AD-A036 877 NAVAL INTELLIGENCE SUPPORT CENTER WASHINGTON D C TRA--ETC F/G 8/10
RESEARCH CARRIED OUT DURING THE SIXTH CRUISE OF THE R/V AKADEMI--ETC(U)
JAN 77 G G NEUYMIN, V F SUKHOVEY

UNCLASSIFIED NISC-TRANS-3880 NL

1 OF 1
AD
A036877

END
DATE
FILMED
4-77

ADA036877

DEPARTMENT OF THE NAVY
NAVAL INTELLIGENCE SUPPORT CENTER
TRANSLATION DIVISION
4301 SUITLAND ROAD
WASHINGTON, D.C. 20390

CLASSIFICATION: UNCLASSIFIED

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

TITLE: Research Carried Out During the Sixth Cruise of the R/V AKADEMIK VERNADSKIY (September 1972-January 1973)

(Nauchnyye issledovaniya v shestom reyse nis "Akademik Vernadskiy" (sentyabr' 1972-yanvar' 1973 gg.))

AUTHOR(S): G.G. Neuymin [redacted], and Sukhovey, V. F.

PAGES: 8

SOURCE: Trudy Morskogo Gidrofizicheskogo Instituta No. 2(61), 1973
Pages 228-239

DDC
RECEIVED
MAR 15 1977

ORIGINAL LANGUAGE: Russsian

TRANSLATOR: C

NISC TRANS[redacted] - 3880

APPROVED P.T.K.

DATE 31 Jan[redacted]77

COPY AVAILABLE TO DDC DOES NOT PERMIT FULLY LEGIBLE PRODUCTION

RESEARCH CARRIED OUT DURING THE SIXTH CRUISE OF THE R/V AKADEMIK VERNADSKIY

(SEPTEMBER 1972 - JANUARY 1973)

[Neuymin, G. G. and V. F. Sukhovey, Nauchnyye issledovaniya v shestom reyse nis "Akademik Vernadskiy" (sentyabr' 1972 - yanvar' 1973 gg.), Trudy Morskogo Gidrofizicheskogo Instituta No. 2(61), 1973, pp. 228-239; Russian]

The article gives preliminary results of processing and analysis of observations made under the USSR National Program of Joint Study of the Caribbean Sea and Adjacent Regions (JSCAR). It discusses the water circulation pattern and certain characteristics of the formation of fields of hydrological, optical, and hydrochemical elements in the Caribbean Sea.

During the sixth cruise of the r/v AKADEMIK VERNADSKIY, the research was done /228* in accordance with the USSR National Program of Joint Study of the Caribbean Sea and Adjacent Regions (JSCAR). The main objectives of the expedition included a study of the circulation of Caribbean waters and water exchange between the Caribbean Sea and the ocean, hydrological and hydrochemical conditions, characteristics of formation of the light field, processes of interaction of the sea with the atmosphere, deep-sea turbulent exchange, bottom relief and structure of the geomagnetic field, bottom deposits, and biological productivity of the seawaters. Eighty-nine drift stations and twenty-three buoy stations were set up, and geophysical surveys were performed on four special ranges and four sections through the arc of Lesser Antilles. The ship's itinerary and location of all the buoy and drift stations are shown in Fig. 1.

The results of measurements made during the sixth cruise were processed in the on-board computing center. Completely new features were noted in the current system of the Caribbean Sea and adjacent regions, and in the structure of the Caribbean waters and distribution of the optical and chemical characteristics. A common char- /230
acter of changes in biological productivity was observed in different regions. New data characterizing the features of the bottom relief and geomagnetic and electric fields were obtained.

The current system and water masses of the Caribbean Sea were studied by the Marine Hydrophysical Institute of the Ukrainian Academy of Sciences over the course of several years: during the Soviet-Cuban expedition in 1964-65 and under the JSCAR program in 1970 and 1972. To date, observations have been performed at 53 buoy stations. These data, as well as measurements of the speed and direction of surface currents by means of an EMIT (electromagnetic instrument for measuring sea currents) and hydrological observations have made it possible to identify a new pattern of surface and deep-sea circulation of Caribbean waters and to determine rather accurately the water exchange between the Atlantic Ocean, Caribbean Sea and Gulf of Mexico through the channels connecting them.

