

Oceanology Crossing the Atlantic on the Akademik Ioffe

Text and photos
by Svetlana Murashkina, PhD in Geography

“The subject of oceanology is the study and research of the totality of events taking place in oceans, seas and lakes,” wrote geographer, academician and founder of Russian oceanology, Juli Shokalskiy, in 1917. Oceanology, or oceanography¹ as it is more commonly called in the West, is an integral part of natural sciences. The ratio of water to land on the planet Earth is approximately 71 to 29 percent. Furthermore, water surface is not only greater in square kilometres, but it is also continuous—whereas, land surface is finite and presented by separate parts washed over by the world’s oceans. So, in essence, oceanography studies this one continuous body of water, the World Ocean!

By this point in history, nobody had yet taken the responsibility of determining the validity of oceanography as a science. Historically, if not considering Moses from the Bible to be the first oceanographer (as he parted the Red Sea, allowing his people to escape their pursuers at the right

moment)², exploration of the oceans was conducted by “Homo Curious”—from the very first people to venture out into the open sea up to the great explorers of the Imperial Age.

The exploration of the oceans occurred in parallel with the development of other sciences, cartography in particular. Every new heroic expedition acquired new data, descriptive at first (as in the early period of the great geographic discoveries) rather than numerical, such as depth measurements and ocean bottom relief views, grounds, temperatures, salinity, transparency and colour of oceanic water as well as direction and velocity of oceanic currents.

British expeditions led by James Cook in the late 18th century were considered to be the first scientific voyages. Three journeys taken by Cook, aimed at finding the southern continent, enriched the era’s geographical knowledge greatly, both directly and marginally. On one hand, new lands were discovered (the eastern shores of New Zealand and eastern Australia), geographic maps were created, detailed reports were made and oceanographic data collected on the physical features of oceans and water movements.

On the other hand, the expeditions served as a challenging push for further expeditions. During the first voyage, for instance, no traces of an expected polar continent in the moderate latitudes of the Pacific Ocean were found. As a result, new French expeditions were sent there.



Crew members and research staff at work on bow of the *Akademik Ioffe*



Portrait of Captain James Cook RN 1782, by John Webber. Collection: National Portrait Gallery, Canberra, Australia. Purchased in 2000 by the Commonwealth Government with the generous assistance of Robert Oatley and John Schaeffer

Great Britain was the first to estimate the importance and dominant position of the sea, including its scientific significance. The idea was actively accepted by France and also Russia from the beginning of the 19th century. After Cook's enterprises and until 1872, there were 29 expeditions undertaken around the globe, 11 of which were British and eight Russian. All in all, the number of scientific marine expeditions during that period amounted to 75.

The first round-the-globe trip by Russian sailors was made on board the ships *Nadezhda* and *Neva* in 1803-1806 under the leadership of Lieutenant Captain Ivan Kruzenshtern. The expedition ships

Crossing the Atlantic

parted company after rounding Cape Horn. *Nadezhda* turned to Kamchatka to explore Okhotskoe and the Japanese seas, and *Neva*, lead by Captain-lieutenant Juri Lisianski went to the Northern Pacific and to Alaska. The ships met up later and returned back around the Cape of Good Hope.

During that three-year journey, depth temperatures were measured as well as the first observations of vertical ranges at ocean depths made. Geographic discoveries in high Southern latitudes were accomplished within the Pacific archipelagos.

In 1819-1821, the Russian Marine Department organized the first Russian Antarctic expedition on board the military boats *Vostok* and *Mirnyi* under the general

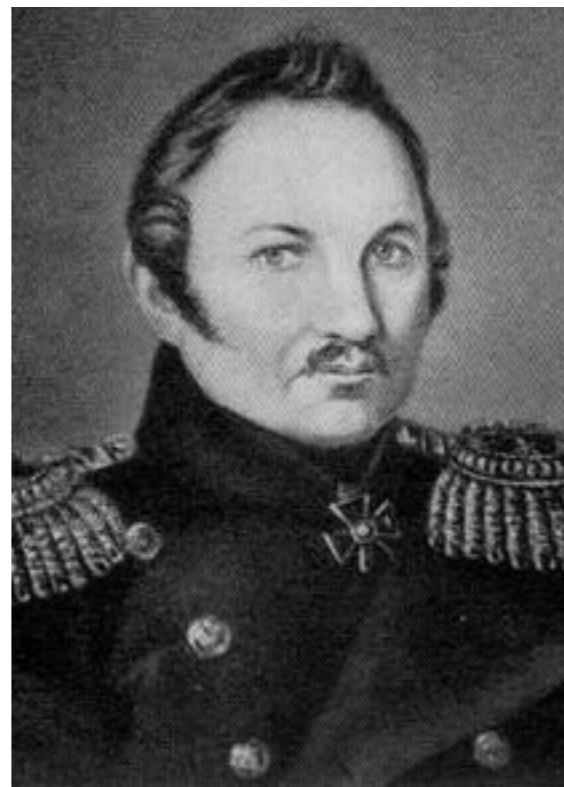
leadership of Captain 2nd rank Faddey Bellingsgauzen (Fabian Gottlieb von Bellingshausen who later rose to admiral). *Mirnyi* was captained by Michael Lazarev.

Their journey reached 69 degrees of Southern latitude when they discovered lands lying to the East of Cape Horn and made remarkable descriptions of geophysical aspects of the Southern Polar province.

The British round-the-globe oceanographic expedition of the *Challenger* (1872 -1876) was a key event in the development of oceanography. The expedition had vast aims: to study the ocean bottom landscapes and relief as

well as observe physical, chemical and biological features on the surface and at depth. The composition of officers was selected with respect to the oceanographic research-oriented character of the expedition. Detailed "field" tasks were prepared, special devices were invented and designed, and laboratories were constructed.

The Naval wooden corvette *Challenger*, having clocked 68,900 sea miles, made 362 deep stations and determination at every point of depth and grounds. Bottom water samples were taken and temperature measured



Faddy Bellingsgauzen, 1778-1852 (Fabian Gottlieb von Bellingshausen)

on the bottom and at different depths. Surface currents were observed as well as some underwater currents. Meteorological observations were made every hour.

