

FIRST NAVADO CRUISE

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INTRODUCTION

The Hydrographic Department of the Admiralty has traditionally pursued geophysical exploration and oceanographic investigation. An example of the former would be Commander FOSTER's voyage of 1828-1830 in H.M.S. *Chanticleer* during which he observed an extensive series of pendulum measurements at many stations on both sides of the Atlantic; whereas an outstanding example of the latter would be the *Challenger* Expedition of 1873-1876 when Wyville THOMSON and John MURRAY were carried round the world to make their deep-sea investigations.

The reading of hydrographic history shows that the carrying of scientists and their equipment in H.M. Survey Ships to explore the oceans has been commonplace.

Since World War II this practice has continued largely with the cooperation of the Department of Geodesy and Geophysics, Cambridge, the more notable voyages being, perhaps, H.M.S. *Challenger* 1950-1951 [1] and H.M.S. *Owen's* [2] more recent participation in the International Indian Ocean Expedition in 1961-1962.

Proposal P.60 [3] submitted by the U.S.A. to the 8th International Hydrographic Conference in May 1962 encourages States Members to give increased emphasis to the subject of oceanography. Great Britain supported this proposal and has recently been increasingly including oceanographic observations during the course of hydrographic surveys.

In August 1962 the British Admiralty Hydrographic Department decided that the time was now ripe for increasing standard oceanographic surveying as part of its function.

It is recognized that a large number of scientific research projects in oceanography are under way in many countries, not least in the United Kingdom, with the object of increasing our knowledge of the nature of the oceans and the earth's crust beneath them. These are clearly tasks for research organizations from which hypotheses and new theories will develop.

The task of oceanographic surveying is seen as a necessary complement to oceanographic research, and the task of the surveyors is to provide a base map for the extension of oceanographic theory to the widest geographical fields for military, commercial and navigational purposes.

THE SURVEY PLAN

It is against the foregoing background that we should view the plan that has been made by the Hydrographer of the Navy for a systematic survey of the North Atlantic from 10° N latitude to the latitude of Iceland, and which for convenience sake has been given the nickname "Navado".

Lines of bathymetric soundings, using a precision depth recorder, are being run across the Atlantic at 3° intervals of latitude from the continental shelf of Africa and Europe to that of North America. At the same time continuous measurements of total magnetic field and gravity are being made, and at selected positions along the lines oceanographic stations are made where core samples and photographs of the seabed are obtained and standard temperature and salinity casts made. The 900-foot bathythermograph is also regularly employed.

This is, of course, by no means the first of such investigations and no new techniques are claimed. What is intended however is the systematic, if widely spaced, cover of the North Atlantic, the data from which will in due course be published in the form of bathymetric, gravity and magnetic profiles, as has been done in the case of Admiralty Marine Science Publication No. 4, Part II [4] giving similar profiles taken by H.M.S. *Owen* in the Indian Ocean.

