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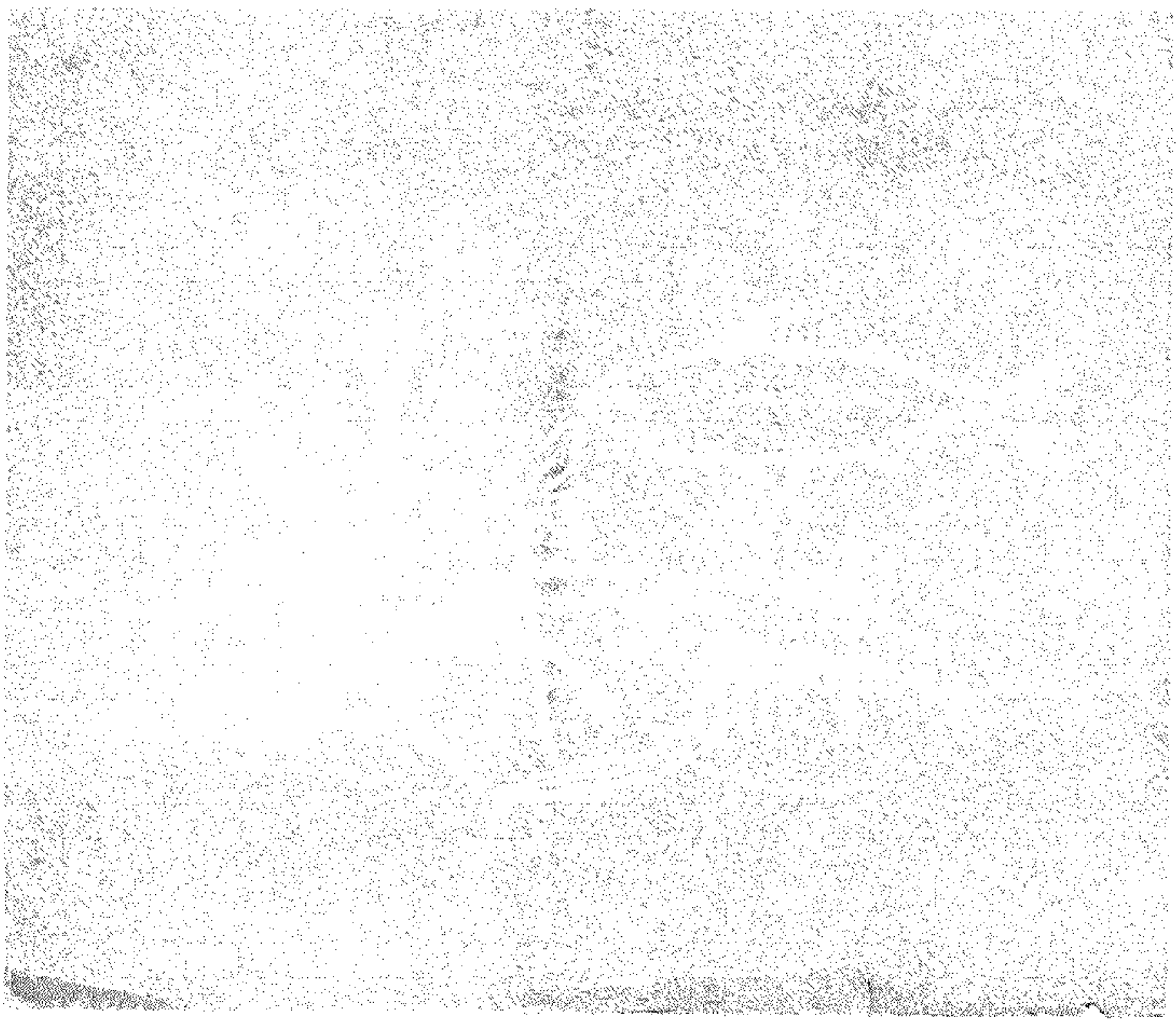
ON

LIVING RESOURCES *of* THE SEAS AROUND INDIA



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AN ASSESSMENT OF THE EXPLOITED PELAGIC FISHERIES OF THE INDIAN SEAS

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Abstract

About two-thirds of the total marine fish catch comes from exploited pelagic fisheries. The three most important pelagic fisheries are the oil sardine, mackerel and Bombay duck which together account for about 65 per cent of the yield from pelagic resources. The balance comes from other numerous pelagic stocks which are being exploited at present. A critical assessment of each of the exploited pelagic resources has been made in this paper in order to estimate the probable magnitude of potential yields derivable from them.

The Indian seas contain a wealth of pelagic fish stocks. A number of species of pelagic fish is found and exploited along both the coasts of India. Nearly two-third of the marine fish landings in India come from the pelagic fisheries. The average annual landings of pelagic fishes based on the data of 10-year period from 1958 to 1967 is estimated at 504,086 tonnes as compared to the average total landings of 764,820 tonnes. Detailed variety-wise landings are given in the Appendix. The average annual landings of various pelagic groups along with the percentage contribution of each of these groups is shown in Table 1.

Table I

The average annual landings (1958–67)

Groups	Landings (tonnes)	Per cent of total pelagic landings
Oil sardine	176,354	34·98
Bombay duck	81,009	16·07
Mackerel	58,781	11·66
Lesser sardines	36,241	7·19
White baits	26,514	5·26
Anchovies	6,562	1·30
Chirocentrus	7,140	1·42
Other Clupeoids	26,468	5·25
Ribbon-fish	29,017	5·76
Carangids	22,298	4·42
Seer-fish	9,514	1·89
Tunas	4,120	0·82
Bregmaceros	4,026	0·80
Sphyrraena	1,661	0·33
Mugil	1,412	0·28
Flying fish	2,295	0·45
Hemirhamphus	1,081	0·21
Miscellaneous	9,593	1·91
Total	504,086	100·00

Of the several pelagic groups mentioned above, oil sardine, Bombay duck and mackerel are single species groups. The group *Bregmaceros* also consists of a single species, while all the other groups consist of a number of species. Some of the groups are true pelagic forms, while some like Bombay duck are not truly pelagic but may be called neretic-pelagic forms. At present the exploitation of all the pelagic groups is confined to a narrow coastal belt due to severely restricted fishing limitations of craft used. But even in spite of this limitation, more than half a million tonnes of pelagic fish are landed on an average every year. It is therefore pertinent to examine the effect of current exploitation on the various pelagic fisheries. For a proper assessment of the effect of fishing on the various pelagic stocks, it is necessary to identify the unit stocks of various species and their limits of distributions. Unfortunately for most of the species, such information is absent. Then again for each unit stock, detailed information is necessary, so that estimates of various parameters of suitable yield equations such as that formulated by Beverton and Holt (1957) can be obtained. Excepting for one or two species, detailed data as required are not available.

