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INFORMATION

Cruise 9 of R/V *Akademik Ioffe*

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SCIENTIFIC PROGRAM AND PRIME OBJECTIVES OF THE EXPEDITION

The key objective of cruise 9 of R/V *Akademik Ioffe* was the study of the seasonal and low-frequency variability of the thermohaline water structure in the Subpolar gyre in the North Atlantic and the distribution of the hydrochemical parameters in the entire depth range. The expedition was carried out within the following scientific programs:

Subprogram "Research on the Nature of the World Ocean" of the "World Ocean" Federal Research Program;

Subprogram "Multidisciplinary Studies of Oceans, Seas, the Arctic, and the Antarctic" of the Federal Purposive Scientific–Technological Program "Investigations and Developments on Prior Lines of Development of Civil Sciences and Technologies";

Program of the Basic Research of the Russian Academy of Sciences;

and also in the framework of the continuing international cooperation within the WOCE–CLIVAR program.

Significant variability of the thermohaline structure of waters in the World Ocean on a decadal scale was found on the basis of the field data collected in the WOCE experiment and the comparison of them with the historical data. It was shown that the variations in the properties of seawater are found in the entire water column. They are recorded even at abyssal depths [1, 5, 6]. The importance of this finding facilitated the fact that the international scientific community decided to continue the field measurements over a series of WOCE sections to study this variability in detail and finally to find its influence on climate variations. The Shirshov Institute of Oceanology supported this decision and, starting from 1997, conducted a number of expeditions to the Atlantic Ocean [3] collecting a significant data set for further study of the processes occurring in this most important region of the World Ocean, thus making a contribution by our country to the WOCE–CLIVAR program. The research within the project "Long-Term Variability of the Meridional Circulation in the North Atlantic" of the Subprogram "Multidisciplinary Studies of Oceans, Seas, the Arctic, and the Antarctic" of the Federal Purposive Scientific–Technological Program "Investigations and Developments on Prior Lines of Development of Civil Sciences and Technologies" is another fact confirming the interest of Russia in the important problem of the influence of oceanic variability on the earth's climate. The expeditions mentioned above were carried out in the framework of the problems formulated in this project.

In addition to the main objective of the expedition, other problems of the original scientific importance were solved in the cruise:

1. Study of the features of the Labrador waters propagation near the source of their formation after the end of the winter convection.

2. Study of the water exchange between the eastern and western deep basins in the North Atlantic.

3. Studies of the currents in the upper 600-m layer and estimates of the value of the nongeostrophic component of the currents.

4. Study of the distribution and composition of the suspended sedimentary matter over the section by determining the concentration and size of suspended particles.

5. Study of mixing in the upper layer and over shallow-water parts of the section.

6. Study of tectonic and sedimentary processes in the North Atlantic.

7. Study of sedimentary processes in the Baltic Sea.

The solution of the problems listed above satisfied the requirements of projects 1.1, 5.2, 7.4, and 8.2 of the subprogram "Research on the Nature of the World Ocean" of the "World Ocean" Federal Research Program.

The scientific program was approved by the Scientific Council of the Shirshov Institute of Oceanology of the Russian Academy of Sciences, in agreement with the Scientific Council for the Problems of the World Ocean of the Russian Academy of Sciences (chairman Academician Yu.A. Izrael') and approved by Academician N.P. Laverov, the vice-president of the Russian Academy of Sciences.

ROUTE OF THE EXPEDITION

On April 17, 2001, R/V *Akademik Ioffe* set out for her ninth scientific cruise from the port of St. John's (Canada). The scheme of the route of the cruise is shown in the figure. On April 18, the ship began the

operation at point 52°42′ N, 51°53′ W and on May 1, 2001, the ship completed the section at point 51°26′ N, 14°26′ W heading to the port of Kiel (Germany).

A total of 43 deep-water hydrographic stations from the surface to the ocean floor were made including 20 stations in the western basin, 9 stations in the Charlie Gibbs Fracture Zone, and 14 stations in the eastern basin.

After leaving Kiel on May 6, 2001, the ship made a survey of the structure of the sedimentary layer in the Baltic Sea using a Parasound parametric echo sounder. On May 8, 2001, the ship returned to Kaliningrad.

The expedition took place during the heavy weather characteristic of the spring period at high latitudes in the North Atlantic. In this relation it is important to note the outstanding seagoing ability of the ship. Only twice, when the wind exceeded 25 m/s and the waves were greater than 8 m, were the planned works interrupted.

