J. mar. biol. Ass. India, 1973, **15** (2) : 735–749

THE INDIAN OIL-SARDINE FISHERY : PROBLEMS IN PERSPECTIVE*

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ABSTRACT

The problems of immediate concern regarding the fishery of Indian oil-sardine, *Sardinella longiceps*, are as follows: Researches should be keyed up on three main lines, namely, *behaviour studies* through analysis of the distribution patterns of the fish in relation to the environment, *population studies* to know the homogeneity of the exploited population as well as its strength and parameters and *spawning studies* for detection, delimitation and evaluation of the spawning areas. Development should include redeployment of effort beyond the present fishing zone, introduction of purse seining on a large scale and the socio-economic problems of the fishing community.

The fluctuations so characteristic of the oil-sardine catches are most probably because of oscillations in the annual recruitment of the juvenile broods which, in turn, appear to be linked up with variations in the intensity of the south-west monsoon. A weak or erratic monsoon is suspected to bring about conditions which are not conducive to successful reproduction and survival of the young fish. A hypothesis is proposed that while a certain minimum amount of rainfall during the spawning period appears a necessary condition, it certainly is not the only responsible factor for production of a good year class.

A symposium on both the oil-sardine and the Indian mackerel is suggested to increase the effectiveness of future attempts of more penetrative studies, since many of the problems are common for both the fisheries which constitute the 'dual-species neritic pelagic fisheries system' of south-west coast of India.

INTRODUCTION

BY far the most important single-species fishery that contributes to the fisheries wealth of not only India but the entire Indian Ocean is the Indian Oil-sardine, *Sardinella longiceps* Valenciennes. The recent reblossoming of its fishery appears to overshadow all its earlier fishery performances and exemplifies a production magnitude and pattern hardly equalled in its past recorded history. There has been such a dramatic increase in the oil-sardine catch in the recent years (1964–1969) that an annual average of about 250,000 tonnes has been reached which represents about 30% of the all-India marine fish production and about 11% of the entire Indian Ocean harvest. When projected against the backdrop of the vast expanse of the Indian Ocean, the importance of this fishery becomes further enhanced since the area from which this quantity is netted forms only a microscopic fraction of a percent and, when compared to an average of 0.08 tonne of fish per square mile of Indian Ocean, the oil-sardine *per se* accounts for about 50 tonnes per square mile. But

*Presented at the 'Symposium on Indian Ocean and Adjacent Seas – Their Origin, Science and Resources' held by the Marine Biological Association of India at Cochin from January 12 to 18, 1971.

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the picture is not as rosy as it appears. That the fairest things have fleetest fortunes is true of the oil-sardine for, the most characteristic feature of this fishery is its erratic behaviour and capricious nature as a resource. During the past two decades alone its annual catch has been found to dip as low as 7000 tonnes as well as rise meteorically to a phenomenal 300,000 tonnes forming respectively 1% and 33% of the total marine fish catch of India. It is its hoary past, its near annihilation in late forties, its revival in the fifties and a most remarkable leap in the sixties that tempts a comparison of the oil-sardine with the mythical bird of Egypt, the *Phoenix*. It is hoped, however, that our *Phoenix* does not indulge in yet another 'self-immolation' act to the detriment of the industry.

From the first research report of Hornell and Nayudu (1924) to the latest monograph on the fish (Antony Raja, 1969), a lot of progress has been registered on elucidation of vital information on the biology and fishery as well as on the technology of the by-products of this valuable resource. There is no doubt that the quantum of research, especially during the last decade, has not only enriched our knowledge considerably but has indicated the emergence of other vital problems offering an intellectual challenge to accept which it is necessary to identify the problems and categorise their priorities. Despite the strides registered, a lot of leeway is to be made requiring acceleration of pace and change of direction, wherever necessary. Not only figuratively but literally too we are still on the shore, in as much as the existing information stems largely from scientific observations on commercial fish landings which can offer only a limited spectrum for deduction. Yet its value cannot be minimised for, while there is no room for complacency, neither is there for despair, as it has set the stage for a take-off.

An attempt is made here to focus attention only on those problems of immediate concern as related to research and development and to suggest a possible course of action, not in the spirit that these have not been recognised or envisaged by other fishery scientists but largely with the intention of bringing them under one body so as to raise the awareness of the problems in perspective and to urge an unity of action despite all the diversity of opinions which by itself symbolizes a healthy growth of knowledge.