The numerous channels of Lesser Antilles provide waters of the South and North Tradewinds with free access to the Caribbean Sea. Waters of the Guyana Current enter mainly through the channel located between the coast of South America and Grenada Island. Although this is the southernmost of the channels of Lesser Antilles, it is

---

*Numbers in the right margin indicate pagination in the original text.

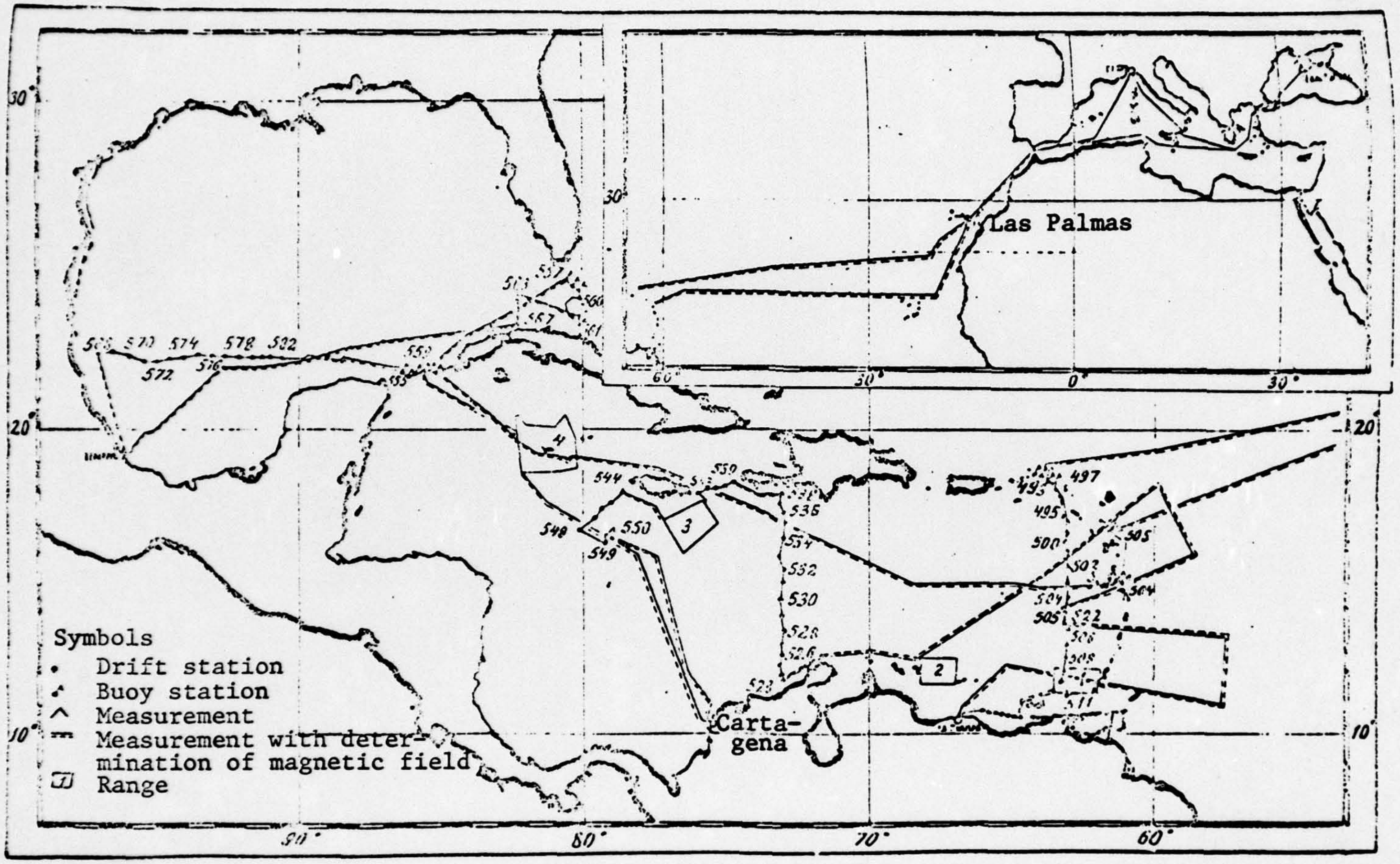

Fig. 1. Itinerary of the sixth cruise and location of drift and buoy stations.

less deep than the central channels, and the flow of Atlantic waters entering the Caribbean Sea through it at high speeds is maximum (33.0 km^3/h). North of it is the group of The Grenadines and St. Vincent Island. The channels between them are shallow, and the flow is insignificant.

The central channels, which are the deepest ones in the Lesser Antilles, have depths of 1100-1200 m. However, because of the lower current velocities, the volume of Atlantic waters entering through each of the channels is smaller than the volume through the Grenada Channel. The total flow of the channels between the St. Vincent and Guadeloupe Islands is 38.0 km^3/h. Channels located north of Guadeloupe Island are shallow. The flow of the deepest and widest one is 14.3 km^3/h. The total flow of the others does not exceed 4-5 km^3/h.

In view of the fact that the largest volumes of Atlantic waters enter the Caribbean Sea through the Grenada Channel and channels in the central portion of the island arc, two axes of flow are observed in the eastern half of the sea. One is located in the southern part, approximately 100-150 miles from the coast of South America, /23
and the other, in the central part of the sea. Both axes of flow come closer together as the waters move eastward. Around 79° W, the Caribbean Current veers northward, passing through a narrow trench of the Nicaragua elevation. The depth of the trench is 1400 m, and its width, approximately 40 miles. Over the remainder of the ridge, the depths are less than 30 m and reach 50 m only in spots. Therefore, most of the waters of the Caribbean Current rush through this trench, sharply increasing the velocities. Beyond, the principal axis of the current has a northwestern direction all the way up to the Yucatan Channel.

