

PROPERTIES OF OCEANS, INLAND SEAS, COASTAL ZONES, AND ESTUARIES

N.N. Mitina

Institute of Water Problems, Russian Academy of Sciences, Moscow, Russia.

Keywords: Oceans, seas, inland seas, coastal zone, mouth areas of rivers, deltas, estuaries, classification, morphology, continental slope, continental rise, continental shelf, abyssal, currents, water masses.

Contents

1. Introduction
 2. Oceans
 - 2.1. Characteristics of Ocean Water (Seawater)
 - 2.2. Current Systems
 3. Seas
 - 3.1. Classification of seas
 - 3.2. Inland seas
 4. Coastal zone
 5. River mouth areas
 - 5.1. Deltas
 - 5.2. Estuaries
 6. Marine pollution
 7. Science and the World Ocean
- Conclusions
Glossary
Bibliography
Biographical Sketch

Summary

Areas, depths, geomorphological and geological features of ocean, classification of seas, bays, straits, different coastal zones and estuaries are described. Basic characteristics of Ocean water (seawater), water masses and currents are given. Main course and features of marine pollution and environment protection measures are discussed. History, problems and ways of the marine science are considered in the article.

1. Introduction

The World Ocean is the body of water with a continuous water surface, occupying the largest depressive geomorphologic feature of the Earth. It surrounds the continents and islands and has a composition dominated by common salt. The total area of the World Ocean is 361.26 million km²; this is about 70.8% of the Earth's surface (61% of the surface in the northern hemisphere, and 81% in the southern hemisphere). The average depth is 3711 m, and the maximum depth is 11 022 m in the Mariana Trench in the Pacific Ocean. The total volume is around 1340.7 million km³. The World Ocean is considered as an open dynamic system, which exchanges matter and energy with the

contiguous natural spheres of the Earth. This exchange has the form of global cycles, in which the heat, moisture, salts, gases and other materials that construct the “body” of oceans and continents take part. During the whole Earth’s history these processes were self regulated and aimed at natural stability. Humanity now threatens to destroy this stability by industrial and other activities leading to negative consequences for nature.

The World Ocean plays a vital role in the global *hydrological cycle* and actively interacts with the atmosphere in a way that is very important for the Earth’s environment. Persistent wind systems transport huge air masses across the oceans and in and out of the land areas. More or less stable currents carry their temperature characteristics to far-distant parts of the oceans, affecting the climatic conditions in bordering lands. The annual inland evaporation of about 66 000 km³ occurring in dry air masses is transported as water vapor out to sea and is precipitated. Of the 502 500 km³ of water evaporated yearly from the ocean, a considerable portion is carried by maritime air masses to the land, where total precipitation amounts to about 110 000 km³ annually. To compensate for the excess of precipitation over land evaporation, 42 600 km³ of water returns to the sea by runoff. In addition to this large-scale phenomenon, there are numerous interactions between the oceans and land; these affect synoptic meteorology and cause salt-water intrusion problems. The Ocean has vast energetic (tidal energy), mineral (chemical substances dissolved in the water, mineral resources) and biological (fish, mollusks, crustaceans, algae) resources. It supports life forms even at maximum depths (11 km), not only in the *euphotic layer*.

2. Oceans

The World Ocean is divided into oceans, seas, bays and straits (see Figure 1).