RESEARCH PROBLEMS

Since the fundamental feature that warrants a scientific probe into a fishery of commercial importance is the oscillations in its yield, both spatial and seasonal, the most important function of a fishery biology programme, which starts when the industry is already well developed, is to seek out the actual cause/causes for these fluctuations and therefrom, if possible, to evolve a method of predicting the appearance of these fluctuations. Hence, in order to develop an embracing description of the whole population a perspicuous understanding of the entire oil-sardine resource is required, complex though it may be, in relation to its *milieu* for efficient utilisation of this valuable ocean wealth. Broadly speaking, towards attaining this goal, research should be keyed up on three main planes, namely, i. behaviour studies, ii. population studies and iii. spawning studies.

Behaviour Studies

By behaviour studies, it is not intended here to imply experimental/endocrinological studies on the sensory faculties of the fish or the significance of sounds produced by it. Nor it is implied to go specifically into aspects of behaviour during feeding,

reproduction etc. for although these studies may indeed be interesting and informative, for the immediate future more fundamental than these must engage our attention. What exactly is meant for this field of investigation is the broad patterns of shoaling behaviour as deduced from the distribution patterns in relation to patterns in the environment. Although yield variations in any fishery are inherent, the most baffling feature of the oil-sardine fishery is its wide and erratic behaviour as a resource. Why is the oil-sardine so capricious in nature? Why and where do they emigrate to? When will they migrate in? In what quantity? These are the questions that revolve around the behaviour pattern of the entire resource. In order to understand the biological mechanisms governing these patterns, it is necessary to start from the simple but basic fact that the fish appear in a particular region, in a particular season and in a particular fashion. This results from the biological rule that the fish assemble in different ways during its various phases of life history, behaving both independently from as well as dependently on the environmental conditions. This mode of assembly must be the most fundamental biological project of the investigations in order to understand where, when, how and why the fish appear or disappear.

The only information we have on the oil-sardine is about their general distribution in space and time during the commercial season because they are very much at our doorstep. When they disappear by about March there is a reasonable speculation why they do so but it is still a mystery where is their sojourn until they reappear in June. Being a shoaling fish they ought to have been detected and reported by other agencies if they continue their pelagic habits outside the fishing belt. The very absence of such reports appears to give rise to a logical doubt whether it is not possible that they have a demersal or bathypelagic phase when the surface waters warm up during the summer months.

A suggestion was put forth by Antony Raja (1969) that the appearance of the oil-sardine all along the coastal stretch may be almost simultaneous depending on the time of outbreak and strength of south-west mlonsoon, the availability of congenial ecological conditions in the inshore waters and the location of spawning areas and that they may start disappearing earlier from their northern limits. But such speculations, as other speculations in the past, cannot be tested unless serious attempts are made to put down the evidences in an orderly manner for an analytical appraisal. There is no other better way to understand the mode of assembly and dispersal than through a series of annual space-time fishery maps for at least a 10-year period from the existing voluminous data. To initiate, the past decade is not only the most recent when techniques of survey and sampling have been improved but it also gives a sample picture of the fluctuating fortunes of the fishery also. These annual fishery maps prepared with details such as the distance from the shore, depth, size composition, a suitable index of abundance etc., for as fine an area as possible and at every suitable time interval would be the starting point for understanding the distribution patterns of the fish at various levels of its life cycle at different places. The annual changes in the manner of avilability will enable us to recognise whether, when and how the fish is 'misbehaving'. In other words, the differences in the patterns of assembly will show which phase of the life history and at what stage and area the differences have occured. From that picture, attempts can be switched over to find out whether these are caused by biological peculiarities of the fish or changes in environmental conditions or due to any differences in the fishing activities. Since the general levels of abundance and patterns of distributions at different places are largely governed by factors in the ecosystem, all the available data on abiotic and biotic factors will have to be analysed and the

salient features projected in relation to the distribution patterns. Not that we have all the details required for these maps, but through a zealous attempt to draw them, we may be able to get not only some idea of the various interrelationships but it will give us some indications also of the kind of information lacking to enable us gear our attempts to collect the same. If, for some reasons, it is not possible to attempt such an analytical probe with the past records, attempts are necessary to initiate it on the above lines for the declared objective. Perhaps when the preferences of the fish are known in the inshore waters, charting and monitoring of the distributional properties of the area beyond the present fishing zone, would indicate the region that might be sought after by the disappearing shoals. It is possible that the annual changes in the patterns of distribution of the oil-sardine population are brought about by either changes in the spawning areas and the migratory routes because of changes in the environment or the rise and fall of the subgroups of population, if any, differing in the distributional areas.

