SURFACE WATER: OCEANS, INTERIOR SEAS, COASTAL ZONES AND ESTUARIES

Yuri. S. Dolotov
Water problems Institute RAS, Russia

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Contents

Summary

The types of surface water in oceans, interior, marginal and intersular seas in different coastal zones and estuaries are discussed. Main dynamic and regional factors influencing on their hydrological, biological and hydrochemical regimes are given.

1. Statification

Oceanic water is subject to continuous fluctuations caused by periodic and non-periodic forces. These forces include gravity, currents (produced by dense and level gradients), friction, tide generating forces, centrifugal forces and the inertial and deflecting forces of Earth's rotation.

Two kinds of movements are distinguished in the layers of oceanic water: 1) laminar or layered movements, when adjacent layers do not mix, and 2) turbulent or rotational movements, when velocities continuously pulsate according to a value and direction around the average in every flow point. As a result of this rotational movement water layers appear and disappear constantly as they inter-mix.

The layer in which vertical gradients of some oceanic characteristics are greatest, is called the skip layer. This can apply to temperature, salinity, oxygen content, density, etc. Some skip layers are formed under determined conditions, such as during vertical mixing or in the superposition of water masses of different origin.

As a rule, the formation of oceanic gradients in surface layers predominates during the lightest times of day and year, and they are destroyed during dark periods. Because of this, the isolines of all oceanic characteristics in surface layers become almost horizontal in summer and almost vertical in winter. As an exception one can mentioned the uppermost surface layer of the ocean, where wind mixing constantly destroys vertical gradients.

The flow of solar radiation falling on the ocean surface and thermodynamic interaction with the atmosphere causes thermohaline changes in the density of surface water. The main area and most temporal variation in density are concentrated in the upper, so-called active ocean layer, the thickness of which is determined by a range of annual oscillations of mass flow, intensity of wind mixing, and also by the character and value of vertical velocity on its lower boundary.

The uppermost part is usually a clearly defined layer, and as a consequence is essentially homogeneous along the vertical, with a thickness varying from several tens to hundreds of meters and limited by the density skip below. In the lower part of the productive layer, called the seasonal thermocline, density increases with depth due to a lowering of temperature and an increase in salinity. An upper quasi-homogeneous layer is generated by mixing with surface waves due to overturning turbulence generated by drift currents, velocity displacement, and dense convection when the ocean surface is cooling or changing in its salinity (e.g. by evaporation).

Here even very small density gradients exist, providing significant vertical mass flows at almost neutral stratification due to intensive mixing. Near the main skip—the lower boundary of the upper quasi-homogeneous layer—the steepest gradients are observed; the temperature gradient often reaches several degree per meter. Normally, regular seasonal changes in water temperature are observed below the skip layer, in the seasonal (or upper) thermocline. The depth at which there are no seasonal changes in water temperature is considered to be the lower boundary of ocean surface water.

2. Water Masses and Mixing

Bodies of oceanic water that possess more or less homogeneous and specific hydrologic, hydro-chemical and biological characteristics and that mix as a whole in the system of total oceanic water circulation are identified as water masses. They can maintain their form for quite a long time in certain climatic conditions. On the boundaries of water masses are zones where gradients of hydrologic and hydro-chemical characteristics change sharply. These boundaries between water masses are called frontal zones. All oceanic water masses are formed near the surface mainly due to vertical winter circulation, and then are transferred by sea currents to other regions and depths. Mixing and currents form mainly vertical distributions of oceanographic characteristics and inter-stratifications of oceanic water.

Depending on the stability of surface layers and basin size, the zone of wind mixing normally extends to a depth of 10-15 m. The smaller the basin's size, the smaller the waves' size and penetration depth of wind mixing. The vertical distribution of oceanic characteristics is distinguished by significant variability. The whole zone becomes completely homogeneous after strong and prolonged storms. The effects of external and internal factors play very important roles in surface water, forming a vertical gradient of oceanic characteristics after wind discontinuance.

The zone of convective mixing extends from the sea surface to very deep profundities. Usually this zone is formed by vertical winter circulation, but in some cases (in tropical and subtropical areas) it can be created by increased salinity as a result of evaporation.

In summer, the zone is often preserved as a cold intermediate layer, which can disappear absolutely at the end of the summer. The zone of convective mixing is the most active zone of the oceans. The influence of mixing on the ocean regime appears first of all in the distribution of variations of physical and chemical properties vertically and horizontally, while vertical variation is higher than horizontal. The seas are classified as interior (inland), marginal, or inter-insular according to their geographical position and degree of isolation from the World Ocean. Interior seas are those that deeply intrude into the land and meet the oceans or adjoining seas through relatively narrow channels (straits).