An important role in the formation of the surface and deep-sea circulation of Caribbean waters is played by the northern channels: Sombrero and Windward. Through these channels enters deep-sea Atlantic water with a temperature of 4°C and a salinity of 34.98-34.99 o/oo, which fills the entire deep-sea portion of the Caribbean Sea and Gulf of Mexico. In the upper layer, the current is directed mainly toward the Caribbean Sea. In the lower layer, two flows, one incoming and the other outgoing, are observed. In the Sombrero Passage, the volume of waters entering the sea is 18.1 km^3/h, and that of outgoing waters is 14.8 km^3/h; in the Windward Passage, the volume of incoming waters is about 45.0 km^3/h, and that of waters draining into the ocean, 14.6 km^3/h. The flow of the Mona Passage is relatively small because of its shallowness

A fairly complex system of currents is also observed in the Yucatan Channel. In the upper layer (from the surface down to 700-1000 m), a current with a velocity reaching 150 cm/sec is directed into the Gulf of Mexico. The flow of this current is 155 km^3/h. The zero isotach rises from the Yucatan coast to 100-150 m and descends to the bottom in the central part of the channel. Thus, in the lower part of the trench there is observed both the inflow of deep-sea water into the Gulf of Mexico and its reverse drainage into the Caribbean Sea. During the operation of the buoy stations, the reverse flow occupied almost the entire lower part of the channel's cross section and amounted to 41.4 km^3/h.

On leaving the Gulf of Mexico, the main flow heads for the Straits of Florida. Three buoy stations were set up here between the coast of Florida and the Key-Sal bank. The maximum current velocity was observed in the region of the middle buoy. It reached 190 cm/sec on the surface and very slowly decreased with depth. The flow /23
of the Florida Current was 125 km^3/h.

