Concepts on the Fluctuations in the Indian Oil Sardine Fishery - A Review

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INTRODUCTION

Oil sardine resources of the Indian Ocean, especially along the West Coast of India contribute considerably to our total marine fish production. If properly exploited and suitably processed, this can even be utilised to earn foreign exchange, besides being a 'Kudumbam Pularthy' for our poverty-stricken fishermen folk. Our concern on this resource is important still, since India has a long coast line of about 5650 kms and a shelf area of approximately 4,12,000 sq. kms, of which only a fraction is being presently exploited.

An important aspect of the Indian Oil sardine fishery is its fluctuations. Computation of the total annual landings of *Sardinella longiceps* for consecutive years shown the catch ranging from 1 to 26% of the total marine catch. It averaged from near total decimation in midforties to more than three lakh metric tonnes in 1968 forming one third of the total marine fish landings. This has made the fishery industrialists not to venture on such widely fluctuating resources, which make the forecasting difficult. Further this has led to some sort of 'nuclearisation' in marine products export sector with prawns as the major export commodity. Absence of diversification will not only be harmful for the industrialists but also for the concerned fishery in the long run.

The term 'fluctuation' can be defined as highly changing or differential availability of the concerned fishery resource to the fishing gear. Several concepts were put forward explaining the triggering of this phenomenon. Though the causes were traced to abiotic (fishery independent) or biotic (fishery dependent) factors the conclusive proof seems, with the current thoughts, to revolve around fishery independent meteorological aspects operating through oceanographical features on homogeneous or heterogeneous stocks. An attempt is made here, to critically evaluate theses and anti-theses relating to the fluctuations with a suggestion for a desirable future line of work.

THE CONCEPTS

(1) **Overfishing:**

As early as 1865, Day had hinted at this, by referring to the increased trade in fish oil and expressed his grave concern that if later years should prove this trend, it would be detrimental to the fishery. Sundara Raj (1934, 1937), Devanesan (1943) were supporters of this view.

The problem of overfishing implies that with increasing effort there would be a decrease in catch per unit of effort. Unless it is proved that the present fishing mortality is more than that associated with maximum catch per recruitment, this view of 'overfishing' cannot be held tenable. Further Banerji (1967) has noticed no relationship between abundance and fishing effort and has observed that the present level of fishing mortality is only half of that associated with maximum sustained biological catch.

(2) **Availability of food:**

This view is based on the fact that the occurrence of dominant food item of oil sardine determines the fluctuations in the fishery. Nair and Subramaniam (1955) and Panikkar (1952) mentioned *Fragilaria oceanica*, a marine phytoplankter, whose abundance coincided with the fluctuations of the fishery.

Subsequent observers like Dhulkhed (1964), Kagwade (1967) however noted that the importance is to be equally shared by *Coscinodiscus* spp., *Pleurosigma* spp. and certain dinoflagellates and copepods as well (Noble, 1969). There seems to be no consistancy in regard to various food items in different size groups, the dominant groups varying in different years (Dhulkhed, 1970).

(3) **Pressure of overaboudant year class:**

Bennet (1968) has assumed that the oil sardine fishery leans more on older year classes. This exerts greater stress on the fry of one or two successive generations in the fishery. Since the commercial fishery of 1964 witnessed such an abundance as to establish a record and continued to support 1965 fishery as well, the rarity of the new incoming juveniles (broods) in 1965 might have prompted the author to see the determinant in this 'pressure-hypothesis'.

Antony Raja (1971) in his subsequent studies has observed that the fishery depended mainly on 0-year class and the fluctuation is mainly related to the spawning activities and survival rate of spawn of the same season, this in turn being related to the atresia of gonad due to erratic South-West monsoon.

The scarcity of juveniles of 1965 fishery was not because of older group's pressure but due to the failure of spawning of that year and hence its own weaker strength. Further, Antony Raja (1969) argues that the subsequent good fishery from 1964 to 1968 did not support this theory since as per Bennet's view, the abundant year class after stiffling out 1965 and 1966 year classes should have turned into a lean fishery in 1967, which was not the case.

