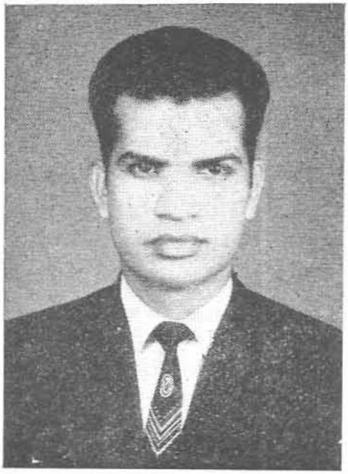
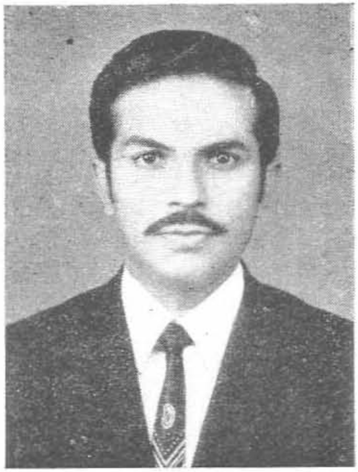


PROTEIN FROM THE SEA



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From the dawn of civilization till the turn of the last century, ma ndepended mainly on land for his sustenance. But cultivable land is steadily decreasing due to the rapid growth of population and substantial increase in the utilization of available land for cultivation. It has been estimated that meat provides 45%, milk 35% and marine products the rest of the animal proteins consumed by man. Considering the vastness of the oceans, which cover about 71% of the surface of the globe producing nearly 400 million tonnes of protein per annum, it is but natural that the importance of exploring new frontiers for additional food resources from the sea must be realised, According to health statistics, an adult person needs 14% protein in his food while children and nursing mothers require 16–20. The UN survey shows that out of the world population of 3700 million, about 2000 million fail to receive the minimum requirement of protein, say 30 gms / day. Amelioration of this acute shortage of protein in our food can only be achieved by exploring new frontiers for food from the vast marine areas.

Protein – its properties

All animals require a wide range of material for their survival and growth, which are obtained from the food they eat. The nutrients required for growth are amino acids, vitamins and mineral elements while the sources of energy are carbohydrates, fats and proteins. Dietary protein thus provides both energy and amino acids. Developments of the last two decades have contributed much to our knowledge of the structure and functions of protein. Proteins (*proteios*-primary) as the derivation of the word implies, are of primary importance to the structure and functions of the living cell, and are built up of a number of simple nitrogen-containing organic molecules called amino acids. There are about 20 amino acids occuring commonly in nature so that the number of possible combinations in large protein molecules is quite large. Vegetable proteins, which are the principal protein resources on land, do not contain all amino acids, especially lysine and methionine; animal protein which contain sufficient quantities of these amino acids are of superior nutritional properties. Composition of protein varies with the source, but all proteins are basically constructed of carbon, hydrogen, oxygen and nitrogen and some contain sulphur, phosphorus (nucleoproteins) and iron also.

A review on the protein resources

When considering the sources of protein food, we refer chiefly to higher crustaceans, mollusca and fishes. They are at or near the end of marine food chains and are produced at a lower rate as compared to the organisms, namely plankters, which are near the beginning of the food chain. They are produced at a higher rate and have a higher standing crop; only a fraction of this population goes into the formation of higher animals now harvested.

SCP (Single Cell Protein) is derived from unicellular organisms such as bacteria, yeasts, fungi and algae. They can be grown on inexpensive culture media and processed to give rise to powder containing 35–75% of protein. Unlike many plant proteins, the lysine content of SCP is adequate and sometimes high, and this could be used as a complete source of protein or as a protein supplement. From Table I (S. R. Tanne baum and R. I. Mateles, 1968, *Science Journal*, May) it is evident that the SCP sources from bacteria and yeasts are more suitable than those from fungi and algae.

Table 1

SCP source	Protein %
Yeast	45—50
Bacteria	40—75
Fungi	38
Algae	65

The plant protein resources of the oceans are mainly constituted by nanoplankters, other phytoplankters and sea weeds. Nanoplankters, measuring about less than 50 microns include highly proteneous organisms such as *Chlorella*, which contain protein amounting to about 56% of its body weight. Another feature associated with this group is their large-scale production due to rapid multiplication. It is no wonder that investigations are being carried out in laboratories to find out the feasibility of including *Chlorella* cells in the food of austronauts during space travels. Experiments are being carried out on the growth of the blue green alga *Spiriluna*, the protein content and amino acid patterns of which are favourable for consumption.

