

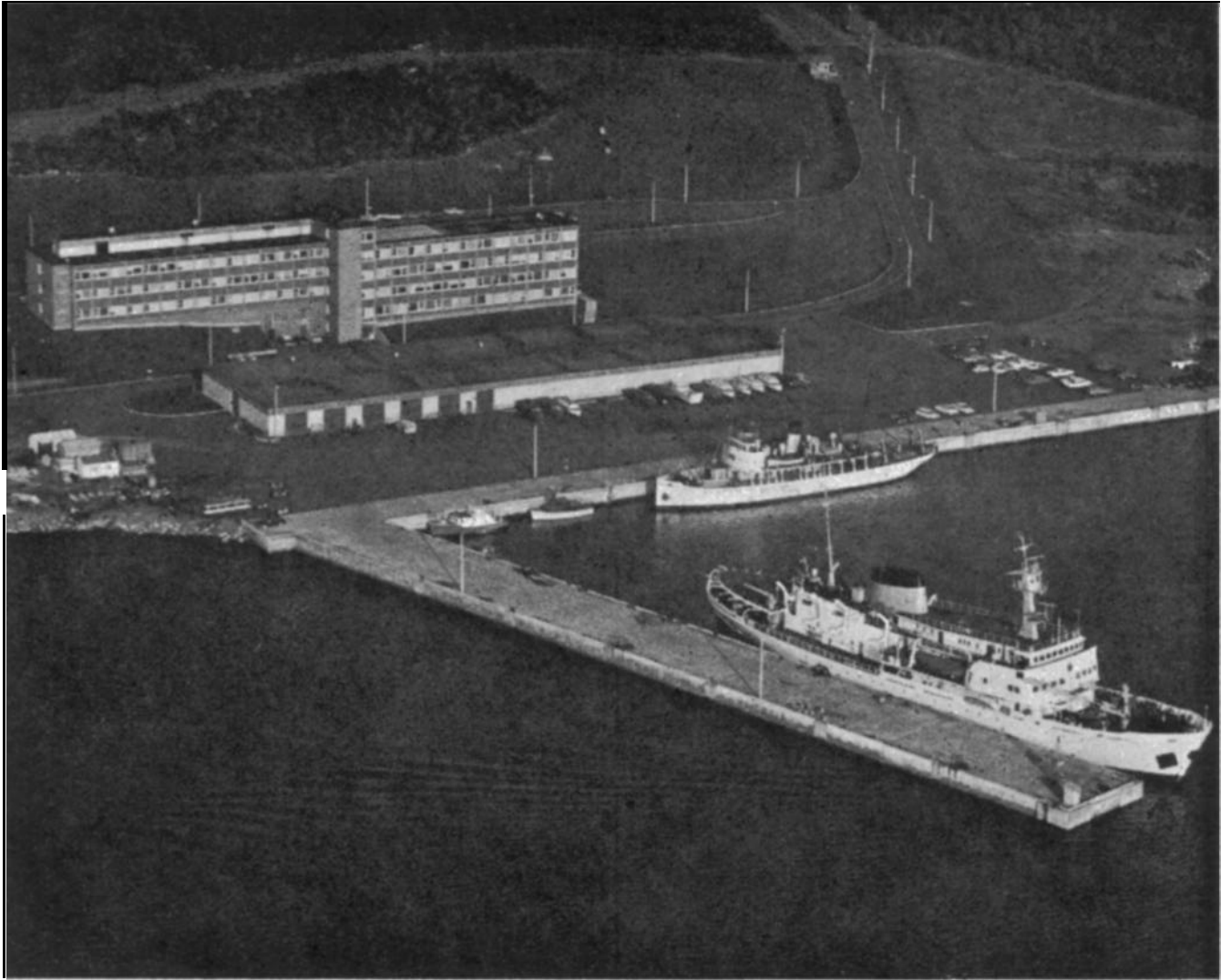
THIRD ANNUAL REPORT

1964

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BEDFORD INSTITUTE OF OCEANOGRAPHY
MARINE SCIENCES BRANCH
DEPARTMENT OF MINES AND TECHNICAL SURVEYS

Dartmouth, N. S. - Canada



THIRD ANNUAL REPORT

1964

REPORT B.I.O. 64-18

DECEMBER 1964

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Foreword

The second complete year of operation of the Bedford Institute of Oceanography has been one of development and growth. The various experimental programmes are now firmly established and results are beginning to be achieved. The pace of hydrographic surveying has been maintained, and control of the operation has gradually passed from Headquarters in Ottawa to the Regional Office at B.I.O. We have taken first steps towards the integration of scientific data-gathering with hydrographic surveying, and indications are that this is worthy of increased emphasis in the coming year.

The most discouraging feature of the year's operations was the resignation of the Director, Dr. W. N. English. He had guided the growth and development of the Institute during its first, and very critical, two years of existence. It is certain that without his firm and vigorous direction, the Institute would not have achieved its present growth, and it is ironical that the achievement of many of the objectives for which he strove was delayed until after he left. The recent announcement of the appointment of Dr. W. L. Ford as Director was enthusiastically received by the staff; we welcome him back to the Maritimes and look forward to an active future under his leadership.

The end of "austerity" in May has paved the way for a sorely needed increase in staff, mainly in the support areas. Administrative and clerical personnel are beginning to arrive, and it is hoped that technicians and Ship Division staff will be recruited soon. The anticipated increase during the next year will bring the total numbers to be about 260, and with the filling of

existing facilities, thought must soon be given to future expansion of accommodations.

The group of marine geologists of the Geological Survey of Canada, under the leadership of Dr. B. R. Pelletier, which moved to B.I.O. in 1963 has now become fully integrated with the rest of the Institute insofar as their scientific work is concerned. They are expected to be seconded for administration and financing to the Marine Sciences Branch, and thus to B.I.O., in April 1965. They are already one of the principal research groups of the Institute, and their annual report appears as Section 3.3. of this volume.

The Atlantic Oceanographic Group of the Fisheries Research Board continues to share our building and facilities and to collaborate in the life and work of the Institute. In accordance with a recent recommendation of the Canadian Committee on Oceanography, they are planning to expand their activities in biological oceanography, and will thus help to round out still further the research program at B.I.O. Their annual report, which is produced separately as a report of the Fisheries Research Board, has been reproduced for information as a special supplement in the present volume.

The notes which follow on the various activities at the Institute were written in each case by the leader of the group concerned. They are reproduced here as submitted, with only minimal editing. For the reader who is not familiar with all the abbreviations used in the text, a list with explanations has been inserted on Page 79.

A View Of B. I. O.

For the past two years, summer students working at the Institute have been required to write a short report on the work upon which they were engaged, and were encouraged to comment upon working conditions and similar topics. The reports are combined in an Internal Report, and a summary has been made by Dr. C. R. Mann. The summary is included below, as it gives an interesting general impression of the Institute, as seen by a cross-section of potential future staff.

"The reports this year were much better written and more informative than those in 1963. In the 1963 reports the students did not think they 'had a very good summer at the Institute, which was understandable - in view of our disorganization and lack of challenging problems that could be given to them at that time. The reports this year made very good reading and all the students felt they had benefited by their stay at the Institute. To quote one, "I have enjoyed my time at B.I.O. I learned a great deal about scientific research, oceanography, and even life. I feel I am a 'better person for "having been here". This type of comment ran throughout and the students left with a very good impression.

"The series of summer lectures were also very well received and there is no doubt that they should be continued. Again, their comments can be summed up by quoting one of them: "The orientation lectures delivered by senior scientists should be continued. They give the student a simple but clear outline of the purpose and future plans of the various branches (groups) at B.I.O., and of the opportunities available in them." One student even went as far as to suggest that we should have lectures on cruises to take the place of those that he had missed at the Institute.

"There are three points which are worth bearing in mind that arose several times in report's:

1. There is no doubt that the students these days are very well aware of the capabilities of a computer and one almost gets the impression that their attitude is - if you haven't got a computer I'm not interested.
2. The students are well aware of salary ranges, and in two cases remarked that salaries at the Institute were generally lower than would be expected in industry. To quote: "I have the impression that the salaries paid the permanent staff at B.I.O. are below average. If this is correct, then it is very unlikely that the ambitious program for summer students will succeed in attracting them as permanent employees after graduation. A scientist, following his chosen line of research, might remain at a low salary because he is his own master, but not everyone can have his own project. Most probably after a few years at B.I.O., these people will leave for a place offering either more opportunities for research or a larger salary?"
3. There is dissatisfaction with the fact that they are not paid for statutory holidays as in industry.

"To sum up, it was extremely heartening to read the reports this after those of last. The students had obviously enjoyed their stay; they had learned something and their criticisms were well thought out, to the point, and a useful guide as to how the Institute appeared in their eyes. These are not to be overlooked, because the student carries back to his university with him some reflection of what life is like at B.I.O."

Research and Surveys

3.1. OCEANOGRAPHIC RESEARCH

3.1a. AIR-SEA INTERACTION

L. A. E. Doe
J. A. Coombs (to June 30, 1964)
R. H. Loucks (from June 25, 1964)
S. D. Smith (Educational Leave, UBC)
V. N. Beck
B. Trudel (Seconded from Electronic Maintenance)
B. G. Pottie (Seconded from Electronic Maintenance)

The immediate aim of our program of Air-Sea Interaction studies is the determination of energy exchanges across the interface by the measurement of turbulent fluxes, and our main emphasis continued throughout 1964 to be on instrumentation. While preliminary results have indicated that our basic approach is promising and our instruments capable of yielding significant measurements, the need for further development of both instruments and techniques was indicated during a field operation in January and February. This was carried out in CSS BAFFIN near Aruba, N. A., in cooperation with Dr. E. B. Kraus and his group of the Woods Hole Oceanographic Institution. Data on wind stress on the sea surface which were obtained during this operation still have not been fully processed owing to delays in digitization. (Our own equipment for digitizing analogue records is still incomplete, but we hope to be self-sufficient in this respect early in 1965).

A new three-component thrust anemometer, the Mark V, has been built by Engineering Services, and will soon be calibrated in the wind tunnel. The main innovation of the Mark V is that the forces are transmitted through a rigid rod, pivoted at the centre. In former models, vibrations of the mounting were transmitted directly to the transducers. The new design should eliminate response due to transverse vibrations of the anemometer frame. Other improvements include better protection and accessibility for the transducers and minimum interference with the air flow by the anemometer body.

The electronic circuitry of the Mark V has been completed by B. Trudel and is almost ready for packing. Using operational amplifiers as the basic circuit components, it is hoped that the problem of drift with time and temperature will have been eliminated or substantially reduced.

To measure the turbulent flux of water vapour we need a miniature, fast-response humidity element. Internal Note BIO 64-43, by V. N. Beck and R. H. Loucks, describes tests and experiments to evaluate a particular sensor which may offer some promise for this purpose. Other elements are also being tested, but it may be that the "state of the art" does not yet permit our requirements to be met.

A miniature, fast-response thermometer is being developed by B. G. Pottie using a micro-bead thermistor as the sensing element. If the system is successful, mounting the sensor directly on the head of the anemo-

meter will facilitate the simultaneous measurement of wind turbulence and temperature fluctuations. Further studies will attempt to evaluate the stability of the system and its suitability for use over the sea surface.

Other instrumentation projects include work by R. H. Loucks on a frequency-modulated output from the transducers of the thrust anemometers, and investigations to find a satisfactory means of telemetering data from the instrument buoy to a data collection centre.

For 1965, there will be a continuation of the instrumentation program. With the availability of several thrust anemometers and the arrival of hot-wire anemometry equipment, the wind tunnel will be extensively used as a dynamic calibration facility. A field operation off Prince Edward Island is scheduled for the summer to collect data on energy exchanges across the air-sea interface. This will afford an opportunity for actual field tests of the new equipment. A stable platform, a modified version of the one used at Aruba, will support the instruments.

We expect to present reports on some of our projects at the First Canadian Conference on Micro-meteorology to be held April 14-17 at Toronto.

3. 1b. ARCTIC OCEANOGRAPHY

A. E. Collin
J. R. N. Lazier

Interest in Arctic Oceanography has been maintained at B.I.O. during the past year in spite of crippling staff losses to the group: Mr. Holler is now in charge of ship operations at B.I.O., and John Dugas, who was formerly working on the Arctic Index project, resigned in June to join General Motors.

The preliminary compilation of the proposed index of arctic oceanographic data and the survey of the material have been completed and the format and geographic limits of the index established. Many of the Baffin Bay charts have been drawn but, unfortunately, this work has been postponed due to lack of staff.

An Assessment of the efficiency of research cruises in arctic icebreakers has been completed and the results presented in B.I.O. Internal Note 64-15.

A. E. Collin participated in the Department of Transport delegation to Russia and the Baltic Countries in February and March and also visited the German Hydrographic Institute in Hamburg and the Scott Polar Research Institute in Cambridge. This trip was the first of an agreed series of exchanges of Russian and Canadian delegations concerned with the problems of navigation in ice. It is expected that a Russian party will visit Canada in the spring of 1965. An account of this visit has been prepared as B.I.O. Internal Note 64-16.

The final preparation of a review of arctic oceanography, undertaken in collaboration with Dr. M. J. Dunbar of McGill University, was completed and the manuscript submitted for publication. This paper is

now published in the second volume of "Oceanography and Marine Biology", Dr. Harold Barnes, Editor.

The preliminary evaluation of the 1963 LABRADOR data from Northern Baffin Bay and Smith Sound has been compiled by Collin and Holler and the results presented in B.I.O. Internal Note 64-37. This material will be reviewed and the manuscript enlarged to include the 1964 observations. It is intended that the final report will be submitted for publication early in 1965.

A successful research cruise was undertaken aboard the D.O.T. icebreaker CCGS LABRADOR during the period September 1 to October 24. The oceanographic staff taking part in this investigation included six investigators from B.I.O., and two technicians from the U. S. Navy Oceanographic Office. The project included investigation of the northern channels leading into Baffin Bay as well as the deep and intermediate water of the Bay. Geological sampling was conducted over a detailed grid in northern Baffin Bay and a series of cores were taken in the deep basin.

In addition to the marine sampling program, a 1200-mile magnetometer survey was completed in eastern Lancaster Sound. This investigation was carried out without interruption during a 4½-day period as a self-contained project. To complete this phase of the work, three additional magnetometer lines were recorded across the deep Baffin Bay Basin bringing the total magnetometer track to 1600 miles.

The U. S. Navy Oceanographic Office requirement for information from selected locations in Baffin Bay for the ice forecast project was undertaken as part of the overall program.

In spite of a 15-day interruption in the scientific program, due to other urgent ship commitments, the 1964 LABRADOR project was completed in record time. Excellent cooperation aboard LABRADOR, favourable weather, and adequate working facilities combined to make this one of the most successful cruises undertaken aboard this icebreaker.

A preliminary study of the physical oceanography of the Labrador Sea based on the ICNAF data of 1963 was completed in April. Since then, a more complete study of the area has been undertaken using the Erika Dan data obtained in the winter of 1962. Some of the problems being investigated include the formation of the intermediate water, the origin of the deep and bottom water, and the exchange between the Labrador Basin and Baffin Bay.

A cruise to the central portion of the Labrador Sea - to study the intermediate water formation, planned for February 1965, - has been postponed for a year. During the next year it is hoped that a study of the available data will isolate specific problems which can be tackled during the proposed cruise. It is also intended that a report on these investigations will be published in 1965.

3.1c. CHEMISTRY AND MARINE RADIOACTIVITY

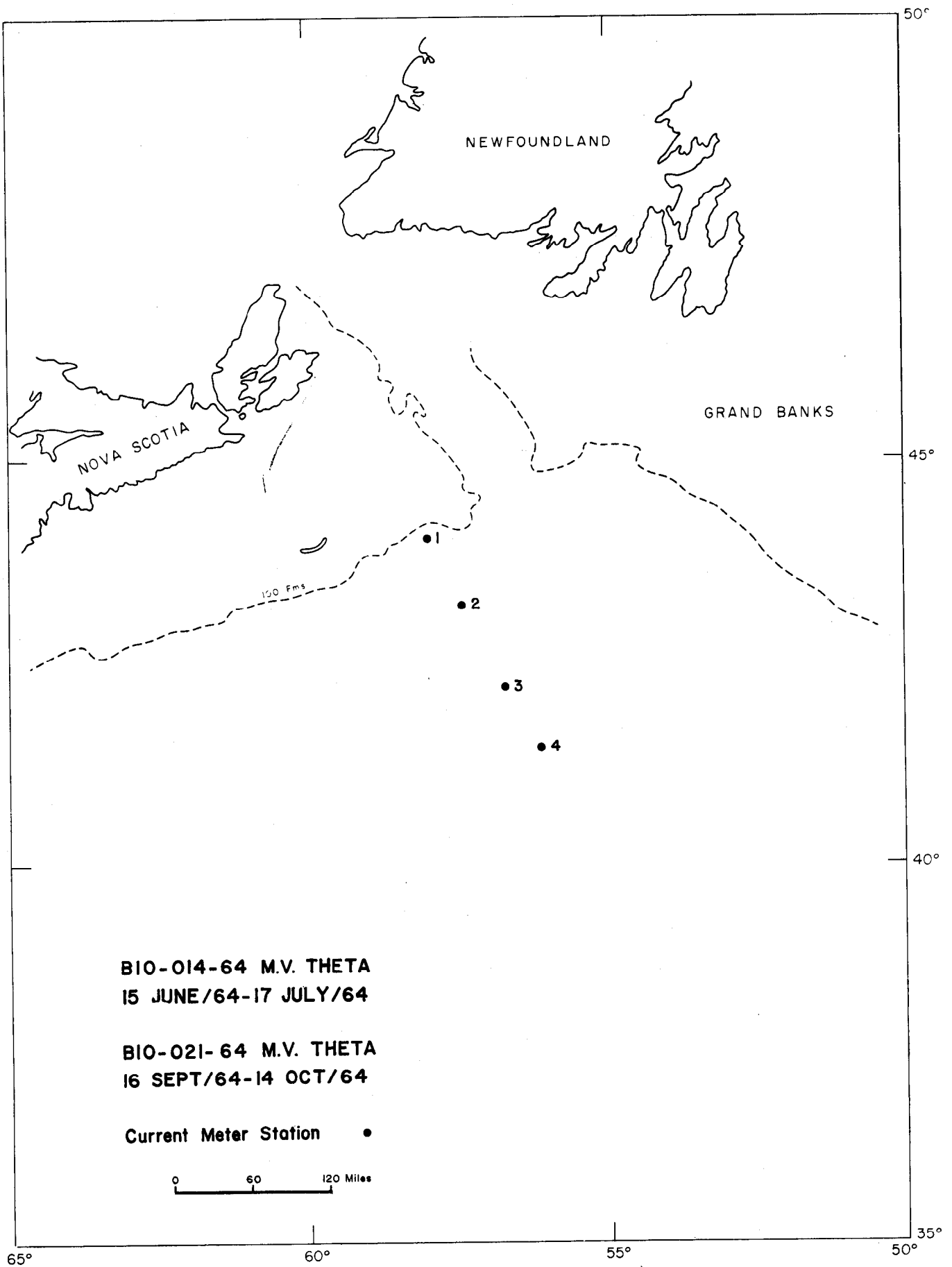
I. M. H. Pagden
A. R. Coote
M. E. MacLean
W. Young
R. S. Hiltz

Samples for fission product analysis have been collected on two cruises this year. On cruise Baffin 9-64, twenty-nine samples from surface, intermediate and deep waters were taken in the area between the Azores and the Continental Shelf, as part of the investigation of the vertical distribution of fission products in the deep ocean. On cruise B.I.O. 20-64 five samples were taken in the region of Kane Basin. Winch problems did not allow the collection of a further fifteen samples in Baffin Bay and adjacent areas in a search for the outflow of fission products from the Arctic into this region. Cruise experience so far indicates the desirability of a few minor modifications to the water samplers, which have operated with 95% success on the collections so far, particularly as it is anticipated that the rate of sampling will be increased in the future.

The scope of the chemical analyses has been reduced so that at present just caesium and strontium are separated from the samples, by a method which gives good yields and is reproducible. Blank analyses performed with Cs¹³⁷ sample analyses show an activity much less than that of the samples until the low background counting assembly, whose prime component is an 11-ton naval mortar, has been installed. The experiments performed so far using the mortar indicate that it contains remarkably little contamination and should prove adequate. The presence of this facility will enable an important set of experiments to be made on blanks so that the radioactive assay of the deep samples may be made with some certainty.

So far no method has been found which allows the quantitative separation of gamma-ray emitting products which have a high fission yield and short half life, i.e. Ce¹⁴⁴, Zr⁹⁵ and Ru¹⁰⁶, in conjunction with the method used for Caesium and Strontium. The development of such a method would be most useful as the same computer programme which is being developed for the measurement, by spectrum analysis, of Cs¹³⁷ and possible contaminant activity may be used for these other radio isotopes.

During 1963 much confidence has been gained in the reliability of the inductive salinometer when used aboard ship. This view has been disturbed as a result of the salinity measurements from the Baffin 009-64 cruise where the errors in measurement of some deep samples were unacceptably large. Consequently, it has been recommended that duplicate salinity samples be taken when these salinometers are used, until the cause of the disparity is discovered. It has also been recommended that a random sample, having a known but not generally disclosed salinity, be measured after every 50 or 100 salinity observations.



Molybdate reactive silicate was measured on the Baffin Gulf Stream cruise (See Section 4.1.) As expected preliminary examination of these results indicates that they may be useful for identification of water masses. Samples taken for total silicate analysis on this cruise have not yet been measured, owing to the present shortage of technical staff.

In September A. R. Coote submitted a thesis entitled, "A Physical and Chemical Study of Tofino Inlet, Vancouver Island, British Columbia", to the Chemistry Department of the University of British Columbia and it was accepted for the M.Sc. degree. This work, carried out under the direction of Dr. P. M. Williams of the Institute of Oceanography at U.B.C. and with the cooperation of Marine Sciences Branch, is being published as B.I.O. Report 64-10. It describes the distribution of properties and flushing characteristics of the inlet and discusses in a quantitative fashion the pH-Alkalinity relationships in the anaerobic basins.

3.1d. CURRENT STUDIES

W. I. Farquharson
D. Dobson
F. D. Ewing

In May, the former Tidal Survey was divided into two sections, "Current Studies" with Oceanographic Research and "Inshore Tidal and Current Surveys" with Hydrographic Service.

For four weeks in June and July and for a similar period in September and October, Current Studies section carried out experiments in laying deep-sea moorings and in acquiring current data at three sites.

The techniques for laying the moorings, in depths of from 1,000 to 2,700 fathoms, were basically the same as those which had previously proved successful in shallow water. A buoyant groundline, of a length 30% greater than the depth of water, was anchored at each end, a surface buoy was attached to one end and the instrument mooring, suspended from a submerged float, to the other anchor of the groundline.

The experiments included position fixing at the recovery of the groundline by means of towed grapnels. Practically simultaneous decometer readings from Decca chains 2 and 6 were used for position fixing. It was found that the repeatability of such fixes was thoroughly reliable and there were rarely any fixing problems during daylight hours at distances of over 400 miles from the two master stations. It was demonstrated that it was feasible to relocate and recover the groundlines on occasions when the surface watch buoys had broken adrift.

Throughout the first cruise the currents were weak at all sites and no serious problems were encountered in maintaining moorings in position. These conditions were the same during the second cruise at the more northerly sites but at the one which lies near the edge of the Gulf Stream a strong westerly current with a surface rate of up to 1.5 knots had set in. With the relatively large cross-section of the available mooring ropes the current drag was so great that the surface

buoys dragged their anchors and broke adrift, while the submerged floats were forced down to such a depth that they exploded. In the course of the experiments at this site a number of buoys and instruments were lost despite intensive searches on which the ship was employed practically throughout this second cruise. When the risk of further losses could no longer be justified the current profile was measured by suspending the current meters below a freely drifting surface buoy whose track was fixed by Decca.

A few days observations were obtained at each of the three sites at depths down to 9,000 feet and it was found that the predominant movements in the near surface layer were of a different type at each. At Station #2 which lies near the foot of the continental slope, the direction of flow turned clockwise through 360° in the tidal period of 12 hours. At Station #3 which is situated in an area of weak currents, the direction of flow turned clockwise through 360° in the inertial period, which in Latitude 43° is about 18 hours. Near the edge of the Gulf Stream where Station #4 lies, a westgoing current predominated.

The Section collaborated with the Trade and Industry Department of the Provincial Government in making a film to be entitled "The Tides of Fundy". A fifty-foot graduated pole was erected in Minas Basin for illustration of the tidal rise; theoretical reasons for the large tides were outlined, suggestions and material for animated explanatory diagrams were provided.

The data from 1963 current surveys in St. Lawrence Estuary and Belle Isle Strait are now in the final stage of analysis and reports are being taken in hand.

3.1e. ENVIRONMENTAL PREDICTION

C. D. Maunsell
W. B. Bailey
R. R. Weiler
J. Butters

The collection of oceanographic data and its interpretation to describe processes active in the sea leads to practical results only when information can be supplied to people in a form they can use. This is the aim of the Environmental Services Group, who provide senior staff to the Office of the Canadian Maritime Commander Atlantic (Oceanographic Services for Defence). The primary function of these services is to provide descriptions of oceanographic conditions as required by the Defence Forces, but much of the data is available to other agencies.

Daily charts showing the distribution of sea surface temperatures and the depth to which the surface mixed layer extends are broadcast regularly by radio facsimile. Since these charts are based on reports from merchant and naval ships which describe conditions where they happen to be, there are serious gaps in coverage which cause difficulties in interpretation and hence, in forecasting probable trends. In order to obtain a more detailed description of a selected area on a controlled basis, an oceanographic survey was carried out in cooperation with the U. S. Naval Oceanographic Office

during November and December 1964. CSS BAFFIN and USNS JAMES M. GILLISS carried out an oceanographic survey of an area about 300 miles by 360 miles extending from the Continental Slope off the northeast United States towards Bermuda. Part of this area is traversed by the Gulf Stream. The ships made frequent bathythermograph observations, occupied conventional oceanographic stations to make temperature and salinity measurements, and made continuous recordings of near surface temperatures. Tracks were arranged to be traversed twice with a five-day interval. During the period that the ship survey was being carried out, aircraft operated by the U.S. Navy and the R.C.A.F. Maritime Air Command made frequent surface temperature measurements over the area, using Airborne Radiation Thermometers sensitive to the infra-red radiation from the sea.

The data gathered during this cooperative study will be used to improve the description of oceanographic conditions issued by both countries, and to carry out research into the application of computers to the forecasting of oceanographic conditions.

Some thought has been given to the application of time series analysis methods to oceanographic data. The large difference between the response time of oceanographic instruments and the interval between observations leads one to anticipate the possibility of serious aliasing problems. A preliminary study carried out by a summer student showed that the present data available for the Scotian Shelf is insufficient to define any other peaks than the annual temperature cycle.

Dr. Maunsell attended the Environmental Symposium held in Rome by the International Commission for the Northwest Atlantic Fisheries in January. Here many of the Fisheries applications of environmental oceanography were discussed. Dr. W. N. English attended the NATO Oceanographic Environment Conference at Naples in March.

3.1f. FROZEN SEA RESEARCH

E. L. Lewis
P. H. Bridge
R. W. Mackay
R.W. Sawler (Seconded from B.I.O., January - March)
B. Trudel (Seconded from B.I.O., January - March)

Locations and Timing

During 1963 the group was based at B.I.O. and in January 1964, travelled to Cambridge Bay, N.W.T. to make field measurements. After returning to B.I.O. in March 1964, staff and equipment were transferred to Victoria, B.C. in order to work contiguously with a group at the Pacific Naval Laboratory having nearly identical logistic problems. Effective operation became possible by May 15, and has continued until the present when preparations are being made to return to Cambridge Bay, N.W.T. in January, 1965 for two months, in order to complete the previous winter's experiment.

Scientific Work

During the period at Cambridge Bay measurements of the natural heat flow through the sea ice were

obtained. Results for temperature distribution and heat flow were taken at hourly intervals and extended over a period of 664 hours, about 500 hours of which were recorded, the rest being lost due to breakdown of the automatic data logging system. Recalibration of the thermistors used for temperature measurement together with determination of error and reproducibility of results from the logging system shows that in the range of greatest interest (0° to -10°C) temperatures were recorded with an accuracy of $\pm .01$ C. It had been intended to measure the enhanced heat flow due to the operation of a bubbler ice removal system but this part of the experiment had to be abandoned to the persistent failure of the engine driving the air compressor.

Measurements of ice thickness, density and salinity were also taken and the temperature structure of the water column beneath the ice was investigated. Computation of these results was completed by mid-August but further analysis and consideration has been deferred until results with the bubbler system in operation are available.

Engineering

Two major projects and a variety of minor ones have been undertaken. The design of a mobile Arctic research unit based on a standard tracked vehicle structure (Thiokol 604) has been completed and construction by contractor begun. The preparation and fitting out of three insulated chambers for use as cold rooms and specification of the necessary refrigeration equipment has been completed. Tenders for this equipment are presently under consideration in Ottawa.

A series of experiments has developed the technique of making highly reliable underwater joints in thin insulated wire (16 ga or less) which must stand storage at -60°F. A multitude of small items have been designed or modified to cope with a very cold environment. Included are compressed air de-icing, engine modifications, design and construction of a special purpose winch and many special fixtures for work in an Arctic winter environment.

Administrative

The establishment of the group in the Victoria area necessarily involved a considerable paperwork output which continues at a lower rate during normal running. Office and laboratory facilities are now complete (cold chambers excepted) and the provision of vehicle housing and storage space is a current topic. The provision of a secretary next year will greatly assist routine office work.

Comment

The outstanding fact apparent from this year's and previous years' work is that a great deal of engineering effort is required to back up a modest scientific program of Arctic investigation. It is estimated that about 80% of available effort should be directed towards engineering and construction for optimum efficiency and staff should be appointed accordingly.

The year's work (apart from the field season) has, as a matter of necessity, been concerned almost entirely with equipment design and construction. It is intended that next year with an increased staff and a deliberately minor field investigation, a full analysis of the results from the previous two winters will be completed.

The work of Dr. K. O. Westphal at U.B.C. on the theory of heat conduction is and has been of most direct interest to us. It is hoped that our association will continue throughout the coming year.

3.1g. GEOPHYSICS

B. D. Loncarevic
D. L. Barrett
P. H. McGrath (until September 1964)
P. J. Berghuis (until November 1964)
G. H. Ewing (Educational Leave)

Cruises

The group spent 186 man-days at sea and participated in the following cruises: BIO 18-64, 19-64, 20-64, 22-64 and 27-64. The areas of investigation were on the Nova Scotia Continental Shelf, Bay of Fundy, and Canadian Arctic. Logistic and tactical support was given to the following groups: (1) Dominion Observatory, Gravity Division, for bottom gravimeter work in the Great Lakes; (2) Geological Survey of Canada, Geophysics Division, and Institute of Oceanography, Dalhousie University, for seismic refraction work in the Gulf of St. Lawrence, northeast of Newfoundland and on the Continental Slope, southeast of Sable Island; (3) Geological Survey of Canada, Geophysics Division, for airborne magnetometer experiments using a ship-based helicopter; (4) University of Toronto, Geophysics Laboratory, for deep sea heat flow experiments.

Instrumental Development

A Geophysics Data Logger, (GEODAL) was the main instrumental development during the past year. This equipment consists of a Parabam Calendar, solid state master digital clock, analogue to digital converter and counter for the gravimeter, a magnetometer counter and digital to analogue converter, a Decca plotter and solid state digital store, a solid state 32-channel punch programmer and a Friden SP2, 8-level paper punch. In the present configuration GEODAL produces a 64-character word once a minute. This information is in a computer-compatible format and makes semi-automatic data processing possible. In use on three cruises during the year, the equipment produced approximately 600,000 gravimeter and magnetometer readings on punched paper tape.

In order to improve the reliability of the magnetometers, the old Berkley counters have been replaced by Hewlett - Packard pre-set counters, and the phase-lock loop is being redesigned. A new, and simpler, bottle was designed as the input detector. It is molded directly onto the cable and thus eliminates the need for a machined fish with O-rings, watertight connectors, etc. The new detector has improved the signal strength by a factor of 4.

The heat flow programme is still in the Instrumental Development stage. Dr. C. R. B. Lister has completed the development of a transistorized digitizing bridge. A B.I.O. development of a miniature binary tape punch is well advanced. The digitizing bridge together with the punch will go into a 2 3/4 inch inside diameter pressure container. The completed heat flow apparatus will be an integral part of a piston corer with the thermistor probes mounted on outriggers attached directly to the coring barrel. Delivery is expected soon of a second heat flow apparatus developed at Chr. Michelsen Institute, Bergen, Norway. This instrument will be used to measure the temperature in the upper sediments in shallow seas over a period of several months. Data will be recorded digitally on magnetic tape and an acoustic telemetering link will be provided.

Gravity Research

One ASKANIA sea gravimeter, Ser. No. Gss2-17, was operated during the year. The original Enograph Potentiometric recorder was replaced by a more reliable HONEYWELL E-17 Stranducer recorder. A set of three Donner accelerometers was acquired for monitoring wave-produced ship accelerations. The gravimeter was calibrated over a secondary land calibration line of 195.2 mgal range, using Dominion Observatory bases at Shelburne, Chester Basin, B.I.O., Truro and Pictou, all in Nova Scotia. The base value at B.I.O. Pier, used in all data reductions was $g=980578.8$ mgal. The reported accuracy of the sea surveys is estimated at 3-5 mgal though the internal accuracy of a survey as judged by values on track cross-overs is around 2 mgal RMS. Accurate navigation remains the biggest operational problem. On the Nova Scotia Shelf, within Decca Navigator coverage, navigation is adequate. An experimental evaluation of VLF navigation is underway. It is anticipated that a short-term accuracy of 0.2 miles relative to a local reference (e.g. a moored buoy) is possible in the open ocean. Establishment of Loran C chains and acquisition of equipment will improve distant offshore fixing.

Gravity readings were obtained on approximately 7,500 line miles of survey track (5,000 miles CSS BAFFIN; 2,500 miles CSS HUDSON). The areas of surveys were approximately 500 miles in the Cabot Strait and Gulf of St. Lawrence, 3,500 miles off the Nova Scotia Continental Shelf and 2,000 miles in the Bay of Fundy. Gravimeter readings are reduced at 5-minute intervals along the ship's track representing approximately one mile station spacing. Preliminary reduction is available for 1/3 of the survey tracks.

The main result of this year's surveys was the discovery of a belt of negative free air gravity anomalies extending from the entrance to Chedabucto Bay to the Laurentian Channel and perhaps farther east. The anomaly is continuous at the - 20m gal contour for a distance of 110 miles. Within this contour are contained two large negative gravity centers of -40 mgal and -60 mgal. There is some indication that the anomaly is displaced in a southerly direction by a fault along the southwest side of the Laurentian Channel. This feature was named the ORPHEUS Anomaly after the Orpheus rocks near Madame Island in Chedabucto Bay.

The analysis of the reliability of shipborne gravimeter measurements, a joint project with the Dominion Observatory, is near completion. Both the LaCoste and the Askania sea gravimeter readings have been processed by the same computer programme. The final report will be issued shortly.

Research in magnetism

As part of the programme of evaluation of the reliability of geophysical measurements at sea, the effect of the ship's magnetism has been evaluated for CSS BAFFIN, CSS HUDSON, and CCGS LABRADOR. The ship's heading correction at 450 ft. towing cable length is 25 gamma peak to peak for BAFFIN, 21 gamma for HUDSON at 365 ft. cable length, and 18 gamma for LABRADOR at 360 ft. cable length. The first two determinations were in the vicinity of Halifax and the last near Thule, Greenland. The next important factor affecting the reliability of the sea magnetometer surveys is the diurnal change. A study of St. John's, Newfoundland, and Halifax station magnetometer records indicates that extrapolation from single shore-based stations could produce serious errors, especially if the survey area is close to the edge of the Continental Shelf. A development contract for four buoy magnetometers was let and the first units are now undergoing evaluation tests. These magnetometers are self-contained, can operate for 30 days on two car batteries and record on four-track magnetic tape. A readout unit has also been developed to list magnetometer readings on a flexowriter and produce computer-compatible punched paper tape. A magnetometer was operated on all shipborne surveys where a gravimeter was used. In addition to 7,500 line miles around Nova Scotia, an additional 2,000 miles were surveyed around Lancaster Sound from CCGS LABRADOR.

Reduction and compilation of the magnetometer surveys has not been started due to the shortage of staff. Preliminary analysis by D. L. Barrett of data from Lancaster Sound indicates that the depth to the source of anomalies in the Sound is great, thus supporting the hypothesis that the Sound is down-faulted. The south side of Devon Island is most likely a fault which trends northeast in Baffin Bay. It has not been possible to trace this fault for any great distance.

B.I.O. has started work in reflection seismology with the aim of developing a technique for both shallow and deep oceanic seismic profiling. The main sound source is a propane-oxygen exploder. A study has been completed on the shape and amplitude of the pressure pulse produced by various sound sources: two different kinds of sparker electrodes, a boomer and a gas exploder. At present, the penetration is limited to the time interval equivalent to the depth of water because of the confusion caused by the multiple bottom arrivals. The resolution is limited by the cavitation pulse. For work on the shelf a sparker unit has advantages because it is easy to handle. For work in deep water the gas exploder should give better results because of the lower frequency of its energy peak; it is, however, a fair weather instrument and cannot be operated when wind speed exceeds 25 knots.

G. N. Ewing, on educational leave at Dalhousie University, is studying the crustal structure under the lower Gulf of St. Lawrence on line from Tracadie, N. B. towards Cape Breton coast. He has observed three crustal layers below the sedimentary cover, with compressional velocities of 5.9, 6.3 and 7.1 km/sec. The mohorovicic discontinuity is at a depth of 49 km under Tracadie, N. B. and 45 km under Cheticamp, Cape Breton. The upper mantle compressional velocity is 8.5 km/sec. In the second phase of this investigation the new seismic evidence will be related to the known gravity and magnetic informations.

3.1h. GULF OF ST. LAWRENCE

W. D. Forrester

A quantitative study was made of the temperature-salinity characteristics in the Gulf of St. Lawrence during the period of July-August and during the winter period of February-March. The results of this study have been published as Report B.I.O. 64-11. This gives an estimate of the volume of water occurring in the Gulf with any given temperature and salinity, both for summer and winter, along with some discussion of the changes in properties from summer to winter. It is planned to prepare and present in the near future similar quantitative T-S diagrams of the Gulf of St. Lawrence for each month of the year. CODC has undertaken to compile the data for this by computer.

