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Fish Population Studies

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Generally, we hear such questions as "what is the magnitude of our oil sardine or mackerel resources?" "Can we get more catch from these resources?" It is, therefore, proper that we carefully examine what is meant by a fishery resource e. g., oil sardine or mackerel resource. A fishery resource is just like any other natural resource (e. g., mineral resource, hydro-electric resource etc.) which is exploited by man. But at the same time, it differs considerably in character from other types like mineral resources. The coal resource in a region is limited in magnitude, even though sometimes we do not know the magnitude. From this fixed resource we can exploit at any desired rate. The resource will be completely exhausted after a period of time depending on the rate of exploitation. In this sense a mineral resource can be described as a non-renewable natural resource which is liable to get exhausted after some period of time. It is also a static resource because we always know how much of the resource remains, once we know how much has been removed. A fishery resource is very much different in character. It is a self-regulating renewable natural resource. Consider a fish population occupying a certain area of the sea. Now when a certain portion of the population is removed, the remaining portion in the habitat gets better food, more area to move about, and this results in faster growth rate, lesser mortality rates and also the spawns get better chance of survival. The result is that the resource resusciates itself quickly. Apart from fishing, the population is also affected by many other fishery-independent environmental factors such as available food supply, change in salinity, temperature of the water, change in ocean-currents etc. Thus the fishery resource is a dynamic resource, ever changing due to impact of fishing and other fishery-independent factors.

Though it is possible to estimate the absolute magnitude of this dynamic resource by tagging experiments and other methods, it is easier to construct simple index which measures the relative abundance of the resource. This index is given by the catch per unit effort. This index however will be a valid measure of the dynamic fishery resources only if our fishing efforts are spread over the entire range of the resource. The term unit effort requires some explanation. If it could be assumed that boats of the same type and size employing the same gear of more or less same dimensions exploit the fishery, then the number of operations of such boats in a year can be taken as the magnitude of effort, or even the total number of fishing hours by all these boats could also be taken as a measure of effort. If, however, a fishery resource is exploited by various types of boats employing diverse types of gear, the measurement of the magnitude of effort poses a problem. In this case, the relative efficiencies of the various types of fishing units have to be first found out, so that the efforts expended by various fishing units can all be expressed in terms of a standard fishing unit. One of the commonest method of estimating the total effort generated by diverse fishing units in terms of a standard fishing unit is to divide the total catch obtained by all fishing units by the catch per unit effort of the commonest or standard fishing unit.

Though the catch per unit effort gives a relative index of abundance of the fishery resource in different years, the information as such is not of much use to fishery scientists. For example, let us assume that catch per unit effort of mackerel in 1964–65 season is 1000 kg and that in 1965–66 season is 900 kg. The above information only tells us that in 1965-66 the abundance of mackerel was less than that in 1964-65. But such changes in a dynamic resource is inevitable. Thus neither a knowledge of the absolute magnitude nor the relative indices of abundance are of any gainful use to us. We have to use a different and meaningful yardstick for measuring the fishery resource. In fact the present catch and effort should be the most appropriate yardstick. Can we get more catch out of the available resource by increasing fishing effort, so that the available resource can regenerate itself to the original level? Or are we catching more than what the resource can yield and the fishing intensity has to be restricted? An answer to these questions will furnish more information on the status of the fishery resource than a mere knowledge of absolute magnitude of the resource which is variable and dynamic. In fact, the knowledge of these types constitute the crux of the problem of fish population studies.

The problem can be studied in two ways. The first method uses the population growth law derived by Schaeffer and others. Any population in the sea will grow i. e., increase in weight due to growth of the existing number and recruitment of new ones and decrease due to natural mortality taking place. The growth rate however will depend on the magnitude of the population in the sea. This growth rate will be obviously zero when the population is zero and again it will be zero when the population is at its maximum. The maximum growth of the population will take place when the population is at some intermediate level. If our catch is equivalent to this growth of population, the population will remain unaltered, that is, in equilibrium, and continue to yield the maximum catch. This is called optimum sustainable yield or equilibrium yield. Several empirical growth laws of the population can be assumed, the simplest of which is a parabolic law of population growth. Based on this, equilibrium level of catch can be worked out. A corollary of this approach states that if the population is in equilibrium, the relation between abundance (i.e., catch per unit effort) and effort is linear and abundance decreases with effort. Thus if we have several years' data, a simple plot will show the relationship between abundance and effort. If this is linear, abundance decreasing with effort, we can be sure that fishing is affecting the population and then determine the level corresponding to the maximum equilibrium yield. If on the other hand, no such linear relation is observed we should say that fishery-independent factors are the predominant factors. Thus the relationship between fishing effort and abundance is a diagnostic character of the status of fishery resource.