The above flows through channels, a large number of observations made with the EMIT, and data from hydrological sections made it possible to plot a preliminary new

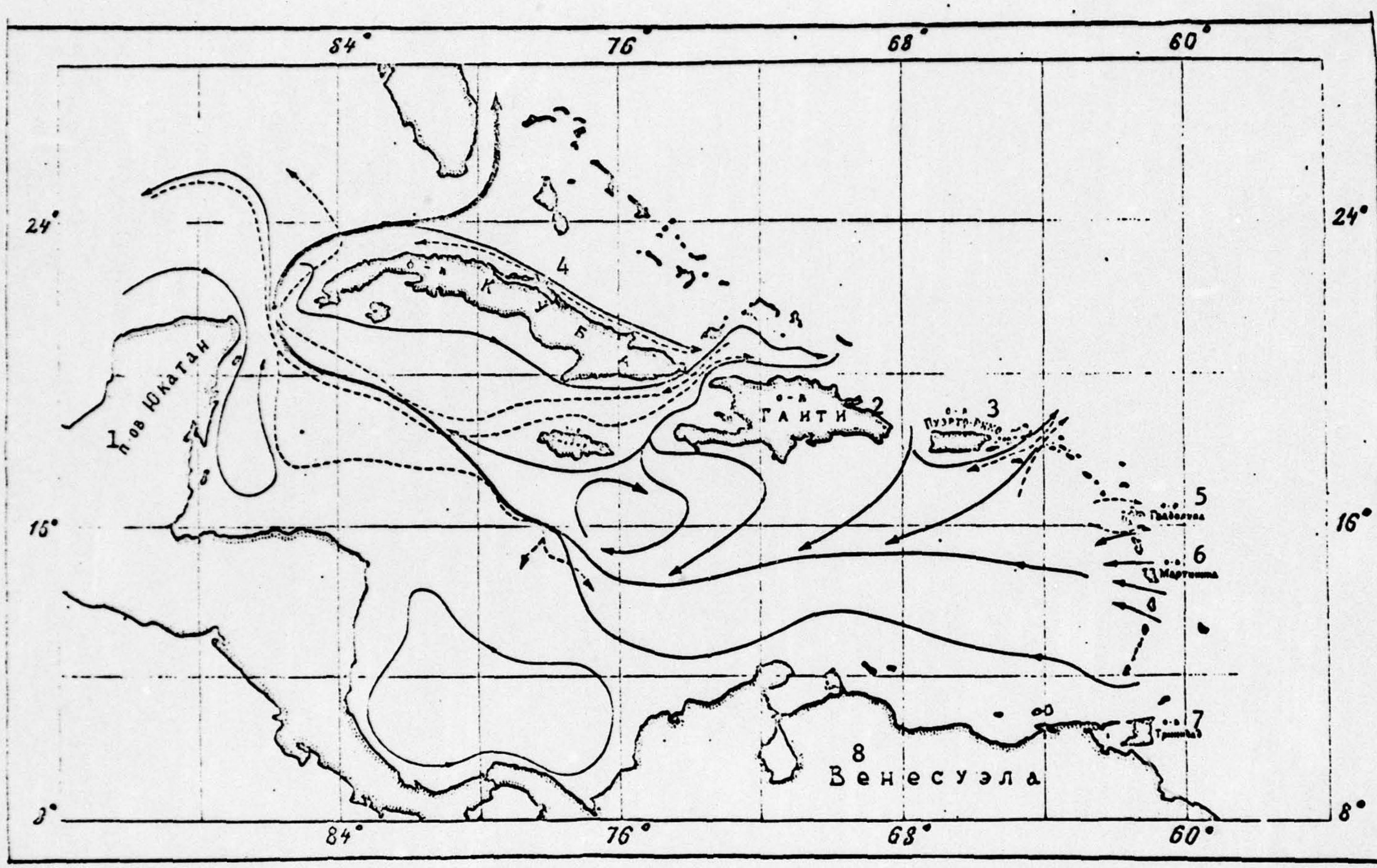

Fig. 2. Preliminary pattern of surface and deep currents of the Caribbean Sea.

