J. Mar. biol. Ass. India, 1960, 2 (1) 115-120

MODERN TRENDS IN MARINE BIOLOGY*

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'One may not doubt that, somehow, good
Shall come of Water and of Mud
And sure the reverent eye must see
And purpose in Liquidity.'

RUPERT BROOKE.

Friends,

I am thankful to you for asking me to participate in the annual meeting to-day. The annual report presented by the Secretary has told us of the good progress which our infant association has made during the first year of its life. This augurs well for the future of the Society. In the coming years, marine biology will play an increasingly important role in the advancement of the sciences of life, and I am sure that the establishment of the Marine Biological Association of India in 1959 will prove to be a significant event in the progress of science in India.

But the achievement of our aims will depend upon the orientation of our efforts to the new horizons in marine biology. An occasion like the annual meeting to-day is appropriate for exchange of ideas, and I accordingly propose to speak briefly on some recent trends in marine biology, with a view to stimulating discussion on the subject.

I note from the Secretary's report that the lay public have been taking an active interest in our association. This impact of marine biology on society is an important trend, and is increasingly evident in countries where marine biological science has been established for some years. For the progress of science, and for science to serve properly as an intellectual tool in appropriate spheres of human activity, scientific thinking has to enter into the warp and woof of the intellectual fabric of human society and should be properly integrated with other intellectual activities. In our country, our national genius has not so far found expression in scientific achievements to the same extent as it has in other spheres like poetry or art, or as in many other countries. This is particularly true of the sciences of the sea. Notwithstanding our coast-line of 3,500 miles, we tabooed the '*Kala pani*' and in neither poetry nor art has the sea proved to us a source of inspiration as it has for some of the English poets.

But it is for another reason that I value this impact of marine biology on society. The advancement of marine biology, as I pointed out before, will contribute much to a better understanding of the phenomena of life and life-processes than at present.

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* Talk delivered at the first General body meeting of the Marine Biological Association of India on 20th December 1959.

This will help us to widen our intellectual outlook, and an intimate and fuller knowledge of the economy of life in the sea and its viscissitudes may ultimately help us to at least reassess some of our social philosophies.

These social and academic values can be adequately realised in marine biology only when it has attained the full status of a scientific discipline. But this has not yet happened. Marine biology may be said to have its origin about the middle of the nineteenth century in the discovery by Johannes Müller that multitudes of minute organisms exist in the surface layers of the sea, and in the erroneous observation by Edward Forbes that life does not exist in the sea below three hundred fathoms. During the last hundred years marine biology has grown in an unconventional way through contributions from diverse sources. The observations of enterprising naturalists, the results of exploratory voyages, clues from other scientific disciplines, the demand for exploitation of the sea for protein food, investigations undertaken for navigational purposes and the establishment of shore-based biological stations for continued long-term observations have all contributed to shape the marine biology as we see it to-day. But casual observations from such varied sources cannot be easily blended into a unified scientific discipline. As Kant stated : 'Accidental observations cannot be necessarily united into a Law'. Science does not consist only of finding facts ; nor is it enough if we rationalise without facts. To quote again from Kant, 'the principle of reason alone can give concordant phenomena the validity of laws, and experience must be directed by these rational principles to have a real unity.' The processes of science are characteristic in that they move by the union of empirical fact and thought, by the analogies of experience, as Kant termed it. The phenomenal development and the great precision attained by the physical sciences have been through this process of linking rational and empirical conceptions. How far has marine biology progressed in this direction ? It is only in recent years that marine biology has begun to develop exactness and attempt at hypothesis to predict events in the sea. In other words a recent trend in marine biology is the inception of its growth into a science.

The abundance of organism in the sea is so great and impressive that the main interest in marine biological investigations centre on population studies. The growing trend in marine biology toward achieving exactness and ability to predict events in the sea is most evident in population studies.

The practical importance of population studies, as is well known, is in relation to Fisheries. A correct assessment of fish-stock versus fishing effort and the prediction of future abundance by analysis of the causes of fluctuations in fish stocks are essential in fisheries. As early as 1914, Johan Hjort drew the attention of marine biologists to the importance of investigating the causes of fluctuations and failures in the important fisheries of Northern Europe and West Atlantic. Since then there has been a growing recognition of the importance of this problem and the urgent need for continued and coordinated investigations in order to analyse not only the seasonal and annual changes but also the long-period fluctuations that seem to occur in populations.

