

**THE WORLD OCEAN ATLAS**  
**A NEW CARTOGRAPHIC WORK DEVOTED**  
**TO THE NATURE OF THE WORLD OCEAN**

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In 1974 the USSR Navy started the issue of the World Ocean Atlas — a major new cartographic work devoted to the nature of the World Ocean.

Participation of the Russian Navy and the USSR Navy in the study of our planet's nature has great traditions. Already during the years of creation of the regular Russian naval fleet, its vessels took an active part in geographical explorations.

An outstanding event in the history of world geographic science was the first Russian round-the-world expedition under the command of I.F. KRUSENSTERN, the results of which were summarized in the world-known *Atlas of the South Sea*, which saw print in 1826. Later, the book *The Vityaz and the Pacific* written by S.O. MAKAROV, in which he made public the scientific results of his voyages in 1886-1889, was received with acclaim. In a still later period the Russian fleet was assigned a task of systematic researches, for which special detachments were formed.

But a really wide scale of oceanographic researches was attained in our country only after the victory of the Great October Socialist Revolution. Hydrographic expeditions and detachments were organized and hydrometeorological observatories were established in all the fleets and by the beginning of the 1939-1945 War they had completed the great work of charting and hydrometeorological researches of the seas bordering our country. This peaceful work was then interrupted, and it was only possible to resume hydrographic research after victory in 1945.

In the post-war years hydrographic and oceanographic researches were developing at an ever-increasing rate. In 1949 was organized the first Soviet oceanographic expedition for exploration of the North Atlantic. In 1955 the Soviet Union started active participation in exploration of the Antarctic and adjacent regions of the World Ocean. Since 1957 oceanographic

vessels of the Soviet Union have consistently taken part in the majority of international oceanographic programs. As a result of the intensive exploration of the World Ocean over the past two decades a great number of data have been accumulated, allowing a new approach to the explanation of some phenomena occurring in the ocean and atmosphere.

In the late sixties/early seventies the USSR Navy, in cooperation with the USSR Academy of Sciences and other Soviet scientific and research establishments, began developing into a common system all the scientific observations made in the World Ocean in all the history of its exploration. The final aim of this work was the creation of a new fundamental scientific work about the ocean — the World Ocean Atlas. The creation of the World Ocean Atlas was headed by the Commander-in-Chief of the USSR Navy, Admiral of the Fleet of the Soviet Union S.G. GORSHKOV.

Up to the present time, work has been completed on two volumes of the World Ocean Atlas. The first volume (the Pacific Ocean) was published in 1974, and the second volume (the Atlantic and Indian Oceans) appears in November 1977.

So what is the new Soviet atlas and what is the difference between it and other existing atlases?

The first difference is that only direct oceanographic observations are used in the construction of the Ocean Atlas, whereas the majority of existing atlases are based on the generalizing of previously issued literary and cartographic sources. The use of a series of direct oceanographic observations reduced to a common system has allowed the new Atlas to avoid subjective evaluations and extrapolations which are in one or another degree characteristic of all previous atlases known to us.

The second difference is that the Ocean Atlas is the first to reflect the latest achievements of oceanography, such as information about the upper layers of the atmosphere, new data characterizing hydrological, hydrochemical and hydrodynamical conditions of ocean water, bottom sediments, relief and structure of the ocean bed, etc.

And finally, the essential difference between the Ocean Atlas and other atlases is that for the first time it contains information not only about the ocean layer and the adjacent atmospheric layer but also about all layers of ocean water down to a depth of 5 000 metres and atmospheric layers up to a height of 16-18 kilometres. In other existing atlases such information is either completely absent or given only for limited areas.

The first two volumes of the Atlas cover approximately 96% of the World Ocean. They are completely uniform in the scaling and arrangement of charts, in symbols and abbreviations, in colouring and all elements of the contents. Even the page numbering of corresponding charts in the first and second volumes coincides, a feature which greatly facilitates the comparison of charts and their use together.