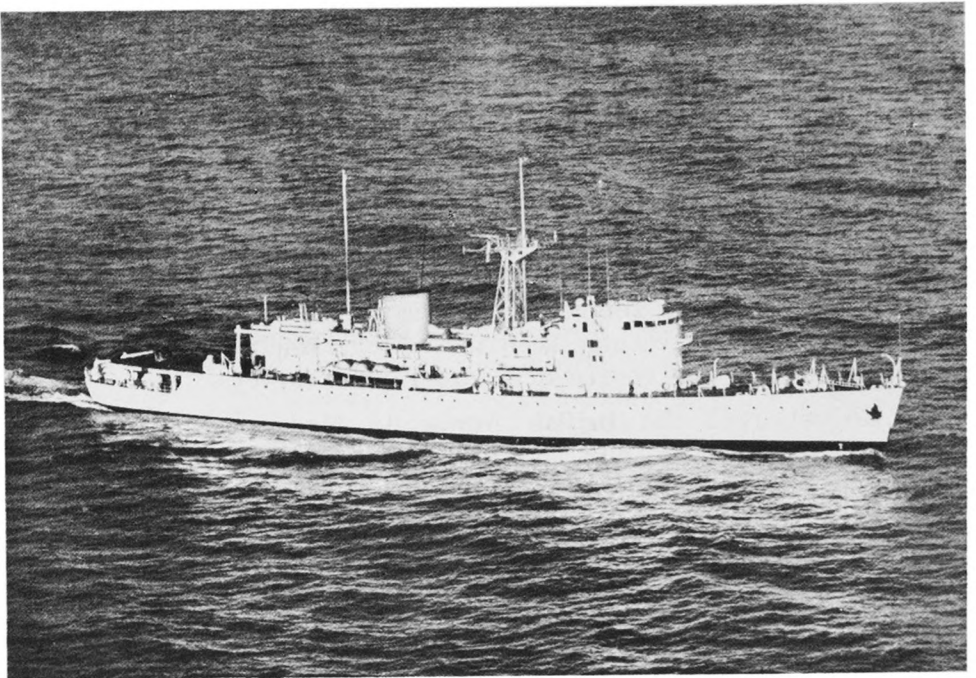


FIG. 1. — H.M.S. *Vidal*, 2 150 tons.

The vastness of the plan obviously makes it a long term project in which more than one Royal Navy survey ship may take part, and in which

it is at present planned that the Royal Netherlands survey ship *Snellius* will take over from *Vidal* in August 1964.

This paper deals with the first Navado Cruise (Navado I) which was carried out by H.M.S. *Vidal* between 11th October 1963 and 31st January 1964, during which observations were made along the first four Navado traverses commencing with a traverse in latitude 10° N.

INSTRUMENTATION

A number of instruments particularly required for the "Navado" survey were installed in *Vidal*. Much of the instrumentation was fitted in the ship's formerly spacious chartroom, and the recorders of all equipment were fitted here so that they could be under the immediate supervision of the Scientist of the Watch. Each special item of equipment will be briefly described :

The Precision Depth Recorder

This instrument is basically a Muirhead facsimile recorder using moist electrosensitive paper 18" wide. It was modified by Kelvin Hughes under direction of the Admiralty Underwater Weapons Establishment and the National Institute of Oceanography.

The internal tuning fork time base of 1025 c/s provides 20 and 100 fathom interval markings on phases of 200, 400 and 800 fathoms as desired. Every hour the equipment automatically records for two minutes on a scale of times six with hundred fathom interval marking which enables the phase to be regularly checked. All recorded depths are based on a mean sound velocity of 820 fathoms (1 500 metres) per second.

The intensity display of the depth profile is built up by means of a helix which causes the writing edge to mark the recording paper at 96 lines per inch. At the commencement of each horizontal scan the 10 kc/s ship's deep echo-sounding machine transmits a sound pulse into the water by means of a hull-mounted transducer, having a beam width approximately 20°. The receiver-amplifier of the deep echo sounder provides the Precision Depth Recorder with a suitably amplified echo and noise background which is fed to the writing edge on the paper by way of a power amplifier in the PDR.

The Gravimeter

This is an Askania-Graf sea gravimeter Model GSS-2 No. 11. It incorporates a new solid-state amplifier which has eliminated the earlier requirement for stabilized frequency 50 cps mains. This instrument worked

continuously without any troubles. It is mounted on an Anschutz stable horizontal platform fitted below the waterline in the ship's main gyro room amidships.