Challenger's accumulated data and reports (50 volumes!) appeared to be a special epoch in the development of oceanography. With *Challenger* came the understanding of the neces-

sity of planned explorations. Since then, oceanographic studies have been part of obligatory programs for nearly every marine venue enterprise.

It is evident that a revolutionary change in the very approach to ocean science and to data collection has taken place during the last 100 years. This change is a transition from data collection by separate expeditions to global systematization of data collection and management of rational collection strategy.

The appearance of new technology—distant satellite research, computer processing of giant data files, new high precision measuring devices—all these provided the possibility of a qualitative jump in the 1960s, from a view of the ocean as an environment with features slowly changing in time and space to an understanding of the fact that in the ocean there exist lots of comparatively narrow zones with sharply changing parameters, oceanic fronts

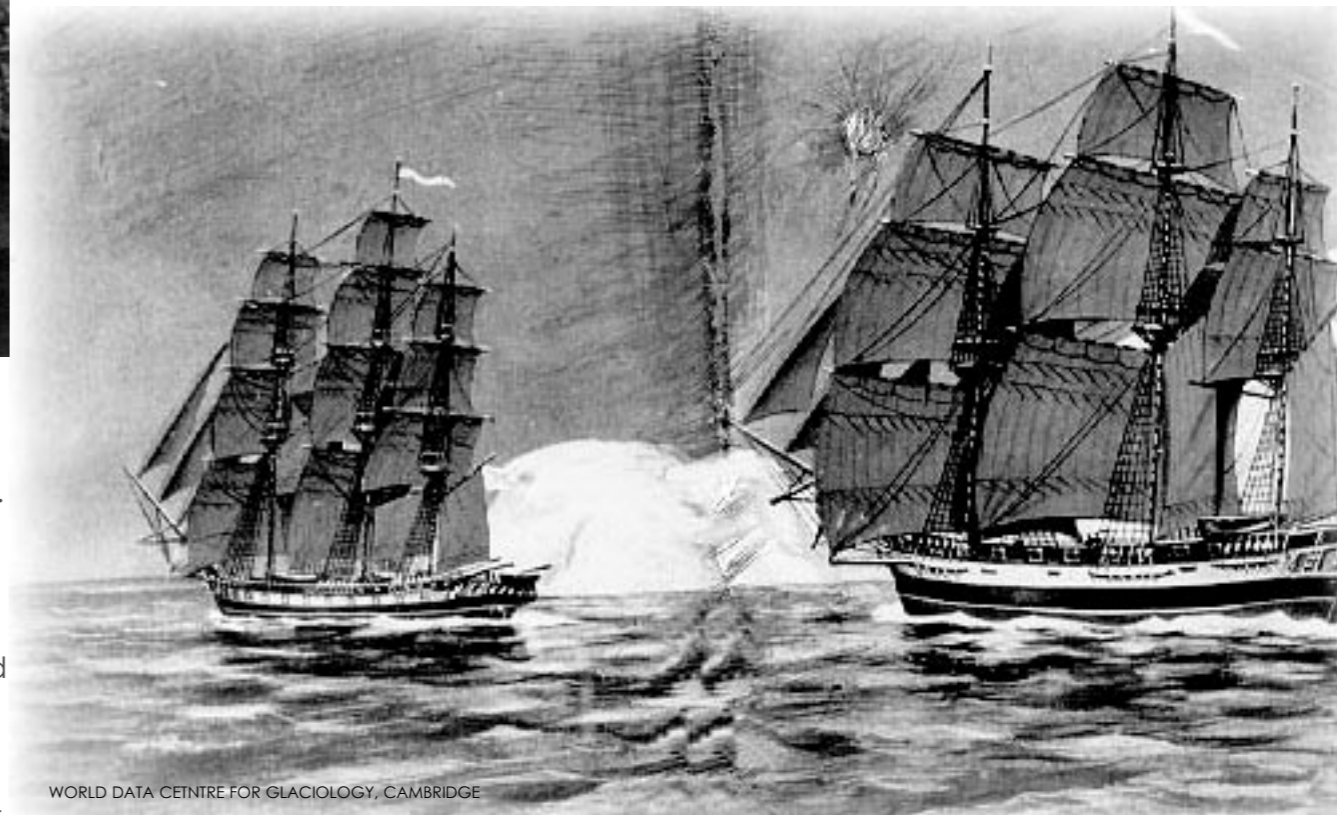


HMS Challenger, 1872. By William A. Herdman. Courtesy of the Freshwater and Marine Image Bank

many kilometres wide whirling like atmospheric cyclones and anticyclones, which appear all the time—they appear, move and disappear. We now know that a so-called "thin structure" exists, which are steady layers of water having vertical dimensions of several meters and horizontal dimensions of several kilometres.

Modern exploration of oceans

It is true that nowadays research vessels sailing under various flags are steadily tracing the World Ocean, from the



Vostok (East) and Mirnyi (Peaceful), 1819-1821

WORLD DATA CENTRE FOR GLACIOLOGY, CAMBRIDGE



ABOVE: The churning Atlantic
RIGHT: Hoisting the carousel
aboard

Equator to the Arctic and the Antarctic. There are nearly no "white spots", or unexplored areas on the map of our planet.

But in the abyss, strikingly blue or iron-grey, there are lots of them. Moreover, all the processes taking place within the oceans are still not an open book for scientists at all.

Modern research is differentiated

and multi-directional with sometimes fundamental and, at other times, applied importance.

First of all, there is the problem of climate and its variability.

Knowledge of the nature of climate

and the ability to forecast weather gives us the possibility to make sound decisions in the choices of prospective methods of development that are harmonious with the environment. Trade forecasts are



parameters. It is during the sea journey that one can touch "live" the main hydrological parameters that characterize sea water such as salinity, temperature and pressure—the so-called CTD parameters. They are some of the main topics of interest in physical oceanography. (See Block 1).

Cast off!

It is the summer of 2005, and I am heading out across the northern Atlantic Ocean on board



ABOVE & INSETS: Sounding devices

also very important with regard to economic concerns as well as space and defence issues.