ii. *Population Studies*

At present we do not know whether our commercial fishery depends on a homogeneous population or on more than one subgroup of the same population. It is axiomatic that population identification is a *sine qua non* because it has been opined that truly homogeneous population of clupeid fishes rarely exist (Rosa and Murphy, 1960). Our oil-sardine resource is neither new nor recently subjected to fishing to eliminate the necessity of considering this problem. Three main paths usually sought to solve this problem are studies on biometrics, tagging and blood groups. The tagging experiments are considered the most efficient but the prohibitive cost involved in embarking on an ambitious and elaborate tagging programme – for, that is what it requires —had made even those countries that can afford the expenditure to think seriously about other methods. The studies of blood groups are hence resorted to which would give an idea of genetic difference. But herein too conflicting interpretations of the data so obtained have come to light recently (Fujino, 1967). Although the method is reported gratifying elsewhere, with the existing local facilities and difficulties of collection and transport of blood samples, although some preliminary academic interest can be bestowed, studies of serious, extensive and comparative nature are not possible in the immediate future. The third of the methods, the biometrical analysis of morphometric and meristic data, is usually rejected because it is being felt that the studies leave much to be desired since the characters are susceptible to changes in environment and cannot be relied upon. However, it has been also cautiously qualified that it should not be discarded as deficient for, in some cases, that may be the only tool available (Rosa, 1963) and that methodological improvements can yet make the method useful under certain circumstances (Rosa and Murphy, 1960). Moreover, the verdict passed on other fishes inhabiting totally different environs and which are capable of long migrations need not be taken as binding for conditions obtained in our waters where, temperature variations at the time of spawning season are rather too small to induce significant variations in meristic characters. Further, unless a method is tested and proved to the contrary it cannot be rejected. What dictates the choice of the method depends on the problem on hand. It is to identify whether there are possibilities for the existence of subgroups—they may be isolated or they may mix incompletely; the isolation may be temporal, spatial, ethological or physiological which are points for subsequent enquiry only. Future studies may perhaps show that there are no heterogeneities in the parameters of the exploited population of the different regions —recruitment, growth, mortality rates etc.—which is yet another method of approaching this problem; that there are no meristic or morphometric characters showing

significant and sustained differences between the areas, in which case, there will not be any justification for a detailed study of a problem which does not exist. Hence it is not advisable to embark on more efficient methods involving a heavy financial lay out but to adopt an expedient method to fix justification, if any, for intensifying the investigations. Other supporting studies of the differences, if any, obtained from the population parameters of different regions, the regional fecundity variations, the differences in the size of the yolk mass of the fertilised eggs and the pigmentation of the larvae when spawning survery is undertaken would all add up as evidences to indicate whether ours is one unit fishery or more.

The oil-sardine is an example indicating the restrictions in the application of any simple model of population dynamics. In view of short life span of the fish, a suspected high rate of natural mortality and the fishing success leaning heavily on the incoming juvenile broods of O-year class whose recruitment is variable and is conditioned by fishery-independent factors, the usual problems associated with stock conservation and sustained yield do not assume serious proportions. However, since annual assessment of exploited stock using suitable models is an important aspect of fisheries research, determination of various parameters of population dynamics is necessary which can be also used in subpopulation research as mentioned above. Moreover, the study is one source of information to obtain the recruitment rate and to know what segment of the population is being exploited as well as the strength of the available resource. While estimating these parameters, it may be necessary to break the catch into space-time groups and comparison attempted between the exploited population of different areas for identical seasons.

There is at present absolutely no published information on natality rendering it impossible to obtain an accurate picture of the rise and fall of the annual juvenile recruitment. The size and age composition studies are required to be extended to provide this information so as correlation analyses of the stock/stocks at various stages can be attempted. There is an element of danger in assigning the age classes based on length composition alone in those years when the sizes of two successive generations may merge due to phenomenal growth of the earliest recruits of the latter generation. It has so happened in certain years that these two year classes, juveniles and adults after first spawning, have presented an almost identical modal size during the commercial season, occurring as they do, mixed in the same shoal, that it is impossible to assign them to their respective ages except through examination of their gonads (stages I & IIb) or perhaps from the scale readings. Hence, some caution is necessary in these studies wherein only length frequency data are utilised.

In order to understand the relationship between the stock sizes at various stages, it is considered essential to collect information on the relation between i. egg abundance in any year and the catch from the resultant year class at a later stage, ii. egg abundance and the catch of the year classes that contribute it and iii. catch of O-year class at any given year and the catch from the same year class at a later stage. While the relationship mentioned last can be investigated now, the information on the other two are associated with an efficient model of spawning survey which alone would give an unbiased and direct verification of the fluctuations in recruitment. Recruitment, as is well known, enters the fishing equation as one of the main population variables that determine the total weight of the exploitable stock and the yield from the fishery. Its quantitative evaluation, the study of its fluctuations and their influence on the course of the fishery are all the more important in the case of the oil-sardine as that appears to be a deciding factor in the quantum of availability. A surer study of this aspect results mainly from the spawning survey.

iii. *Spawning Studies*

Although recruitment can be estimated from abundance indices of the O-year group appearing in commercial catches, the direct evidence is from the egg-census survey. There may be an objection to this because so far there is no evidence that recruitment bears a close relationship to the total egg production for patterns of recruitment depend on the survival rate of the spawn. Of course, there is logic in this arguement but while this may not be applicable where a population density is subjected to variations of wide range, it will be shown in the subsequent section that when the spawning potential of individual fish suffers through an element common to all, the cumulative egg production also would suffer, thus affecting recruitment.

