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SOME CONCEPTS ON THE PRODUCTIVITY OF TROPICAL SEAS

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ABSTRACT

The paper gives a critical review of the different environmental factors which may be responsible for the differences in the productivity of the lower and higher latitudes. The various factors which contribute to the low productivity in the tropical and subtropical seas as compared with the temperate and polar seas are analysed. The reasons for limited high productivity zones in the coastal waters of the tropical and subtropical regions are explained as due to upwelling in coastal waters and divergence in offshore waters. The need for intense exploration and location of high productivity zones in the typically tropical and seasonal 'Monsoon type' of upwelling in the seas bordering India is emphasised as also the adoption of modern craft and gear to exploit the seafood resources.

The productivity in any area is a measure of the rate at which carbon dioxide is photosynthetically fixed as plant material. The plant material in its turn is converted to pelagic fish through various trophic levels. The lower trophic levels representing the phytoplankton and zooplankton provide food for the fish larvae and juvenile fish. A number of studies have established a direct relationship between productivity at lower trophic levels and fish production.

The production of phytoplankton which are the primary producers is limited by the availability of some essential nutrients such as nitrates and phosphates which may be in short supply in the upper illuminated photic zone. There is always a larger amount of nutrients in the deeper waters below the photic zone which in the polar and temperate seas are brought to the surface in winter by extensive vertical mixing or turbulence. In summer the warming up of the surface water prevents mixing owing to thermal stratification and when the available nutrients are used up production may come to a stand still in the photic zone. For optimal production there should be an optimal depth and speed for vertical turbulence. If its range is too short all the available nutrients are quickly depleted and the photic zone is isolated from further supplies. If it goes too far down below the photic zone, there is a danger of the phytoplankton carried down below the range of light for effective photosynthesis and ultimately a loss to total production if kept under these conditions too long. Turbulence in shallow waters is also not conducive to production owing to the churning action of bottom particles which are held in suspension reducing light penetration.

The statement that tropical waters are comparatively poor in nutrient salts and that they cannot support a rich plankton is a gross over simplification of the matter according to Hart (1953b). Hart (*loc. cit.*) states that there are at least three vital factors, nutrient concentration, light penetration and the degree of stabilisation of the surface layers that provide a sound working hypothesis to account for the comparative poverty of warm seas as a whole in contrast to the rich plankton of most (not all) temperate and polar waters. However, while the open sea in lower latitudes is relatively sterile owing to thermal stratification which precludes any complete or rapid renewal of nutrients from the nutrient rich deeper layers, the situation is quite different in the coastal areas with upwelling or in offshore region of divergence. For example along the Californian coast (Moberg, 1936); in the region of divergence along the equatorial counter currents and along the west coast of Africa (Hentschel, 1928) there is rich production. The Peru Current in tropical and subtropical regions brings to the surface an abundant and continuous supply of nutrients which results in heavy phytoplankton production mainly near the coast but in some sections this intensity is maintained to a distance of 320 km seawards (Gunther, 1936). In one small island of the Chinchas group there are estimated to be some five or six million marine birds, such as cormorants, pelicans and garnets which daily remove at least 1000 tons of small fish from the surrounding water and the great guano deposits on the shore of these regions may be as much as 30 m in thickness (Schott, 1932).

While some limited areas in the warmer seas such as the upwelling regions off the coast of Africa and South America are exceptionally rich and may maintain substantial quantities of nutrients at the surface, over vast areas of the tropical seas there is a very strong discontinuity layer at a depth of 60 to 150 m as a result of thermal stratification. Any nutrient brought to the surface is immediately synthesised and this may account for the low and very often undetectable level of nutrients in the tropical surface waters. The deeper layers may have ample nutrients for rich production but the light energy is greatly reduced with depth being only about 25 per cent of the surface value. It seems to follow rationally from this that such rich plankton production as is known to occur in warm seas is limited to times and places where turbulence breaks down the thermocline and enriches the upper layers of the euphotic zone with nutrients. The great upwelling regions such as the Peru Coastal Current, Benguela Current (Hart, 1953a) and Canary Current show some upwelling activity throughout most of the year except near the equatorial limits. The upwelling regions of the Californian Current is more seasonal (Sverdrup and Allen, 1939). The typically tropical and seasonal "Monsoon Type" of upwelling along the coast of India and southern Arabia are well known as rich areas of plankton production (Ryther and Menzel, 1965; Panikkar and Jayaraman, 1966; La Fond, 1955; Murthy and Varadachari, 1968; La Fond and La Fond, 1968). Because of the high degree of stability of the surface layers through most of the year in the tropical seas, turbulence in its beneficient aspect has to be looked for as a prerequisite of rich production in them (Hart, 1953b).

