OUR PELAGIC FISHERY RESOURCES-

Present and Potential Harvest

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PELAGIC REALM

The two primary divisions of the oceans are (1) the benthic and (2) the pelagic, the former referring to the ocean floor which supports the demersal resources and the latter, the entire column of water, accomodating the pelagic resources. The pelagic region is a part of the marine biocycle and geographically, it is divisible into Atlantic and Indo-Pacific. Ecologically, the pelagic realm can be bifurcated as neritic (inshore) and oceanic (open-sea) provinces depending on the depth to which light penetrates and to the extent and depth of the continental slope. Broadly speaking, the neritic pelagic refers to that area up to the continental slope where the depth is 200 m and the oceanic pelagic, the area beyond. Again, the pelagic environment may also be considered as enclosing two major strata, the richly lighted euphotic stratum, varying in depth up to 100 m and the weakly lighted dysphotic stratum, varying in depth from 30 to 500 m. The pelagic fishes are those that move about between the bottom and the surface but, as the maximum production of phyto-and zooplankton is restricted to the richly lighted zone, the majority of the shoaling pelagic fishes belongs to the euphotic stratum.

In the cold waters, the number of species constituting the pelagic fisheries is comparatively smaller than in the tropical region but this is compensated for by a larger number of individuals of the few species that occur. The availability of a variety of genera and species constituting the pelagic fishery in the tropical area is certainly advantageous for commercial exploitation but from the point of scientific inquiry, this situation would present difficulties. An ecosystem of multi-species fishery whose contituent members differ in their spawning seasons, growth and feeding habits is a harder regime both for comprehension and for interpretation of the fishery.

The broad general features of the pelagic fishes are the following: They are gregarious in habit, swimming either in large shoals like sardine or mackerel, or in schools like tuna or seer fish. Many of the shoaling species have efficient straining gill apparatus for procurement of food which is largely planktonic in character. There is not much of selective feeding amongst the smaller pelagic fishes, the food variations often depending on the variations in the availability of plankton. The larger pelagic fishes may be selective feeders and their movements are often determined by the movements of their feed. As compared to demersal species, the pelagic fishes have a shorter span of life. The spawning season is one of variable nature, either prolonged or restricted. Similarly, the spawning habits may also vary between complete and fractional shedding of sexual products. The success of spawning is largely governed by external factors like suitable temperature, salinity, oxygen, dissolved chemicals, turbidity, currents, availability of food etc. The eggs of almost all the pelagic fishes are pelagic (freely floating) — the notable exception being those of herring — and hence greater numbers are produced to overcome the losses inherent with this group.

PRESENT HARVEST

From the latest figures available (FAO Yearbook of Fishery Statistics, 1970), it is seen that the pelagic fishes constitute about 53% of the total marine fish landings of the world. Area-wise, the Pacific ocean contributes about 23 million, the Atlantic, 9 million and the Indian Ocean, 1.5 million tonnes. In the harvest from the Indian Ocean, our coast accounts for 40%. Whichever be the area, among the pelagic fishes, the clupeoids, comprising the popularly known anchovies, herrings, sardines, sprats and menhaden occupy the top position with as much as two-thirds of the total pelagic fish harvest of the world oceans. No doubt, much of this importance credited to the clupeoids and to the Pacific Ocean in the pelagic fish production largely goes to the Peruvian anchovy, which, as the largest single-species fishery of the world, accounts for nearly 60% of either the group or the oceanic area it belongs to.

From the Indian seaboard, about 600,000 tonnes, forming two-thirds of our total catch are raised from the pelagic community, of which, all the three major fisheries, namely, oil-sardine, mackerel and Bombay duck, enrich the marine living resources wealth of the west coast. Group-wise, in tune with the general feature of the world catch, the clupeoids form the bulk with 56% (332,000 tonnes). What importance the Peruvian anchovy is to the Pacific Ocean can be roughly likened to the oil-sardine of the Indian Ocean, where it contributes 15% of the exploited pelagic resources. Practically the entire harvest of 211,000 tonnes in India, forming 35% of the total pelagic fish production, comes from the southwest coast of India. Its sister species, the lesser sardines, constitute 8%, followed by its cousins, the anchovies, with 6% and other clupeoids with 7%. Among the scombroids, that realise 96,000 tonnes (16%), the mackerel accounts for 79,000 tonnes (13%) and the seer fishes and tunas, the rest. The Bombay duck fishery with 76,000 tonnes and 13% comes third. The ribbon fishes (6%), the carangids (4%) and other miscellaneous pelagic fishes (6%) complete the tally. The average catch figures (1963–72) of the important categories of pelagic fishes, state-wise, are given in Table I.

