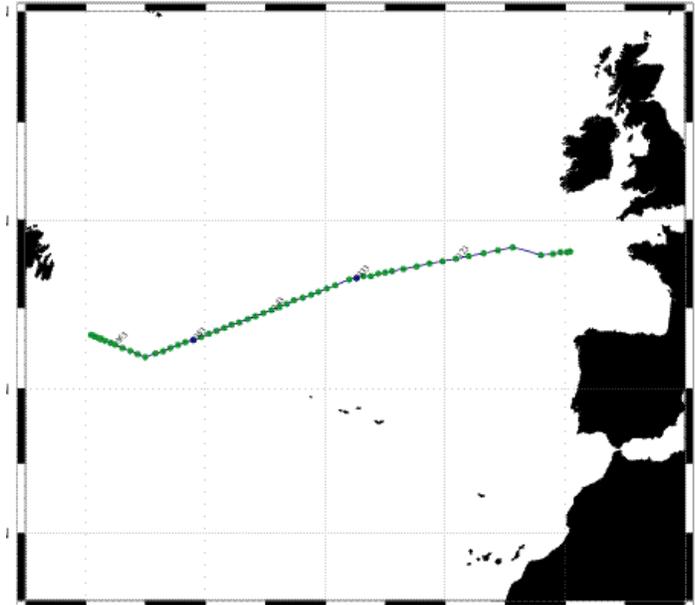


WOCE Line **AR19**  
Expocode **90AV15\_1**  
Chief Scientist **S. M. Shapovalov/RAS\***

Ship R/V Akademik Sergei Vavilov  
Region North Atlantic

Ports of call Kaliningrad, Hamburg  
(Germany), Halifax (Canada)



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### **Cruise 15 of R/V Akademik Sergei Vavilov in the North Atlantic under the Auspices of the WOCE International Program**

S. M. Shapovalov\*, A. V. Sokov\*, and S. A. Dobrolyubov"

\*Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia

\*\*Geographical Department, Moscow State University, Moscow, Russia

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### **SCIENTIFIC PROGRAM AND PRIME OBJECTIVES OF THE EXPEDITION**

Cruise 15 of R/V Akademik Sergei Vavilov was carried out in accordance with the prior plan of action for 1999 envisaged by the "World Ocean" Federal Program affirmed by the Russian Government on August 10, 1998 (resolution no. 919) in the framework of the list "Critical Technology of the State Level" affirmed by the Governmental Commission on Scientific-Technological Policy on July 21, 1996, and the Program of the Department of Oceanology, Physics of Atmosphere, and Geography of the Russian Academy of Sciences.

The scientific program of oceanological investigations during cruise 15 of R/V Akademik Sergei Vavilov included research into the following areas:

- Distinguishable features of the interaction between the subpolar and subtropical gyres in the North Atlantic.
- Estimating the natural seasonal and low-frequency variability of the thermochaline water structure of the subpolar gyre in the North Atlantic including its deep-sea part.
- Studying the spatial structure of the northern and western deep-sea boundary currents near the eastern and western continental shelves in the North Atlantic,
- Estimating the heat and salt exchange rate between the subpolar and subtropical gyres in the North Atlantic.