During the last thirty years some important studies have been made to analyse these short-period, as well as long-period fluctuations in populations. The causes of seasonal and annual changes in populations are relatively easy to understand. But the causes of the long-period trends in population are not easy of analysis. One of the best documented studies is by the Plymouth School of Marine Biology, which has investigated the change in the phosphate content, current patterns and fertility in the English Channel for over twentyfive years. The decline in the Pacific halibut fishery was traced by Thompson (1937) to overfishing and the improvement of the fishery was achieved by regulation of the fishery. But the view that the decline in fishery was caused by overfishing was criticized by Burkenroad (1948), who regarded the change in abundance as primarily a 'long-term fishery independent', trend or oscillation. The occurrence of natural fluctuations or oscillations must be admitted, but it is unlikely on *a priori* grounds, Beverton and Holt (1957) point out, that there has been in this instance ' a temporal coincidence of fishery limitation and a sudden change in stocks in a favourable direction '.

The occurrence of regular natural fluctuations with a peak of abundance every fourteen years has been demonstrated by Burkenroad (1948) on the basis of evidence gathered by him on the relative abundance of starfish in Southern New England waters during the last hundred years. The possibility of these oscillations being due to internal biological control has been suggested by Burkenroad (1948).

These population studies illustrate the union of empirical facts and theoretical methods, which we said, is the distinctive feature of science. The adoption of this procedure in marine biology is a significant trend. The concept of the dynamics of an open system is finding its application in marine biology with special reference to exploited fish populations. Beverton and Holt (1957) have extended the concept, regarding the open system itself as but one element in a higher system, comprising all other interdependent biotic factors.

A population can also be viewed as a level of integration of organisms, where it is meaningful to speak of birth rate, sex ratio, age structure, growth form, and where there might emerge new properties conferring selective value on the species. The rich and varied populations inhabiting the seas provide excellent opportunities for understanding these properties of populations which may help us to obtain a better insight into the problems of our own species.

In population studies the emphasis is on the relations between the individual and its neighbours of the same species within the sphere of its distribution, and the population is regarded as a community of individuals, all having a definite growth. Another equally important concept in marine biology is the ecological concept, in which the emphasis is on the resemblances between the different species in their physiology and in their relationships with the environment. When we speak of phytoplankton or zooplankton, we ignore the taxonomic categories. The ecological unit is an integration of different species and has a remarkably consistent behaviour and pattern irrespective of the species composition. It is in this ecological approach that we see some of the most pronounced trends in marine biology.

The earlier ecological studies were descriptions of natural history and faunistic lists. But now employing quantification and statistical analysis, the concept of ecological unit has emerged, and we are now beginning to be interested in the dynamics of the ecosystem.

There have been striking developments in the collecting and sampling techniques and in the quantitative assessment of plankton, benthic organisms etc. The analysis of the environment also is becoming more thorough and, it seems as Rae

(1958) pointed out the gross physical and chemical parameters are not the all-important ones but the less obvious factors, like micronutrients, trace elements, vitamins, external metabolites etc., may play the prime role in determining many of the variations of marine population in time and space.

Another trend in marine ecology has been the introduction of parallel experimental methods in the laboratory and field, especially for planktonic studies, and Rae (1958) has pleaded for the establishment of a school of plankton husbandry.

Some of the significant contributions to the new picture of marine ecology have been in connection with the studies in productivity, plankton relationships and movements. The investigations on the phosphate cycle in the English Channel by Armstrong and Harvey, and the productivity studies in the same region by Harvey, have given us a clearer idea of the ecological group, which we may now conceive as a dynamic system for the transformation of energy. We may ultimately look to a time when we may be able to define the ecological unit as an open system and explain its energetics in relation to environment and life-history.

How complicated the problem is, we may realise if we remember that the environment is not much less complex than the organism. Loosenoff in his excellent work on *Crassostrea virginea* examined over 1,500 relationships in order to determine variables which may correlate with biological variables.

The importance of the biological economy of the sea can be realised from the fact that, of the fraction of the solar energy that is utilised for photosynthesis in the world, nine-tenths is accounted for by marine plants, and one-tenth alone by the land plants.