Table 1. *Average annual pelagic fish production (1963–72) from the Indian coast, in thousand tonnes (The total of vertical columns of some categories of fish do not exactly correspond to the total of the west coast because of incidence of less than one thousand tonne in some states which are covered up under 'Others' in the table).*

Region	Oil-sardine	Lesser sardines	Anchovies	Other clupeoids	Mackerel	Bombay duck	Ribbon fish	Carangids	Others	Total	Percentage
West Bengal & Orissa	—	2	1	2	—	1	1	—	3	10	2
Andhra	—	13	7	7	2	—	7	3	6	45	7
Tamil Nadu & Pondicherry	—	16	13	10	3	—	10	9	14	75	13
Kerala	178	10	10	2	31	—	8	6	15	260	43
Karnataka	32	2	1	1	22	—	—	—	7	65	11
Goa	—	1	—	—	15	—	—	—	8	24	4
Maharastra	—	2	1	10	6	27	6	5	4	61	10
Gujarat	—	—	—	9	—	48	—	1	2	60	10
East Coast	—	31	21	19	5	1	18	12	23	130	22
West Coast	211	15	13	22	74	75	15	12	33	470	78
Total	211	46	34	41	79	76	33	24	56	600	100
Percentage	35	8	6	7	13	13	5	4	9	—	100

Between the two coasts, the west contributes 78% of the all-India pelagic fish yield (470,000 tonnes), of which 59% is accounted for by the oil-sardine, mackerel and Bombay duck. In the total fish harvest of the west coast, the pelagic fishes constitute 70%. Only off Maharashtra. the percentage of pelagic fishes is low at 40, but it forms 74, 94, 84 and 74 in the respective total fish catches of Gujarat, Goa, Karnatataka and Kerala. In the total oil-sardine production, Kerala accounts for 84% and Karnataka, 15%. In the mackerel harvest, Kerala takes a share of 42%, Karnataka 30%, Goa 20% and Maharastra, the remainder. In the average Bombay duck yield, Gujarat shows 64% and Maharastra, the balance.

On the east coast, the yield of pelagic fishes amounts to 130,000 tonnes, forming 22% of the total pelagic fish catch of the country. Unlike the west coast, the pelagic fishes form about one-half (53%) of the east coast's total fish production. The Tamil Nadu coast (including Pondicherry) contributes the best part of the pelagic yield with 58%, followed by Andhra (34%) and West Bengal and Orissa (9%). There is no dominant single-species fishery here, as seen on the west coast. The clupeoids realise 55% of the east coast's pelagic fish yield, in which the lesser sardines constitute the most important category with 24%. The next in order are, anchovies (16%), ribbon fishes (14%) and carangids (8%).

In the all-India catch, the largest landings of carangids come from the Tamil Nadu coast while the next important areas are Kerala and Maharastra. In the group of 'other clupeoids' (fishes other than the sardines and anchovies), the important ones are the wolf herring (*Chirocentrus* spp.) along Andhra and Tamil Nadu and the shad (*Hilsa* spp.) off Tamil Nadu and Gujarat coasts. They represent roughly one-third of the respective state's total of other clupeoids.

There is a regular sequence in the pattern of distribution of these pelagic fishes around the Indian coast. The Bombay duck dominates along the Gujarat and Maharastra coasts but is replaced by the mackerel and the oil-sardine on the southwest coast along Goa to Kerala. With the decline in the strength of these two stocks around the peninsular curve, the lesser sardines and to some extent the anchovies and the ribbon fishes form the bulk in that region. The quantum of these fishes get progressively reduced as we proceed north along the east coast, culminating, in what can be termed as the poorest crop of pelagic fishes, from the Orissa-West Bengal waters.

The commercial season for all the important pelagic fishes on both the coasts is the same, i.e., October to March, with peak catches during October to December on the west coast and January to March on the east coast. This may be attributable to a large extent to the favourable ecological conditions that result after upwelling in the respective post-monsoon periods.