When detailed data are available, Beverton and Holt model of estimating the optimum yield has been employed. In the absence of detailed information, the following approximate method has been used for the assessment of maximum yield from the currently exploited stocks.

If fishing affects the stock, then the following relation is expected to hold good:

$$Y/f = a - bf$$

where Y/f = catch per unit effort, f = fishing intensity, and a and b are constants.

The corresponding yield equation is given by

$$Y = af - bf^2$$

a parabolic form. This is somewhat similar to Schaeffer's (1953) approach.

Differentiating the yield equation and putting

$$\frac{dY}{df} = 0,$$

we get an estimate of maximum yield $Y_{max} = a^2/4b$ corresponding to the fishing intensity $f = a/2b$.

In this paper, assessments of various groups of pelagic fisheries as mentioned in Table I by using one or the other method has been made and they are given hereinafter separately for each group.

1. Oil Sardine Fishery

This fishery is based on a single species, *Sardinella longiceps*, and at present it is restricted to a narrow coastal belt on the west coast of India between Quilon in Kerala and Ratnagiri in Maharashtra. Stray catches of the species have, however, been obtained on the west coast outside the jurisdiction mentioned above and also on the east coast. The fishery generally starts in June–July and continues till March–April. The adult specimens make their appearance in the fishing area first, followed by juveniles in a couple of months' time. The fishery is characterized by a wide fluctuation in the annual catch. During the 10-year period from 1958 to 1967, the minimum annual catch was 63,647 tonnes in 1963 and the maximum 274,333 tonnes in 1964, the average annual catch during the period being 176,354 tonnes. Kesteven (1967) has stated " the prevailing view is that these fluctuations are caused by variations in accessibility of the stocks to the severely restricted fishing range of the gear in use at present and these variations in accessibility represent changes in the disposition of the migratory paths taken by the fish. It is thought that even maximum accessibility to existing gear brings only a proportion of the stocks under exploitation". Sekharan and Dhulkhed (1967) on the other hand feel that the annual catch fluctuations appear to be related mainly to the variations in the newly recruited year-class to the fishery.

The spawning season of oil sardine extends from June to October or even later, but there sappears to be two spawning peaks, one early in the season and another towards the end of the season. By considering the monthly length-frequency curves for several years from commercial samples collected at 5 different centres on the west coast and by arranging the monthly progressions of modal values of two main broods corresponding to the two peak spawning seasons, it has been possible to get a growth pattern of the fish for nearly 36 months. The commercial landings are always of fish above 10 cm. Bertalanffy's growth equation was fitted separately to the growth pattern observed at each place of observation. The statistical analysis did not show any significant difference between the growth equations obtained for different places. Hence a pooled equation was used. The estimates of the relevant parameters are obtained as follows:

$$l_\infty = 20 \cdot 66 \text{ cm},$$

$$k_0 = 0 \cdot 0440 \text{ (on a monthly basis)}$$

$$\text{and } t_0 = -15 \cdot 9800 \text{ months.}$$

The estimated sizes of oil sardine at the completion of 1, 2, 3 and 4 years of age on the basis of the fitted equation above are 14·6, 17·1, 18·6 and 19·4 cm respectively. These estimates closely agree with those of Balan (1968) who on the basis of growth check studies on scales has estimated the mean sizes at successive ages as 14·3, 16·4 and 18·6 cm respectively. Though there are other divergent views of sizes attained by the fish at successive ages (Nair, 1953), the estimates derived above have been used for the purpose of all other subsequent calculations.

Table II gives the relative abundance in numbers of the various year-classes represented in the commercial catch from the fishing seasons 1954–55 through 1965–66. The relative abundance is the catch per operation of Mathi kolli vala, which has been taken as the standard unit of effort.

TABLE II

Relative abundance of various year-classes in the commercial catch

Year	Relative abundance of year-classes			
	0–year	1–year	2–year	3–year
1954–55	20,628	1,503	40	12
1955–56	4,302	1,134	2,010	618
1956–57	7,443	611	943	989
1957–58	24,387	3,493	174	10
1958–59	7,621	13,287	3,940	29
1959–60	17,992	3,633	2,506	158
1960–61	30,335	8,668	1,459	91
1961–62	30,612	6,769	610	15
1962–63	17,051	4,156	495	..
1963–64	4,014	2,793	496	50
1964–65	44,970	802	2,089	228
1965–66	20,282	6,142	140	62

From Table II, it will be seen that there are great annual fluctuations in the newly recruited 0-year class and that the fluctuations in the annual catch depend on the strength of the newly recruited class. There are also some evidences of annual changes in the availability, though these were not of very high magnitude.

The total instantaneous mortality can be estimated by comparing the abundance of the same year-classes over successive fishing seasons. But as availability changes as well as changes of fishing intensity may affect such comparisons, the following slightly modified formula has been used for the estimation of Z:

$$Z = -\log_e \frac{(N_0 + N_1 + N_2)\,x}{(N_1 + N_2 + N_3)\,x + 1}$$

where N_i = the relative abundance of the *i*th year-class and the suffix x and $x + 1$ denote the two consecutive fishing seasons for which such comparisons have been made. Table III gives the values of estimated Z and corresponding values of fishing intensity for each fishing season:

TABLE III

Annual mortality and effort

Year	Estimate of Z	Effort (10^3 units)
1955–56	1·075	2,585
1956–57	0·896	3,804
1957–58	0·482	13,781
1958–59	1·374	4,011
1959–60	0·859	2,499
1960–61	1·699	8,057
1961–62	2·100	12,163
1962–63	1·872	8,147
1963–64	0·850	1,311
1964–65	2·020	10,980

By plotting the Z values against the effort figures, it is found that excepting for the point corresponding to the year 1957–58, all other points more or less fall in a straight line. Omitting the 1957–58 point and fitting a least square straight line through the other points, we get

$$Z = 0{\cdot}6717 + {\cdot}0001250 f.$$

This furnishes an estimate of natural mortality $M = 0{\cdot}67$. The fishing mortality F has thus varied from 0·18 to 1·33 with an average value of about ·75. The average Z during the period was thus 1·42. Sekharan and Dhulkhed (1967) by considering the decrease of the same year-class through 1957–58 to 1962–63 have estimated the total annual mortality rate "*a*" as 0·81, which is equivalent to $Z = 1{\cdot}66$. This estimate is not far different from the estimate of 1·42 obtained earlier in this paper.