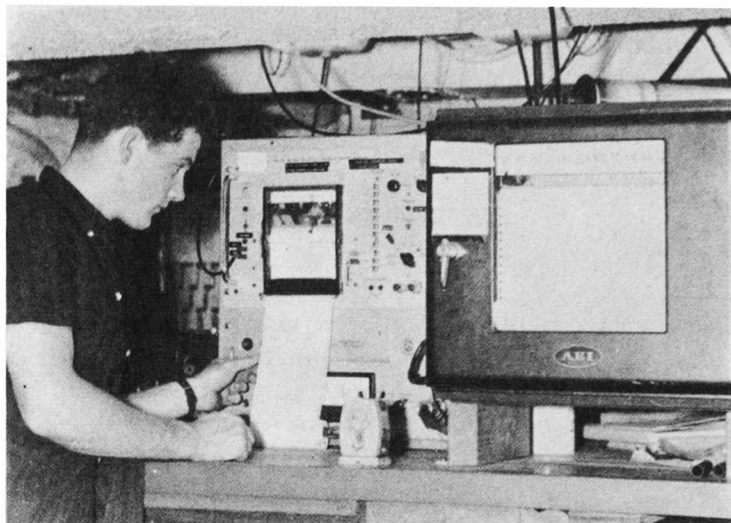


FIG. 2. — Gravimeter and magnetometer recorders in the Chartroom.

The stable platform is designed to accommodate either an oil-erected or an electrically-erected vertical gyro. For the present cruise it was fitted with an oil-erected gyro. This new platform has an unlimited range of pitch and roll adjustment which was found completely satisfactory in operation.

The Magnetometer

This was a proton resonance magnetometer designed by the Department of Geodesy and Geophysics, Cambridge, and manufactured by Bruce Peebles. It measures total magnetic field and gives analogue and digital recording of the field at one minute or half minute intervals. There were some teething troubles in operating this instrument in *Vidal* during the earlier traverses but latterly it gave excellent results.

Farnborough Range/Rate VLF System

Onboard for the Navado I cruise was a Varian Rubidium Vapor Frequency Standard and three Textran Phase-tracking VLF Receivers. This equipment was provided by the Royal Aircraft Establishment, Farnborough, England, where the data were required for use in their studies of VLF propagation.

The equipment gave continuous recording of phase and signal strength of GBR Rugby, NBA Balboa and one other station — variously WWVL Boulder, Colorado, NAA Cutler, Maine and NPG Seattle.

The phase shift data are being used by the Cambridge scientific team who are onboard to study the possibility of using the velocity information in conjunction with D.R., S.I.N.S., etc. for gravity Eotvos correction.

This VLF equipment worked extremely well throughout the cruise.

Data Recording System

The gravimeter, magnetometer and the Farnborough VLF systems were monitored by a central data recording system producing both analogue and digital records of all data. The equipment used for this purpose was a British twelve-channel recorder fitted with Elliott analogue-digital conversion and tape punch programming equipment.

Omega

This is a long range hyperbolic navigation system under development by the U.S. Navy Electronics Laboratory, San Diego. The Omega transmitters operate on a frequency of 10.2 kc. For coverage in the Atlantic, the master transmitter is located in Balboa, Canal Zone, Panama. The slaves are in Forestport, New York and Criggion, Wales. By measuring the phase differences of the received signals the Omega receiver indicator produces two lines of position. The Criggion-Balboa pair should be able to provide a line of position with an accuracy of $\pm 1/2$ n.m. or less during the period of system daylight and about ± 1 n.m. during system night. The accuracy of the Forestport-Balboa pair and the fix accuracy are somewhat limited in the eastern Atlantic by the present system geometry.

The Hydroplastic Corer

This is a conventional type of piston corer but using a 10-foot plastic replaceable coring tube of 3 inches diameter. The steel tailpiece with vanes, pilot weight tripping arm and removable 50 lb lead weight rings are used for each cast, being secured by bolts to the head of the plastic tube, as is the core cutter and catcher which is similarly secured to the bottom of the tube.

Thus the core obtained is not removed from the plastic tube which is detached, sealed and despatched ashore complete. The fact that the core is not extruded onboard makes it impossible to determine in the field whether any portion of the core is being sucked up by the piston, and laboratory analysis has to be awaited to assess the true length of the core obtained.