POTENTIAL HARVEST

Attempts to estimate, in a rough way, the potential harvest from the seas have been approached in three ways: 1) By extrapolating the trend line of annual production of past years, which would help only in forecasting the possible yield for a few years ahead, 2) by considering our knowledge of the unused harvestable resources and 3) by calculations based on the food web and transfer of energy through successive trophic levels. Largely, it is the third way that is very often employed; the other two have limitations either in terms of time, or for want of adequate knowledge of untapped resources. The third method involves calculation of harvestable crop from the net primary production which is 60% of the gross amount in terms of carbon. As a first approximation, it is assumed that at each stage beginning with the herbivores, carbon is transferred at an ecological efficiency rate of 10% of the previous level. For example, if 10,000 kg. of carbon is available as net primary production, 1000 kg. is obtained at the first stage, 100 kg. at the next, 10 kg. at the third and 1 kg. at the fourth. As these are values of dry carbon, each of these values has to be multiplied by a factor, 10, to get the wet weight of the potential resource at each stage. A gross estimate of exploitable fish yield in a coastal area has been placed at 4% of the net carbon production, which means that the calculation is traceable to a stage roughly midway between the second and the third trophic levels.

Based on the above consideration and based on the values of organic productivity given by Jones and Banerji (1973), the state-wise potential fish yield is given in Table II along with the

Table II. *Region-wise potential fish yield (as 4% of net organic production of carbon), in thousand tonnes.*

Region	up to 50 m depth	50 to 200 m depth	Potential yield	Present yield (1968-72)
West Bengal	105	54	160	25
Orissa	181	27	208	
Andhra	176	61	237	79
Tamil Nadu (east) & Pondicherry	238	48	286	164
Tamil Nadu (west)	10	22	32	
Kerala	134	51	185	354
Karnataka	75	29	104	93
Goa	27	12	39	27
Maharastra	270	83	353	184
Gujarat	687	36	723	84
East Coast	700	190	890	268
West Coast	1203	233	1436	742
Total	1903	423	2326	1010

average yield of the last 5 years. No doubt, it is not correct to do such state-wise dissection for the simple fact that fishes know no state boundaries and migrate over wide areas, especially the pelagic ones, utilising the food of their entire migratory route. However, two important features stand out strikingly from the table. One is that, at the respective northernmost areas of the two coasts, the potential yield is fantastically higher than the present yield. The other is, in the area between Goa and Kerala (considered as a contiguous (near: adjoining) fishery zone of similar character), the present harvest is twice of the potential yield of the nearshore belt up to 50 m depth! The most important reason for this anomalous situation is in considering the yield at a stage in between the second and third trophic levels, whereas the most abundant pelagic fish, the oil-sardine, belongs mainly to the first trophic level and the next important, the mackerel, to the second. Hence, if we consider the transfer of energy at a stage lower down, in between the first and the second, the potential fish biomass would be ten times than what is shown in the table for that area.

In addition to the difficulty of assigning a proper trophic level to many organisms (in fact, a given organism may operate at more than one trophic level), the difference of assumption over the percentage ecological efficiency at which carbon is transferred from one trophic level to the next and the divergence of opinion on the harvestable portion of the total potential biomass under the existing fish capture methods, can result in differences in the estimates arrived by different authors. Schaefer (1965) is of the view that the effective ecological efficiency may be higher than 10% and that 15% would be a reasonable guess although 20% is a possibility. An attempt is made herein to project the available fish potential (pelagic and demersal combined) of the Indian coast, based on our present knowledge of the trophic level the important fishes belong to, and their percentage contribution in the current exploited state. The Indian coast, for this purpose, is considered as broadly divisible into three regions, namely, 1) the northwest (Gujarat and Maharashtra), 2) the southwest and 3) the east. The basic assumptions for the calculations are : For region (1), 33% of potential biomass to come from trophic level II and 67% from level III, for region (2), 40% from level I, 50% from II and 10% from III and for region (3), 6% from level I, 50% from II and 44% from III.

