	82·0	24·6	70	81·7	20·5
85– 89	19	87·3	27·4	37	86·4	21·5
90– 94	12	93·4	29·2	31	92·4	22·7
95– 99	7	97·0	31·1	38	96·5	23·8
100–104	16	101·6	33·5	20	101·8	25·6
105–109	42	107·0	35·3	22	106·7	27·2
110–114	33	111·8	37·5	7	111·7	29·3
115–119	7	116·3	38·8	20	117·5	31·1
120–124	5	122·8	42·5	23	121·8	32·0
125–129	..	..	..	19	126·5	33·2
130–134	..	..	..	9	131·7	34·6
135–139	..	..	..	2	136·7	34·6

It will be seen that the increase in height is not directly proportional to increase in length.

Theoretical 50% release length.—The mean diagonal sizes of the meshes of the various nets and the expected 50% release lengths are indicated in Table III.

TABLE III

Theoretical 50% release length

Net	Mesh-size (in mm.)	Theoretical 50% release length of	
		S. albella (in mm.)	*S. gibbosa* (in mm.)
Hand-net ..	8·5	33 (30–34)	36 (35–39)
Shore-seine ..	9·0	35 (35–39)	38 (35–39)
	12·0	44 (40–44)	49 (45–49)
	14·0	51 (50–54)	58 (55–59)
Boat-seine ..	16·5	60 (60–64)	66 (65–69)
Gill-net ..	26·0	83 (80–84)	103 (100–104)

As the size-composition of the catches has been analysed in terms of frequencies in 5 mm. size-groups, it is obviously necessary, for purposes of comparison, to indicate the size-groups in which these theoretical release lengths would fall. These are shown within brackets in Table III. With increase in length beyond these values, a fish will have diminishing chances of escape from a mesh, but as Buchanan-Wollaston (1927) observes, " the size at which all the fish are retained is very indefinite". However, above the 50% release length, a series of hauls could, for all practical purposes, be regarded as representing the size-groups available in the waters fished, provided mesh-size is the only determining factor. This should especially be true of the catches of bag-type nets, though in the case of gill-nets there is an upper limit to the range of sizes they can take. In other words, the modal size caught in a net should, under ordinary circumstances, either coincide with or exceed the calculated 50% point. The two values should be expected to coincide at the time when a year-class first enters the catches of a net. A comparison of the modal lengths observed and expected at the time when a net first samples a year-class commercially would be interesting in this connection.

Size of year-classes of S. albella *when first caught in various nets.*—The dominant size-groups of *S. albella* of the 1952–55 year-classes at the time of their first entry into the catches of the various nets are shown in Table IV.

TABLE IV

Modal sizes of the year-classes of S. albella *when first seen in the catches of various nets (Mesh-size given within brackets)*

Nets and mesh-size (in mm.)	Year-classes				Expected modal size (*i.e.*, the theoretical 50% release length) (in mm.)
	1952 (in mm.)	1953 (in mm.)	1954 (in mm.)	1955 (in mm.)	
Hand-net (8·5)	30–34	..	25–29	35–39	30–34
Shore-seine (9)	35–39	..	25–29	..	35–39
Shore-seine (12)	50–54	40–44	40–44	45–49	40–44
Shore-seine (14)	65–69	65–69	50–54	60–64	50–54
Boat-seine (16·5)	..	60–64	60–64	70–74	60–64
Gill-net (26)	..	90–94	70–74	75–79	80–84

It will be seen that in some cases the year-classes entered the catches of a net at a modal size well below the expected level. The same phenomenon has been noticed in controlled fishing experiments with nets of various mesh-sizes elsewhere (Lucas *et al.*, 1954; Graham, 1954). It must be remembered here that the 50% release length is only a convenient index of the selective properties of a net, and that the percentage of capture beneath this level does not fall off abruptly to zero, but only diminishes gradually, possibly to an indefinite point (Buchanan-Wollaston, 1927). The chances are that many individuals below the 50% point would be retained by the mesh, the magnitude of the catch depending on their real abundance in the area fished. Some amount of deviation from the calculated values has also to be expected because of errors inherent in the methods adopted. When meshes were measured, they were stretched to the maximum possible extent, with the sides lying almost parallel to each other, but it is only rarely, if ever, that such conditions are realised during actual hauling of the nets. The meshes would hardly be limp and loose at that time; on the other hand they remain quite taut and strained, and there would quite probably be a reduction in their effective diagonal size (also Lucas *et al.*, 1954). Variations