A wide lacuna—the most serious and vital—in our knowledge is on the area of spawning and the distribution of eggs and larvae. The importance of the knowledge of distribution, abundance and biology of the younger stages in the pre-recruitment phase towards providing answers to many problems in population studies is too well known to need recapitulation. The early stages of larval history are considered to be the critical stages with respect to mortality rate and on which partly depends the success or the failure of yearly broods, since survival rate is mediated through environmental changes. Detection, delimitation and evaluation of spawning areas will make an important contribution to the solution of the problem of stock identification also for, genetic differences in subpopulations may be reflected in larval characters such as pigmentation or in the diameter of yolk mass of the fertilised eggs (Rosa and Murphy, 1960). Further, one of the most effective ways of understanding the reason for impaired or declined resource comes from the knowledge of biological conditions of the spawning grounds. Attempts to comprehend the behaviour of any fishery resource, in fact, should start *inter alia* with the identification of the eggs and larvae of the concerned species and their area of production followed by a census survey. It is the painful dearth of knowledge on this aspect that has given rise to several speculations and controversies since indirect evidences can be interpreted subjectively. Being essentially a coastal species, the spawning grounds also should be fairly close by. The availability of sizable quantity of fry as small as 30 to 40mm in the nearshore waters during certain years and other indirect evidences indicate that the spawning grounds are not very far and yet they appear far enough since detection has been elusive. The main handicap in bridging this hiatus has been the lack of ocean-going facilities for, the intense spawning takes place at the height of monsoon when neither the indigenous crafts nor small powered boats can venture out to the desired distance. It is true, quite a number of exploratory cruises were conducted in the recent past and in connection with the International Indian Ocean Expedition Programme but the reason why no larval material of this fish could be collected appears to be that the area inside of 50 m depth has not been seriously combed. The absence of any reports in the deeper waters sampled by the cruises also appears to be a pointer in believing that the fish breed in the inshore waters only. The urgent necessity of a spawning survey at least on a modest scale has been stressed by the scientists for some time past but unfortunately for various reasons this phase of investigations has remained unattended. It is, however, hoped that sooner than later, the importance of this line of investigation is realised to overrule all other considerations. With reasonable chances this author feels that such attempts during one spawning season alone—to begin with, off Calicut region between Tanur and Tellicherry inside of 50 m depth — may be met with results paving the way for further elaborate investigations.

iv. *The Effect of Monsoon on the Fishery*

Among the various causes for the fluctuations in catch, as far as the oil-sardine is concerned, it can be said that they are fishery — independent and are due to fluctuations in the strength of juveniles recruited every season, which, in turn are governed by changes in the environmental conditions. The latter may affect the population in two ways, either by limiting the availability of the fish in the fishing grounds or they may affect the spawning act, the resultant offsprings and thereby the recruitment to the stock. Since no great oscillations take place in the environment during the peak commercial season but the period before that is subjected to the vagaries of the south-west monsoon, the first of the two can be kept at the background for the present, thus, narrowing it down to the logical alternative. Hence, our concern should be on the whole range of phenomena which lead to the reproductive act and those that lead from that act to recruitment which takes place during the monsoon months of June to September.

It has been generally agreed that there must be a critical level of egg production below which recruitment to the stock would definitely decline (Parrish, 1956). This critical level can be affected by reduction in the quantity of spawning stock to such a low level as to reduce the recruitment through reduced reproduction or by reduction in the spawning potential of each fish so much so the spawning potential of the entire adult population is impaired. Since the evidences of poor spawning stock of 1960 and 1964 producing rich year classes and large spawning stocks of 1963, 1965 and 1969 producing poor year classes rule out the possible operation of the first it is logical to presume that the other alternative is responsible for the reduction in yearly recruitment. The maintenance of egg production above a level is thus the first essential for the attainment of maximum productivity from the stock. Although this level has not been determined for any fish anywhere it does not mean that it can never be determined.

