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Some Development Patterns of Plankton Communities in the Upwelling Areas of the Pacific Ocean

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Abstract

The principal trophic levels, each subdivided into groups of organismic elements, are distinguished in the planktonic communities of the Eastern Equatorial and the Peruvian upwellings. Production intensity or metabolism have been determined experimentally for all elements. A scheme is suggested for computing production from data on metabolism for all the elements of a community, as well as for computing net and real production and other functional characteristics for definite trophic levels and the community as a whole. Based on the quantitative estimation of the efficiency of primary production and other functional characteristics, the development of communities is divided into production and destruction periods; they are, in turn, subdivided into steps associated with a certain degree of water trophicity. The balance of net production of the communities in the Peruvian upwelling indicates that the excess production of a community above the shelf is utilized completely in the narrow (100 to 150 sea miles) band of off-shore water. This paper describes an attempt to trace the changes taking place in the functional characteristics of plankton communities and to compare them with the changes observed in the communities of the Peruvian and East-Equatorial upwellings.

Introduction

In modern bio-oceanology, increasing attention is being paid to the study of the patterns of functioning of marine communities and ecosystems. Biological processes in the ocean are most intensive in areas of tropical upwellings. Here, the earliest stages of development and patterns of matter and energy transformation in the communities may be traced in their "purest" form. That is why the study of the communities of these regions is of particular interest.

Several specific cruises were organized by the Plankton Laboratory of the Institute of Oceanology of the USSR Academy of Sciences on the R.V. "Vitiyaz" (Cruises 44, 50, 52) and the R.V. "Akademik Kurchatov" (Cruise 17) for the study of the pelagic communities of tropical regions and their zones of most intensive upwelling. The major results of investigations carried out in the areas of the Equatorial and Peruvian upwellings have been set out in "Ecosystems of the pelagic zone of the Pacific Ocean" (Vinogradov, 1975) and in articles by Vinogradov (1974, 1978), Vinogradov *et al.* (1976, 1977), Mikheev (1977), Sorokin (1977, 1978), Shushkina *et al.* (1978), Sukhanova *et al.* (1978) and others.

Materials and Methods

Field material was collected during Cruise 17 of R.V. "Akademik Kurchatov" at the equator between 97° and 155°W (14 January-7 February, 1974), and along a 130-mile section from the coast of Peru (Cape Pacasmaio, 7°30'S) into the ocean (27 February-4 March, 1974), in the 0 to 150-200 m layer (Fig. 1). A detailed characterization of the area investigated, as well as sampling technique and treatment of collected material has been presented by Vinogradov (1974, 1975), Fedorov *et al.* (1975a, b), and Sorokin (1978).

The taxonomic composition of microplankton (organisms smaller than 1-2 mm) as well as its concentration and vertical distribution were estimated from samples taken with a 140 l Plexiglas water bottle. Sampling depths were deter-

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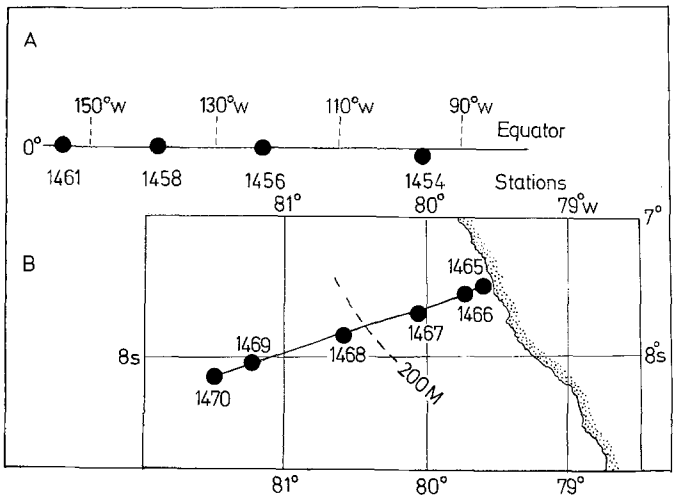

Fig. 1. Location of R.V. "Akademik Kurchatov" stations in areas of East-Pacific upwellings: (A) Stations at Equator; (B) stations on Peruvian coast

mined by preliminary measurements (continuous recordings) of the vertical distribution of temperature, salinity, density, turbidity, chlorophyll luminescence and field of bioluminescence. The samples were collected at the extreme points of these curves or at the depths of maximum gradients. Most of the microplankton elements could be examined using a single sample, a procedure that permitted minimum bias arising from differences in time of collecting outboard samples. The phytoplankton and bacterioplankton from these samples were examined and production, bacterial destruction using the ^{14}C method and the value $K_2 = 0.25$ for bacterioplankton were determined by Sorokin *et al.* (1975a, b) and Sukhanova *et al.* (1978). Zooflagellates and infusorians have been dealt with by Tumantseva and Sorokin (1975), and other zooplankton by Vinogradov *et al.* (1976) and Mikheev (1977).

Organisms ranging in size from 1 to 20-30 mm were recorded from vertical stratified hauls taken with a 80/113 JOM net (mouth opening 1 m^2) and filtering cone made of sieve No. 38 (180 µm) (Flint, 1975; Timonin and Voronina, 1975; Mikheev, 1977).

Analysis of the collected material revealed the following basic trophic groups of plankton communities: phytoplankton (p), bacteria (b), heterotrophic flagellates (a_1), infusorians (a_2), non-predatory zooplankton – small (m) and large (f), and zooplankton with predominantly carnivorous food habits – small (s) and large (v). Each trophic level was, in turn, divided into smaller trophic groups of organismic elements according to size composition and type of feeding (Table 1).

The experimental material obtained during Cruises 44, 50 and 52 of the R.V. "Vitiyaz" and Cruise 17 of the R.V. "Akademik Kurchatov" allowed quantitative determination of the basic ecological-physiological characteristics of the elements recognized in the communities; however, as the estimates of mean dial rations of the various animals (Pavlova *et al.*, 1971; Petipa *et al.*, 1971, 1975; Arashkevich, 1975) varied widely depending on the effect of a number of factors not lending themselves to recording, these could not be used as a basis for calculations.

More reliable results were obtained from determinations of the rates of metabolism and oxygen consumption, the micromanometric method being used for microplankton (Klekovski *et al.*, 1975), and the polarometric method or the Winkler technique for larger plankters (Shushkina and Pavlova, 1973; Musaeva and Vitek, 1975; Musaeva and Shushkina, 1978, and others). Oxygen consumption was measured at the *in situ* temperatures of the communities investigated. As the value R (respiration) differed but little in closely related animals living at 20°C in areas of intensive upwelling and at 30°C in oligotrophic waters (Musaeva and Shushkina, 1978), the metabolism-weight relationship $R = f(W)$ was used without introducing corrections for temperature. The caloricity of the various organismic elements (Shushkina, 1977) and the intensity of production of some of them (Shushkina and Pavlova, 1973; Shushkina and Kislyakov, 1975) were determined.

A scheme of energy flow through the community, based on field and experimental data, was constructed for each station (Fig. 2).

The production and food consumption values of the elements were calculated from experimental determinations of metabolic rate, using the maximum value of expenditure for growth (K_2^{max}) accepted from numerous data from the literature and personal experimental data.[1] A $K_2^{max} = 0.6$ was assumed for different-aged populations, which comprised most of the elements of the communities investigated; and a $K_2^{max} = 0.7$ for the two elements (meroplankton and juvenile euphausiids) which consisted mostly of larval forms.

The functional characteristics were calculated in accordance with the follow-

[1] Phyto- and bacterioplankton production was determined experimentally using the ^{14}C method.