Cores of average length of 8 feet in the tube were obtained at each of 19 stations, no core being obtained at Charlie 12 where the bottom is of coarse sand. No attempt was, of course, made to use this corer on the Mid-Atlantic Ridge.

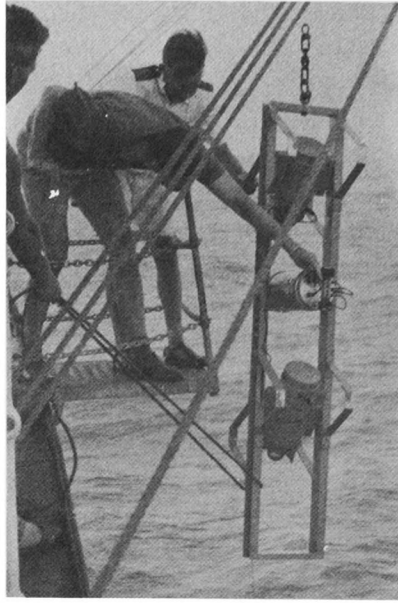


FIG. 3. — Deep Sea Camera. Adjustments to the 'pinger' unit before lowering.

The Alpine Underwater Camera

Two of these cameras made by the Alpine Geophysical Company of U.S.A. were employed. These are completely self contained, being battery-operated, and are lowered to the seabed on the oceanographic wire. They were used successfully down to depths of 5 300 metres.

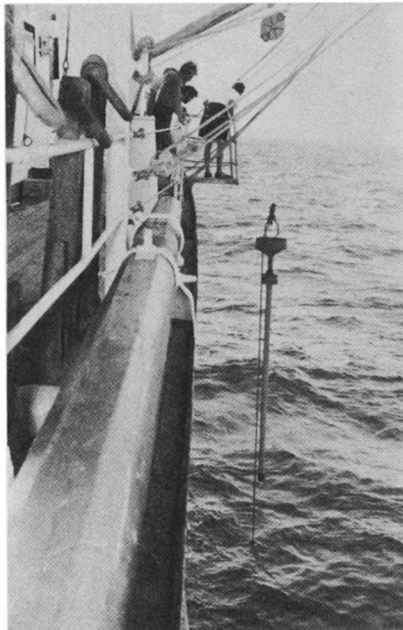


FIG. 4. — Hydroplastic corer ready for descent.

The equipment consists of camera, pinger and flashlight mounted vertically on a steel frame. The pinger is of 10 kc frequency which may be heard on earphones through the echo sounder receiver-amplifier. A periodic single pulse signal is available during the descent of the camera which changes to a fast rate signal when the trigger weight hanging below the frame operates camera and light. In this way the operator is able to control the oceanographic winch to take a series of seabed photographs as required.



FIG. 5. — Ocean floor at Station Delta 19 —
2 932 metres. Lat. 15°53' N, Long. 18°35' W

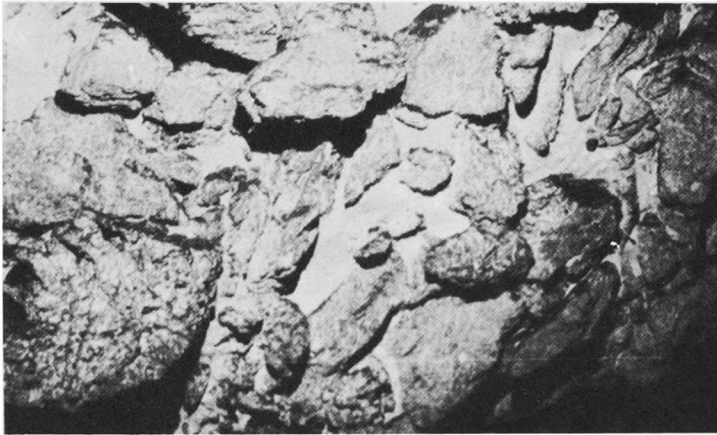


FIG. 6. — Rocky surface of the Mid-Atlantic Ridge —
2 195 metres. Lat. 15°53' N, Long. 46°52' W.