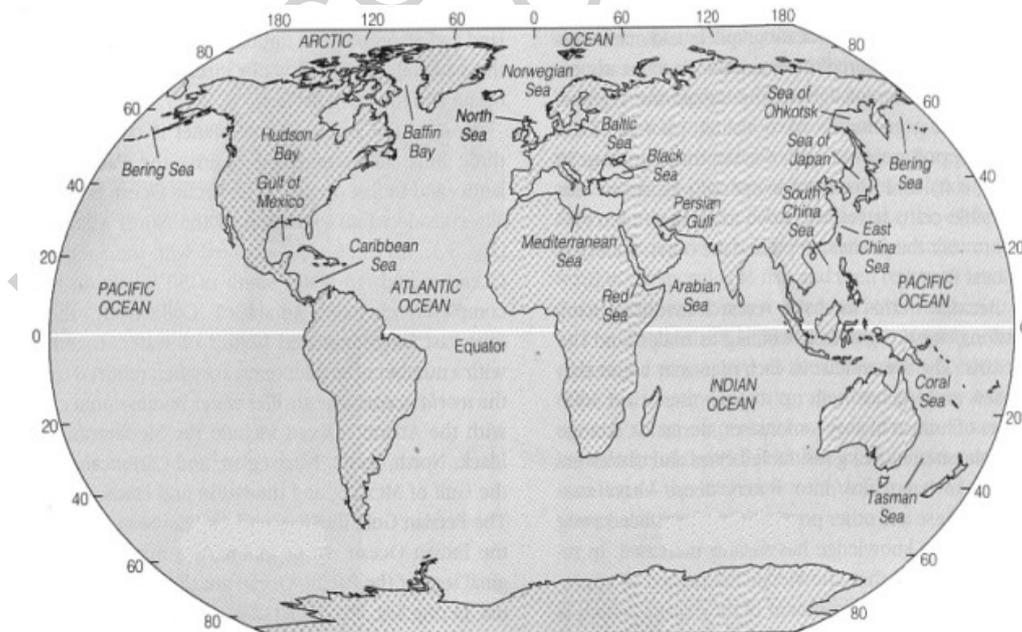


Figure 1. Major basins of the World Ocean. Source: *Philip’s Atlas of the World. Introduction to World Geography.* (1997). George Philip Limited, UK (modified).

Oceans are the major parts of the World Ocean, which have independent basins, being semi-isolated by surrounding continents, and having:

- independent systems of atmospheric circulation which determine the variety of climatic conditions over the surface,
- independent systems of surface and deep currents and therefore independent horizontal and vertical systems of distribution of hydrological, hydrochemical and biological features.

There are essentially four oceans: Pacific, Atlantic, Indian and Arctic. Their areas are 49.9%, 25.7%, 20.5% and 3.9% accordingly (see Table 1). The term “Southern Ocean” is often used, but this area has no independent abyssal basin (its area is 86 millions km²).

Ocean (with seas)	Square, million km ²	% from the World Ocean area	Depth, m		Location of the maximum depth
			Average	Maximum	
Pacific	179,7	49,9	3976	11022	Mariana Trench
Atlantic	92,4	25,7	3597	9222	Puerto Rico (Milwaukee) Deep
Indian	73,9	20,5	3711	7450	Java Trench
Arctic	14,1	3,9	1225	5608	Molloy Deep (Greenland Sea)
World	361,3	100,0	3711	11022	Mariana Trench

Table 1. Basic data on the oceans Source: *Philip’s Atlas of the World*. (1997). Source for average depth: Fundamental Soviet Encyclopedia (1979). Moscow, BSE.

Among the main **geomorphological** and **geological features** of oceans, we can distinguish:

- underwater edges of continents,
- transitional zones from oceans to continents, in particular the systems of islands,
- ocean basins which include the abyssal plains (bottom) of oceans,
- mid-oceanic ridge zones, and
- submarine mountains (see Figure 2).

Underwater edges of continents combine the three relief elements: 1) continental shelf, 2) continental slope and 3) continental rise. The common feature for these three parts is similarity in continental composition, composed of three layers: sedimentary, granite and basaltic layers.

Continental shelf: part of the continental margin with a flooded gentle slope (slope less than 1:1000) and having a common geological structure with the continent, located between the coastline and the line where the slope sharply increases. The width can vary from a few kilometers to 500 km. As a rule, the continental shelf boundary is situated at a depth of 100 to 200 m. The shelf of the Arctic Ocean is the widest (up to 400 km) and the shelf around Antarctica is the deepest (to 350 m).

