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INFORMATION

Cruise 8 of R/V *Akademik Ioffe* in the Atlantic Ocean under the Auspices of the WOCE/CLIVAR International Program

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Scientific Program and Prime Objectives of the Expedition

Cruise 8 of R/V *Akademic Ioffe* was carried out in accordance with the "World Ocean" Federal Program affirmed by the Russian Government on August 10, 1998 in the framework of the continuing international cooperation within the WOCE/CLIVAR program, the participation in which was affirmed by the Resolution no. 919 of the State Committee on Science and Technology of the USSR and Presidium of the Academy of Sciences of the USSR on July 24, 1989.

The key objective of the cruise was the investigation of the interaction processes between the South and North Atlantic. The key to an understanding of the earth's climate lies in the interaction of these two systems. The scientific goal of the cruise was the observation of temperature, salinity, hydrochemical parameters, and currents over a transatlantic section in the equatorial zone.

The data obtained in the cruise will be a part of the Global WOCE Dataset, which will be used in the development of models for forecasting climate changes and investigating the low-frequency variability of the ocean. The geographical location of the section allows one to obtain additional information about the present-day state of the equatorial zone of the Atlantic. In addition, the results of the expedition will allow us to solve a number of independent and extremely important problems:

(1) To obtain a reliable estimate of the natural seasonal and low-frequency variability of the thermohaline water structure in the equatorial Atlantic and, especially, in its deep-water part on horizontal scales comparable with the scale of the ocean;

(2) To obtain the boundary conditions at the southern periphery of the North Atlantic on the basis of the measurements over the section, which, together with the data of the section along 48° N carried out by German oceanographers in May 2000, will provide the data needed for modeling the variability of the global meridional convective circulation (GMCC) in the North Atlantic;

(3) To specify the present-day thermohaline structure of waters in the equatorial Atlantic; to estimate the rate of heat, salt, and fresh water exchange between the South and North Atlantic and to calculate the meridional transport of these characteristics; to determine the large-scale thermohaline circulation and its interaction with the observed atmospheric fields; and to estimate the long-term variations in the thermohaline structure and circulation in the North Atlantic;

(4) To obtain the distribution and composition of suspended matter in the regions of underwater "waterfalls" in the Atlantic Ocean (Mediterranean intrusion, deep-water Kane Gap, Ceara abyssal plane);

(5) To obtain the composition of the aerosol sedimentary matter in the central part of the Atlantic Ocean and the composition of dissolved lipids in the surface layer over the section;

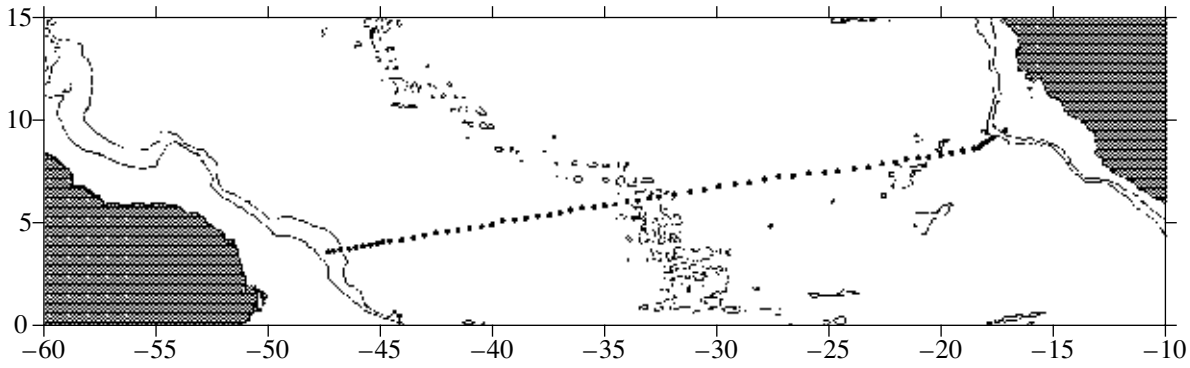
(6) To obtain the fine structure of the Holocene, Pleistocene, and more ancient sediments in the Baltic Sea and Atlantic Ocean using the records of the bottom topography and structure of the bottom sediments with a parametric echo sounder operating on the route of the ship; to obtain their spatial distribution and thickness, which is necessary for distinguishing the processes of sediment accumulation and refinement of the geological history of the basin development.

A separate technical goal of the cruise was to put into operation an automated system for recording meteorological observations and the condition of the surface layer of the ocean (temperature and salinity) on the route of the ship in order to produce datasets of hydrophysical parameters of high accuracy within project 1.1 of the "World Ocean" Federal Purposive Scientific-Technological Program.