The photographs are taken at an angle of about 30° to the vertical which enables shadow effect to give shape to bottom features. The camera has a fixed focus of 10 feet.

The operation of the cameras was highly satisfactory and no flooding occurred through hand-tight screwed joints fitted with O ring washers.

The cameras were only available on Lines Charlie and Delta.

The Nansen Water Bottles

Reversing water bottles manufactured by Bergen Nautik were used from the oceanographic winch in serial casts, in the normal manner, to obtain serial temperature and salinity data from surface to seabed at each oceanographic station. One oceanographer from the United States Naval Oceanographic Office and one ship's hydrographic surveying officer checked against each other all temperature readings made.

The Oceanographic Winch

The oceanographic winch was fitted in the ship when she was built in 1952. It is a Stothert and Pitt electric driven deep-sea winch carrying 5 000 fathoms (9 140 metres) of seven-stranded $3\frac{1}{2}$ mm diameter oceanographic wire. With this is used a standard type metre block and a Dillon dial display dynamometer reading up to 2 250 lbs. A dynamometer of such a type is an essential aid to successful deep-sea coring.

CRUISE REPORT

Vidal sailed from United Kingdom for the first Navado Cruise on 12th October, 1963, calling in at Port Leixoes, Portugal from 15th-21st October to calibrate the gravimeter at the gravity station on Pedros Rubras airport.

From there the ship proceeded south past Cape Verde to the vicinity of the Bijouga Islands to commence Line Alpha (10° N) on October 30th. This line was completed on 11th November when the ship entered harbour at Trinidad.

Here two Surveying Officers and a detached survey party of 14 men with two echo-sounding launches were landed to undertake surveys required in the Approaches to Trinidad.

On 21st November the ship passed close south of Barbados to commence Line Bravo (13° N). This line terminated on 4th December off the entrance to the Gambia River, and Bathurst was visited for a few brief days which enabled some relaxation to be enjoyed and the gravimeter to be calibrated.

Line Charlie (16° N) was commenced south of Dakar on 8th December and passed through the Cape Verde Islands close south of Buonavista during the night of 9th December. This line was terminated off Guadeloupe on 19th December when the ship proceeded to Trinidad for Christmas and to re-embark the detached survey parties.

Line Delta (19° N) was commenced on 4th January, 1964, north of the Virgin Islands and was completed on 17th January off the African coast when course was set for Santa Cruz, Teneriffe to calibrate the gravimeter. The ship reached the United Kingdom at the end of January at the end of this first Navado cruise.

PERSONNEL

During the running of the Navado lines there was an Officer of the Watch on the bridge and, in direct communication with him, a Scientist of the Watch in charge of the equipment in the Chartroom, where the latter was assisted by a Surveying Recorder to read and record depths from the PDR.

Six scientists were normally carried in *Vidal* during this Navado period. Although there were some changes owing to other commitments, the numbers were most frequently as follows :

<i>No.</i>	<i>Parent Department</i>	<i>Particular Equipment</i>
1	Admiralty Underwater Weapons Establishment.	Precision Depth Recorder.
1	United States Naval Oceanographic Office.	Coring and Serial Casts.
2	Department of Geodesy and Geophysics, Cambridge.	Gravimeter and Magnetometer.
1	U.S. Naval Electronic Lab., San Diego.	Omega VLF fixing unit.
1	Netherlands Hydrographic Office.	General acquaintance for taking over Netherlands participation in Navado.

Although each scientist had his own particular equipment or task to attend to, all kept watch in rotation in the Chartroom. It was extremely gratifying to have in the ship scientists from three different countries collaborating in this way.