Reverting to the relationship between the monsoon and recruitment, it is interesting to recall that there is a popular belief among the fishermen, who are actually in the field for generations, of some connection between monsoon rainfall and the ensuing fishery. Even as early as 1910, Hornell felt that conditions resulting from the south-west monsoon may play a large part in influencing the fishery and suggested, among other things, a study of local rainfall. Chidambaram (1950) also felt that fluctuations are caused by varying degrees of spawning success and larval survival. But how exactly spawning is affected during the monsoon remained unanswered till recently when studies have indicated that during certain seasons heavy follicular breakdown results in the ovaries both before and after spawning, thus reducing the stock of eggs available/released. This physiological phenomenon of atresia, in those years when the monsoon was erratic and rainfall feeble, was found to be very pronounced both in the percentage of ova affected as well as in the percentage of fish experiencing it. This feature was witnessed in 1963, 1965 and 1969 which were interestingly the years when the fishery for juveniles was found to be poor at Calicut. On further analysis of rainfall during the monsoon, there was a striking deficiency in the average daily rainfall during what is suspected as the spawning fortnights, namely, a week before and after the New Moon day in these years as compared to others. Hence, it was postulated that while an average daily rainfall of about 30 mm during the spawning fortnights would contribute towards normal maturation and spawning process, anything less than 20 mm would result in large scale pre- and post-ovulation atresia and affect the ensuing fishery for the juveniles (Antony Raja, 1969). There may be a serious question how the spawning fortnight has

thus been established. It is true that evidences are rather meagre but till such time when they are forthcoming to prove or disprove, those that are available (Devanesan, 1943; Antony Raja, 1969) have to be taken cognizance of. In consideration of environmental effects, an enlightened selection has to be made for, it is truism that scientific knowledge develops partly in techniques and partly in theories.

It is proposed to present here a model for the oil-sardine on the lines very similar to that of Marr (1960) who related temperature regime for the fluctuations in the strength of year classes of Pacific sardine. What is proposed may be a crude hypothesis accounting for a portion, at least, of the causes for the fluctuations. This is done more with the idea of stimulating work in the direction than as a final answer. What has given encouragement to place this hypothesis is not only because of successful predictions this author could make for 1963, 1965 and 1969 seasons, thus testing it against time but also because of the results of contemporary studies showing a striking relationship between the monsoon intensity and the abundance in the ensuing fishery (Murthy and Edelman, 1970). A suspected correlation between the precipitation caused by the rainfall during pre-spawning months and the subsequent strength of recruitment in *Sardinella aurita* (Ben-Tuvia, 1960) and a recent publication linking atresia with year class abundance in river impoundments of Northern Pike, *Esox lucius* (June, 1970) are also other sources influencing presentation of this hypothesis.

The kind of relationship that is postulated is that if the average daily rainfall during the spawning fortnight is below a threshold value, then the chances of production of a successful year class are unlikely. On the other hand, if the rainfall regime is adequate, successful year class may or may not be produced for the survival rate is dependent on other factors also. In other words, an adequate amount of rainfall is "a necessary condition but not a guarantee" (Marr, 1963). To examine this proposal, if the strength of the juvenile year class is plotted as a dependable variable on the mean daily rainfall and the field is divided into four quadrants, by a horizontal line passing through the average value of several year classes and by a vertical line passing through a threshold value of the rainfall, successful year classes should be found in the upper right quadrant and the unsuccessful ones in both the lower left and right quadrants whereas none should fall in the upper left quadrant.

The catch data at Calicut for a 10–year period (1960-1969) relating to October-December months which is the period of peak production and which belongs largely to the juvenile community has been taken into consideration here. The catch per gear has been used as an index of abundance of the recruited year-class although the estimated number of the juvenile recruits alone should be more accurate. Hence, some inexactitude is inevitable but can be condoned as only a broad outline is herein attempted. These data are plotted as a function of mean daily rainfall during the days falling a week on either side of the New Moon day of the months June to August of the respective years. The horizontal line passes through the average catch per gear of the 10-year period, 665 kg, and the vertical line passes through an overall mean daily rainfall of 22.6 mm. It is seen from Fig. 1 that except the 1960 and 1969 year-classes all the others fall in the expected quadrants. The position of the 1960 and 1969 year-classes in the upper left chamber would appear to invalidate the proposed theory. But a closer examination of the records show that each of these two years was an anomalous one in its own way. In 1960, the fishery was supported by an unusually large-sized individuals with a modal size of 145 mm unlike its normal dependance on the 110 or 120 mm groups. Corresponding to this the average weight of the fish was about twice than normal, thus inflating the

catch data. In the case of 1969, the fishery was sustained to a very great extent by the spent fish as an unusual departure from normal—a condition similar to the one seen in 1965 (Bennet, 1969; Antony Raja, 1969). In addition to this, it is very likely that the complete conversion of the gear from cotton to nylon twine from 1967 would have also contributed to the increase in the catch per gear since one of the reasons for the continuous good harvest from the oil-sardine fishery is doubted to be this conversion (Antony Raja, 1969). If the estimated numerical strength of the juveniles alone were to be plotted with necessary corrections for the increased gear efficiency, if any, the points for these year-classes also would fall in the lower left chamber.