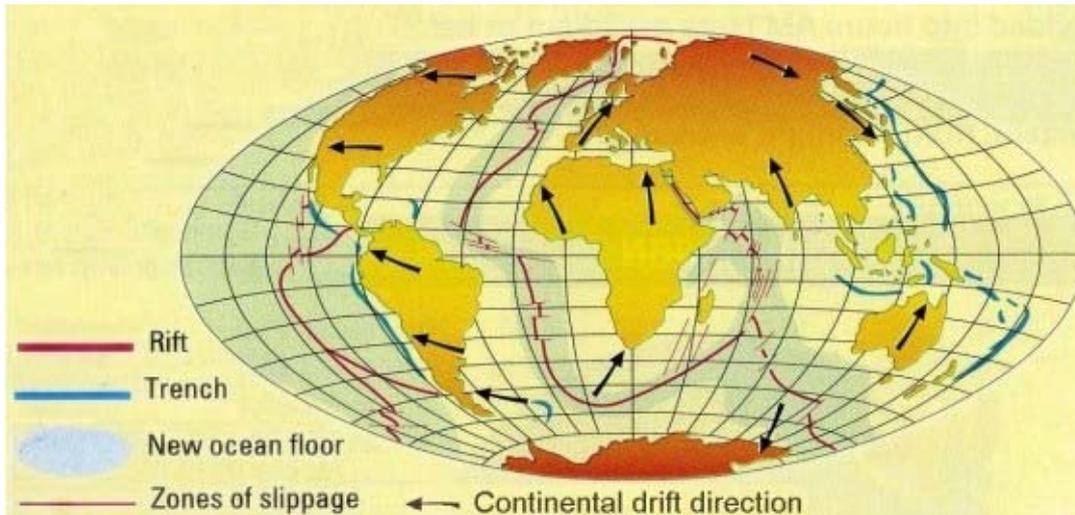


Figure 2. Distribution of rifts (Mid-Ocean Ridges), trenches and slippage

Continental slope: the underwater edge of a continent located between the shelf and the ocean basin, dropping from 100-200 m to 1500-3500 m with steep slopes (more than 4° , and in some places from 35° to 90° . and abrupt relief (breaks, canyons). Transport of sediments as mud-floods are characteristic of this relief form.

Continental rise: the plain adjacent to the lower part of the continental slope and inclined to the ocean bottom. A gently sloping zone (up to $10-12^\circ$) to a depth of 2000-3600 m adjacent to the (steeper) continental slope. The continental rise is formed by a thick layer of sediment, accumulated at the base of the continental slope as a result of sediment transport from the continental shelf and continental slope (Schukin, 1974).

Abyssal plain: a wide accumulative plain area with average depth of 4-6 km. A peculiar feature of ocean basin topography is the system of **Mid-Ocean ridges** or rifts, which stretch for a total of more than 60 000 kilometers along the middle of the bottom of the Atlantic, Pacific, Arctic and Indian Oceans. This is a great cordillera-type mountain system, 1-3 kilometers high over the ocean bottom, delimited by steep slopes. The *spreading* process is coincident with the mid-ocean ridges. The presence of rift valleys 25-50 km wide along the ridge axis, and perpendicular transform faults are typical for mid-ocean ridges. The average depth of the rift zone is about 3.0 km.

2.1. Characteristics of Ocean Water (Seawater)

Seawater is generally composed of water, solids, and gases. The physical properties of seawater are different from those of fresh (river) waters not only with regard to concentration of salt but also as regards temperature and pressure. The solids include suspended particles of inorganic matter, living organisms, and organic detritus, in addition to salts. The ratio of total solids to total sample of seawater is known as the salinity. The ratio of the halide ions (Cl^- , Br^- , and I^- measured by chemical titration) to total sample of seawater is approximately what is known as the chlorinity. Both salinity and chlorinity are expressed in parts per thousands or per mille, denoted by promille

(‰). More than 99.9% of the salinity of ocean water is due to eight ions, the two most important of which (Na^+ and Cl^-) are the constituents of common salt. The proportions of the salts, as percentages by weight, are shown in Figure 3.

