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Kort proposal for cooperative study of the North Atlantic dynamics and hydrology

(IOC Resolution IV-14)

IOC Resolution IV-14 concerning the North Atlantic Ocean, requested "SCOR and ACMRR in cooperation with ICES and ICNAF and taking into account all the work in progress to study the possibility of developing cooperative investigations of this region reporting their recommendation to the next session of the Commission including, if feasible, suggested plans for its conduct."

It was noted at the Sixth Meeting of the IOC Bureau and Consultative council (Paris, May 1966) that the proposed studies had not yet been sufficiently developed within SCOR for presentation to the IOC. Professor Kort had been asked by SCOR to prepare a proposal for these investigations for consideration at the next Executive Meeting.

Professor Kort's proposal of 15 December 1966 is attached. It has not yet been endorsed by SCOR nor can it be formally presented to IOC until it has been reviewed by the organizations in the IOC Resolution.

The proposal is presented for ICNAF review and comment.

Yours very truly,

L.R. Day
Executive Secretary

LRD/ss

8 February 1967

TO THE INTERNATIONAL PROJECT OF STUDYING THE NORTH ATLANTIC DYNAMICS AND HYDROLOGY

I. The main problems of studies

As many-year studies have shown, the oceanic circulation in the North Atlantic is one of the most important links in the system of motion of the World Ocean water masses. Now, we may already take for granted the great influence produced by the water circulation in the North Atlantic (directly or through atmospheric processes) on the climate and weather in Western Europe and the eastern part of North America, on the distribution and variations in the abundance of food fishes and on the navigational conditions in the northern part of the Atlantic Ocean. However, the conducted studies and the collected data are still far from being adequate for solving a number of problems connected with the possibility of predicting one or another change in theabove-mentioned influence. Moreover, the physics of many processes and phenomena determining and controlling the influence of the North Atlantic circulation on the nature of geophysical and biological processes in the Northern Hemisphere is not yet clear in many respects.

Thus, for example, for the most exhaustively studied current of the North Atlantic system - the Gulf Stream - there are some questions to be answered concerning the deviation of this current from the coasts of the continent, its vertical structure, the origin of meanders, their size and position in the stream, their essentially non-stationary character, etc. Almost absent are data on the different time scale fluctuations in mass transport and on the variability in heat and salt content; the role of Florida and Antilles currents in the genesis of the Gulf Stream proper is still obscure, etc. Most of these questions can be still in larger part concerned with other links of the North Atlantic oceanic circulation. So far, there remains to be essentially not verified one more rather well-distributed pattern of the large-scale interaction between the oceanic and atmospheric circulations in the North Atlantic. According to this pattern the intensification of trade winds and equatorial drift currents dependent on the former ones results in increasing heat transport from the accumulation region to the Gulf Stream system. Further advancement of this positive heat anomaly leads to stirring up of atmospheric activity at the polar front and, consequently, to the intensification of westward transport and trade winds. As fast as the positive heat anomaly goes out of the polar frontal zone and is replaced by colder water, the atmospheric activity above the polar front grows weak. This results in wind and current attenuation in middle and low latitudes. Simultaneously, as the positive heat anomaly moves to the Arctic front, the atmospheric processes above the northern parts of the Atlantic become intensified. The wind and current attenuation in low latitudes slows down heat transport by the Gulf Stream system with the result that conditions are created for decelerating processes in high latitudes (at the Arctic front). When this deceleration begins heat accumulated in the equatorial region in this relatively quiet time stirs up atmospheric activity at the polar front contributing to a new intensification of atmospheric activity in the trade wind zone and to the appearance of a new wave of the positive heat anomaly. The investigations made by the Soviet scientists show that the duration of such a cycle of the interaction between the oceanic and atmospheric circulations in the North Atlantic equals, approximately, 4 years. Thus, the irregular northward displacement of oceanic heat observed within the North Atlantic current system causes a continuous evolution of atmospheric processes. At the same time, atmosphere exerts a reverse and a very active influence on the state of the ocean. The above-mentioned process of atmospheric and oceanic circulation variability is of a pronounced oscillating character (with a period of 4 years) in which self-regulation is inherent. The analysis of the sea level fluctuations in the North Atlantic shows a well pronounced synchronism in the dynamic interaction between the oceanic circulation (its drift component) and the field of tangential forces of the atmospheric circulation. Further specification of the relationships in the regime of the large-scale interaction between the ocean and the atmosphere on the example of the North Atlantic would be of paramount importance for the development and improvement of long-term weather and climate forecasts, for fishing predictions and for solving many other geophysical and oceanographic problems.