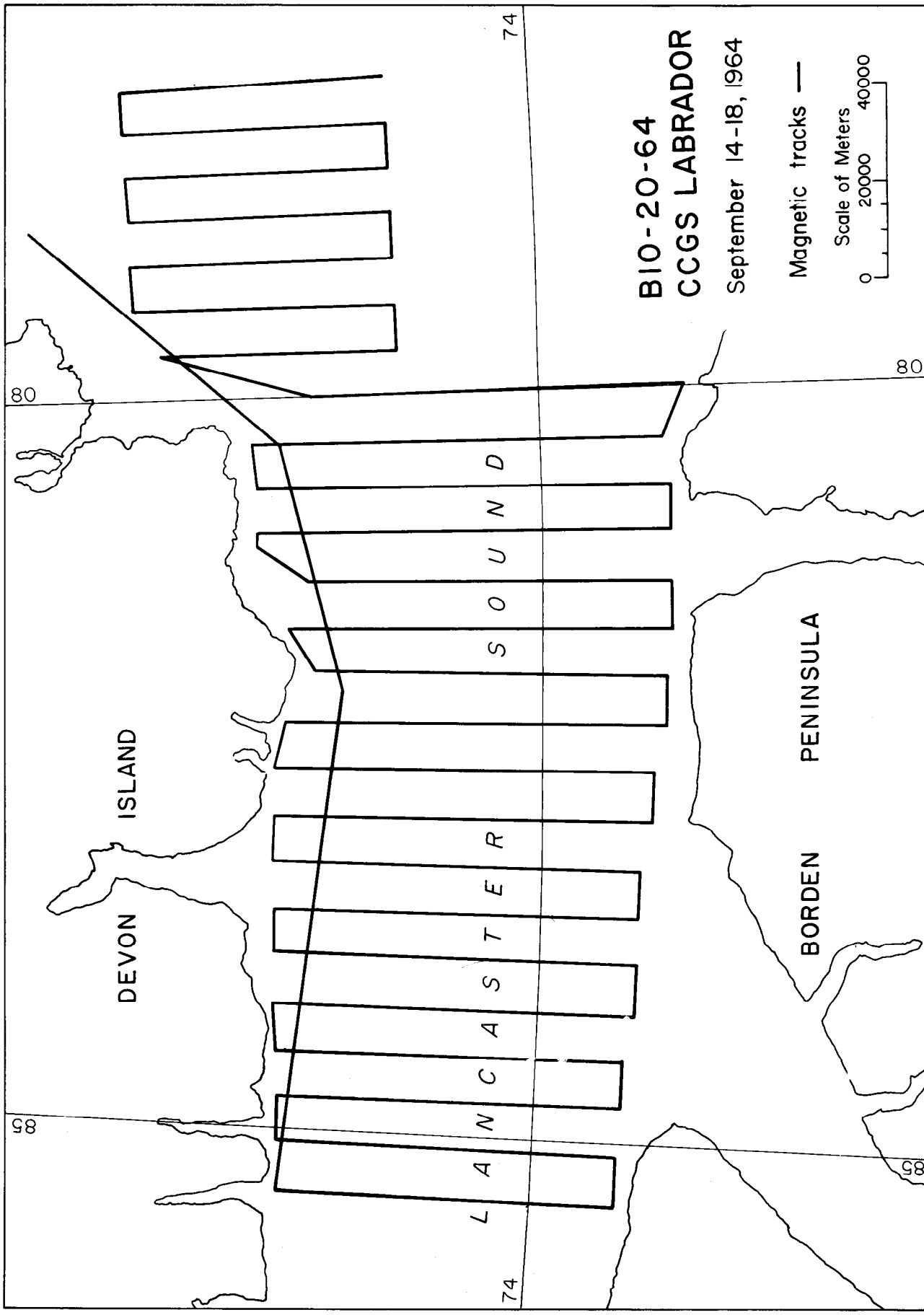
A current and oceanographic survey of the section of the St. Lawrence River from Pte. à Michel to Cock Pt. is planned for May-June 1965. An attempt will be made to anchor strings of water bottles across the section and to trip them simultaneously by a clockwork device that will release a messenger at a pre-set time from the top of the string. It is intended to do this once each day for several days until observations have been achieved at representative phases of the semi-diurnal tidal cycle. Recording current meters will be in place in the section during all this time and tide gauges will be in operation at each end of the section. From these observations it is hoped to learn more about the circulation in the Gulf of St. Lawrence, and also to assess the usefulness of the geostrophic approximation in coastal channels to augment current meter information.

Much thought and experimentation has gone into the design and acquisition of the necessary mooring, observing, and release equipment as well as into planning the actual survey program. A test run of prototype equipment was successfully carried out in Bedford Basin in October, and it is hoped that the finished field equipment can be made available in time for the proposed survey date. The experimental design of the messenger release mechanism was undertaken by the B.I.O. Engineering Services, and the mooring problems are under consideration by the B.I.O. Current Studies section.

3.1i. NORTH ATLANTIC

C. R. Mann
T. R. Foote
A. B. Grant

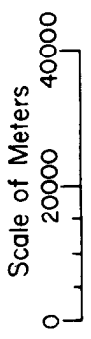
This year saw the completion of the collection of data in the deep water from the east coast of Canada to



**BIO-20-64
CCGS LABRADOR**

September 14-18, 1964

Magnetic tracks —



DEVON ISLAND

L A N C A S T E R
S O U N D

BORDEN PENINSULA

80

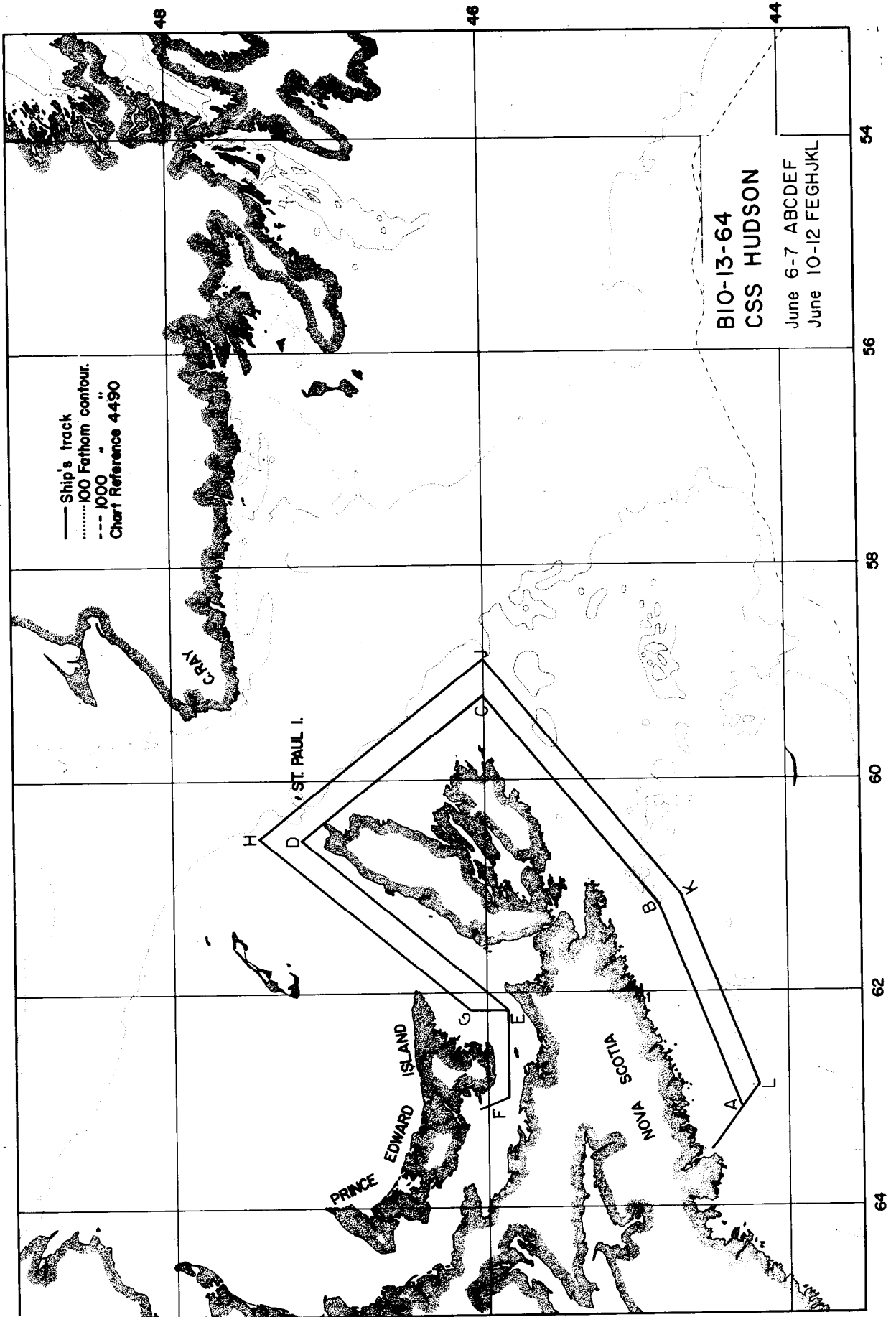
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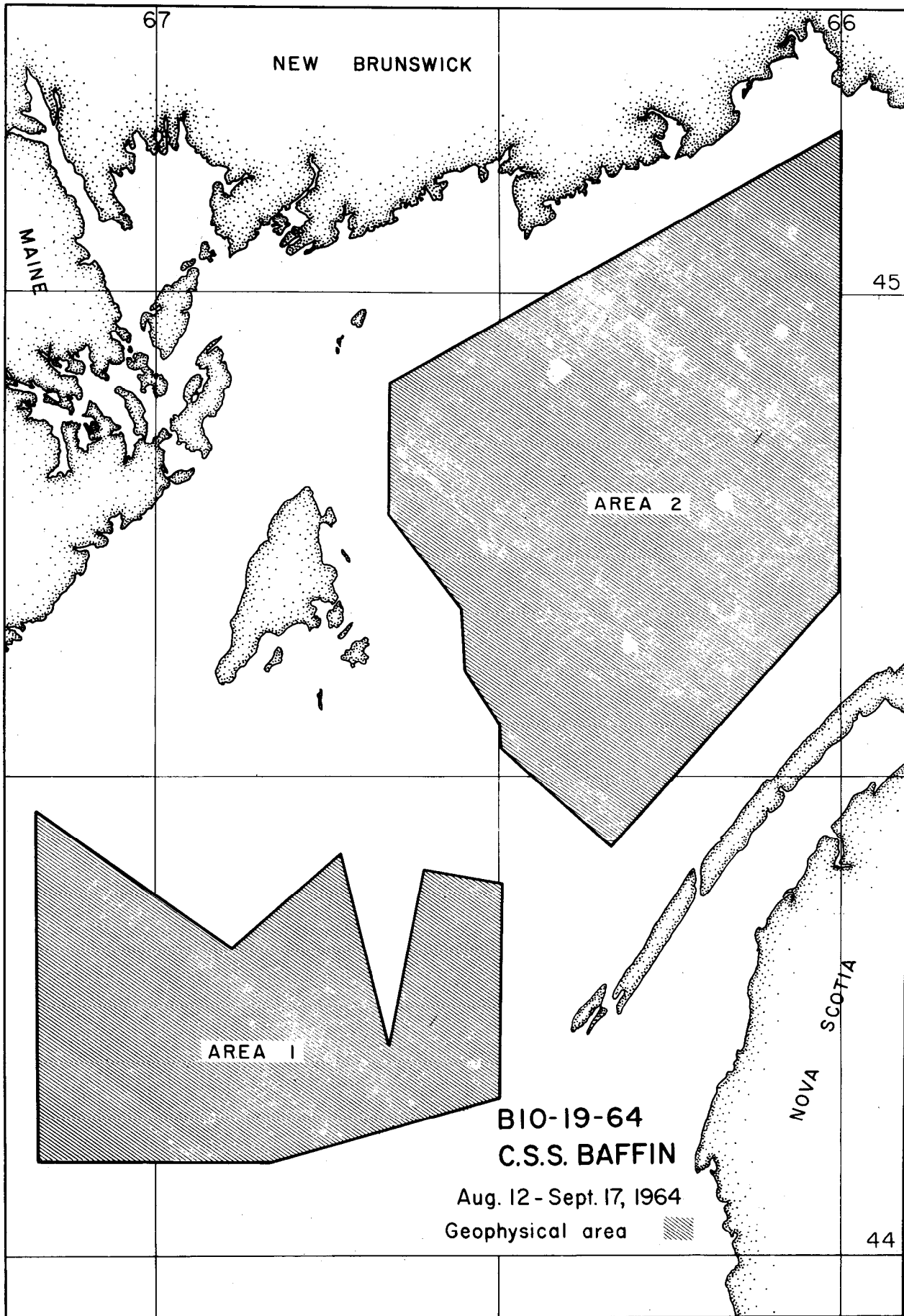
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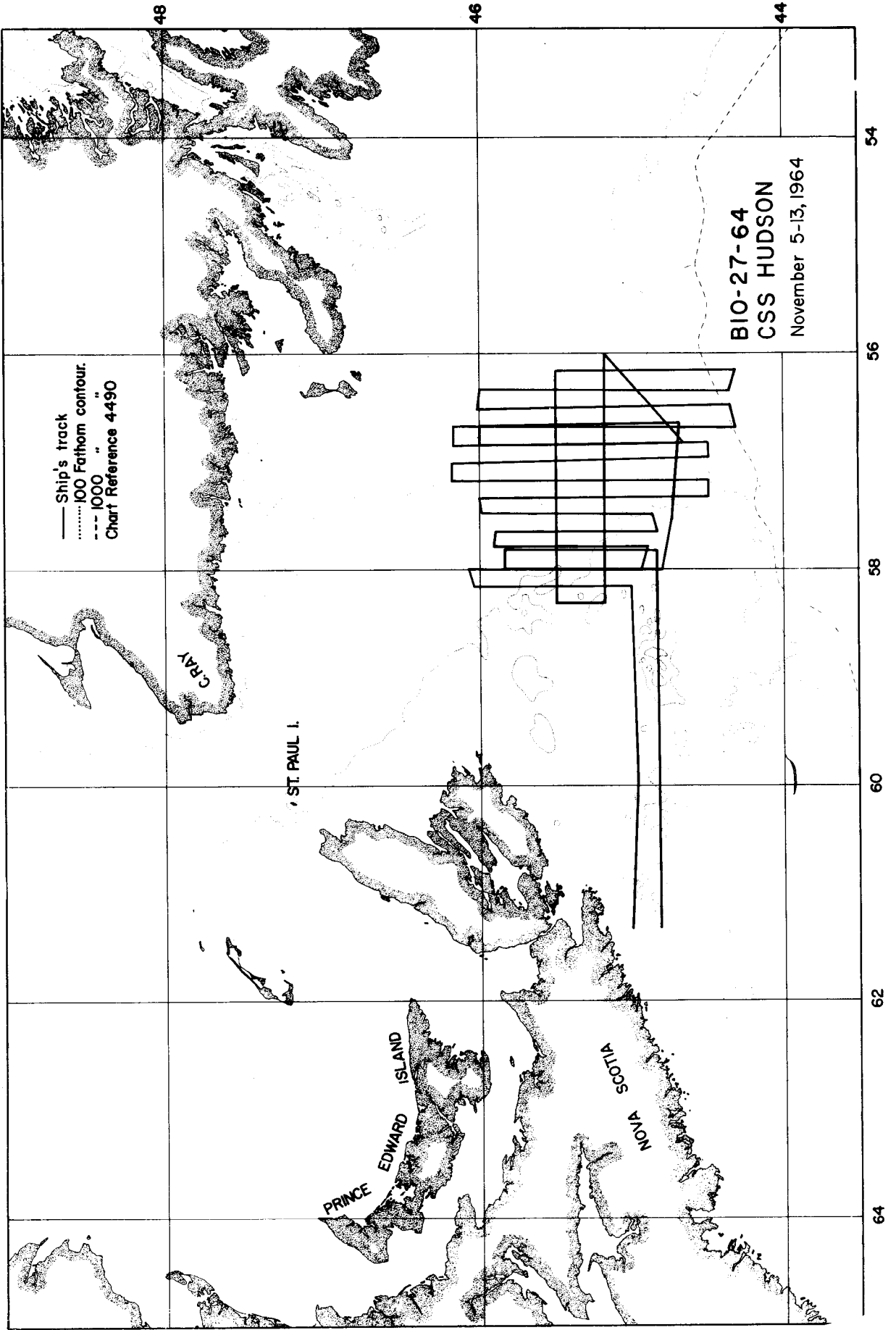
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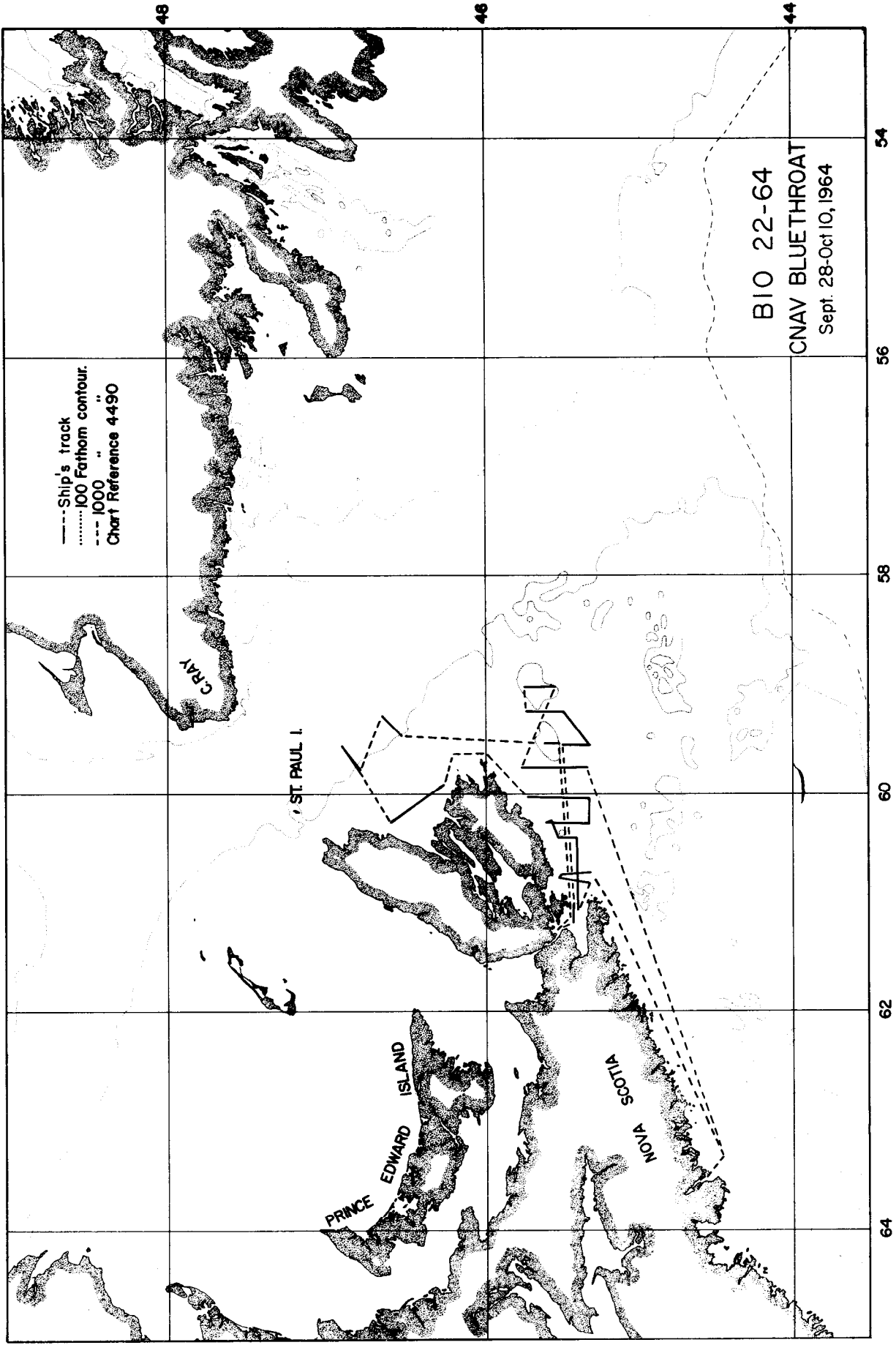
74

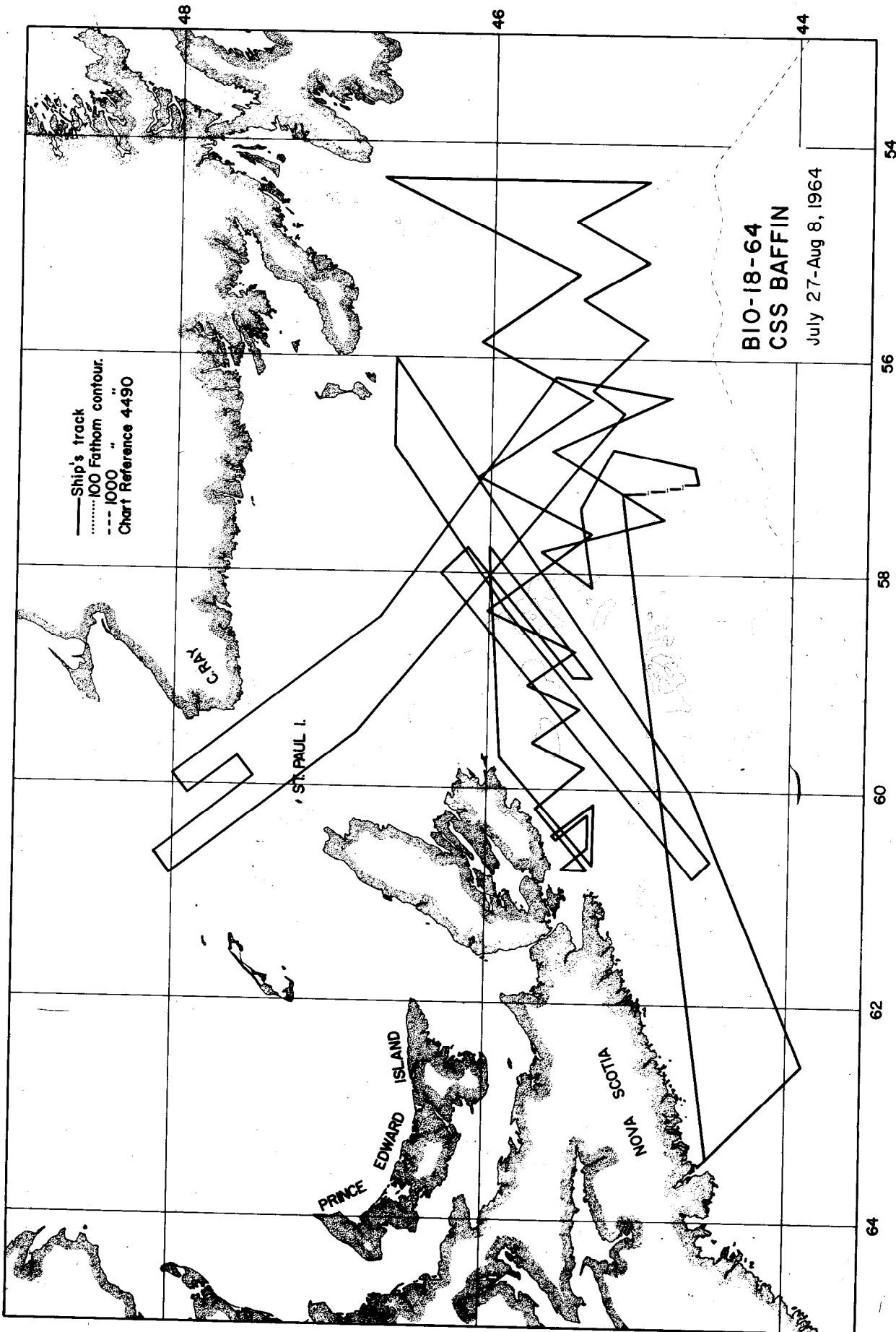
74

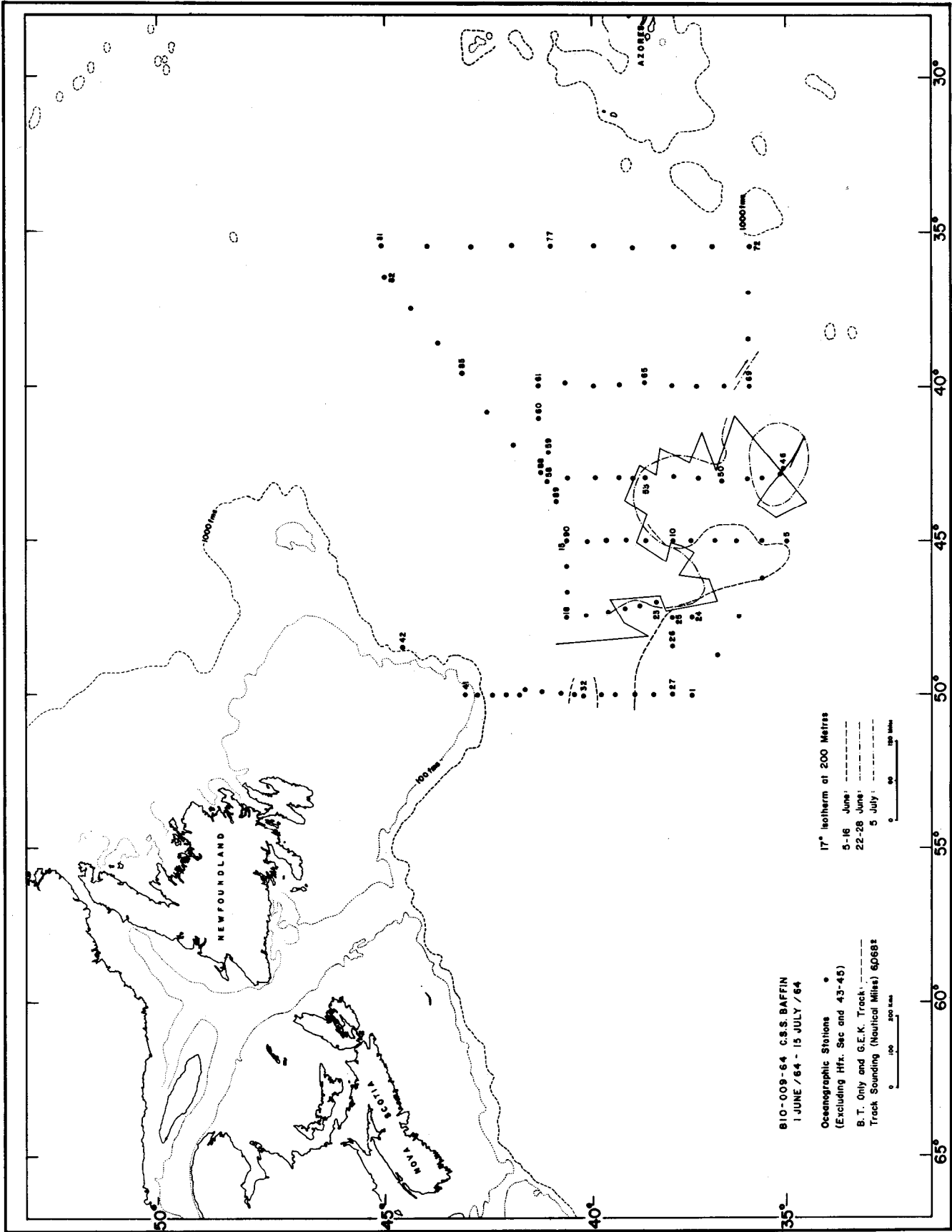












B10-009-64 C.S.S. BAFFIN
1 JUNE / 64 - 15 JULY / 64

Oceanographic Stations
(Excluding Hfr. Sec and 43-45)
B. T. Only and G.E.K. Track: ---
Track Sounding (Nautical Miles) 6068z

17° Isotherm at 200 Metres
5-16 June:
22-28 June: - - - -
5 July: - · - · -

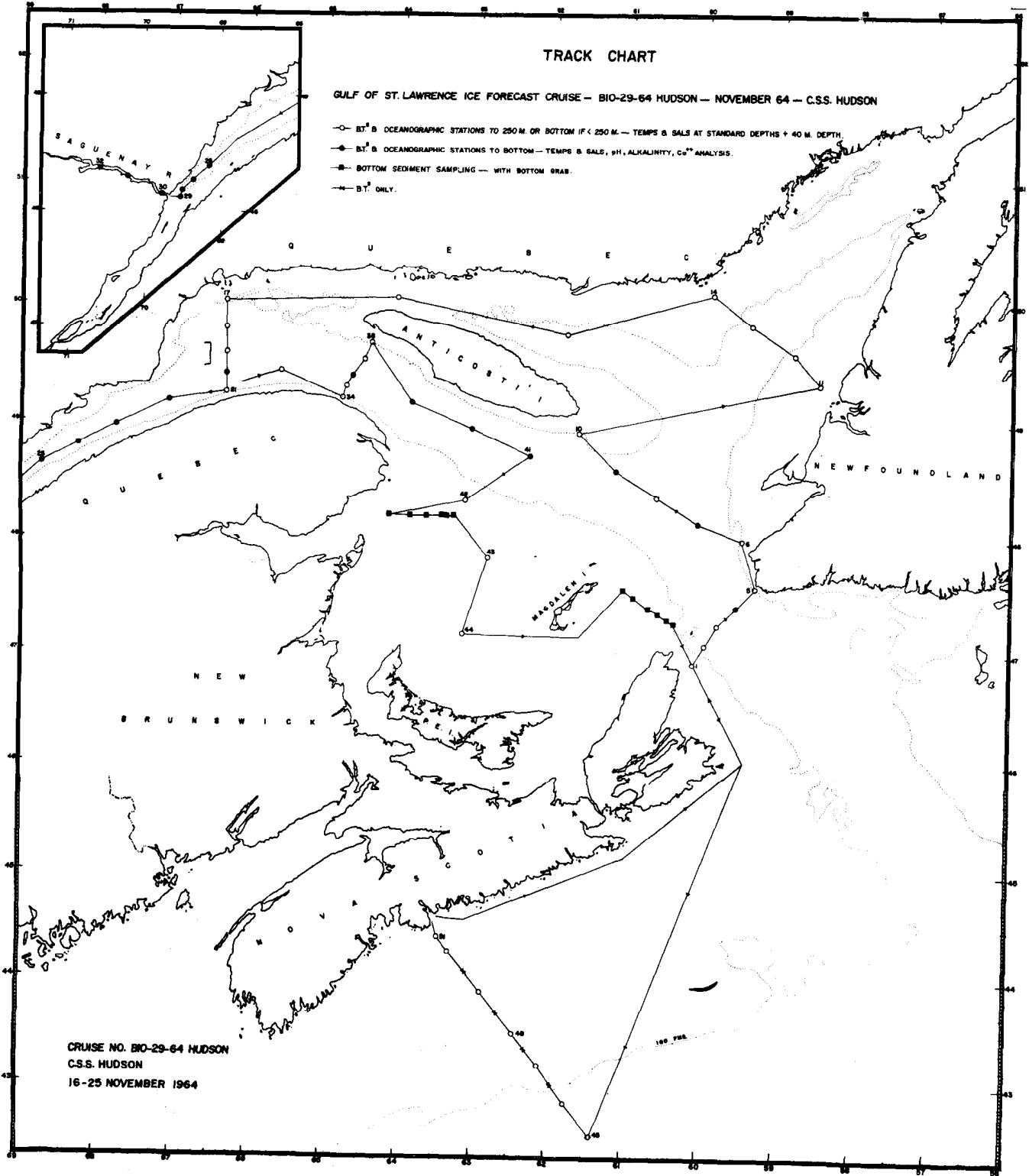
0 100 200 N.M.

0 50 100 Miles

TRACK CHART

GULF OF ST. LAWRENCE ICE FORECAST CRUISE - BIO-29-64 HUDSON - NOVEMBER 64 - C.S.S. HUDSON

- BT'S OCEANOGRAPHIC STATIONS TO 250 M. OR BOTTOM IF < 250 M. - TEMPS & SALTS AT STANDARD DEPTHS + 40 M. DEPTH.
- BT'S OCEANOGRAPHIC STATIONS TO BOTTOM - TEMPS & SALTS, pH, ALKALINITY, CO₂ ANALYSIS.
- BOTTOM SEDIMENT SAMPLING - WITH BOTTOM GRAB.
- B.T. ONLY.



CRUISE NO. BIO-29-64 HUDSON
C.S.S. HUDSON
16-25 NOVEMBER 1964

the Azores, which was started two years ago. This was accomplished in a cruise on CSS BAFFIN to the south-east of the Grand Banks in June and July. An extensive grid of oceanographic stations was run between the Grand Banks and the Azores. Temperature, salinity, dissolved oxygen and silicate data were obtained from surface to bottom, and in addition large samples were obtained for radioactive isotope analysis.

The results confirmed and extended the findings of the cruise in this area in the spring of 1963. The Gulf Stream was again found to continue as a well-defined current running to the southeast from the tail of the banks. It also acted as a northeast boundary for the upper 400 metres of the Sargasso Sea. In addition to the oceanographic stations, the Gulf Stream was followed using BT and GEK until it apparently came to an end about 500 miles to the southwest of the Azores. A large eddy was observed to have broken off from the Stream to the southeast of the Grand Banks in much the same fashion as had been observed in "Operation Cabot" in 1950 and in "Gulf Stream 60". In the latter two cases the observations were made almost due south of Nova Scotia, that is, to the west of the Grand Banks rather than the east. In addition to this eddy, a large body of water whose temperature, salinity, and oxygen were almost constant to 1,000 metres (temperature 14.7°C, salinity 36.15‰, oxygen 5.44 mg/l) was found north of the stream at Latitude 41°W Longitude 43°N. Apparently, this mass of water had been formed by some sinking process very recently. Examination of this year's and last year's cruises shows a considerable amount of water whose temperature was around 14° - 16° in this area, so that it seems possible that the area is one where formation of water of these temperatures occurs.

The processing of the data has been held up because of difficulties with the salinity measurements. The portable auto-lab salinometer gave considerable difficulty during the cruise and this, together with difficulty with the N.I.O. bridges back in the lab, resulted in a poor set of salinities. In order to determine how good they are, all deep data that has been obtained in the area by B.I.O. and other agencies is being plotted up to determine the scatter that might be expected in the deep water. As a result of the difficulties on the cruise, it has also been decided that no further reliance will be placed in salinities measured at sea using the portable salinometers, until such time as we are certain that we have completely reliable equipment. Salinity determinations will be made in the salinity lab at B.I.O.

Almost all the effort of the Group has been devoted in the last 2½ years to the acquisition of equipment and to collecting the data. Most of it has been processed and drawn up in sections. During 1965 it is planned to confine the work to the analysis and reporting of the results. As a first step in this, an Atlas is being prepared of all the data that has been collected throughout the area during the last 2½ years.

In addition to the work in the open ocean, members of the Group undertook the sea ice survey in the Gulf of St. Lawrence in November in collaboration with the Atlantic Oceanographic Group, and one of the staff has

spent three months working on photogrammetry with the Hydrographic Service in the Gulf of St. Lawrence.

3.1j. THEORETICAL STUDIES

G. T. Needler
K. O. Westphal
C. Quon (Education Leave from September)
R. Reiniger (Educational Leave)
C. Ross (Educational Leave).
R. C. Richards

During the past year members of the group have been active in several fields associated with the oceanographic research program at B.I.O. One of the basic areas of investigation is concerned with the development and examination of models of ocean circulation. In this direction, an attempt has been made to describe some of the properties of the equatorial undercurrent by a mathematical model. In the model the effect of mixing in both the vertical and horizontal directions has been included. The vertical eddy viscosity has been taken to be a function of the stability. It is hoped the model can be used to examine the development of an undercurrent at the equator when an appropriate wind stress is applied at the surface, but at the present time a tractable analytical solution to the resulting equations has not been found and numerical solution has not been attempted.

Work has continued during the year on several aspects of the problem of heat conduction in an ice sheet with the associated melting or freezing at the ice-water interface. Where possible, this work has been applied to the experimental program in frozen sea research conducted by Dr. E. L. Lewis. Dr. Westphal has written a report on his application of Portnov's method to the melting of an ice sheet for the case that there is a constant heat flux with ablation at the ice-water interface and an insulated boundary at the other interface. Similar methods have been applied in an investigation of the formation of an ice sheet due to radiation cooling. A report on this work is being prepared. In the future, more work will be carried out on problems dealing with ice sheets with more complicated boundary conditions at both interfaces.

Since the departure on educational leave to Cambridge of Mr. Quon in September, no member of this group has been directly concerned with the problems of wave hindcasting and forecasting. Before leaving, Mr. Quon wrote a report describing a representation using Tchebysev polynomials for the cutoff frequency associated with the Pierson-Neumann-James wave spectra. This representation should be valuable when the Pierson-Neumann-James spectra are used for wave forecasting or hindcasting using a computer.

An investigation has been started into the methods used to obtain experimentally measured oceanographic parameters at standard depths and to calculate quantities such as dynamic height and potential energy anomaly from these parameters. It is felt that the methods used by B.I.O. and C.O.D.C. do not always give the "best" results. During the summer, Mr. Ross and Mr. Reiniger were able to devise an interpolation

routine of an empirical nature which gives interpolated values of oceanographic parameters in regions of high curvature similar to the values obtained by hand plotting and without the characteristic "overshooting" of the present interpolation systems used by C.O.D.C. and others. Up to the present time, a satisfactory way of obtaining an estimate of the error resulting from this interpolation routine has not been found.

During the past year the reduction of current meter data has continued. Approximately 750 days of records have been read and re-read. Programs have now been developed to handle readings at five-minute intervals. This has necessitated, in the case of the 29-day analysis, the use of a table look-up for the evaluation of the trigonometric polynomials. Approximately one hundred 15-day analyses have been performed along with twenty 29-day analyses. Fourteen 15-day analyses have been completed for the West Coast using twenty-minute intervals. A program is now being developed to handle periods less than fifteen days. Also during the past year, a program for the prediction of tidal streams in a format similar to the tide table was written. Assistance has also been given to Dr. Westphal in the development of his programs and to the Geological Survey Group at B.I.O. in the development of their programs for sedimentary analysis.