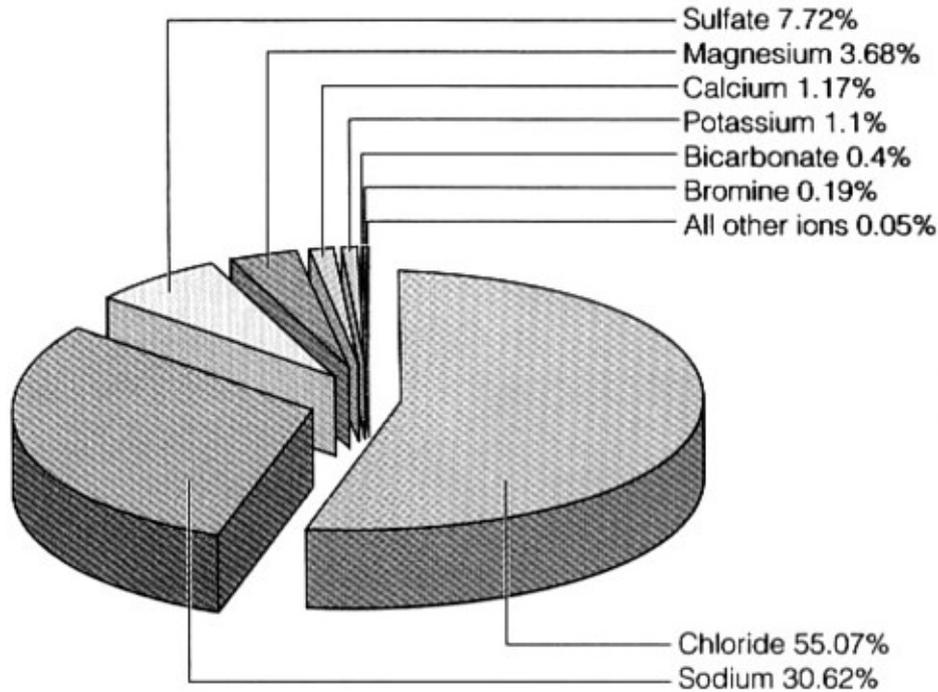


Figure 3. Principal ions in seawater.

Source: Skinner B.J., & S.C. Porter, (1994). *The Blue Planet. An Introduction to Earth System Science*. John Wiley & Sons, Inc. USA.

In some parts of the World Ocean, waters may significantly differ in quantitative salt composition. The total solids in typical seawater are almost completely ionized. The most important factors effecting salinity are (1) evaporation, (2) precipitation, (3) inflow of fresh water, and (4) freezing and melting of sea ice. Average salinity of seawater is about 34.75‰. The salinity of the seawater normally ranges between 33 and 37‰ and is related to latitude (see Figure 4). High salinity values occur in tropical and subtropical waters where evaporation exceeds precipitation. The highest salinity levels occur in enclosed seas such as the Arabian Gulf, and the Red Sea.. Salinity values generally decrease both north and south of the equator, but low values are also found off the mouths of large rivers.

Seawater density and some other physical properties depend almost entirely on temperature, salinity, and pressure. Average density of the World Ocean waters is 1045 ton/m^3 . The maximum density of seawater is reached at a temperature of 4 °C, high salinity and high pressure. When water in a certain region of the sea possesses a definite temperature and salinity for a wide variety of conditions, it forms a continuous *water mass*. Water that is less saline or cooler is more compressible.