Finally, despite the fact that the North Atlantic has been comparatively more covered by oceanographic survey than other areas of the World Ocean, there are still many purely regional problems there to be solved. Thus, there are only scarce data on the Antilles and Guiana currents and on their role in the Gulf Stream regime; the character of water exchange between the Atlantic Ocean, the Carribean Sea and the Gulf of Mexico has not yet been studied; the branching of the North Atlantic current into separate flows and the dynamic state of the Sargasso Sea are not quite clear either.

The above-mentioned still incomplete number of problems pertaining to the North Atlantic is indicative of an extremely great urgency in the development of researches in this part of the World Ocean.

The experience of international cooperation in the Tropical Atlantic studies under the "EQUALANT" programme convinces one in realizability of solving major problems of the North Atlantic on the basis of close international cooperation and collaboration. Proceeding from the enumberated problems the international programme of studying the system of the North Atlantic currents should include three main kinds of investigations:

a) regional oceanographic surveys,
b) special studies at hydrographic polygons,
c) many-year observations at fixed stations and along oceanographic sections.

II. Programme of studies

I. Regional oceanographic surveys in the poorly studied regions of the North Atlantic:

1) Guiana current,
2) Antilles current,
3) Yucatan current,
4) Sargasso Sea,
5) Polar oceanographic front,
6) The branching area of the North Atlantic current
7) The area of deep water upwelling off North-West Africa.

The oceanographic surveys are made in each of the regions simultaneously from several ships (the number of ships is determined by the necessity in maximum synchronizing the surveys) in the summer and winter seasons during 3-4 years. The duration of operations during each survey should not exceed 2-3 weeks. In addition to the fulfilment of the whole integrity of hydrological observations, the programme of the surveys should provide for mooring buoy stations with current meters at the most important points of the regions under study.

2. Special studies in the Gulf Stream.

Data available on the structure of the Velocity fields in the ocean indicate the extreme complexity and variability of the latter ones. For example, Fuglister's work on the results of the Gulf Stream surveys have shown the existence in it of a continuous spectrum of the velocity field variations ranging from the small-scale fluctuations up to space-time variations of 1000 km and 1 year.

The example cited shows that the dynamical studies in the ocean require, first of all, that the space-time structure of the dynamical processes should be thoroughly investigated. Such studies can be realized only through specialized cruise operations which will include observations of current velocities and temperature at long-time stations with a duration, at best, of about 1 year, made simultaneously at many points.

The analysis of such observations would yield detailed characteristics of the structure of the velocity and temperature fields in the ocean (correlation and spectrum functions, etc.); spatial and time scales of different types of disturbances; Reynolds stresses, lateral friction and inertial effects in the ocean current dynamics.

Besides, these studies will make it possible to elucidate the questions of energy balance in the ocean current system. To ascertain the above-mentioned problems the Gulf Stream system and the North Atlantic current are the most convenient objects.

To study the above problems and basic regularities in the Gulf Stream dynamical structure it is necessary to conduct surveys, at least, at two conjugate hydrographic polygons located in regions with differnet dynamical regimes (the area of the western boundary current deviation and the meandering area).

Polygon No. 1. At the Hatteras Cape traverse in the main flow of the Gulf Stream a T-shape polygon is placed composed of 13 anchour buoy stations: 9 stations - at a section across the current and 4 stations - along the current axis. The length of the transverse section is 48 miles and that of the longitudinal one - 24 miles, with a distance between stations of 6 miles. At 50, 100, 250, 500, 1,000, 2,000, 3,000 and 4,000 m depths autonomous instruments are placed for the measurements of current velocities and water temperature. Minimum intervals in the measurements are 5 minutes, the duration of the surveys being 3 months.

Polygon No. 2. In the meandering area a T-shape polygon of 13 buoys is placed. A transverse section along the meridian 60°W stretches from 37°N to 41°N (9 stations); a longitudinal section - along the parallel 39°N from 60°W to 62°W (4stations). The stations are spaced 30 miles apart. The depths at which observations are made are the same plus 750 m depth. The duration of work is 6 months.

In the vicinity of each buoy station temperature and salinity measurements are made with the aid of hydrographical casts and sounders once a week at Polygon No. 1 and twice a week at Polygon No. 2.