During research voyages, studies are made from the deck of the ship by remote methods. The practice of expedition study includes current velocity measurements, observation of light regimes and biotic factors of environment as well as measurements of hydro-chemical

the Russian research vessel, *Akademik Ioffe* (Block 2), which can not, of course, be compared with the *National* expedition that took this route in 1889³. It is practically regular now, this short scientific cruise. Russian oceanographers are completing it for the fifth time. The last three times took place annually, which

Atlantic Ocean⁴.

The planned duration of this journey is a little less than three weeks. That much time is needed to head out of port from Gdansk, Poland, journey across the Baltic Sea, put out to the North Sea via the straits of Kattegat and Skagerrak around Denmark, reach 60 degrees northern latitude and cross the Northern Atlantic, record the oceanographic section from the Faroe Islands to Greenland, and then, turn to the south to reach Newfoundland.

Now out to sea, I see that the Gdansk port cranes disap-



LEFT: The windmills of Denmark
INSET: The port of Copenhagen

Denmark

A day in the life of Ioffe
When the ship reaches 60 degrees latitude, work in the open sea begins. The scientific crew now labours in permanent round-the-clock shifts, and the chief of the expedition becomes

the main director on board (after the captain, of course). The chief scientist is the person responsible for deciding whether to continue working or miss intermediate stations under severe weather and sea conditions. The target: to collect data until we get to the very end of this ocean section. It may sound a bit dramatic, but obtained data—input of this expedition and the whole Russian national oceanographic science community—goes to the international cooperation and research effort. The ship sails along a marked course and makes stops at points where deep measurements are planned. These are stops for hydrological stations with CTD-



to Canada



In Russia, scientists play different roles at the same time—they are researchers, managers, providers, etc.. In foreign countries, it is not the same. Special managers are responsible for the technical provisions of the project and equipment. In Russia, all responsibilities are carried out by the chief of the expedition and the chiefs of various departments. Transportation of all the loads on board, winding of new rope

peared from sight long ago, as well as the Danish wind mills producing electricity—the symbol of modern Denmark. The huge hull of our white ship breaks waves under the sunny blue skies of summer upon the North Sea. I see the stoic silhouette of the captain's bridge and steering deck-cabin where one can take in a grand

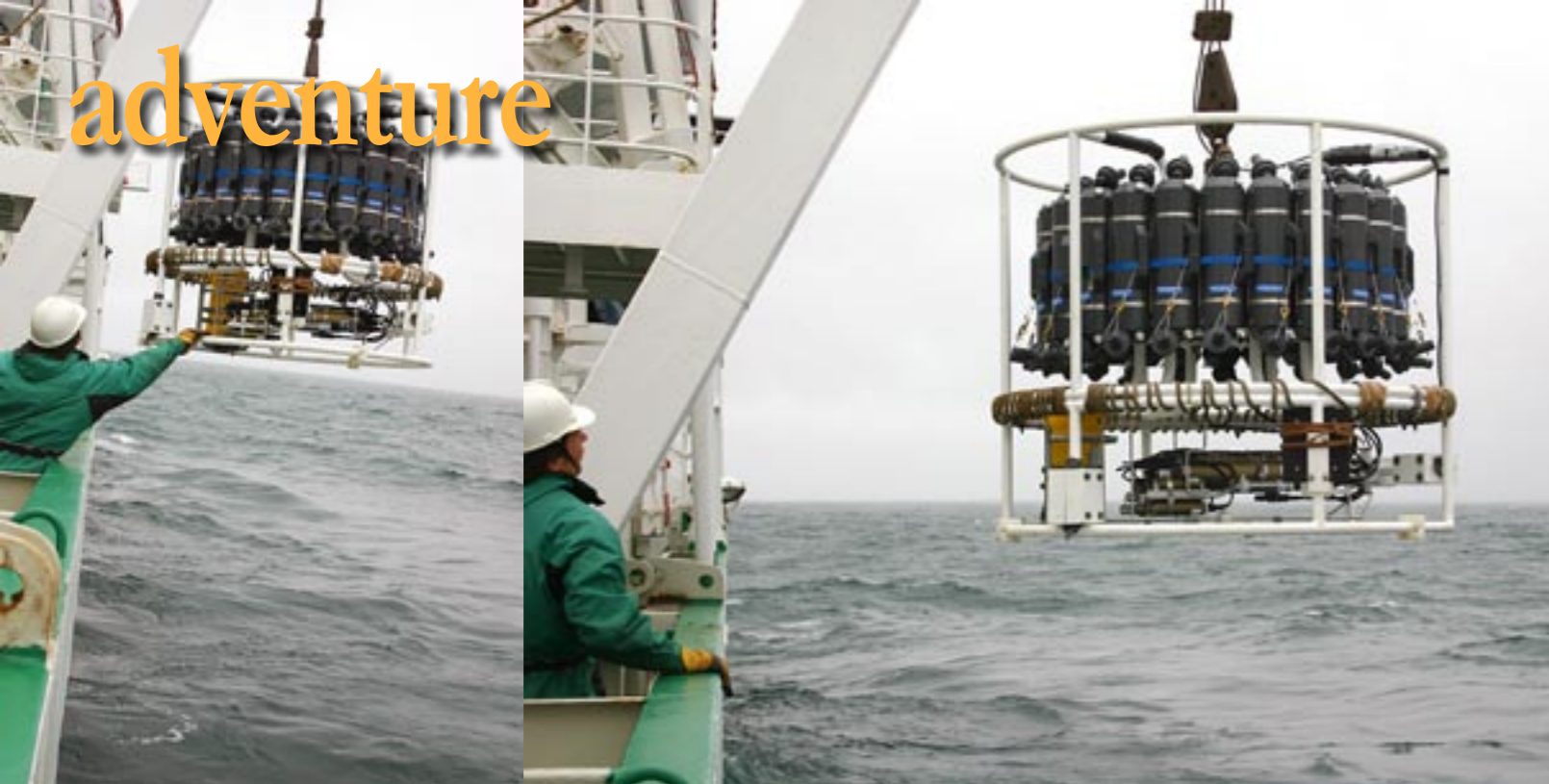
view of all the space out to the very horizon, a forest of antennas on the upper deck and the navigator deck... Everything looks reliable and instills a sense of confidence.