3.2 HYDROGRAPHIC GROUP

R. C. Melanson	R. K. Williams	R. C. Lewis
F. L. DeGrasse	A. D. Kenney	A. L. Adams
L. P. Murdock	S. S. Dunbrack	G. H. King
P. L. Corkum	V. J. Gaudet	E. J. Comeau
T. B. Smith	J. G. Martin	W. R. MacKay
R. C. Amero	W. J. Probert	R. B. Lawrence
L. D. Quick	M. G. Swim	R. G. Wallis
J. M. R. Pilote	M. A. Hemphill	C. J. Pellerin
C. J. Langford	R. M. Cameron	J. W. Pritchard
J. G. Shreenan	G. M. Yeaton	T. J. Carew
T. M. Calderwood (Graphic Analysis Section)		

Introduction

The Hydrographic Group at B.I.O. has now completed its second year under the same roof as other groups concerned with oceanic studies. It is felt that this year will go on record as being the year that the first progress was made in "combined operations", i.e., cruises where research activities were carried on in conjunction with the charting operation. One major combined operation took place in the Bay of Fundy, and one of a lesser degree was undertaken in the Caribbean. The feasibility of such operations has now been proved and they should meet with even more success in future, as the field officers concerned become more familiar with the activities of the various groups.

Hydrographic charting in the East Coast Region was conducted by five ships, and the tides and currents survey by a 45-foot launch. One of the ships operating in this region was manned and directed from Ottawa, so cannot be considered a B.I.O. responsibility.

All undertakings met with considerable success, with the exception of the winter survey undertaken by the CSS HUDSON, which was plagued with equipment breakdowns throughout the survey period.

Personnel

At the commencement of 1964, the number of hydrographers at B.I.O. was 26. During the year three hydrographers and one tidal technician transferred from Ottawa. One resignation took place, one survey technician was engaged and transferred to Ottawa for training. Seven summer students and two N.C.O.s from Army Survey Establishment were employed during the survey season. Our present strength, including the Inshore Tides and Currents Groups, now stands at 31.

Hydrographic Surveys

During 1964, the following charting projects were carried out:

CSS HUDSON, with Mr. L. P. Murdock in charge, continued charting the Grand Banks using the two-range Decca Lambda system of navigation. This was a continuation of the survey commenced in 1963 by the CSS BAFFIN. The purpose of this was to satisfy three requirements: general charting, charting of the fishing grounds, and charting for oil explorations. This was the first major assignment for this ship following her construction, and unfortunately, as with most new ships, quite a number of mal-functions developed in her equipment. The charting accomplished during the survey period March 23 to April 27 was minute; however, since the time at sea did serve as an excellent evaluation period for the ship, during which many of her shortcomings came to light, the time is considered well spent.

CSS BAFFIN, with Mr. H. R. Blandford in charge, conducted a two-range Decca survey of the Bay of Fundy from August 11 to October 30. The purpose of this survey was to satisfy two requirements: general charting, and charting for the fishery. This was a combined survey, in which other groups interested in oceanic studies participated. The B.I.O. Geophysics Group conducted magnetic and gravity studies with shipborne apparatus, the Magnetics Group of the Geological Survey of Canada from Ottawa carried out magnetic studies by airborne instruments, and from time to time biologists from Dalhousie University made plankton tows. This was the first combined operation of this magnitude undertaken by one of our ships, and from all verbal reports, it enjoyed considerable success. The hydrographic portion was completely successful, covering the Bay to a stage where a much smaller unit can now complete the unsurveyed areas with relative ease when priorities warrant it.

The survey was expedited by establishing the necessary horizontal control, electrical centers, and erecting the first Decca chain with personnel dispatched from B.I.O. prior to the ship's arrival in the area. It is felt that considerable amounts of time and money were saved by doing this, and the method should be repeated in future wherever possible.

During March and April BAFFIN was engaged in charting in the vicinity of the British Virgin Islands under the direction of the Hydrographic Division in Ottawa.

CSS KAPUSKASING, with Mr. P. L. Corkum in charge, conducted surveys in Chaleur Bay from June 1 to October 23. The purpose of this survey was to satisfy two requirements: general charting and the production of a detailed plan of an area undergoing industrial development. In addition to this survey, a calibration of Conventional Decca Chains 6, 7 and 9 along a portion of the Nova Scotia coast and in the Gulf of St. Lawrence was to be performed on an opportunity basis.

The survey was supported by a Bell helicopter operating from shore-based camps. The primary function of this assistance was to establish control about the Bay's perimeter. The helicopter was a considerable asset, and the work output of the establishment was perhaps doubled by having such support.

The accomplishments of this operation include the survey of about 30% of the Bay and the extension of horizontal control to about two-thirds of the perimeter.

CSS MAXWELL, with Mr. J. M. R. Pilote in charge, conducted surveys along the Nova Scotia coast and in the Gulf of St. Lawrence during the period May 4 to October 30:

Location	Purpose
(a) Pubnico, N. S.	Completion of a number of outstanding field sheets to the point where the data could be incorporated into a new chart, or corrections made to existing charts.
(a) Richibucto, N. B.	Resurvey of the entrance to Richibucto Harbour and to ascertain changes in the channel caused by storm surges.
(c) Ile du Bic, P. Q.	Examination of a critical shoal. This danger was not shown on the British Admiralty Chart for the area, with the result of a ship grounding in 1963.
(d) Father Point, P. Q.	Wharf survey for chart revision.
(e) Cape Breton, N. S.	A conventional Decca survey of a 20-square mile area, to be incorporated into new chart edition.
(f) Deming Island, N. S.	Production of a properly controlled plan of the Loran establishment.
(g) Sheet Harbour to Ship Harbour, N. S.	As for Project (a).

This establishment had a very successful season, completing all of the foregoing projects except the last. Unfortunately, the weather was very inclement along the Nova Scotia coast during the major part of the season; otherwise, all projects would have been completed.

CSS ACADIA, with Mr. J. E. V. Goodwill in charge, conducted surveys in the Gulf of St. Lawrence and along the south and east coast of Newfoundland during the period May 23 to October 14.

Since the surveys undertaken by this establishment were under the direction of Ottawa, no attempt will be made to list the projects or accomplishments.

CSL ANDERSON, with Mr. C. J. Langford in charge, conducted a detailed survey of tides, currents and tidal streams in the immediate vicinity of Belledune Point, Chaleur Bay, and a general circulation study between Belledune Point and Caplan, P.Q., during the period June 2 to September 10. Assistance was also given to other B.I.O. personnel concerned with littoral drift studies.

The primary purpose of the Belledune survey was to provide data required for the large industrial development proposed for this area; the results will also be used for navigational purposes. During a three-weeks' period in August, an experiment was conducted in measuring currents by aerial photography. The results of this experiment are not known to date, but it is expected that they will be favourable and that this method of current measurement over large areas will become common in the near future.

This project was completed and data were supplied to the consultant engineers concerned with the Belledune study. All field data are now undergoing analysis for the production of current atlases and technical and data reports.

Regional Office

Field projects undertaken are as follows:

- (a) Horizontal control along part of the Labrador coast and on the west side of Ungava Bay by two hydrographers operating from the CCGS LABRADOR during the period July 12 to August 25.
- (b) Survey of Barrie Beach and D.N.D. wharves in Halifax Harbour.
- (c) Horizontal control at the Head of the Bay of Fundy.
- (d) Horizontal control in the vicinity of Jeddore, N. S.
- (e) Shoal examinations and wharf orientation in Lunenburg Harbour, N. S.
- (f) Survey of property adjoining B.I.O. holdings.

Training

A training program under the direction of Mr. L. D. Quick was conducted during the period January 6 to March 18. The purpose was to familiarize the hydrographers with the basics of navigation and seamanship, and to provide a refresher course in tellurometer and echo sounder maintenance. It had been intended to extend this training to include astronomy and certain aspects of oceanography but time did not allow. Eight hydrographers attended classes throughout the training period, and other B.I.O. personnel sat in on lectures of interest to them.

While this was a worthwhile effort, it is not intended to conduct classes on such a large scale during 1965: Now that a Branch Career Planning Officer has been installed at Ottawa, it is expected that some uniform training procedure will be introduced.

It is intended, however, to further the hydrographers' knowledge in other phases of oceanic studies by assigning field officers to the various groups at B.I.O. during the winter months. It is quite apparent that the hydrographer will have to become more versatile and take an active participation in most phases of oceanography. This can only be done by working in close association with the scientists. It is felt that the eventual goal will be to place the hydrographer on a level of versatility where he will be capable of collecting, and processing up to a certain stage, many of the data concerning most aspects of marine studies. It is realized that some of the hydrographers will not make this transition as quickly as others, but the potential is there and will only come to light as they are given the opportunity to work with the scientists.

Research and Development

Mr. R. K. Williams conducted experiments with a hydrophone for checking the accuracy of echo sounders. The main objective of these experiments was to find out if the use of a hydrophone could be substituted for our present method of accuracy checks by lowering a bar below the transducers. These trials have had considerable success, but are still inconclusive; they will not be completed until sometime in 1965, when pressure recording equipment has been received.

Mr. Williams also made a field evaluation of the "Edo" 9006 shallow water sounding machine. The purpose of this evaluation was to assess the machine's overall performance, and compare it with that of the shallow water sounders presently used.

The test pointed out that the sounder in its present state would not be acceptable for our purpose. It was found that the outboard transducers had such a high "Q" that a resonant response was built up to such a level that the incoming depth signal was obliterated when the launch proceeded beyond a speed of two knots. The manufacturers have been notified of our findings, and now intend to re-design the transducer with a lower "Q".

Graphic Analysis Section

On May 20, 1964 the Graphic Analysis Section came into existence at the Bedford Institute of Oceanography. Its purpose was basically to compile data for any group within the Institute who have need for such a service, but lacked the staff. Another responsibility of this section was that of receiving and compiling GEBCO data as collected by oceanographic cruises originating from the Institute.

To date, services have been provided to the following groups: Marine Geophysics, Physical Oceanography, Radio Chemistry and GEBCO, plus numerous small projects from other sources.

Due to the necessity of such a service and the immediate lack of qualified compilers and draftsmen; the initial staff for the section was comprised of hydrographers on rotation from field duty. At present, the permanent staff consists of one map compiler-computer.

It is now a certainty that such a section is of considerable importance to the Institute. The demands for assistance are continually increasing, and the growth of the section will have to be governed accordingly. In order that the services offered and work performed contain uniformity and standardization, steps must be taken to procure a permanent staff of qualified persons.

Rotational Assignment

Following the system initiated in 1963 nine hydrographers were placed "on rotation" and assigned duties at B.I.O. rather than in the field. In addition, three persons who had completed their field season during the early months in the year were given similar duties. Two were assigned to other B.I.O. groups: one with Geology, the other with the Currents Section of Physical Oceanography. One, as previously mentioned, was assigned to conducting a small research program on sounding equipment. The remainder were assigned duties within the Hydrographic Section. These consisted of small field surveys in the vicinity of Halifax Harbour, the graphic analysis of data, the preparation of technical records, and the writing of chapters for the proposed Hydrographic Manual.

Mr. F. L. DeGrasse, who acted on behalf of the Regional Hydrographer many times throughout the year, furthered his knowledge of administration. He also became more familiar with the other B.I.O. Groups, so that he now has a better appreciation of their undertakings and aims. Mr. L. D. Quick, who spent his rotational period with the Geological Group, has been placed in an advantageous position of now knowing something of this group's oceanic studies. This knowledge will stand him in good stead when the hydrographic survey has evolved to the stage where the hydrographer-in-charge conducts a combined operation comprising both hydrographic charting and scientific data gathering. This assignment also gave Mr. Quick a better appreciation of data that can be extracted from the echo sounder graphs collected during the course of hydrographic charting. Dr. L. H. King of the Geological Group has expressed a great deal of enthusiasm over the amount of information contained in these graphs, and with the findings of this year a report co-authored by Dr. King and Mr. Quick may be forthcoming. Mr. V. J. Gaudet, who was assigned to the Currents Section of the Physical Oceanography Group during his rotational period, has been given some appreciation of the oceans' circulatory pattern and the tedious tasks involved to bring this pattern to light. The hydrographers assigned to the Graphic Analysis Section during rotation have become more familiar with the outcome of some of the field data collected by various groups of the Institute, and this places them in some stage of preparation for the time when the B.I.O. Groups become more integrated. The hydrographers assigned to writing chapters for the proposed Hydrographic Manual now have a much better knowledge of hydrography than

before. Since a great deal of research had to be conducted before the chapters could be written in detail, the writers were forced to digest what had been written on hydrography by other authors. Mr. R. K. Williams, who spent much of the year conducting experiments with echo sounders, now has a much better knowledge of electronics. Some of these men have also gained from the added experience in the art of writing technical reports. And finally, another aspect which cannot be overlooked in rotation from the field is the human factor; the hydrographers had the opportunity of spending a summer with their families, and having had this opportunity, should approach their 1965 field assignments with new zeal.

This was quite a large group to place in advantageous office positions for the summer, and it is realized now that this calls for a long-range planning program to reap full benefits. However, it is felt that the personnel have gained considerable experience in matters other than field work by having this opportunity to stay in for a season. In future years, more of the people on rotation will be given the opportunity to work with other B.I.O. groups and expand their knowledge.

Change in Organization

Effective June 1, a change in the East Coast Regional organization was made, when the Current Section was divided into two parts. The "Current Studies" group, headed by Cdr. W. I. Farquharson, was placed under Dr. C. R. Mann, Senior Oceanographer, while "Inshore Tidal and Current Surveys", headed by C. J. Langford, was retained within the Hydrographic Group.

Displays

A hydrographic display was presented onboard the HUDSON by F. L. DeGrasse during the period June 7 to 10, at Charlottetown, P.E.I. This was in conjunction with the Royal Society Conference being held there and the Province's Centennial celebrations.

A display on hydrography and oceanography, presented at the Nova Scotia Fisheries Exhibition at Lunenburg during the period September 15 to 19, won special mention by the judges for its interest and presentation.

Proposed 1965 Field Program

CSS HUDSON - During the period that this ship is conducting studies in Hudson Bay, shore-based party will carry out a survey of Churchill Harbour; one hydrographer will remain onboard to collect

bathymetry in the Bay proper, as compatible with the other operations.

CSS BAFFIN - Will continue charting the Grand Banks during the period May 3 to November 7.

CSS KAPUSKASING - Will continue the Chaleur Bay during the period May 17 to October 31. There is a possibility that the survey will be curtailed for a one-month period in mid-season so that an evaluation can be made of a horizontal echo sounder:

CSS ACADIA - Will continue charting in the Gulf of St. Lawrence and along the east coast of Newfoundland.

CSS MAXWELL - Will conduct small harbour surveys in the Gulf of St. Lawrence for a three-months' period-May, June and July. This ship will then proceed to the Great Lakes to conduct three months of charting. The B.I.O. staff from the MAXWELL will spend the remainder of the survey season operating from a shore-based establishment in the Sheet Harbour area.

CHARTER VESSEL No. 2 - Will conduct a tidal and current survey at the Head of the Bay of Fundy in conjunction with a feasibility study by other agencies for harnessing the tides for hydro-electric power.

Conclusion

The B.I.O. Hydrographic Group enjoyed a productive year, completing about 90% of all field projects. The hydrographers on rotation were given the opportunity to become more familiar with the overall purposes of the Institute. The plan for certain integration of hydrographers with other B.I.O. Groups should prove advantageous to all concerned. When it has been fully implemented, it should allow more hydrographic charting to be accomplished, also more oceanic data to be collected than at present; this will follow from a more efficient use of both personnel and ships. Of course, to exploit this development to its fullest potential, there would have to be a considerable increase in field officer strength.

Responsibility for hydrographic operations has now been transferred from the Ottawa Headquarters office to the Bedford Institute. In view of the magnitude and importance of the tasks ahead of us, it is expected that the survey group will increase in size, and, we are sure, in efficiency. The role of the hydrographer in the work of the Institute promises to be increasingly diversified and productive.

STATISTICAL SUMMARY OF FIELD WORK - 1964

	HUDSON	BAFFIN	H.Q.	KAPUSKASING	MAXWELL	ANDERSON	TOTAL
N. Miles Sounded	343.7	6922	52.7	2863.7	1349.0	-	11,531.1
Ship Track Sounding (N. Miles)	-	-	200	-	-	-	200
Area Surveyed (Sq. N. Miles)	208	2680	-	345	116	-	3,349
Area Triangulated (Sq. N. Miles)	-	-	-	-	23	-	23
Tellurometer Traverse (N. Miles)	-	203	585.0	228	19	-	1,035
Shoals Examined	-	4	32.0	59	294	-	389
Coastlining (N. Miles)	-	1	1	131.3	19	-	152.3
Triangulation Stations Est.	-	49	102	87	71	-	309
Stations Monumented	-	32	44	26	17	-	119
Conventional Decca Calibration Stations (Lambda)	2	19	-	126	15	-	160
Tide Gauges Est.	-	2	1	4	6	5	18
Bench Marks Est.	-	3	-	12	6	11	32
Stretchline Sounding	-	-	3.3	-	-	-	3.3
						Self-Recording	
Current Meters Used	-	-	-	-	-	12	12
						481 days Data	
Moored Obs. Stations	-	-	-	-	-	9	9
						21 Days	
Anchor Obs. Stations	-	11	-	-	-	15	26
Photo Control Shore Stations	-	-	-	-	-	18	18
Photo Control Sea Stations	-	-	-	-	-	18	18
Stadia Traverse Stations	-	-	-	-	-	13	13
Sub-tense Method. Stations	-	-	-	-	-	1	1
Chaining	-	-	-	-	-	9000 ft.	9000 ft.
Stations Occupied	-	-	-	-	-	11	11
Observations	-	-	-	-	-	1300	1300
Stations Built	-	-	-	-	-	8	8
Stations Occupied	-	-	-	-	-	3	3
Beach Sectioning	-	-	-	-	-	2000 ft.	2000 ft.
Beach Sectioning Obs.	-	-	-	-	-	9	9

3.3 MARINE GEOLOGY

B. R. Pelletier
G. A. Bartlett
D. E. Buckley
R. Cormier
G. A. Duncan
D. R. Horn
L. H. King
R. J. Leslie
J. I. Marlowe
A. C. Grant
G. Vilks
F. J. E. Wagner
K. Hooper
K. M. Kranck
S. S. M. Pitcher

Introduction

During the year 1964, Marine Geology projects were undertaken over the Arctic Ocean, adjacent channels of the Arctic Islands, Nares Strait, Baffin Bay, Atlantic Ocean, River and Gulf of St. Lawrence, Northumberland Strait, and numerous bays and inlets of the Atlantic Provinces. These activities involved studies of sediments on the sea floor and the associated fauna, submarine topography, geological formations and structures, and stratigraphy of the unconsolidated sedimentary layers. In the laboratories, samples were studied from mechanical petrographic, spectrochemical, wet chemical, and palaeontological aspects. The total program is designed to lead to knowledge on the origin of our continental shelves, geological processes, evolution and speciation of certain fauna, past oceanic climates and geography, and modern oceanic environmental factors which govern sedimentary deposition and ecological niches.

Study material was collected by means of bottom grabbers, dredges, both gravity and piston covers, and hand-picking by SCUBA divers. These various investigations were augmented with the aid of the following: bottom photographs for observing the nature of the sea bottom; echo sounder records for obtaining depths of water above sea bottom in order to carry out physiographic analyses; and geophysical instruments for obtaining the thickness and structure of the unconsolidated sediments above bedrock, the configuration of the bedrock, and the structure of the bedrock involving rocks of various ages which may occur a few hundred feet below the sea floor.

Personnel

In this year two marine geologists, one scientific officer, and one laboratory technician were added to our staff. One Geologist's position was occupied by G. A. Bartlett, who received his Ph.D. degree in May at the time he joined the staff. Another Geologist's position was won by R. J. Leslie who joined the staff in September, while the Scientific Officer position was filled by D. E. Buckley who was transferred to Marine Geology in October. A competition for the position of Marine Geological Technician was advertised and the successful candidate should commence work early in the

new year. Three of our staff remain on educational leave and three more are obtaining further academic qualifications at their own expense.

Cooperative Projects

In keeping with the idea of employing non-scientific operational personnel to the best of their abilities, we are extending the concept to other working groups. However, such activity and thought is not one-sided as we have been approached by many groups at B.I.O. to join them in cooperative ventures. This practice of team work with other groups was continued from last year and developed along all levels of research and survey. Some of these cooperative projects will lead to joint reports and thus enhance the career development of all participants particularly in the technical fields. We have such projects already underway with the Hydrographic Group at B.I.O., the Fisheries Research Board of Canada, the Polar Continental Shelf Project, the Geological Survey of Canada in Ottawa, the Dominion Observatory, several Canadian universities, and the Oceanographic Research Group at B.I.O. Much of our efforts with the universities is in the form of physical and financial support of their research. In the long term we are developing areas in which young scientists can develop whom we hope to recruit in the future. However, the real purpose of such support is to widen our contacts domestically and internationally, assist worthwhile students in their careers, and stimulate wide interest in the field of marine geology.

Field and Office Activities

Due to the dual nature of the projects, it is difficult to separate field projects from laboratory investigations. Therefore, the following activities of Marine Geology are included under a single heading. These activities include those of both the continuing and the seasonal staff, and all were undertaken as projects of the Bedford Institute of Oceanography. Outside activities, reports and publications are listed elsewhere.

G. A. Bartlett commenced a field and laboratory study of certain benthic fauna in coastal and nearshore environments of the Atlantic Provinces in order to relate the faunal and sedimentary facies to certain oceanographic factors. This is primarily a study on foraminiferal ecology. Several field stations are being monitored during winter and early spring. In addition, Bartlett is engaged upon, or completing the analyses on the following: (1) faunal collection submitted by J. I. Marlowe, from the submarine canyon called "The Gully" on the continental slope off Sable Island; (2) faunal collection on material obtained by one of our seasonals, Mr. Eric Smith, while under the auspices of the Pan American Company on the Grand Banks of Newfoundland; and (3) faunal collections submitted by L. H. King on material obtained from the outer continental shelf off Halifax. Bartlett, with B. R. Pelletier, organized and supervised a SCUBA course for Institute personnel.

D. E. Buckley completed a sedimentological study of the beach and offshore area at Belledune Point on Chaleur Bay, New Brunswick, and with A. C. Grant wrote B.I.O. Report 64-12 on this investigation. Buckley

also completed his laboratory analyses on a sedimentological study in Malpeque Bay, Prince Edward Island, and has submitted a manuscript which is presently undergoing critical review. Buckley also wrote B.I.O. Report 64-2 on hydraulic settling tubes and their application to sedimentary studies. He also developed a program for electronic computing which has greatly facilitated the handling of data and accelerated the entire laboratory program. He is presently on educational leave at the University of Southern California where he is studying for a Ph.D. in geology.

R. Cormier supervised the processing of samples in the Sedimentology laboratory and, by organizing the seasonal staff, was able to process a record number of samples. He assisted Buckley in the field on the Belle-dune Point study, and carried on with programming of data in the laboratory. Cormier has commenced a new training assignment along with his regular duties. He is processing sediments from the Bay of Fundy collected by the Canadian Hydrographic Service, and will prepare graphical and cartographic illustrations of the results. He will support this work with a written report that will deal with certain sedimentological parameters. Cormier also participated in the SCUBA diving courses.

G. A. Duncan assisted King in the organic geochemistry laboratory and, in the absence of Cormier, supervised operations in the sedimentology laboratory. Duncan is now commencing a new training assignment which deals with the processing of sediments to determine both carbonate and organic carbon content. He will prepare a report on this work which will be illustrated by means of graphical records and cartography on distributional patterns and trends. Duncan also participated in the SCUBA diving course.

D. R. Horn continues his educational leave at the University of Texas, where he is studying for a Ph.D. degree in geology.

L. H. King undertook a bottom sampling program along the Halifax section of the Scotian Shelf aboard CSS KAPUSKASING, and augmented his study with numerous oceanographic data such as bathymetry, salinity, temperatures, and oxygen analyses. He carried his studies into the laboratory where he is examining various aspects of organic geochemistry pertaining to the sediments, as part of an environmental analysis of the study area. He is assisted by Duncan in the laboratory, and by L. D. Quick of the hydrographic survey group who is preparing graphical and cartographic illustrations of the study. Quick is also assisting King in making a detailed interpretation of the bathymetry. King has been engaged in the organization of the organic geochemistry laboratory, and much of his analytical work is of the pilot type in order to establish a working routine in the processing of his samples. King also participated in the SCUBA diving course.

R. J. Leslie is completing a manuscript on the marine geology of Hudson Bay. He had previously submitted two papers on this subject which are now available in the open literature.

J. I. Marlowe undertook a bottom sampling program on the continental shelf and slope southeast of

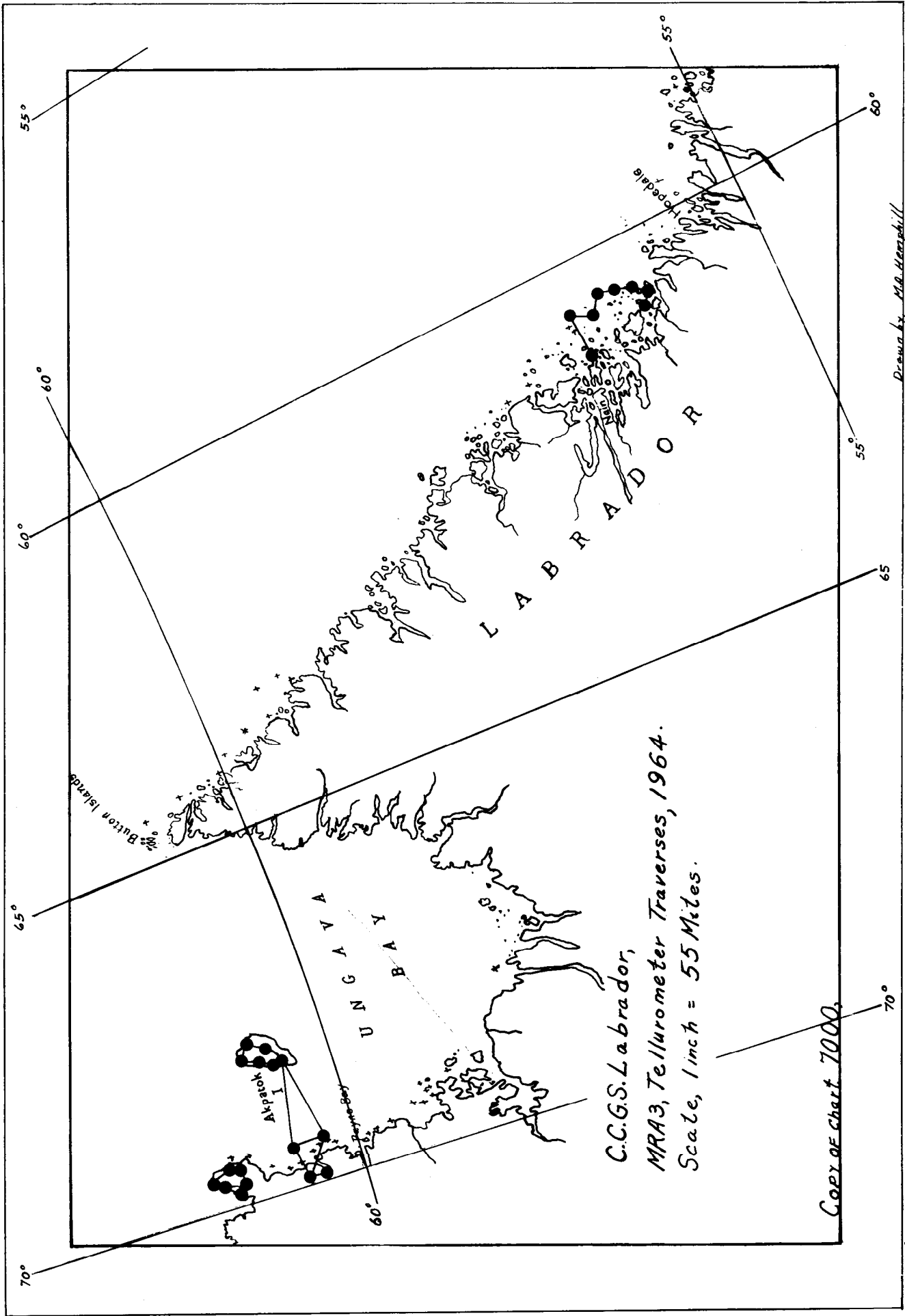
Sable Island in a feature called "The Gully". This work was undertaken aboard CSS KAPUSKASING. In mid-May he assisted Professor D. Swift and his student, N. Silverberg, of Dalhousie University in a similar program in an area adjoining his own. In June, Marlowe supervised a marine geology project in Northumberland Strait. In September and October, he joined the CCGS LABRADOR at Thule, Greenland to undertake a sampling program in Baffin Bay and Nares Strait. During the year he continued his sedimentological and petrographic analyses on material obtained on oceanographic cruises, and submitted two manuscripts for publication.

B. R. Pelletier attended a government management course held at Carleton Place, Ontario, during the month of January. In April and May he continued a bottom sampling program over the Arctic Ocean in collaboration with the Polar Continental Shelf Project. Mr. **R. Lahey** of the Atlantic Oceanographic Group assisted him on this project. In early June he was Scientist-in-charge of the HUDSON and ACADIA when they paid a courtesy call to Charlottetown, Prince Edward Island, to coincide with the meetings of the Royal Society of Canada held there this year. At this meeting Pelletier and several other members of B.I.O. gave papers dealing with marine geology and geophysics of the Canadian Arctic and Eastern Seaboard. During the year he prepared departmental reports and publications and directed the overall activities of the Marine Geology at the Bedford Institute.

S. S. M. Pitcher assisted Cormier in the sedimentology laboratory and for one month during the spring she assisted **D. H. Loring** in the laboratories of the Atlantic Oceanographic Group. Miss Pitcher prepared numerous cartographic illustrations for our staff, and greatly assisted these officers in the preparation of their reports.

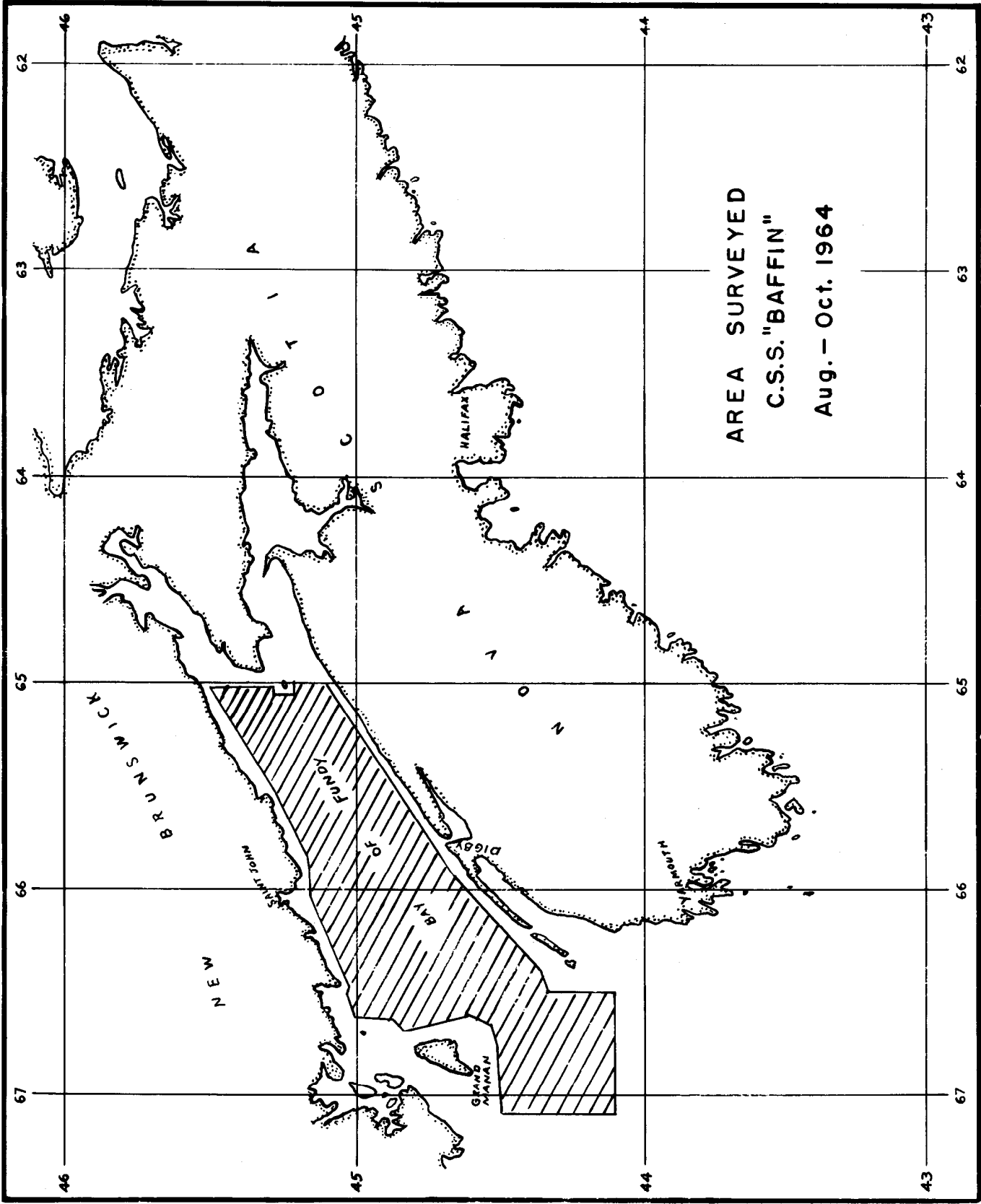
G. Vilks completed his inshore sampling program during late April, May and June in Satellite Bay, District of Franklin. This program deals essentially with benthic foraminifera, and is in collaboration with the Polar Continental Shelf Project. He participated in a cruise of the Atlantic Oceanographic Group aboard CNAV SACKVILLE which took place in the Saguenay River, the River and Gulf of St. Lawrence, and Northumberland Strait. Vilks continued his laboratory studies on the foraminifera, and submitted a report for B.I.O. which is now available in the open literature. He rewrote the Fortran program for the IBM computer in connection with the processing of sedimentological data. Vilks enrolled at Dalhousie University where he is presently studying for an M.Sc. degree while on educational leave.

F. J. E. Wagner is continuing her palaeontological studies in Ottawa. She is engaged on research involving Arctic foraminifera as well as fauna from the Champlain Sea deposits on eastern Canada. Miss Wagner is also preparing reports on molluscs occurring in Pleistocene beds and raised marine deposits. She has produced B.I.O. Report 64-1 on her Arctic studies.