Scope of the studies performed

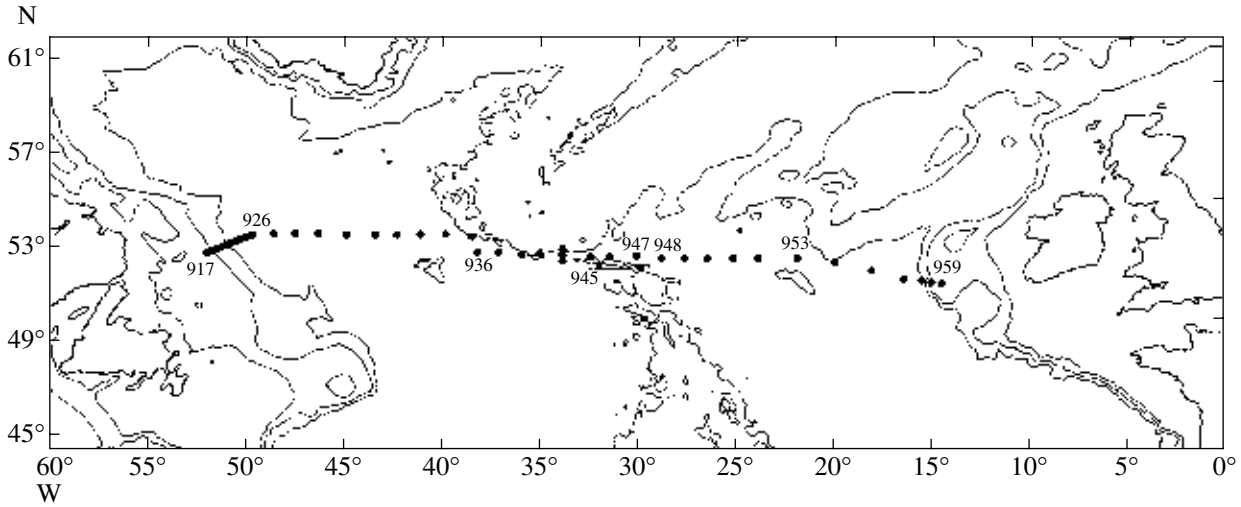
1	Mileage	3107
2	Number of CTD stations	43
3	Standard meteorological observations	132
4	Number of facsimile weather charts received and analyzed	58
5	Number of water samples with Niskin bottles for hydrochemical analysis	396
6	Number of hydrochemical analyses, among them:	1617
	oxygen	605
	silicates	605
	salinity	407
7	Samples of suspended matter in the water	296
8	Number of microstructure profiles	96
9	Length of tacks with bottom profiling:	
	in the Atlantic Ocean	2540 miles
	in the Baltic Sea	240 miles

METHODS AND MEANS FOR MEASUREMENTS AND DATA PROCESSING

The vertical distributions of temperature and salinity were observed with the use of an oceanographic NBIS Mark-IIIB CTD probe. In March 2001, the measuring channels for temperature, conductivity, and pressure of the instrument were calibrated on the laboratory test bench at the Federal Department of Marine Navigation and Hydrography (Bundesamt für Seeschiffahrt und Hydrographie (BSH), Hamburg). A rosette section (General Oceanics Rosette, Model 1015) equipped with twelve GO Niskin bottle samplers was used together with the CTD probe for water sampling.

The salinity values were determined in the cruise using an Autosal 8400B salinometer manufactured by the Guildline company (Canada). On April 9, 2001, the salinometer was certified and calibrated at the manufacturing company. The content of dissolved oxygen was determined by the Winkler method modified by A.M. Chernyakova. The concentration of silicates was determined with a KFK-3 photoelectric colorimeter. A Coulter counter was used to determine the volume concentration of suspension in seawater samples.

The measurements of the microstructure in the upper 200-m layer using a MSS free-falling microstructure profiler supplied by the specialists from University of Girona (Spain) were made at the hydrographic sta-



Location of the stations over the transatlantic section along ~53° N carried out in cruise 9 of R/V *Akademik Ioffe*.

tions simultaneously with CTD profilings. The profiler was designed and manufactured in Germany within the EUREKA EUROMAR MICSOS EU 1246 project. Throughout the entire section, the measurements of currents in the upper 600-m layer were carried out using the acoustic current profiler (ADCP). The meteorological information was recorded by a Wetos 625 onboard meteorological station and a portable Davis Weather Monitor II station.

A Parasound parametric seismoacoustic profiler (manufactured by the Krupp Atlas Electronic company) designed for depth measurements simultaneously with seismoacoustic profiling of the bottom sediments was used to carry out geological geophysical studies. The depth of the signal penetration in the deep-water sediments reaches 100 m, while the resolution to distinguish separate layers is 0.5 m.

VOLUME OF THE WORK PRELIMINARY SCIENTIFIC RESULTS

In order to solve the main problem of the expedition—to study the seasonal and low-frequency variability of the thermohaline water structure in the Subpolar gyre of the North Atlantic—the data obtained in the cruise were compared with the results obtained in previous years: the sections of R/V *Erica Dan* along 53.5° N made in 1962 and R/V *Knorr* along 50–54° N made in 1981. The International Temperature Scale ITS-90 was used for temperature calculations; salinity calculations were carried out according to the Practical Salinity Scale PSS-78. The results obtained in 2001 compared to the previous surveys indicate that the water column between 1000 and 3000 m became significantly less saline (by 0.05–0.06‰) and somewhat cooler.