1 - Yucatan Peninsula; 2 - Haiti; 3 - Puerto Rico; 4 - Cuba; 5 - Guadeloupe; 6 - Martinique; 7 - Trinidad; 8 - Venezuela.

pattern of circulation of the waters. This pattern is shown in Fig. 2. The axes of the surface currents are indicated by solid lines, and those of deep currents, by dashed lines. Further processing of the observations will make it possible to determine this pattern more accurately.

In view of the intensive water exchange between the Caribbean Sea and the ocean, not only the hydrological but also the hydrochemical elements, i.e., content of dissolved oxygen, phosphates, concentration of hydrogen ions in the sea, are similar to the corresponding elements in the adjacent regions of the ocean. The oxygen content of the upper sea layer 80-100 m thick is mostly higher than 4.5 ml/l, amounting to 100-106% of saturation. Since a general drift of the waters from east to west exists in the sea, the isolines of the oxygen content are inclined (like those of all the other hydrological elements) in the south-north direction. The rise of the isolines in the southern part of the sea also extends to the upper part of the oxygen minimum layer. However, the lower boundary of the oxygen minimum and the underlying layers are horizontal. The oxygen content of the minimum layer is the same as that of the ocean waters entering through the channels, i.e., under 3.0 ml/l. Somewhat less oxygen is present in the southwestern part of the sea (under 2.8 ml/l). Below 600-800 m, the oxygen content gradually increases and reaches 4.7 ml/l in the layer of the deep maximum, observed as a result of the inflow of deep Atlantic water through the Windward and Sombrero Passages into the sea. In the sea region adjacent to the Windward Passage, the oxygen content in the layer of the deep maximum is 5.4-5.6 ml/l, whereas it is only 5.0 ml/l near the Sombrero Passage.

The pH values observed at all the stations correlate well with the oxygen content. They are in the range of 8.10-8.20 in the surface waters, gradually decrease with depth to 7.90-8.00 in the oxygen minimum layer, then increase to 8.20-8.30 in the deep oxygen maximum layer.

The phosphate content of the Caribbean Sea is practically the same as that in the adjacent regions of the ocean. The isoline of the 5 μg/l concentration essentially remains no higher than 100 m. A phosphate concentration maximum above 50 μg/l is /234
observed in the 500-1000 m layer. The inflow of phosphates into the upper layers takes place slowly, and therefore the photosynthesis layer is very poor in them (0-5 μg/l). Despite strong currents, the weak mixing of waters of the upper layer with lower waters is due to the fact that a sharp increase in salinity coinciding with the temperature discontinuity layer is observed in the upper layer of subsurface subtropical water. Enormous density gradients which prevent turbulent mixing are created at the upper boundary of the subtropical water layer by the increase in salinity and decrease in temperature. Only in the southern part of the sea, where a surge effect and emergence of high-salinity subsurface waters on the surface are observed, does the phosphate content of the photosynthesis zone rise to 10 μg/l.

The optical characteristics of the waters were studied along the following three lines: (1) regional distribution of the attenuation index of directed light, (2) distribution of natural solar radiation in the sea, and (3) study of field inhomogeneities of the bioluminescent potential.

The attenuation index of directed light was measured with a logarithmic photometer-transparency meter in six intervals of the visible and near-uv regions of the spectrum down to a depth of 400-800 m. The data obtained showed that the entire open area of the Caribbean Sea, with the exception of shallow regions and water areas affected by the runoff of large rivers, is characterized by the presence of a surface layer of reduced transparency formed above the density discontinuity layer, below which a gradual clearing of more homogeneous waters is observed. The optical properties of surface waters of the southeastern part of the sea are largely determined by the run-off of the Orinoco River and also by Atlantic Ocean waters penetrating through the channels of the Lesser Antilles. The Orinoco waters are characterized by a very low transparency because of a large quantity of suspension. Spreading over the surface, they form a thick optically scattering layer in the 0-50 m layer. The influence of the Orinoco is appreciable in the surface layer and in the region of the Cariaco Basin. In the deep part of the basin, the curves of vertical distribution of the light attenuation index are similar in many respects to the analogous curves for the Black Sea, apparently as a result of the stagnant nature of the deep waters and the presence of hydrogen sulfide.