The estimated figures of 6 to 10 million tonnes up to 50 m depth and an additional 2 million in the region beyond would appear as a set of unbelievable numbers in the context of the present average yield of just over one million tonne. Of course, only a part of this vast potential could be brought ashore because oi several limiting factors, like diffused distribution of fish that cannot form a basis for economically viable exploitation and loss due to predation by other inhabitants of the sea. The question, then, would be at what level could our potential be harvested? It would appear from Table III that, at present, comparatively greater percentage of available resources is exploited on the west coast than on the east and that even on the west coast, the northern areas are taking more advantage of the resources level than the south. This may probably be a reflection of the differences in the extent of the areas actively fished. Schaefer (1965) visualised a general harvestable yield of 19% of the potential biomass at 10% efficiency and 8% at 15% efficiency levels. For shallower regions up to 50 m depth around the Indian coast, a much *higher percentage would be justified*, especially because the present yield itself is more than the above percentages on the west coast. There is already an opinion that in intensively exploited areas, man can take 50% of the potential and yet maintain the resource (Graham and Edwards, 1962). Hence, if the entire belt up to 50 m depth around both the coasts of India could be exploited as intensively as it is done in the present traditional grounds, a modest consideration of 40% of the potential at 10% ecological efficiency and of 20% at 15% efficiency level would not be unrealistic, maybe rather conservative. Even then, the harvestable potential would be about 2.3 million and 2.1 million tonnes at the respective efficiency levels with an average of 2.2 million tonnes. If we add to this the possible harvest from the 50–200 m depth zone, anticipating only half of the earlier exploitable percentages at the respective ecological efficiencies, the resultant figure would be 2.6 million tonnes. The present estimate, thus, is rather very close to that of Prasad *et al.* (1970), Jones and

Table III. *Potential biomass of fish, in million tonnes, compared to the current yield of 1.01 million tonnes (average of 1968-72).*

Region	up to 50 m depth				50 to 200 m depth	
	Potential at 10% efficiency	Current yield (%)	Potential at 15% efficiency	Current yield (%)	Potential at 10% efficiency	Potential at 15% efficiency
Gujarat to Maharastra	0.96	28	2.16	12	0.12	0.27
Goa to west Tamil Nadu	2.81	18	4.37	11	1.29	1.97
West Coast	3.77	20	6.53	11	2.09	1.56
East Coast	2.00	12	3.80	7	0.63	1.20
Total	5.77	18	10.33	10	2.72	1.76

Banerji (1973) and Nair *et al.* (1973) who have placed the potential yield as 2.3 or 2.4 million tonnes.

Within 50 m area, where our immediate concern is, out of 2.2 million tonnes, the share of the west and east coasts would be 1.4 and 0.8 million tonnes respectively. Apportioning the amount to the current ratio between the pelagic and demersal resources, it appears that about 1,000,000 tonne from the west coast and 400,000 tonnes from the east coast could come from the pelagic stocks as against the average current landings of 470,000 tonnes from the west and 130,000 tonnes from the east coast. In short, in the light of present exploitation as confined to about one-half or even less of the envisaged area, about twice the present catch is the potential harvest of pelagic resources from the west and three times from the east coast.

Banerji (1973) has estimated the optimum yield from the pelagic resources of the present fishing area as 620,000 tonnes which is about the annual average of the last 10 years and which has been slightly exceeded in the average of last 5 years. Added to this, the fact that, although the average annual rate of increase in pelagic fish production in India during the last 20 years (1952–72) is 6.3%, it is almost zero during the last 5 years, would show that the present belt of exploitation has yielded the maximum benefit to our efforts. A fishery which is confined within certain traditional limits would be incapable of yielding more than a certain amount of fish however intense the effort is. As Schaefer (1965) has rightly observed, whatever ecological efficiency factor is operative and whatever be the estimate made, an obvious way of increasing the harvest is by fishing on the stocks at lower trophic levels, that is, at stages I and II. To this level belong our major pelagic fisheries of sardines and mackerel. Hence, we have to shoot our nets yonder still and the modest expansion up to 50 m depth should be largely oriented towards rapid development of purse seine and pelagic trawl fisheries.

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REFERENCES

Banerji, S. K. 1973. *Proc. Symp. Living resources of the seas around India*, Spl. Pub. CMFRI, 114–135.

Graham, H. W. and R. L. Edwards. 1962. *Fish in nutrition.* Fishing News (Books) Ltd., London, 3-8.

Jones, S. and S. K. Banerji. 1973. *Proc. Symp. Living resources of the seas around India*, Spl. Pub. CMFRI, 1–17.

Nair, P. V. R., S. Samuel, K. J. Joseph and V. K. Balachandran. 1973. *Ibid*, 184–198.

Prasad, R. R., S. K. Banerji and P. V. R. Nair. 1970. *Indian J. Anim. Sci.*, 40 (1), 73–98.

Schaefer, M. B. 1965. *Trans. Am. Fish, Soc.*. 94 (2), 123–128.