The problem can be viewed in another way. The commercial fishery begins to exploit the fish from a certain age, which we may call the minimum age of capture. The period of exploitation will depend on how long the fish lives. The weight of a fish will be more if we catch it when it is older than when it is young. But natural mortality operates throughout the life of the fish and sometimes it increases with age. Thus though an older fish will be bulkier, there may not be many fish left in a population, to catch at that old age. Hence we should better start catching the fish at an age when the growth rate equals natural mortality rate. Thus the catch depends on the minimun age of capture. The catch will also depend on the number of fish of capturable age entering into the fishery every year. The subsequent growth rate of the fish, natural and fishing mortality rates and also the longevity of the fish will influence catch. Thus if we can estimate the rate of growth, the age of capture, the longevity of the fish and natural mortality rate it is possible to determine the magnitudes of catch corresponding to various rates of fishing mortality, that is, fishing effort, and determine the level of fishing effort which will yield optimum catch. This is most important in relation to fishery management in the sense that a decision can always be taken as to whether the fishing intensity is to be expanded or restricted. Similarly at the current level of fishing effort, we can determine the magnitude of catch that can be derived if we vary the minimum age of capture. This will enable us to determine the most profitable minimum age at which we should begin to catch the fish so that we get the maximum weight of catch per fish. The problem of fish population studies thus reduces to the one of estimating the various vital statistics of the fish population, namely, the growth rate, natural mortality rate and the fishing mortality rate.

The growth rate of a fish can easily be ascertained if we know the sizes of the fish at different ages. Various methods are available for the determination of the age of a fish. The most popular method is by identifying the modal positions of the length frequency distribution obtained by taking samples from the commercial catch. This method does not furnish the age of individual fish but only indicates the average size of the fish at the end of successive ages. It has various limitations and needs careful handling. The second method of age determination is based on counting growth checks on scales, otoliths etc , brought about by periodic disturbances in environmental or physiological conditions. This is a very widely used method in temperate climate, where during the extreme rigours of cold season the growth ceases and it leaves its imprint in the harder structures like scales, otoliths etc. This method has been successfully employed for the determination of age in the case of some of the Indian fish but has not given any results in the case of many others. The third method of determining growth rate is by tagging fish and noting down the size of the fish at the time of release and again its size at the time of recapture. This method has so far not been tried in India because of many difficulties associated with the problem but very recently lobsters have been tagged and from the recaptures valuable information have been obtained. A programme to tag mackerel and oil sardine has already been initiated. The mortality rates can be determined either by comparing the relative abundance of a brood of fish at its successive ages or again from tagging.

Once the necessary estimates of the required vital statistics are obtained, it has already been mentioned that the status of a fishery can be determined.

The mackerel and oil sardine form two of our most important fisheries in India and the two together form nearly 25% of the total landings of marine fish in India. The two fisheries are characterized by high fluctuations in their annual catch. No relation has been found out between abundance and fishing effort. Hence it is obvious that the fluctuations in the fishing success of these two fisheries are not due to fishing but are most probably brought about by fishery-independent factors. Both these fish are very fast growing in the initial period of their life and then the growth slows down considerably. Both have very short life span with a high natural mortality and a relatively low fishing mortality rate. In such a fishery, the fishing success will depend on the strength of the incoming group (recruits) in the fishery. In fact in both the fisheries, the major portion of the catch comes from the O-year class (i. e., fish less than one year old) and the fluctuations in the catch have varied along with fluctuations of the O-year class. It is necessary to search for the fishery-independent factors which cause such wide fluctuations in the yearly recruits and bring about wide fluctuations in the annual catch of these fisheries.