But excitement is still palpable on deck. Anticipation is an essential component of the sailor's profession. And research always has a lot to consider.

to the operational winch, set-up of the research camp including unpacking and checking high-precision devices, preparation of work places, reliable fastening of computers and other devices onto tables —nobody can rule out roughness at sea. Vira slow!



Arriving in St. Jones, Newfoundland



THIS PAGE: Carousel deployment

Crossing the Atlantic

extremely careful, even knowing that the ship is above a plain (lower terrain) and not above the Reykianess Range (oceanic ridge), for example.

...400 meters to the bottom... 200 meters to the bottom... "Winch, half... hundred meters to the bottom... Maina dead slow, 50 meters to the bottom, winch to stop! ...Winch here—stop."

The signal to close the "deepest" bottle is sent by a simple movement of the computer mouse. Then, a smooth ascent begins with stops at previously planned depth values. Bottles, one by one, are forced to close after being filled with ocean water. Stops occur on levels that correspond with various water masses in order to get a uniform picture of samples along all

water thicknesses and to determine the position of the nucleus of each water mass and the frontiers between them.

The next exciting moment is the

the deck. Hydro-chemists hurry to take necessary quantities of deep ocean water for laboratory tests.

The station is done, and the captain's bridge receives the order to continue moving ahead. The ship steadily increases its speed, and we move onward to the next planned station.

During this cruise, oceanographic section as long as 1,164 sea miles was completed. Complex measurements of sea water parameters from the surface to the bottom of the ocean were made at



Gathering ocean water for investigation

instant when the carousel shows itself! The winch is ordered, "Vira slow!" The sonde is pulled overboard by the hook, and the men carefully hoist the device onto

40 points. At these stations, meteorological observations were made and gigabytes of information about acoustic features of the bottom were registered. The

sensing ability (determining vertical profiles of electrical conductivity, temperature and depth) and water sampling (See Block 3).

Current ship time is 16:41:01, which means GMT (Greenwich) is 18:41:01. *Akademik Ioffe* slowly but steadily reaches the position of the planned stop for station #1152 (#36 according our section schedule), and the level of "scientific" activity on board increases dramatically.

Coordinates of this ocean section are 59 degrees 50 minutes Northern Latitude and 39 degrees 20 minutes Western Longitude. Supposed depth is 2,840 meters. Supposed duration of labour at this station is 2 hours 10 minutes.

The ship slows down. A monitor showing the parameters of our movement reveals steadily decreasing speed: 6.7 knots.... 5.6..... 1.6. One knot really means that the ship has come to a "stop". We have reached the station position, but the engines must continue to work. The captain cannot stop the engines completely under such rough conditions.

The water temperature is 9.6°C.

Air temperature is 7.3°C. The deck is wet, splashed by the salty sea.

A complex device nicknamed "carousel" is prepared for deployment. Ropes that secure it on board are undone. The winch is readied. "Vira!"—Upwards!

The rosette of devices, guided carefully by strong men's hands, loses contact with the deck and moves forward above the gunwale and over board to hang above the water. Now, the trick is to catch the next wave. This construction weighs 200 kg, but in the water, it achieves amazing buoyancy, so one must be extremely careful. Done. Slowly giving the rope to the winch, the carousel, looking like a turquoise jelly-fish, descends... disappearing from sight.

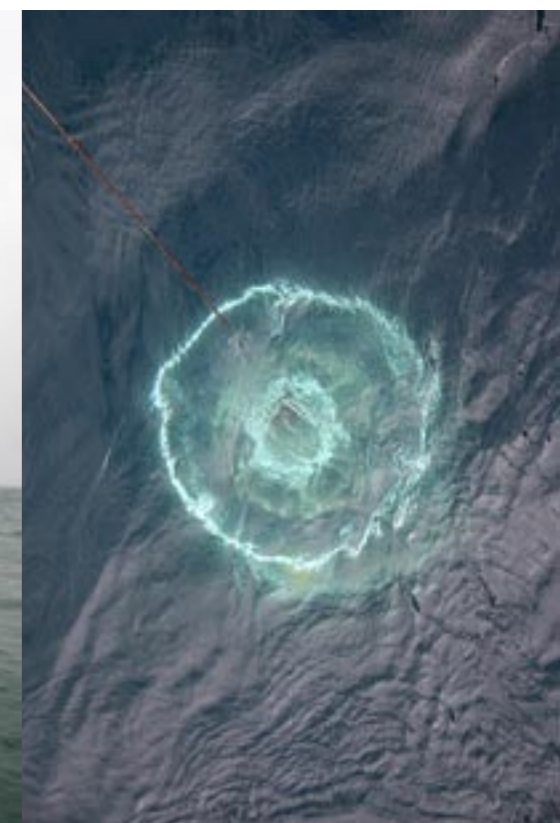
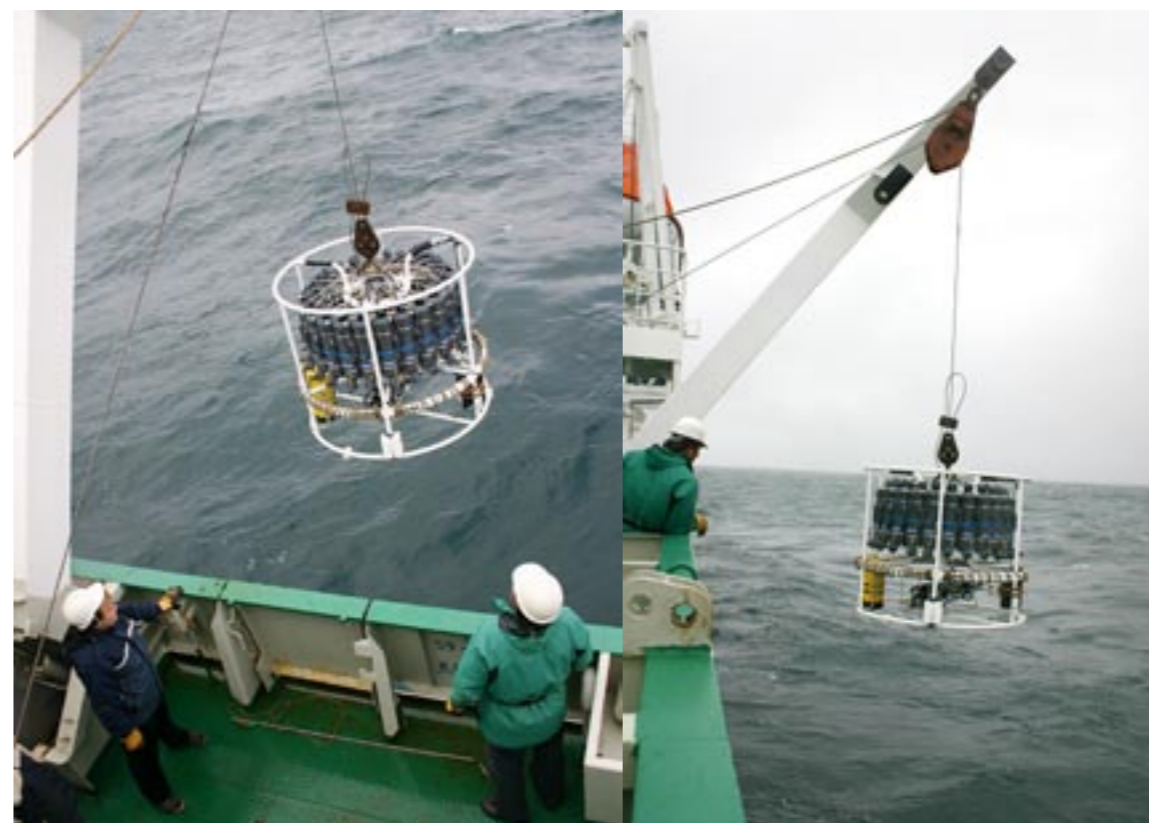
When deploying and raising up the sonde, it is very important that the process be very smooth, without jerking and bumping the deck, since it is upon these factors that the future fate of the rope, devices and cruise results depend.