The local features in the distribution of the transparency characteristics of the surface waters are in good agreement with the plankton biomass values. This applies particularly to the southern part of the sea, where an upwelling takes place.

Measurements of underwater irradiance were performed with the aid of a new meter, /23
whose preparation and adjustment were completed during the cruise. The underwater irradiance was measured for both the descending and ascending light flux in five regions of the visible spectrum and in the near-uv region at a wavelength of about 360 nm. The attenuation indices "from above" and "from below" and diffuse reflection coefficients calculated on the basis of these measurements are in good agreement with the pattern of geographical distribution of optical types of waters cited by Erlov in the book "Optical Oceanography."

The bioluminescence was measured during transitions to moonless nights. Values of the bioluminescent potential varied in the range of $0.15\text{-}0.7\cdot 10^{-2}$ $\mu W/cm^2$, and in some cases, intervals with a quiet and level variation of luminescence alternated with intervals of abrupt and pronounced changes in luminescence level. Statistical analysis of data obtained in the most diverse regions of the Caribbean Sea and Gulf of Mexico showed that the law of decrease in the energy of fluctuations of bioluminescent potential with frequency is close to the well-known -5/3 power law.

In addition to the measurements described, observations of the color of water were made by means of specially designed instruments while the ship was moving. The principle of measurement is based on a comparison of the luminescence of light coming from the sea in the blue and green regions of the spectrum. (It should be noted that these measurements were the first of their kind in the Soviet Union, and the results obtained indicate that they are very promising). A significant advantage of this method is the fact that all the measurements are made while the ship is traveling. Data obtained during the sixth cruise show that the ratio of the luminescence of the blue color to that of the green color, which serves as the color index of water, may change by a factor of over 60 with the characteristics of the water masses in different regions. If the color index of the most transparent water in the Atlantic Ocean is arbitrarily taken as unity, then this index will be about 1.5 for the open part of the Caribbean Sea and increase to 8 in the southeastern part. On passing from the Caribbean Sea to the Canary Islands, this index first decreased to 1, then began to increase (approximately 400 miles from Cape Verde Islands). The color index reached its maximum value of 60 in the region of Cap Blanc Bank.

The results obtained suggest that when all research ships are equipped with this /23
type of instruments, it will be possible in the next few years to compile a detailed water color atlas for the entire World Ocean.

The water turbulence characteristics were measured in deep layers of the Caribbean Sea - below the density discontinuity layer. In order to study the horizontal turbulence in the region of the mesoscales, the velocity and direction of the currents were measured at different levels by means of automated AIST meters. The space-time structure of the velocity and temperature fields in the region of the microscales was studied by setting up an AGAT measuring unit, which permitted the simultaneous recording of all three components of the current vector, temperature fluctuations, and mean velocity modulus.

Results of a study of the horizontal turbulence field show that in the region studied, the dimensions of the inhomogeneities do not exceed a few meters in the great majority of cases. In the microscale region, the spectral characteristics obtained show a complex energy distribution in the $6.25 \cdot 10^{-3}$ - 2.5 Hz frequency range. In most cases, graphs of the spectral density functions show from one to several peaks (energy pumping regions) on different portions of the frequency scale; this apparently corresponds to the presence of internal waves with different periods.

