Fishery Technology Vol: 1 No. 1 & 2
December 1964

STUDY OF PRIMARY PRODUCTION AND ITS IMPORTANCE IN AN INTEGRATED FISHERIES RESEARCH PROGRAMME *

R. RAGHU PRASAD
(Central Marine Fisheries Research Sub-station, Ernakulam)

The importance of the oceans as a source of cheap protein food is too well-known to be emphasised. In recent years there has been a tremendous increase in the fishing activity in all maritime nations and during the last few years the total world production has markedly increased. To get the maximum sustainable yield of these natural resources, it is necessary that the exploitation is planned in a scientific manner and the results of research relating to the various phenomena of the marine biosphere including such reference to the accompanying physical and chemical phenomena should form the basis for this planning,

Fishery scientists have attached considerable importance to the problem concerning the availability and natural fluctuations in the abundance of stocks of marine fish and other commercially important organisms. Obviously the magnitude of a fishery and to certain extent the natural fluctuations in the abundance and availability of these are intimately connected with and in a way dependent upon the sources of their food. Therefore, a proper understanding of the primary organic production will not only enable the estimation of total organic matter that is produced by the oceans but will also allow comparisons of ocean regions as possible sources of food. The factors determining primary production and fishery production are concerned with mutual interactions of a larger number of factors and to have a complete understanding of these it is necessary to study and understand all these interrelations in their entirety. There are serious obstacles to achieving this and the problem is enormous and expensive owing to the vast extent of the oceans and the non-random distribution of the organisms living in the sea. No matter how assiduously a few research vessels work the portion of oceans examined cannot be more than pitifully small. Nevertheless, it is possible to achieve useful measures with less than perfect understanding although the ultimate goal should be to have a perfect understanding. Herein lies the need to study in detail the process of primary organic production in an integrated programme of fisheries research, for the entire chain of events leading to the product-

* Published with the permission of the Director, Central Marine Fisheries Research Institute.

ion of fish and other economically important animals is based on the process of feeding and assimilation and transformation of assimilated food to new body substances which in turn is dependent entirely upon the transformation of inorganic matter into organic matter by plant material. In harvesting the organic matter from the sea, man concerns himself primarily with the animals nearer the end of the food chain because of the simple reason that it is convenient to him and easy to harvest as the widely dispersed organic matter in the lower level of the chain cannot be easily obtained in a concentrated form.

Primary production can be defined as light energy transformed by photosynthesis into energy containing plant material and this rendered available for further biological use. Thus, photosynthetic fixation of carbon dioxide to form plant material is the most important single factor which ultimately govern the commercial potentiality of any body of water. The quantitative measurement of this process is therefore of great importance particularly to the development of fisheries and as has been remarked "the situation is not unlike that which would prevail if livestock raisers lacked knowledge of, or interest in pasture conditions." The gross production being an intangible quantity, it will be the net production that will be of real concern to the fishery scientists.

The terrestrial production has been estimated to be about 2×10^{10} tons of carbon per year. Since the ocean waters cover more than 70% of the earth's surface it is to be hoped that the production in the entire hydrosphere is greater than that of the land. Recent estimates have shown that the oceans in their entirety are atleast two to three times more productive than all the land masses put together and what the marine plant environment lacks in average production per unit area is made up by its total size.

It is well-known that the autotrophic plants in the sea especially the plankton algae found in the upper water layers of the oceans are the prime synthesisers of organic matter and this directly or indirectly serve as food for all the other organisms in the sea. The rate and extent of this production of organic matter, however, is subject to wide variations within a region as well as between regions. The problem of the study of the primary production thus is extremely complex. The factors controlling organic production are pretty well known but there does not seem to be any consensus of opinion on the quantity of organic matter that is annually produced in the hydrosphere. This is primarily because of the lack of satisfactory methods for measuring production, lack of uniformity in methods adopted by various workers making direct comparisons difficult, if not impossible, and the problem of adequately sampling the oceans spatially and temporally. "In theory the net productivity of a column of water may be deduced from the change, with time, of the concentration of biotically active elements, notably carbon, oxygen, phosphorus and nitrogen. Ideally, such a method is perhaps the most satisfactory approach to the problem of marine productivity as it can give results integrated over comparitively long periods of time and over wide sea areas. This removes most of the uncertainties attached to 'instantaneous' measurements when applied to such a heterogeneous system as marine phytoplankton. But such a method is beset with many difficulties and uncertainties such as analytical, in the case of CO_2, nitrate, etc., interchange of oxygen and CO_2 with the