Phytoplankters, which contain a high amount of protein, besides fat and oils, are another group of synthesisers in the Sea. Protein content of species of diatoms *viz. Chaetoceros lauderi, Skeletonema costatum* (Table II) (Lewin, C. J. and Gullard, R. R. L., 1963, Diatoms, *Ann. Rev. Microbiology*, Vol. 7) etc. are more than 50% of their body ash free dry weight. Further, along the food chain these minute plants provide the main source of basic protein requirement to other organisms.

Table II

Diatoms	Protein in % of ash free dry weight
Thalassiosira sp.	45 . 1
Chaetoceros sp.	48 . 6
Chaetoceros lauderi	62 . 4
Skeletonema costatum	60 . 0
Soscinodiscus sp.	39 . 5
Cerataulina bergoni	58 . 5
Leptocylindrus danicus	46 . 3
Navicula sp.	37 . 4

Larger plants known as seaweeds are also important as a source of plant protein. Seaweeds have different colours, depending on the pigments present in them. Investigations show that the green and red seaweeds have relatively higher protein content than the brown seaweeds.

Table III

(M. U. Rao, 1971, CMFRI Bullettin, No. 20)

Green Seaweeds	Protein gms/100 gms of dry seaweeds
Ulva lactuca	7 . 69
Ulva rigida	22 . 42
Ulva fasciata	25 . 48
Cladophora monumentalis	16 . 28
Red Seaweeds	
Porphyra sp.	16 . 01
Asparagopsis taxiformis	16 . 19
Gracilaria lichenoides	7 . 62
Hypnea sp.	7 . 50
Centroceras clavulatum	20 . 12
Acanthophora muscoides	21 . 83
Brown Seaweeds	
Spathoglossumvariabile	15 . 66
Padina gymnospora	12 . 27
Cystophyllum sp.	11 . 21
Sargassum johnstonii	10 . 90
S. tenerrium	12 . 14

The extracts made from these seaweeds contain a high percentage of protein. Red seaweeds yield a mucilage phycocolloid, agar agar and the brown seaweeds yield alginic acid. Apart from protein, seaweeds also contain valuable minerals and vitamins. In Japan and some south-east Asian countries, they are largely consumed as direct food for human begins.

Utilization of the protein synthesized by the minute plant material (primary producers) in the sea is carried out by small animals – the zooplankters, which are the secondary producers in the marine food chain. Production of these organisms and their conversion have been discussed elsewhere (Parameswaran Pillai and Gopinathan, 1973, *Seafood Exp. J.*, Ann. No.). Zooplankters are the source of basic animal protein in the aquatic environment and some of them e.g., copepods, contain protein which amount to about 58% of their body weight. Recent studies show that a meal of shrimps made from mysids or euphausiids contains 76.05% of crude protein on a dry weight basis. One of the most promising stocks of the macro-zooplankters in the marine environment which is being investigated by the Russian and Japanese scientists is the Antarctic Krill (*Euphausia superba*). They grow to about 5 cm and sometimes occur in dense swarms at the surface. Rough estimates made by scientists suggest that the potential annual yield of the krill could at least be 50 million tonnes. (J. A. Gulland, 1968, *Science Journal*). Soviet experiments demonstrated that bumper catches of euphausiids can be made easily and if the technical problems of separating the meat from the shell can be solved, krill could be used for direct human consumption. Production of liquid protein from the krill, has been successfully carried out recently by the Japanese scientists in the Tokai Regional Fisheries Laboratory.

Clarke *et al.*, (1948 *Ecology*) carried out investigations on the chemical composition and the nutritive value of marine zooplankters and showed that the dry plankton was composed of 52–59% of protein, 1–4% of fat, 13–17% carbohydrates and 19–33% ash. Plankton, with the observed chemical composition, was calculated to have an approximate maximum energy content of 4 calories/gm dry weight.

Further along the food chain, larger crustaceans such as prawns, lobsters and crabs have a high protein content equivalent to that of the fish. They represent the second step in the food chain as they convert synthesized portein directly from the organic materials and basic plant food. Biochemical studies have shown that *Penaeus monodon* contains 80–85% (P.V. Rao, personal communication) and crab meat contains 50–55% of protein in their bodies on a dry weight basis.