While the general view that production in the sea tended to increase with latitude, the work of Riley (1929) has divided opinion on the matter. Working on a range of stations in north Atlantic and measuring the production of oxygen by phytoplankton at different depths, Riley (1939) came to the conclusion that as much or more production was going on at the tropical stations owing to greater depth of light penetration than those further north. Steeman-Nielsen (1952) experimenting with the rate at which radio-active carbon is taken up by the photosynthetic organisms, supports the thesis of somewhat poorer production in the tropics and he has criticised Riley's methods.

The plankton observations made on deep-sea expeditions in the last few decades have also indicated a somewhat varying standing crop with a tendency to show higher values at the higher latitudes. Lohman (1920) in the "Deutschland" expedition to the Atlantic in 1911 found that in tropics, the microplankton per litre of sea water could be counted in thousands, in temperate oceanic waters in tens of thousands, and in temperate coastal waters in hundreds of thousands. The above observations made by the expedition have also been borne out by counts of diatoms made throughout the annual cycle in coastal waters at different latitudes. At Low Isles in the tropics the average daily number of diatoms counted in a liter was 5,753 (Marshall, 1933); off Plymouth 14,282 (Lebour, 1915); at La Jolla 39,994 (Allen, 1927) and at Loch Striven 1,009,400 (Marshal and Orr, 1927).

Ascending the various levels of production to the point of annual fisheries yield, Wimpenny (1953) has taken figures of the commercial fish landings, in thousands of metric tons, of some important countries north of 30°N Lat and others between 30°N Lat. and 30°S Lat. The corresponding landings for the same countries have been given by me from the FAO yearbook of Fisheries statistics for the year 1970 (Table 1). While the figures for y950 and earlier years show a substantially lower yield in the tropical and subtropical countries as compared with the countries in the higher latitudes, the figures for 1970 show a markedly increasing trend of catches for the same countries. The phenomenal increase in the catches off Peru is due to a change in the fishing regulations in 1955 which permits taking of anchovies for fish meal and oil. Peru today tops the list of fish production in the world.

Table 1. *Annual commercial fish landings in thousands of metric tons in countries north of latitude 30°N and those between 30°N and 30°S* (FAO Yearbook of Fishery Statistics for 1950-51 and 1969-70

North of 30°N				30°N to 30°S			
	1950-51		*1970*		*1950-51*		*1970*
Russia	1,800		7,250	Africa	800		4,150
Europe	3,900		11,970	India & Pakistan	905	(1950)	2,166
Japan	3,796		9,309	Ceylon	37		100
Korea (N)	1,326	(1938)	800	Indonesia	420	(1949)	1,249
Korea (S)	628	(1938)	934	Malaya	177		365
Canada	948		1,378	Indo-China	410	(1949)	2,472
U. S. A.	1,583	(1946)	2,714	Australia	46	(1950)	140
	13,981		34,355	Philippines	266		989
				Mexico	55	(1950)	353
				Brazil	155	(1950)	493
				Peru	84	(1950)	12,612
				Venezuela	78	(1950)	114
					3,433		25,203

Wimpenny (1953) has given a number of reasons which operate in favour of inferior production in lower latitudes. Among these high temperature is likely to increase the respiratory rate of phytoplanktonic organisms more than the photosynthetic rate, resulting in reduced production. The deeper photic zone in the lower latitudes results in a wider dispersal of plankton food, involving more energy in its pursuit and leaving less for building up body tissues and food reserves. In warm seas the communities of commercial fishes and their food organisms are more complicated and divided into a larger number of species. The species may get linked together in long food chains with special food organisms and consequent wastage of considerable effort in the pursuit of food. These result in wastage of potential production in the use of extra kinetic energy. The higher metabolic rate in tropical and semi-tropical fish find it more expensive in food to maintain the same unit weight as in cooler seas. The mortality rate is also likely to be higher when food is sparse owing to greater break down rate.

In conclusion it may be said that while there is a concensus of opinion that the higher latitudes are more productive than the lower latitudes, there are vast areas in the tropical and subtropical regions which are highly productive. These are areas subjected to upwelling in the coastal areas and divergence in the offshore regions.

It is well known that the seas bordering the tropical and subtropical countries have not been as well or as extensively exploited as some of the European countries and when this is done with modern methods of fishing the disparity in production is likely to narrow down further.

The urgent need for the exploration and location of productive areas in the tropical and subtropical seas and a rational exploitation of the fishery resources to supply a cheap source of protein for the chronically protein deficient food of the developing countries bordering the warmer seas cannot be over emphasised.

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