Taking the values of $K = {\cdot}5028$ (annual basis), $t_\infty = 4$ years and $t_r = 3$ months $= 0{\cdot}25$ years, and $M = 0{\cdot}6717$, the values of Y/R were calculated from Beverton-Holt equation for various values of F. It was found that Y/R was maximum with a value of 0·173148 W_∞ at F = 1·40. During the period, the average F was 0·75 with a corresponding value of Y/R equivalent to ·152587 W_∞. This shows that further increase in fishing effort will not substantially increase the yield per recruit. The yield can at best be increased by 12% only.

It may be argued that the above calculations are biased since the same were based only on the available portion of the oil sardine stock in the narrow belt of fishing area exploited at present. Beverton and Gulland (1958) have made a study of the possible bias in the estimate of Y/R, when M is estimated from a partially exploited stock. They have stated that a complete understanding of the dynamics of a partially fished stock can be had if only information on the abundance and structure of the unfished part and on the exchange rate between the fished and unfished part are available. Theoretical studies, however, show that when a relatively small fraction of a population is heavily fished as may be the case in respect of oil sardine fishery at present, the tendency will be to overestimate M, which may perhaps lead to the conclusion that more fishing would produce greater yields, whereas, in fact the opposite would be true. They have, however, found out that when F is below 1·0, the estimate of Y/R based on simple model may not be unreasonable. Hence in case of partially fished stock, one has to be extremely careful in drawing conclusions. In the case of oil sardine fishery, the present estimate of F was about 0·75 and hence the conclusions drawn above may not be unreasonable. The maximum possible yield from inshore exploitation for oil sardine was calculated in another way. Taking the relation $Y/f = a - bf$, the least square values of a and b were estimated based on effort and catch data for the 10-year period from 1958 to 1967 separately for Mysore and Kerala, where more than 99% of the oil sardine catch were landed. Table IV gives the relevant results.

TABLE IV

Least square estimates of a *and* b *and* Y_{max}, F_{max}

	Estimates of				Average	
	a	b	Y_{max} (tonnes)	f_{max} (1000 m-hrs.)	Y (tonnes)	f (1000 m-hrs.)
Kerala	5·8910	0·00004972	174,497	59,241	153,087	48,311
Mysore	15·6727	0·00162426	37,807	4,824	21,269	6,884

From Table IV, it will appear that in Kerala, by increasing the fishing intensity by about 23%, it is possible to increase the catch by about only 14%. On the other hand in Mysore, the average maximum catch of 37,807 tonnes will be possible only if the present fishing intensity is reduced by about 30%. Taking both the states together, an increase of about 22% in the yield is possible, though it will require a close monitoring of fishing effort in the two States.

Both the methods of assessments point out clearly that only marginal increase over the present average yield is possible by any further increase of fishing intensity in the fishing area exploited at present. The possible increase is probably of the order of 20% over the current average annual landings.

2. Mackerel Fishery

Two species of mackerel, *Rastrelliger kanagurta* and *R. brachysoma*, have been recorded from the Indian waters. *R. brachysoma* occurs only in the Andaman Sea where it forms fishery of little importance. *R. kanagurta* is the predominant species in the Indian waters and occurs along both the west and east coasts, but the major fishery of *R. kanagurta* exists only along the west coast from

Quilon in Kerala to Ratnagiri in Maharashtra. The fishing season is generally from August to March, the season starting earlier in the southern portion of Kerala and extending later on to the northern parts of Mysore and above. The fishery starts with the arrival of mackerel shoals in the inshore waters where they are caught by boat-seines, shore-seines and gill nets. The fishery is subjected to great annual fluctuations and there appears to be some inverse relationship between the abundance of this species and oil sardine. The annual landings of mackerel varied from 23,862 tonnes in 1964 to 133,655 tonnes in 1960 and the average for the 10-year period from 1958 to 1967 was 58,781 tonnes forming about 11·66% of the total pelagic landings. The spawning season appears to be a prolonged one beginning by about April and lasting till September on the west coast. In the east coast the spawning appears to be during or after the north-east monsoon. The mackerel are pelagic fish occurring in shoals. The shoals usually move along the current of water at high tide. When there is a strong easterly wind, mackerel shoals come close to the shore through deeper layers of water and it is then that the fish are exploited at present. By following the modal values of different broods, it was possible to get a growth pattern of the fish. The fish is a very fast-growing one. The fish seems to attain a size of 21·5 cm at the completion of the first year of its life and a size of 24·0 cm at the second year of its life. Fitting a Bertalanffy's growth equation to the average size of the fish, we get the following estimates of the 3 parameters in the growth equation :

$l_\infty = 23{\cdot}9$ cm.

$t_0 = {\cdot}17$ years

$K = 4{\cdot}92$ (on yearly basis)

Though divergent views are still there regarding age-size relation of mackerel, the relation as found out in the above has been accepted in this paper for further calculation. Based on these, the relative abundance of fish in the different year-classes as obtained from the catch data at Karwar are given in Table V. The effort input in each year is also shown in the last column.

TABLE V

Relative abundance of various year-classes in the commercial catch at Karwar

Year	Relative abundance of year-classes			Estimate of Z	Effort (1000 units)
	0–year class	1–year class	2–year class and above		
1948–49	401·4	80·7	6·5	2·71	35·3
1949–50	507·0	27·4	4·7	1·51	19·4
1950–51	394·1	101·7	16·1	3·22	44·5
1951–52	356·8	18·5	1·3	2·41	36·1
1952–53	167·7	27·2	6·5	3·03	40·8
1953–54	336·2	9·4	..	1·35	39·3
1954–55	147·1	89·3	0·6	2·64	49·6
1955–56	94·3	15·0	1·8	0·94	51·4
1956–57	74·5	35·3	7·2	1·00	36·3
1957–58	480·0	39·1	1·4	1·31	47·6
1958–59	203·7	139·1	1·1	..	91·9
1959–60	..	..	..	..	..
1960–61	206·7	54·7	26·0	3·86	91·6
1961–62	36·1	5·4	0·1	0·51	17·6
1962–63	83·1	23·7	0·5	3·00	74·9
1963–64	732·4	30·6	0·4	0·71	16·5
1964–65	206·5	330·7	15·8	2·01	11·1
1965–66	43·1	42·9	29·0	..	6·4

From the figures of Table V, estimates of Z were obtained by applying the same formula as in the case of oil sardine, namely,

$$Z = -\log_e \frac{(N_0 + N_1)_t}{(N_1 + N_2)_{t+1}}$$

where the notations have the same meaning as before. The estimated Z's are shown in Table V. Plotting Z against f and fitting a least square line we get an estimate of M to be 0·65. The average Z during these years was 2·02. Thus the average F was about 1·37, *i.e.*, about 1·40.