in the length of the hauls have also to be taken into account. According to Gulland (1956), variations in selectivity occur from haul to haul, and " these are in part due to the length of the haul—the longer the haul, the more fish escape and the higher the 50% point". Again, clogging of the meshes by large fish would reduce the chances of the young fish to escape. Hence, even if the expected 50% release point of a net is slightly above the modal sizes available in a particular area, fishing by such a type of net would still be a commercial proposition if there is sufficient abundance of fish in that locality. In the fishery for *S. albella* a difference of about 10 mm. is often seen between the two points (Table IV). But if the modal size actually observed in the catches of bag-type net is above the theoretical limit, it evidently gives a reliable picture of the stock position in the area at the time of fishing. Instances of this type have also been recorded, as shown in Table IV. The indication here is that the operation of the particular net could profitably have been begun earlier.

Comparison of size-groups that were retained by shore-seines with the size-groups that escaped.—During the 1954 season, a comparative study was made of the size-groups that escaped from the shore-seines when the bag was nearing the shore, with others which were caught in the bag and in the wings (Fig. 9). The author recognizes the fact that for a full and proper investigation of this aspect, it is necessary to undertake fishing experiments under controlled conditions. But owing to various difficulties these could not be carried out. The best alternative currently practicable, was to collect the fish which escaped in large numbers from the bag when it was about to be hauled ashore. The claim, of course, is not made that the collections thus made represented all the size-groups which were released from the bag, because the small sizes probably begin to escape from the time when hauling starts. In Table V the modal sizes of escaping fish are compared with those found inside the bag and in the wings (14 mm. mesh), and the theoretical 50% release lengths of the various meshes.

As far as could be made out when the bag was about to be hauled ashore, *S. albella* small enough to escape from the net was present in the coastal waters only in April, May and June. The modal size of the released fish was always smaller than that caught in the bag. During the other months very few sardines could be seen escaping from the net. But the surprising point was that fish present in the bag and in the wings had the same modal length, even though these two parts of the shore-seines had different mesh-sizes during the April to June period. This obviously indicates the absence or scarcity of larger sizes in the nearshore waters and the abundance of the

TABLE V

Modal size-groups of S. albella *which were released by shore-seine bags, and those that were caught in the bag and in the wings (in mm.)*

Months	9 mm. bag			Wings (14 mm.)		12 mm. bag			Wings (14 mm.)		14 mm. bag			Wings (14 mm.)	
	Modal size of fish released by bag	Modal size of fish inside bag	Theoretical 50% release length of bag	Modal size of fish caught	Theoretical 50% release length of wings	Modal size of fish released by bag	Modal size of fish inside bag	Theoretical 50% release length of bag	Modal size of fish caught	Theoretical 50% release length of wings	Modal size released by bag	Modal size of fish inside bag	Theoretical 50% release length of bag	Modal size of fish caught	Theoretical 50% release length of wings
April ..	20–24	25–29	35–39	25–29	50–54	..	..	..	..	..	..	..	..	..	..
May ..	..	..	..	..	..	25–29	40–44	40–44	40–44	50–54	..	..	..	..	..
June ..	..	..	..	..	..	35–39	40–44	40–44	40–44	50–54	..	..	..	..	..
July ..	..	..	..	..	..	..	..	..	..	..	..	50–54	50–54	50–54	50–54
August ..	..	..	..	..	..	..	..	..	..	..	..	55–59	50–54	55–59	50–54
September ..	..	..	..	..	..	..	..	..	..	..	..	60–64	50–54	60–64	50–54

younger ones. It has to be explained here that the fish entangled in the wings constitute only a very small percentage (less than 0·5) of the total landed by the shore-seines. The main part of the net that traps the fish is the bag. From June onwards, the major size-group caught in the bag coincided with or exceeded the expected 50% release size. The conclusion seems legitimate that from that time onwards shore-seines were sampling the stock of juveniles in the coastal waters adequately.