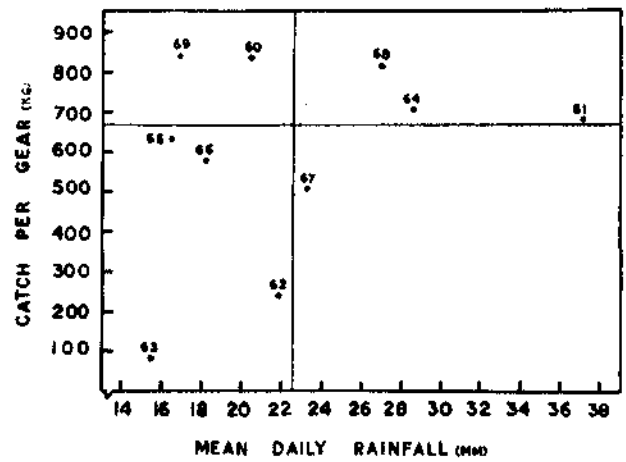

Fig. 1. Relationship between the catch per gear of the oil sardine during October-December and the mean daily rainfall of the spawning fortnights of June to August of the same year for the years 1960 - 1969 at Calicut.

It is not the intention of this author to imply that rainfall amount by itself is responsible for variations in spawning success but it seems as an indicator of general climatic/oceanographic conditions that would control spawning process. What is suspected is that a chain reaction, brought about by failure of monsoon or even an unequal distribution of monsoon conditions during spawning, begins by affecting the spawning potential of the fish and if this feature continues in all the major spawning months of June to August, the overall egg production is affected and the survival rate of eggs and larvae may also suffer as they would be out of phase with the required normal environment for development—one of the causes may be the depleted oxygen content due to upwelling not compensated for by enough wind mixing—which may be followed by low food production in the coastal waters and culminate in the availability of weaker stock for exploitation. Perhaps the sardine has a habit pattern or a built-in reaction that requires a particular set of conditions—may be temperature, salinity, turbidity, dissolved material, flow of currents or some other yet unspecified factor, singly or in combination—to produce the trigger mechanism of spawning followed by an undisturbed rhythm of reproduction. Perhaps the rainfall is just an indication of the likelihood of obtaining or no. obtaining this complex set of requirements.

While this minimum monsoon intensity is one element involved in the opportunity for successful spawning, this may get minimised if other conditions for a good

survival are not operative. For example, if the wind and current establish a drift system that is not shoreward, the younger stages may be carried away to distant waters where chances of survival may become reduced and hence their availability in the inshore waters diminished. This may be the reason why, inspite of average monsoon conditions, successful year classes are not produced in certain years. Thus, in addition to conditions ideal for spawning, a second requirement is a suitable water mass during the period of larval survival.

The above model, however, should be subjected to a critical analysis by bringing in other oceanographic factors operating during June to August, with special reference to the spawning fortnights, so as to identify which of the abiotic factors would have caused a set back in spawning in 1963, 1965, 1969 and probably in 1966 also, so that a safe method of prediction can be evolved which is "to recognise one event that is followed by others, to recognise that event as the beginning of a sequence of 'results' of a particular 'cause'(Revelle, 1960). It is most appropriate to quote here the concluding cautious remarks of Marr (1960) when he proposed his model: "The model must, therefore, be regarded as only a first approximation. It is my hope that it is realistic enough to both warrant and inspire critical testing in the laboratory and at sea."

For the fisheries that are characterised by natural fluctuations it is indeed a difficult task to develop a method of prediction. In the case of the oil-sardine, since the fishery is largely dependent on the juvenile community recruited every year a realiable forecast for the ensuing fishery from September has to be done very quickly with the data collected during June to August period. Since experience indicates that at the present rate of exploitation it is possible that an exceptionally rich year class may be able to contribute in such a good quantity to the fishery for two successive seasons as to obliterate a failure of the juvenile broods in the latter of the two years as was the case in 1965, certain amount of caution is necessary to make a forecast covering the entire biomass of oil-sardine that will be available for exploitation in a particular season. At present a modest beginning has been made to predict the strong likelihood of a weak recruitment based on the gonadal picture and the amount of rainfall. There is further scope to improve on this method to ensure accuracy, although for the present it remains rather qualitative of gross changes. As Simpson (1956) has put it, apart from the value of forecasting to the industry, predicting what is going to happen and checking it against the actual events is to the fishery biologist one form of the universal tools of formulating a hypothesis and putting it to test. The fishing industry is not only interested in knowing the prospects of the oil-sadine fishery but expects also from the scientists the likely quantity available as well as the area of availability. For this direct and positive prediction we have to look forward to the spawning survey programme and for that time when aerial scouting is made a reality.