The following bodies have been taking part in author development and annotation of the charts of the Ocean Atlas: the USSR Main Naval Staff, the Head Department of Navigation and Oceanography of the USSR Ministry of Defence, the Naval Academy and the Military Medical Academy; research institutions of the USSR Academy of Sciences: the Botanical

Institute, the USSR Geographical Society, the Geological Institute, the Main Astronomical Observatory (in Pulkovo), the Zoological Institute, the Institute of Geography, the Institute of Geomagnetism, Ionosphere and Radio Wave Propagation, the Institute of Oceanology; research institutions of the Head Department of the Hydrometeorological Service at the Council of Ministers of the USSR: the Arctic and Antarctic Research Institute, the USSR Research Institute of Hydrometeorological Information, the USSR Hydrometeorological Research Centre, the Main Geophysical Observatory, the State Oceanographical Institute, the Leningrad and Moscow State Universities, the USSR Research Institute of Fishery and Oceanography, the Pacific Research Institute of Fishery and Oceanography, the Arctic Research Institute of Geology.

Design and printing of the charts of the Ocean Atlas is by the cartographic and polygraphic agencies of the USSR Ministry of Defence and of the Head Department of Geodesy and Cartography at the USSR Council of Ministers.

Each volume of the Ocean Atlas consists of seven sections :

1. History of Ocean Exploration (11 plates of charts).
2. Ocean Bed (29 plates of charts).
3. Climate (79 plates of charts).
4. Hydrology (102 plates of charts).
5. Hydrochemistry (11 plates of charts).
6. Biogeography (7 plates of charts).
7. Reference and Navigational-geographical Charts (48-50 plates of charts).

Every section of the Atlas is preceded by an explanatory text in which a concise account is given of the material used for its preparation. Methods and special features of chart construction are described and an evaluation of the accuracy of charts is given.

Allow me now to describe in more detail the contents of the first volume of the Ocean Atlas, already in the hands of readers.

This volume begins with charts showing the most important Russian expeditions in the Pacific Ocean undertaken before the mid-19th century and the history of discoveries by Europeans of shores and islands of the Pacific. For instance, in detail are shown the Russian discoveries in the North Pacific and mid-Pacific, the Tuamotu Archipelago and the Marshall and Caroline Islands. Separate pages are devoted to the most important Russian and foreign expeditions in the Pacific from the beginning of the 19th century till 1871, from 1872 till 1914 and from 1919 till 1939.

Much attention is given to oceanographic researches in the Pacific after the Second World War. These researches are described over three pages, which clearly bring out the growth in this region.

The section "Ocean Bed" includes the topics : bottom relief, earthquakes and volcanoes, tsunamis, tectonics, geomorphology, types of coasts and bottom sediments.

Bottom relief is characterized by a collection of bathymetric charts and a chart of bottom dissection, characterising the Pacific Ocean bottom by prevailing types of relief forms and their morphology.

The chart "Earthquakes and Volcanoes" shows the geographic distribution of the epicentres of strong earthquakes and the distribution of volcanoes in relation to certain elements of tectonics. The chart represents the most important underwater volcanoes with a record of activity, and the majority of the active volcanoes on land.

The topic "Tsunami" is represented in the Atlas by two charts characterizing this phenomenon by force and origin. Another chart shows isolines giving the running time of tsunami waves from the place of origin to the shores of Kamchatka, the Kuril and the Hawaiian Islands.

The tectonic charts of the Atlas represent the main features of the tectonic structure of the Pacific bottom and the framing of the Pacific tectonic belt.

A special chart is devoted to the structure of the earth and the earth's crust, and also to the character of thermal flow through the ocean bottom.

The chart "Geomorphology" reflects the main structural features of the ocean bottom relief and that of the adjacent land. The chart is constructed on the principle of the morphogenetic classification of relief, offered by the Soviet academician I.P. GERASIMOV in 1946.

The chart "Types of Coasts" shows navigational characteristics of the coasts and some factors which have conditioned their structure (composition of rock, direction of folds of the adjacent land). Types of coasts are given in the classification developed by the Institute of Oceanology of the USSR Academy of Sciences, based on morphogenetic features. For navigational characteristics, large-bay and small-bay coasts are indicated and the distance of the 20-metre isobath from the coastline is shown.

The main purpose of the charts "Bottom Sediments" is to show the distribution of contemporary sediments and their components on the ocean bottom, and also the zoning of sediment-accumulating processes. The results of analysis of samples, collected during the numerous voyages of the Soviet research vessels *Vityaz* and *Ob*, have served as initial data for the definition of boundaries of sediment distribution. Additional data on contemporary sediments, collected by other Soviet and foreign expeditions, have also been used.