By taking $t_\infty = 3\cdot0$ years, $t_\rho = 0\cdot25$ years, $K = 4\cdot92$, $t_0 = 0\cdot17$ and $M = 0\cdot65$, the values of Y/R were calculated for various values of F. The maximum value of Y/R is reached at $F = 1\cdot55$, the value being $0\cdot4080\ W_\infty$. The value of Y/R corresponding to present average value of $F = 1\cdot40$ is $0\cdot4072\ W_\infty$. Thus we are almost exerting the maximum fishing effort and are nearer to the optimum yield, and further increase in fishing effort in the fishing area exploited at present may fetch only marginal increase in catch. The maximum possible yield was also calculated from the catch and effort data for each state by fitting the relation

$$Y/f = a - bf.$$

In the case of Kerala, the maximum Y_{max} was found to be about 63,000 tonnes corresponding to the effort 224 million man-hours. The average input of effort at present is 48 million man-hours with an average catch of 23,970 tonnes. Thus the catch can be increased by about 2½ times by increasing the effort by more than 4 times. In Mysore, the estimate of b was found to be +ve. The present input of effort in Mysore is about 6·9 million man-hours. A marginal increase of effort to 7·0 million hours will produce on an average 27,600 tonnes as against the present average of 26,000 tonnes.

Beverton and Holt model of analysis shows that very little increase in Y/R is possible by further increase in effort. On the other hand, the parabolic relation between catch and effort seems to indicate further increase in yield from inshore regions with further increase in effort. It is difficult to say which interpretation is correct. Banerji (1967) has shown elsewhere by considering the pattern of decrease in the abundance of mackerel in the inshore waters off Karwar within a fishing season, that catch could be further increased without affecting the stock by intensifying fishing effort.

It will thus be prudent at the present stage of knowledge to assume that the inshore catch cannot be increased by more than 25%. Thus the potential yield of mackerel from inshore waters may not be more than 85,000 tonnes.

3. Bombay Duck Fishery

This fishery consists of a single species *Harpodon nehereus*. The major fishery is along the Maharashtra and Gujarat coasts and some minor fisheries exist along the West Bengal, Orissa and Andhra coasts. The State-wise average landings based on landing figures from 1958 to 1967 are given in Table VI.

Bapat (1967) has shown by morphometric studies that Maharashtra stock of Bombay duck is different from that of Gujarat and the east coast stock differs more from any of the west coast stocks.

The fishing for Bombay duck begins by September after the south-west monsoon and remains in full swing up to the end of January on the west coast of India. The main fishing gear on the west coast is a stake bag net (*Dol*), though they are also caught in boat-seines, shore-seines and trawl nets. The fish moves away from the inshore waters by about February and reappears in big shoals by September–October.

TABLE VI

Average landings of Bombay duck

States	Landings (tonnes)
West Bengal and Orissa	309
Andhra	579
Maharashtra	28,034
Gujarat	52,070
Others	17
TOTAL	81,009

Bapat *et al.* (1952) have shown from length-frequency studies that the fish attains a length of about 127 mm. at the end of the first year and 217 mm. at the end of the second year. The commercial catches are constituted of fish in the size range of 60–270 mm. in total length, specimens of above 210 mm being about 18%.

For finding out the maximum sustainable yield from the exploitable stock, a and b of the relation $Y/f = a - bf$ were estimated from the catch and effort data of the various stocks. From these, the maximum sustainable yields were found out for the different unit stocks. The estimates of a, b and Y_{max} are shown in Table VII.

TABLE VII

Estimates of a, b *and* Y_{max}

States	Estimates of a	b	Y_{max}
West Bengal and Orissa	·020	+·0000036065	..
Andhra	·020	−·0000002237	447
Maharashtra	1·970	−·00002857	33,607
Gujarat	5·100	−·0001118	58,162

In West Bengal and Orissa, the estimate of b is positive indicating that catch per unit effort rises with increasing effort. This will mean that the present level of fishing exerts no influence on the stock at present and the catch could be safely increased by increasing effort. The present level of fishing is about 7 million man-hours. If the fishing intensity is increased to 12 million man-hours, an average of about 800 tonnes of Bombay duck could be expected as compared to the present average of 309 tonnes. In Andhra, the present catch seems to have exceeded the optimum catch which is about 450 tonnes. A slight reduction in fishing will be beneficial for the fishery. The estimated optimum catches from Maharashtra and Gujarat would together add to about 92,000 tonnes. Thus if the present method of exploitation within the coastal waters continues, a catch of more than 93,000 tonnes cannot be expected.

4. Lesser Sardine Fishery

Various species of *Sardinella*, other than *Sardinella longiceps*, are exploited along both the west and east coasts of India. Nine species of *Sardinella* are commonly recognized from Indian waters (Nair, 1955) but four species generally support the commercial fisheries. They are *S. albella*, *S. gibbosa*, *S. sirm* and *S. fimbriata*. The fishery for *S. sirm* is restricted to the extreme southern part of peninsular India but the fisheries of other 3 species often overlap one another in their areas of abundance.

The lesser sardine fishery commences in Maharashtra waters immediately after the south-west monsoon is over. The catches consist of *S. fimbriata* in the north and *S. albella* and *S. fimbriata* in the south and are caught by shore-seines and gill nets. In Goa and Mysore, *S. gibbosa* and *S. fimbriata* constitute the lesser sardine fishery. The season starts from September and lasts till February. Shore-seines, purse-seines, cast nets and gill nets are used for fishing. In Kerala, the same gear which exploit oil sardine are used for the lesser sardines from September to February. On the south-east of India, the lesser sardine fishery consists of *S. gibbosa* and *S. albella*. The fishery is aotive from April to October in Palk Bay and from November to March in the Gulf of Mannar. In the northern part of Madras coast, the fishery depends on *S. fimbriata* and *S. sirm* with a duration from December to April. In Andhra and Orissa, the fishery commences from October and lasts till January and depend on *S. gibbosa* and *S. fimbriata*. Thus 3 to 4 species support the lesser sardine fishery. Separate figures of landings by species are not available, neither the identities of unit stocks known. Table VIII shows the average landings of all lesser sardines for each State.