A special goal of the cruise was to transport a group of delegates of the 31st International Geological Congress and organizing ship accommodation for another group of delegates during the congress and conducting a seminar–school on the problems of present-day geology.

Financial Support of the Expedition

The cruise was carried out by the Shirshov Institute of Oceanology, Russian Academy of Sciences, supported by special funding from the Russian Academy



Location of the hydrological stations over the section carried out in July 2000 during cruise 8 of R/V *Akademik Ioffe.*

of Sciences for conducting expeditions in 2000 and by the Ministry of Science and Technologies of the Russian Federation within the Federal Purposive Scientific-Technological Program "Investigation of the Nature of the World Ocean" (projects 1.1, 2.6, and 7.3). In addition, the organizing expenses of the expedition were defrayed by the "Long-Term Variability of the Meridional Water Circulation in the North Atlantic" project in the frameworks of the subprogram "Multidisciplinary Investigations of Oceans and Seas, Arctic, and Antarctic Regions" of the "Investigations and Developments on Prior Lines of Development of Civil Sciences and Technologies" Federal Purposive Scientific-Technological Program, and by the INTAS–RFBR 95-0972 and INTAS 96-2062 international grants.

Expedition Route

On June 27, 2000 the ship put out for her eighth scientific cruise from the port of Kaliningrad, and on June 29–30 called at the port of Hamburg (Germany), where scientific equipment was loaded. On July 13, 2000 the ship reached the point of the start of the operation on the section (09°25.89′ N, 17°21.55′ W).

During the period from July 13 to 28, a section of 62 stations was made (figure). On August 5, the ship called at the port of Rio de Janeiro (Brazil) to take part in the 31st International Geological Congress, which was held on August 5–17.

On August 17, after leaving Rio de Janeiro, the ship turned to its port of registration conducting accompanying works at full speed. On September 1, a station for CTD calibration was observed in the Iberian Basin.

On September 9, 2000, R/V *Akademik Ioffe* returned to Kaliningrad.

Methods and Means for Measurements and Data Processing

The vertical distributions of temperature and salinity were observed with the use of an oceanographic General Oceanics Mark-IIIB CTD probe (serial no. 1110-01). The probe is supplied with a pressure sensor (Paine Model 211-35-440; 1500Ω bonded titanium strain gauge bridge, tube type), platinum resistance thermometer (Platinum Thermometer Rosemount Model 171 BJ) and a four-electrode ceramic conductivity cell (NBIS, Inc #B10086 4-electrode cell $4 \times 4 \times 3$ cm long), and two thermistors (Renwal #GC32SM2) to compensate for the inertia of the platinum resistance thermometer and to determine the temperature of the pressure sensor. Before the cruise, each of the measuring channels of the instrument was calibrated on the laboratory test bench at the Federal Department of Marine Navigation and Hydrography (Bundesamt fur Seeschiffahrt und Hydrographie, (BSH) Germany).

A rosette section (General Oceanics Rosette multibottle array system Model 1015 with onboard registration unit, Model 1015-PM) was used together with the CTD probe for water sampling. The rosette is equipped with twelve GO Niskin bottle samplers 1.7 l in volume (model COM 1015-12-1.7). A Niskin bottle 2.5 l in volume was used for taking a greater water sample in the near bottom layer for the analysis of suspension and the uranium compound content.

At each of the stations, the water bottles were equipped with frames for mercury reversing deep-water protected and unprotected thermometers of high resolution manufactured by GOHLA Precision GmBH. The data of protected and unprotected thermometers were used for inspecting the time dependence of the oceanographic probe sensors. Thus, 422 independent measurements of temperature and 278 measurements of water sampling depth were carried out at 64 stations.

A calibration station was observed in the Iberian Basin at a point with coordinates 38°11.78′ N, 17°34.00′ W at a sea depth of 5697 m to compare the records of the CTD probe with the reference *T,S* curves [2, 4] in the deep waters of the Northeast Atlantic.

The offboard unit was provided with a *BENTHOS* pinger designed for the determination of the instrument location with respect to the bottom. The signals from the pinger were recorded by the onboard echo recorder,