Drawn by M.B. Humphill

Copy of Chart 7000



AREA SURVEYED

C.S.S. "BAFFIN"

Aug. - Oct. 1964

BUNSWICK

NEW

FUNDY

BAY

OF

DIGBY

GRAND

STAIRS

HALIFAX

A

I

A

O

C

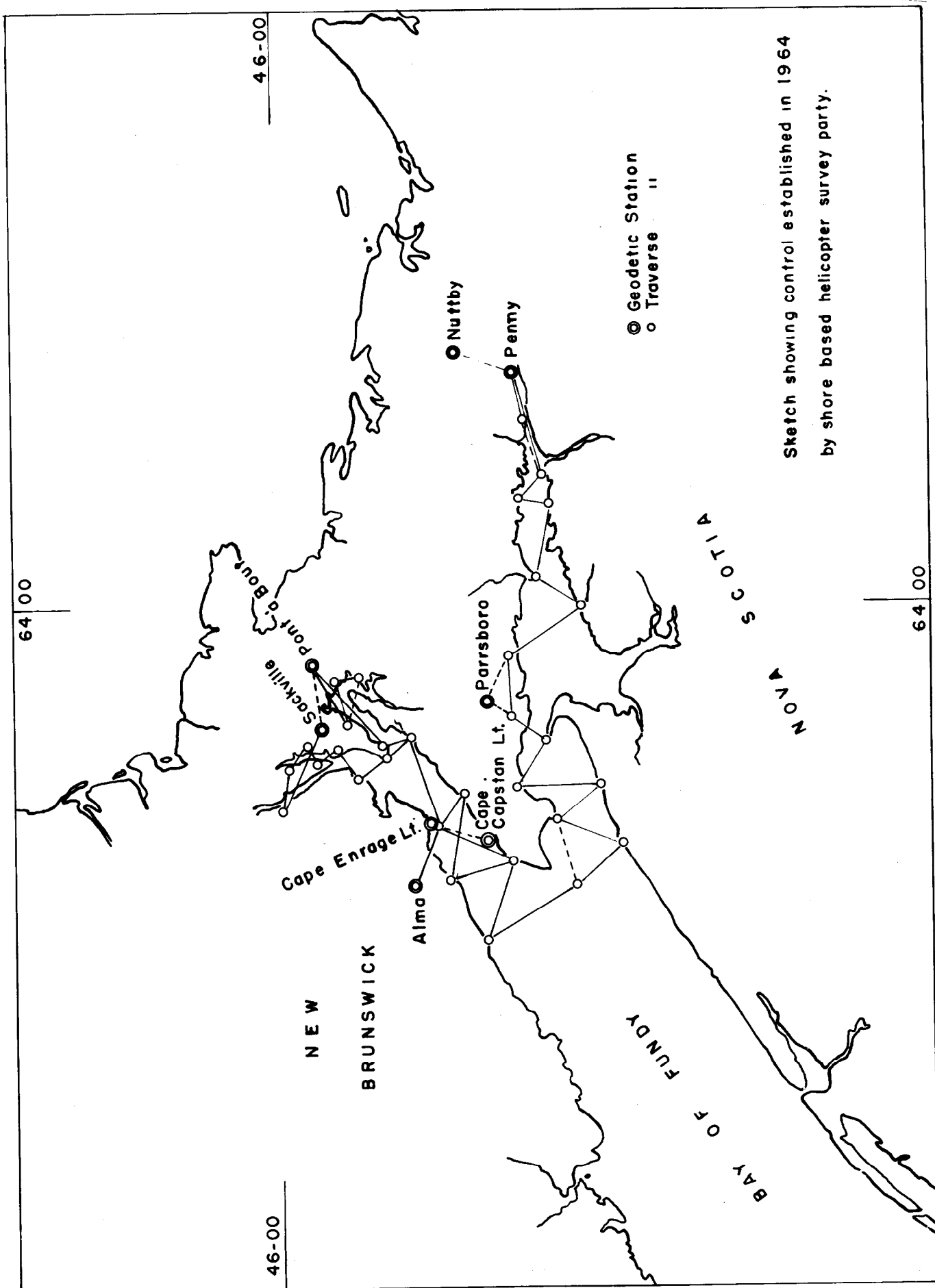
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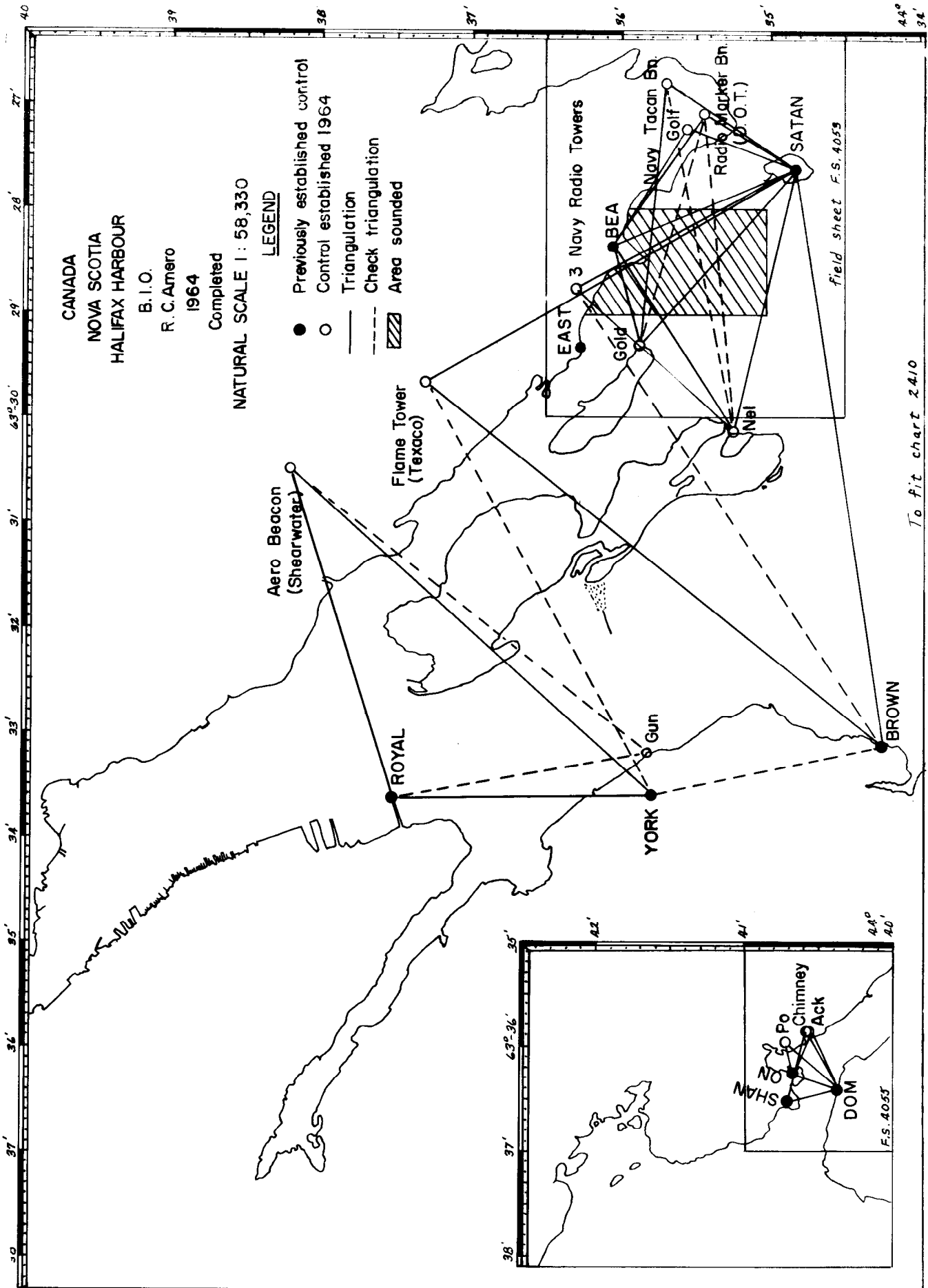
N

SEVENTH



● Geodetic Station
○ Traverse

Sketch showing control established in 1964
by shore based helicopter survey party.



CANADA
NOVA SCOTIA
HALIFAX HARBOUR

B. I. O.
R. C. Amero
1964
Completed

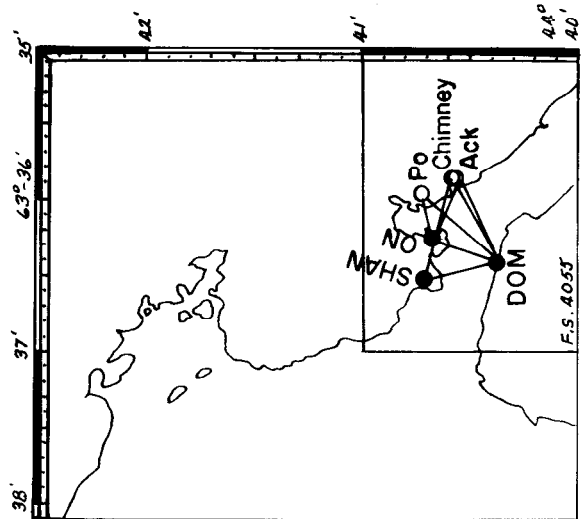
NATURAL SCALE 1 : 58,330

LEGEND

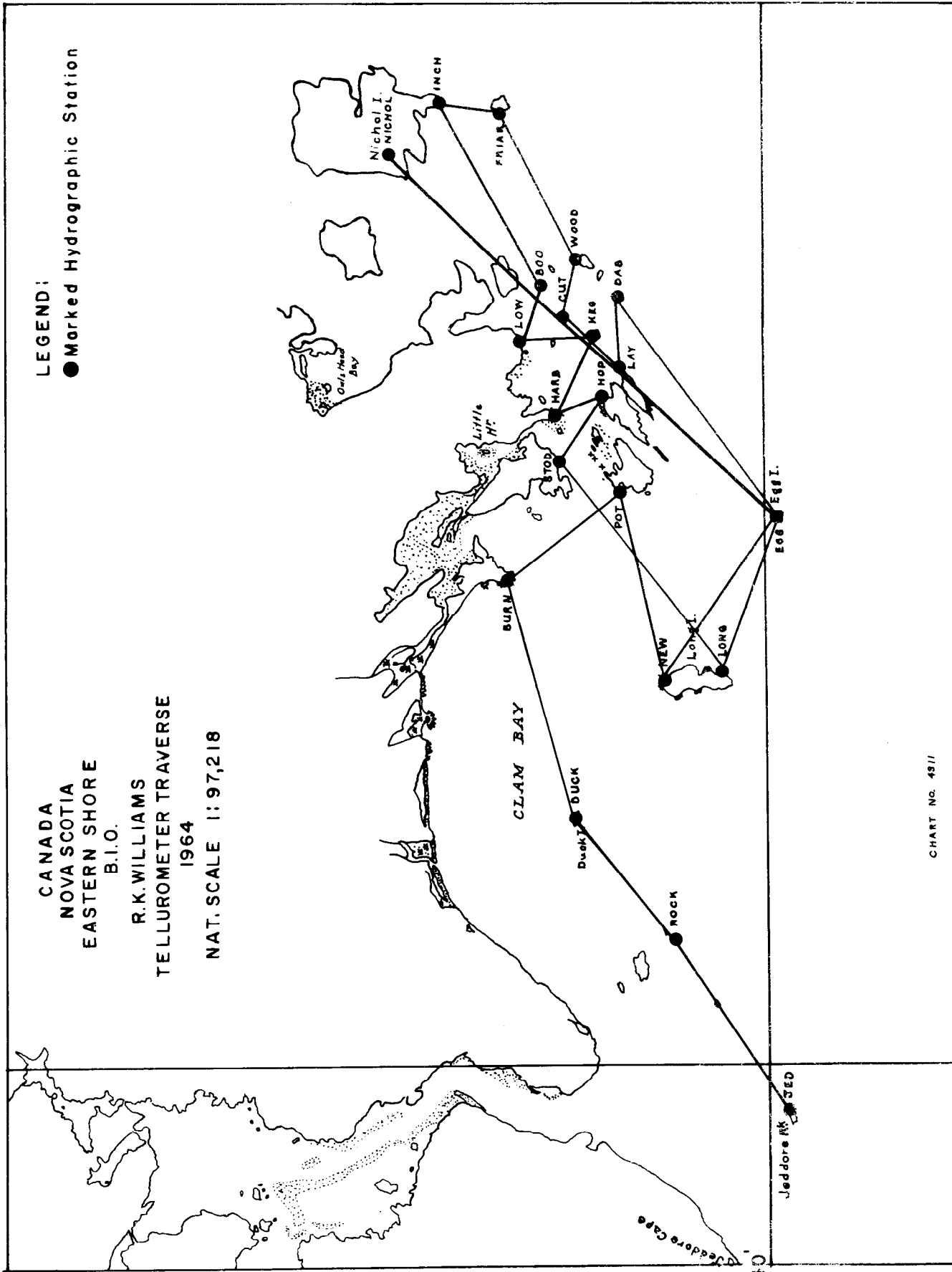
- Previously established control
- Control established 1964
- Triangulation
- - - Check triangulation
- ▨ Area sounded

Field sheet F.S. 4053

To fit chart 2410



63° 00'



LEGEND:
 ● Marked Hydrographic Station

CANADA
 NOVA SCOTIA
 EASTERN SHORE
 B.I.O.
 R.K. WILLIAMS
 TELLUROMETER TRAVERSE
 1964
 NAT. SCALE 1:97,218

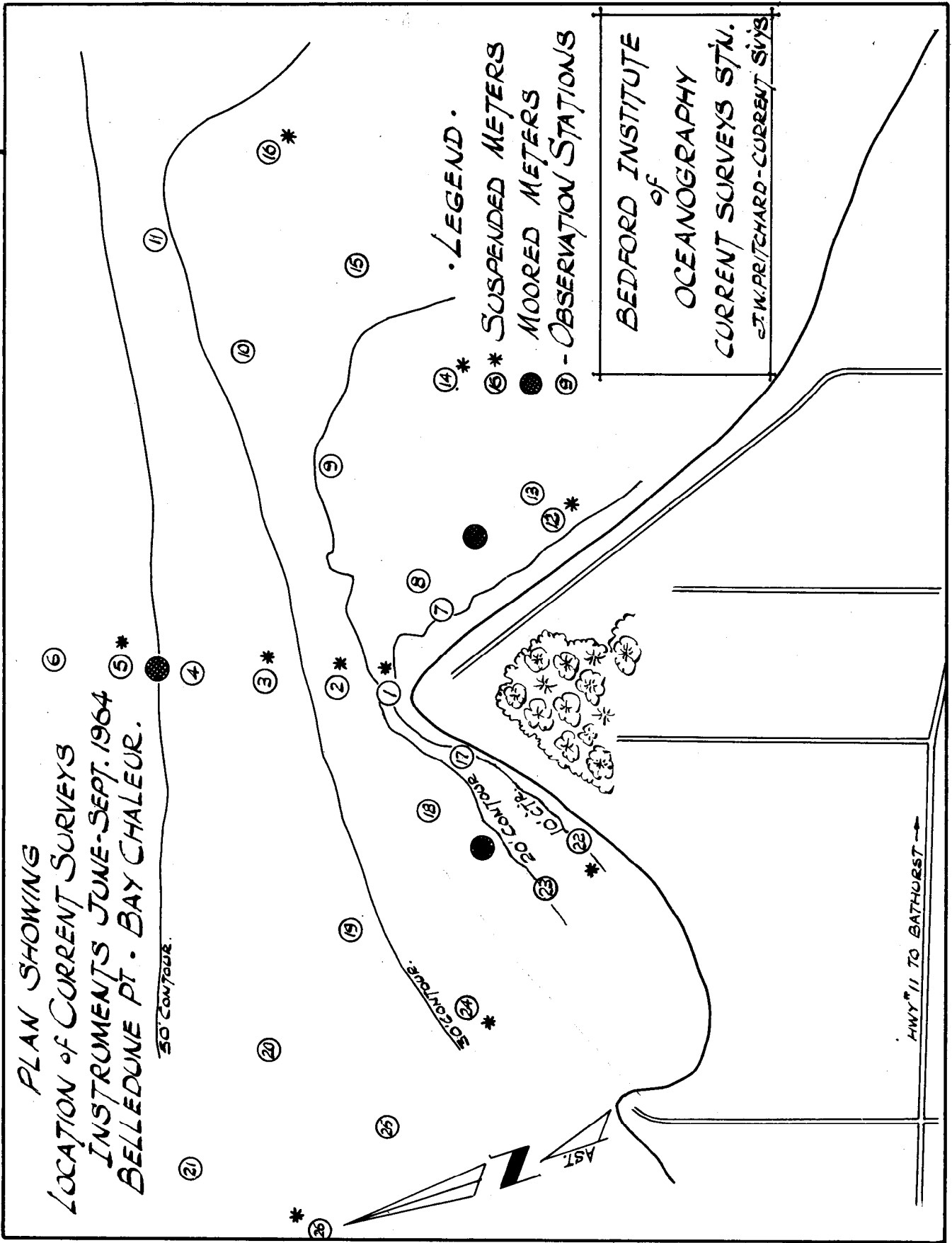
CHART NO. 4511

44° 40'

44° 40'

63° 00'

PLAN SHOWING
 LOCATION OF CURRENT SURVEYS
 INSTRUMENTS JUNE-SEPT. 1964
 BELLEDUNE PT. BAY CHALEUR.

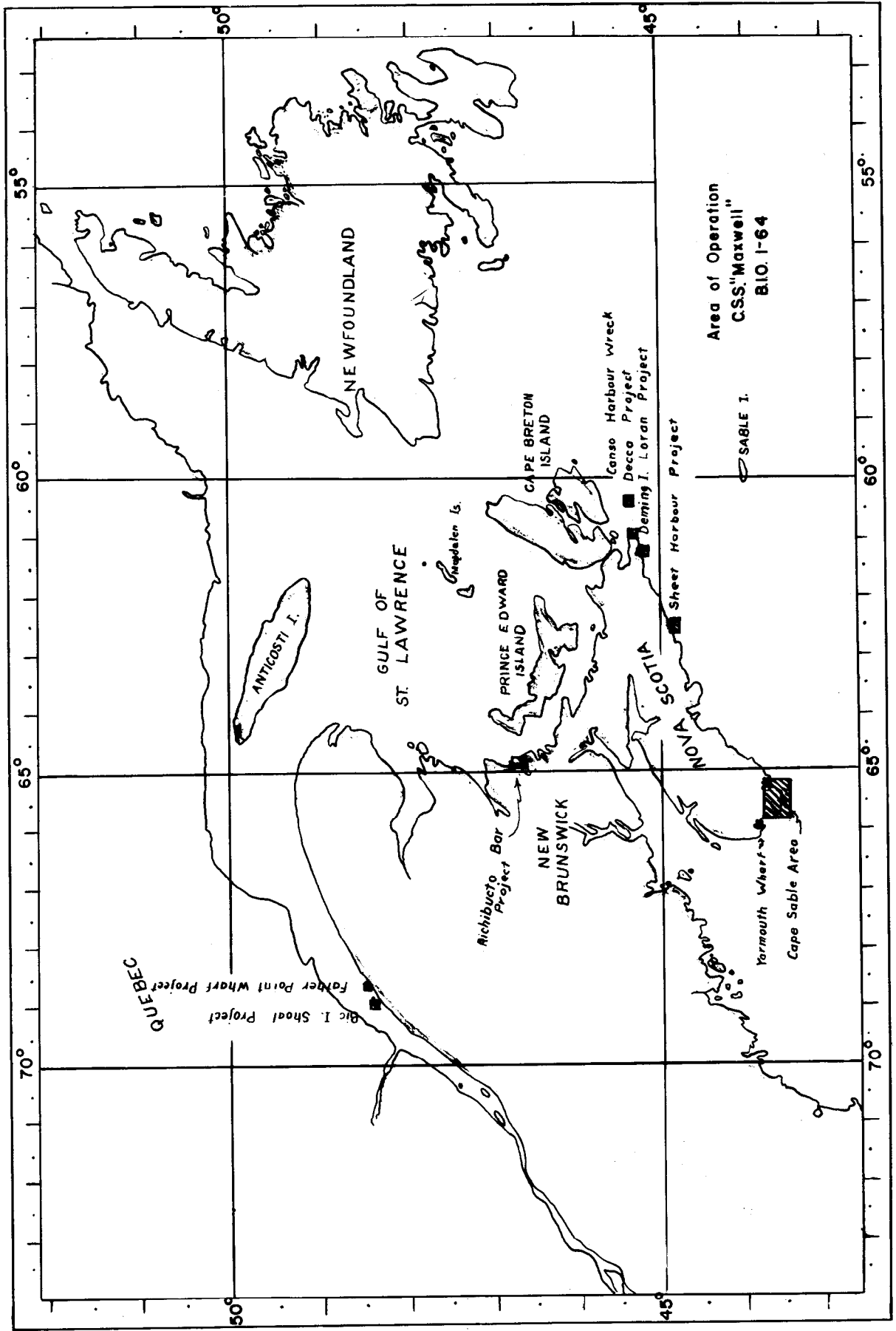


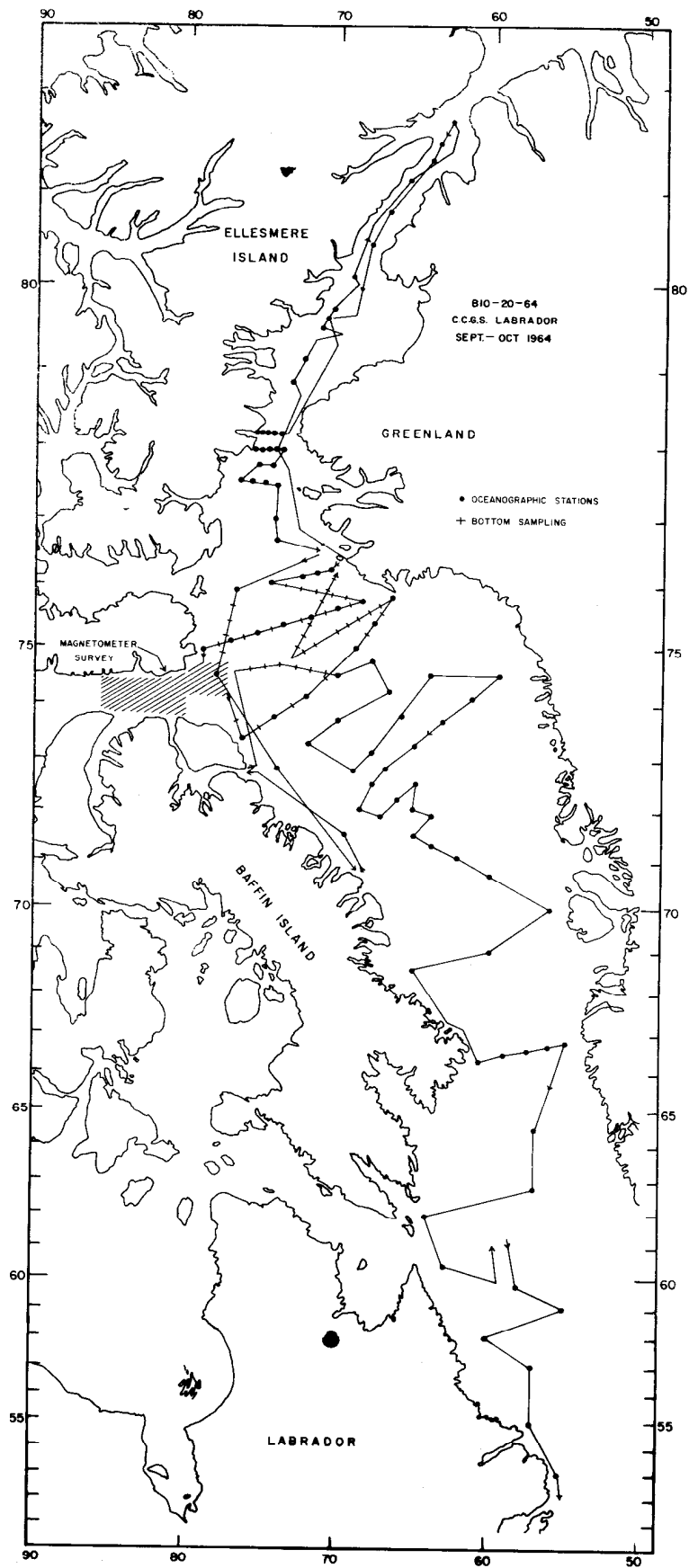
LEGEND.

- ⑮* SUSPENDED METERS
- MOORED METERS
- ⑨ - OBSERVATION STATIONS

BEDFORD INSTITUTE
 of
 OCEANOGRAPHY
 CURRENT SURVEYS STN.
 J.W. PRITCHARD - CURRENT SVYS

HWY #11 TO BATHURST →





Seasonal Staff

Professor K. Hooper of Carleton University commenced a field and laboratory study of the eastern Champlain Sea deposits in an area east of Miss Wagner's study. He also worked on recent sedimentological and palaeontological material from the Gulf of St. Lawrence. He is preparing reports on his earlier investigations in the adjacent waters of the Gaspé area of Quebec and New Brunswick. Hooper recently published a palaeontological report on material collected under departmental auspices, dealing with new spectrochemical research techniques. He is presently on sabbatical leave at New York University.

K. M. Kranck carried out a bottom sampling program in Northumberland Strait in collaboration with the Fisheries Research Board of Canada, aboard the PANDALUS. She has recently completed B.I.O. Report 64-15 dealing with her previous sedimentological and petrographic analyses on sediments collected by the Canadian Hydrographic Service from Exeter Bay, Baffin Island. She is presently engaged on detailed analyses of the material collected from Northumberland Strait.

A. C. Grant assisted Buckley in the office on a sedimentological analysis of material collected from the beaches and offshore areas of Belledune Point, New Brunswick. He is a co-author with Buckley of B.I.O. Report 64-12 which deals with this investigation. In September and October, he participated in an oceanographic cruise aboard the CCGS LABRADOR which took place in Nares Strait and Baffin Bay. Grant collected sediments along several transects in northern Baffin Bay, and will analyze this material as a requirement for the M.Sc. degree. He returned to the University of New Brunswick to complete his studies.

Laboratory Activities

At present we have four laboratories in which bottom material is processed for analysis in the following areas:

The Sedimentology Laboratory

This laboratory is under the supervision of R. Cormier who is assisted by Miss S. S. M. Pitcher. It is equipped to prepare marine sediments for mechanical analyses involving the pipette withdrawal method and the Ro-Tap sieve shaker. Heavy mineral separations are made by means of standard heavy liquids and the Franz Isodynamic Separator. Both the light and heavy mineral fractions are prepared for petrographic study. In this laboratory calculations involving analytical results are made, and data are programmed, all in a form suitable for scientific reports. Considerable layout space is available for geologists to slice cores and make preliminary petrographic analyses. Production has increased considerably over last year's output due to the following factors: it was the first full year of operation; personnel are more experienced now; changes in methods have taken place; more equipment has been added; and overtime pay has been granted. Production is broken down as follows:

Investigator	Pipette Analysis	Dry-Sieving Analysis	Heavy Mineral Separations	Mineral Mounts (slides)
B. R. Pelletier	32	45	77	90
G. A. Bartlett	9	1	-	-
D. E. Buckley	93	-	93	40
L. H. King	134	-	134	-
J. I. Marlowe	80	-	80	160
K. M. Kranck	38	151	50	in process
R. J. Leslie	92	-	in process	-
Belledune Study	80	276	-	-
Fisheries				
Research Board	5	-	-	-
R. Cormier	10	50	-	-
Re-run	10	-	-	10
TOTALS	583	523	434	300

The Micropalaeontology Laboratory

This is an open laboratory in which all investigators can carry out the preliminary separation of fauna from sediments before making the faunal analysis. This separation is undertaken by means of heavy liquids in which the flotation principle is used. Approximately 650 samples were processed and the faunal residues were mounted on slides for study under the binocular microscope. The Cushman Catalogue of Foraminifera consisting of 65 volumes, has been added to the laboratory as it is one of the most fundamental tools in foraminiferal research. Study collections of the various project areas are being prepared for museum display in this laboratory, in order to aid both workers and visitors engaged in comparative studies. Facilities are also available for the preparation of sketches, microphotographs and general cartographic illustrations.

The X-Ray Laboratory

This laboratory contains a Norelco high angle X-Ray diffractometer and X-Ray spectrographic unit. Both the diffractometer and spectrograph are served by a single 50 KV X-Ray generator having CuK radiation. A single electronic control panel and recording unit also serves both instruments.

Analytical work with this instrumentation was confined mainly to diffraction studies of marine sediments from the Gulf of St. Lawrence and the Scotian Shelf and Slope off Sable Island. Approximately 200 samples were processed and analyzed for clay minerals, chiefly by **D. H. Loring**, of the Atlantic Oceanographic Group. Loring assisted workers from Dalhousie University and B.I.O.

We also received a number of mineral standards, and it is planned to compile a catalogue of standard traces.

The Organic Geochemistry Laboratory

This laboratory is equipped with the following apparatus: freezer for preserving sediments, continuous centrifuge, ultrasonic vibrator, freeze-dry unit, lapidarian unit, carbon-hydrogen analyzer, nitrogen analyzer, electrobalance and various Mettler scales, polarizing microscope with vertical illuminator and optical reflectance unit combined with a monochromatic light source, Leco carbon analyzer, various wet chemical apparatus, and cartographic facilities.

This laboratory is concerned with studies on the constitution of the organic component of marine sediment and the relation of the chemical nature of the organic matter to widely differing sedimentary occurrences and depositional environments. During the past years considerable progress was made toward defining the sedimentary environment on the Scotian Shelf in the area of Emerald and Sambro Banks. Five distinct sedimentary environments were recognized and mapped in the area. The geological samples were correlated with echograms from a Kelvin-Hughes echo sounder (26B), and it is now possible to delineate the sediment boundaries with a high degree of accuracy. A preliminary report on this work is in progress. This sedimentological study is an essential step to any serious consideration of the organic matter and its relation to environment.

In order to make a chemical structural assessment of the organic matter, it is first necessary to isolate organic matter of a low inorganic content from the sediment so that reliable physical, chemical, and optical properties can be obtained. Progress on such a separation is still in the developmental stage, and it is anticipated that the separation will be on a routine basis early in the new year.

The facilities and techniques for measuring the following properties of the organic matter are all operational: carbon, hydrogen, oxygen, nitrogen, sulphur and ash contents, density, volatile matter content, solubility in organic solvents, and infra-red analysis. The infra-red analyses are being carried out at the Mines Branch in Ottawa. By means of the above properties, various chemical structural parameters can be obtained.

3.4 INSTRUMENT DESIGN GROUP

R. L. G. Gilbert

J. Brooke

H. W. MacPhail

Whilst much work can be carried out in the fields of survey and research with existing equipment, it is very clear that new or improved work can only be carried by using new equipment, and that the speed of existing operations can be increased by improving existing equipment. The results of the past year have strengthened the belief that, whilst production of equipment should be carried out by commercial interests, the design and development of such equipment can only be satisfactorily carried out by staff in direct and close contact with the final users.

The recruiting of new staff for the group is presently

underway, and activities should increase during the next year. The resignation of Mr. N. S. Oakey during the summer was a severe blow, but we wish him well in his studies at McMaster University.

3.4a. ELECTRONIC DESIGN

The most noticeable aspect of the year's work was the strong trend towards digital equipment, and the growing concern amongst research and survey staff at the problems involved in transcribing chart and other analogue records into figures so that computations can be carried out. The graphic-analogue to digital converter has been completed, a comprehensive service manual written, and a description of the converter is about to be published; it is hoped that commercial manufacture will take place in the near future. A series of programming units have been built, and service manuals written, for the geophysics group; digital inputs are accepted from a digital clock and calendar, a magnetometer, a gravimeter, and the Decca positioning system, and the readings are punched on paper tape. These units have proved exceptionally successful and reliable in the field, having operated continuously for months without breakdown. Similar equipment is likely to be demanded to an increasing degree as the advantages of a recording system whose output can be fed directly into a computer are realized; and it appears likely at present that such systems will continue to be used when a computer is permanently available on board ship. Four magnetometers, to be used in sub-surface floats, etc. have been designed and built by a commercial company; the readings are automatically logged on digital magnetic tape. These magnetometers have been plagued by a succession of faults, and design staff have spent a considerable amount of time in tracing and rectifying faults; at present, the units are with the manufacturer, but it is hoped that they will be in good working order early next year.

The Richardson current meter reader has been built to a stage which shows that an analogue record can be produced from the digital film. Unfortunately, the Richardson current meter has become unfashionable, so that this development is now of little interest, except for possible future instruments which may digitally record data on 16mm. film. The wave-recording program is described elsewhere; during the year measurements were taken simultaneously with a wave-pole and the B.I.O. accelerometer recorder (in Aruba) and with the N.I.O. shipborne wave recorder and the B.I.O. recorder (off Nova Scotia, CCGS WOLFE), but the analysis of these data is not yet available.

Not the least of the duties of the Instrument Design Group is the promulgation of advances in modern technology. The treatment and processing of semi-conductor slices has reached such a state that a micro-circuit flip-flop formed on a single chip of silicon, is now cheaper than a similar circuit built from conventional components; the size of the micro-circuit is, of course, diminutive. One computer manufacturer has taken advantage of this development to produce a powerful but compact digital computer; complete with peripheral equipment it costs considerably less than \$20,000.00 and

mounts on a normal desk-top. The implications of this development must be forcibly pointed out - no longer need the scientist arrange his working life around the timetable of a central computing centre; the time is not far-distant when the scientist will object as strongly to sharing a computer as he does now to sharing an office - and the cost of each is now similar. Serious thought must be given immediately to the relative advantages of one moderate-sized central computer, and ten of the miniature units, at the same cost; the usage philosophy is so different that a mistake now could set back the Institute's programs by many years.

3.4b. MECHANICAL DESIGN

The mechanical design section has contributed to a number of B.I.O. field projects by advising research and survey staff on mechanical matters. In addition a number of design projects have been completed during the year, and successful prototypes constructed; they are listed here.

CCS KAPUSKASING - Lab design and "A" frame. Conversion of large winch to Lebus spooling for 20,000 of 3/8" dia. wire rope.

Current Meter Bracket-Design of bracket to support Richardson current meter for deep ocean work.

Trip Release Device-Mechanical release operated by a messenger. Can be used to release line from anchor or other purposes.

Magnetometer Pressure Case-A sealed case to contain magnetometer (by Barringer) and batteries so that the total unit can be assembled, tested and rolled into its container.

Bottle Trip - For near-ocean bed work so that a sample can be taken at a known distance from the floor.

Time Release Device - This device can be set to release a messenger at a required time within 12 hours. It will be used for simultaneous bottle sampling in spring 1965.

Punch Tape Recorder - Originally started as a direct copy of a Woods Hole Development which was loaned for this purpose. This project has resulted in major re-design because of the many non-commercial parts used in the prototype. The recorder will be used for a sediment profile corer.

"Doe" Anemometer Mark V-A new model of the anemometer has been designed and built for testing; this is based on Dr. L. A. E. Doe's original principles and incorporates his latest thoughts on the concept.

3.4c WAVE RECORDING

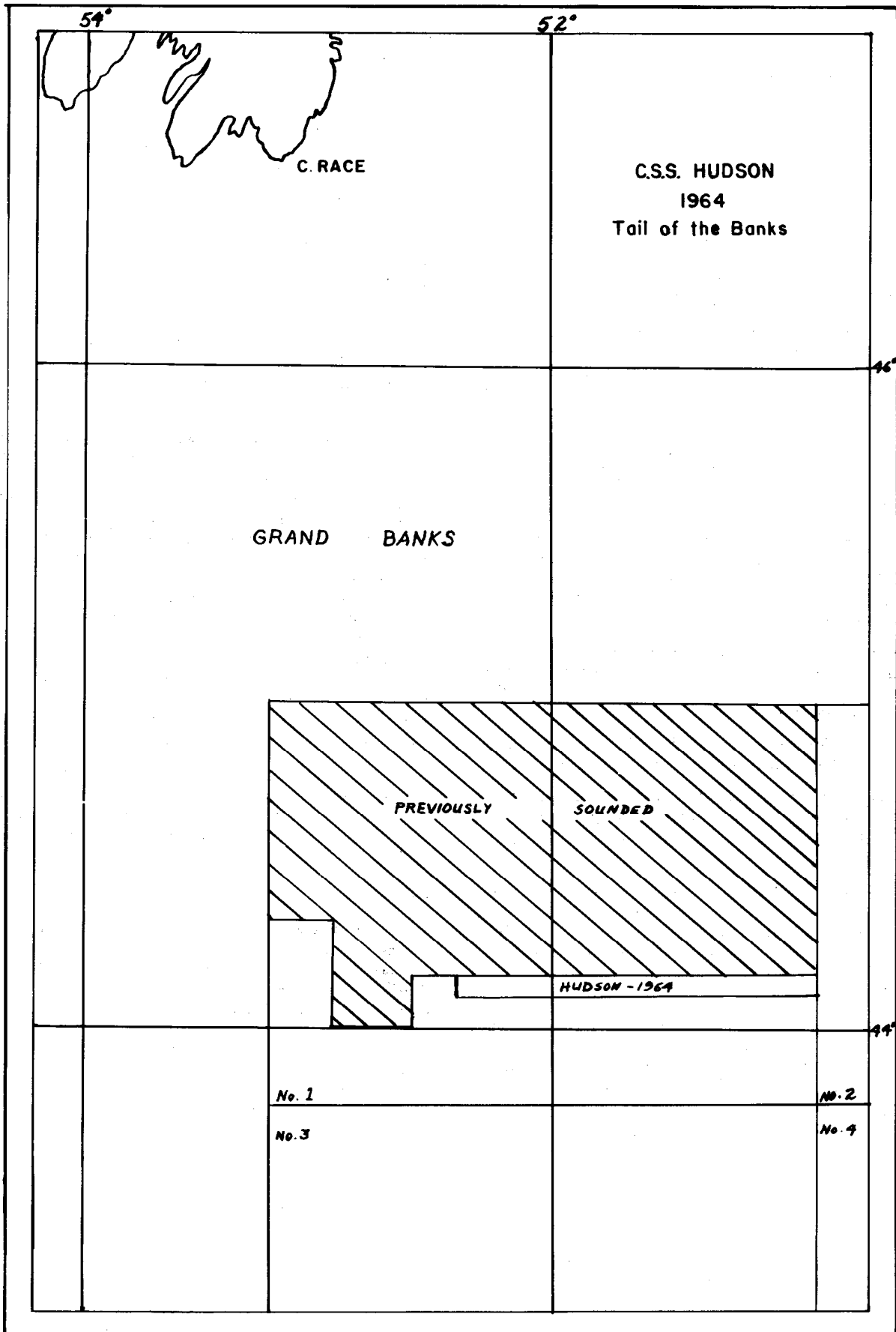
R. L. G. Gilbert
N. S. Oakey (until July)
J. A. W. McCulloch (D.O.T. Met Branch - part-time from September)
S. Derco (D.O.T. Met Branch - from September)
H. W. MacPhail
W. G. Price
D. S. Snowdon

The wave recording program was reinstated this year at the request of the Department of Transport, who wish to investigate the possibility of modifying the loading regulations of Great Lakes vessels. The program is to cover two years of observations, and will attempt to experimentally verify wave-hindcasting techniques in the Great Lakes and Gulf of St. Lawrence; in addition, correlation will be made between stresses in a few instrumented ships and wave-activity.

The field program was eventually started in October after many delays due to lack of staff and supporting equipment. Wave recording stations were set up in Lake Superior and Lake Michigan, but the adverse weather conditions encountered whilst setting the buoys, coupled with unexpected difficulties due to the unsuitability of the main mooring buoys and the presence of severe electrical interference at receiving sites, minimized the number of stations which were successfully operated. Nevertheless the main purposes of the operations were achieved: sufficient records were obtained to be used to verify digital analysis methods and equipment; an evaluation was made as to the type of field party required; the overall system was evaluated for the Great Lakes area; and general guidelines were established for this work to be carried out next year.

The two major technical problems to be solved this winter are to establish the most suitable type of mooring buoy, and to modify the radio receiving equipment, so that it is not affected by electrical interference. In addition, new equipment has to be procured, tested, and modified, to provide sufficient stations to enable next year's program to take place.