(4) **Differential gear - accessibility:**

It has been observed that the fluctuations are caused by variations in the accessibility of the stocks to the severely re-

stricted fishing range of the gear in use at present and these variations in accessibility represent changes in the disposition of the migratory path taken by the fish. It is thought that even the maximum accessibility to existing gear brings only a portion of the stocks under exploitation (Banerji, 1967; 1968). This theory obviously presupposes heterogeneity of the sardine stocks since differential migratory paths hardly exist in homogeneous stocks (Cushing, 1968).

More recent research (Narasimha Rao and Dhulkhed, 1976) however supports this trend of heterogeneity in oil sardine stocks. In fact, the serological and biochemical approach for identifying fish species and populations has been reviewed (Ligny, 1969) and as a tool of identifying fish populations in pelagic fish stocks of Indian Ocean region (Dwivedi, 1967).

Recent serological studies (Dhulkhed and Nagesh, 1975) have also proved the existence of genetically different groups of oil sardine along the West Coast of India, by revealing the presence of antigens A and B and distribution of three phenotypes A, AB and O in these fishes

The search for intraspecific differences by electrophoresis of the eye lens proteins was initiated by Smith (1962; 1965), which in earlier studies was based on morphometric and merestic counts (Balakrishnan, 1965; Prabhu and Dhulkhed, 1972). Preliminary investigations in these lines at Mangalore (Rao and Dhulkhed, 1974) have indicated the presence of an extra component in electrophoretograms suggestive of genetic differences in oil sardine stocks as observed by Smith (1962) in the case of bluefin tuna and Kelpbass, and by Dwivedi (1967) and Vrooman (1964) in the Pacific sardine.

(5) **Differential sea level pressure :**

Studies of Chidambaram and Menon (1945) correlating the catches with the amounts of rainfall indicates the influence of monsoon intensity upon the fishery. But Murthy and Edelman (1971) feel that it is difficult to adopt rainfall as an index of monsoon intensity, because of the orographical influences upon it. The field of pressure would reflect the monsoon intensity to the utmost degree of accuracy. The pressure gradients at the surface during monsoon are one of the best and simplest expressions of monsoon intensities in different years. Hence the studies of temporal variations of monsoons in terms of pressure gradients would offer an explanation of the fluctuations in the abundance of the fish.

When the relations between the trend of sardine fishery and the trend of monsoon intensity as expressed by pressure difference $\triangle P$, has been subjected to regression analyses it has been observed that there is a critical value of monsoon intensity above which the catches improve with increasing monsoon activity and below which the catches decrease with increasing monsoon intensity.

No doubt the influence of a strong monsoon would enrich the nutrient supply to the surface and sub-surface layers of the sea by causing a corresponding upwelling along the West Coast of India, but at the

same time, the lower layers of poor oxygen would be brought upward creating unfavourable conditions for the fish to thrive and hence the fall in catch (UNDP/FAO Pelagic Fishery Project Progress Report No. 6, 1974) with increasing monsoon. When the monsoon is above its critical strength, the depletion of oxygen of the top layers due to upwelling would be much more compensated by the addition of oxygen due to strong winds and waves. Thus the intensity of monsoon over and above its critical value is favourable not only for enrichment of nutrients but also for dissolved oxygen. It should be understood, however, that the difference of pressure ∇P (Sea-air interface turbulance) need not be correlative of rainfall index during spawning fortnights studied by Antony Raja (1969).

(6) **Adolescence :**

This is the phenomenon wherein, in tropics, the fish reaches maturity but does not spawn for want of ideal conditions and instead, resorbs the maturing ova, as reported in the case of hake (Hickling, 1930) and Norway pout (Gokhale, 1957). Though it is unlikely, certain peculiar features found in the ovaries of the fish in 1965 and 1969 appear to indicate that this probability also has to be looked into (Antony Raja, 1969).