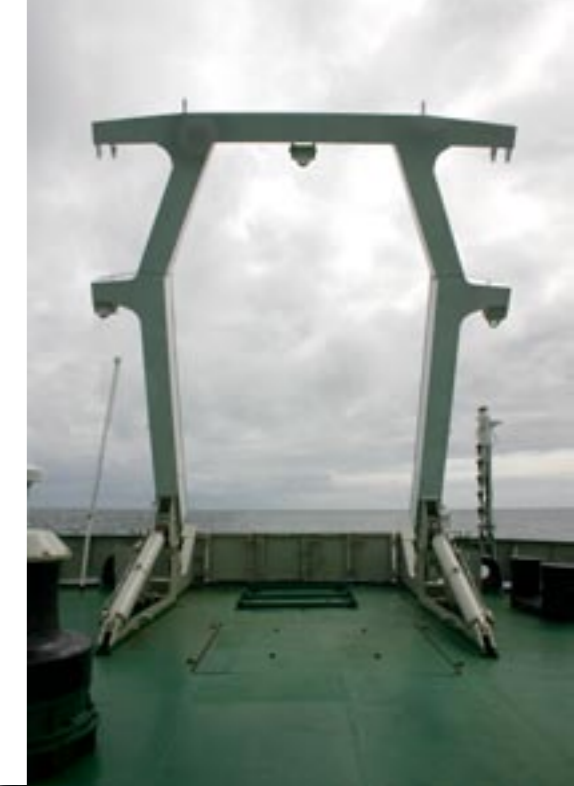
In order to measure currents precisely, the rope with the devices, which reaches depths

up to 3,000 meters, must be kept in a vertical position. This can be achieved only by the fine work of the navigator, especially with the wind velocity equalling 20 meters per second and swells as high as 6-8 meters while the ship moves in a direction opposite the wind.

At this time, any unfastened objects on the ship tend to float freely in space, so wet table clothes are placed on the tables in the saloon to avoid the "running away" of plates and covers. But the deck hands continue to work.

The men on duty watching corresponding data on a monitor screen, guide the winch-men: "Winch, 1,000 m passed... Continue to descend... Continue to descend." The ship goes up and down on the waves. Velocity is 1 knot, winds are 15.8 m/sec. The monitor shows the line of the rope with sonde deployment. The two kilometre mark is passed. "Winch, 500 meters to the bottom. Maina slow!". One must be





Researchers working in labs and on deck

data will be processed later when we return home.

Everything was okay. No extraordinary situations arose. Greenland glaciers appeared in the fog, and *Akademik Ioffe* turned to south towards St. Jones. Sometimes, to the left and to the right of the deck, little fountains appeared. Then humped backs appeared—whales were passing by heading in their own direction.

We met no ships coming or going—60 degree latitude is not the most popular route. It was just us and the ocean, which changed its colour from bright silver to mysterious blue. And the people on board were still not yet tired of looking into the very depths of the ocean. They are true romantics of oceanography who dreamt of sea journeys since their college days and consider scientific data obtained on these journeys to be more precious than publication in a foreign magazine or academic status.

International cooperation

Alex Sokov is the deputy director of the P.P. Shirshov Institute of Oceanology of the Russian Academy of Science and principal investigator of the Russian interdepartmental project "Meridian-Plus" of the Federal special program "World Ocean". Russian oceanographic research lies within the sphere of interests of international programs led under the patronage of the IOC UNESCO (International Oceanographic

Commission), the WMO (World Meteorological Organization) and other intergovernmental organizations.

The North Atlantic research cruise is a good example of Russian participation in international research. Indeed, the North Atlantic is the very place that hosts one of the world's main regions for intensive energy exchange between ocean and atmosphere, which determines the moderate climate of Western Europe and the climate of the European part of Russia.

It is also here, where the Atlantic branch of the so-called "global convective circulation of the World Ocean" locks—turning from a northerly to southerly direction and heading downward. This circulation is similar to the ocean conveyor belt on the planetary scale, which transfers giant volumes of water masses between high and low latitudes of the main oceans—the Pacific, Indian and Atlantic.

The fact that European climate is determined by the character of energy exchange between ocean and atmosphere in the Northern Atlantic and the intensity of the conveyor belt at work has been known for several decades already, but many important details of this connection still need more quantitative specifications.