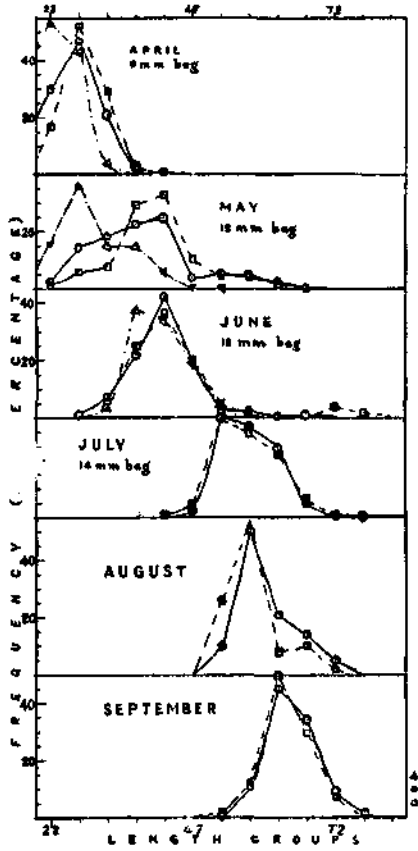

FIG. 9

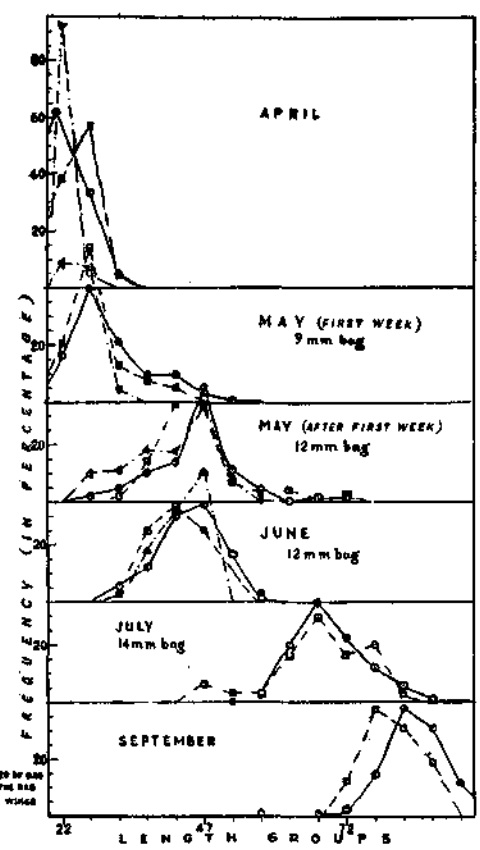

FIG. 10

FIG. 9. Size composition of *S. albella* collected from various parts of shore-seine in 1954.

FIG. 10. Size composition of *S. gibbosa* collected from the various parts of the shore-seine in 1954.

Sardinella gibbosa

Size of the year-classes when first caught in various nets.—Table VI shows the modal sizes at which the year-classes 1952–55 first entered the catches of the various nets.

TABLE VI

Modal sizes of the year-classes of S. gibbosa *when first seen in the catches of various nets (Mesh-size given within brackets)*

Nets and mesh-size (in mm.)		Year-classes				Expected modal size (*i.e.*, the theoretical 50% release length) (in mm.)
		1952 (in mm.)	1953 (in mm.)	1954 (in mm.)	1955 (in mm.)	
Hand-net	(8·5)	30–34	..	25–29	35–39	35– 39
Shore-seine bag	(9)	35–39	..	25–29	..	35– 39
	(12)	60–64	40– 44	45–49	45–49	45– 49
	(14)	65–69	60– 64	65–69	60–64	55– 59
Boat-seine	(16·5)	..	65– 69	60–64	70–74	65– 69
Gill-net	(26)	..	100–104	85–89	90–94	100–104

As stated earlier, the expected modal length at which an year-class first enters the catches of a net would be the theoretical 50% release point. In actual fishing operations some deviations were noted. The reasons for this have been explained earlier in the section on *S. albella*.

Sizes which were retained by shore-seines and which were released.—As in the case of *S. albella*, samples were collected of (1) fish that escaped from the bag when it was nearing the shore and (2) those caught in the bag and in the wings. Table VII and Fig. 10 give the modal sizes of the different categories.

An interesting point noted was that both the escaping fish and those which were retained in the bag had the same modal length (20–24 mm.) in April, while the group expected inside the bag was 35–39 mm. The catches were even then profitable, which shows the extent to which young fish had concentrated in the coastal waters. From the second week of May onwards, the major length-group recorded inside the bag either coincided with or exceeded what was determined in advance.