Table VIII

Average landings of lesser sardines

States	Landings (tonnes)
Orissa and West Bengal	1,442
Andhra	8,765
Madras	9,636
Kerala	12,564
Mysore	1,061
Maharashtra	2,437
Other places	336
Total ..	36,241

From Table VIII, it will be seen that sizable landings of lesser sardines take place in Andhra, Madras and Kerala. In these States as also elsewhere the lesser sardine fisheries are purely coastal fisheries and depend entirely on 0-year classes and nowhere in India exists a fishery of adults and spawners of lesser sardines.

For finding out the maximum yield that can be derived from the coastal stocks of lesser sardines, the relation $Y/f = a - bf$ was fitted separately for each State. In the absence of any knowledge of unit stocks, this appears to be the only feasible method of stock assessment. The results are given in Table IX.

TABLE IX

Estimates of a, b *and* Y_{max}.

States	Estimates of		Y_{max}
	a	*b*	
West Bengal and Orissa	0·384	−0·000023	1,606
Andhra	..	..	..
Madras	0·588	−0·000007	12,369
Kerala	0·750	−0·000009	15,613
Mysore	0·255	−0·000013	1,251
Maharashtra	0·134	−0·0000001	4,469

In the case of Andhra, the value of *b* is positive, indicating that catch per unit effort increase instead of declining with increased effort. This means that fishing exerts at present no influence on the coastal stock of lesser sardines in Andhra waters and a substantial increase of fishing for lesser sardines is possible. But since the same gear are used for catching other fishes and the effects of fishing intensity on some of them are already visible, it may not be possible to increase the fishing intensity very much, unless specialized gear for catching lesser sardines are devised. It may reasonably be assumed that the potential yield of about double the present average catch of 8,769 tonnes can be obtained from the Andhra waters in the immediate future. Thus a potential yield of about 53,000 tonnes can easily be lifted from coastal fisheries of lesser sardines. At the same time, gill net and purse-seine fisheries in the offshore waters could be developed to catch the older age groups which at present are inaccessible for exploitation. It is difficult to furnish any estimate of catch from the exploitation of older groups.

5. WHITE BAIT FISHERY

Seven species of *Anchoviella* are recognized from the Indian waters. They are *A. commersoni, A. heteroloba, A. indica, A. tri, A. zollengeri, A. baganensis* and *A. bataviensis* but only the first 3 species form the bulk of the commercial fisheries. The fishing season varies with locality and species but generally the season extends from June to January. The principal gear used for fishing are shore-seines and boat-seines and are operated inside the coastal waters. The average annual catch obtained in different States are given in Table X.

TABLE X

Average annual catch of white baits

States	Catch (Tonnes)
West Bengal and Orissa	638
Andhra	5,918
Madras	10,792
Kerala	8,640
Mysore	294
Maharashtra	209
Others	23
TOTAL	26,514

The major portion of the catch comes from the coastal waters of the 3 States of Andhra, Madras and Kerala.

The estimates of *a*, *b* and Y_{max} are furnished in Table XI for each State.

TABLE XI

Estimates of a, b *and* Y_{max}

States	*a*	*b*	Y_{max} (Tonnes)
West Bengal and Orissa	0·174	−0·000011	707
Andhra	0·306	−0·000004	6,310
Madras	0·221	−0·000001	19,808
Kerala	0·348	−0·0000 03	9,789
Mysore	−0·003	+0·000006	..
Maharashtra	0·029	−0·000001	264

Excepting in Mysore, the present pressure of fishing intensity seems to be influencing the coastal stocks of white baits that are currently exploited at present. The average sustainable yields that can be derived from the coastal waters of each State are shown in Table XI. In Mysore, the relative abundance increases with effort, indicating that the present level of fishing is producing hardly any effect on the stock and the same can be increased substantially. At present only 194 tonnes of white baits are caught from Mysore waters; probably this could be safely increased to about 1,000 tonnes without affecting the stock. Thus the total potential yield from white baits stocks from all around the coasts can be estimated at 37,878, *i.e.*, about 38,000 tonnes as against the present average of 26,508 tonnes.

6. ANCHOVY FISHERIES

Anchovies form very minor fisheries in almost all maritime States and consists of the genus *Thrissocles.*

As in the case of white baits, the fishing season extends from June to January. They are fished by shore-seines, boat-seines and gill nets. The average annual catches obtained in each State are as in Table XII.

TABLE XII

Average annual catch

States	Catch (Tonnes
West Bengal and Orissa	176
Andhra	1,207
Madras	1,969
Kerala	1,776
Mysore	578
Maharashtra	766
Others	100
TOTAL	6,562

The estimates of a and b and Y_{max} for the different States are shown in Table XIII.

TABLE XIII

Estimates of a, b *and* Y_{max}

States	Estimates of		Y_{max}
	a	b	
West Bengal and Orissa	−0·0342	·00000105	278
Andhra	−0·0611	·00000073	1,278
Madras	−0·1031	·00000115	2,311
Kerala	−0·0458	·00000017	3,085
Mysore	−0·0717	·00000204	630
Maharashtra	−0·0877	·00000217	866

In all States, the fishing is exerting effect on the inshore stocks of Anchovies. The maximum sustainable yields from these stocks work out to about 8,600 tonnes.

7. *Chirocentrus* FISHERY

The wolf-herring or the *Chirocentrus* fishery depends on two species, *C. nudus* (predominant) and *C. dorab*. Both the species considered together, they form a fishery all along the coasts. The State-wise average annual landings are shown in Table XIV.

TABLE XIV

Average annual landings of Chirocentrus

States	Landings (Tonnes)
West Bengal and Orissa	236
Andhra	1,323
Madras	3,633
Kerala	405
Mysore	138
Maharashtra	1,015
Others	390
TOTAL	7,140

The fishing is done by drift net and gill net operated close to the surface in sea at night. The season is almost round the year with peak season from February to July for *C. nudus* and September to April for *C. dorab*. It is a shoaling fish, although large-scale migrations do not occur.

The catch of *Chirocentrus* shows a rising trend over the past few years. As before, the estimates of a, b, and Y_{max} are shown State-wise in Table XV.