One of the problems that needs to be settled for the forecasting of climatic changes is: What factors cause fluctuations in the intensity of the con-

veyor belt activity within ten-year periods, and what atmospheric processes are "reliable" for that fluctuation? The



The P-Frame, a lifting device on the stern

of thousands of US dollars. To satisfy these costs, people in the Russian Institute of Oceanology, with the support of the Ministry for Economy of the Russian Federation, created and brought to life a successful pattern of partial funding of research cruises using recruited funds from tourist

answers to these questions are very important just now when, during the past decade, unprecedented warming of the North Atlantic and Arctic Oceans have been observed.

That's why transatlantic cruises are so important. They are the Russian contribution to international programs such as CLIVAR (Climate Variability), NORDIC WOCE (North Ocean Circulation Experiment) and ASOF (Arctic Sub Arctic Ocean Fluxes). Not every state can afford to conduct full-scale oceanographic research on independent cruises. A full day's work on one of the ships belonging to the Institute of Oceanology, such as the *Akademik Ioffe* or *Akademik Mstislav Keldysh*, costs several tens

companies.

The results of every independently accomplished expedition enrich Russian science not only directly through research procedures and data obtained, but also indirectly. By contributing its input into international cooperation, Russia possesses equal rights to use the results obtained by other countries that accomplish programs within the framework of international projects—and that is necessary for acquiring an integral picture of the world.

Heading for the Antarctic

Measurements in the World Ocean are not limited by sounding from our ship's board. Data obtained during the



The *Akademik Ioffe*

Crossing the Atlantic

now being finished.

In particular, it was found that increasing temperatures of the Atlantic Layer in the Arctic ocean, which have been observed since the early to mid-1990's up to the present, did not take place uniformly, but occurred with arrivals to the Arctic Basin, from time to time, of anomalous warm "spots" of Atlantic origin. ■

the Arctic Basin, play a major role in forming global climate. Furthermore, these regions are very sensitive to fluctuations and possible climatic changes.

Acoustic thermometry is a method of remote observation of large-scale variation of temperature in the ocean. The method of acoustic thermometry of the ocean is based upon the almost linear dependence of the speed of sound underwater upon temperature. The system includes a fixed source (acoustic transmitter) and a receiver (array) in the ocean.

The first Arctic acoustic thermometry experiment took place in April 1994. Due to the efforts of the employers of several research bodies of the Russian Academy of Science, ice camp Turpan was established 300 km north of Spitsbergen. During the whole month, powerful Russian acoustic transmitters sent signals at 20 Hz across the entire Arctic Ocean to receiving arrays located at ice camp Narwhal in the Lincoln Sea and ice camp SIMI in the Beaufort Sea, covering distances of 2,100 and 1,200 km.

It became possible to measure, with great precision, the main parameters of the signals describing features of ocean water and sea ice cover. Acoustic monitoring in the Arctic was regarded as worthwhile by administrators, and in October 1998, within the frames of first-hand actions of the Russian Federal special program, "The World Ocean", a new and autonomous acoustic source was deployed by the Russian team at the sea bottom close to the shelf border northwest of the Franz-Joseph Land archipelago. This source, together with an American autonomous receiving array, worked nearly one and a half years. The processing of the enormous amount of data received from the device is only

North Atlantic cruise of the research vessel *Akademik Ioffe* is being processed. Meanwhile, the other ship of the Institute of Oceanology, *Akademik Sergey Vavilov*, went out in October 2005 to complete the next cruise along another route: Kaliningrad (Russia) – Cape Town (SAR) – Antarctica – Ushuaia (Argentina). The Chief of Expedition was Dr Sergey Gladyshev, Russian coordinator of the international experiment researching the South Ocean for which such countries as Russia, France, Germany, SAR and USA participated and placed their research programs on board.

During this expedition and in addition to complex oceanographic measurements taken by the research staff,

two autonomous floating buoys were launched supplied with navigational instruments and CTD sensors. The buoys are to float for the next two years in the rarely investigated region between the southern part of the Atlantic and Indian Oceans. Devices on the buoys will "shuttle" from the surface to a depth of 2,000 m and back scanning CTD parameters of water masses and transmitting the data via satellite upon surfacing. Satellite information will come to the data collection centre ashore.

After the successful launch of these two buoys, Russia gained operation of several similar devices in the World Ocean, which enables Russian scientists to use results from all the other buoys

and a half-thousand similar devices (belonging to other countries) floating in other parts of the World Ocean.

Acoustic research in the Arctic

Dr Sergey Pisarev, coordinator of the Russian-American project ATOC (Acoustic Thermometry of Ocean Climate), is a leading research scientist of the P.P. Shirshov Institute of Oceanology of the Russian Academy of Science. He said that two original systems of acoustic thermometry have worked for more than one and a half years, all in all, in the Arctic Basin—the least accessible location for traditional oceanographic "contact" measurements.

The deep regions of the Arctic Ocean,

COMMENTS

¹ In Russia, despite the fact that discussion about the application of the terms, *oceanology*, study of the ocean, and *oceanography*, description of the ocean, continues within the scientific community, both terms are used nearly equally nowadays. In foreign literature, the term *oceanography* is most often used.

² Munk, Walter. *The evolution of physical oceanography in the last hundred years*. Scripps Institution of Oceanography, La Jolla, California, USA.

³ The German expedition on board the *National*, which investigated the Northern part of the Atlantic Ocean in 1889 accomplished the journey from Northern Europe approximately along the 60th degree Northern Latitude to Greenland, and further to the south, Newfoundland, then continued on to the Bermuda Islands.

⁴ This hydrological section is assigned to Russia within the framework of the international program CLIVAR (Climate Variability). In 2005, 40 stations along 1,164 sea miles were checked. Measurements enable scientists to determine year-to-year variations of water features in the investigated region according to their thermohaline (variations of temperature and salinity) and hydrochemical parameters in the moment of sharp climate changes as well as changing of borders between separate water masses in the section by means of comparing the results with data received during previous sections in 1997, 2002, 2003, 2004.



LEFT: Carousel deployment
BELOW: Water sampling

water density, thus participating in peculiarities in the formation and movement of water masses, influencing the character, direction and intensity of currents.

