

GLOBAL VARIATIONS OF CHEMICAL COMPOSITION OF OCEANS, INLAND SEAS, COASTAL ZONES, AND ESTUARIES

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Summary

Major processes determining salinity in different areas of the World Ocean, as well as production and degradation processes and water dynamics influencing the pattern of nutrient distribution in the euphotic layer and in deep waters, are reviewed. Processes of development of maximum concentrations of phosphates and nitrates, as well as minimum contents of oxygen in deep waters are discussed. Special attention is given to anaerobic waters (the Black Sea, the Kariako basin, etc.) and subanaerobic waters (Arabian Sea, Peruvian coastal zone, etc.). Variants of freshwater intrusion into the ocean are discussed for the estuaries of the Amazon, the Congo, the Ganges, and the Ob' rivers.

1. Salinity distribution in the World Ocean

The surface layer salinity ranges from 30-32 to 36.5-37.5‰ in open oceanic waters, far from river-mouths while in the river-mouths it drops down to 1-2‰. In inland seas such as the Red Sea and Arabian Gulf salinity increases up to 40-41‰.

The mean surface salinity of the World Ocean is 34.73‰. In the Pacific Ocean the value is minimum (34.85‰) while in the Atlantic ocean it is maximum (35.30‰). The Indian Ocean reveals a somewhat intermediate mean value of salinity, i.e. 34.87‰. These variations are mainly caused by the different relationships of evaporation and precipitation which are inherent in the oceans (see Figure 1).

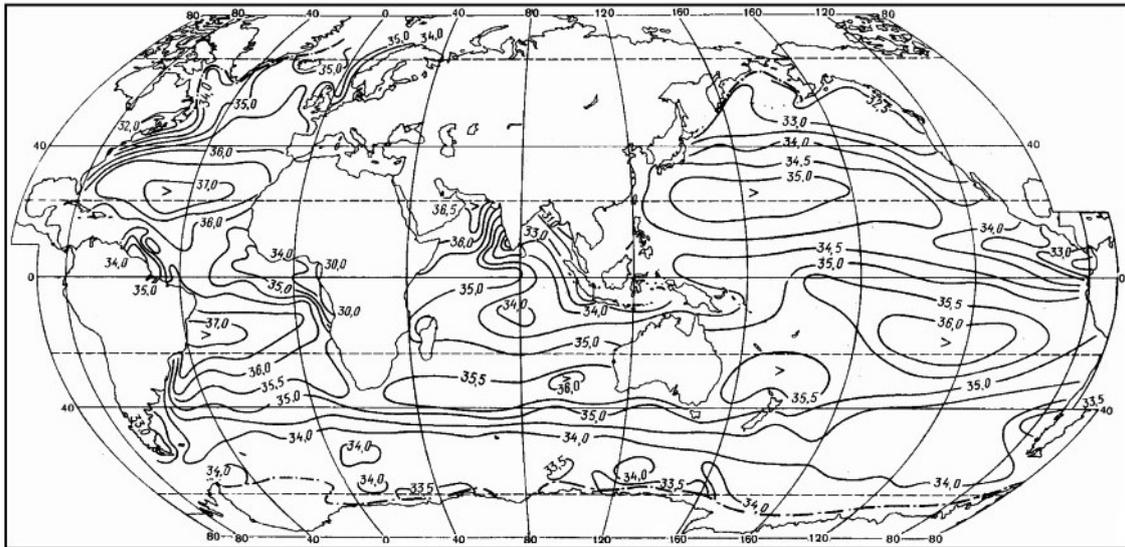


Figure 1. Distribution of salinity (%) in surface waters of the World Ocean in February (Oceanic Chemistry, 1979)

The chart of salinity distribution shows that the maximum values of salinity characterize a broad belt spreading from 20-30°N to 20-30°S, i.e. the zone of global anticyclonic eddies where evaporation is maximum. The same latitudes on land exhibit deserts (Sahara, Gobi, Kalahari, etc.).

Due to a considerable excess of evaporation over precipitation in the Atlantic Ocean salinity of the surface waters is markedly higher than that of the deep waters (34.7-34.9‰). This phenomenon causes formation of highly salt and cold intermediate, deep, and bottom North Atlantic water masses in the subarctic areas in winter. Influence of deep and bottom North Atlantic waters is noticed in the Indian and Pacific Oceans (see Figure 2). The chart of the salinity distribution on the 500-meter horizon clearly shows a plume of highly saline waters with a start-point in the Strait of Gibraltar where the Mediterranean waters with a high salinity of 36.0-37.5‰ slide down the continental shelf to 500 to 1000 m and after their density attains the ambient values they spread along the isopycnal surface.

Similar sources of highly saline waters in the Indian Ocean are the Red Sea and Arabian Gulf.

In the Pacific Ocean there are no intermediate water masses with high salinity.

In all the three oceans the Antarctic Convergence Zone (~50°S) is a place where intermediate water masses with a low salinity form, sink down to 1000 m, and spread northward. In the Pacific Ocean there is a second source of intermediate water masses with a low salinity in the frontal zone of Oyashio-Kuroshio (~40°N); these water masses spread southward.