In addition to this, along the Gulf Stream flow between Polygons Nos. 1 and 2 current and temperature measurements, as frequent as possible, are made with the aid of GEK, neutral buoyancy pingers (Swallow's pingers), the thermistor chain and aircraft radiation thermometers.

In the presence of artificial Earth satellites with polar orbits above the area under study, the spatial variability of the Gulf Stream flow is determined with the aid of drift buoys furnished with active reflectors.

The duration of work at Polygon No. 1 has been determined on the basis of the prevailing frequency in time-space variations in days and miles, while at Polygon No. 2 - in weeks and tens of miles.

3. Many-year hydrological observations at "standard thermic sections" and in the areas of weather ship anchorages.

As it has been pointed out above, the development of methods for long-term oceanographic and meteorological forecasts is impossible without understanding the regularities of the large-scale interaction between the ocean and the atmosphere. The North Atlantic is the most characteristic region in this respect.

To study the processes of this kind the programme envisages the arrangement of many-year (6-10 years) systematic (seasonal) observations at the following standard thermic sections:

1) From Halifax to NE;
2) From St. John's to SE;
3) Norfolk - Bermudas;
4) Florida Strait;
5) From San Luis to NE;
6) Dakar - Green Cape Ils;
7) From Brest to W;
8) From Bergen to NW.

The length of each section is determined by the necessity of a certitude in crossing one or another flow in the system of the North Atlantic currents.

The programme of studies at the standard thermic sections includes temperature measurements at all standard depths from the surface down to 2,000 m depth with the help of thermosounders or ordinary deep-sea thermometers. The duration of ship operations at such sections may be from 3 to 5 days. The observations in the Florida Strait are made with the aid of a communication cable. Many-year thermometric series obtained in this way can be used to estimate variations in heat content of the baroclinic layer of each flow in theNorth Atlantic current system over many years. The comparison of the many-year variations of thermal stress in the North Atlantic currents with atmospheric processes would make it possible to reveal the basic perculiarities in the large-scale interaction between the ocean and the atmosphere in the North Atlantic.

A many-year series of electromagnetic measurements in the Florida Strait would characterize the variations in mass transport by the Floride current which is a very important addition to the analysis of variability of the North Atlantic currents.

To study the inter-year thermal stress variations the thermometric measurements are made at the sections not seldom than once a season; to study the seasonal variations the sections are repeated every month.

For the measurements of one month frequency the section between Norfolk and Bermudas (section No.3) and Bergen section in the Norwegian Sea (section No.8) should be considered as the most representative ones.

One of the indispensable conditions of conducting observations at the standard thermic sections is their accomplishment at one physical moment. To synchronize these observations it is necessary to work out a strictly coordinated International calendar of "hydrological days".

To raise the statistical value of thermometric observations at the standard sections and for a more broad coverage of the spectrum of variations in the thermal stress of the North Atlantic current system it is necessary to organize systematic (daily) thermometric deep-sea measurements from weather ships A, B, C, D, E, K and M located in the North Atlantic under the programme of observations at the standard sections. The meteorological programme of weather ships should include standard actinometric measurements.

The system of many-year observations of heat content variations in the ocean should also spread over the most representative shore and island hydrometeorological stations of the states of the North Atlantic basin.

The total duration of the many-year observations at the standard thermic sections of 6-10 years is a minimum one and is determined by the necessity of a certain coverage by observations of one-two four-year cycles in the distribution of thermic anomalies in the North Atlantic waters and of their interaction with atmospheric processes. Thus, the main objective of these studies would be at the first stage (6-10 years) the establishing of the mechanism of the large-scale interaction between the ocean and the atmosphere in the North Atlantic and the accumulation of data for statistical characteristics of seasonal variability of the processes going on in the ocean and atmosphere.

III. Manpower and equipment required.

A detailed estimation of the manpower and equipment required for the fulfilment of the outlined research programme is most appropriate to be made after this plan is approved in principle by the Intergovernmental Oceanographic Commission. At the present stage the scope of expenditures is estimated by the total ship time required for the fulfilment of the research programme:

a) regional oceanographic surveys - 450-510 ship months or 37-43 ship years;

b) conjugate hydrographic polygons in the Gulf Stream system - 30-35 ship months or 2.5 ship years;

6 aircraft surveys with the aid of the radiation thermometers;

c) many-year observations at "standard thermic sections" - 420-700 ship months or 35-58 ship years.