Temperature

Temperature depends on the quantity of solar heat meeting the water surface, water-atmosphere heat-exchange, closeness of big ice formations and oceanic currents. Ocean water temperature is measured directly with metallic resistor thermometers and thermostats. Temperature influences the instrument error (faults, mistakes) of other sensors that have direct contact with water, which causes the necessity to introduce amendments to the results of measurements of other parameters.

Hydro-static pressure

Hydro-static pressure is needed for the determination of the depth to which measuring devices are deployed and at which other parameters are measured. At the same time, hydro-static pressure data are an inevitable part in the process of the determination of salinity and density of ocean water, sound velocity within water and some other water characteristics. The dependence between hydro-static pressure and the depth of device deployment is rather complicated, but for practical purposes, relatively simple equations connecting absolute pressure and depth are used.

Block 2. AKADEMIK IOFFE

Akademik Ioffe is one of the research vessels of the P.P. Shirshov Institute of Oceanology of the Russian Academy of Sciences (IO RAS), sister-ship of the *Akademik Sergei Vavilov* based in Kaliningrad. It was built in Finland in 1989. Velocity: 10.5 knots (max – up to 15 knots). 6,700 tons displacement. Max length is 117.1 m, width 18.2 m, 6 m set. Board height is 10 m. The vessel is autonomous regarding fuel and water for 60 days. It can host 117 passengers on board with 43 crew members. There

Crossing the Atlantic

are various weight-lifting devices on board (i.e. cranes, winches), research instruments and equipment for complex studies of the ocean: deep water, multi-radial and parameter echo-sounders, side hydro-scanner, a system of dynamic positioning, modern navigational system GPS, automatic meteorological station, acoustic Doppler current gauge (measurement device), special hydro-acoustic complex, CTD's and water sampling devices, a station of registration and processing of satellite information. There are 12 laboratories on board—their general area is 300 square meters.

Block 3. DEVICES: CTD Sondes

CTD sondes are used widely to measure CTD parameters. Nowadays, it is the main device used during expedition research cruises. At every station of the section, a measuring complex is deployed practically to the sea bottom: a carousel with 24 5l-volume bottles (these are special vessels made of a chemically pure material for water sampling from




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trimix expeditions



Block 1. CTD PARAMETERS

CTD parameters include conductivity, salinity, temperature and depth. Salinity is calculated through conductivity, and in fact, not the depth, but hydrostatic pressure is measured. Water temperature changes are usually accompanied by changes in other factors, most importantly in currents, which determine the physical features of water masses. CTD parameters serve as a basis for calculating important features of ocean water such as density, vertical stability, ductility, temperature of freezing, sound velocity and refraction of light coefficient. CTD parameters can be regarded as a signature, since they are the most independent group of parameters, different from the other environmental factors, which depend more or less upon salinity, temperature and pressure.

Salinity

Salinity is the saltiness or dissolved salt content of a body of water. Prior to 1978, salinity or halinity was expressed as ‰ ("promille"). In 1978, oceanographers redefined salinity in Practical Salinity Units (psu). Salinity depends on atmospheric precipitation, river drainage and evaporation from water surfaces. Changes in salinity influences changes in



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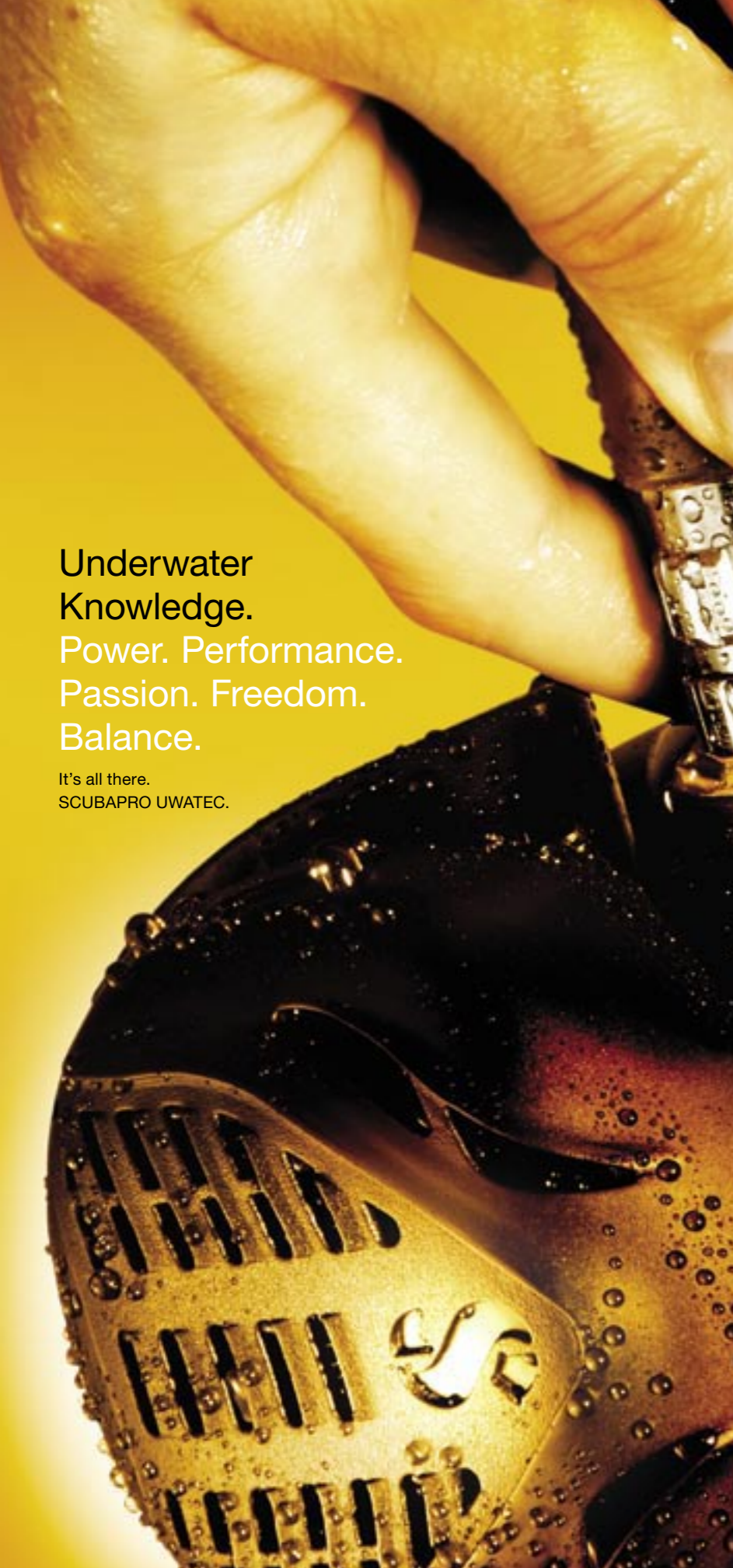
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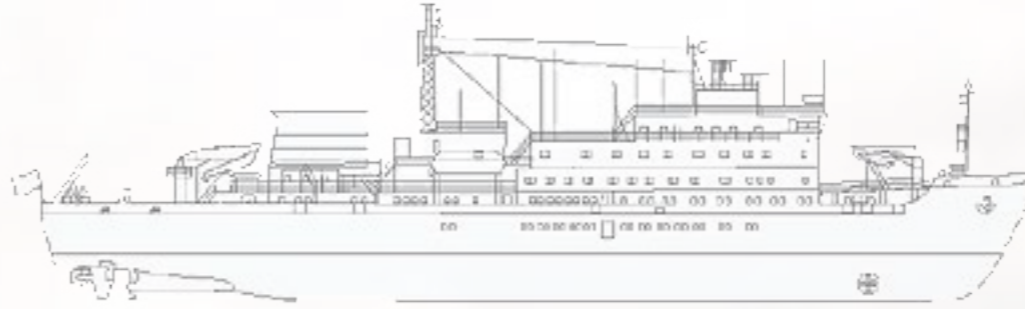
separate depth levels in order to examine salinity, dissolved oxygen contents, silicon and phosphates); oceanographic sonde, which continuously registers temperature, electrical conductivity, pressure, transparency; acoustic current speed and direction profiler; and an altimeter showing the distance between the deployed device and the sea bottom. CTD sondes make it possible to receive profiles (during vertical descent and ascent) of the vertical distribution of temperature and conductivity (salinity). Depending on the model, CTD sonde transfers information to an on board computer via special cables on-line or accumulates data in memory blocks of the sonde itself, to be retrieved after sonde ascent. The main producers of these devices are the American companies, Sea-Bird Electronics, Inc. and Falmouth Scientific, Inc., and Italy's IDRONAUT S.r.l.