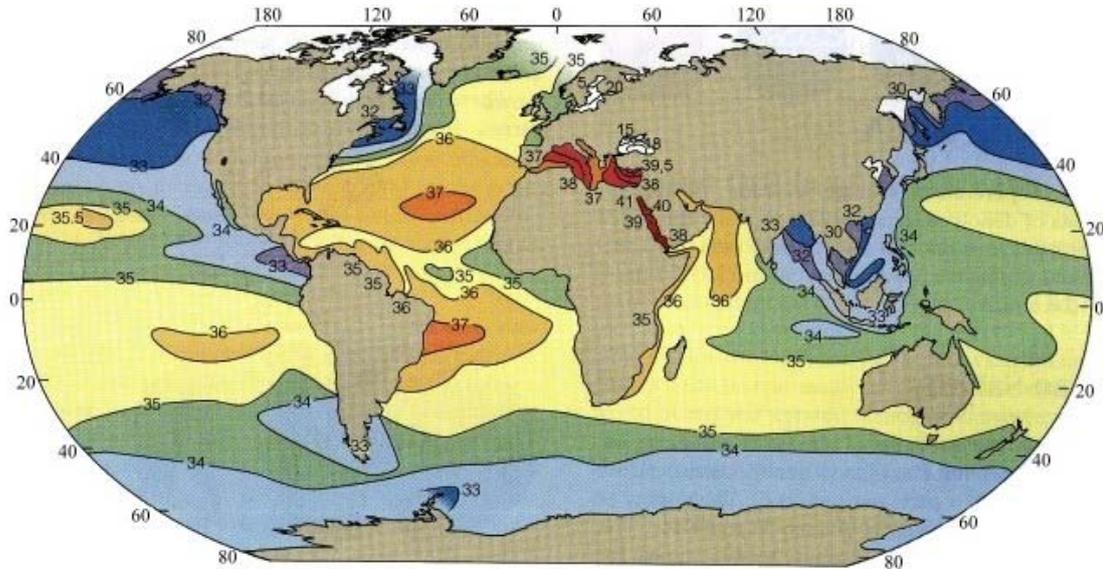


Figure 4. Average surface salinity of the World Ocean.

Source: Skinner B.J., & S.C. Porter, (1994). *The Blue Planet. An Introduction to Earth System Science*. John Wiley & Sons, Inc., USA.

The vapor pressure over ocean water is somewhat lower than that over fresh water, depending on salinity. Because of the salinity, the freezing point of seawater is lower than that of fresh water. Since, on average, the specific heat of ocean water is much higher than that of fresh water, the temperature variation in seawater is much lower than that of the fresh water. The temperature in the open ocean varies between about 32 °C and the freezing point, -2 °C.

Two types of ice can be formed in the oceans: frozen seawater, and icebergs, which are broken-off pieces of glaciers. The average annual temperature of the surface waters in the World Ocean is 17.5 °C; the highest average temperatures are found at the equator (up to 28 °C), while moving to the poles it drops down to -1.9 °C). Seasonal temperature fluctuations occur to a depth of 100 to 150 meters. More than half the ocean surface is warmer than 20 °C (see (Figure 5). About 93% of the ocean volume is colder than 10 °C and 76% is colder than 4 °C.

The horizontal variation of the surface temperature of seawater depends on many factors: solar radiation, wind action, ocean currents, evaporation, precipitation, and river inflow. The vertical variation in temperature allows us to recognize several consistent layers.

The near-surface layer temperature is close to that of the lower layer of the atmosphere, and it decreases gradually with increase in depth. This layer is followed by a *thermocline* layer, which is characterized by rapidly decreasing temperature with depth. Below the thermocline is a deep-water layer in which temperature gradually decreases again with depth and until it reaches constant low temperature of the bottom-water layer.