NAVIGATION

The importance of navigation during oceanographic cruises cannot be overstressed. The position of ocean soundings and gravity and magnetic anomalies must all be known to the greatest accuracy obtainable if these data are to be of value. Added to this the ship's velocity must be exactly known at all times if an accurate Eotvos correction is to be available for correcting underway gravity measurements.

During the Navado I cruise, the main reliance was placed on astro navigation, morning and evening star sights being possible on the great majority of days in these latitudes at this time of year. However, as Navado cruises are carried out into more northern waters, increasing reliance will have to be placed on VLF systems such as Omega.

The need to know the speed of advance of the vessel is paramount, and to achieve this much care was taken. 190 engine revolutions were selected as the standard ship's speed for oceanographic cruising, these being a comfortable maximum using one engine on each of *Vidal's* two shafts. Every opportunity was taken to run the vessel over measured mile distances to assess her present speed at these selected revolutions, for, of course, this varies with time out of dock and the amount of marine growth accumulated on the hull. Unfortunately various established measured mile distances are often found to be in poor repair, the beacons having fallen down, so that much time is sometimes wasted in steaming to a charted measured mile distance only to find it unusable.

It was found advantageous to use both the old style Walker's log over the stern in addition to the Chernikeef log which protrudes beneath the hull. The Walker's log undoubtedly gave more reliable and consistent results.

The steaming distance between one oceanographic station and another varied between two and three days and it was customary to set course from the observed position at the end of one such station so that the latitude of the Navado line should be regained by the time of arrival at the next station.

Speed or course were not altered then between the oceanographic stations and the automatic pilot was used.

In order that each scientific team onboard should be able to have a record of the ship's navigation during the cruise, and so that the British Meteorological Office should have the maximum data available for the assessment of surface currents experienced, the "Meteorological Office Currents, Oceanographical and Ice Log" was used to record the navigational data. This is a loose-leaf log and copies of the pages were reproduced onboard as required by scientific users.

MARINE BIOLOGY

Oceanic Birds

No marine biological programme was attempted except for the collection of sight records of seabirds, because these can be obtained so easily. All the oceanic birds seen during the four traverses were recorded on the printed reporting forms provided by the Royal Naval Bird Watching Society, who have organized a world-wide data collecting scheme for this type of information.

The close association between the distribution of most seabirds and seawater of particular temperatures with its associated plankton and surface marine animals makes their occurrence an interesting indication of oceanographic conditions. It is considered that no oceanographic voyage is really complete without a record of the seabirds seen.

Great care must be taken to secure full value from the observations,

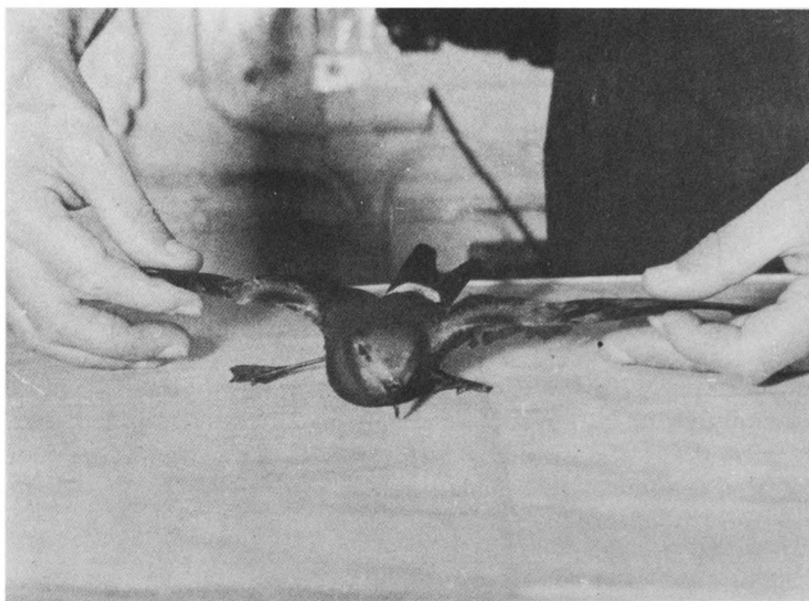


FIG. 7. — Leach's Storm Petrel onboard (16° N, 25° W on 10th December 1963) .