Relation between size-groups released by shore-seines and those caught by hand-nets.—A comparison was made during the 1954 season of modal sizes of *Sardinella* spp. released by shore-seines and those taken by torch and hand-net boats. Table VIII shows the results.

TABLE VII

Modal size-groups (in mm.) of S. gibbosa *which were released by shore-seine bags, and those that were caught in the bag and in the wings*

Months	9 mm. bag			Wings (14 mm.)		12 mm. bag			Wings (14 mm.)		14 mm. bag			Wings (14 mm.)	
	Modal size of fish released by bag	Modal size of fish inside bag	Theoretical 50% release length of bag	Modal size of fish caught	Theoretical 50% release length of wings	Modal size of fish release by bag	Modal size of fish inside bag	Theoretical 50% release length of bag	Modal size of fish caught	Theoretical 50% release length of wings	Modal size of fish released by bag	Modal size of fish inside bag	Theoretical 50% release length of bag	Modal size of fish caught	Theoretical 50% release length of wings
April ..	20–24	20–24	35–39	25–29	55–59	..	..	..	..	..	..	..	..	..	..
May ..	20–24	25–29	35–39	25–29	55–59	45–49	45–49	45–49	45–49	55–59	..	..	..	..	..
June ..	..	..	..	..	..	45–49	45–49	45–49	40–44	55–59	..	..	..	..	..
July ..	..	..	..	..	..	..	..	..	..	..	..	65–69	55–59	65–69	55–59
August ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
September ..	..	..	..	..	..	..	..	..	..	..	..	80–84	55–59	75–79	55–59

TABLE VIII

Modal sizes of Sardinella *spp. released by shore-seines and those caught by torch and hand-net boats*

Months	*S. albella*		*S. gibbosa*	
	Modal size-group released by shore-seines (in mm.)	Modal sizes caught by hand-nets (in mm.)	Modal sizes released by shore-seines (in mm.)	Modal sizes caught by hand-nets (in mm.)
April ..	20–24	25–29	20–24	25–29
May ..	25–29	25–29	20–24 (1st week)	20–24 (1st week)
			45–49 (After 1st week)	40–44 (After 1st week)
June ..	35–39	35–39	45–49	45–49

A close approximation was usually found between the two. Torch fishing in effect expresses the density of the stock of young fish; so also does the release of young fish by shore-seines. At least because of the difference in mesh-size, a correspondence between the two modal size-groups is only to be expected. It may be of interest to add here that during the season referred to above, both torch-fishing and the release of young fish from shore-seine bags extended over the same period, April to June.

Other factors that influence the size-composition of catches.—Foremost among these are the fishing methods themselves. The methods employed sometimes result not only in the concentration of effort on certain size-groups but also in the total exclusion of others from the catches. Torch-fishing is an illustration of the point in question. Success here depends upon the attraction of young fish to a source of light. When a torch is lighted near a spot where young sardines are shoaling, they gather around the boat and even jump towards the light; the hand-net transfers them to the canœ. Each complete operation of the hand-net (dipping in water, taking out and emptying) takes only a few seconds, and it can very well be imagined that the length-groups comprising the catch would reflect more the size-composition of the shoal than the effect of mesh-selection (*vide* Gulland, 1956, for relation between the length of haul and size-composition of catch). This should explain

the demonstrated difference between the expected and observed modal sizes of the catches of torch and hand-net boats. Reference to Figs. 1–8 will show that the largest modal sizes taken by hand-nets were 45–49 mm. in the case of *S. albella* and 60–64 mm. in the case of *S. gibbosa*. It remains to be seen whether larger sizes of *choodai* could be caught with the aid of brighter lights or coloured ones.