The main cause of the effect is the formation of a thick layer of the Labrador Water (LW) at the beginning of the 1990s. This layer is cooler and fresher than in the previous decades. A more intensive heat transfer from the sea surface in the autumn–winter period and advection of fresher and cooler waters in the system of the Subpolar cyclonic gyre causing a stronger cooling of the upper layer in the Labrador Sea may be the physical processes responsible for this change. Despite the cooling and salination of the newly formed LW, which began in the middle of the 1990s, its contribution to the calculation of the mean values over the area of the section remains insignificant. Moreover, now, the process of freshening also involves the Northeastern Deep Water Mass (NEDW) both in the western and eastern basins. In 2001, a sharp decrease in the intensity of the zonally averaged circulation was found, which is primarily caused by the less intensive transport in the North Atlantic Current (upper layer in the eastern basin) and weakening of the deep water transport to the south. Unlike the previous surveys, our data indicate that the transport in the intermediate layer of the Labrador Water was more intensive than in the deep layer. We can conclude that the warming and salination of this water mass, which had already been occurring over about five years, had not yet become a process that could lead to the intensification of the meridional circulation.

The section crossed several large oceanic structures from the west to the east. They are the continental slope and the Labrador Basin with depths up to 4000 m, the Charlie Gibbs transform fault and the rift valley of the Mid-Atlantic Ridge (near 34° W) with recorded maximum depths exceeding 4800 m, and the Western European Basin with depths up to 4500 m. Several sedimentary ridges are seafloor features of a higher order, which are interesting from the point of view of sediment redistribution by the near-bottom currents. Sedimentary waves several kilometers long with a height from 20 to 50 m and more, which were distinguished in the bottom profiling taken with a sampling interval of 1100 m, are characteristic elements of the seafloor in these accumulative regions.

The study of the volume concentration and dispersion properties of the suspended matter mainly in the near-bottom layer of the ocean allowed us to distinguish the mesoscale anomalies caused by hydrodynamic and topographic effects. For example, a giant "column" of suspended matter reaching 1.5 km in height was found over the Gloria rift (43–47° W). The cause of this phenomenon is matter precipitation from the near-bottom currents flowing from the Norwegian–Greenland Basin. Concentrations of suspended matter anomalous for the abyssal depths of the ocean are found in the waters of the Charlie Gibbs Fracture Zone and over it.

The main result of the accompanying seismoacoustic survey is the detailed study of the structure of the upper layer of the sediments with a thickness reaching 50 m in all of the geological structures of the seafloor crossed during the cruise. The analysis of the seismoacoustic data shows that they correlate well with the results of the deep-sea drilling (site 611 DSDP). Tectonic structures were studied using high resolution seismoacoustic survey in the Charlie Gibbs transform fault and in the region of its intersection with the rift valley of the Mid-Atlantic Ridge. In the Baltic Sea, seismoacoustic survey was carried out along the profiles crossing the drilling sites and stations of the geological core sampling. The majority of the Parasound records correlate well with the geological sections. The results of this correlation can be extended over the entire area of the adjacent regions in the Baltic Sea.

More detailed information about the scientific results of the cruise is contained in the cruise report [2].

REFERENCES

1. Lappo, S.S., Sokov, A.V., Tereshchenkov, V.P., and Dobrolyubov S.A., The Cooling and Desalination of the Intermediate and Abyssal Waters in the Western Part of

the North Atlantic at the Beginning of the 1990s, *Dokl. Ross. Akad. Nauk*, 1996, vol. 347, no. 4, pp. 548–551.

2. *Otchet 9-go reisa NIS "Akademik Ioffe"* (Report of Cruise 9 of R/V *Akademik Ioffe*), Moscow: Shirshov Institute of Oceanology, Russian Academy of Sciences, 2001.
3. Sokov, A.V., Tereshchenkov, V.P., and Dobrolyubov, S.A., Cruise 36 of R/V *Professor Shtokman* within the Frames of the WOCE International Program in the North Atlantic, *Okeanologiya*, 1998, vol. 38, no. 4, pp. 629–632.
4. Shapovalov, S.M., Sokov, A.V., and Dobrolyubov, S.A., Cruise 15 of R/V *Akademik Sergei Vavilov* within the Frames of the WOCE International Program in the North Atlantic, *Okeanologiya*, 2000, vol. 40, no. 5, pp. 791–793.
5. Koltermann, K.P., Sokov, A.V., Tereschenkov, V.P., *et al.*, Decadal Changes in the Thermohaline Circulation of the North Atlantic, *Deep-Sea Res.*, 1999; *Part* II, vol. 46, nos. 1–2, pp. 109–138.
6. Siedler, G., Church, J., and Gould, J., *Ocean Circulation and Climate*, Academic, IGS, 2001, vol. 77.