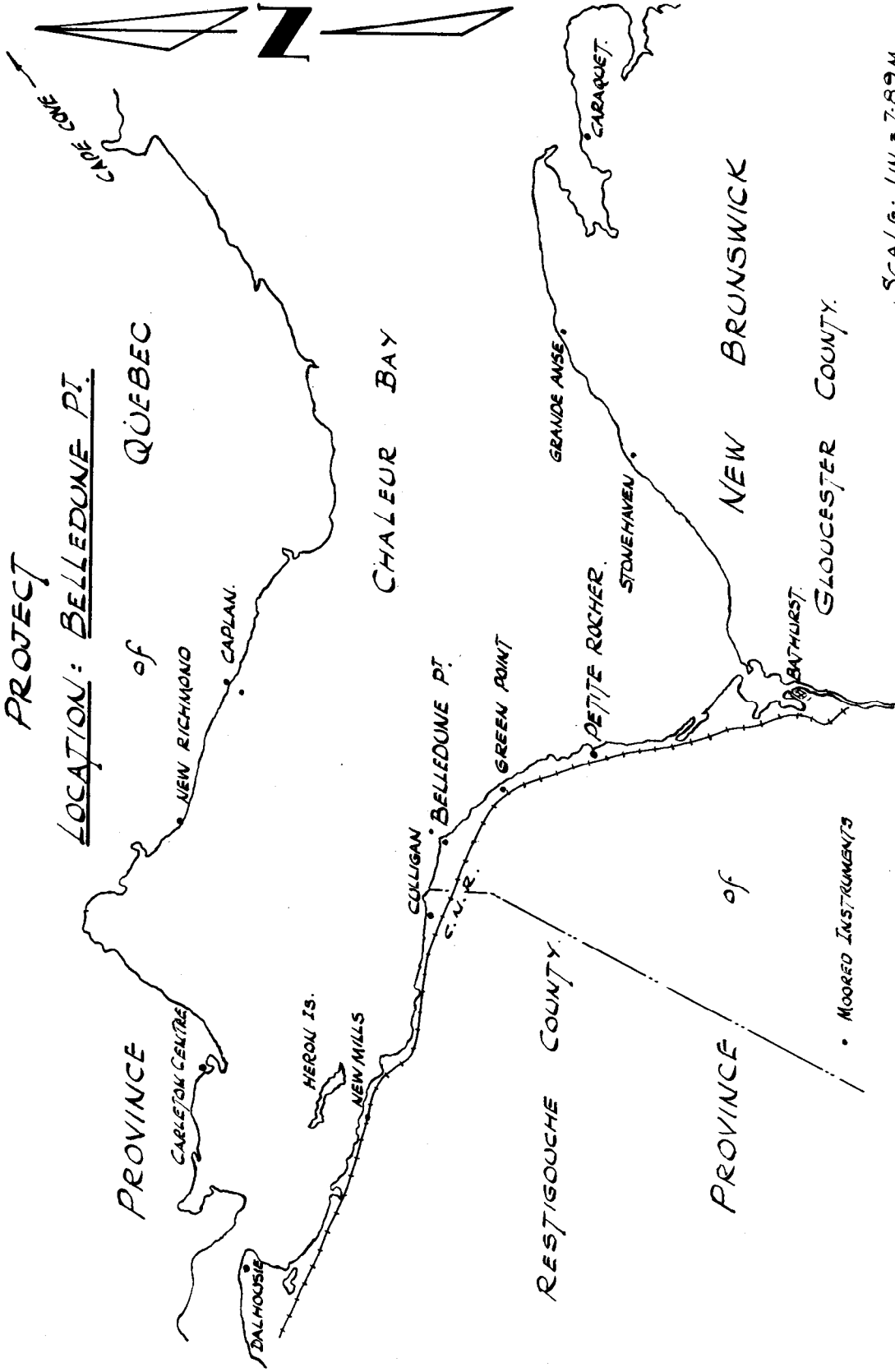
The shortage of staff at B.I.O., coupled with the increase in field activities next year to provide 12 stations in Lake Superior and the Gulf of St. Lawrence, from April to December, has forced us to look for assistance elsewhere. The National Research Council, who are already equipping some ships with strain-gauges and recorders, are to take over the field program; they will work in conjunction with the D.O.T. Meteorologists, and future B.I.O. participation will be mainly limited to assistance in the general field of instrumentation.



PLAN SHOWING
 GENERAL AREA FOR 1964 CURRENT SURVEYS
 PROJECT

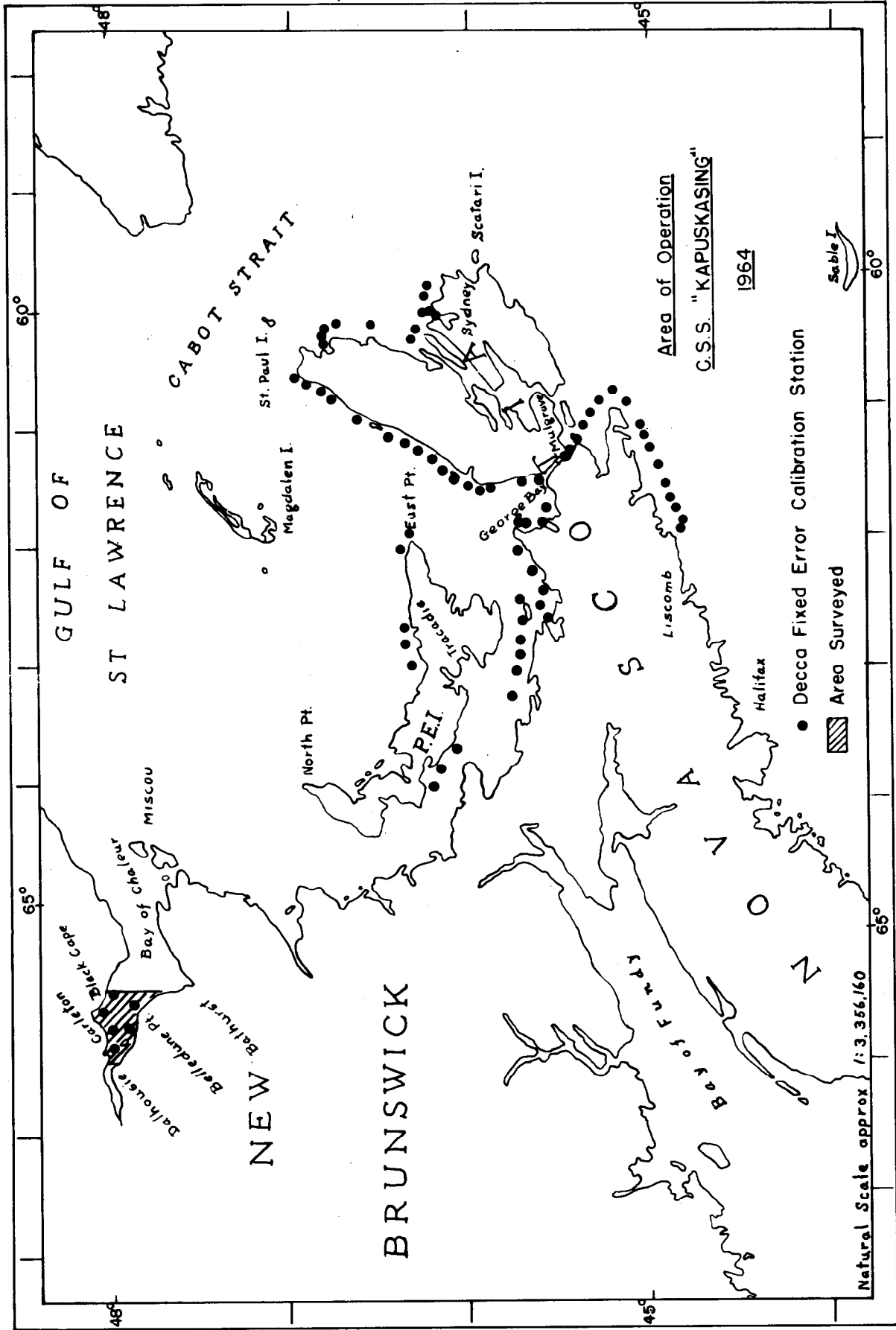
LOCATION: BELLEDUNE PT.

of QUEBEC



SCALE: 1 IN. = 7.89 M.

OPERATIONS BASE: PETITE ROCHER.



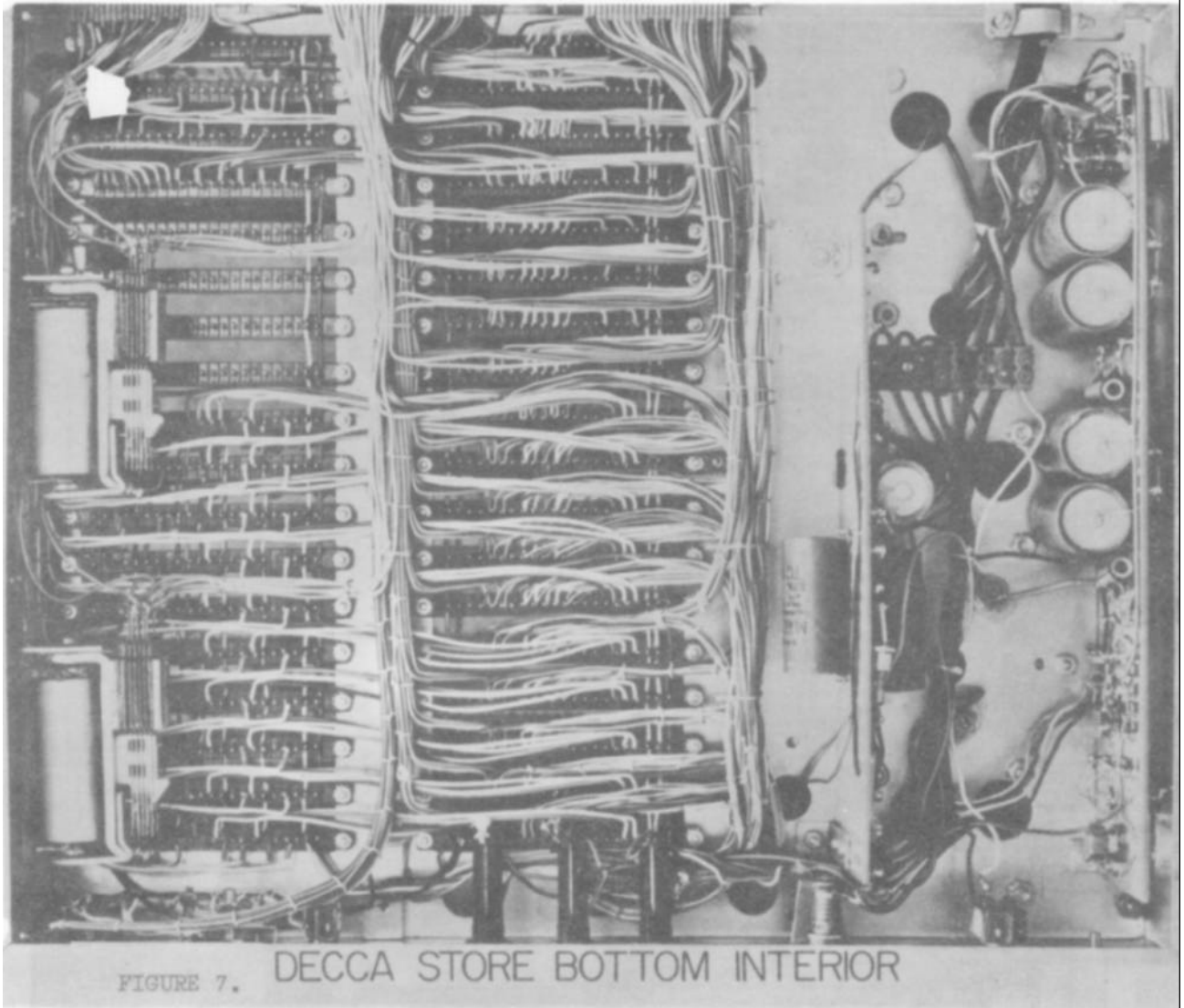


Figure 7. Decca Store Bottom Interior

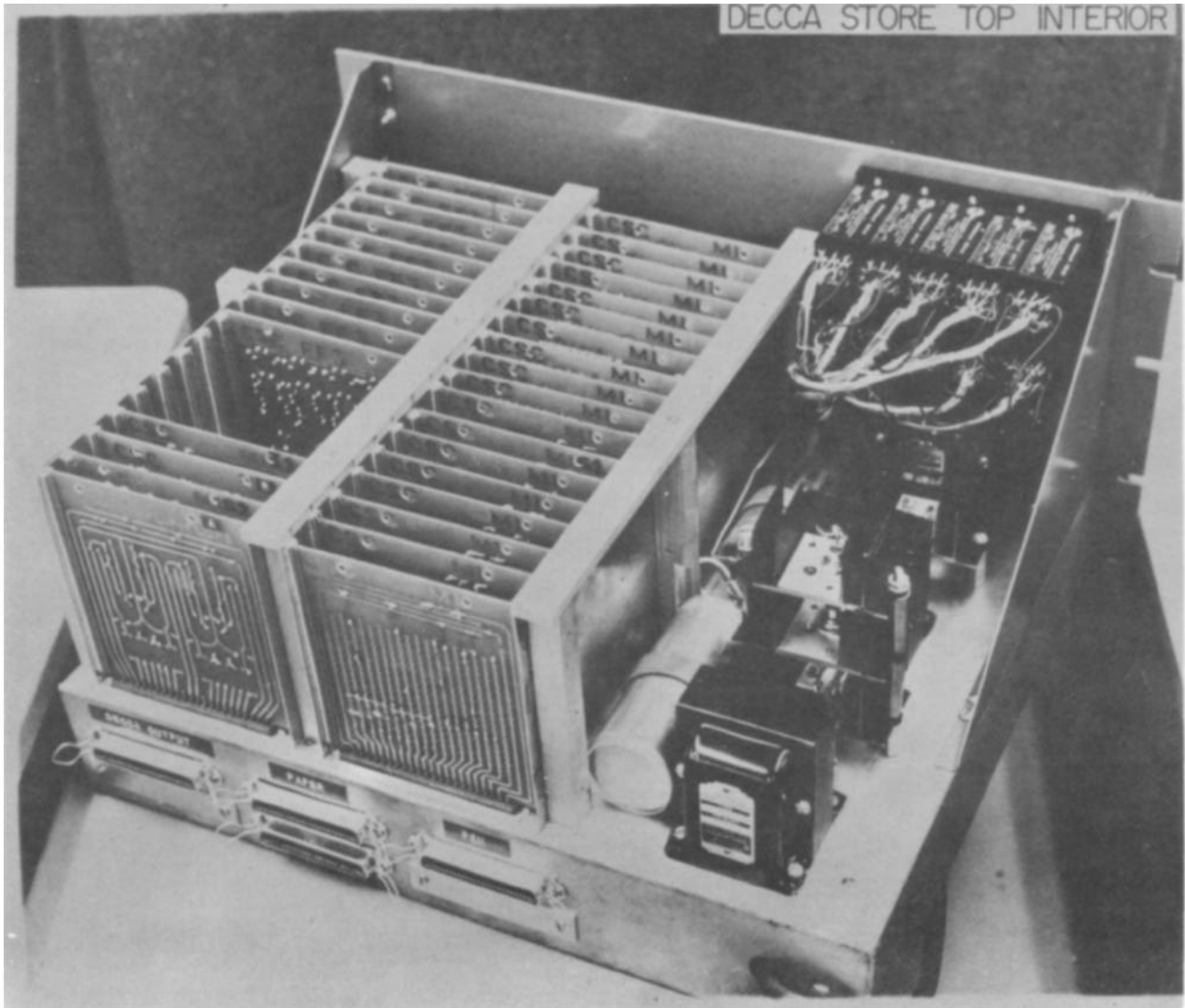


Figure 8. Decca Store Top Interior



Figure 1. B.I.O Stable Platform - at B.I.O. January 1964



Figure 2. The B.I.O. Stable Platform - Aruba, January 1964
Launching from CSS BAFFIN.

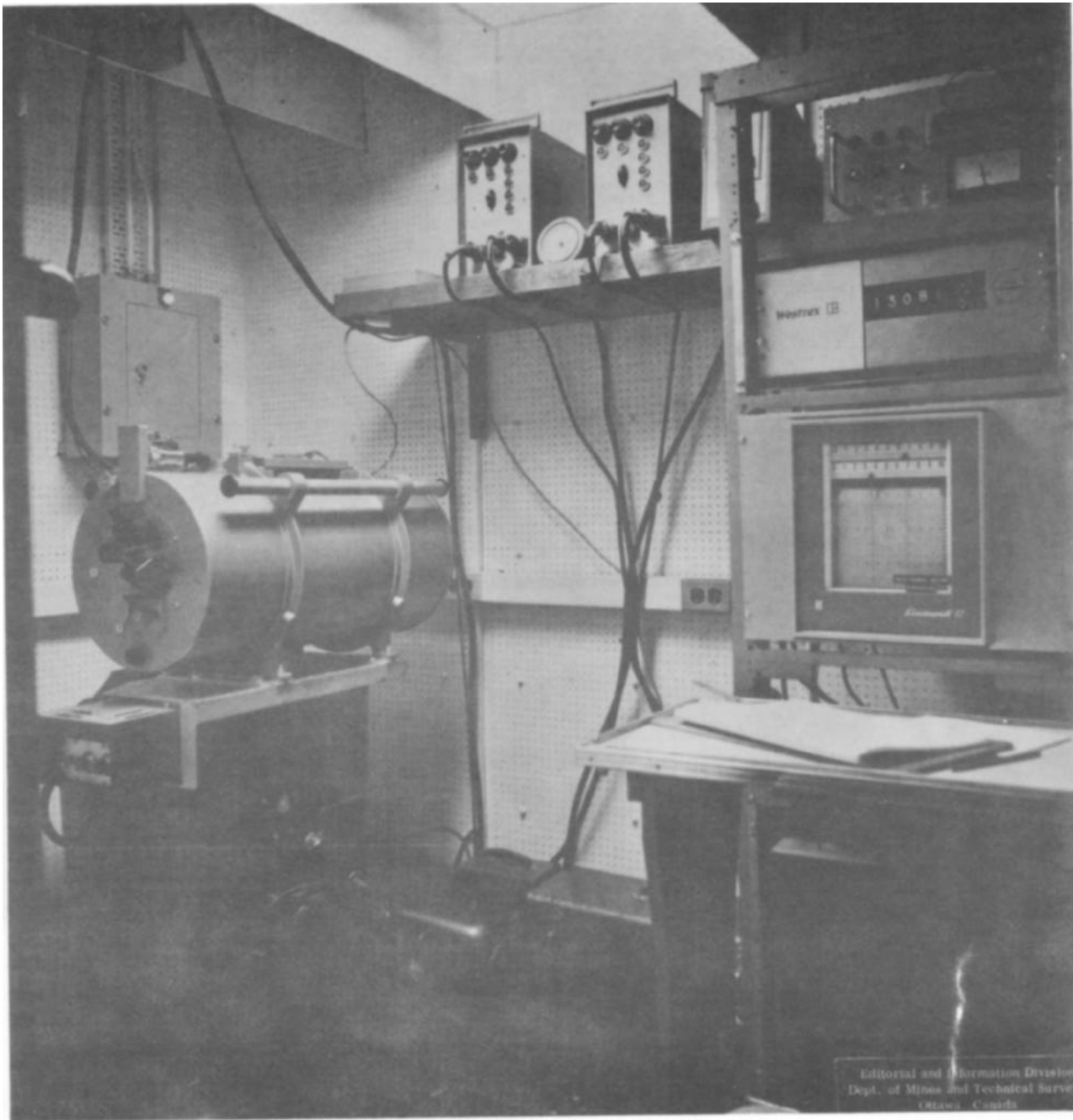


Figure 10. Gravity Laboratory on CSS HUDSON.. With this installation, significant negative gravity anomaly east of Cape Breton was first discovered.

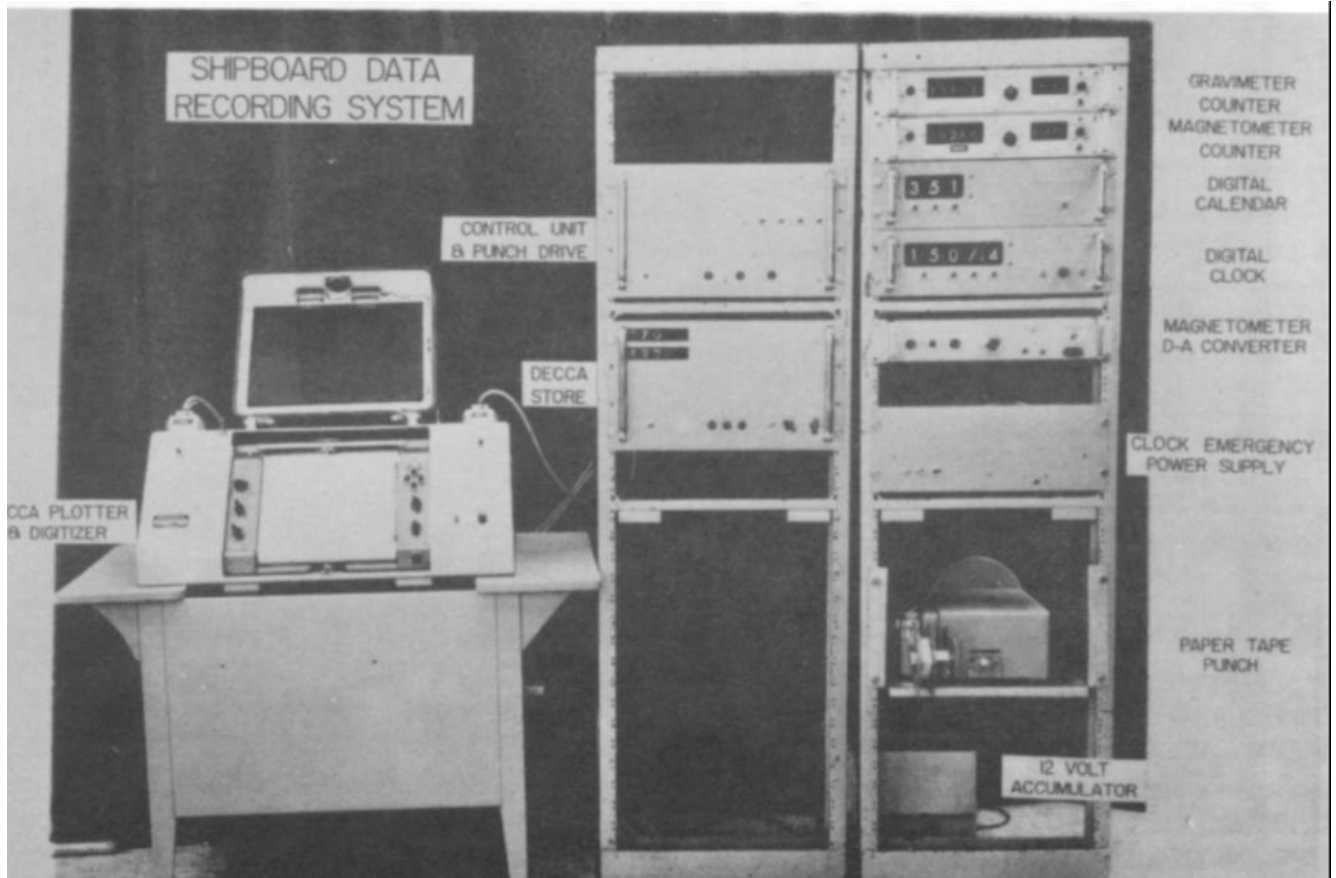


Figure 6. Shipboard Digital Data Recording System

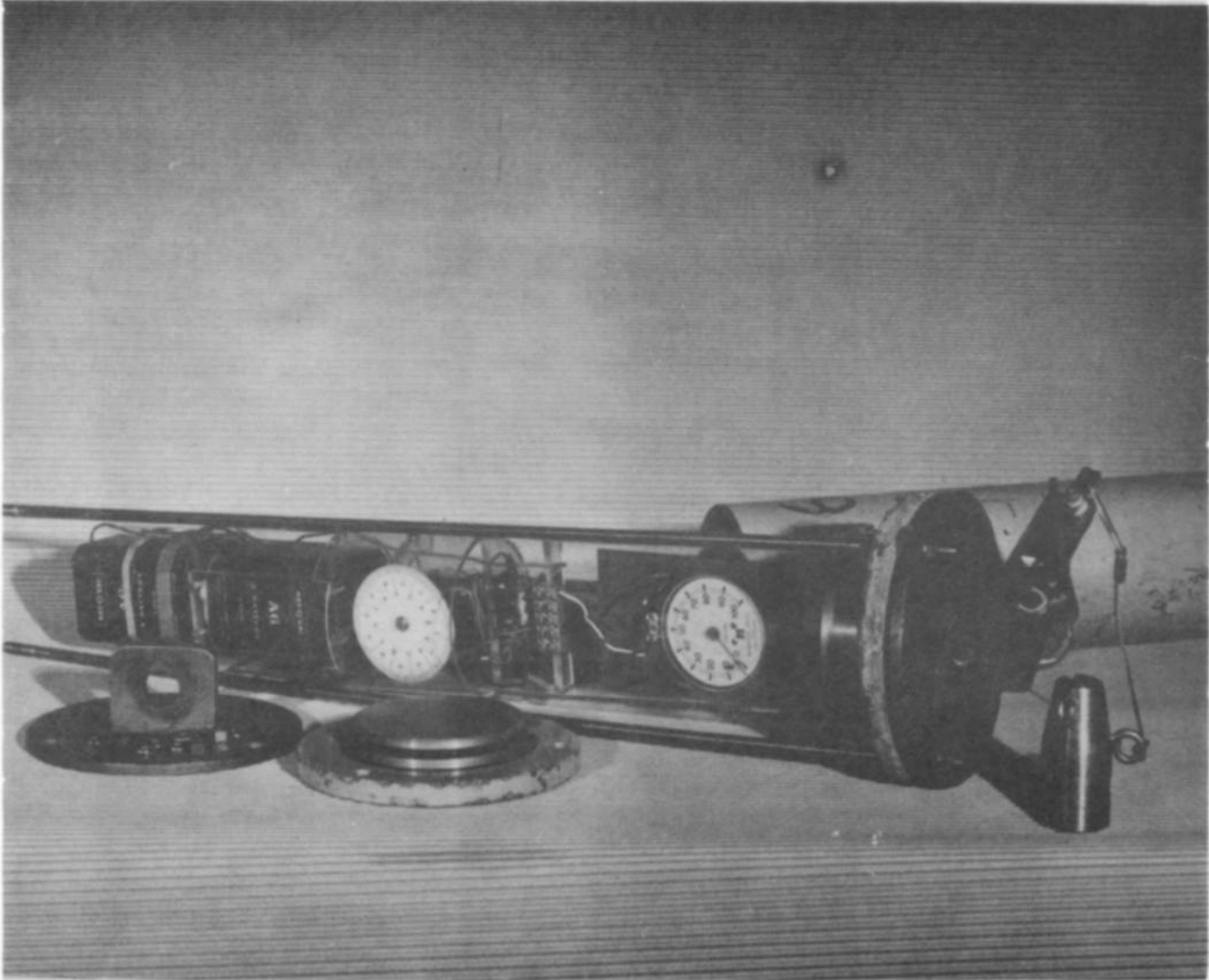


Figure 5. Pre-timed Release Device and Pressure Recorder
Designed and Built at B.I.O.

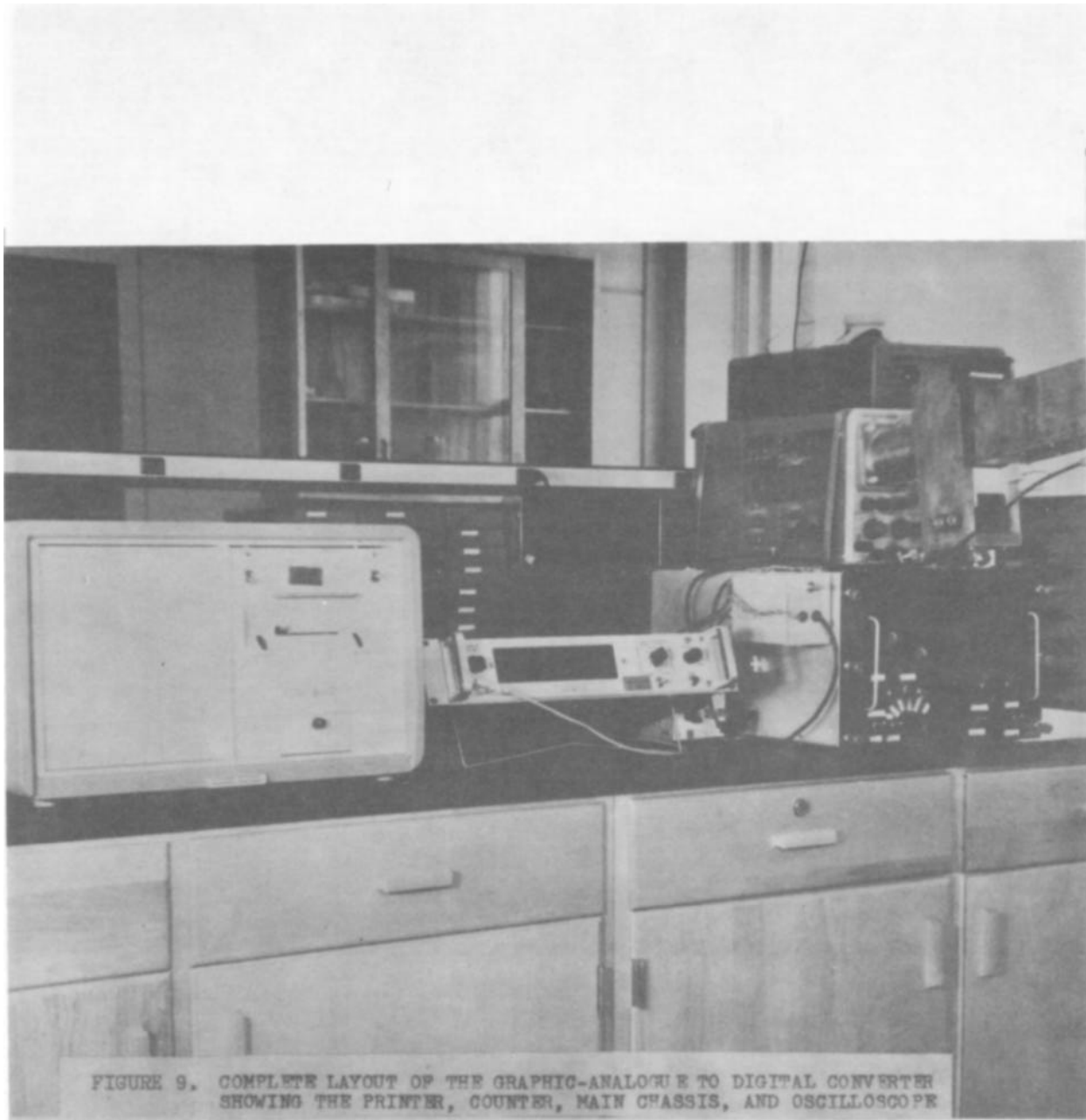


Figure 9. Complete Layout of the Graphic-Analogue to Digital Converter
Showing the Printer, Counter, Main Chassis, and Oscilloscope



Figure 4. "A" Frame and Winch Fitted to CSS KAPUSKASING. by B.I.O.
April 1964

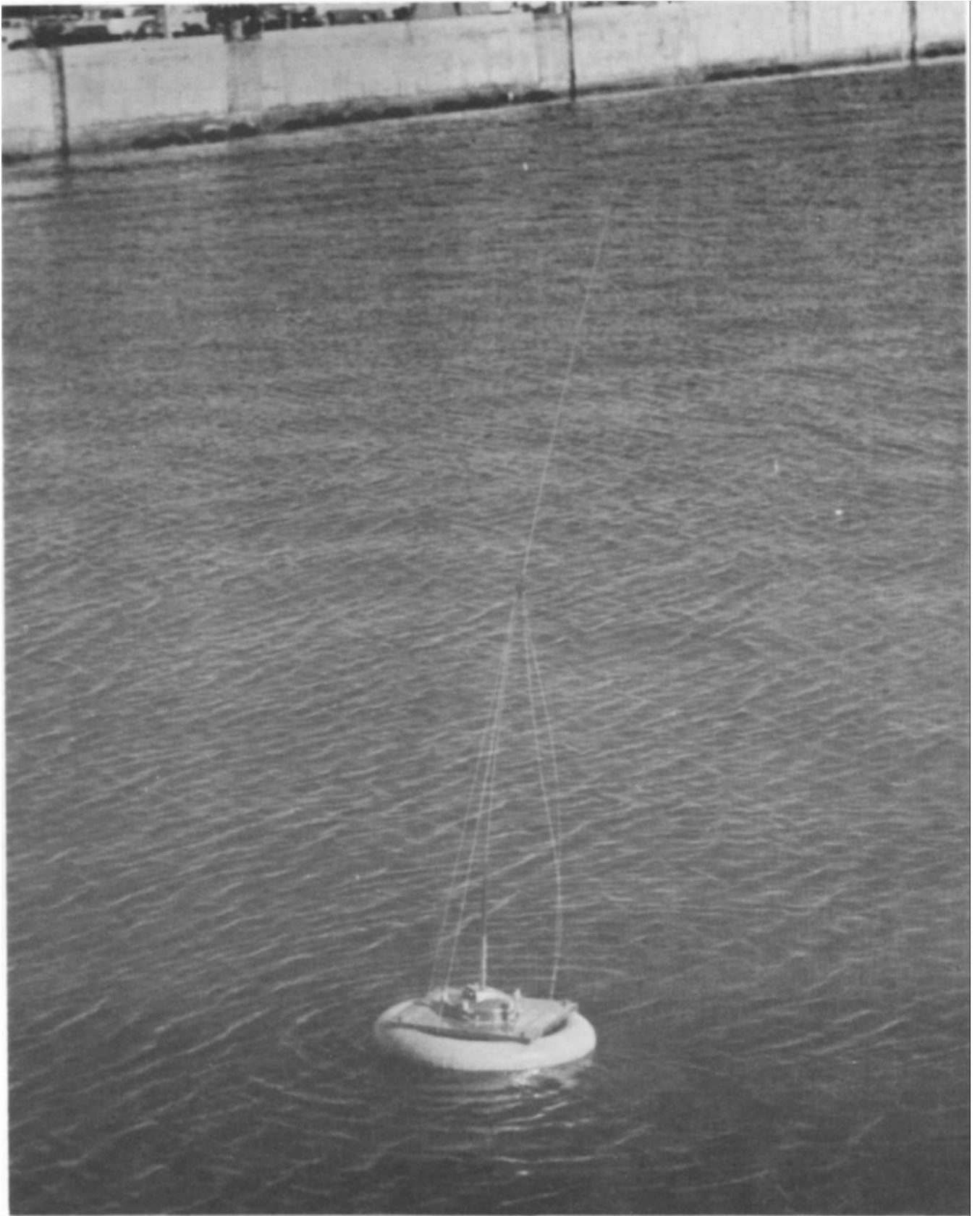


Figure 3. The B.I.O Free-Floating Wave Recorder

Support

4.1 ADMINISTRATION

The administration group at B.I.O. has, perhaps more than other groups, been suffering from the austerity limitations during the Institute's first two years. The recent increase in staff is already very evident in improvements in areas such as stenographic service, and a considerable amount of administrative work which others have had to carry out in the past will be taken over by the group. The most obvious such activity concerns storekeeping, and new stores staff are presently setting up a comprehensive stores system which should relieve the scientific and technical staff of such responsibilities.

Library

Accessions

Books (volumes).....	829
Unbound material . . .(items)	963 (reprints, serials, etc.)
Periodicals (issues)	1288 (number of issues recorded in Kardex)

Statistics

Number of books and periodicals circulated	674
Number of inter-library loans	97
Number of catalogue cards typed and filed	3180
Number of author entries prepared for the Union Catalogue of the Nova Scotia Provincial Library. (These cards will be processed for inclusion in the Union Catalogue of the Na- tional Library)	484
Number of DSIS Abstract cards processed and filed	2000
Number of photocopies made	5000

Accounts

Between January 1 and November 30, 1964 this office has been engaged in:

- Checking, typing and processing 1,616 Purchase Requisitions--estimated total cost \$1,712,700.00.
- Typing, processing and paying 72 Field Travel Claims--total expenditure \$3,184.00.
- Typing and processing 86 Other Travel Claims (Administrative, Removal, etc.)--total expenditure \$12,934.02.
- Preparing and issuing pay cheques to an average of 15 Depot and Regional Staff Prevailing Rate employees - total expenditure \$32,197.91.

- Processing and paying 184 accounts, (brokerage, electricity, express, freight, motor vehicle repairs, telegrams, telephones, etc.) - total expenditure \$47,085.60.
- Receiving, recording, distributing and returning (after signature) a total of 1,316 Inventory Control Slips (F50).
- Maintenance of B.I.O. Administration Bank Account; Financial Allotment Control Ledgers; and preparation of monthly financial statements.

Effective October 1,1964 the payment of the wages of ships crews was transferred to the Halifax Regional Treasury Office. It is intended to transfer the Depot Staff "Prevailing Rate" and Ships Officers effective January 1, 1965 and April 1, 1965 respectively.

Personnel

During the last quarter of the year ten additional administrative staff have been hired and the improvement in service is very noticeable; four more positions remain to be filled.

The recruiting of staff for all areas of the Institute is now proceeding, and it is anticipated that the majority of the positions will be filled during the next few months.

During the year there were twenty-one staff reclassifications. This summer, a total of twenty-four university students were employed, as well as six students from the Nova Scotia Institute of Technology.

Buildings

There have been no major changes in buildings of the Institute during the year. With the increase of staff, space is at a premium and after a survey of facilities a reallocation of staff was made in order that there would be maximum use of the space available.

Visits

During the year there were many visitors to the Bedford Institute. In February "open house" days were held for university and college students, as well as senior high school students. During the months of July and August the City of Dartmouth provided two senior high school students who showed visitors the facilities of the Bedford Institute. Regular guided tours were held six times each day. Well over one thousand tourists from various parts of Canada, the United States and other countries such as England, Ireland, Scotland and Bermuda visited the Institute.

Several groups such as those attending the Annual Congress of the Canadian Association of Physicists, the Royal Meteorological Society of Canada, Dalhousie Alumni and service personnel toured B.I.O.; generally, these groups made arrangements for the visits with individuals on the Institute staff.

4.2. ENGINEERING SERVICES

The engineering services group, in common with the whole Institute, has developed during the year into an integrated organization. During the course of the year we have been promised a considerable increase in staff and recruiting has started; it is anticipated that next year will see the group able to provide to a considerable extent the services needed by the research and survey staff.

Much of the work carried out by the group is routine, including maintenance of mechanical and electronic equipment; in this area, a start has been made towards setting up systematic servicing and quality control methods, and this trend will be continued. During the latter part of the year Mr. L. Fitzgerald won a promotional competition to the Geophysics Group; his promotion is well deserved, and it is hoped that other technicians will display such interest and enthusiasm in the work to which they are assigned that they may win similar competitions.

4.2a. ELECTRONIC MAINTENANCE

During the winter period the Electronics Maintenance section carried out the overhaul of the following equipment:

Echo sounders	49
Radiotelephones	53
Tellurometers	20
Radars	7
Wireless Room Equipment	4
Decca Positioning Systems	2
Ancillary Decca Positioning Equipment	6
Various Scientific Electronic Instruments..	9

There were seven new installations Performed by the electronic maintenance staff, plus a modification to the Decca transmitting mast aboard BAFFIN and HUDSON.