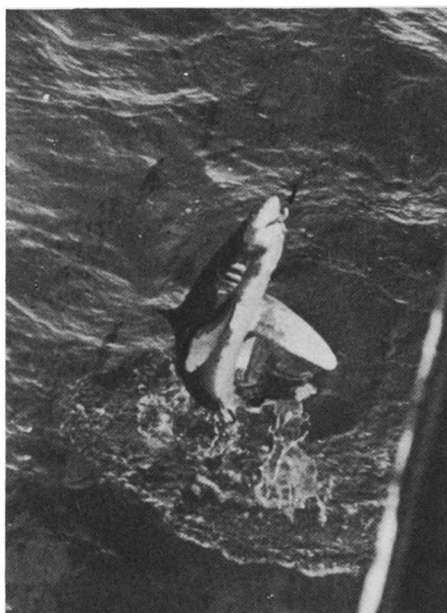


FIG. 8. — American ground shark being hauled onboard.

and the R.N.B.W.S. obtains advice from experienced ornithologists who vet the reports and advise observers on techniques and problems of identification. Photographs of oceanic birds (such as the one given, which confirmed the identity of the storm-petrels recorded as Leach's Petrel *Oceanodroma leucorhea*) are, of course, of particular value. All the records obtained by the R.N.B.W.S. are ultimately deposited in the Bird Room at the British Museum (Natural History) for general reference.

Deep Scattering Layer

This was evident on the PDR trace both by day and night along the great majority of the four oceanographic traverses. Three distinct layers could often be discerned ascending and descending at dusk and dawn respectively, each at a different vertical speed.

Sharks

At all stations, with the exception of Alpha 4, Charlie 13 and Delta 14, American ground sharks appeared as soon as the ship stopped for observations. Usually about six would be present at a time and these were easily caught by the seamen with shark hooks and meat bait. Those caught averaged 5 feet in length.