TABLE XV

Estimates of a, b *and* Y_{max}

States	Estimates of a	Estimates of b	Y_{max} (Tonnes)
West Bengal and Orissa	·0503	−·00000207	306
Andhra	·0795	−·00000105	1,505
Madras	·1544	−·00000153	3,895
Kerala	·0129	−·0000008	520
Mysore	·0218	+·0000003	..
Maharashtra	·0702	−·00000101	1,220

In Mysore, the present fishing intensity does not exert any influence on the stock. The catch could be increased by increasing effort. The maximum catch in other States are shown in Table XV. Considering all aspects, the average potential catch from coastal waters would not be more than 8,000 tonnes.

8. OTHER CLUPEOIDS

This is a broad group comprising of various species of the following genera: *Hilsa, Clupea, Coilia, Chaetoessus, Anadontostoma, Nematolosa, Dorosoma, Corica, Pellona, Ilisha, Opisthopterus, Raconda, Spratelloides, Albula, Elops, Megalops, Chanos* and *Tenualosa.* No individual fisheries for any of the genera exist but they are caught along with other fishes in shore-seines, gill nets and boat-seines. The fishing season extends throughout the year for the group as a whole. The State-wise distribution of the average annual catch is given in Table XVI.

TABLE XVI

Average annual catch of other clupeoids

States	Average catch (Tonnes)
West Bengal and Orissa	646
Andhra	3,502
Madras	5,071
Kerala	2,627
Mysore	721
Maharashtra	7,327
Others	85
TOTAL	26,468

The constants a, b and Y_{max} were estimated State-wise from the catch and effort data for 10 years and they are shown in Table XVII.

TABLE XVII

Estimates of a, b *and* Y_{max}

States	Estimates of *a*	Estimates of *b*	Y_{max}
West Bengal and Orissa	·1371	−·0000055	849
Andhra	·0922	−·0000004	4,961
Madras	·3057	−·0000036	6,454
Kerala	·0611	−·0000001	7,476
Mysore	·4012	−·0000382	1,051
Maharashtra	·7319	−·0000164	8,166

The total optimum yield of other clupeoids from the inshore stocks for the whole country would probably come to 29,000 tonnes as compared to the present annual average of 26,431 tonnes.

9. RIBBON-FISH FISHERY

James (1967) has stated the occurrence of 4 species of ribbon-fish in Indian waters. They are *Trichiurus lepturus*, *Lepturacanthus savala*, *Eupleurogrammus muticus* and *E. intermedius*. Of these four species *T. lepturus* occurs almost all along the coastline and is the most predominant species. The distribution of other three species appears to be patchy. The season for the fishery in different States varies considerably but generally extends from July to March. The most common types of gear operated for these fishes are shore-seines and bag nets of different shapes and sizes. All the four species are pelagic and move in shoals in shallow waters, but *T. lepturus* is known to occur in depths where they are caught by lines. The State-wise distribution of average annual catch is as in Table XVIII.

TABLE XVIII

Average annual catch of Ribbon-fishes

States	Average catch (Tonnes)
West Bengal and Orissa	537
Andhra	4,746
Madras	12,201
Kerala	6,317
Mysore	199
Maharashtra	4,238
Gujarat	768
Others	11
TOTAL	29,017

The identities and number of unit stocks of the 4 different species are not known. Hence the 4 species have been considered to form one stock along the coastal water of each State. As before, the relation $Y/f = a - bf$ was fitted separately for the catch and effort data of each State. The estimates of a, b, and Y_{max} are presented in Table XIX.

TABLE XIX

Estimates of a, b *and* Y_{max}

States	Estimates of		Y_{max}
	a	*b*	
West Bengal and Orissa	·1368	−·00000773	605
Andhra	·3117	−·00000430	5,656
Madras	·0737	+·00000221	..
Kerala	·0927	+·00000069	..
Mysore	·0727	−·00000567	233
Maharashtra	·5426	−·00001440	5,111
Gujarat	·0616	−·00000110	862

In the two States of Madras and Kerala, the present fishing intensity does not seem to affect the ribbon-fish stocks. Within the present range of fishing intensities, the catch per unit effort increases with effort, indicating that substantial increase in the offtake of ribbon-fishes is possible by suitably increasing the fishing intensity in these States. But since gears used for this fishery are also common for other fisheries and the present fishing intensity is already exerting pressure on these stocks, substantial increase in effort may not be advisable without affecting the yield of other species. Only marginal adjustment of effort seems to be justified. In Madras, the present input of effort is about 58·79 million man-hours and that in Kerala is 48·31 million man-hours. An increase to 60 and 50 million man-hours of effort in these two States will give an expected yield of about 12,400 and 6,400 tonnes. These coupled with the maximum yield possible from the coastal stocks of other States will lead to an average maximum sustainable yield of 31,300 tonnes as compared to the present offtake of 29,017 tonnes.

10. CARANGIDS

This is a very broad grouping. The most predominant species is ***Decapterus russelli.*** The other species caught are ***Megalaspis cordyla, Selaroides leptolepis, Caranx kalla*** and ***Chorinemus*** spp. The coastal waters along both the coasts form excellent fishing grounds for several species of carangids. The fishing season varies considerably from State to State. A good fishery of ***Decapterus russelli*** exists along the west coast of Madras and Kerala. Considerable annual fluctuations are noticed in the annual catches of carangids. The State-wise average annual catches of carangids are shown in Table XX.

As before, estimates of a, b and Y_{max} were obtained from the catch and effort data for each State. The estimates are shown in Table XXI.

In all the States considered above, the present fishing intensity is exerting pressure on the costal stocks of carangids. The maximum calculated yield for these States total up to 23,808 tonnes

TABLE XX

Average annual catch of carangids

States	Catch (Tonnes)
West Bengal and Orissa	113
Andhra	2,042
Madras	10,815
Kerala	7,338
Mysore	576
Maharashtra	882
Others	532
TOTAL	22,298

TABLE XXI

Estimates of a, b *and* Y_{max}

States	Estimates of		Y_{max}
	a	*b*	
West Bengal and Orissa	·0262	—·00000126	136
Andhra	·1031	—·00000123	2,160
Madras	·3658	—·00000300	11,151
Kerala	·2498	—·00000179	8,715
Mysore	·1769	—·00001203	650
Maharashtra	·0936	—·00000220	996

as compared to the present average catch of 21,766 tonnes, showing a possible increase of about 10 per cent over the present catch. Thus for the whole of the country, the expected potential sustainable yield will be not more than 25,000 tonnes.