Another group of organisms which provides a high protein rich food are molluscs which include mussels, oysters, clams and cephalopods. Mussels, oysters and clams are specially important since they are filter feeders, consuming the small organisms and particles of drifting organic matter in water. They are nearer to the base in the food chain, making the potential production per unit area very high. Squids of various types are rich in protein and are widely used in Japan and Mediterranean countries as food. The properties of easy digestibility and high content of minerals and vitamins make these animals a high ranking food (Table IV. Alagarswamy, K. 1973, *Seafood Exp. J.*, Ann. No. Osamu, D and Shigeno, K. 1971, *Aqua Culture*.)

Table IV

Molluscs	Protein % of body weight (dry basis)
Clams	10–15
Oysters	11–12
Cockles	5–6
Blood clams	12–13
Scallops	14–15
Mussels	8–9
Pearl oysters	19–20
Squid meal	81–82

It has already been recognised that fishes contain protein of high nutritional value and thus they acquire a high place amongst the aquatic foods (Table V-data from various sources) Not all fishes are favoured for comsumption, but even trash fishes can be converted advantageously into fish meal for cattle/poultry feed by various processes and thus indirectly could be used for the benefit of mankind. Another product now manufactured from cheap varities of fish is the Fish Protein Concentrate (FPC), which is an odourless and tasteless fish powder, containing 70–75% of protein. This could be used mainly for human consumption in addition to its other applications such as bacteriological peptone for microbiological work, etc. In India, the production of FPC is at its infancy, but it can be developed on a larger scale soon. Fish ham, a by-product of the fish sausage industry and which contains 13–14% of protein is yet another food produced from the fishes. The Central Institute of Fisheries Technology, Cochin, has contributed much towards the economic utilization of trash fish landed all along the Indian coast, through the production of bye-products such as fish soup powder, soup tablets, fish flakes and fish noodles. The Institute has also developed a good quality FPC from the discarded head portions of prawns.

Table V

Fishes	Protein % of body weight dry basis
Cartilagenous fishes	
(Sharks, rays etc)	22–23
Sardines	60–65
Mackerels	19–20
Bombay duck	9–10
Pomfrets	18–20
Seer fish	15–18
Tuna	25–28
Ribbon fish	20–22
Ambasis commersoni	65–25
Flat fishes:	
Cyanoglossus spp.	70–78
Synaptura sp.	80–82
Jew fish	15–18

Most of the clupeoid fishes depend directly on plants for food, and hence their food chain is short and more efficient. Some fishes feed on zooplankters. However, majority of the fishes are carnivores and thus go to the apex of the food chain. Although carnivorous fishes are highly relished as table fish, in view of their dependance on material that could be used as items of human food, their production occurs at the highest point in the food chain. It is also worth mentioning that when compared to the harvest of carnivores from the sea, it is more rewarding to cultivate those forms which occupy the lower links of the food chain and which have a high conversion efficiency.

Whales, a group of marine mammals also form a store-house of rich protein. Baleen whales feed on zooplankters, small shrimps and prawns and this feeding behaviour is associated with its filtering mechanism. They thus have only three links in their food chain. Recent studies carried out by Japanese scientists proved that Fin Back Whale (plankton feeder) meal contains about 82.34% crude protein while the protein content in the sperm whale which feeds on squids and fishes is about 78.97% (Osamu, D and Shigeno, K. 1971, *Aquaculture*).

The annual world harvest of seafood has been showing an increase of 7–8% and now it is about 70 million tonnes. At present, this supplies more than half of the animal protein for about half of the world population. It is estimated that with the increase in population, the fish requirements by the early 21st century would be more than 200 million tonnes. India, with a long coastline of nearly 6000 Km and an extensive continental shelf has a catch of about 1 2 million tonnes of marine fishes. However, it is disheartening to note that the per-capita availability and the intake of ptotein by us is one of the lowest in the world. To augment and judiciously exploit known resources and an intensive search for finding new resources is the only solution to this much needed problem. Fishery Scientists in India have made a good start in this line and have obtained interesting results. Research Projects, which are being undertaken at the Central Marine Fisheries Research Institute are oriented towards elucidating various problems such as culture possibilities of primary producers; detailed investigations on secondary producers of the marine food chain; large scale culture of seaweeds and their possible utilization and suitably modified developmental programmes of artificial farming of fishes, prawns and shell