The total ship time demand, taking into consideration the duration of the studies of the whole programme, is 22 ship years. The above estimation proceeds from that 4-6 ships will take part in regional oceanographic surveys in each separate region with the duration of work of 2-3 weeks. In the surveys at the conjugate hydrographic polygons in the Gulf Stream 5-7 ships will participate during 6 months. For observations at the standard thermic stations 8 ships a year will take part in the surveys with the total duration of work of 22 days for each of the 6 ships and of 60 days for each of the 2 ships.

Location of regions to study, standard sections, hydrographic polygons and weather ships can be seen from the attachment.

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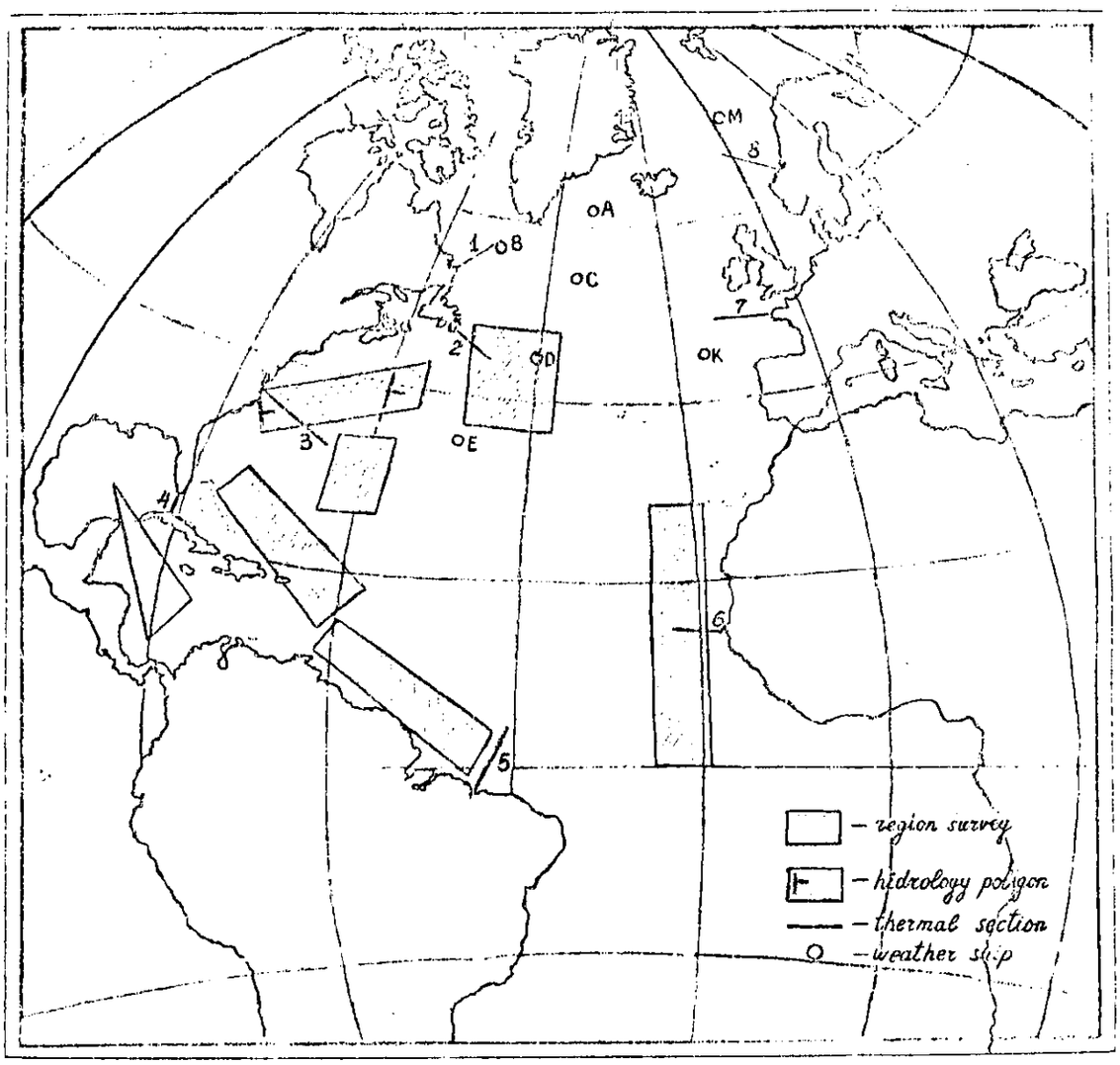
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