From August or September onwards, to about February, the modal size-groups of gill-net landings increases, at least to some extent; but from February to about July it remains more or less the same. Thus selection would appear to be sharp during one period and not so during another. This might perhaps be related to the way in which sardines get entangled in gill-nets. Buchanan-Wollaston (1927) states that "catchableness is not a continuous function of size, but has certainly two points of discontinuity, one caused by the presence of gill-covers coupled with the greater hardness of the head than the body, the other by the presence of the two angles of the maxillæ which form a kind of barb. The effect of these two 'barbed' points, and particularly of the latter mentioned, is to produce multimodal selection." In gill-nets sardines may also be caught at a third point, namely, between the operculum and the dorsal fin. The height of the sardines decreases from the region of the dorsal fin to the maxillary point. Hence compared to sizes taken at the region of the dorsal fin, those caught at the other two points should be progressively larger. The change in mode noticed during the August to February period is perhaps the result of some such shift with regard to the region of the body by which the sardine gets entangled in the net. Whether trapping of fishes at the maxillary region occurs in commercial catches, is open to question. The author's observations in the field have seldom shown sardines entangled in the net by the maxillary "barb". Gill-net activity during the February to July period seems to depend on trapping of the sardines at the opercular region only, because of which the modal size-classes of their landings remain more or less stationary. Undoubtedly deviations would occur owing to factors that operate against the law of mesh-selection. However, the largest modal length-group that can be taken through trapping at this point, can be calculated, employing the same procedure as before. Table IX gives the height of the head along the line of the joint between the opercle and preopercle in sardines of the length-groups which are relevant here. The size-groups corresponding to a head-height of 26 mm. (mesh-size of gill-nets is 26 mm.) are 115–19 mm. for *S. albella* and 135–139 mm. for *S. gibbosa*. These calculated maxima of sizes equalling the dimensions of the mesh of gill-nets would have been still smaller, if the height of the head

TABLE IX

Relation between length and head-height in Sardinella *spp.*

Size-groups (in mm.)	*S. albella*			*S. gibbosa*		
	No. of fish examined	Average length (in mm.)	Average height of head (in mm.)	No. of fish examined	Average length (in mm.)	Average height of head (in mm.)
80– 84	7	82·7	18·6	..	..	..
85– 89	17	87·4	19·4	..	..	..
90– 94	9	93·0	20·6	..	..	..
95– 99	6	97·0	21·5	..	..	..
100–104	12	101·4	22·8	9	101·7	20·1
105–109	30	107·3	24·0	11	107·1	21·1
110–114	21	111·7	25·2	4	112·3	22·4
115–119	6	116·5	25·6	19	117·6	22·7
120–124	4	123·5	27·9	23	121·8	23·7
125–129	..	..	..	19	126·5	24·2
130–134	..	..	..	9	131·7	25·1
135–139	..	..	..	2	136·5	26·3

had been measured at the region of the free margin of the operculum. But the readings were taken at the line of the joint between the preopercle and opercle with a view to determining the theoretical maximum modal size than can be caught by gill-nets at the opercular region of the fishes. The largest modal length-groups observed so far in gill-net landings were 110–114 mm. in the case of *S. albella* and 125–129 mm. in the case of *S. gibbosa*.

Hodgson (1927) found from his experiments with drift-nets of different mesh-sizes that they were very sharp in selection. The modal length caught was different in each case; the bigger the mesh the larger was the mode. There were also variations in the size-ranges of the landings. Because of sharpness in selection, it is apparent that a proper evaluation of the avail-

ability of larger individuals in the population cannot be undertaken from an analysis of the catches of the gill-nets used in the *choodai* fishery at present. Discussing the results of their experiments with gill-nets of different mesh-size in the fishery for *Lucioperca*, Havinga and Deelder (1949) state that " the close correlation between the size of the mesh and the length of the fish caught implies that with commercial nets that are generally used, only very few large fish are caught".

Differential distribution of size-groups.—The fact that the modal length of gill-net catches remains more or less stationary during the February to July period could, of course, be explained as showing that these nets are not operated in areas frequented by sardines of larger size. The author, however, favours the view already advanced above. That there is a real differential distribution of the size-groups will be evident if a comparison is made between the length-groups taken by gill-nets and shore-seines. During the March to July period when the bigger length-groups representing 1-year-olds enter the catches of gill-nets which are operated 5–6 miles offshore, they are absent from the landings of shore-seines at all centres except Dhanushkodi where the coastal waters are deeper than at other places. It has already been stated before that shore-seines are used within a belt of 1 to 1½ miles from shore. Even during the other months some differences were noticed between the size-groups that constituted the catches of the two nets. Perhaps as the sardines grow beyond a particular length they tend to prefer deeper waters further off the shore.

