

POTENTIAL FISH RESOURCES OF THE INDIAN OCEAN

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ABSTRACT

Earlier estimates of exploitable fish resources from the Indian Ocean are largely based on computation from primary production or from the calculated potential yield of different categories of fish. These estimates appear to be on the higher side. The declining trend in world fisheries and the reduction in the total catch of India since 1971, must be viewed with utmost concern. With the increasing cost of fishing, a careful assessment of the economics of fishing is necessary before any large scale operation is undertaken in deeper waters.

INTRODUCTION

From the recent findings that the world oceans are nutrient impoverished and have a low primary productivity (Ryther, 1969), it is becoming increasingly important to make a realistic estimation of exploitable food resources of the Indian Ocean, particularly when considerable financial resources are going to be diverted to the management and utilisation of living resources. Several estimates are available in the literature, based on theoretical grounds for the entire Indian Ocean or for the biosphere as a whole; but as our knowledge is advancing it is becoming very clear that the sea should no longer be considered the great reservoir of food, as it was taught in the past.

Some authors have indicated the fish yield of the Indian Ocean as 10-11 million tonnes (Prasad *et al*; 1970; Prasad and Nair, 1973), while Ryther (1969) has estimated that the potential sustained yield of the world oceans is about 100 million tonnes. Since the Indian Ocean is about one-fifth of the total oceans, its potential yield theoretically should be about 20 million tonnes.

In this communication an attempt has been made to examine how far the earlier estimates are realistic.

METHODS OF ESTIMATING LIVING RESOURCES

Most of the estimates of potential living resources are based on the studies of primary productivity on the assumption that the ecological efficiency from one trophic level to the other is about 10% i.e. approximately 10%

of the total primary production (phytoplankton) will be available at the secondary level of production (zooplankton) and 10% of this at the tertiary level of production (fish) in the marine food chain. Thus, if the phytoplankton production is about 100 g of carbon in a given area and time, it will give rise to 10 g of zooplankton and 1 g of fish and possibly 0.1 g of tuna-like carnivorous fishes in terms of carbon. Very often, the validity of such an estimate has been questioned. However, some well-known fishery biologists (Chapman, 1965) have indicated that ecological efficiency of the order of 25% should be used for estimating the tertiary production or the second or the third stage carnivores. He thus calculated that the potential harvest of the sea should be of the order of 2.0×10^9 tonnes. Recently, Qasim and Easterson (1974) have found that the ecological efficiency in a shrimp is about 21%, when it is fed on natural detritus. Cushing (1973) raises the carbon value to the wet weight of fish using the factor 7.47.

Gulland (1971) has made a different approach for estimating the maximum potential yield. Using the simple Schaefer (1954) model which begins as unfinished biomass (B_0), the maximum potential yield (Y_{max}) is estimated as $Y_{max} = 0.5 \times M \times B_0$; where M is the natural mortality coefficient. This method also has several limitations as the extrapolation of the initial figure of potential yield to get the final prediction may lead to uncertainties in different geographical regions.

ESTIMATE OF PRIMARY PRODUCTION FROM DIFFERENT REGIONS OF THE INDIAN OCEAN

Table 1 gives some of the available data on primary productivity of the different regions of Indian Ocean. It is clear from the table that apart from coastal waters and upwelling areas, the productivity of the rest of the ocean is low. This becomes even more clear from Table 2 which gives the productivity values pertaining to the two monsoons in the Indian Ocean. The rate of primary production in the upwelling areas as given in Table 2, is much greater than in other regions and the productivity during SW monsoon in all the areas is three times greater than in NE monsoon.

Table 1. Average primary productivity of different regions of the Indian ocean.

Regions	Production gC m ⁻² day ⁻¹	Authors	
Western Indian Ocean	0.24	Prasad <i>et al.</i> , (1970)	
Eastern Indian Ocean	0.19		
Continental Shelf	0.51		
West coast of India	<50 m 50-200 m > 200 m	1.19 0.25 0.18	Nair <i>et al.</i> , (1973)
Saudi Arabia and north - west Indian Ocean	1.0-6.4	Ryther <i>et al.</i> , (1966)	
Gulf of Oman	5.7-6.4	Ryther and Menzel, (1965)	
Region of S. Africa	0.03-1.08	Mitchell-Innes, (1967)	
Agulhas Current	0.02-0.94	Burchall, (1968)	

Table 2. Productivity of the Indian Ocean during SW and NE monsoons (Cushing, 1973). The values are in gC m⁻² day⁻¹.