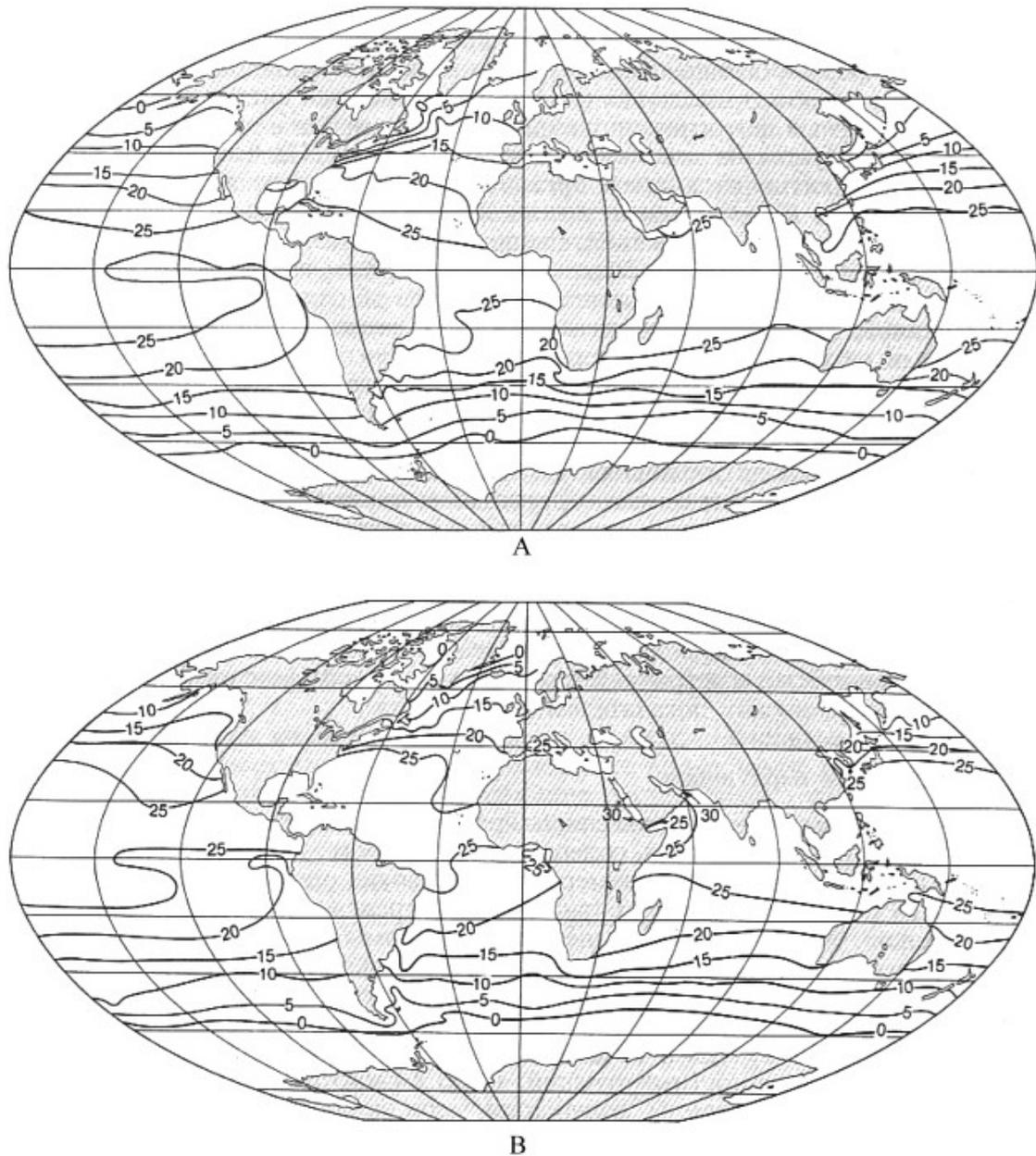


Figure 5. Average surface temperature of the World Ocean: A) in February, and B) in August.

In the bottom layer the temperature is 1.4 to 1.8 °C, while in the polar regions it is lower, at 0 °C). The thermocline layer has a mean thickness of 200 meters. It can be permanent and can extend to more than one kilometer deep. It may also be shallow and vary with the seasons, thus becoming known as a seasonal thermocline. At great depth the temperature distribution is determined by deep circulation, which imports water from the surface. Water circulation in the layer down to 150-200 meters is determined mostly by the winds prevailing over the Ocean; beneath this layer circulation is mainly attributable to variations in density in the water layers.

-
-
-

TO ACCESS ALL THE **30 PAGES** OF THIS CHAPTER,
Visit: <http://www.eolss.net/Eolss-sampleAllChapter.aspx>

Bibliography

Fundamental Soviet Encyclopedia (1979). Moscow, BSE.

Costanza R., (2000). The Ecological, Economic, and Social Importance of the Oceans. Seas at the Millennium: An Environmental Evaluation (Edited by C. Sheppard). Elsevier Sciences Ltd.

IPCC. (1996). Climate change 1995: The Science of Climate Change. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel of Climate Change. Cambridge University Press, Cambridge, 586 p.