The projects conducted by this section are as follows:

- (1) the modification and testing of a Kelvin-Hughes echo sounder to employ a thyatron for switching in the transmitter;
- (2) the modification of a Ferrograph echo sounder to enable the operator to fix the time of a sounding;
- (3) the investigation of modifying an EDO 9006 echo sounder to enable it to determine sea ice thickness; this project is still under investigation;
- (4) the evaluation of available single-sideband communications equipment (RCA and Redifon) ;
- (5) the provision of a telemetry link for the Air-Sea Interaction Group.

The Electronic Maintenance department at B.I.O. underwent a complete reorganization during the past few months. Labs were set up and staffed to carry out the maintenance and overhaul of the different groups of electronic equipment, such as (1) echo sounders and R/T equipment, (2) Decca positioning systems, (3) tellurometers, (4) standards and test equipment. To

complete the electronic maintenance concept for B.I.O., test instructions and test data sheets have been prepared for the overhaul of echo sounders and R/T sets, and similar instructions and data sheets for other equipments are being prepared at present. It is planned to conduct a Decca and a Tellurometer course this winter similar to those given last year.

4.2b. MECHANICAL SERVICES

Under the direction of Mr. R. Balfour, the service of the Depot workshops continues to meet the problems so regularly provided by B.I.O. staff. For all round versatility one has to go far to equal the record of this vital section of B.I.O.: snowplowing to keep the place open in the winter, erecting new storage racks, handling the ships lines in and out, changing office space around, to mention only a few of the "other" activities of this group. The addition of a machinist, sheet metal worker, diesel mechanic and a carpenter has alleviated some of the overload. In addition it is hoped that the new staff will enable us to overhaul the hulls as well as the engines of the launches.

The Instrument Machine Shop contributed directly to various of the design projects mentioned in Section 3.4; it was also constantly involved with minor projects such as designing and building items that in themselves do not constitute projects but are time consuming. Besides these items there is the constant demand for small maintenance jobs; in common with all areas, the instrument machine shop suffers from the handicap of too few hands to maintain a sustained new development program.

4.3. OCEANOGRAPHIC SERVICES

The following samples were analyzed for salinity in the salinity laboratory at B.I.O.:

B.I.O. (M. & T.S.)..	4750
Atlantic Oceanographic Group	1180
F.R.B.-St. John's, Nfld	400
F.R.B.-St. Andrews, N. B	70
Naval Research Establishment	75
McGill University	250
Defence Research Board	250

6975

Bathythermograph slides were processed by the bathythermograph laboratory as follows:

Agency	No. of B.T. Slides
B.I.O. (M. & T. S.)	422
Atlantic Oceanographic Group	126
F.R.B.-St. John's, Nfld	1107
F.R.B.-St. Andrew's, N. B	483
Royal Canadian Navy	631
Arctic Unit, Montreal	19
Sambro Lightship	507
Naval Research Establishment	224

3519

13,274 prints of the slides were completed by December 10, 1964 and distributed as follows:

- 1 File Copy
- 1 Copy to Contributor (except St. John's, Nfld. who received 2)
- 1 Copy to Woods Hole Oceanographic Institution, Woods Hole, Mass.
- 1 Copy to U.S. Hydrographic Office, Washington, D.C.

A backlog of approximately 800 B.T. Slides remain to be processed.

In addition to the B.T.s the laboratory continued to collect the daily observations obtained at Sarnbro Light vessel by D.O.T. and drew up charts of temperature for each month. Copies were forwarded to St. Andrews Biological Station.

The bathythermograph calibrator built by contract in British Columbia has been delivered to the Pacific Naval Laboratory, Esquimalt, for testing. If it meets specifications it will be put into operation at B.I.O. in 1965.

4.4 SHIPS

CSS HUDSON

Departed B.I.O. on her first assignment on January 20 and returned 10 days later with commutator trouble on the port propulsion motor.

Officially commissioned at B.I.O. on February 14 by the Honourable W. M. Benidickson, Minister of Mines and Technical Surveys.

Full speed trials and ice-breaking trials March 10-16.

Winch trials March 23-26.

Hydrographic survey work March 26 - April 27.

Returned to B.I.O. April 27 with port propulsion motor not operating.

Tested port and starboard propulsion motors alongside at B.I.O. Test carried out by builder and motors appeared to be O.K.

Engine trials May 14-19. Vessel returned to B.I.O. with leaking tubes in main engine coolers.

Represented the Department at the 100th anniversary of Confederation at Charlottetown June 6-10.

Carried out geophysical investigations June 10-12.

Replacement of main engine coolers and other repairs carried out alongside at B.I.O.

Trial cruise - engines, motors and controls June 25-July 2.

Departed B.I.O. for Saint John Shipbuilding and Drydock for repairs and warranty docking/refit July 20.

Returned to B.I.O. October 11.

Trial cruise October 20-30.

Geophysics cruise November 5 - 13.

Oceanographic cruise November 16 - 25.

Oceanographic cruise (IODAL-Biology) December 7-20.

Vessel engaged in search and rescue work south of Sable Island on December 9 and 10 with Canadian Coast Guard.

There are still some defects to be remedied, but the vessel now appears to be operational. Further ice-trials and winch trials are required and these are scheduled for January 1965.

CSS BAFFIN

This vessel has had an exceptionally long and busy season.

The first cruise was to Aruba and the Virgin Islands, January 7 - May 9.

Oceanographic cruise in the Atlantic June 1 - July 15.

Geophysical survey July 27 - August 8.

Hydrographic survey Bay of Fundy, August 12 - October 30.

Oceanographic survey November 16 - December 15.

Testing of new equipment December 17.

With the exception of the port gear box, which is now beginning to give trouble, the vessel has stood up well. During the coming refit period, a permanent gravity laboratory will be installed and a flume tank stabilization system fitted.

CSS KAPUSKASING

This vessel began her season's work with a marine geology survey, April 6 - May 15, and continued with hydrographic survey in Chaleur Bay June 1 - October 23. She is scheduled to be outfitted with EDO transducer and improved oceanographic facilities during the coming refit.

CSS ACADIA

This vessel was engaged in hydrographic survey work in the Gulf of St. Lawrence and off the coast of Newfoundland May 22 - October 14.

Represented the Department at the 100th anniversary of Confederation at Charlottetown June 7 - 10.

She carried out a training cruise with IODAL-biology students on October 20.

Arrived at Pictou for winter lay-up October 23.

During the season minor repairs were carried out on her boilers. Temporary difficulties were also experienced with unsuitable coal.

CSS MAXWELL

This vessel was engaged in hydrographic survey work from May 8 - November 6. Two operating days were lost when repairs had to be made to one of her launch davits and to the deep freeze.

MV THETA

This vessel was chartered by B.I.O. from May 20 - October 17.

Seismic and magnetometer survey-IODAL - May 26 - June 12.

Deep ocean mooring of current meters June 8 - July 17.

Seismic survey July 22 - September 9.

Deep ocean mooring of current meters September 15 - October 13.

CSL ANDERSON

Current observations - Belledune Point - June 2 - September 13.

This launch is now being condemned. The Perkins diesel has been removed for use as spare on other launches.

CNAV BLUETHROAT

Geophysics survey September 28 - October 9.

Statistics on B.I.O. Ships

	HUSON	BAFFIN	KAPUSKASING	ACADIA	MAXWELL
Days away from home base	111	275	169	126	167
Miles travelled	23,130	42,483	10,822	5,189	4,643
Number of cruises	11	6	2	2	2

Ships Personnel

Judging from the reports of hydrographers and

oceanographers, the qualifications of both the officers and the crews of B.I.O. vessels are improving. However, it is still difficult to obtain qualified engineers and machinists. The senior engineers on the diesel-driven vessels (HUDSON, BAFFIN) are encouraging junior personnel to improve their qualifications and to study for better tickets. Four Deck Officers have attended radar courses at the Navigation School. Four Deck Officers and one Engineer have attended a Meteorological Course given by D.O.T. Two officers have been granted educational leave to study for better certificates. The deck officers are taking an active part in the recently started GEBCO program. So far the HUDSON and the BAFFIN have been involved. The recorded data is checked by the B.I.O. hydrographic staff. A change in policy with regard to winter lay-up was decided upon. With the exception of the ACADIA (which continues to be based at Pictou) none of the ships' crews have been placed on "seasonal lay-off" but have been sent on leave instead. During the summer five "relieving" crew were hired for the ships to give crew an opportunity to take some of their leave during the summer months; it is hoped that the number of relieving crew may be increased next year. This new policy has been received very enthusiastically by a large majority of ship's crews. Positions for five "relieving" ships officers were allocated to the division during the year and four are now filled.

Paylists

The amount of work in the office has increased considerably. On October 1 a new pay procedure for ships' crews and ships' prevailing rates was inaugurated. This is now being handled by B.I.O. under the direction of Mr. G. W. Booth through the Regional Treasury Office in Halifax. Starting on April 1, 1965 it is the intention to follow the same system for ships' officers. Though the workload has increased in the office, the amount of office work onboard ship has decreased, and a full time writer is no longer considered necessary onboard all the vessels. The intention at the present time is to employ writers on the HUDSON and the BAFFIN only. The others are required at the office and may be sent to the KAPUSKASING and the ACADIA for short periods if and when required.

Publications and Reports

5.1 PUBLICATIONS (Complete list to date)

Author	Title	Contribution No.
Pelletier, B. R. (G.S.C.)	Triassic Stratigraphy of the Rocky Mountain Foothills between Peace and Muskwa Rivers, Northeastern British Columbia. Geological Survey of Canada, Paper 63-33.	1
Leslie, R. J. (G.S.C.)	Sedimentology of Hudson Bay, District of Keewatin. Geological Survey of Canada, Paper 63-48.	2
Loncarevic, B. D.	Accuracy of Sea Gravity Surveys. NATURE, 198, 23-24, April 6, 1963.	3
Platford, R. F. (A.O.G.)	The Activity Product of Ferric Hydroxide by Turbidimetry. Canadian Journal of Chemistry, Vol. 42, pp 181-183.	4
Campbell, N. J.	The Origin of Cold High Salinity Water in Foxe Basin. J. Fish. Res. Bd., Canada, 21 (1) :45-55.	5
Collin, A. E., and Dunbar, M. J.	Physical Oceanography in Arctic Canada. Oceanogr. Mar. Biol. Ann. Rev., 1964 2, 45-75, Harold Barnes, Editor.	6
Barrett, D. L., Berry, M., Blanchard, J. E., Keen, M. J., and McAllister, R. E.	Seismic Refraction Studies on the Nova Scotian Shelf. Travaux Scientifiques de l'Association Internationale de Seismologie, 1964.	7
Loncarevic, B. D., Matthews, D. H.	Bathymetric, Magnetic and Gravity Investigations (Indian Ocean Expedition 1961-62). Admiralty Marine Science Publication No. 4, Parts 1 and 2, London, August, 1963.	8
Drake, C. L., Campbell, N. J., Sands, G., and Nafe, J. E.	A mid-Labrador Sea Ridge. NATURE, Vol. 200, No. 4911, pp 1085-1086.	9
Bartlett, G. A. (G.S.C.)	Preliminary Investigation of Benthonic Foraminiferal Distribution on the Atlantic Continental Shelf, Southeast Nova Scotia. Geological Survey of Canada, Paper 64-5.	10
Forrester, W. D.	Thermocline Structure in the Equatorial Pacific. J. Mar. Res. 22, 2, 1964.	11
Loncarevic, B. D.	Geophysical Studies in the Indian Ocean. ENDEAVOUR, 23, No. 88, 43-47, Jan. 1964.	12
MacIntyre, W. G., Platford, R. F. (A.O.G.)	Dissolved Calcium Carbonate in the Labrador Sea. J. Fish. Res. Bd., Canada, 21 (6).	13
Barrett, D. L., Berry, M., Blanchard, J. E., Keen, M. J., and McAllister, R. E.	Seismic Studies on the Eastern Seaboard of Canada: The Atlantic Coast of Nova Scotia. Can. J. Earth Sci. 1, 10-22.	14
Nota, D. J. G., and Loring, D. H. (A.O.G.)	Recent Depositional Conditions in the St. Lawrence River and Gulf, Marine Geology. MARINE GEOLOGY, 33 pp, Elsevier Publishing Co. Also in press F.R.B. "Studies" Series.	15
Vilks, G. (G.S.C.)	Foraminiferal Study of East Bay, MacKenzie King Island, District of Franklin. Geological Survey of Canada, Paper 64-55. Also B.I.O. Report 64-4.	16

Oakey, N. S., and Gilbert, R. L. G.	A Graphic-Analogue to Digital Converter In press, Electronic Engineering.	17
Platford, R. F. (A.O.G.)	The Activity Coefficient of the Magnesium Ion in Sea Water. J. Fish. Res. Bd., Canada, 22 (1).	18
Pelletier, B. R. (G.S.C.)	Paleocurrents of the Triassic of Northeastern British Columbia. S.E.P.M. Research Symposium - in press.	19
Pelletier, B. R. (G.S.C.)	Sedimentation in Arctic Waters. S.E.P.M. Research Symposium - Abstract.	20
Loring, D. H. (A.O.G.)	Resume of Marine Geological Work by the Atlantic Oceanographic Group, 1961-64. Maritime Sediments, Vol. 1, No. 1, 1965.	21
Kranck, K. M. (G.S.C.)	Sediments of Exeter Bay, Baffin Island, District of Franklin. In press, Geological Survey of Canada. Also B.I.O. Report 64-15.	22
Marlowe, J. I. (G.S.C.)	Probable Tertiary Sediments from the Continental Slope off Nova Scotia. In press, Marine Geology. (The International Journal of Marine Geology, Geophysics and Geochemistry).	23
Collin, A. E.	Hudson Bay and Approaches. Also - Arctic Archipelago. In press, Encyclopedia of Earth Sciences.	24
Bartlett, G. A. (G.S.C.)	Benthonic Foraminiferal Ecology in St. Margaret's Bay and Mahone Bay, Southeast Nova Scotia. In press, Geological Survey of Canada. Also B.I.O. Report 64-8.	25
Pelletier, B. R. (G.S.C.)	Marine Geology in Arctic Canada and Hudson Bay In press, Encyclopedia of Earth Sciences - edited by Rhodes Fairbridge.	26
Loncarevic, B. D.	Gravity Measurements at Sea. Geophysics Dictionary, Pergamon Press, London - in press.	27
Loncarevic, B. D.	Accuracy of Sea Gravity Surveys: Comparisons of Shipborne and Submarine Gravity Values. NATURE, Jan. 1965.	28
Pelletier, B. R. (G.S.C.)	Development of Submarine Physiography in the Arctic Archipelago and its Relation to Crustal Movements. In press-Royal Society of Canada. Also B.I.O. Report 64-16.	29

5.2. B.I.O. REPORTS

B.I.O. 64-1	F. J. E. Wagner (G.S.C.)	Faunal Report II-Marine Geology Program, Polar Continental Shelf Project, Isachsen, District of Franklin.
B.I.O. 64-2	D. E. Buckley (G.S.C.)	Mechanical Analysis of Macroscopic Dispersal System by Means of a Settling Tube.
B.I.O. 64-3	N. J. Campbell R. H. Loucks J. R. N. Lazier	A Preliminary Assessment of the Physical Oceanography of the Labrador Sea During Norwestlant 2, 1963.
B.I.O. 64-4	G. Vilks (G.S.C.)	Foraminiferal Study of East Bay Mackenzie King Island, District of Franklin.
B.I.O. 64-5	W. I. Farquharson	Gaspe Passage - Current and Oceanographic Survey 1962.
B.I.O. 64-6	K. O. Westphal	On the Melting of Ice Sheets Under the Influence of a Bubbler System.
B.I.O. 64-7	C. Quon	A Tchebysev Representation of the PNJ Spectral Cutoff Frequencies for Ocean Wave Prediction by Computer.
B.I.O. 64-8	G. A. Bartlett (G.S.C.)	Benthonic Foraminiferal Ecology in St. Margaret's Bay and Mahone Bay, South- east Nova Scotia.
B.I.O. 64-9	J. I. Marlowe (G.S.C.)	Marine Geology, the Western Part of Prince Gustaf Adolf Sea.
B.I.O. 64-10	A. R. Coote	A Physical and Chemical Study of Tofino Inlet, Vancouver Island, British Columbia.

- B.I.O. 64-11 W. D. Forrester A Quantitative Temperature Salinity Study of the Gulf of St. Lawrence.
- B.I.O. 64-1.2 D. E. Buckley A Preliminary Statement on a Sedimentological Study of the Beach and Marine
A. C. Grant Area at Belledune Point, Chaleur Bay, New Brunswick.
(G.S.C.)
- B.I.O. 64-13 R. L. G. Gilbert The Design of a Deep-Water Wave Recorder.
- B.I.O. 64-14 N. S. Oakey A Graphic-Analogue to Digital Converter.
R. L. G. Gilbert
- B.I.O. 64-15 K. Kranck Sediments of Exeter Bay, District of Franklin.
(G.S.C.)
- B.I.O. 64-16 B. R. Pelletier Development of Submarine Physiography in the Canadian Arctic and its Relation
(G.S.C.) to Crustal Movements.
- B.I.O. 64-17 J. I. Marlowe The Geology of Part of the Continental Slope Near Sable Island, Nova Scotia.
(G.S.C.)
- B.I.O. 64-18 Third Annual Report.

5.3 B.I.O. INTERNAL NOTES

B.I.O. Internal Notes, formerly known as Institute Notes, are unpublished, unedited notes intended for internal circulation. They are encouraged as a first step in the preparation of a manuscript or as a first record of work, which may be unfinished or incompletely considered. External distribution, if any, is at the author's discretion.

- B.I.O. 64-1 L. D. Quick Proposed Training Programme.
R. C. Melanson
- B.I.O. 64-2 A. Holler "A" Frame Davit for Oceanographic Observations-A Short Description of the
Installation on the CCGS LABRADOR.
- B.I.O. 64-3 K. Manchester Geophysical Survey of the CCGS LABRADOR - July - October 1963.
T. Lea
P. H. McGrath
- B.I.O. 64-4 W. I. Farquharson Current Measurements (W.H.O.I. and Geodyne).
- B.I.O. 64-5 P. J. Berghuis Short Summary of Facilities CSS HUDSON.
- B.I.O. 64-6 R. C. Richards Summary of Papers Presented at I.U.G.G. Meeting, Berkeley, Calif.
- B.I.O. 64-7 F. L. DeGrasse Laser as a Potential Yardstick for Surveyors.
M. Duval
- B.I.O. 64-8 W. I. Farquharson Current Section-Proposed Programs 1965.
- B.I.O. 64-9 B. D. Loncarevic Sea Gravimeter Reliability Test.
- B.I.O. 64-10 R. C. Melanson Information Gathered During a Visit to the U.S. Coast and Geodetic Survey,
C. J. Langford Washington, D.C.
- B.I.O. 64-11 C. J. Langford Current Surveys, Baie Chaleur.
- B.I.O. 64-12 D. Dobson Report on International Buoy Symposium held at Washington, D.C. - March
24-25, Marine Technology Society.
- B.I.O. 64-13 W. N. English Notes on Meeting of USN/ONR Advisory Committee on Long Range Telemeter-
ing Buoy Development - Dec. 9-11, 1963 - Scripps Institution of Oceanography,
La Jolla, Calif.
- B.I.O. 64-14 B. D. Loncarevic Heat Flow Measurements in Shallow Seas.
- B.I.O. 64-15 A. E. Collin Preliminary Assessment of Action of Icebreaker Field Research Programmes.
J. R. N. Lazier
- B.I.O. 64-16 A. E. Collin Report of the Department of Transport Delegation to Russia and Other Baltic
Countries.
- B.I.O. 64-17 C. G. Connelly Abbreviations for Scientific Societies Affiliated with Oceanographic Studies.
(Ottawa)

B.I.O. 64-18	F. L. DeGrasse	Proposed Graphic Analysis Section, B.I.O.
B.I.O. 64-19	A. E. Collin	Notes on the Arctic Oceanographic Program, Prepared for the Research and Program Review Meetings - May 26, 27 and 28.
B.I.O. 64-20	R. L. G. Gilbert	Requirements for Oceanographic Launches.
B.I.O. 64-21	R. C. Richards	Processing of Data from Sea Ice Heat Flow Experiments.
B.I.O. 64-22	C. Quon	Wave Forecasting and Techniques
B.I.O. 64-23		Presentation of B.I.O. Proposed Programs at Research and Survey Program Review Meeting - May 26, 27 and 28, 1964 - Summary Minutes of Discussion.
B.I.O. 64-24	R. H. Loucks	A Note on the Dynamic West Greenland Current.
B.I.O. 64-25	R. H. Loucks	A Note on an Attempt to Modify a Differential Transformer so as to Obtain Frequency-Modulated Output.
B.I.O. 64-26	R. Hurdal	Daily Magnetic Variations at Sea - Some Practical Considerations.
B.I.O. 64-27	R. F. Reiniger	Suggested Improvement to Interpolation Programme.
B.I.O. 64-28	K. O. Westphal	Processing of Data from Sea Ice Heat Flow Experiments - Part 2.
B.I.O. 64-29	J. I. Marlowe (G.S.C.)	Suggestion for a Geological-Ecological Study in the Granada Trough and the Lesser Antilles.
B.I.O. 64-30	G. P. Cant (A.O.G.- F.R.B.)	Transparency Measurements with the Hydrowerkstaetten Transmissometer (Cruise S79).
B.I.O. 64-31	R. V. Cooper	Investigations of Sea Gravimeter Characteristics (Askania GSS2-17).
B.I.O. 64-32	R. A. Clarke	Estimation of Errors for Deep Sea Reversing Thermometers.
B.I.O. 64-33	R. A. Clarke	Periodic Changes of the Waters of the Scotian Shelf.
B.I.O. 64-34	J. Brooke	Standardization of Oceanographic Buoys.
B.I.O. 64-35	J. Brooke	Near Oceanbed Bottle Tripping Device.
B.I.O. 64-36	J. Brooke	Current Meter Bracket.
B.I.O. 64-37	A. E. Collin A. M. Holler	Oceanographic Observations in Nares Strait, Arctic Canada.
B.I.O. 64-38	J. A. Coombs	Principle of the Photogrammetric Method of Determining Water Current Velocities.
B.I.O. 64-39	R. L. G. Gilbert	Notes on the Horizontal Echo Sounder.
B.I.O. 64-40	R. O. Kuehnel	A Very Low Frequency (VLF) Navigation System for Ships.
B.I.O. 64-41	P. J. Berghuis P. L. Corkum	Report on a Visit to the American Congress of Surveying and Mapping 24th Annual Meeting - and American Society of Photogrammetry - 30th Annual Meeting - Washington, D.C., March 15 - 20, 1964.
B.I.O. 64-42	R. C. Richards	Summary of Lectures Presented at N.U.F.F.I.C. International Summer Course on Some Physical Aspects of Oceanology in Shallow Seas.
B.I.O. 64-43	V. N. Beck R. H. Loucks	Evaluation of a Miniature Electrical Humidity Sensor.
B.I.O. 64-44		Summer Reports 1964 - Student Assistants.

Lectures and Talks

6. LECTURES AND TALKS

The following is a partial list of presentations by members of the staff.

- | | |
|--|--|
| Buckley, D. E. | Talk on Marine Geology in Canada to Department of Geology, University of Southern California, Los Angeles, Calif., U.S.A. |
| Cormier, R. | Talk on Mineral Separation to Saint Mary's University, Halifax, N. S. |
| Doe, L. A. E. | Six-week series of lectures on Physical Oceanography for UNESCO in Pakistan, October 15 - November 30. |
| King, L. H. | Seminar on Organic Constituents in Marine Sediments, given to Dalhousie University, Halifax, N. S. |
| Loncarevic, B. D. | Sea Gravimeter Reliability Test - paper to American Geophysical Union, Washington, D.C., April 23, 1964. |
| Loncarevic, B. D. and Berghuis, P. J. | Shipborne Gravity Measurements on the Nova Scotia Continental Shelf-paper to Royal Society of Canada, Charlottetown, P.E.I., June 9, 1964. |
| Loncarevic, B. D. | A Proposal for a Gravity Survey of the World Oceans - paper at Symposium on the "Extension of the Gravity Anomalies to Unsurveyed Areas" held at Ohio State University, November 18, 1964. |
| Loncarevic, B. D. | Arctic Geophysics, Orpheus Anomaly and Continental Drift-paper at Scripps Institution of Oceanography, La Jolla, Calif., December 14, 1964. |
| McGrath, P. H.
Manchester, K. S.
Keen, M. J. | Geophysical Studies in the Labrador Sea, Davis Strait and Baffin Bay-paper to Royal Society of Canada, Charlottetown, P.E.I., June 3, 1964. |
| Marlowe, J. I. | Two seminars on Carbonate Petrology, held at Dalhousie University, Halifax, N. S. |
| Pelletier, B. R. | Seminar on Regional Sedimentation Problems, Newfoundland Memorial University, St. John's, Nfld. |
| Pelletier, B. R. | Talk on Marine Geology Program at B.I.O. to faculty and students of Newfoundland Memorial University. |
| Pelletier, B. R. | Triassic Paleocurrents of Northeastern British Columbia - paper presented at S.E.P.M., Toronto, Ont. |
| Pelletier, B. R. | Arctic Submarine Physiography and Crustal Movement - paper presented to Royal Society of Canada, Charlottetown, P.E.I. |
| Pelletier, B. R. | Seminar on Regional Sedimentation to Geology Department, University of New Brunswick, Fredericton, N. B. |
| Pelletier, B. R. | Talk on Marine Geology Program at B.I.O. to the Canadian Institute of Mining and Metallurgy, Fredericton, N. B. |
| Vilks, G. | Seminar on Field and Laboratory Study of Foraminifera of Satellite Bay, District of Franklin, held at Dalhousie University, Halifax, N. S. |

A number of B.I.O. staff have been appointed to the Faculties of Dalhousie University, and are giving the following courses of lectures:

Oceanography I	L. A. E. Doe and R. W. Trites (A.O.G.)
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Part of Geology 12: Physics of the Earth	B. D. Loncarevic
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Graduate Course in Fluid Mechanics in Physics Department	C. R. Mann
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The following additional lectures were also given at Dalhousie University:

Two sessions as Guest Lecturer in Physical Oceanography	W. D. Forrester
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Part of Graduate Chemistry Course: The Scientific Method	R. L. G. Gilbert
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Three series of "in-house" lectures have been given during the year, by many B.I.O. staff. A course providing an outline of oceanography, and activities at the Institute, was given, primarily for hydrographic staff, in the spring; a course outlining the activities at the Institute was given for summer students; and an introductory course on oceanography was given to RCAF and RCN staff in November.

Staff

7. SENIOR STAFF, DECEMBER, 1964

Doe, Dr. L. A. E. A/Director
 Gilbert, Dr. R. L. G. Engineer-in-charge
 Holler, Capt. A. M. A/Marine Superintendent
 Mann, Dr. C. R. Senior Oceanographer
 Melanson, R. C. A/Regional Hydrographer
 Pelletier, Dr. B. R. Head, Marine Geology
 Scott, S. H. Administrative Officer
 Trites, Dr. R. W. A/Oceanographer-in-charge,
 Atlantic Oceanographic Group.

Ewing, G. N.* Scientific Officer
 Farquharson, Cdr. W. I. Technical Officer
 Forrester, W. D. Senior Scientific Officer
 Lazier, J. R. N. Scientific Officer
 Lewis, Dr. E. L. Senior Scientific Officer
 Loncarevic, Dr. B. D. Senior Scientific Officer
 Loucks, R. H. Scientific Officer
 Mason, Dr. C. S. Scientific Officer
 Maunsell, Dr. C. D. Senior Scientific Officer
 Needler, Dr. G. T. Scientific Officer
 Pagden, I. M. H. Scientific Officer
 Quon, C.* Scientific Officer
 Reiniger, R. F.* Scientific Officer
 Richards, R. C. Scientific Officer
 Ross, C. K** Scientific Officer
 Sandstrom, H.* Scientific Officer
 Smith, S. D.* Scientific Officer
 Westphal, Dr. K. O. Scientific Officer

PROFESSIONAL and SENIOR TECHNICAL STAFF HYDROGRAPHIC SURVEY

Amero, R. C. Technical Officer
 Cameron, R. M. Technical Officer
 Corkum, P. L. Technical Officer
 DeGrasse, F. L. Technical Officer
 Dunbrack, S. S. Technical Officer
 Gaudet, V. J. Technical Officer
 Hemphill, M. A. Technical Officer
 Kenney, A. D. Technical Officer
 Langford, C. J. Technical Officer
 Martin, J. G. Technical Officer
 Murdock, L. P. Technical Officer
 Pilote, J. M. R. Technical Officer
 Probert, W. J. Technical Officer
 Quick, L. D. Technical Officer
 Shreenan, J. G. Engineer
 Smith, T. B. Technical Officer
 Swim, M. G. Technical Officer
 Williams, R. K. Technical Officer

MARINE GEOLOGY

Bartlett, Dr. G. A. Geologist
 Buckley, D. E.* Scientific Officer
 King, Dr. L. H. Geologist
 Leslie, R. J. Technical Officer
 Marlowe, Dr. J. I. Geologist
 Vilks, G.* Scientific Officer

ENGINEERING

Atkinson, A. S. Engineer
 Balfour, R. Technical Officer
 Brooke, J. Engineer
 Sutherland, H. B. Technical Officer

OCEANOGRAPHIC RESEARCH

Bailey, W. B. Senior Scientific Officer
 Barrett, D. L. Scientific Officer
 Bridge, P. H. Engineer
 Butters, J. Technical Officer
 Collin, Dr. A. E. Senior Scientific Officer
 Coote, A. R. Scientific Officer
 Dobson, D. Technical Officer
 Elliott, J. A.* Scientific Officer

PARTIAL DIRECTORY OF SHIPS OFFICERS

CSS BAFFIN

Master W. N. Kettle*
 A/Master P. M. Brick
 Chief Officer A. R. Turnbull
 2nd Officer G. C. Dale
 Chief Engineer J. F. Boutilier
 2nd Engineer D. Marr
 *Educational Leave

CSS HUDSON		2nd Engineer	E. G. Clarke
Master	W. J. Vieau	CSS ACADIA	
Chief Officer	M. J. A. Wagner	Master	J. W. C. Taylor
2nd Officer	D. S. McGarvie	Chief Officer	J. R. ,Gillis
Chief Engineer	S. J. Lambert	2nd Officer	F. W. Sheppard
2nd Engineer	W. F. Buchan	A/Chief Engineer	J. L. Lavoie
CSS KAPUSKASING		2nd Engineer	J. W. Baker
Master	W. Thorne	CSS MAXWELL	
Chief Officer	A. Porter	Master	S. Baggs
2nd Officer	G. K. Zinck	A/Chief Engineer	J. A. Mossman
Chief Engineer	R. Berntsen	*Educational Leave	

LIST OF ABBREVIATIONS

AOG	Atlantic Oceanographic Group
BIO	Bedford Institute of Oceanography
BT	Bathythermograph
CCGS	Canadian Coast Guard Ship
CCO	Canadian Committee on Oceanography
CNAV	Canadian Naval Auxiliary Vessel
CODC	Canadian Oceanographic Data Centre
CSC	Civil Service Commission
CSL	Canadian Survey Launch
CSS	Canadian Scientific Ship
DM&TS	Department of Mines and Technical Surveys
DOT	Department of Transport
FRB	Fisheries Research Board of Canada
GEBCO	General Bathymetric Chart of the Oceans
GEK	Geomagnetic Electrokynetograph
GSC	Geological Survey of Canada
ICNAF	International Commission for Northwest Atlantic Fisheries
IODAL	Institute of Oceanography, Dalhousie University
IOUBC	Institute of Oceanography, University of British Columbia
MSB	Marine Sciences Branch
M&TS	Mines and Technical Surveys
NCO	Non-commissioned Officer
NIO	National Institute of Oceanography (U.K.)
R/T	Radio Telephone

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**SPECIAL
SUPPLEMENT**

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**FISHERIES RESEARCH BOARD OF CANADA
ATLANTIC OCEANOGRAPHIC GROUP**

Bedford Institute of Oceanography,

Dartmouth, N. S.

ANNUAL REPORT

AND

INVESTIGATORS' SUMMARIES

1964

December 31, 1964

R. W. Trites, A/Oceanographer-in-Charge

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FOREWORD

In 1956 the period that the Annual Report covered was changed from the calendar year to the fiscal year. This year the Annual Report is reverting to the earlier procedure of covering the calendar year in order to satisfy more easily both the needs of the Board and the Canadian Committee on Oceanography.

FISHERIES RESEARCH BOARD OF CANADA
ATLANTIC OCEANOGRAPHIC GROUP
Dartmouth, Nova Scotia

A N N U A L R E P O R T

1964

INTRODUCTION

The Atlantic Oceanographic Group, located at the Bedford Institute of Oceanography, is a division of the Fisheries Research Board's Biological Station, St. Andrews, N. B. The program of AOG is aimed at uniting the physical, chemical, and geological studies with those of biological oceanography. In view of the developing programs in oceanography by other Federal agencies, it was proposed a few years ago that the Board be prepared and responsible for providing and undertaking increased activities and research in biological oceanography. With this in mind, AOG has revised its programs. The intent is to gradually develop a program through four specific research programs: Biological Oceanography, Geological

and Geochemical Oceanography, Physical Oceanography, and Chemical Oceanography. The basic philosophy adopted is that if direct and fundamental links between the fisheries and the environmental parameters are to be established, it will require an integrated study. Moreover, it is contended that such a program to be successful will require a strong biological content.

In general terms the studies carried out in 1963 were continued. Current investigations include theoretical and applied physical oceanography, benthic biology, chemistry, and geochemistry. Although specific phases of the studies are of special interest in the applied sense, the present program as a whole is slanted towards problems concerning groundfish and other bottom-oriented fisheries in the Gulf of St. Lawrence.

Summary of Research Investigations

Physical Oceanography

The study of the circulation, dynamics, and driving forces in the Gulf of St. Lawrence was continued. Although there are a considerable number of synoptic observations of oceanographic parameters in the Gulf, very little attention has been given to the question of what is driving the circulation. The complexity of the equations of motion makes a rigorous solution impossible at the present time. However, useful results frequently can be obtained by modelling for only some of the terms in the equations. In this respect, work has continued on the two-dimensional electrical analog model of wind-driven circulation in the Gulf of St. Lawrence. This model indicated that the wind makes an important contribution to the surface circulation. Moreover, it is apparent that the local wind in a particular segment of the Gulf is not always indicative of the wind-driven circulation in that region. The encouraging results from this simplified model, have led to the design of a three-dimensional electrical analog which will allow variations in depth to be considered. Construction of a rectangular prototype of this model has commenced.

Manuscript reports detailing the use of electrical analogs in Physical Oceanography and their application to the Gulf of St. Lawrence have been prepared. Atmospheric pressure data were analyzed by computer to determine the long-term wind stress patterns over the Gulf. These data and the method of analysis are contained in a manuscript report.

The current measurement program associated with DM&TS operated on only a minor scale this year. At the request of AOG, two current meters and a temperature recorder were laid near bottom in the Magdalen Shallows by M&TS staff using M/V HARENGUS during the last week of June. The current meters, which were recovered three months later, had apparently operated for only a short portion of the time, owing to having been interfered with in some unknown manner. The temperature record indicated fluctuations less than 0.5°C over the three-month period.

In support of Lobster studies, two current meters were mounted in frames and placed on the bottom in the Richibucto area of New Brunswick. They were left for two months. One installation had been fouled by fishing gear and attempts to recover the meter using skin divers were unsuccessful.

An oceanographic cruise was carried out in the southeastern Gulf of St. Lawrence during late July and early August. Non-tidal drift was observed by the use of parachute drogues and transponding radio buoys. A network of oceanographic stations was occupied for the purpose of calculating geostrophic flow and vertical velocity. Preliminary results from this work indicated a current of about one knot setting northeast along the western Cape Breton shore and around Cape North. Along the north shore of Prince Edward Island the flow was westward indicating the possibility of a clockwise gyre between P.E.I. and the Magdalen Islands.

In August the work on optical oceanography was terminated for the present at least, as the result of resignation of the staff member carrying out these studies. Prior to this, effort was directed towards developing suitable instrumentation and techniques for measuring turbidity. The Coulter Counter was taken into the field in Chaleur Bay in support of DM&TS studies of nearshore conditions in the Pt. Belledune area. A hydrowerkstaetten transmissometer was used in the Northumberland Strait area in August.

The Edgerton camera was used extensively in a support role to the biological and geological programs. A smaller, less cumbersome framework was developed, so that the camera could conveniently be fitted into standard oceanographic station routine.

As a result of the interest shown in the preliminary charts prepared in 1963 showing mean seasonal bottom temperatures in the Gulf of St. Lawrence, a more extensive analysis has been undertaken using all available data. Charts of bottom temperature and salinity by months have been completed. All available data were submitted to CODC so that computer facilities could be used to produce the desired information. In addition to bottom temperatures and salinities, maps of mean monthly temperature will be available for standard oceanographic depths as well as other descriptive temperature and salinity features.

Geology and Geochemistry

Geological investigations of the morphology and sedimentology of the Magdalen Shallows which were initiated in 1963 were continued in 1964. In 1964 (Cruise S-79) additional bottom sampling stations were occupied in the western, eastern, and northern regions of the Shallows to complete the sampling coverage of this area on a reconnaissance scale (sampling stations at 10-15 nautical mile intervals). However, the coverage has not yet been completed for the bottom sediments in Northumberland Strait, Georges Bay, and the Bay of Chaleur.

This sampling program has provided some 230 sediment samples from this region for laboratory studies together with information on the (bottom topography and oceanographic conditions on the Shallows. This year laboratory analyses of the physical characteristics (grain size distribution, lithology, and composition) of the sediments were carried out on the majority of these samples. On the basis of the data thus obtained, it has been possible to describe in general terms the distribution and characteristics of the various types of sediment deposits on the Magdalen Shallows and to assess the general depositional conditions in this region.

In 1964, further studies were made of the geochemistry of the major elements in the sediments occupying the Laurentian Channel between Pte. des Monts and the Gaspé Passage. Additional chemical analyses for ferrous iron, sulphide sulphur, and carbon dioxide were carried out on these sediments along with the determination of the ion-exchange capacity in terms of calcium in the sediments.