Marine ecology is rapidly growing along several lines, establishing links not only with other aspects of marine biology but also with palaeogelogy and geochemistry. Even more than population studies, ecological studies demand long-term programmes in which the investigators work in the same area and on the same problems for long periods.

In this connection I would like to explain with an analogy the relationship of marine biology to oceanography and fishery biology. The world of human experience can be diagrammatically represented by three concentric circles, of which the outer represents the cosmosphere, the middle the biosphere or realm of life, and the inner the sociosphere of which man is the centre. Oceanography would correspond to the cosmosphere, marine biology to the biosphere, and fishery biology, which has direct human value, to the sociosphere. All these branches are dynamically interrelated and have some common areas of investigation like hydrography. This interrelationship is becoming increasingly evident in research projects undertaken in various institutions.

The dynamic trends in marine biology, which we illustrated with reference to population studies and ecology, are also seen in the attempts to explain marine biological processes in biochemical terms. It is now generally recognised that the most significant development in modern biology is the consistent effort to bring to molecular or biochemical level the classic problems of morphology, development, inheritance, evolution and ecology. Marine biology offers an exceptionally rich scope for this new approach. The origin and evolution of life, evolution of metabolic patterns and the adaptations of organisms to overcome ecological barriers and colonise new habitats, migrations, interrelationships of organisms, productivity, and a host of other problems can have illuminating analysis with a biochemical approach. It is becoming increasingly evident that there is a common fundamental biochemical ground plan to which all living organisms conform, and superimposed on this are numerous secondary and specific systems, which are mostly adaptional in character.

The importance of the biochemical approach is illustrated by the interesting way in which marine biological investigation was grafted to research in dairying at Reading, and investigations on whales and planktonic organisms were linked with problems connected with vitamin A in cow's milk. It seems as though even dairy research has a 'sea change'! Equally interesting aspects of the biochemical approach are seen in the study of external metabolites and distribution of vitamin B^{12}. The suggestion has been made by Kon (1958) that the study of the fluctuations of water-soluble metabolites and vitamins in relation to planktonic successions and blooms will be a fruitful feature of the marine biochemistry of to-morrow. The same investigator has strongly pleaded for research vessels in future to hunt for specimens, not for enshrining them in formalin but for investigations in dynamic biochemistry.

I have so far discussed a few of the modern trends that promise to forge marine biology into a unified science and bring into existence some order out of the chaos of observations and data that have been collected so far.

I now pass on to a brief review of a few other developments in marine biology. Marine biology has kept pace with technological developments in science, and has pressed into its service several technical devices undreamt of before, including television and underwater photography. But it is not only the physical and technological sciences that have influenced the trends in marine biology. The study of the, behaviour of marine organisms has become significant in marine biology. Recently, Waterman (1958) has suggested that the behaviour of certain pelagic forms may be determined by polarised light. Miyadi (1958) has pointed out with experimental evidence that for purposes of obtaining really useful knowledge to control fish production, it is advisable to make comparative studies on the social life of fishes both by experiments and in nature.

Thus marine biology seems to be establishing contacts with various scientific disciplines and even sociology and philosophy. But what about its relation to classical and academic biology? Marine biology awaits installation in its rightful place in general biology. Modern biological theories and experiments have been in a large measure without reference to marine life. In the wealth and variety of marine life there is unexcelled scope for investigations that will open new horizons in genetics, cytology, cytogenetics and experimental evolution. Our biological theories can neither be conclusive nor balanced until we are able to discover and use what Rae (1958) termed the marine equivalents of the guinea pig, mouse and *Drosophila*. Yes, biology as a whole will have to undergo a 'Sea change.'

Reviewing the modern trends in marine biology, we feel that the task ahead of us is tremendous, and so are the qualifications and intellectual equipment for undertaking the task. Marine biology is growing into a synthetic and exact science, and the sea with the life in it has to be studied as a dynamic whole. Like several rivers flowing into the sea and merging with it, the various intellectual disciplines are merging in marine biology. In thinking of the vastness of the subject we cannot help being reminded that, 'into the Kingdom of knowledge, as into the Kingdom of Heaven, whosoever would enter must become as a little child.'

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