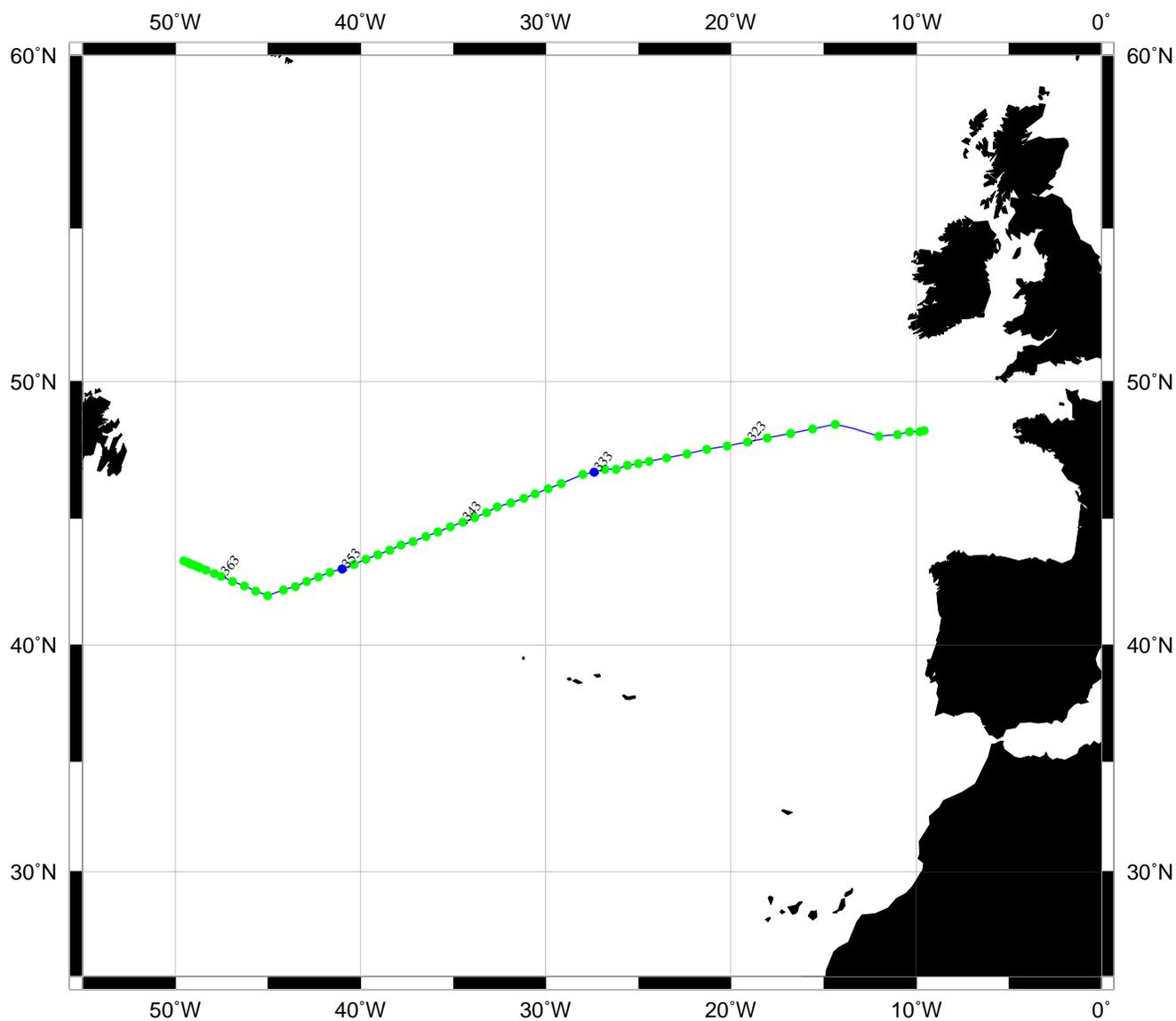
### **FINANCIAL SUPPORT FOR THE EXPEDITION**

The major financial source for the expedition was provided by the Ministry of Science and Technologies of the Russian Federation for carrying out the prior action envisaged by the program "Investigation of World Ocean Nature." 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 framework of the subprogram "Multidisciplinary Investigations of Oceans and Seas, Arctic and Antarctic Regions" of the "Investigations and Developments on Priority Lines of Development of Civil Sciences and Technologies" Federal Purposive Scientific-Technological Program, direct financial support of the expeditions of the Russian Academy of Sciences, and INTAS-RFBR 95-0972 grant.