Regions	South-west monsoon	North-east monsoon
Arabian upwelling	1.16	0.23
Arabian sea	0.76	0.12
Javan upwelling	0.85	0.28
East tropical ocean	0.70	0.26
Equatorial region	0.40	0.15
East Africa and Mozambique Channel	0.83	0.42
Bay of Bengal	—	0.21
Average for whole ocean	0.50	0.15

BROAD DIVISIONS OF THE INDIAN OCEAN

The Indian Ocean has an area of $75.47 \times 10^6 \text{ km}^2$ (Sverdrup *et al.*, 1962). The total area can broadly be divided into :

Open Ocean	$66.92 \times 10^6 \text{ km}^2$
Upwelling area	$0.07 \times 10^6 \text{ km}^2$
West Coast of India upto 200 m depth	..	$0.4 \times 10^6 \text{ km}^2$
East Coast of India upto 200 m depth	..	$0.17 \times 10^6 \text{ km}^2$
Other coastal regions	$7.90 \times 10^6 \text{ km}^2$

Of the total area, the open ocean constitutes about 90%, the upwelling areas about 0.1% and the coastal waters approximately 9.9%.

Similarly, using the productivity indices, the total area of the Indian Ocean, as given by Krey (1973) can be sub-divided into :

Oligotrophic waters	$19.6 \times 10^6 \text{ km}^2$
Transitional waters between subtropical and subpolar zones, extremity of the area of equatorial divergence	..	$23.75 \times 10^6 \text{ km}^2$
Waters of equatorial divergence and oceanic regions of subpolar zone	..	$18.89 \times 10^6 \text{ km}^2$
Coastal waters, upwelling and neritic waters		$13.24 \times 10^6 \text{ km}^2$

PRIMARY PRODUCTIVITY OF DIFFERENT REGIONS

Using both the divisions of the Indian Ocean noted above and the average rate of primary production for each region, the annual primary production for the total area of Indian Ocean has been shown in Tables 3 and 4. As can be seen from Table 3, according to Ryther's (1969) the total primary production works out as $86 \times 10^8 \text{ tonnes C year}^{-1}$ whereas from the classification of Krey (1973), the primary production would be of the order of $104 \times 10^8 \text{ tonnes C year}^{-1}$ (Table 4). The difference between the two estimates does not seem to be large and hence the average production of the Indian Ocean could be kept as $94 \times 10^8 \text{ tonnes C year}^{-1}$ approximately.

Table 3. Annual primary productivity of different regions of the Indian ocean based on the classification of Ryther (1969).

Region	Total area (km ²)	Average daily production (gC m ⁻² day ⁻¹)	Total annual production (tonne C year ⁻¹)
Open Ocean	66.92x10 ⁶	0.34	83x10 ⁸
Upwelling areas	0.07x10 ⁶	1.00	0.25x10 ⁹
<i>Coastal waters</i> (Continental shelf upto 200 m)			
West coast of India	0.40x10 ⁶	0.70	1.0x10 ⁸
East coast of India	0.17x10 ⁶	0.50	0.3x10 ⁸
Other coastal regions	7.90x10 ⁶	0.60	1.7x10 ⁸
Total	75.46x10 ⁶		86.x10 ⁸

Table 4. Annual primary productivity of different regions of the Indian ocean. The classification of regions is as indicated by Krey (1973).

Region	Total area (km ²)	Average daily production (gCm ⁻² day ⁻¹)	Total annual production tonn C year ⁻¹
Oligotrophic waters (open ocean)	19.60x10 ⁶	0.34	24x10 ⁸
Transitional waters between subtropical and subpolar zones, extremity of the area of equatorial divergence (open ocean)	23.75x10 ⁶	0.34	29x10 ⁸
Waters of equatorial divergence and oceanic regions of subpolar zones (open ocean)	18.89x10 ⁶	0.34	23x10 ⁸
Coastal waters, upwelling and neritic waters	13.24x10 ⁶	0.60	28x10 ⁸
Total	75.48x10 ⁶		104x10 ⁸

POTENTIAL FISH YIELD FROM PRIMARY PRODUCTION

Using 10% ecological efficiency at each trophic level, the secondary production in terms of carbon would be 9.4×10^8 tonnes C year⁻¹ and the first level tertiary production would be 0.94×10^8 tonnes C year⁻¹ or about 90 million tonnes. This estimate would be valid if we assume that only mackerel or mackerel-like fishes are produced everywhere in the Indian Ocean. If, on the other hand, we take the secondary stage carnivores, the estimate would be of the order of 9 million tonnes of tuna or tuna-like fishes in the Indian Ocean. Since both these assumptions would be unrealistic, the total yield would be somewhere in between the two, perhaps nearer to 20-25 million tonnes or 149-186 million tonnes in terms of fish if the carbon is raised to wet (fresh) weight of fish (factor, 7.47).