A small amount of work was carried out on the

skeletal composition of shells in 1964. A suite of shells (waved whelks, banded whelks, horse mussels, scallops, and moon shells) from Passamaquoddy Bay, Northumberland Strait, and Georges Bank was received from the Biological Station, St. Andrews, New Brunswick. Semi-quantitative X-ray analysis of these shells showed that: waved whelks and moon shells were aragonite in composition, scallops were calcite in composition, while banded whelks and horse mussels contained mixtures of both. The horse mussel was studied further as it appeared to be possibly useful as an environmental indicator. Further analysis, however, indicated that the calcite aragonite ratio for horse mussels from a specific area is a function of shell weight. No clear relationship with environmental parameters has yet been established.

Biological Oceanography

The analysis was completed on the bottom samples taken at some of the groundfish fishing stations in the Magdalen Shallows in 1963 and an attempt made to relate the benthic organisms to the stomach contents of cod caught at the same time. No significant results were obtained as the cod had eaten very little infauna and no attempt was made to sample the hyperbenthos. As a result of the multiple sampling for bottom fauna, several distinct associations of animals were found. Most of the indicator species were molluscs or polychaetes. The cod, however, had been feeding on hyperbenthic species such as euphausiids and mysids and these animals were not taken by the bottom sampling technique used.

Attempts were therefore made at Richibucto in June to sample hyperbenthic organisms with a modified Icelandic high speed sampler. Multiple samples were taken with both the high speed sampler and the Van Veen grab at each of three stations in about 5 - 10 fms. of water. Results of this survey seem to indicate that there are concentrations of mysids and euphausiids close to the bottom during the day which are not adequately sampled by the Van Veen grab. In August similar samples were taken further offshore in deeper water. Daytime tows with the Icelandic sampler showed no large hyperbenthic organisms. It is not at present known whether this is a result of the effects of depth or other parameters.

Completion of the analyses of the multiple sampling stations carried out during S-67 have indicated considerable variation in abundance from station to station for several species. Although the sampling area was initially chosen to be one where the temperature and type of bottom was thought to be relatively uniform, subsequent observations indicate a significant variation in a number of the sediment parameters. Correlations between these and abundance of some of the benthic organisms is very striking.

During the last few months of 1964 active study has been given to establishing a second biological oceanographic program in plankton, secondary productivity, and the environmental factors, as it affects fish species of current and potential commercial interest. The program will be primarily concerned with identifying biological and other oceanographic factors which govern seasonal and local congregations of commercial species.

At present the area where this program is contemplated is the Gulf of St. Lawrence, but with proposed expansion and additional support, extensions to include other Canadian Atlantic regions will likely occur at a later date.

Chemical Oceanography

The past year has been spent in making physico-chemical measurements on the major inorganic ions in sea water, since it is felt a good understanding of the general chemistry is essential before the more specific and local problems can be attacked.

Activity coefficient measurements allow estimations of the concentration of various inorganic complexes in sea water to be made. The mean activity coefficients of sodium chloride and sodium sulphate in sea water have been measured as a function of temperature and salinity. The 'Individual' Activity Coefficients of the Sodium and Magnesium ions in Sea Water have been measured with a salt bridge. From these results and other data, the extent of complexing of some of the major ions in sea water was calculated.

Work is progressing, in cooperation with the Graduate School of IODAL, on the solubility product of calcium carbonate at low temperatures. The greatest single problem is that of measuring the carbonate ion concentration in sea water saturated with calcium carbonate. A Spectrophotometric method has been tried and rejected as unworkable, and the classical method based on alkalinity measurements has been adopted. Calcium was determined by complexometric titration.

The carbonate data from the ICNAF cruise Nor-westlant 2 have been published.

Technical Services

Salinity and BT Processing

The Group maintains shared responsibility for routine processing of salinities and bathythermographs on the East Coast. During the year a total of 13,274 salinity samples were analyzed and 3,519 bathythermograph slides were processed at the Bedford Institute.

Data Processing

The Canadian Oceanographic Data Centre processes all physical oceanographic data, providing the Group with interpolated data of temperature, salinity, oxygen, sigma-t, sound velocity, dynamic height, specific volume anomaly, and potential energy anomaly. The Group was responsible for coding and submitting data from ten oceanographic cruises to CODC for processing.

Cruises

The bulk of the Group's field studies is undertaken at sea aboard CNAV SACKVILLE, a vessel provided for oceanographic purposes by the Royal Canadian Navy (Figure 1). The SACKVILLE cruises, which are coordinated by the Oceanographer-in-charge, are programmed jointly with the ships of the Department of

Mines and Technical Surveys. All ships are shared between M&TS staff, FRB staff, and Dalhousie Institute of Oceanography staff.

This year the ship was available for oceanographic work for less than four months. Extensive refitting was carried out including the installation of flume stabilization tanks and a bow propeller. During the year, three cruises were carried out by the ship. Two of these were the responsibility of AOG and one was carried out independently of the Group. AOG personnel participated on a cruise of the HUDSON and on field work in the Richibucto area using the PANDALUS and a Fisheries Patrol vessel. AOG is assigned responsibility for arranging for occupation of the Halifax Section. This year it was occupied six times.

Staff and Facilities

The establishment of the Group comprises nine professional, eight technical, and two administrative and clerical. At present there are three vacancies on the professional staff and one is on educational leave. Two of the technical positions only became available in the latter part of the year. Offices, laboratories, and storage space are provided at the Bedford Institute of Oceanography.

Other Activities

The Group is an active member of the East Coast Working Group and has sponsored and supported a number of joint surveys on the East Coast.

Senior staff members have been engaged on consultative matters involving oceanographic problems, instrumentation, research programs, talks and lectures, and television programs. Some members lecture or assist in directing graduate student research at the Institute of Oceanography, Dalhousie University.

Subsequent to the Reports of the International Passamaquoddy Engineering Board to the International Joint Commission in October, 1959, a new study of the power project was undertaken by the U. S. Department of the Interior and reported in 1963. As some members of AOG had been closely involved with previous work, it was requested that we review the possible changes in the physical oceanographic features in order that any revision necessary in terms of the possible effects on fisheries could be made.

In cooperation with the Newfoundland Department of Fisheries, instrumentation assistance was given to the Captain of the M/V BEINER. This involved overseeing the purchase and installation of a recording thermometer aboard the vessel.

R. W. Trites,

A/Oceanographer-in-charge

December 31, 1964

PUBLICATIONS

The following publications have been published or submitted during the year:

- Loring, D. H., 1964. "Resume of marine geological work by the Atlantic Oceanographic Group, 1961-1964", Quarterly Publication concerning studies in modern and ancient sediments in the Atlantic Provinces and adjacent areas. Vol. 1, No. 1, Jan. 1965.
- MacIntyre, W. G. and R. F. Platford, 1964. "Dissolved calcium carbonate in the Labrador Sea". J. Fish. Res. Bd. Canada, 21(6).
- Nota, D. J. G. and D. H. Loring, 1964. "Recent depositional conditions in the St. Lawrence River and Gulf". Marine Geology (In Press).
- Platford, R. F., 1965. "The activity coefficient of the magnesium ion in sea water". J. Fish. Res. Bd. Canada, 22(1), (In Press).
- Prakash, A. and A. H. Viswanatha, Sanna, 1964. "On the occurrence of 'red water' phenomenon on the west coast of India". Current Science, 33 (6) : 168-170.

Manuscript Reports

- Blackford, B. L. and Y. W. Tsang, 1964. Average wind stress data for the Gulf of St. Lawrence". MS Rept. (Oceanogr. and Limnol.), No. 183.
- Blackford, B. L., 1964. "Electrical analogs in physical oceanography". MS Rept. (Oceanogr. and Limnol.) No. 184.

In Preparation

- Blackford, B. L. "A simple two-dimensional electrical analog for wind-driven circulation in the Gulf of St. Lawrence".
- Loring, D. H. "Sediments on the Magdalen Shallows - A reconnaissance study".
- Loring, D. H. "Geochemistry of the major elements in the sediments of the St. Lawrence River and Estuary".
- Platford, R. F. "The activity coefficient of sodium chloride in sea water".
- Platford, R. F. and T. Dafoe. "The activity coefficient of sodium sulphate in sea water".

PERSONNEL

January 1, 1964 -December 31, 1964

Scientific

R. W. Trites, M.A., Ph.D.	A/Oceanographer-in-charge
D. H. Loring, M.Sc., Ph.D.	Scientist 2
R. E. Platford, M.Sc., Ph.D.	Scientist 2
G. P. Cant, B.Sc., M.Sc.	Scientist 2
	(to August 31, 1964)
B. L. Blackford, B.Sc., M.Sc.	Scientist 2
A. Prakash, B.Sc., M.Sc., Ph.D.	Scientist 2
	(from August 1, 1964)
J. R. Chevrier, B.A., B.Sc.	Scientist 1
	(to September 30, 1964)
D. L. Peer, M.Sc.	Scientist 2
	(on educational leave)

Technical

G. B. Taylor	Technician 4
C. J. Bayers	Technician 3
C. C. Cunningham	Technician 3
T. A. Grant	Technician 1
R. J. Lahey	Technician 1
M. Hodgson	Technician 1
T. A. Holler	(from December 28; 1964)

Clerical

H. K. Gamester (Mrs.)
S. H. M. Rushton (Mrs.)

Term and Seasonal

Y. W. Tsang

I. Burbidge (Miss)

Clerk 3
Stenographer 2

Student Assistant
(from April 27 - August
26, 1964)

Student Assistant
(from May 19 - August
21, 1964)

J. A. Wood (Miss)

P. Christie

W. G. MacIntyre

Student Assistant
(from June 8 - Septem-
ber 25, 1964)

Student Assistant
(from June 8 - Septem-
ber 18, 1964)

Graduate Student
Dalhousie University

FIELD STUDIES IN THE SOUTHERN GULF OF ST. LAWRENCE

In support of Lobster studies of the St. Andrews Biological Station, two self-recording Richardson type current meters were mounted in frames and placed on the bottom in Kouchibouquac Bay near Richibucto, N. B. The meters were located at Lat. $46^{\circ} 43' 18.8''$ N; Long. $64^{\circ} 43' 59.4''$ W and Lat. $46^{\circ} 48.56'$ N; Long. $64^{\circ} 48.8'$ W, respectively. The former was near the Fairway buoy off Richibucto and the latter was near a special buoy installed by DOT for FRB. The meters were placed near the larger buoys so that they could be recovered by skin divers. Unfortunately, the FRB buoy was fouled by fishing gear and set adrift. Considerable effort was expended to recover the meter by using skin divers but was not successful. The other meter at the Fairway buoy was in place for slightly more than two months, June 2 to August 5. On June 20 movie photographs were taken of this meter and at that time it was working satisfactorily. However, on August 5 it was observed to be fouled by plant growth to the extent that the rotor was not working satisfactorily. Thus there is only about $1\frac{1}{2}$ months of good data. The data film from this meter is presently being analyzed by computer. Averaged direction data are not yet available but the speeds are about 0.15 knots average with several maximums of about 0.5 knots. The speed indicator was located roughly two feet off bedrock bottom and the direction vane six feet off bottom. The meter was programmed to sample speed and direction for one minute at twenty-minute intervals.

At the request of AOG, M&TS staff moored two self-recording Richardson type current meters and a Geodyne temperature recorder near the bottom on the Magdalen Shallows late in June. The installation was located midway on a line joining North Point, P.E.I. to South Cape, Magdalen Islands, Lat. $47^{\circ} 06'$ N; Long. $62^{\circ} 54'$ W. This installation was retrieved in late September. It was suspected that the installation had been fouled in some unknown way. One of the meters functioned for only a short time and since the data film from the other has not yet returned from computer analysis, it is not known whether or not useful results were obtained. The temperature recorder functioned properly and the record indicates a temperature of 0°C which did not fluctuate by more than $\frac{1}{2}^{\circ}\text{C}$ during the three-month period. The temperature sensor was located

within two feet above the bottom and sampled temperature continuously with a chart advance of 0.066" at twenty-minute intervals.

During late July and early August an oceanographic cruise (S-79) was carried out in the southern portion of the Gulf of St. Lawrence. Non-tidal drift was observed by the use of radar buoys attached to parachute drogues and in addition two radio transponding buoys were used. A network of oceanographic stations was occupied three times for the collection of data to calculate geostrophic flow and vertical velocities.

Parachutes were located at three depths (6, 20, and 45 metres), just above the thermocline, just below the thermocline, and near bottom respectively. Figures (2), (3), and (4) show drift tracks from the three layers, respectively. The observed movements indicate that the motion in the layer above the thermocline was much greater and much more wind dependent than in the deeper layers. The dashed tracks in Figures (2) and (4) occurred during a two-day period when the ship was absent from the region. A wind storm of 35 knots from the westerly quadrant also occurred during the same period and its effect on the drift motion is apparent, especially in the upper layer.

These results must be interpreted with caution because data collected over so short a period cannot be truly representative of the long term average, especially if wind conditions at the time are not typical. With this word of caution in mind the more predominant features shown by the drift buoys may be mentioned.

- (1) A marked dependence on wind conditions especially in the surface layer.
- (2) Evidence of a strong current setting northeast along the western Cape Breton shore and curving clockwise around Cape North.
- (3) Evidence of a westward setting current along the north shore of P.E.I. indicating the possibility of a clockwise gyre situated just to the north of P.E.I.

B. L. Blackford.

LABORATORY MODELS OF CIRCULATION

It is reasonable to assume that the dynamic circulation phenomena of the Gulf of St. Lawrence result from the combined effect of the various driving forces which are present. Furthermore, it is also reasonable to assume that fisheries and other related biological phenomena are dependent to some extent on circulation. Thus a basic understanding of the biological phenomena cannot be obtained without first having a 'basic knowledge of the circulation phenomena. In particular it will not be possible to predict fluctuations in biological phenomena without first being able to predict circulation phenomena from a knowledge of the driving forces. Ideally one would like to predict the driving forces as well.

In attempting to determine a quantitative understanding of the mechanism connecting the driving forces to the resulting circulation, it appears essential to supplement pure synoptic observations by the alternative approach of looking at causes and their subsequent effects. That is, from the point of view of a hydrodynamic system being set into motion by the action of various driving forces. Models based on simplified forms of the hydrodynamic equations of motion can be constructed and the effect of individual or combined driving forces on them may be studied. In this respect work has continued on the two-dimensional electrical analog model of wind-driven circulation which was reported in the previous annual report. Effort has been

directed towards a study of the effect of applying different boundary conditions along with a typical wind stress pattern. The results obtained are encouraging although they are of course subject to the simplifying approximations present in the model. It has indicated that the wind makes an important contribution to the average circulation. Moreover, it is apparent that the local wind in a particular segment of the Gulf is not always indicative of the wind-driven circulation in that region. A manuscript report giving a detailed description of this model and a discussion of the results obtained to date has been prepared.

The encouraging outcome of this simplified model has led to the design of a three-dimensional electrical analog which allows variations in depth and density to be considered. Construction has commenced on a rectangular prototype of this analog and if the outcome is

PHYSICAL OCEANOGRAPHIC STUDIES OF THE ST. LAWRENCE ESTUARY

The current measurement program initiated in the Gaspé-Pointe-des-Monts area in 1962 and 1963, was not continued in 1964. In both 1962 and 1963 only very scanty temperature and salinity observations were taken. The results of the 1962 survey however were very encouraging in that there appeared to be a broad agreement between the geostrophic flow and the residual flow as computed from the current meters. The mass field observations, however, were widely spaced both in time and distance and therefore did not permit firm conclusions to be drawn as to possible interrelationships between field of mass and field of flow.

The 1963 program was aimed at concentrating the mass field observations to a short period of time and at closely spaced stations by a Section line from Pointe-des-Monts to Grosses-Roches in order to shed more detailed light on the possible interrelationship. Currents were measured in detail across this section by DM&TS during June and July. A coordinated program using CNAV SACKVILLE and M/V THETA was carried

SAGUENAY RIVER ESTUARY

Oceanographic stations in the Saguenay River Estuary, a deep, narrow, fiord-type inlet, have been occupied on six occasions since 1961. (SACKVILLE - 56, July, 1961; SACKVILLE-62, May 1962; CARTIER-1, July 29, 1963; SACKVILLE-79, August 1964; HUDSON-29, November 1964). The results of the first cruise have been reported previously (AOG Annual Report, 1961-62). The parameters observed in the first cruise indicated a typically positive estuarine pattern. Salinity of the brackish seaward-moving surface layer ranged from 5‰ near the land to 20‰ near the mouth. However, dissolved oxygen concentrations were found to be relatively high (5.97-7.32 ml/l) in the deep layer and is suggestive that either that was very low oxygen consumption or that the deep basins were very well ventilated. Further observations were taken in order to gain added insight as to possible mechanisms.

The observations, although not well distributed over the year, do shed more light on some of the features. In general the temperature, salinity, σ_t , and dissolved oxygen values at 200 metres depth in the inner basin

follow successful, application to the Gulf is contemplated. A description of this analog is contained in a manuscript report on the general use of electrical analogs in physical oceanography.

To facilitate studies of the above nature, atmospheric pressure data were analyzed by computer to determine the long-term wind-stress patterns over the Gulf. Monthly data based on two separate ten-year averages were analyzed giving a total of twenty-four wind-stress patterns. A predominant feature of these long-term patterns is the high magnitude and high cyclonic vorticity present. This in itself is of importance since it is indicative of a similar type of wind-driven circulation pattern. A manuscript report giving these data and the method of analysis is available.

B. L. Blackford.

out so that reasonably synoptic temperature and salinity observations could be obtained. Each ship started simultaneously from either end of the line and occupied the section six times over a 48-hour period.

The analyses of the current meter data have just recently been completed and only preliminary comparisons with the geostrophic flows have been made. The average geostrophic transport was completed for the two-day period and is illustrated in Figure (5). Only broad qualitative agreement with the results of the current meter analysis was evident. The results confirmed those of earlier investigations in revealing a dominant North to South cross-channel flow in this region. Sufficient facilities, however, were not available to permit recording oceanographic parameters along a line of stations perpendicular to this cross-channel flow.

Analysis of these data, together with those taken in the Gaspé-Anticosti region in 1962, are expected to be completed and a report prepared in 1965.

R. W. Trites.

closely the values at 30-50 metres depth just seaward of the mouth of the Saguenay.

On all cruises, except those of the CARTIER, the values of dissolved oxygen were above 5 ml/l at and below the 200 metre level in the inner basin. On the CARTIER cruise oxygen values in the deep basins were found to be as low as 3.6 ml/l.

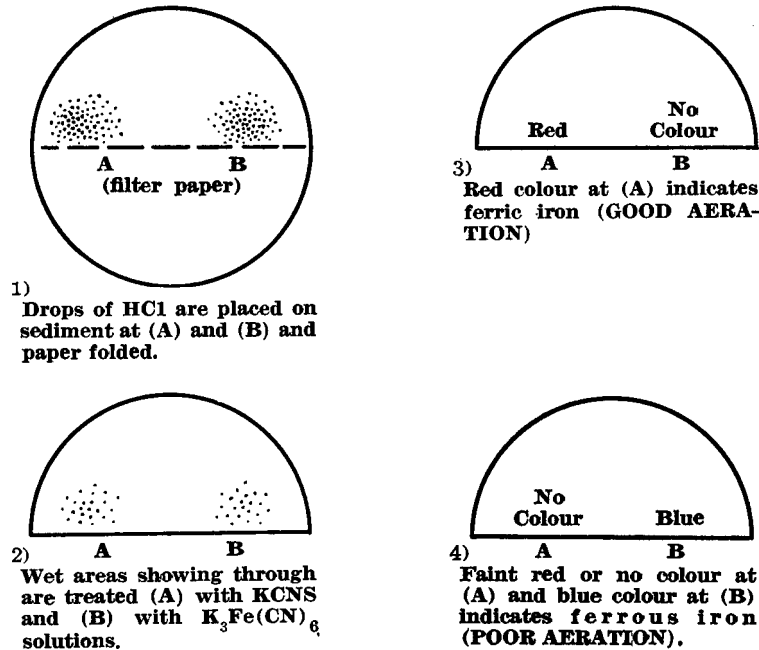
The two sections run by the CARTIER were just ten days apart. Over this period the oxygen values at 200 metres depth increased about 1 ml/l (from about 3.7 ml/l), temperature remained constant at about 0.85°C, salinity increased by about 0.2‰ and σ_t by 0.1. It appears therefore that a fairly vigorous replacement was occurring during this period. Calculations are being made to determine the minimum velocities that must have been present across the entrance sill to account for the observed change in oceanographic properties within the estuary.

R. W. Trites.

DISTRIBUTION OF TEMPERATURE & SALINITY IN GULF OF ST. LAWRENCE

As a result of the interest shown in the preliminary charts prepared in 1963 showing mean seasonal bottom temperatures in the Gulf of St. Lawrence, a more extensive analysis has been undertaken using all available data. Charts of bottom temperature have been completed, for each month of the year. Averages were taken by 5 x 5 minute and 10 x 10 minute squares of latitude and longitude for the last 15 years of data. Analysis

performed for squares of these dimensions revealed no data available for the majority of squares, even for the month when there was the greatest number of observations. The accompanying table shows the % of the squares for which observations are available for each month. Even for these squares, most have only one observation and therefore nothing can be said about the variation from the mean.



It is clear therefore that even for such an easily observable parameter as temperature we have only a very scanty coverage. Charts contoured from such meagre information therefore must be used with caution as extensive extrapolation and interpolation has been applied.

Temperature, salinity and density data at standard oceanographic depths are being analyzed in a fashion similar to the bottom data. These will be available in 1965.

R. W. Trites
T. A. Holler

HYDROSPACE OPTICS

Effort in this field primarily was divided along two paths: (1) developing suitable instrumentation and techniques for measuring turbidity, and (2) developing camera equipment as a support role to the benthic biological and geological studies.

In connection with a current and sediment study being carried out by DM&TS, the Coulter Counter was calibrated and taken to Belledune Point, N. B. in June where it was used in a survey of suspended load conditions in the waters around the Point. An investigation was made into the possibility of using a computer to process particle counting data. It would seem that such a plan is practical for data from analysis of bottom sediments but not for particle counts made on sea water samples.

During cruise S-79, a shallow water Hydrowerkstaetten transmissometer was used to obtain a profile of the transparency of the water between Richibucto, N. B. and P.E.I. Figure 6 shows the relative transparency pattern obtained. The surface water on the western

side of this section is of uniform turbidity down to a depth of 7m. Below this there is a fairly rapid transition to somewhat clearer water which extends to the bottom. Samples of pebbles and cobbles with some sand were taken from the bottom at these stations. In the deeper water toward the eastern side of the Strait, a sharp boundary exists between the surface water and the very turbid layer overlying the sandy bottom. From this work and from studies by other workers it appears that nine or ten stations are barely sufficient to reveal significant horizontal variations in turbidity across a section consisting of two shores and two or three types of bottom sediments.

Work on the design of a tri-colour transparency meter was carried on for several weeks. A suitable configuration was arrived at for the light source collimator and the receiver collimator and beam-splitter. However, details such as the shape of the lamp filament and design of the pressure chambers presented difficulties which could not be conveniently solved at that time.

A two-day photographic survey, using the Edgerton camera, was carried out to supplement the bottom sampling program in Kouchibouquac Bay. Some effort was required to resolve serious discrepancies between topographic and hydrographic charts in order that the photographs could be properly positioned.

The Edgerton camera was mechanically rearranged in order to make it much more compact and less awkward to handle aboard ship. The new arrangement was successfully used on cruise S-79. Some further refinement is anticipated.

Initial steps were taken to make use of optical

measurements in connection with field studies in fish behaviour. A study was made of the natural illumination and water transparency data for the waters off Nova Scotia in order that a decision could be reached as to what type of optical program would appear to be most promising. Measurements of the total natural visible irradiance on a horizontal plane at various depths seemed to be the easiest to obtain in great number while interfering least with other activities of a field study.

G. P. Cant

R. W. Trites

SEDIMENTS ON THE MAGDALEN SHALLOWS

Geological investigations of the morphology and sedimentology of the Magdalen Shallows, which were initiated in 1963, were continued in 1964. In 1964 (Cruise S-79), additional bottom sampling stations were occupied in the western, eastern, and northern parts of the Shallows. Recently, CSS HUDSON occupied 12 bottom sampling stations on the Shallows to complete our sampling coverage of this area on a reconnaissance scale. However, this coverage does not extend to Georges Bay, Northumberland Strait, Bay of Chaleur, or the eastern coastal waters of the Magdalen Islands.

This survey of the bottom sediments was undertaken to provide the basic data for use in studying the relationships between sediment composition and the occurrence of benthic animals, especially those which are common foods of fishes.

Laboratory studies of the physical characteristics of the sediments (grain-size analyses and lithological studies) have been conducted on the majority of the samples. On the basis of the data thus obtained and with the aid of underwater photographs of the bottom at selected localities, it is possible to describe the distribution and important characteristics of the sediments. A general assessment can also be made of the conditions controlling deposition in the region.

As a result of this new information, the tentative

sediment distribution map produced last year (AOG Annual Report, 1962-63) has now been replaced with the sediment distribution map shown in Figure 7. The basis of the sediment classification used in the preparation of the new sediment distribution map is a triangular diagram (Figure 8) on which are plotted the proportions of gravel (material greater in size than 2 mm), sand (material between 2 mm and 0.0624 mm), and mud defined as all material finer than 0.0624 mm, i.e. silt plus clay). The grain size scales used for the sediments are the Wentworth scales (Table 1). Depending on the relative proportions of these constituents and the median diameter of the major grade, the sediments fall into 10 major textural classes. Table 2 shows the percentage of each textural class found in the samples together with the percentage of the major grade sizes.

The overall picture of the geographic distribution of textural classes (Figure 8) and the sediment distribution along cross-sectional and longitudinal bottom profiles of the Magdalen Shallows given in Figure 9 are based on an interpretation of the sediments found at the sampling locations (Figure 10). The boundaries between different sediment types have been based on this interpretation, although the establishment of precise boundaries has been precluded by the reconnaissance nature of this work (sampling interval of 10-15 nautical miles for most parts of the Shallows).

WENTWORTH SIZE SCALES

TABLE 1

Grade	Side Class	Size		
		mm	Phi	Units (ø)
Gravel	Boulder	>256		- 8 to -12 ø
	Cobble	64.0		- 6 to - 8 ø
	Pebble	4.00	to 64.00	- 2 to - 6 ø
	Grannule	2.00	to 4.00	- 1 to - 2 ø
Sand	Very coarse sand	1.00	to 2.00	0 to - 1 ø
	Coarse sand	0.50	to 1.00	1 to 0 ø
	Medium sand	0.25	to 0.50	2 to 1 ø
	Fine Sand	0.125	to 0.50	3 to 2 ø
	Very fine sand	0.0625	to 0.125	4 to 3 ø
Mud	Silt and Clay	<0.0625		

TABLE 2

Major Grade Sizes	Percent of Total Samples
Gravel	33.51
Sand	58.39
Mud	8.10
Textural Class	Percent of Total Samples
Gravel	24.84
Sandy gravel	8.67
Gravelly sand	11.56
Muddy gravelly sand	1.16
S a n d	32.95: Medium
	24.5
	Fine
	70.5
Muddy sand	12.72
Sandy mud	1.16
Mud	6.94

D. H. Loring
R. J. Lahey

GEOCHEMISTRY

Geochemical studies were continued in 1964 on the sediments occurring in the estuary of the St. Lawrence River from Pointes-des-Monts to the western approaches of Anticosti Island. This year, the sediments have been analyzed for ferrous iron, carbon dioxide, and sulphur. Measurements have also been made of the ion-exchange capacity of the sediments. As a result, the geochemical studies on this group of sediments are nearly complete. Additional sampling was carried out above Pointe-des-Monts this year (Cruise S-79) in order to extend our studies of the major element composition of the sediments to the mouth of the Saguenay River.

The result of our geochemical studies are briefly summarized under ferrous iron, carbon dioxide, sulphur, and ion-exchange capacity measurements.

Ferrous Iron

The division of the total iron content, of the sediments into two component parts (Ferric and Ferrous, Fe^{+3} and Fe^{+2}) has clarified some aspects of the geochemistry of this element. The geographic distribution of total iron in the sediments (Figure 11) indicated that iron was concentrated in fine grained sediments in the submarine trough occupying the central part of the river and estuary of the St. Lawrence River, although it was not clear which iron species was responsible for this distribution pattern. Division of the total iron content into ferric and ferrous iron species has solved this problem. Ferric iron contents vary between 0.88% and 3.18% (average value 1.56%) in the sediments. The geographic distribution of ferric iron (Fe^{+3}) in the sediments indicates (Figure 12) that this iron species increases in concentration away from the shoreline, with decreasing grain size of the material, except in localized areas such as on Banc Parent. Ferrous iron contents vary between 1.45% and 2.83% (average value 2.15%) and are the dominant iron species (Figure 13) except in localized areas such as in the central part of the submarine trough southwest of Pointe-des-Monts. The geographic distribution of ferrous iron (Figure 13) differs from the distribution of ferric iron in that the distribution of ferrous iron is not closely related to the texture of the sediments. The geochemical relationships that exist between ferric and ferrous iron are best illustrated by the distribution pattern of the $\text{Fe}^{+3}/\text{Fe}^{+2}$ ratios in the sediments. Figure 14 shows that the $\text{Fe}^{+3}/\text{Fe}^{+2}$ ratios increase with decreasing grain size of the material away from the shoreline towards the central parts of the submarine trough. Within the centre of the

trough, the $\text{Fe}^{+3}/\text{Fe}^{+2}$ ratios of the river are slightly higher than those found in the estuary. Field observations and Eh measurements have shown that the sediments in this region are reducing in nature beneath a thin (1-2 cm thick) red oxidized surface layer. The increasing values of the $\text{Fe}^{+3}/\text{Fe}^{+2}$ ratios away from the shorelines towards the central part of the submarine trough reflects an increasing enrichment of ferric iron in the sediments as well as trend towards more oxidized surface sediments.

Although the sediments in direct contact with bottom oxygenated water become oxidized, it is unlikely that this is the main process responsible for higher $\text{Fe}^{+3}/\text{Fe}^{+2}$ ratios of the sediments in the central part of the trough, since field observations have shown this layer to be very thin. Ventilation of the surface sediments by the burrowing activity of polychaetes is considered to be one of the means by which the sediment would tend to become more oxidized in character. Incorporation of iron from solution at the sediment-water interface is also considered to take place in these sediments.

Carbon Dioxide

Quantitative carbon dioxide measurements of the sediments were undertaken to provide more reliable results than were obtained in 1963. Although more precise calculations were made of the CaCO_3 contents in the sediments using the new results, no significant changes were necessary for the distribution pattern of CaCO_3 in the sediments of the river and estuary, as derived from the work in 1963.

Sulphur

Acid soluble sulphur (sulphide sulphur) analyses were carried out this summer. Sulphur contents ranged from 0.01% to 0.8% in the sediments of the river and estuary. No significant geographic distribution pattern emerged from this study.

Ion-Capacity Measurements

Ion-exchange measurements were initiated this year to study the adjustments of the fine-grained sediments to the estuarine environment. A separate report covers the results of this work.

D. H. Loring
R. J. Lahey

SKELETAL COMPOSITION OF MOLLUSCAN SHELLS

X-ray diffraction studies of the polymorphic composition of molluscan shells were continued in 1964. This year, studies were conducted on suites of scallops, waved whelks, banded whelks, horse mussels, and moon shells from Passamaquoddy Bay, Georges Bank and Northumberland Strait. This selection of shells was supplied by the FRB Biological Station, St. Andrews, N. B.

Semi-quantitative x-ray diffraction analyses of selected specimens from each suite indicated (Table 1) that the waved whelks and moon shells were entirely aragonitic in composition. The scallops from each locality were found to be entirely calcitic. The banded whelks, however, differed from the waved whelks in that their skeletons contained appreciable amounts of calcite (60-90%). The horse mussels were also found to have mixed calcite and aragonite skeletons.

Since molluscan shells of mixed calcite and aragonite compositions are sometimes sensitive indicators of the physical and chemical environment surrounding the shells, it was decided to quantitatively investigate the skeletal composition of the banded whelks and horse mussels from each geographic location. For this phase of the investigation, a standard calibration curve in the

form of the ratio of Intensity (CPS) Calcite to Intensity (CPS) Calcite + Aragonite versus weight percent of calcite-aragonite mixtures. This curve was established for varying proportions of calcite and aragonite. Matrix effects were eliminated by preparing the standard mixtures from two pure end-member shells (Scallop-Calcite shells; Waved whelk-Aragonite shells). Standard calcite-aragonite mixtures and specimens were analyzed by the Philips X-ray diffractometer using optimum instrument settings for the analyses of calcite and aragonite.

At the present time, only limited quantitative data for the suite of banded whelks are available for discussion. These results show (Figure 15) that the aragonitic component of the banded whelks tends to decrease with increasing weight of the shell in the Passamaquoddy Bay suite. This trend is also recognized to a much lesser degree in the shells from Georges Bank. As only one specimen has been analyzed from the Northumberland Strait suite, no trend is evident. Analysis of additional samples from the suite of banded whelks is planned to assess the significance of these trends. The suite of horse mussel shells will also be investigated in some detail.

D. H. Loring.

TABLE 1

SUITE	SAMPLE NO.	LOCATION	SHELL WT.	% COMPOSITION	
				CALCITE	ARAGONITE
Waved Whelks		Passamaquoddy Bay			
(Buccium undaum)	63-LA-6	"	10.03	0	100
	63-LA-1	"	20.13	0	100
	63-LA-3	"	28.16	0	100
	63-LJ-6	Georges Bank	11.53	0	100
	63-LJ-4	"	13.56	0	100
	63-LJ-3	"	16.48	0	100
	63-LF-5	Northumberland St.	17.71	0	100
	63-LF-3	"	21.85	0	100
	63-LF-1	"	30.86	0	100
Banded Whelks		Passamaquoddy Bay			
(Neptunea decemcostata)	63-LB-4	"	21.98	82.5	17.5
	63-LB-2	"	38.34	89	11
	63-LI-6	Georges Bank	11.14	62.5	37.5
	63-LI-3	"	14.82	67.5	32.5
	63-LI-2	"	23.18	89.5	10.5
	63-LG-2	Northumberland St.	48.45	79	21
Scallops		Passamaquoddy Bay			
(Placopecten magellanicus)	63-LD-4	"	34.42	100	0
	63-LD-6	"	36.64	100	0
	63-LD-3	"	41.60	100	0
	63-LD-2	"	41.77	100	0
	63-LD-5	"	46.51	100	0
	63-LD-1	"	52.01	100	0
	63-LD-6	Northumberland St.	25.59	100	0
	63-LL-4	"	28.12	100	0
	63-LL-3	"	30.71	100	0
	63-LL-5	"	32.55	100	0
	63-LL-1	"	40.58	100	0
	63-LL-2	"	51.71	100	0
	Moon Shells		Georges Bank		
(Lunatia heros)	63-LH-5	"	26.68	0	100
	63-LH-2	"	57.19	0	100
	63-LH-1	"	106.95	0	100
	63-LE-4	Northumberland St.	14.57	0	100
	63-LE-3	"	17.52	0	100
	63-LE-1	"	31.41	0	100
Horse Mussels		Passamaquoddy Bay			
	63-LC-1	"	12.48	50	50
	63-LC-3	"	30.65	to	to
	63-LC-6	"	46.28	to	to
	63-LC-5	"	47.12	to	to
	63-LC-2	"	54.92	to	to
	63-LC-4	"	60.47	30	70
	63-LK-6	Georges Bank	13.97	53	45
	63-LK-5	"	14.31	53	47
	63-LK-4	"	61.11	43	57
	63-LK-3	"	67.15	50	50
	63-LK-2	"	78.79	33	67
	63-LK-1	"	99.30	24	74

DETERMINATION OF CATION EXCHANGE CAPACITY

Important to the study of plant nutrition is the nature of the sediment by which the plant is nourished. More specifically one must know the kind and amount of ionic species available for exchange between plant and sediment. Indeed, the process of ion exchange is the method by which the sediment adapts itself to its estuarine environment. The actual process consists in the replacement of the ions inherited from the soil environment (Ca^{++} , H^+) by absorption of surfaces of particles, by the most abundant ions in the overlying sea water (Na^+ , K^+ , Mg^{++}). Since soil particles have more anions than cations (cf. alumino-silicate skeleton: $[\text{Al}_2(\text{AlSi}_8\text{O}_{10}(\text{OH})_2)]^-$ the surfaces of the particles bear negative electrostatic charges which are available for reaction with the positive charges of the environment.

The number of cations required to neutralize the negative surface charges of a clay material is referred to as the "Cation exchange capacity" of that material. This is expressed as milliequivalents (of charge) /100 grams (of material). The basic reaction is: $\text{Ca}^{++}\text{clay} + \text{Na}^+ + \text{Na}^+ \text{clay} + \text{Ca}^{++}$ to solution. In the presence of a higher relative sodium concentration, a sodium clay should form by ion exchange. Concentration is the driving force that allows the sodium ions to compete successfully for the negative exchange sites on the surface of the clay particle.

The determining factors affecting preferential absorption of certain ionic species are many and various: ionic radius, amount and intensity of charge, radius of hydrated-ion sphere, salinity of solution, cation exchange capacities of minerals, size and shape of sites, etc., etc. There is, at present, some evidence to suggest that marine clays may be predominantly Mg^{++} - K^+ exchange material, but more experimental data are necessary on this point.

The cation exchange capacity determinations were made with respect to the calcium ion, according to the method described in **Soil Chemical Analysis** (M. L. Jackson) Chapter 4, Prentice Hall, May 1960. Essentially, the method consists of three steps:

(1) Removal of all reference exchangeable cations originally present in the sediment sample. This is done by leaching the sediment with a more concentrated solution of the competing positive ion, under conditions of elevated temperatures and correct (acidic) pH.

(2) Upon removal of all the original exchangeable cations, the sample is repeatedly washed in a prepared solution of the exchangeable cation. This fills up all the available sites. The excess is removed by washing with an acetone-water mixture.

(3) The cations now filling the exchange sites are again leached completely out by washing the sediment repeatedly in a concentrated solution of a competing cation. (This is obviously a repeat of step 1). The resulting solution of reference cation now forced out of the exchange sites is then quantitatively analyzed for the amount of cation contained. In this case, calcium is determined by titration with EDTA, using Eriochrome Black T in MeOH solution as indicator, and alkaline cyanide solution to depress any interferences. The cation exchange capacity of the sediment may be calculated from the amount of titrant used multiplied by the titre of the EDTA.