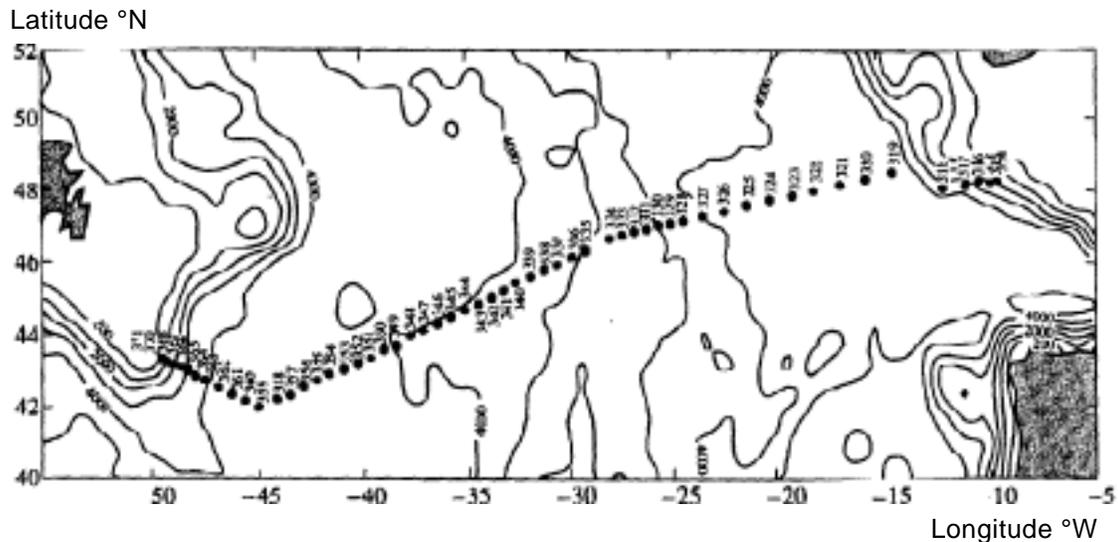
### **ROUTE OF THE EXPEDITION**

The expedition began on October 13, 1999. The ship put out from Kaliningrad on October 15 and called at the port of Hamburg (Germany), where scientific equipment and a cable-rope for STD probes were loaded. On October 19, the ship left Hamburg and on October 23, it reached the observation field. The location of the section planned corresponded to the standard section of WOCE A02 (the figure). The coordinates of the initial and end points of the section were 48°16' N, 09°34' W and 43°23' N, 49°32' W, respectively. The last station of the section was performed on October 7. On October 9 the ship called at the port of Halifax, where the equipment obtained in Hamburg was unloaded and sent to Germany in a container. The scientific team of the expedition, which consisted of 14 scientists from the Shirshov Institute of Oceanology, Moscow State University, and All-Russia Scientific-Research Institute for Marine Fisheries and Oceanography, left the ship for Moscow on November 10.

## Station Locations for AR19: Shapovalov, 1999



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Location of the hydrological stations in section A02 (according to The WOCE notation) performed in October-November 1999 in cruise 15 of RV Akademik Sersei Vavilov.

## METHODS AND MEANS FOR MEASUREMENTS AND DATA PROCESSING

The vertical distributions of temperature and salinity were observed with the use of an oceanographic MarkIII/CTD probe supplied with an Intelligent Rosette Sampling System developed by General Oceanics with 24 Niskin bottle samplers 2.5 L in volume.

The offboard unit was provided with an altimeter (BENTHOS 2110 Altimeter) designed for determining the location of the set with respect to the bottom. The signals from the altimeter were transmitted to the onboard computer in the real time mode, which provided the measurements in the vicinity of the bottom.

The equipment for the deep-water hydrological operations was placed at the expedition's disposal by the Federal Department of Marine Navigation and Hydrography (Bundesamt für Seeschifffahrt und Hydrographie- BSH, Hamburg, Germany) under the auspices of the Russian Foundation for Basic Research-INTAS joint grant no. 95/0972.

The salinity analysis in the water samples was performed on board the ship with the use of a Guideline. AUTOSAL 8400 salinometer. The amount of dissolved oxygen was determined by the Winkler method modified at the Shirshov Institute of Oceanology, RAS. The concentration of silicates, phosphates, and nitrites was determined with the KFK set. Silicates were determined by the Korolev method. Phosphates were determined by the Morphy-Riley method modified by Sugawara, and nitrites were determined by the Bendschneider-Robinsonson method.