According to their geographical position, interior seas can be subdivided into continental and intercontinental types. A continental sea is usually shallow and intrudes into the land within a continent (e.g. the Sea of Azov, the Black and the White Seas, and Hudson Bay). An intercontinental or mediterranean sea is a part of the World Ocean located between continents and connected with the ocean or other seas by straits (e.g. the Mediterranean and the Red Seas). A marginal or adjacent sea is a part of the World Ocean adjoining the continent and partially separated from it by a peninsula or a group of islands or simply by uplift of the ocean bottom. They can be on the continental shelf (a 'shelf sea'), or on the continental slope (e.g. the Barents, the Laptev, the Norway, and the Bellinghausen Seas).

An inter-insular sea (encircled by islands) is a part of the World Ocean surrounded by a more or less dense circle of islands, the straits between which prevent free water exchange with the open ocean. Examples include the Javan, the Bandu and the Sulu Seas. Isolated water masses, sometimes possessing extremely different physical and chemical properties from the water around them, are created in each sea. The main factors affecting these water masses are: fresh water balance; intensity of convective mixing; water exchange with adjoining seas as determined by the size and depth of the straits connecting this sea with the ocean, and current velocity.

While water found in the open part of the World Ocean contains a fairly constant composition of main ions and comparatively specialized range of variation in biogenic elements, the composition of water in marginal and interior seas, can differ significantly from that in the World Ocean.

This difference in composition can be explained by the strong influence of surface runoff in the seas. The greater the surface runoff and more limited the water exchange between a sea and the World Ocean, the more significant is this difference. An inflow of ground and thermal water to the bottom can also significantly change the chemical composition. The Red Sea provides the best example of these processes.

Coastal zones, due to the active influence of hydrodynamic factors, are the most dynamic in comparison with other areas of seas and ocean. Very active mixing of water extends down to significant depths. This is the upper part of the continental shelf, which is exposed to the constant influence of wave action, and its lower boundary can be conditionally determined according to the regular annual occurrence of strong storms.

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Bibliography

Dolotov Y.S. Dynamic conditions of coastal relief and sediments formatting. Pub. «Science», Moscow, 1989, 269p. (in Russian). [fundamental monography concerning dynamic processes in coastal zones of the World Ocean, based on data of detailed stationary studies].

Geographical Encyclopedic Glossary. Concepts and termins. Pub. «Soviet Encyclopedia», 1988. – 432p. Chief editor Treshnikov A.A. (in Russian). [modern glossary of termins concerning different areas of geographical science].

Oceanology. Physics of Ocean. Vol.1. Hydrophysics of Ocean. Pub. «Science», Moscow, 1978. – 455p. (in Russian). [part of fundamental monography of leading Russian scientists concerning chief problems on study of physical processed in the World Ocean].

Safyanov G.A. Estuaries. Pub. «Mysle», Moscow, 1987. – 190p. (in Russian). –[summarized work on study of estuarine processes based on vast natural data, collected in different parts of the World Ocean].

Sokolow A.A. Hydrography of USSR (Waters of Land). Hydrometeoisdat, Leningrad, 1952. – 471p. (in Russian). [summarized work concerning different types of the land waters].

Zenkovich V.P. Principles of teaching about marine shores development. Pub. «Academy of Sciences of USSR», Moscow, 1962. - 710p. (in Russian). [fundamental monography of head of Russian scientists school study of shore processes].

Zubov N.N. Dynamic Oceanology. Hydrometeoisdat, Moscow-Leningrad, 1947. – 430p. (in Russian). [fundamental monography concerning dynamic physical processes in seas and oceans].

Biographical Sketch

Dr. Sci. Dolotov Yuri Sergeevich is a Corresponding Member of Russian Academy of Sciences, and Chief Scientist of Water problems Institute of RAS. In 1954 graduated from the Geographical Faculty of Moscow State University. In 1961 he obtained his PhD Degree, and in 1990 completed his thesis for a Doctor's degree. His main fields of professional interest are study of relief-forming and sedimentary depositional processes in coastal areas of the World Ocean, especially of prolonged relief-change in coastal zones and sand coasts; participation in solution of problems related to seashore protection, rational use of coastal territories and conservation of coastal nature. His most significant publishing works are: Monographs – "Processes of heavy mineral placers formation in nearshore marine areas" (with co-authors); "Processes of sediment differentiation and sedimentary strata stratification forming in nearshore marine areas" (with co-authors), "Dynamic relief-forming and depositional sedimentary environments in nearshore marine areas", and "Problems of rational use of coastal space and nature conservation in the World Ocean".