Discussion

The procedure adopted here of regarding the diagonal size of the mesh and the height of the body of sardines as factors determining selection perhaps introduces some error in the theoretical calculation of the release lengths of a net. The reasons for taking the diagonal size instead of the circumference of the mesh have been explained before. Apparently, instead of the mean size, the modal size of the mesh could have been taken into account. It was however feared that this might lead to complications in procedure, since the frequency curve for mesh-size is often flat or nearly so at the top. Even in such cases a mode could perhaps have been found, but then for fixing its value it would have been necessary to examine a large number of meshes with doubtful advantage. Moreover, though the meshes of a net, as a rule, conform to a particular standard, deviations to occur, as was witnessed by the author on 13–9–1955 when he examined the meshes of 10 boat-seines. The maximum diagonal size of the various units on that

day ranged from 13·5–21·5 mm. with different modal diagonal sizes occurring in different nets. Many of these difficulties could be obviated by comparing the length-frequency of catches with the mean size of the meshes for a particular period. The close approximation seen between the expected and observed modal size-distribution when a year-class first enters the catches of the various nets is sufficient proof of the soundness of the method. On the other hand, the 'mean' shows only the point of selection and does not indicate the range of values to be expected on either side of this point.

An important aspect to be considered when investigating selection is the tendency of fishes to shoal in particular size-ranges. If a shoal is dominated by a length-group a little below the selection point of a net, the latter might still take that size because of various factors that operate against the law of mesh-selection. The amount of catch would of course be determined, among other things, by the number of fish constituting the shoal, the extent to which the meshes are clogged, and the method of fishing (for instance, fishing with torches). For a proper study of mesh-selection and the differential distribution of length-groups, experimental fishing has to be undertaken, but on account of limited facilities this could not be attempted in the course of the present investigation. The various limitations notwithstanding, the present study, it was hoped, would yield some results of importance to the industry.

About 95% of the total catches are at present composed of the 0-year-class. The question naturally arises as to whether the fishing folk should not attach more importance than they have done hitherto to older age-groups. Here, account has to be taken of the fact that about 90% of the total catches are landed by shore-seines and that, as far as could be seen in the course of the present study, sardines more than about a year old rarely frequent the fishing grounds of these nets, which lie within a belt of 1–1½ miles from the shore. It still remains to be investigated whether an increase in the proportion of older fishes in the stock could be obtained by restricting the capture of the underyearlings.

As has been pointed out earlier, the contribution made by boat-seines forms only a negligible element (less than 0·5%) of the total *choodai* production. These nets are operated mainly for *Leiognathus*; their landings also include *Lactarius*, Carangids, Sciænids, *Upeneus*, prawns and *Dussumieria*. Evidently, the technique of fishing with boat-seines in the Mandapam area is adjusted for catching fishes that cannot strictly be called surface-dwelling types, as for instance, sardines. They catch *choodai* more by accident than by intent. It will be interesting to recall in this connection

that off Malabar, boat-seines account for a good proportion of the sardine landings.

From the analysis of the size-frequency of catches, it is seen that during the period March to about July, gill-nets normally capture 1-year-olds, while shore-seines capture mainly the 0-year-class. Therefore at least as far as the fishery of this period is concerned, there is little to confirm the apprehension of the shore-seine men that the use of gill-nets is detrimental to their trade. It is of course possible that the latter, if operated just outside the fishing range of the shore-seines, might diminish to some extent the approach of the young fish to the coastal waters, but experimental fishing coupled with a comparison of the catch-per-unit-of-effort of the two nets is essential for establishing this point. On the other hand, from August to about February, since the catches of both types of nets are supported by the same year-class there is room for some misgiving on the part of the shore-seine men, but the point can be settled only through controlled experimental fishing.