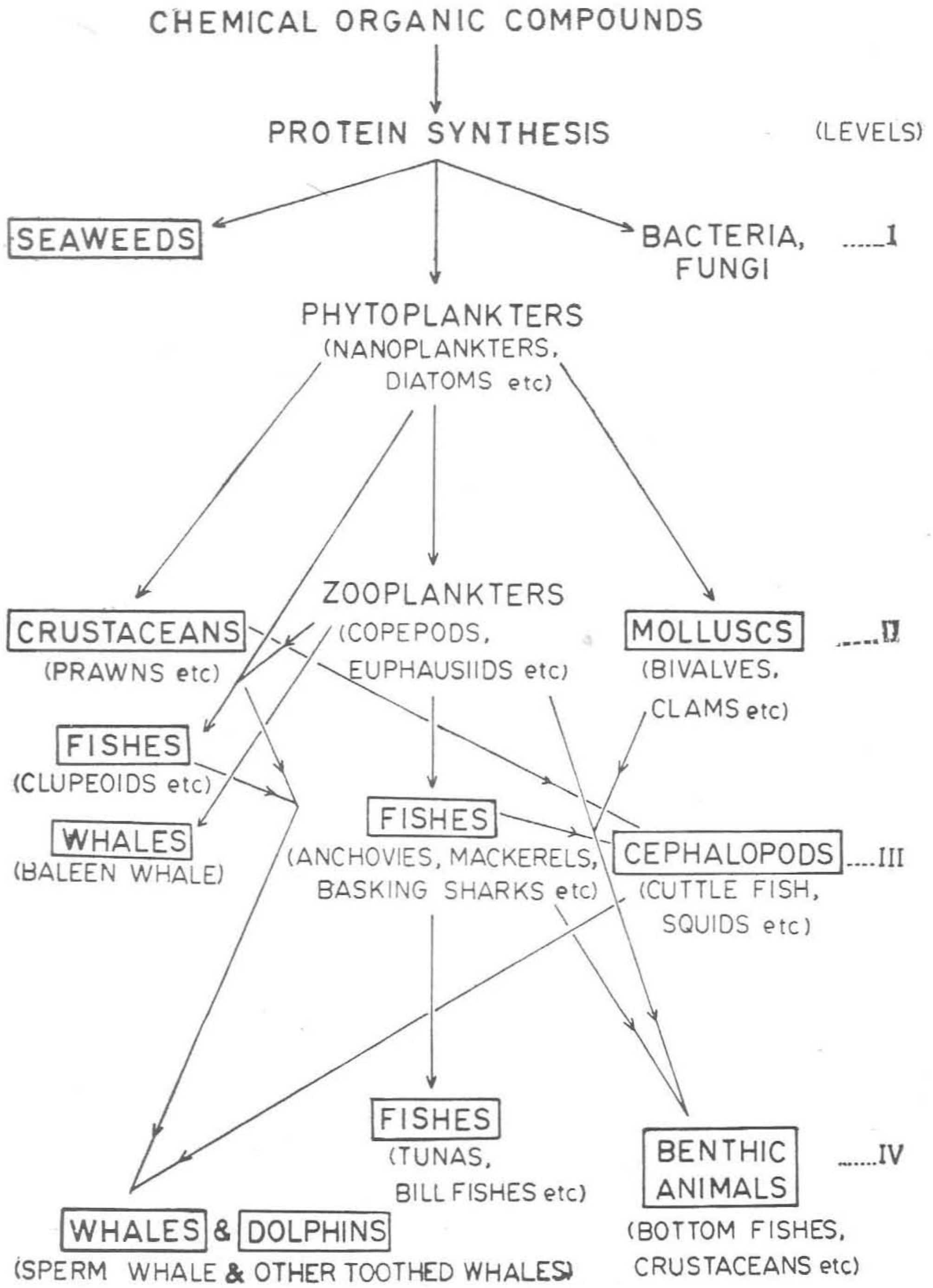

Fig. 1. *Major protein sources from marine environment. Presently exploited resources are 'blocked'. Possible inter-group nutritional relationships are indicated.*

fishes in coastal areas. Results of these investigations would certainly provide incentive for such endeavours in commercial terms.

In spite of the high protein content and nutritive value of many marine food resources like oysters, mussels and cephalopods, they are not utilized widely as food. It has to be agreed that the problem of consumer acceptance is an important aspect which needs immediate attention with the idea of encouraging the consumption of diversified fishery products. We must make an attempt to utilize the organisms which are very near to the base of the food pyramid so that the efficiency of energy conversion is not lost. Semi-enclosed waters of our coast and innermost coastal areas provide excellent grounds for fish and shell fish cultivation. Intensive researches are necessary to understand energy inter-relationships and the natural nutritional cycle of cultivable organisms. ●