From the research point of view it appears that an ideal field calendar for the immediate future allowing the laboratory to continue its activities, would be to undertake with a modern research vessel a 4 months' spawning survey during June to September followed by 6 months' experimental fishing with purse seine along with a programme of intensive tagging and drift bottle experiments and then embark on fish finding cruises from March to May to trace the area of oil-sardine emigration. Collection of oceanographic data—physical, chemical and biological—throughout all these cruises supported by aerial scouting, if possible, would bring in such a feast of data for the scientists that they may be able to unravel some of the present

mysteries, confirm or reject their theories and concepts and evolve a synoptic picture of their source which, today, is impossible to paint.

DEVELOPMENT PROBLEMS

As the manner of exploitation is entirely in the hands of the fishing industry leverage activities for the successful implementation of a fishery development programme depends on the co-operation of the fishermen to listen and their ability to understand. Their scorn for the researchers is reflected best in their attitude at the landing place for, they have a conviction that they are better informed of the fish and its surroundings (which, it should be admitted, is true to a certain extent) than the scientists. This conviction coupled with their resentment on the continued low level of their socio-economic status appears to be the reason for their apathy to research activities. They also have certain prejudices like their objection to the operation of mechanised vessels in their areas of opera ion for the fear that the engines' noise may frighten away the shoals. Here lies their ignorance for they have not seen the response of the shoals to the noise of the engine-how the shoals although getting dispersed a the approach of the mechanised vessels reform later to their original form. It is not that they are not willing to learn but they are rather slow in doing so. This cannot be helped considering the fact that even in well advanced countries with more enlightened fishing community this handicap has always been encountered. They may not respond immediately to suggestions that come from quarters other than their own but prefer to wait until somebody risks adoption and succeeds. Then they go *en masse* as has been witnessed recently on the Malabar coast in the conversion of all the existing types of *kolli vala* of cotton yarn into that of nylon twine. This is the only modernisation the fishing community has taken to willingly with reference to pelagic fisheries exploitation. It is very well known that for increasing the fish catch no means could ensure greater success than the mechanisation of fishing crafts and modernisation of fishing gears. So far, the oil-sardine exploitation has not had the benefit of mechanisation as a result of which the area of exploitation has remained static perhaps ever since the industry started developing. Even the narrow coastal stretch of 10 miles width is mostly covered on the Kerala coast, whereas along the Kanara and Konkan coasts the dependence is largely on the shoals migrating very near the shore—up to 1-2 miles. It is also a common sight on the North Kanara coast where preference is for mackerel that even if oil-sardine shoals are available, no serious attempt is made to capture them because it is not economical to operate a huge shore seine for the sake of a couple of tonnes of low-priced oil-sardine. Reliance on conventional shore seines for the shoals to migrate in dense congregations to the shore deprives the fishing community of the vast quantity of both oil-sardine as well as mackerel that may be available a little beyond. Redeployment of effort in different directions has been stressed for some time past but the fishermen by habit and inclination are adverse not only to changes in the method of operation but have strong objections too if any such manoeuvres are attempted by other agencies. Hence, it needs to be convincingly demonstrated to them that deployment of more effort and in a fitting manner is the only way to minimise the natural fluctuations in the availability.

The purse seine has been shown all over the world as the most efficient gear for the shoaling pelagic fishes. Experimental fishing conducted by the vessels of the Indo-Norwegian Project have also demonstrated that while catches of 9–10 tonnes per haul have been frequent (Menon, 1969), even as large a haul of 16 tonnes is a possibility (Menon, 1970) which should do credit even to a *Rampani*. But whereas 60–80 fishermen are needed for the operation of the latter, purse seining can be done

with 10 fishing crew. At present the developmental activities are largely seen in the procurement of trawlers for exploitation of prawn resources in view of their dollar earning capacity and thus the prospects of quick money. The industry has been rightly warned that the area is not a bottomless cornucopia for unrestricted trawling and that unchecked clamour for the golden egg may eventually endanger the bird! A strong case is, hence, made out for diversification of fishing effort on such lucrative resources as the oil-sardine and mackerel. We need enterprising entrepreneurs to come forward to take to purse seining, of course, care being taken in the beginning to keep away from the present operational zone.