## **EXTENT OF THE WORK**

In total, 58 deep-sea hydrological stations were carried out. Among them, 21 stations were carried out in the eastern basin and 37 stations were performed in the western one. The following observations were performed at each deep-sea hydrological station.

- Recording the vertical distributions of temperature, electric conductivity, and content of dissolved oxygen.
- Sampling water at several levels for the subsequent laboratory determination of salinity, dissolved oxygen, silicates, and phosphates.
- Measurement of air temperature, velocity, and wind direction, as well as observations of the sea surface condition.

## **PRELIMINARY SCIENTIFIC RESULTS**

To reveal the climatic variability of the thermohaline water structure, the expeditionary data were compared with the data obtained in this section by German oceanologists during 1993-1998 and placed by them at our disposal during our visit to Hamburg. To estimate the intensity of mass, heat, and salt transfer across the plane of the section, we used the method described in [1]. As a reference surface, we used the isopycnal  $\sigma_{\theta} = 2000$ , and the total flow was presented as a superposition of geostrophic, Ekman's, and barotropic (determined from the Sverdrup relationship) currents. The integral mass transfer across the section plane by each of the components was assumed to be zero (the location of the reference isopycnal surface varied depending on this condition).

**The major conclusions made on the basis of the data analysis are the following.**

1. The climatic change of the characteristics of the Labrador water mass (LWM) core in the North Atlantic is found to be proceeding. In the Western Basin, from 1993 to 1996, a sharp drop of the LWM temperature has been observed without significant variations in salinity. Since 1996, the temperature and salinity of the LWM have been increasing. From 1996 to 1999, the temperature and salinity has increased on average by  $0.1^{\circ}\text{C}$  and  $0.02\text{‰}$ , respectively. This process is an isopycnic one. In the Eastern Basin, the general tendency of variability of the LWM characteristics is the same. The temperature of the LWM core, however, had begun to increase here only since 1998, and salinity variations are less important.
2. The time of propagation of the LWM from the source up to  $48^{\circ}\text{N}$  was determined on the basis of the known heating and salinating characteristics of the LWM in the Labrador Sea since 1994 [3]. For the region of the western deep-sea boundary current (WDBC) and the eastern slope of the Mid-Atlantic Ridge, this interval is two and four years, respectively. These values precisely correspond to the travelling velocities of the climatic signal in the LSW layer calculated previously within the frames of the project.

3. Stable desalination and cooling of the deep-water layer occurred in the Western Basin of the Northern Atlantic along 48°N from 1993 to 1999. This is best pronounced in the Northeastern deep-sea water mass (NWDM) layer entering the Western Basin through the Charlie-Gibbs Fracture Zone. The cooling of the core of NWDM reaches 0.3°C in the WDBC and 0.2°C near the western slope of the Mid-Atlantic Ridge. The corresponding values of desalination are 0.015 and 0.01‰. The desalination and cooling of the deep-sea water are slightly less pronounced in the Northwestern deep-sea water mass, the source for which is the intermediate water of Arctic origin entering the North Atlantic through the Denmark Strait threshold.
4. In comparison with 1997-1998, marked changes in T,S characteristics of the Mediterranean water is found in the eastern basin of the North Atlantic. The temperature and salinity of the core east of the Mid-Atlantic Ridge have increased by 0.5°C and 0.15‰, respectively. One of the possible reasons is the reduction of the northward transport of Mediterranean water due to the reconstruction of the circulation in mid-latitudes.
5. Calculations of the mass and heat transfer across the plane of the zonal section for the principal water masses show that the maximum intensification of the meridional thermohaline circulation occurs in 1999 in comparison with previous years: the southward deep sea water flow and the northward heat flux were more intensive than their mean climatic values by 20%. Thus, the heat flux in the autumn of 1999 achieved 0.75 PW, which is by 0.12-0.15 PW greater than the mean value.

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