11. SEER-FISH FISHERY

Three species forming the commercial fishery are *Scomberomorus commerson, S. guttatus* and *S. lineolatus*. All the 3 species are found in varying degrees of magnitude along both the coasts of India. In Madras State, the fishing starts in March and terminates in October. In Andhra State, the fishing generally lasts from February to May. On the west coast of India, the season is from October to May with peak during November–December. Nothing definite is known about the migratory movements of the fish. They seem to move to the inshore waters when there is abundance of small fishes and crustaceans there. Not much information on age, growth and mortality are available. The average annual catch in the different states are shown in Table XXII.

TABLE XXII

Average annual catch of seer-fish

States	Catch (Tonnes)
West Bengal and Orissa	259
Andhra	2,420
Madras	3,253
Kerala	1,690
Mysore	492
Maharashtra	912
Gujarat	481
Others	7
TOTAL	9,514

The estimates of a, b and Y_{max} based on the effort and catch data are given separately for each State in Table XXIII.

TABLE XXIII

Estimates of a, b *and* Y_{max} *for seer-fish*

States	Estimates of		max
	a	b	
West Bengal and Orissa	·0400	−·000001381	290
Andhra	·0572	−·000000161	5,080
Madras	·0968	−·000000687	3,410
Kerala	·0729	−·000000692	1,919
Mysore	·0226	+·000006289	..
Maharashtra	·1339	−·000003782	1,185
Gujarat	·0705	−·000001980	628

Only in Mysore, the catch per unit effort seems to increase with increasing effort. The present input of effort in the State is about 6·88 million man-hours. At 7·00 million man-hours the average expected yield of seer-fish is 2,096 tonnes. In all other States, the current fishing seems to be exerting influence on the stocks and the estimated maximum sustainable yields for each State are given in Table XXIII. Adding them up along with the estimated Mysore catch of 2,096 tonnes, the total maximum yield for the country will be 14,608 tonnes against the present average yield of 9,514 tonnes.

12. Tuna Fishery

There are excellent fishing grounds of tuna close to Laccadives and Minicoy and some fishing along the coasts of India. The fishing season is generally from September to May. The fishery consists of three species: *Katsuwonus pelamis*, *Euthynnus affinis affinis* and *Neothunnus macropterus*. The Skipjack is the most predominant species. The fishing is done by pole and line, whiffling line, drift net and shore-seines. The region-wise distribution of landings is given in Table XXIV.

TABLE XXIV

Average annual landings of Tuna

States	Catch (Tonnes)
West Bengal and Orissa	43
Andhra	414
Madras	863
Kerala	2,127
Mysore	104
Maharashtra	304
Laccadives	265
TOTAL	4,120

The estimates of a, b and Y_{max} from the data of catch and effort figures are given separately for each State in Table XXV.

TABLE XXV

Estimates of a, b *and* Y_{max}

States	Estimates of		Y_{max}
	a	b	
West Bengal and Orissa	·0157	−·000001264	49
Andhra	·0052	+·000000063	..
Madras	·0538	−·000000646	1,120
Kerala	·0852	−·000000751	2,415
Mysore	·0133	+·000000264	..
Maharashtra	·0081	+·000000222	..

No effort figures are available for Laccadives and hence Y_{max} cannot be calculated. In Andhra, Mysore and Maharashtra the estimates of b are +ve, indicating more fishing can be done. With marginal increase in fishing effort, the expected yields in the 3 States are 420, 110 and 300 tonnes respectively. Thus the expected maximum yield of tuna from the inshore waters cannot exceed 5,000 tonnes. The tunas are oceanic fish. The shoals approach the coasts of Laccadives and Minicoy from the southern side at the beginning of fishing season and move northwards probably to the feeding grounds. Similarly, schools of skipjack occasionally enter the coastal waters in pursuit of small shoaling fishes. It is these schools or shoals which are caught in the inshore waters. Hence the chance of increasing the catch by exploiting the inshore schools is very little. The real increase can come by exploiting the tunas in the high seas. Elsewhere, in another paper, an estimate of potential yield of tuna from the high seas has been given.

13. *Bregmaceros* Fishery

The fishery consists of a single species *Bregmaceros mcclellandi* and is caught mainly on the Maharashtra coasts along with other species in " Dol " net. From the available catch and effort data, we get the relation

$$Y/f = \cdot 380 - \cdot 000008524\, f.$$

The maximum catch is obtained at 22·3 million man-hours of effort and estimated at 4,235 tonnes. The present input of effort is 22·4 million tonnes and the average catch is 3,885 tonnes. Thus with a slight decrease in fishing effort, it is possible to gain an increase of about 10 per cent in the yield.

Table XXVI

Average optimum yield of pelagic fisheries

	Average annual yield (Tonnes)	
	Present	Optimum
Oil sardine	176,354	213,000
Bombay duck	81,009	93,000
Mackerel	58,781	73,500
Lesser sardines	36,241	53,000
White baits	26,514	38,000
Anchovies	6,562	8,600
Chirocentrus	7,140	8,000
Other clupeoids	26,468	29,000
Ribbon-fish	29,017	31,300
Carangids	22,298	25,000
Seer-fish	9,514	14,600
Tunas	4,120	5,000
Bregmaceros	4,026	4,200
Others	16,042	25,000
Total	504,086	621,200

14. Other Pelagic Fisheries

There are a few other pelagic fisheries like *Sphyraena*, flying fish, *Hemirhamphus*, *Belone* and *Mugil*. The flying fish is generally caught by specialized catamarans at a distance of 20 to 25 miles from the shore off Central Madras coast in May and June. The fishery is highly variable and annual catches fluctuate considerably. Some flying fish are also caught in Andhra coast by hooks and lines. Good local fisheries of *Hemirhamphus* and *Belone* exist in Gulf of Mannar and Palk Bay. There are not enough data for these small fisheries even for rough assessment of their status. In any case, the potential yield cannot exceed very much from the present yield. Probably 25,000 tonnes as compared to present average catch of 16,042 tonnes could be caught without affecting the stocks.

15. Expected Maximum Yield from Inshore Stocks of Pelagic Fish

From the available data, the optimum yields that can be derived from exploiting the pelagic stocks in the inshore waters have been derived from each group of pelagic fish. Table XXVI summarizes the present average annual yield together with the average optimum yield that can be derived from each pelagic group.

Thus the optimum catch from the present exploitation in the inshore waters cannot bring more than 25% over the present average annual catch.