The topics of the section "Climate" are considerably extended in comparison with the atlases of similar type. First, the charts of this section show the distribution of all the most important climatic parameters from the ocean surface to a height of 16-18 kilometres, and not only mean values of these parameters but also their extreme values and their frequency. Secondly, as a rule the annual variation of climatic elements is shown, as the majority of the charts are for 12 months.

The section "Climate" consists of three parts having different topics: "Heat Regime of the Atmosphere" (oceanic heat balance and atmospheric temperature regime), "Water Regime of the Atmosphere" and "Atmospheric Circulation".

The part "Heat Regime of the Atmosphere" includes charts showing the components of oceanic heat balance, monthly charts of air temperature

at the ocean surface, and seasonal charts of air temperature on the isobaric surfaces of 500 millibars (5 kilometres), 200 millibars (12 kilometres) and 100 millibars (16 kilometres). Many elements of these charts are published for the first time.

The part "Water Regime of the Atmosphere" includes charts of oceanic water balance (volume of precipitation, evaporation, precipitation-evaporation difference), monthly charts of frequency of precipitation and seasonal charts of absolute and relative air humidity and water content of the atmosphere. Here one can also find charts of thunderstorms, cloudiness, frequency of fog, and visibility.

Published for the first time for the open ocean are charts of frequency of precipitation by intensity and phase conditions, charts of absolute and relative air humidity, charts of thunderstorms, water content and mean cloudiness.

The charts of the part "Atmospheric Circulation" give characteristics of the air circulation at the ocean surface (for each month) and on the isobaric surfaces of 500, 200 and 100 millibars (for four months). Included here also are charts of jet streams, vertical cross-sections of the atmosphere up to a height of 18 kilometres along three meridians, charts of types of atmospheric circulation and atmospheric fronts; and concluding the section is the chart of the climatic zones and regions of the Pacific.

The charts of the section "Climate" are abundant in complex and versatile information. For example, monthly charts of the series "Wind at the Ocean Surface" show (on the main chart and on the inserts): frequency of direction and speed of wind, its mean and maximum speed, direction, speed and steadiness of the resultant wind, and frequency of storms. Additionally, these charts show the main paths and frequency of tropical and extratropical cyclones and also the paths and frequency of anticyclones, and atmospheric pressure values.

The section "Hydrology" describes in detail the main parameters of ocean water (temperature, salinity, density, and sound velocity) along the standard hydrological horizons from the surface down to a depth of 5 000 metres. The charts of these parameters are constructed as a result of processing the volume of world hydrological data which includes hydrological observations made in the World Ocean mainly from 1925 till 1972.

One of the benefits of the Atlas is a representation of distribution of temperature, salinity and density against the characteristic seasons or months. These charts should be considered basic or standard for different hydrological calculations.

As is known, the study of the interaction of ocean and atmosphere demands a detailed and accurate knowledge of temperature conditions of the boundary layer of these media. Such information is given on the charts "Water-Air Difference of Temperature".

Characteristic features of the spatial structure of ocean waters can be seen on the hydrological cross-sections, oriented mainly by meridians and parallels.

Different aspects of water dynamics are for the first time interpreted

in the light of modern climatic theories and models for the ocean as a whole. The Atlas gives adequately complete characteristics of tidal movements, not only for the narrow coastal zone, but also for the open ocean.

By the dynamic method with special consideration of datums, elements of water mass transport are calculated at depths of 100, 200 and 500 metres. The complex phenomenon of sea waves, difficult to render in charts, is characterized in detail, and for the first time an evaluation is given of mean and maximum heights of waves and their period for each month of the year.

The mixing processes going on in the ocean, which are very important for the vertical distribution of physical and chemical parameters, are represented on the charts of wind mixing and convective mixing.

The chart "Water Structure" showing the main hydrological water structures and ocean water masses is a great success in systematizing and generalizing oceanic processes.

Data on the chemical composition of water, collected up to the late sixties and early seventies, has allowed for the first time an evaluation of the hydrochemical regime of ocean waters. This relates to oxygen, carbonate system elements and biogenous compositions. New and interesting are the charts of oxygen minimum and phosphates. The charts of the section "Hydrochemistry" are of assistance in evaluating biological productivity of ocean waters. Included in the section is the chart of the chemical structure of water, showing for the first time ocean zonation by chemical characteristics.