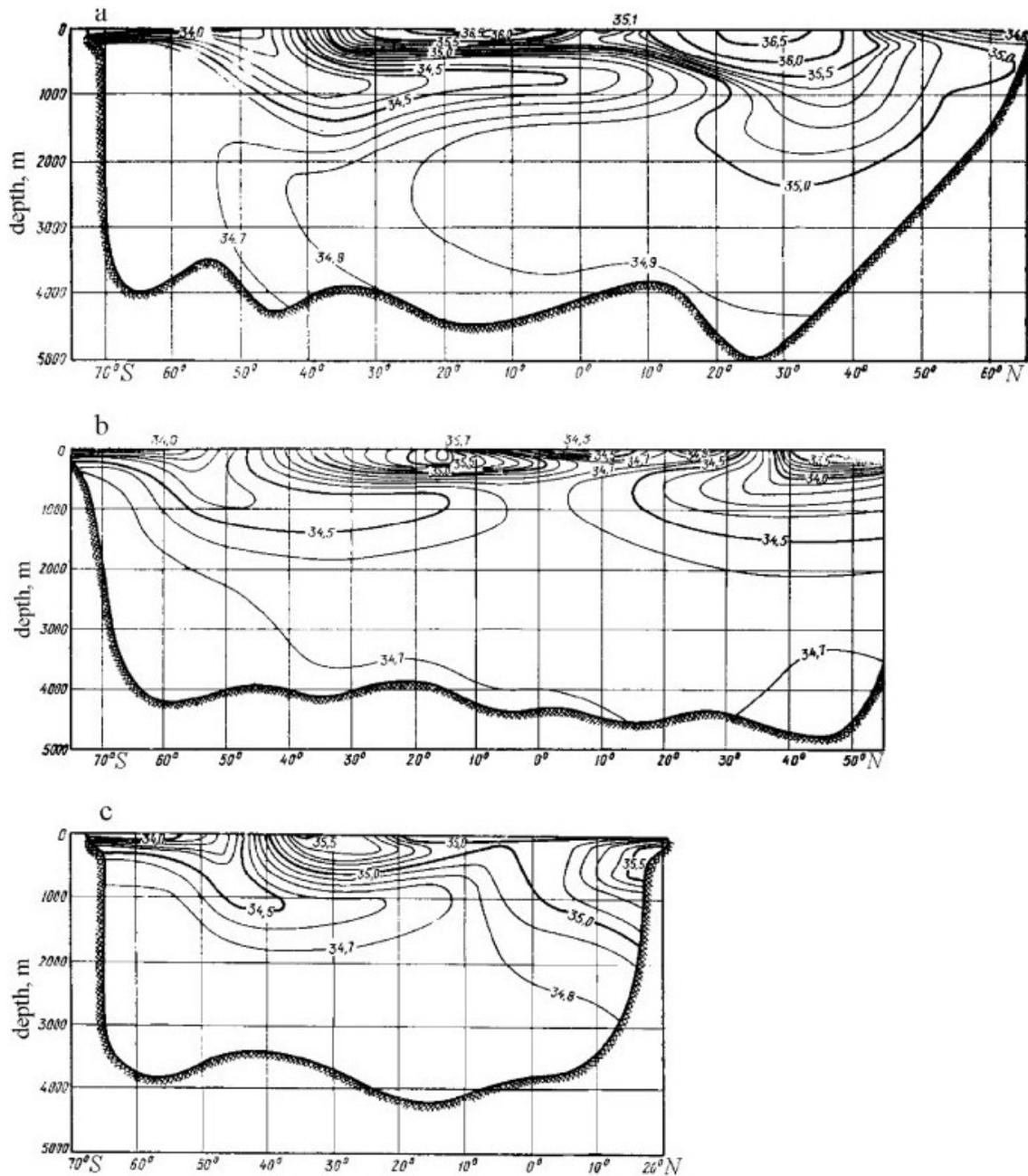


Figure 2. Salinity (‰) at the meridional section in the Atlantic (a), Pacific (b), and Indian (c) oceans. (Oceanic Chemistry, 1979)

In the Indian Ocean, especially, in the north-western part and in the southern subtropical area (30-40°S), evaporation also highly exceeds precipitation. As a result, and also because of the influx of highly saline waters from the Arabian Gulf and the Red Sea formation of intermediate, deep, and bottom North Indian Ocean water masses takes place. However, the volume and salinity of these waters are less than those of the North Atlantic water masses.

Conversely, in the Pacific Ocean precipitation exceeds evaporation not only in high latitudes, but also in the equatorial and tropical zones (only subtropical waters demonstrate a reverse situation). As a result, there are no conditions for formation of

deep highly saline waters in the Pacific Ocean and the entire water column below 2000 m is taken by the deep waters of Atlantic and Indian origin and the bottom waters from the Southern Ocean.

In the Arctic Ocean the surface salinity totals 30.3 to 34.1‰. This low value is associated not only with precipitation excess over evaporation, but also with a tremendous riverine runoff. All the polar seas, including the Bering Sea, the Sea of Okhotsk, Hudson Bay, Davis Strait, and the Beaufort Sea have surface salinity below 33‰. Likewise, the polar seas in the southern hemisphere have surface salinity below 34‰. There are almost no vertical variations in salinity in the water column below 2000 m in the entire World Ocean. In the Atlantic Ocean these deep waters reveal salinity of 34.9‰ while in the Pacific Ocean the value is 34.7‰.

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Biographical Sketch

Victor V. Sapozhnikov is a Doctor of Science (Geography). He is Head of the Marine Ecology Laboratory of the Russian Federal Research Institute of Fisheries and Oceanography (VNIRO) and Professor of Moscow State University. He is the author of 397 scientific publications. His field of scientific interest is methods of hydrochemical analysis and hydrochemical basis of biological productivity of the World Ocean. He has headed hydrochemical teams in 30 research expeditions to various areas of the World Ocean.