Hydrological measurement complex

The 911plus is a premier real-time CTD accurate to the highest international standards. It features high resolution sampling (24 Hz), pump-controlled T-C ducted flow up to 10,500 meters (15,000 psi) depth capability, maximum auxiliary sensor flexibility and optional modem channel for Water Sampler control. The 911plus has eight 12-bit A/D channels, and supports redundant C&T sensors or custom auxiliary digital inputs. The 911plus consists of the 9plus underwater unit and the 11plus V2 Deck Unit.

The underwater unit for the 911plus CTD includes modular temperature and conductivity sensors with TC Duct, SBE 5T submersible pump, redundant T and C input channels, 8 differential inputs, low pass-filtered A/D channels, a water sampler modem channel, stainless steel guard cage and SEASOFT software.

The standard SBE 9plus underwater unit has an aluminium housing rated to 6,800 meters (22,300 ft) and is supplied with one



Schematic of *Akademik Ioffe*

conductivity and one temperature sensor (fitted with a TC Duct and constant-flow pump) and an internally mounted temperature-compensated Paroscientific Digiquartz pressure sensor for 6800 meters (10,000 psi) full-scale range. Input channels and bulkhead connectors are provided for an optional second (redundant) pair of temperature and conductivity sensors. Other standard features include an 8-channel, 12-bit A/D converter with differential inputs and low pass filters and high-power capability for support of commonly used auxiliary sensors (e.g., SBE 43 dissolved oxygen, SBE 18 or SBE 27 pH, transmissometer, fluorometer, ambient light, altimeter), a modem channel for real-time water sampler control and a port for connection of an optional bottom contact switch.

SBE 11plus V2 Deck Unit includes RS-232 and IEEE-488 computer interfaces, a modem channel for real-time water sampler control (including water sampler control push buttons and status lights), NMEA 0183 interface for adding GPS position to CTD data, 12-bit A/D input channel for surface PAR sensor, switch-selectable 115/230 VAC operation, audio tape interface (data backup), LED read out for raw data and audible bottom contact (or altimeter) alarm. The 11plus V2 also provides a remote pressure output (useful as an input signal for towed vehicle control) and a programmable serial ASCII data output containing up to seven variables in computed engineering units. Calibration coefficients are stored in EEPROM, and a separate micro controller converts raw CTD data to temperature, depth, salinity, etc. The 11plus V2 is shipped in a free-standing cabinet with a hardware kit for mounting in a stand-

Crossing the Atlantic

ard 19-inch electronics rack.

Receiving CTD data

SEASAVE software is used to receive CTD data. It enables one to set the connection of the board unit and computer. This software makes it possible to determine ports and data transmitting velocity from the carousel, the order of bottles closing (one by one or in a given order). The software also provides the possibility to register GPS data into a CTD file or separately. During data transmission, one can see on one diagram the distribution of four given parameters with depth range.

Precision

Modern science demands measurement precision to the millesimal regarding temperature and salinity. During measurements in the ocean, precision of CTD measurements are lost mostly because of different inertia (Inertia: the time needed for the sensor to change its data, or testimony, due to penetration into new water layers with new dimensions of the measured environment parameters) of temperature and conductivity sensors. SBE company found the way to overcome different inertia of their sensors. The sondes are washed by water in a different regime—not like in real time, depending on descending sonde velocity, but uniformly, with fixed speed. The fixed speed is provided by a special pump that circulates sea water via sensors during sonding.

CTD data processing

Data processing is made with the assistance of SBE Data Processing software. Data processing consists of data levelling regarding pressure; data averaging in the given interval regarding pressure, depth and time of registration; introducing amendments; calculation of all parameters; filtration of data and creation of graphs and diagrams.



Dr Sergey Pisarev on the *Akademik Ioffe* in Copenhagen