The following items were studied in the atmosphere-ocean boundary layers: (1) conditions of formation and development of wind waves, (2) waves in the surface layer of the sea, (3) velocity field above a wavy surface, (4) temperature fluctuations in the air and water near the interface. A PGS-5 partly submerged gradient station was used to measure the sea surface elevations, vertical and horizontal velocity components of the air flow, vertical and horizontal velocity components of water, vertical component of wave motion at a fixed level, and fluctuations in air and water temperature near the interface. An estimate of the frequency dependence of the wave spectrum was made for different types of waves. The dependence $S(f) \sim f^{-4.5}$ is confirmed for fully developed wind waves. The surge wave spectrum of the same direction in the absence of local wind is narrower: $S(f) \sim f^{-6}$. In the case of mixed waves (surge waves of different directions and short wind waves), the wave spectrum varies with /237 frequency as $S(f) \sim f^{-3.5}$. In addition to measurements made with the gradient station, observations during the cruise were performed by means of a special "following" buoy, which made it possible to get an idea of the interaction of the ocean and atmosphere on scales beyond the limits of the main energy-carrying frequencies of surface waves.

One of the objectives of the sixth cruise of the r/v AKADEMIK VERNADSKIY was to carry out geological and geophysical investigations over special ranges, geophysical sections through the Lesser Antilles Island arc, along the course of the ship, and also on geological stations. Comprehensive geological-geophysical surveys were made in the following regions of the Caribbean Sea: (a) zone where the southern tip of the inner volcanic arc of Lesser Antilles connects with the continent and the Aves Ridge, (b) central part of the island arc of Dutch and Venezuelan Antilles, (c) fault zone on the southeastern slope of the Nicaraguan Rise south of the island of Jamaica, and (d) central part of the Cayman Ridge and deep-sea Cayman Trench. On each range and section, measurements of the bottom relief and intensity of the complete vector of the geomagnetic field were made, and samples of bottom sediments were taken. The observations performed revealed new characteristics of the anomalous magnetic field above various morphological structures. In particular, it was noted that the amplitude of the anomalies above the Cariaco Basin reaches 1000 gamma. Above the Venezuelan and Colombian Basins, an amplitude of 400-450 gamma was recorded. A map of the anomalous magnetic field of the eastern Caribbean Sea was prepared.

In addition to the magnetometric studies, the intensity of the electric field was measured during the sixth cruise. A preliminary processing and analysis of these measurements showed that in the region of the Caribbean Sea, the relative intensity of the electric field is low and amounts to an average of 10 μV/m. The maximum field intensity was recorded in the Straits of Florida and Yucatan Passage, where it reached 24 μV/m.

In order to study the biological productivity of the Caribbean Sea, determinations of the primary production, species composition, spatial and vertical distribution of the zooplankton biomass, qualitative composition and population of the ichthyoplankton as well as quantitative development of heterotrophic and denitrating bacteria in the hyponaston were made during the sixth cruise. The rate of nitrogen fixation was determined for the first time in the Caribbean Sea by using the stable isotope nitrogen-15 as the label. Preliminary analysis of the data obtained makes it possible to make a general estimate of the spatial and vertical measurement of biological production indices over the water area surveyed.

The spatial distribution of the indices in the Caribbean Sea showed a common character of their changes. There was a distinct increasing trend of the population of heterotrophic bacteria, primary production, seston volume and population of fish larvae from the northern to the southern regions, due to a corresponding increase in phosphate concentration in the photosynthesis zone. All the channels examined are characterized, on the whole, by lower values of the indices studied as compared to the Caribbean Sea. Thus, the total quantity of microorganisms in the Caribbean Sea in one meter of water is twice as large as in the Yucatan Channel and seven times as large as in the Straits of Florida. The number of nitrogen-fixing microorganisms in the channels is almost five times smaller, and the average values of primary production, seston volume and population of fish larvae are two to three times lower than in the Caribbean Sea. Along with the general character of changes in the mean indices of biological productivity, the individual characteristics of each region are clearly manifested in the channels. The slight quantitative development of the various levels of biological productivity in the channels is apparently due to high current velocities, since the production processes should be attenuated in a powerful directional flow of surface waters.