There is little value in developing a fund of knowledge on the resource if those who actually capture the fish do not get a financial return commensurate with the efforts and hazards taken. Glut in the market should never be allowed for that brings down the price considerably hitting the fishermen more. At certain places, impounded sardine/mackerel, on the expectation of better financial gains on the subsequent days, are sometimes totally lost as a result of asphyxiation and even the survivors exhibit such a flabby body texture that their freshness is lost and their market value lowered. Were there shore installations for immediate storage, proper handling and organised disposal, such disappointments can be avoided. Not that these and allied problems have not seized the attention of those concerned but they are related here only to emphasise that the scientific endeavours and those towards development are closely interrelated. Even if the scientists succeed in developing measures for increased exploitation and the fishing community also responds to them favourably, the cumulative benefit will not be perceived by the community if simultaneous leverage activities on the shore for processing, handling and marketing based on the study of supply and demand, consumer preference etc., are not evolved in a parallel fashion.

A simple question the industrialist would like to ask is whether the scientists can ensure a steady annual yield of oil-sardine for the industry. The answer is, regretfully, no! The case of the Pacific sardine may be recalled here. Among all the marine fishes, perhaps, it is the most thoroughly investigated one; yet with all the varied and sophisticated talent in ocean sciences, the best documented records of distribution, catch, effort and recruitment and a well-knit cooperative programme of investigations at California, no one could stop such a complete eclipse of the Pacific sardine by the anchovy, that the former, which was contributing an average of 400,000 tonnes before the fifties of the present century, is off the records now! This is not cited as a defence for the scientists' inability to ensure a steady annual yield but only to emphasise how complex the behaviour of the oceanic environment is. Since annual recruitment is controlled by factors in nature beyond human control, it is not possible to prevent any sudden decline. However, the scientist would cautiously say, with the present state of his knowledge and the current mode of exploitation, that if a suitable structure of socio-economic-cum-fishing conditions can be created within which the under - and unexploited resources in waters beyond the 10–mile stretch can be fished in proportion to the ascendency of the different species in the ecological system, it is *possible* to harvest yields of sustainable quantity *provided* the strength of the recruited offsprings of these species has not been affected to a disastrous level by ecological conditions.

Our oil-sadine resource has many advantages as compared to other world sardine fisheries of commercial importance. Among them one is that it is a rather purely indigenous resource for the present, relatively under exploited with no external competition for it. Perhaps by virtue of historical and traditional fishing

we may have a legal right over the resource. At the same time it should not be forgotten that the oil-sardine shoals do frequent the contiguous waters of the neighbouring countries.

Finally a word on the rapport between the scientists and the industry may not be out of place here. There will always be a lag between, on the one hand, the time the scientists arrive at their findings and the time they formulate their recommendations and on the other, between the latter and the time the fishing community accepts them. This is inevitable. But the more effectively and speedily this communication is established the shorter the time lag will be, so that neither the scientists feel depressed that their efforts are not appreciated nor the community feels that the scientists are living in utopia.

PROPOSAL FOR A SYMPOSIUM

The above perspective on the problems facing the scientists and the industry form only the broad outline of a much wider, varied and complex job but, nevertheless, will clearly and unequivocally point out the necessity of a cooperative effort of collating all the data and intelligence available with the different interconnected disciplines to develop a dynamic concept of the total environment. Any comprehensive scientific inquiry into the oil-sardine cannot exclude consideration of the Indian mackerel for, not only together they form a 'dual-species neritic pelagic fisheries system' of the south-west coast of India but many of the problems mentioned in the preceding pages are common for both the species. It can be tentatively stated that while the decline in the mackerel catch in certain years may be either due to its own recruitment of a weaker year class and/or due to an over abundance of the oil-sardine acting like a biological barrier, the diminution in the sardine catch can be safely attributed to the earlier cause only. However, several factors will have to be considered for a definite assessment of the relationship between these two fisheries so that a clearer understanding of the biological changes in the environment can be obtained (*vide* Antony Raja, 1969).

Summarising the proceedings of the Symposium on "The changing Pacific Ocean in 1957 and 1958", Sette and Isaacs (1960) expressed "..... a basic understanding and subsequent basic forecasting of the fluctuations of a coastal fishery, probably, can be best attained by a *thoughtfully limited* study of the entire ocean, in addition to concentrated concern with the immediate area of the fishery." This realisation should mobilise all those engaged and interested in pelagic fisheries development and stimulate much thought and inquiry into the vast and critical events that so profoundly influence the area of distribution of these two pelagic fishes. There are also technological problems concerned with the proper utilisation of the raw material towards production of quality by-products which have not been dealt in this account. Hence, to launch purposeful and meaningful deliberations on all the problems, vital and unresolved, as well as those that may yet remain unidentified, it is necessary to have a much wider platform for discussions on both the oil-sardine and mackerel. The proceedings, documenting the evidences, ideas, concepts and theories of a large body of scientists and industrialists, would then bring the interdisciplinary awareness of the interrelationships between the environment, these pelagic fishes and their chief predator, Man, which would further increase the effectiveness of future attempts of more penetrative study of causes and implications.

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