International Petroleum Encyclopedia (2001) Penn Well, USA, Vol. 34.

Izrael Yu. , Tsiban A.B., (1992). Anthropogenic ecology of ocean, Moscow, Nauka. (*in Russian*).

Handbook of Applied Hydrology (1960) Ed. By Ven Te Chow, McGRAW HILL BOOK COMPANY, New-York - San Francisco – Toronto – London. p.

Kennish M.J. (1997). Practical Handbook of Estuarine and Marine Pollution. CRC Press Marine Science Series.

Kuusisto E., Lemmela R., Liebscher H., & Nobilis F. (1997). Climate and Water in Europe: Water Quality and Aquatic Ecosystems. WMO.

Longinov, V.V. (1966). Lythodynamics of coastal zone on the tideless seas, Leningrad, Nauka, (*In Russ.*).

Mee L. (1992). The Black Sea in crisis: a need for concerted international action. *Ambio* 21, pp. 278-286.

Philip's Atlas of the World. Introduction to World Geography. (1997). George Philip Limited, UK.

Sea geomorphology, (1980). Terminology reference book. Moscow: Nauka. (*In Russian*).

Semptner, A, (1995). Modeling ocean circulation. *Science* 269, pp, 1379-1386.

Schukin I.S. (1974). General geomorphology. V.3. MSU Pub. House. (*in Russian*).

Skinner B.J., & S.C. Porter, (1994). The Blue Planet. An Introduction to Earth System Science. John Wiley & Sons, Inc., USA.

Strahler A. N. (1960). Physical Geography, 2d ed., copyright © 1960 by John Wiley & Sons, Inc

U.S. Department of the Interior Minerals Management Service. Gulf of Mexico OCS Oil and Gas Lease Sales: 2003-2007, (2002). Final Environmental Impact Statement. Vol. 1. Published by U.S. Department

of the Interior Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA, (MMS, 2002).

Biographical Sketch

Natalia N. Mitina graduated from the Geographical Faculty, Moscow State University in 1977. She received her Candidate of Sciences degree (equivalent to Ph.D.) in submerged landscapes of the Sea of Japan in 1994 at St-Petersburg State University and Doctor Degree in 2005. Since 1996 she has held a position of Senior Research Scientist at the Department of Water Quality and Ecology, Institute of Water Problems, Russian Academy of Sciences in Moscow. Natalia N. Mitina is a Senior Fulbright Scholar of 2002-2003. She is the author of more than 60 scientific publications. Her research interests are in the fields of conceptual methodologies of formation and classification of subaquatic landscapes, and their stability and transformation as a result of natural processes and anthropogenic load. She is dealing now with estimation of anthropogenic load on river mouth natural complexes and recommendations for their protection. Her main publications are:

Mitina N.N. Geoecological investigations of the subaquatic shallow-water landscapes. M, Nauka, 2005, 200 p. (*in Russian*)

Mitina N.N. "The dynamics of main landscape forming factors of river mouth regions under different anthropogenic load", 2002, *Surface Water Hydrology*. A.A. Balkema Publishers Lisse/Abingdon/Exton (pa)/Tokyo, Edited by V.P. Singh, M. Al-Rashed, M.M., Sheriff, Vol. 1, pp.451-456.

Puzachenko Yu. G., Mitina N.N. "Marine Communities" State and Protection of Biological and Landscape Diversity for the Caspian Region. National Report, Part 2.1. Moscow, Ministry of Natural Resources for Russian Federation. 2000. Pp. 39-79.

Mitina N.N. "Estimation of the Natural Aqua-complexes Sensibility to Potential Climate Fluctuations in the Coastal Zone of the Sea of Japan". Proc. 2-nd Int. Conf. on Climate and Water. Espoo, Finland 17-20 August, 1998, Vol. 2, pp. 605-614.

Mitina N.N. The Significance of the Mouths of Small Rivers for the Preservation of Aquatic Ecosystem. British Hydrological Society Occasional Paper, UK, 1998, No. 9, pp. 54-59.