Such an estimate would only be valid theoretically and shall certainly be subjected to a series of errors. In the first place, the animals eat food not at the rate at which algae are produced in the sea (photosynthesis). Secondly, the potential yield is not equivalent to the sustained annual harvest which we get from the sea. The potential yield is shared by a variety of animals (carnivores) at the higher trophic levels of which man only forms a part.

POTENTIAL YIELDS OF VARIOUS GROUPS OF FISHES

Gulland (1971) calculated the potential yields of different categories of fishes from the Indian Ocean. These have been shown in Table 5 and the total potential fish catch has been estimated as 14.3 million tonnes.

PRESENT HARVEST

The present fish harvest from the Indian Ocean is approximately 2.5 million tonnes of which about half is contributed by India (Qasim, 1972). Much of the fish production in almost all the countries bordering the Indian Ocean comes from the coastal waters. The total potential catch of tunas from the Indian Ocean, from all types of fishing, has been given as 110,000 tonnes (Gulland, 1971). The present catch of tunas already seems to reach this figure. Similarly, the potential catch indicated for the crustaceans as 250,000 tonnes, (Gulland, 1971) seems to have already been achieved.

CONCLUSION

The foregoing account indicates that the estimate of potential yield from the Indian Ocean varies from about 10 million tonnes to 186 million tonnes. It is, therefore, questionable whether such a wide variation in the estimate is going to be useful to planners.

Table 5. Potential yields of various groups of marine food resources.
The values are in millions of tonnes (Gulland, 1971).

Resource	Western Indian Ocean	Eastern Indian Ocean	Throughout Indian Ocean	Total
Large Pelagic fishes				
Large tuna, billfishes	—	—	0.1	—
Skipjack, bonitos etc.	—	—	0.6	0.7
Shoaling pelagic fishes				
Anchovies	2.0	0.7	2.7	
Herrings, sardines	1.0	0.5	1.5	
Mackerel, Jack mackerel	1.0	0.8	1.8	6.0
Demersal				
Croakers, snappers sharks, rays and other demersals	4.4	3.0	7.4	7.4
Crustaceans				
Lobsters, rock lobsters	•	•		
shrimps, prawns	0.1	0.1	0.2	0.2
crabs	•	•		
			Total	14.3

• denote values less than one lakh tonnes

In 1970, the fish catch in India, for the first time, crossed one million tonnes and in 1971, it recorded 1.2 million tonnes (Qasim, 1972). Since then, the annual fish production in India has been decreasing and in 1974 it has reached a surprisingly low figure.

Similarly, the world's seafood production after reaching 70 million tonnes in 1970-71, has recorded a decline and this fall has been attributed to the failure of the anchoveta fishery of Peru.

However, whatever may be the cause, the general trend in the decline of world fish catch and also of India's should be viewed with considerable alarm. The author strongly feels that almost all the coastal waters of the Indian Ocean are either over-exploited or have reached the optimum level of exploitation and hence any further fishing pressure in these regions may lead to overfishing or depletion of resources. The first symptom of this has become apparent from the failure of Bombay duck fishery of Gujarat and Maharashtra States in 1974.

If we accept the view that it is unlikely that the fish production will increase substantially from the coastal waters then it must largely come from the open ocean to approach the calculated figures noted earlier. If the economics of fishing operation in the open ocean are taken into account, keeping in mind the increasing cost of fuel, continued escalation in the prices of all raw materials etc., the viability of large scale fishing in the open sea where productivity is low would be highly questionable. It is only conceivable if the price of processed seafood in the world market becomes so high as to make even a small non-quality catch pay for the entire operation.

The tacit assumption, therefore, that the desired increase in fish production is always possible by increasing the exploitation of wild stocks will have to be revised soon. Furthermore, the fish production in coastal waters is constantly decreasing because these regions have become highly susceptible to destructive forces of pollution and other ever-increasing human activities. Hence, the only hope of producing seafood at a reasonable cost to feed the very large human population in developing countries is either by utilising unconventional seafood resources (krills etc.) or by generating extra food resources (Qasim, 1975) through mariculture.

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