Volume of the work

1.	Mileage	13835
2.	Number of CTD stations	65
3.	Meteorological observations with the WETOS system were carried out during the whole cruise with a time interval of 15 s. The volume of the information obtained in Mb	4
4.	Number of facsimile weather charts received and analyzed	35
5.	Number of water samples with Niskin bottles for hydrochemical analysis	768
6.	Number of hydrochemical analyses, among them:	1528
	oxygen	764
	silicates	764
7.	Number of water samples for salinity analysis	520
8.	Number of temperature measurements with deep-water reversing protected thermometers	422
9.	Number of depth measurements with deep-water reversing unprotected thermometers	278
10.	Measurements of currents in the upper layer using ADCP in km	12913
11.	Records with the Parasound echo sounder in km	25252
12.	Number of samples of eolian suspension	15
13.	Number of water samples from the upper layer filtered to determine the organic matter composition	7
14.	Number of water samples for investigating the uranium and plutonium isotopes	20
15.	Number of suspension samples, among them:	89
	suspension samples from the deep-water levels	29
	suspension samples from the sea surface	53
	eolian suspension samples	7
16	Number of water samples processed in the Coulter counter, among them:	418
	suspension water samples from the deep-water levels	358
	suspension water samples from the sea surface	53
	eolian suspension samples	7

which provided the measurements in the closest vicinity of the bottom.

Usually, the water bottles were closed at the following depths: 50, 300, 500, and 800 m (Antarctic Intermediate Water, AAIW), 1000 m (Upper Antarctic Circumpolar Water, UCPW), 1200 and 1500 m (Upper North Atlantic Deep Water, UNADW), 2000, 2500, and 3000 m (Middle North Atlantic Deep Water, MNADW), 3500 m (Lower North Atlantic Deep Water, LNADW), 4000 m, and at the near bottom level (Antarctic Bottom Water, AABW).

No salinity analysis was performed on board the ship due to the instability of the onboard Beckman-RS10 salinometer, which was revealed during the cruise. We collected 520 samples of seawater for the subsequent onshore laboratory salinity determinations. The amount of dissolved oxygen was determined by the Winkler method modified at the Shirshov Institute of Oceanology. The concentration of silicates was determined with the KFK-3 set (serial no. 9 201 420). The photoelectric colorimeter KFK-3 was calibrated and tested before the cruise at the *ZOMZ* Zagorsk optical–mechanical factory (a customer's copy of the calibration certificate no. 523 was issued on June 5, 2000). Collection of aerosols was made using the "sail" method.

The measurements of the current velocities in the upper 600-m layer were carried out using the onboard RD-VM0075 Doppler acoustic profiler manufactured by the RDI company (United States). Two calibrations of the ADCP were carried out in order to evaluate the errors of velocity measurements related to the technological defects of installing the acoustic antennas of the profiler at the bottom of the ship and to compare the accuracy of the measurements of the absolute profiles of velocity calculated in the bottom tracking regime with the navigation data.

The Coulter counter and onboard filtering device of the MILLIPORE company were used to determine the volume concentration of suspension in seawater.

Preliminary Scientific Results

(1) An upwelling of the Antarctic Intermediate Water (AAIW) was found in the western part of the section between 42° and 45° W. A characteristic domelike distribution of the salinity contour lines is observed here from the levels of 700–800 m to the levels of

250–300 m. This confirms the theoretical result obtained in [6]. This is an important climatological factor because the AAIW represents one of the components of the upper limb of the GMCC, precisely because of its so-called cool part, which compensates for the lack of freshwater in the North Atlantic. It is mainly formed in the Pacific sector and due to the upwelling is entrained into the warm layers of the GMCC, which spread into the Atlantic from the Indian Ocean.

(2) Significant cooling in the bottom layer of the Antarctic Bottom Water (AABW) in the western basin was found. The temperature of the bottom layer decreased by approximately 0.1°C as compared to 1993. In the depth range between 4000–4500 m, an increase of temperature by 0.2–0.3°C is observed. According to [1], the cooling in the near-bottom layer over the section has been observed since at least 1957. The authors of this study also noticed a warming in the intermediate waters and in the upper part of the deep waters, which occurred from 1957 to 1993. A similar result is obtained at 24° N [3]. Thus, a long-term trend of decreasing in the near-bottom water temperature and increasing in the temperature in the intermediate waters exists in the entire tropical part of the North Atlantic.

(3) A comparison was made between the currents in the upper layer measured in the western part of the section using ADCP with the calculated geostrophic currents. A similarity between both the structure and the velocities of the measured and calculated currents was found. The location of the cores of the equatorial currents coincides well with the previous measurements in this region [5].

(4) The distribution of the volume concentration of suspension over the section displayed the main features of the structure and dynamics in the Equatorial Atlantic: the Deep Western Boundary Current, the Guinea Upwelling, and the cores of the Antarctic Bottom Water. Thus, the determination of suspended matter provides an important supplementary parameter in the multidisciplinary study of the structure and dynamics of water masses.

(5) We started the compilation of national high-accuracy data sets on the climatic variability in the equatorial Atlantic including the values of temperature, salinity, oxygen, silicates, volume concentration of suspension, velocity in the upper layer, and accompanying meteorological observations.

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