(7) **Pressure by mackerel-fishery in "dual species neretic pelagic fisheries complex":**

This concept is essentially based on long term statistical computations of catch statistics for both mackerel and oil sardine fisheries. An overall inverse relationship between the two has been observed inferring a probable influence of mackerel fishery on oil sardine availability though it need not be the rule. Catch trends from 1964 to 1968 have shown that under the overabundant sardine catches, mackerel had failed to establish.

In an ecosystem of multiple fisheries, differential daily and seasonal rhythms of activities may result in the survival of one and the failure of the other. Further, the catch statistics of the years 1957, 1958 and 1960 showed more or less equal catch, for both these fisheries.

(8) **South-West monsoon rainfall:**

The current trend in research (Antony Raja, 1969) which has inferred oil sardine fishery leaning largely on the O-year class, relates the fluctuations to the causal factors during the process of reproduction. Antony Raja (1967; 1971) reported vascular hypertrophy and pre-ovulation follicular breakdown in advanced ovaries resulting in follicular rupture and dis-integration of differentiated ova, forming corpora atretica.

The possibility of atresia taking place due to quicker decomposition of alimentary tract lying in close proximity to the ventral surface of the ovary and triggering its post-mortem changes has been ruled out since all ovaries of the same sample did not exhibit this phenomenon and even samples caught from nearshore presented this feature. Further, if proximity to alimentary tract results in the decomposition of ventral side of the ovary earlier, after some lapse, it should set in throughout the organ which was not so.

Another possibility for atresia is that the fish heading for spawning grounds have started developing ripe ova and entered into Stage V, but when they are caught at that moment, all these ripe ova get ruptured due to shock, for, it has been shown that such disturbances can affect the ovofollicular system (Bretschneider and Duyvene de Wit, 1947). The presence of a few partially as well as fully transparent ova around the external oviducal opening in most of these fishes appears to be indicative of this possibility. It appears also likely that the disturbance may be physiological – a set back in the spawning rhythm due to some unfavourable conditions not providing the required stimulus for the act.

Perhaps, ruling out these chance factors. Antony Raja (1971) has observed a good correlation between the percentage of atretic follicles and erratic monsoon rainfall during the spawning fortnights, lower the monsoon greater the percentage. For instance, he recorded a rainfall of 13, 19 and 12.5 mm only during the years 1963 '65 and '69 when the rate of recruits were much depleted and an average of 30 mm rainfall was recorded during the years of good fishery in 1961, '62 and '64.

(9) **Scarcity of juveniles in the inshore belt:**

One point pertaining to the scarcity of oil sardine juveniles contributing to fluctuations in the shelf area during and immediately thereafter of monsoon months may be related to the reports indicating the preference of juveniles of 5–13 cm group for copepods, cladocerans, etc. (Bensam, 1967). This tendency suggestive of carcinivorous habit is related by Bensam (1967) to (a) indirect selection of larger items by less efficient seiving mechanism of developing gill rackers while adults, over 14 cm or so with fully developed filtering device, become predominantly phytoplanktonic (b) that the juveniles are chiefly predators on planktonic crustaceans and adults on phytoplankters. Sekaran (1970) has also stated that in *Sardinella alabella* and *S. gibbosa* of Mandapam, the ratio of copepods to diatoms in stomach contents decreased with an increase in fish size.

Further studies in this regard relating the plankton biomass assay and the sardine juveniles in inshore areas are highly desirable.

Thus a resume of the different concepts of fluctuations in Indian oil sardine fishery seems to bring forth the importance of abiotic or fishery independent parameters which may trigger the process through biotic factors. In this respect, three most important subjects have to be pursued, namely (a) structure, strength and identity of sardine stock/stocks with estimation of primary phenomena of population dynamics, b) spawning survey and c) environmental studies. Greater co-ordination of effort and collation of data from different disciplines like oceanography, meteorology and biology will contribute to formulate more precise theories on the fluctuations in oil sardine resources. This would, in turn, help to forecast the probable trends in the fishery thus leading to a rational, overall management of this most important pelagic fishery of India.

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