Studies of radioactive contamination of the atmospheric layer adjacent to the water and of the ocean were continued during the sixth cruise. Aerosol samples were taken by means of a ventilation unit over the entire itinerary of the ship. Samples of atmospheric precipitation were collected by using a special filter with a four-day exposure. Analysis of the samples gave the following results: during the cruise, the concentration of radionuclides in the atmosphere varied from $0.09 \cdot 10^{-3}$ to $0.75 \cdot 10^{-3}$ dis/sec/m^3, the average being $0.263 \cdot 10^{-3}$ dis/sec/m^3. The density of radionuclide precipitation on the ocean surface ranged from 0.12 to 0.48 dis/sec/m^2 per day. Instrumental measurements of the gamma background of seawater were made at the buoy and drift stations. Analysis of the results showed that the main contribution to the gamma background is made by K^{40}.

This paper draws only the most general and preliminary conclusions based on the initial processing of the observational data obtained during the cruise. A detailed analysis of all the measurements is being performed in the laboratory. The results of the various studies mentioned above will be published in a special collection of papers. /2 measurements showed that in the region of the Caribbean Sea, the relative intensity of the electric field is low and amounts to an average of 10 μV/m. The maximum field intensity was recorded in the Straits of Florida and Yucatan Passage, where it reached 24 μV/m.

In order to study the biological productivity of the Caribbean Sea, determinations of the primary production, species composition, spatial and vertical distribution of the zooplankton biomass, qualitative composition and population of the ichthyoplankton as well as quantitative development of heterotrophic and denitrating bacteria in the hyponaston were made during the sixth cruise. The rate of nitrogen fixation was deter- /12
mined for the first time in the Caribbean Sea by using the stable isotope nitrogen-15 as the label. Preliminary analysis of the data obtained makes it possible to make a general estimate of the spatial and vertical measurement of biological production indices over the water area surveyed.

The spatial distribution of the indices in the Caribbean Sea showed a common character of their changes. There was a distinct increasing trend of the population of heterotrophic bacteria, primary production, seston volume and population of fish larvae from the northern to the southern regions, due to a corresponding increase in phosphate concentration in the photosynthesis zone. All the channels examined are characterized, on the whole, by lower values of the indices studied as compared to the Caribbean Sea. Thus, the total quantity of microorganisms in the Caribbean Sea in one meter of water is twice as large as in the Yucatan Channel and seven times as large as in the Straits of Florida. The number of nitrogen-fixing microorganisms in the channels is almost five times smaller, and the average values of primary production, seston volume and population of fish larvae are two to three times lower than in the Caribbean Sea. Along with the general character of changes in the mean indices of biological productivity, the individual characteristics of each region are clearly manifested in the channels. The slight quantitative development of the various levels of biological productivity in the channels is apparently due to high current velocities, since the production processes should be attenuated in a powerful directional flow of surface waters.

Studies of radioactive contamination of the atmospheric layer adjacent to the water and of the ocean were continued during the sixth cruise. Aerosol samples were taken by means of a ventilation unit over the entire itinerary of the ship. Samples of atmospheric precipitation were collected by using a special filter with a four-day exposure. Analysis of the samples gave the following results: during the cruise, the concentration of radionuclides in the atmosphere varied from $0.09 \cdot 10^{-3}$ to $0.75 \cdot 10^{-3}$ dis/sec/m^3, the average being $0.263 \cdot 10^{-3}$ dis/sec/m^3. The density of radionuclide precipitation on the ocean surface ranged from 0.12 to 0.48 dis/sec/m^2 per day. Instrumental measurements of the gamma background of seawater were made at the buoy and drift stations. Analysis of the results showed that the main contribution to the gamma background is made by K^{40}.

This paper draws only the most general and preliminary conclusions based on the /239
initial processing of the observational data obtained during the cruise. A detailed analysis of all the measurements is being performed in the laboratory. The results of the various studies mentioned above will be published in a special collection of papers.