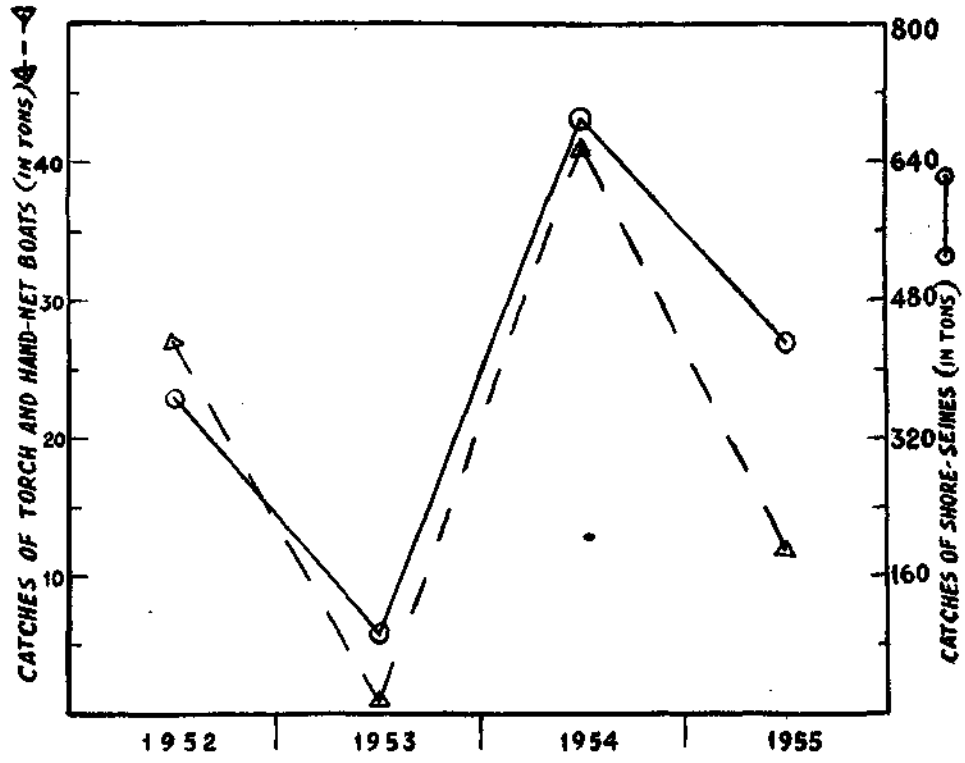

FIG. 11. Relation between the catches of torch and hand-net boats at Munakkad and the catches of shore-seines at Thedai and Pullamadam during the years 1952-55.

The author has been making a detailed study of the fishery at three important centres, namely, Munakkad, Thedai and Pullamadam. At Munakkad, fishing is done only by torch and hand-net boats, and the total number of boats operating there is twelve. The last two are centres where *choodai* are caught exclusively by shore-seines, the total number of nets amounting to 13. In Fig. 11, a comparison is made between the total *choodai* landings recorded by the torch and hand-net boats at Munakkad and by the shore-seines at Thedai and Pullamadam, during the seasons 1952–55.

The two curves are closely parallel; the correlation would probably have been greater if the catch-per-unit-of-effort, instead of the total catches, had been compared. This, being beyond the scope of this paper, is not attempted here. Unfortunately, data on gill-net landings were not complete and hence could not be presented here. At present, the status enjoyed by boat-seines in the industry is not significant, while shore-seines and hand-nets account for about 95% of the total production. As the fishery is prosecuted at a time when the sardines are in a state of rapid growth, it is necessary, in future, to undertake an investigation of the contribution made by the different size-groups. Equally important should be the periodical check-up of the meshes of the various nets.

Summary

The types of boats and gear employed in the *choodai* fishery, the mesh-size of the various nets, the approximate periods when they are used and the location of their fishing grounds are described. The fishery is supported by two species, *viz.*, *Sardinella albella* and *S. gibbosa*.

Boats using torches and hand-nets operate mainly on the smaller length-groups of the 0-year-class. Shore-seines also depend mainly on the 0-year-class at all centres except Dhanushkodi, where a small proportion of their catches includes 1-year-olds. Gill-nets fish 1-year-old *Sardinella* spp. from March to about July, but from August or September onwards they also fish the 0-year-class. Boat-seines land mainly sardines of the 0-year-class, but very often their catches include older fishes as well.

The modal sizes at which the 1952–55 year-classes first entered the catches of the various nets are indicated. These are correlated with the 50% release lengths derived from the diagonal sizes of the meshes and the height-length relation in *Sardinella* spp.

Modal lengths of fishes released by bags of shore-seines, retained inside the bags and caught in the wings are compared.

A comparison is made of the major size-groups taken by torch and hand-net boats and those released by shore-seines.

Other factors besides mesh-selection that might influence size-composition of catches are discussed.

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