atmosphere, regeneration problems, complications arising from lateral and vertical transport, etc." Although various indirect methods of estimating production of organic matter have been in vogue, the first direct method of estimation was introduced in 1924. Three approaches are being generally adopted now by various workers to gather data on primary production. Firstly, field measurements of various parameters, secondly mathematical models of seasonal and local changes in plant biomass and thirdly laboratory measurements. Of these, the first undoubtedly supplies the bulk of the information. In recent years with the availability of radio - active isotopes, methods have been devised by which these tracer elements could be made use of in the study of primary production in the sea. The Carbon—14 method thus has become the most widely accepted one for directly measuring photosynthesis. This new tool in the study of primary production is of considerable use and has replaced the other less sensitive methods but it should not be regarded as providing all the necessary answers to the problems. Unfortunately all these have certain limitations and the methods now used are based on taking a presumably representative sample and determining some parameter of it.

Photosynthetic production of organic matter is dependent upon a relatively narrow upper layer of about 100 m or less which varies seasonally and geographically. The great majority of these marine photoplankters are non-motile and as they are heavier than the sea water the cells sink. The sinking of these cells below the illuminated areas has disastrous implications but this is retarded by various mechanisms. The sinking of phytoplankters from the sufaee waters results in an increase in the depth of the illuminated zone. Similarly, the concentration of plankton in the surface water decreases with the increase in temperature and this phenomenon renders the water more transparent and the illuminated zone becomes deeper as it happens in tropical waters. The interrelationship of these factors give a wide variety of production values. Again, during photosynthesis phytoplankton takes in from the sea water essential nutrients, which are found in solution for the building up of particulate organic matter. This particulate organic matter undergoes a series of changes and these again are subject to wide fluctuations from time to time and from place to place. The magnitude of production will be particularly high in the inshore regions and along regions of upwelling where prevailing winds transport surface water seaward resulting in the upwelling of nutrient rich bottom waters. In the open sea too a similar phenomenon occurs as a result of wind transport and such areas known as divergences support large concentrations of phytoplankton. This phenomenon has been called 'deep-ploughing'. As on land, photosynthesis takes place in the presence of sunlight. But unlike land plants the phytoplankton populations in the sea are unable to utilise to maximum efficiency high light intensities. In the case of land plants the light energy gets diffused by passing through the leaf surface into the interior and the chloroplasts are exposed to lower and more optimal light intensities. In contrast, the light intensities falling on phytoplankton (single cells) in the euphotic zone may vary from optimal to less or more than optimal intensities. Therefore, it is believed that if the entire euphotic zone could be illuminated optimally photosynthesis would be at least about five times the magnitude that is now recorded.

It is often remarked by many that in tropical marine areas the magnitude of production is relatively low. But recent investigations definitely point to the fact that this presumption is based on incomplete understanding of the production cycle. While in the higher latitudes, where sunlight is a limiting factor, production is rather concentrated to a few months, it takes place at a steady but lower level throughout the year in an illuminated zone which is deeper in the tropical seas. This steady but somewhat low level of production occurring in tropical seas is believed to be maintained by the regeneration of the nutrients within the illuminated zone and by upwelling of water from deeper layers which is rich in nutrients and added to this there is the rapid bacterial regeneration of nutrients caused by the higher temperature.

The rate and extent of organic production are the main criteria in deciding the relative yield of various water masses and consequently in fisheries research the estimation of organic productton in an area gives a fairly good indication of the conditions affecting the production of fish. However, a word of caution is necessary here for a very high organic production in a particular area does not necessarily imply a correspondingly high yield in terms of useful and economically important products and further figures of organic production may in almost all cases yield correlation only as regards endemic stocks of a region and not the transient populations. Therefore, the need to assess production on the world wide basis becomes inescapable. In this connection the recent ventures such as ihe International Indian Ocean Expedition, International Co-operative Investigation of Tropical Atlantic, the U. S. Antarctic Research Programme and similar programmes to explore in detail the other major oceans on a co-operative basis are highly commedable and it is to be hoped that as a result of these investigations the fishery biologists will be in a better position to assess the potential resources from the oceans.