Discussion

The seas of India both along the east and west coasts contain a vast wealth of pelagic fish of many species. The abundances of some of the species are very considerable. All these pelagic species are subjected to migrations, some making long migrations, others short. The exact pattern of migratory circuits and the probable causes of such migrations are not clearly known for most of the species, though some preliminary knowledge of the same is available at least for some. When the different stocks of pelagic fishes in course of their migration enter the narrow coastal belt where the fishing activities are restricted at present, they are exploited. The entry of many of pelagic stocks in the present fishing region is subjected to many physical and biological influences. In the case of some of the stocks like lesser sardines only the 0-year class juveniles enter the coastal waters while the adults stay off-shore. In the case of other stocks also, it is possible that the older age groups do not migrate to the inshore waters. Aside from such cases of differential migration, the possibility remains that only a fraction of each pelagic stock enters the inshore water and becomes accessible to fishing. This fractional accessibility may also change from year to year due to hydrological and ecological factors. The magnitude of the fractional accessibility is not known at present for each individual stock, though from other evidences it is known that this magnitude is small. It has been stated already that the current exploitation of the various pelagic stocks both along the east and west coasts yield on an average an annual catch of about 504,000 tonnes, and the various constituents of this yield are shown in Table I. Oil sardine, lesser sardines, mackerel and Bombay duck constitute more than 70% of the present pelagic yield.

An assessment of the accessible stock of various pelagic groups which are being currently exploited within a narrow coastal belt indicates that most of them are being exploited efficiently. On the basis of available data, the optimum sustainable yields for each pelagic group have been calculated and they are shown in Table XXVI. It will be seen that the optimum yield from all stocks amount to 621,200 tonnes which is about 25% higher than the present average yield of 504,000 tonnes. It is certainly desirable to have the benefit of even this marginal increase, but this will require a good deal of monitoring of fishing effort in each State. This is so because the same generalized gear is used for catching almost all pelagic fish, and the influence of fishing intensity on various pelagic stocks is different. In any case, an average optimum catch of 621,000 tonnes from the accessible inshore stocks is possible. But the real increase in yield of pelagic fish must come from the exploitation of pelagic stock outside the present fishing region.

If the magnitude of the abundance of each pelagic stock outside the present fishing range were available, it would have been possible to estimate the expected yield from these offshore stocks. But such information is not available at present. Some indirect assessment, however, seems to be possible.

In another paper in the present volume (Jones and Banerji), it has been shown from productivity studies that the potential yield from seas around India up to 200 m depth contour is about 2288 thousand tonnes. This includes both demersal and pelagic fish. It is assumed that the proportion of pelagic fish will be maintained at present level, *i.e.*, at 66%, the potential yield of pelagic fisheries from the seas around India up to 200 m depth contour would be about 1,510 thousand tonnes. It has been shown that inshore exploitation cannot yield more than 621 thousand tonnes. Hence the balance of about 900 thousand tonnes would obviously have to be got from exploitation of the offshore areas up to 200 m depth contour. In comparison to the present average annual landings of pelagic fish, the prospective increase is 1,016 thousand tonnes. It is difficult to give any estimate of the variety-wise break-up of this prospective increase. Kesteven (1967) has given the following variety-wise break-up of prospective increase from empirical considerations:

	Prospective increase (1000 tones)
Sardine and mackerel	.. 900
Harpodon ..	.. 100
Other pelagic fishes ..	.. 300
Total pelagic fishes	.. 1300

It is interesting to note that the above empirical estimate of prospective increase agrees reasonably well with our estimate.

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APPENDIX

Annual landings of various groups of pelagic fish

(Landings in metric tonnes)

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	Average	P.C. of total pelagic
1. *Chirocentrus*	5,549	5,128	5,320	6,748	8,898	7,345	7,565	7,347	7,884	9,015	7,140	1·42
2. Oil sardine	123,731	69,234	189,016	167 884	110 299	63,647	274,333	261.863	247,214	256,324	176,354	34·98
3. Lesser sardines	39,958	41,167	32.003	19,763	19,551	27,173	40.398	42 770	64,643	34,980	36,241	7·19
4. White baits	29,346	24,477	35,885	22,103	19,168	23,672	25,199	24,377	26,679	29,237	26,514	5·26
5. Anchovies	3,960	8,108	7,522	4.961	5.872	5,704	6,619	4 811	8,837	9,222	6,562	1·30
6. Other clupeoids	19,232	25,364	32,412	22,781	22,747	22,551	26 712	23,314	33,236	30,273	26,468	5·25
7. Flying fish	388	1,068	6,470	1,206	4,154	962	920	437	3,676	3,073	2,295	0·45
8. *Hemirhampus* and *Belone*	348	383	213	493	149	3,443	1,527	1,188	1,819	1,244	1,081	0·21
9. Ribbon-fish	41,918	31,870	17,467	19 515	20,586	16.452	25 891	41,921	45,124	29,463	29,017	5·76
10. Carangids	22,026	12,904	26,458	26,512	11,859	20,939	29.839	21,072	23,586	27,797	22 298	4·42
11. Mackerel	123,282	62,198	133 655	34,485	29,103	76 980	23,863	43,095	31,959	29,194	58,781	11·66
12. Seer-fish	7 889	6,590	8,650	11,449	10,941	9,116	11,160	9,436	10,053	9,854	9,514	1·89
13. Tunas	3,239	2,866	5,615	7,805	2,297	4 454	5,002	3,698	2,850	3,370	4,120	0·82
14. *Sphyraena*	830	972	1, 85	1,388	1,120	1,258	1,662	1,924	1,065	4,403	1,661	0·33
15. *Mugil*	743	246	912	862	880	1,505	2,916	1,413	1,488	3,155	1,412	0·28
16. *Bregmaceros*	3,884	3,821	6.096	3 900	3 164	5,407	3,721	5,491	2,659	2,107	4,026	0·80
17. *Harpodon nehereus*	67,188	57 210	108,564	93 844	83,933	91.870	81,342	73 894	77,363	74,882	81,009	16·07
18. Miscellaneous	3,772	8,871	6.143	6,891	9,926	11,704	12,050	12,824	11 433	12,317	9,593	1·90
Total pelagic	497.283	363,337	624,416	452 590	364,647	399,482	580,710	586,913	601,568	569,910	504,086	..
Total all fish	756,994	584,587	879,641	683,569	644,244	655,484	859,582	832,777	889,651	862,631	764,820	..
P.C. to total all fish	65·78	62·15	70·98	66·21	56·60	60·94	67·56	70·48	67·62	66·07	65·91	..