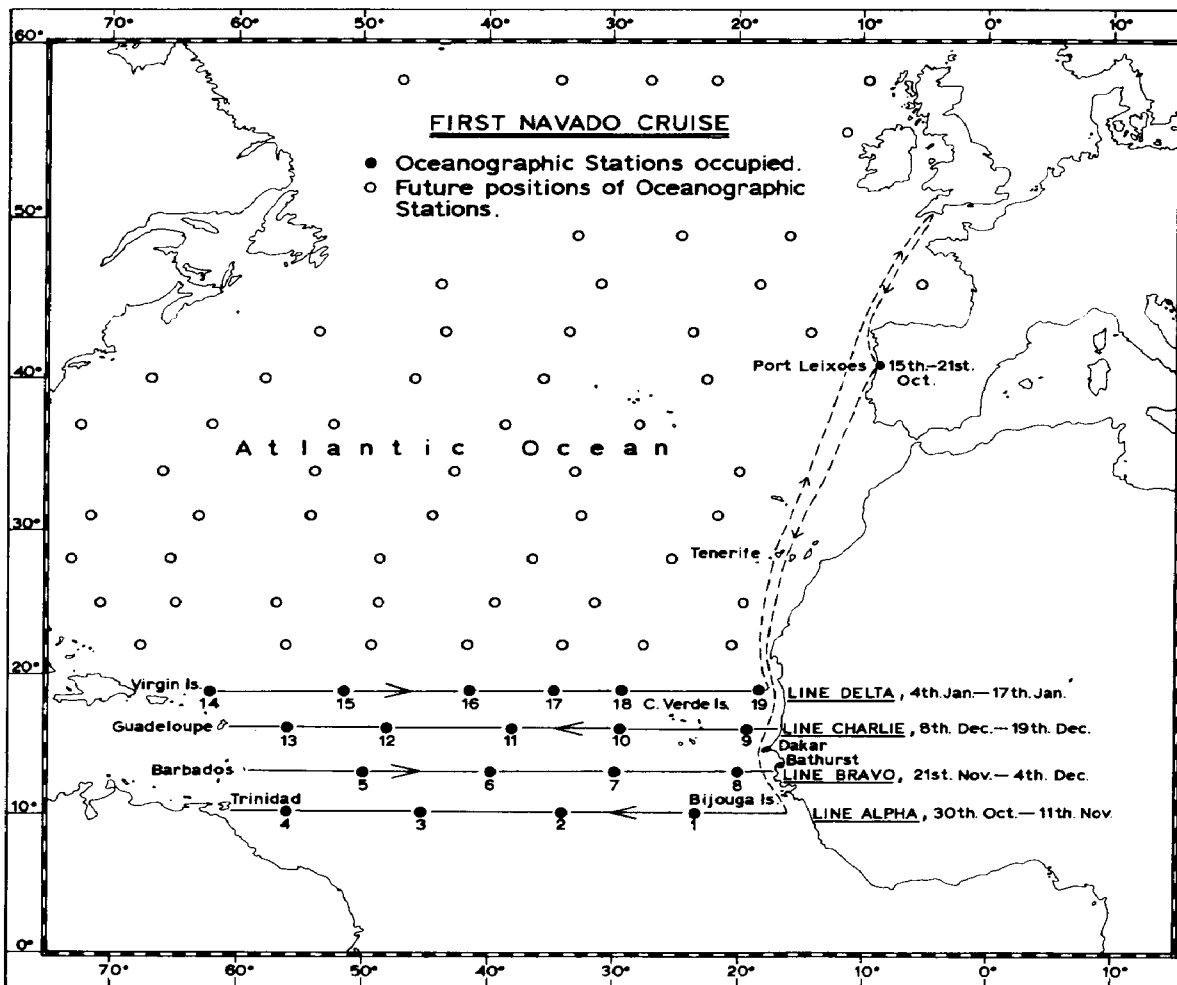


FIG. 9. — Plan of first Navado Cruise.

CONCLUSION

It would appear, at first sight, that this cruise has been an encouraging start to a systematic oceanographic survey of the North Atlantic. Scientists from three different countries co-operated closely with surveying officers of the Royal Navy, each learning something from the other about oceanographic fieldwork.

Hydrographic surveyors engaged in this work are resolved to apply to oceanographic observing the highest standards they have traditionally applied to their hydrographic work; only if this is achieved are the resulting oceanographic surveys of value.

Oceanographic surveys, like hydrographic surveys, are of little use until results are published, and the proof of Navado cruises will only be found in due course in such publications.

A meeting of scientists and others representing all departments or establishments having a direct interest in the work was held on the termination of the cruise and here the responsibilities for processing and publishing the various quantities of data were agreed.

References

- [1] GASKELL, T. F. and RITCHIE, G. S. : H.M.S. *Challenger's World Voyage 1950-52*, *International Hydrographic Review*, November 1953.
- [2] *Admiralty Marine Science Publication No. 4* : Bathymetric, magnetic and gravity investigations H.M.S. *Owen 1961-62*, Part I Text, Hydrographic Dept., Admiralty, London, 1963.
- [3] International Hydrographic Bureau : *Proposals submitted to the 8th International Hydrographic Conference*, Monaco, April 1962.
- [4] *Admiralty Marine Science Publication No. 4* : Bathymetric, magnetic and gravity investigations H.M.S. *Owen 1961-62*, Part II Profiles, Hydrographic Dept., Admiralty, London, 1963.