The charts representing organic life in the ocean are combined in the section "Biogeography" and give a general description of the biological structure of the ocean. It is interesting to note that the very conception of biological structure was worked out about a quarter of a century ago by the Soviet academician L.A. ZENKEVICH, and this section of the Atlas should be considered as a cartographic realization of his ideas. The contents of the charts describe in detail the whole chain of organic life in the ocean, from phyto- and zooplankton to marine mammals.

The section "Biogeography" of the Ocean Atlas gives wide and complete characteristics of ocean inhabitants. For the first time, quantitative characteristics are given of such complex biological elements as primary production, biomass of zooplankton and of bottom fauna. Quite new is the chart of bottom trophic areas.

In this section the most detailed is the topic "Fish", showing distribution of fish inhabiting the surface layer and deepwater layers of the ocean. Fish living at depths down to 200 metres are represented mainly by commercial species. Besides fish, the reader will find in the Atlas detailed information about molluscs, whales, pinnipeds, seabirds and other representatives of oceanic fauna, and also on the dynamics of whaling, migration paths of seabirds over the ocean, etc.

The last section of the Atlas contains reference charts and navigational-geographical charts. Reference charts represent the topics : geomagnetism, astronomy, sea and air communications, medical-geographical conditions, and the populations of Oceania and Australia. The collection of naviga-

tional-geographical charts consists of an index chart, charts of different regions of the Pacific and plans (mainly of ports).

The charts of geomagnetism show the main elements of the Earth's magnetic field, their annual variation, and the location of magnetic observatories in the Pacific.

The astronomical charts present diagrams of the times of sunrise and sunset, diagrams of navigational and civil twilight duration, and time zones of the Earth. There are charts of the star sky and the solar system and of both hemispheres of the Moon.

The chart "Sea Communications" shows the main navigation tracks corresponding to recommended routes and gives the characteristics of the main ports of the Pacific.

The chart "Air Communications" shows the main airlines and airports in the Pacific region, and gives characteristics of the main international airports.

The chart "Medical-Geographical Conditions" indicates the spreading of the most dangerous diseases, both of natural origin and transmissible, and the location of medical establishments and offices of the World Health Organization. Specified are areas of spreading of the especially dangerous diseases (plague, yellow fever, cholera), covered by regulations of international conventions. Ports are indicated where plague outbreaks have been recorded among humans or rodents.

A separate chart is concerned with malaria, this disease being up to now one of the most widespread in the tropical zone.

The chart "Medical-Geographical Conditions" shows also the distribution in the Pacific of sea animals dangerous to man (sharks, poisonous fish and molluscs). All the medical-geographical charts are original; they have been constructed in cooperation with the Military Medical Academy.

In the chart "Populations of Oceania and Australia", classification of the said populations is ethnical-linguistical, based on the principle of cognation of languages.

Navigational-geographical charts by their contents and scale are divided into three groups :

1. General charts, at a scale of 1:12 000 000 (covering together the whole Pacific Ocean).
2. Regional charts, at scales of from 1:250 000 to 1:3 000 000.
3. Plans of ports, from 1:25 000 to 1:200 000.

All charts are drawn in Mercator orthomorphic cylindrical projection.

The Atlas ends with an index consisting of two parts : the first part contains names referring to the charts of those sections of the Atlas which are concerned with certain topics, and the second part contains names referring only to the navigational-geographical charts. There are altogether about 10 000 names in the index.

Such are, in general, the contents of this first volume of the World Ocean Atlas (the Pacific Ocean). The second volume (the Atlantic and Indian Oceans) is in contents and volume of data completely analogous to the first volume.

The new Soviet Atlas is intended for scientists, Army and Navy officers, captains and mates of merchant and fishing fleets. The vast cognitive material contained in the Atlas also allows its use as an educational aid for the higher schools of relevant types. The contents of the Atlas will be useful for scientists studying the ocean and atmosphere or the protection of the environment, or planning and carrying out marine expeditional and research work.

The issuing of the World Ocean Atlas is a contribution by the Soviet Union to the knowledge of the nature of our planet. The twenty-fifth Congress of the Communist Party of the Soviet Union held in 1976 designated the study of the World Ocean as one of the most important fields of modern science. Our marine cartographers consider it a great honour to have taken part in this work, the results of which are aimed at the benefit of all mankind.