Discussion of Results

The method of determination used produces reasonable results, (Table 1) with rather good precision, the standard deviation being 2.7. In the author's opinion, however, such a method of determination is impracticable as a routine method. The reason for this is that the method is slow and somewhat tedious as it is possible to do only about four samples per day. This number can, of course, be increased by duplication of equipment. By the very nature of the determination, many washings per each step are necessary (as many as 5 to 7), much time is used up in the long centrifuging time (10 minutes) after each washing, so that a sample may whirl around in the centrifuge for about three hours each day before the sample is completely processed. Such centrifuging is quite necessary, as, otherwise, material is lost as the supernatant washings from each step are decanted off. At the last step in the procedure, the washings must be perfectly clear or else, in the Ca^{++} determination, any murkiness of solution will impair the end-point in the titration. Results were plotted on a map of the area (Figure 16).

Interpretation of Results

From observations of the results obtained and plotted on the regional map of the area showing sediment grain size, it is immediately obvious that the cation exchange capacities are noticeably higher in that region where the sediment size is less than 0.002 mm., i.e., clay. Along the coasts of the Gaspé Peninsula and Quebec, and also the approaches to Anticosti the cation exchange capacities are low. Here the most obvious explanation is that the finer sediments have a greater surface area, i.e., more "spaces" for exchangeable ions.

J. A. Wood
D. H. Loring

TABLE 1
 Cation Exchange Capacity Results: (WRT Ca⁺²)
 (or change
 (expressed as meg. exch. cap./100 gms. (material

Sample #	Result #1	Result #2	Result #3	Comment
116	24.9			
115	29.95	28.7	29.1	Result #3-sample unwashed
114	32.6	34.2	24.6	
113	28.8	30.5	28.24	"
112	17.4	19.4	17.9	
110	28.4			
109	29.2	26.2		
108	29.4			
107	11.6			
77	7.63			
76	19.55			
75	35.2	30.25		
74	34.65			
73	21.35			
72	23.0			
71	20.9			
70	36.9	31.4	35.4	
69	19.05			
68	31.25			
67	30.			
65	7.5			
64	35.0			
63	43.3	37.8	48.1	43.2
62	21.3			
61	33.2			
59	14.9			
58	26.1	25.1		
57	38.8			
56	38.5	34.3		
55	20.7			
54	21.75			
53	9.4			
52	6.9			
51	6.4			
50	20.3			
49	16.6	20.3		
47	8.2			
46	34.9			
45	34.8			
44	12.9			
43	8.4			

TECHNIQUE FOR MEASURING OXYGEN ACTIVITY IN MARINE SEDIMENTS

In 1964 a technique for the field measurements of the oxygen activity in marine sediments has been adopted from the rapid soil aeration test used by soil chemists. The basis of this test is that the ferric/ferrous ratio of the sediments is directly related to the intensity of the oxygen supply in the sediments. The following procedure has been taken from the method given by M. L. Jackson, Soil Chemical Analysis, Prentice Hall, May 1960.

The sediment tests for ferric and ferrous iron should be made within 20 or 30 seconds of obtaining the sample. The aeration and attendant chemical reactions take place very rapidly. To make the test, a filter paper

is creased along the diameter (see diagram below). For bottom grab samples two tests are made on each sample, one from the surface layer of the sample and one from the interior of the sample. For each individual test, two pinches of sediment are placed on opposite ends of the paper. Two drops of HCl are added to each of the sediments on the filter paper. The paper is then folded over and squeezed tightly until the liquid comes through the paper. To the wet areas on the outside of the paper, one drop of KCNS solution is added to the left wet area, and one drop of K₃Fe(CN)₆ solution is added to the wet area on the right (see diagram below). Appearance of a red colour from the KCNS treated area indicates ferric

iron (good oxygen supply); appearance of the blue colour from the $K_3Fe(CN)_6$ treated area indicates ferrous iron (poor oxygen supply).

If both ferric and ferrous iron tests are obtained, the oxygen deficiency is usually not severe. The importance of making the test very quickly on obtaining the sample can be demonstrated by permitting additional sediment samples to be exposed to the air for a few minutes, particularly in sunlight and repeating the test. A negative ferric iron test soon becomes a positive one and shows the rapidity of oxidation once the sediment is

BENTHIC FAUNA STUDIES

The original intention of the S-67 sampling program was to study the extent of variation which could be found in an area of approximately uniform environmental conditions of water and sediment type. The area selected for study was the sand bottom of relatively uniform depth which lies to the west of Cape Breton Island between Prince Edward Island and the Magdalen Islands (Figure 18). Subsequent sediment analysis has revealed that significant differences in sediment type do occur in this area which were not evident from field observations. The bottom in this area was believed to be always in the intermediate water layer which has a seasonal temperature variation from about $-1.8^{\circ}C$ to $1^{\circ}C$. Subsequent investigations have shown that this may not be true. The station at the extreme eastern end of the line (47), is omitted from the following discussion as it was on a mud bottom and supported a fauna which was entirely different from that of the sandy area.

As ten samples were taken at each station it was possible to compare the mean biomass per station for all the commonly occurring species. Out of a total of 91 species six were found to show significant differences in mean wet weight/m² between stations (see Figure 19).

The type of distribution shown here could be attributed to a number of causes, as:

(1) Diurnal vertical migration, i.e., the stations could not be sampled at the same time each day (this would apply to the crustacea only).

(2) Sampling bias, i.e., sampling was not as efficient at stations of "apparent low biomass".

(3) Action of an ecological factor such as food supply or sediment type allows a larger population to be maintained, i.e., the population differences are real and permanent.

The first cause cited is unlikely because there is no continuous decline in biomass with approaching daylight as would be expected with crustacea which rise off the bottom during the day. The stations were sampled in numerical order, the first (48) was begun at 13:30 ADT and the last (52) was completed at 0930 next morning. Evidence against the second is provided by the fact that low or high biomass levels do not always occur at the same station.

A recent detailed analysis of the sediment from this area supports the third hypothesis. Differences in grain size, sorting coefficient and silt clay content have been shown to occur among those areas which seemed, from preliminary field observations, to have identical sediment types. Correlations have been found between the distribution of two species of the crustacea and the grain size and sorting coefficient of the sediment (Figure 20). The possibility therefore exists that the abundance of

exposed.

During SACKVILLE cruise S-79 (1964) this test was carried out at 40 stations (Figure 17). The results show that the top layer of sediments have a good oxygen supply, (oxidizing conditions) and that the bottom layer has a poor oxygen supply (reducing conditions). Consequently, the results of these tests are in close agreement with the results derived from our studies of geochemistry of ferric and ferrous iron in the sediments.

R. J. Lahey

these organisms is influenced by these sedimentary parameters or that both the sediment characteristics and population abundance are the result of the action of another environmental factor.

The similarity of the distribution of the sand dollar *Echinarachnius parma* and the polychaete *Pectinaria hyperporea* seems to suggest a related or common factor (or combination of factors).

At present the distribution of only the most abundant species is given. Some of the less numerous but larger species which contribute a greater amount of biomass, will require a different sampling technique. Also as a contagious distribution has been found to be the rule in nature, the size of any possible aggregation would influence the accuracy of sampling.

During June 1964, three stations were sampled in the Richibucto area in order to compare a number of different methods of obtaining quantitative information on benthic fauna. Five samples were taken with a 0.1 m² Van Veen bottom grab at each station. Over the same area two tows were made with a modified Icelandic Sampler designed to "fish" the extreme bottom layer of water in order to obtain hyperbenthic animals. The tows were made at a speed of 4 knots for a period of 10 minutes. A large number of Mysids (3 species) and Decapods (2 species) were obtained which were not obtained at all by the Van Veen grab. Also due to its greater coverage of the bottom, some less abundant species including a species of starfish and 3 species of amphipods were taken. These were not sampled by the grab either. Burrowing species such as the sand dollar and polychaetes were not sampled with this instrument. No attempt was made to make these samples quantitative.

Tows were also made with a dredge which sampled the same animals as the grab (mostly sand dollars). Although this sampler covered more area it was not quantitative and did not retain smaller organisms.

The grab used in this survey was fitted with a camera with the intention of photographing an area before sampling it. Due to the failure of the shutter mechanism, however, no photographs were obtained.

In the month of August during S-79 three more stations were sampled in Northumberland Strait by multiple grab samples and trawl tows. No large hyperbenthic animals were obtained but whether their absence is due to the difference in area or time is not at present known. Tows were made during both daylight and darkness but as they were made at different stations the effect of diurnal migration cannot be ruled out at all stations.

D. L. Peer

BENTHIC FAUNA AT GROUND FISH FISHING STATIONS

During the HARENGUS cruise GRF-52, quantitative sampling for benthic organisms was carried out at the regular fishing stations with the intention of determining whether the stomach contents of fish were related to the benthic fauna present in the area. No significant results were obtained as the cod (the only fish whose stomach contents were determined) had eaten very little infauna and no attempt was made to sample the hyperbenthos.

As no quantitative information has been obtained from this area before, the comparison of the benthic community will be described in detail here. The station positions are shown in Figure 21.

Stations 1, 9, and 11 can be treated together because of certain similarities in their faunal composition. At these three locations the biomass in wet weight of Amphipods and Tubicolous polychaetes was significantly higher than that found at stations 2, 3, 4, 5, and 6. In all three cases the dominant Amphipod (by wet weight) was tentatively identified as *Paratryphositis abyssi*. At stations 1 and 11 the dominant Tubicolous polychaete was the Maldanid *Maldane sarsi* while at station 9 it was *Praxillella praetermissa*.

Although the sediment at station 9 was classified as mud in the field, a more detailed analysis has shown the sediment of this area to consist of sandy mud (see Figure 7). This may explain the replacement of *Maldane sarsi* by *Praxillella praetermissa* at station 9. Both these polychaetes are burrowing forms and would be influenced by the characteristics of the sediment. All of the pelecypods found at stations 1 and 9 were identified as *Yoldia limatula*. The sediment at these stations was mud. This probably accounts for the presence of *Yoldia limatula* as it is a selective deposit feeder.

Station 2 (50 fm)

The sediment at this station consisted of unsorted

gravel and sand. Here the dominant group of organisms were the echinoderms, including the brittle star *Ophiura robusta* and *Ophiophilis aculeata* and the sea urchin *Strongylocentrotus droebachiensis*. At this station as in all subsequent stations mentioned in this report, the biomass of Amphipods and Tubicolous polychaetes was significantly lower than at stations 1, 9 and 11.

Station 3 (> 100 fm)

The total biomass at this station was extremely low this being the only station sampled where the total biomass in wet weight was to any degree different from the others. No one group of organisms was particularly dominant at this station.

Station 4

At this station the most dominant species was the starfish *Ctenodiscus crispatus*. Individuals of this species appeared only at this location where one specimen was taken in each grab sample. The average wet weight of this animal was about 5 grams.

Station 5

Here the wet weight of bivalve molluscs was significantly higher than at any other station sampled. This group consisted almost entirely of *Astarte* sp., a filtering mollusc, which was also present at stations 2, 3, and 4, but in a much smaller concentration.

Cumacea also occurred here in large numbers. The dominant species being *Diastylis rathkei*. Cumaceans were present at all stations but had a significantly higher biomass at stations 5 and 9.

The actual biomass of the Cumacea is extremely low at all stations (< 1% of total), but their abundance at these two stations may have ecological implications.

D. L. Peer

PLANKTON AND SECONDARY PRODUCTIVITY

During the last few months of 1964, active study has been given to establishing a second biological oceanographic program in plankton, secondary productivity and the environmental factors, as it affects fish species of current and potential commercial interest. The program will be primarily concerned with identifying biological and other oceanographic factors which govern seasonal and local congregations of commercial fish species. At present the area for which this program is contemplated is the Gulf of St. Lawrence, but with proposed expansion and additional support, extensions to include other

Canadian Atlantic coastal regions will likely occur at a later date.

The proposed program will include phyto and zooplankton sampling, allied physical and chemical measurements, and examining correlations between abundance of planktonic fish food organisms and concentrations of commercial fish stocks. The rate of development of the program will be dependent on rate of assimilation of staff and facilities.

A. Prakash

ACTIVITY COEFFICIENTS IN SEA WATER

While the concentrations of major inorganic salts in sea water are known to an accuracy of better than one percent, the partition of these salts among their various ion forms and complexes are known only to an order of magnitude in many cases. Since the form and amount

of some of these species may be quite important to reactions occurring in the sea it is of interest to establish their concentrations. For example, certain sound frequencies are very strongly absorbed by a relatively small concentration of a magnesium sulphate complex in sea

water. In order to measure the extent of this complexing we can apply equilibrium constants from the literature to sea water if we know the activities of the species concerned. Activities, rather than concentrations, must be used in concentrated solutions such as sea water, otherwise large errors can result. These activities can be obtained only by direct measurement, and a program is underway to systematically measure the activities of the major ions in sea water.

Specific ion electrodes have been set up to measure the activities and activity coefficients of the following ions:

- Na+ (glass electrode)
(sodium amalgam electrode)
- Cl- (silver - silver chloride electrode)
- SO₄⁼ (lead amalgam - lead sulphate electrode)

In addition the activity coefficient of the magnesium ion has been measured by deriving its activity at the point of initial precipitation of Mg(OH)₂ in sea water. The activity coefficients, f, measured for the above ions are given below:

f at 25°C	Salinity			
	5 ‰	15 ‰	25 ‰	35 ‰
fNa+	0.747	0.724	0.691	0.680
fNa ⁺⁺	0.17	0.08	0.07	0.06
(fNa ⁺ +fCl ⁻) ^{1/2}	0.795	0.730	0.690	0.672
(fNa ²⁺ +fSO ₄ ⁼) ^{1/3}	0.620	0.435	0.405	0.378

f at 35‰	Temperature		
	15°C	25°C	35°C
fNa+	0.658	0.680	0.681
(fNa ⁺ +fCl ⁻) ^{1/2}	0.679	0.672	0.685
(fNa ²⁺ +fSO ₄ ⁼) ^{1/3}	0.440	0.378	0.408

All these measurements are good to about ±2-5% except for the fMg⁺⁺ values which are only good to ±40%.

From the above data it was possible to deduce the extent of formation of some complexes in sea water at 25°C and 35‰ salinity.

- 1.5% of the total Na⁺ exists as NaSO₄⁻
- 3% of the total Mg⁺⁺ exists as MgSO₄[°]
- 35% of the total SO₄⁼ exists as NaSO₄⁻ and MgSO₄[°]

R. F. Platford
T. Dafoe

THE SOLUBILITY PRODUCT OF CALCIUM CARBONATE IN SEA WATER

Sea water is supersaturated with calcium carbonate in most areas although uncertainty in the value of its solubility product at low temperatures makes it difficult to say whether this supersaturation state extends to less saline waters such as the Gulf of St. Lawrence. Whether supersaturation exists or not is of prime importance since precipitation and deposition of calcium carbonate can only take place from supersaturated water. Measurements made by an earlier worker on the solubility product of calcium carbonate are being extended to temperatures from 0°-15°C, in order to predict the state of saturation at these low temperatures more accurately.

Several measurements have been made, in cooperation with the graduate school of IODAL, on the solubility product of calcium carbonate at low temperatures. Sea water, saturated with calcium carbonate, is analyzed for calcium ion (by complexometric titration) and for carbonate ion (by alkalinity analysis). If the solution is indeed saturated with CaCO₃, the product [Ca⁺⁺] x [CO₃⁼] is the solubility product at that temperature. The calcium ion concentration can be measured to better than 1% but the carbonate ion concentration can only be determined to about ±5% by the

existing indirect method. The carbonate ion has a weak absorption band in the ultraviolet region but this method of measuring [CO₃⁼] does not appear workable because of its relatively poor sensitivity.

Calcium carbonate is unusual in that it has a negative temperature coefficient of solubility in aqueous solution and our results indicate that the effect of temperature on solubility is greater than that previously estimated. The results to date are summarized below.

Crystal Form	Solubility Product (mole ² /l ²)	
	0°C	25°C
Calcite	0.70±0.05 x 10 ⁻⁶	0.55±0.04 x 10 ⁻⁶
Aragonite	-	0.91±0.04 x 10 ⁻⁶

The carbonate data from the IONAF Norwestlant - 2 have been worked up and reported on. This work is now considered to be complete.

W. G. MacIntyre
R. F. Platford

TECHNICAL SERVICES

The Bathythermograph and Salinity laboratories at the Bedford Institute are operated as joint services by DM&TS and AOG. Prime responsibility for the BT lab is assumed by AOG with assistance from DM&TS while the reverse situation prevails for the Salinity lab.

Following is a list of contributing agencies and numbers of BT slides and salinity samples provided by each:

Agency	Salinity	BT	Other Samples & Collections
Dept. of Mines & Technical Surveys	4748	422	
Biological Station, St. Andrews, N. B.	70		483
Biological Station, St. John's, Nfld.	400		1107

Atlantic Oceanographic Group	1269	126	867
Royal Canadian Navy		631	
Sambro Lightship		507	
Arctic Biological Station, Montreal, Que.	19	19	
Naval Research Establishment, Dartmouth, N. S.	75	224	
Defence Research Board	250		
Total	6831	3519	867

Total BT prints distributed in 1964 - 13,274.

A backlog of approximately 800 BT slides remain to be processed.

T. A. Grant
C. C. Cunningham

SUMMARY OF OCEANOGRAPHIC CRUISES

During the year the Group supported at sea, four cruises and assisted in two field parties. The CNAV SACKVILLE had an extensive refit resulting in the ship not being available until the middle of July. During October and November the SACKVILLE had a bow thruster installed along with flume tanks, for making the ship a more stable platform.

S-79

This cruise took place in the Gulf of St. Lawrence and had four phases.

Phase 1 - Consisted of releasing parachute drogues and plotting their tracks.

Phase 2 - A series of oceanographic stations was occupied together with tracking parachute drogues and transmitting drift buoys.

Phase 3 - Bottom samples were taken at 37 locations together with bottom temperatures and salinities. Eight oceanographic stations were occupied in the Saguenay River.

Phase 4 - This consisted of bottom sampling in the southwestern Gulf.

S-80

IODAL carried out this cruise for the purpose of investigating the crustal structure of the earth at the

bottom of the Continental Slope off Sable Island. The Halifax Section was occupied during this cruise.

S-81

This cruise had a dual purpose. The Halifax Section was occupied twice, on the way out and on the way in, with a few days interval. Trials were also carried out on the bow propeller and flume tanks.

10-4-64

The Halifax Section was occupied on this cruise with AOG assisting. The cruise was part of sea and winch trials on CSS HUDSON.

10-29-64

This was a joint DM&TS-AOG cruise carried out in the Gulf of St. Lawrence at the request of Ice Central.

Alkalinities and pH measurements were made along a line running from Cabot Strait in the deep waters to the Saguenay River. Three stations were also occupied in the Saguenay River.

Bottom photographs were taken in the Richibucto area by members of AOG. One member of the Group also assisted the Geological Survey of Canada in Mould Bay, N.W.T.

G. B. Taylor
C. J. Bayers



Figure 1 CNAV "Sackville"

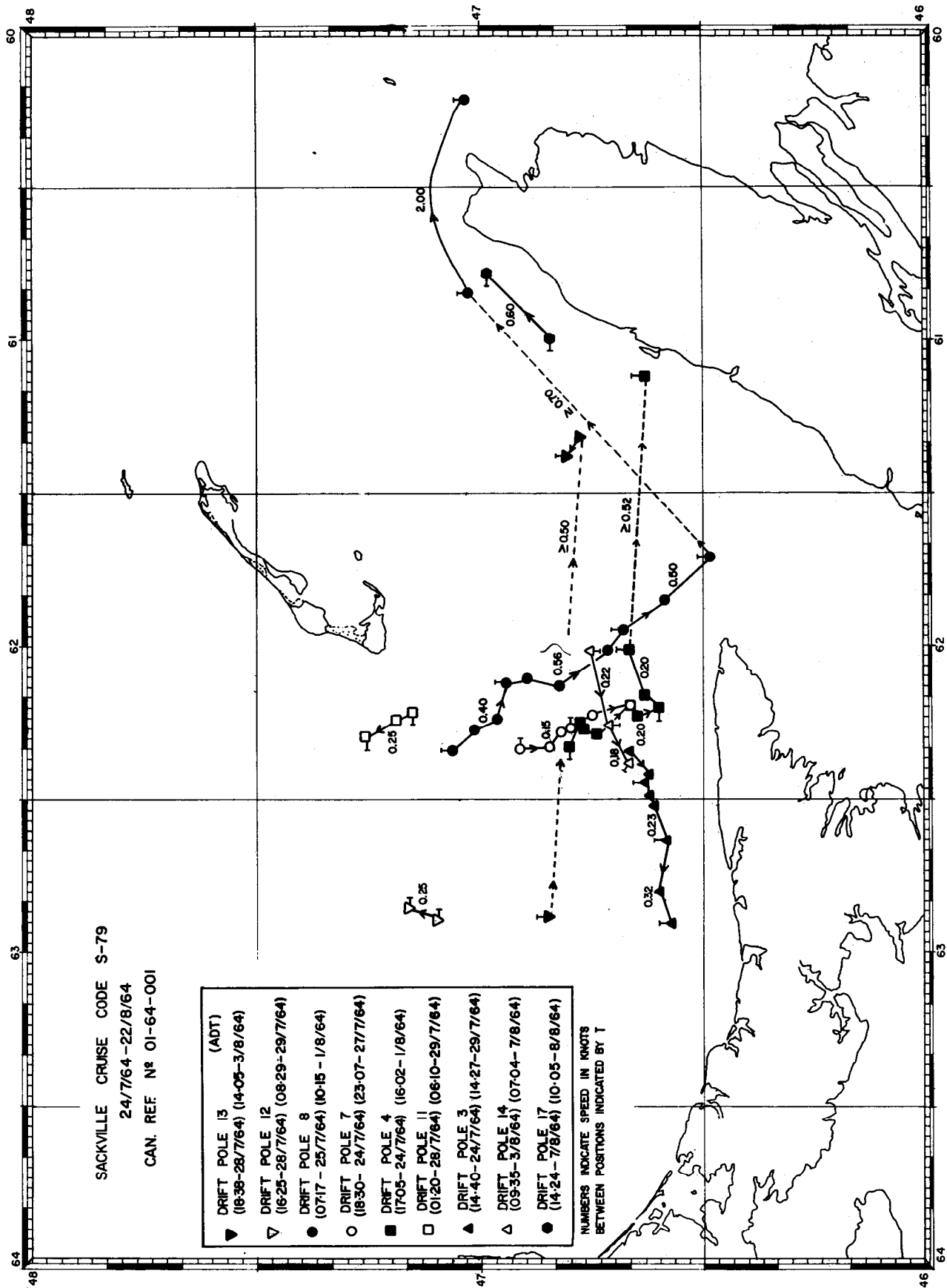


Figure 2 Tracks of drift drogues located at 6 metres depth

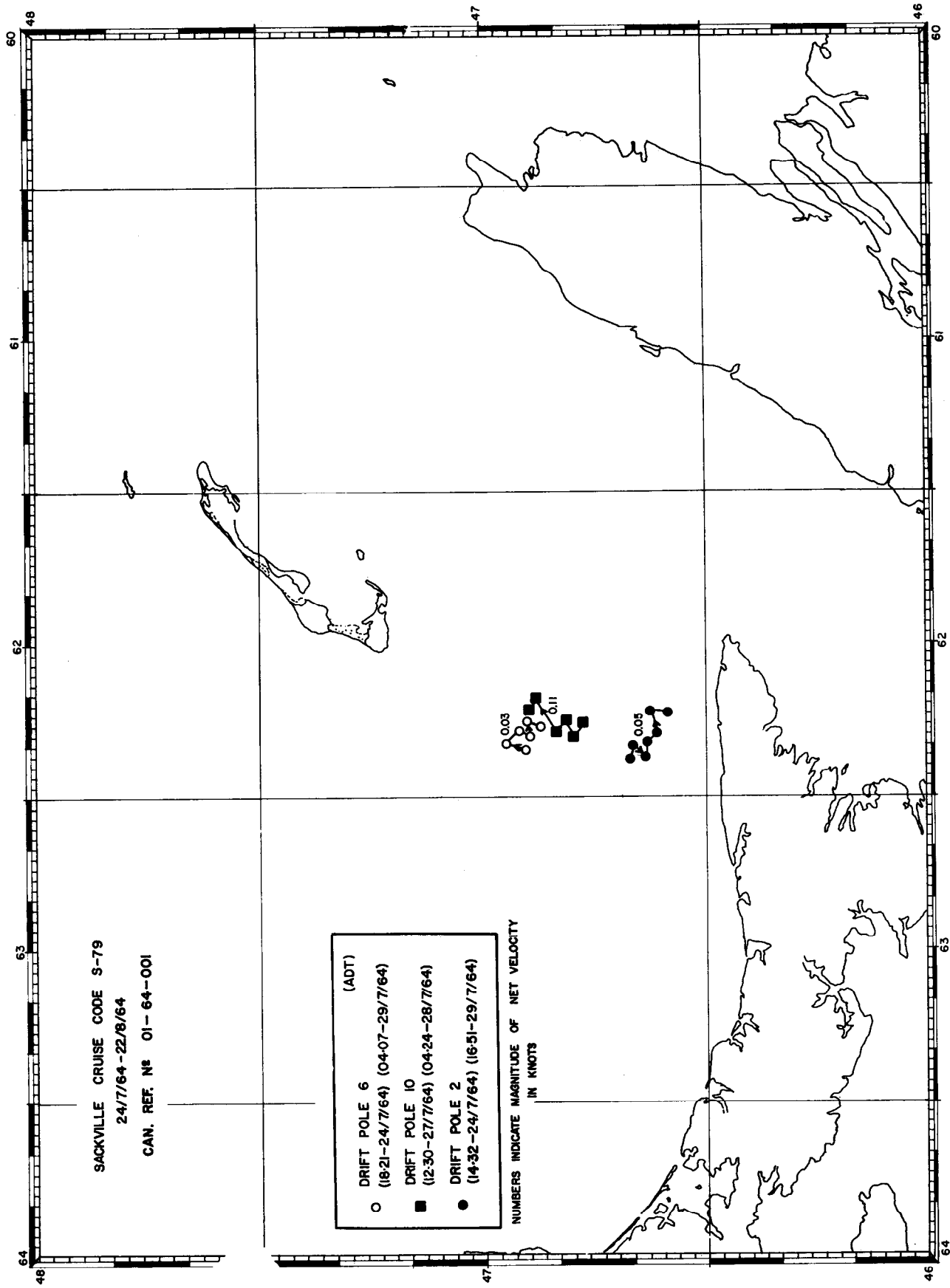


Figure 3 Tracks of drift drogues located at 20 metres depth

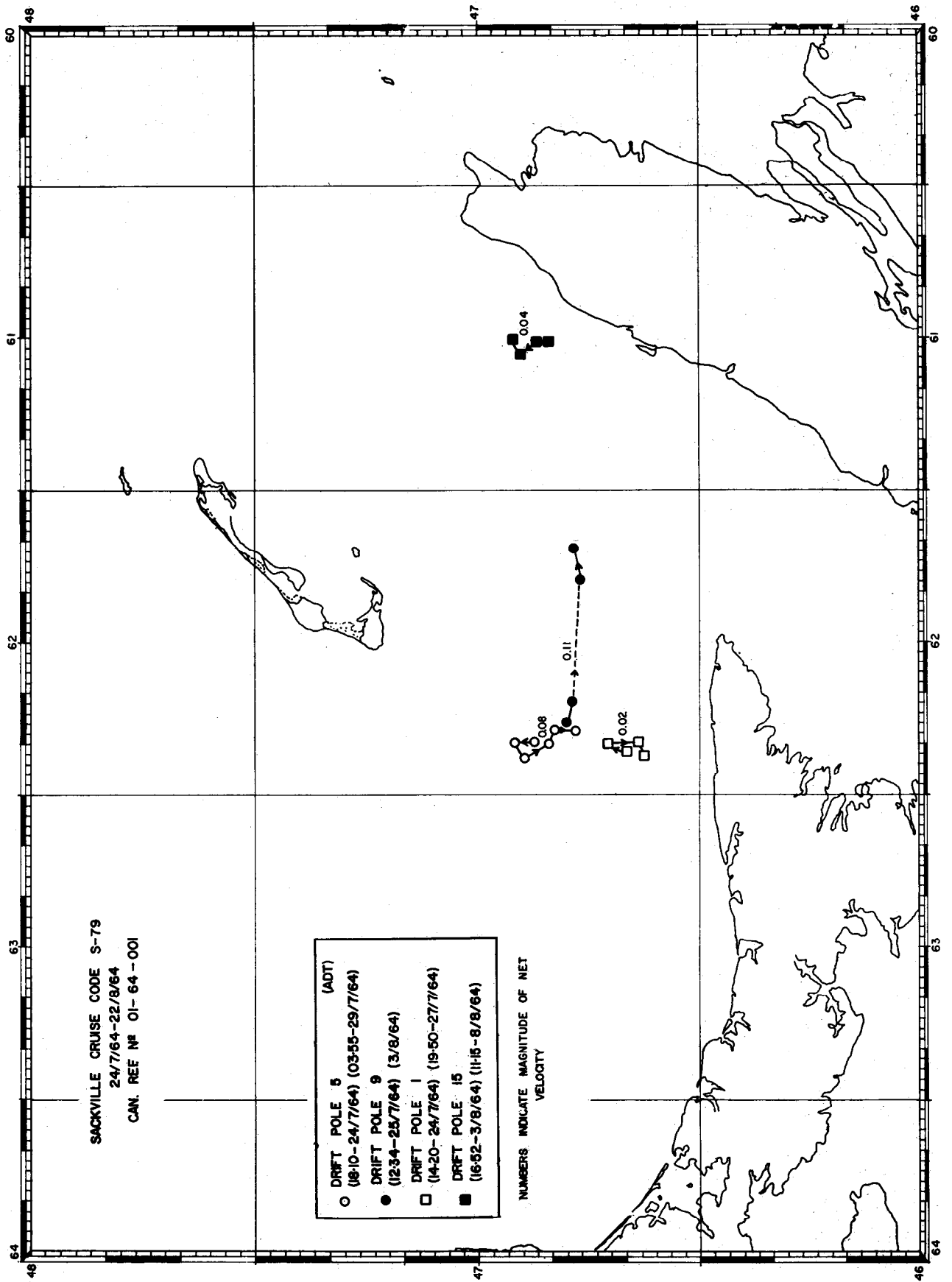


Figure 4 Tracks of drift drogues located at 45 metres depth

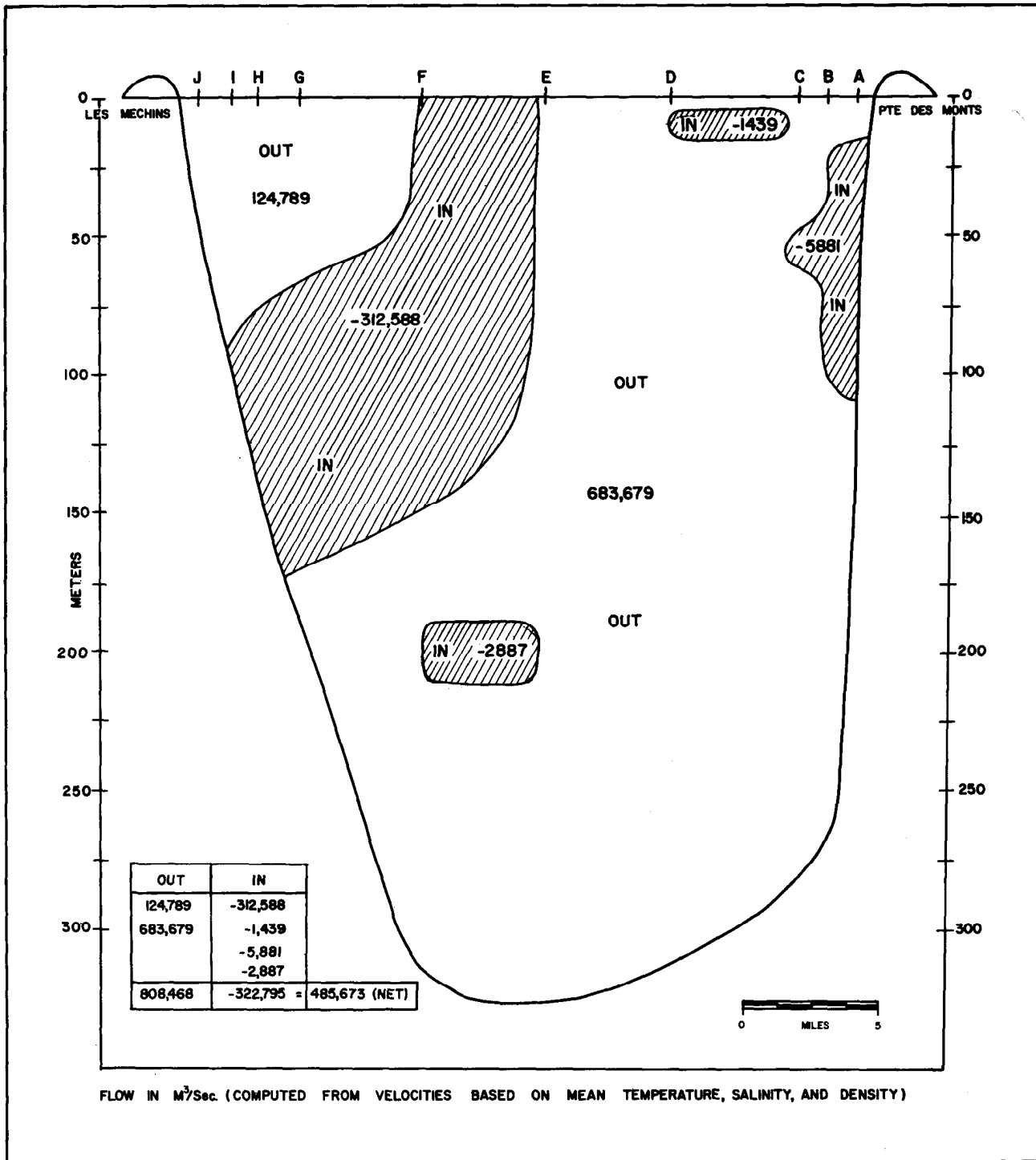


Figure 5 Average geostrophic transport through section at Pte. des Monts, July 1-6, 1963

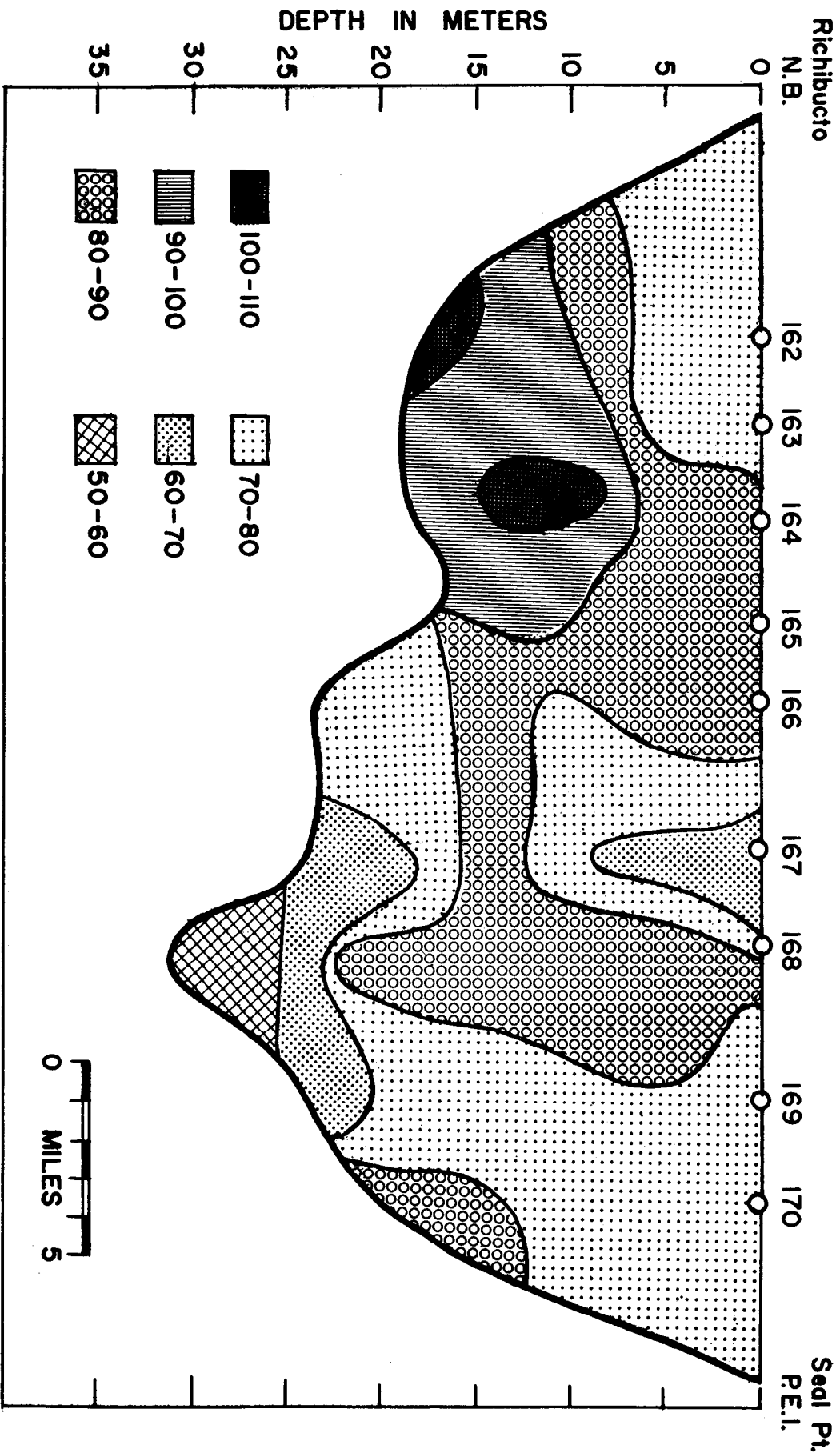


Figure 6 Profile of relative transmissivity between Richibucto, N.B. and Seal Pt., P.E.I., August, 1964

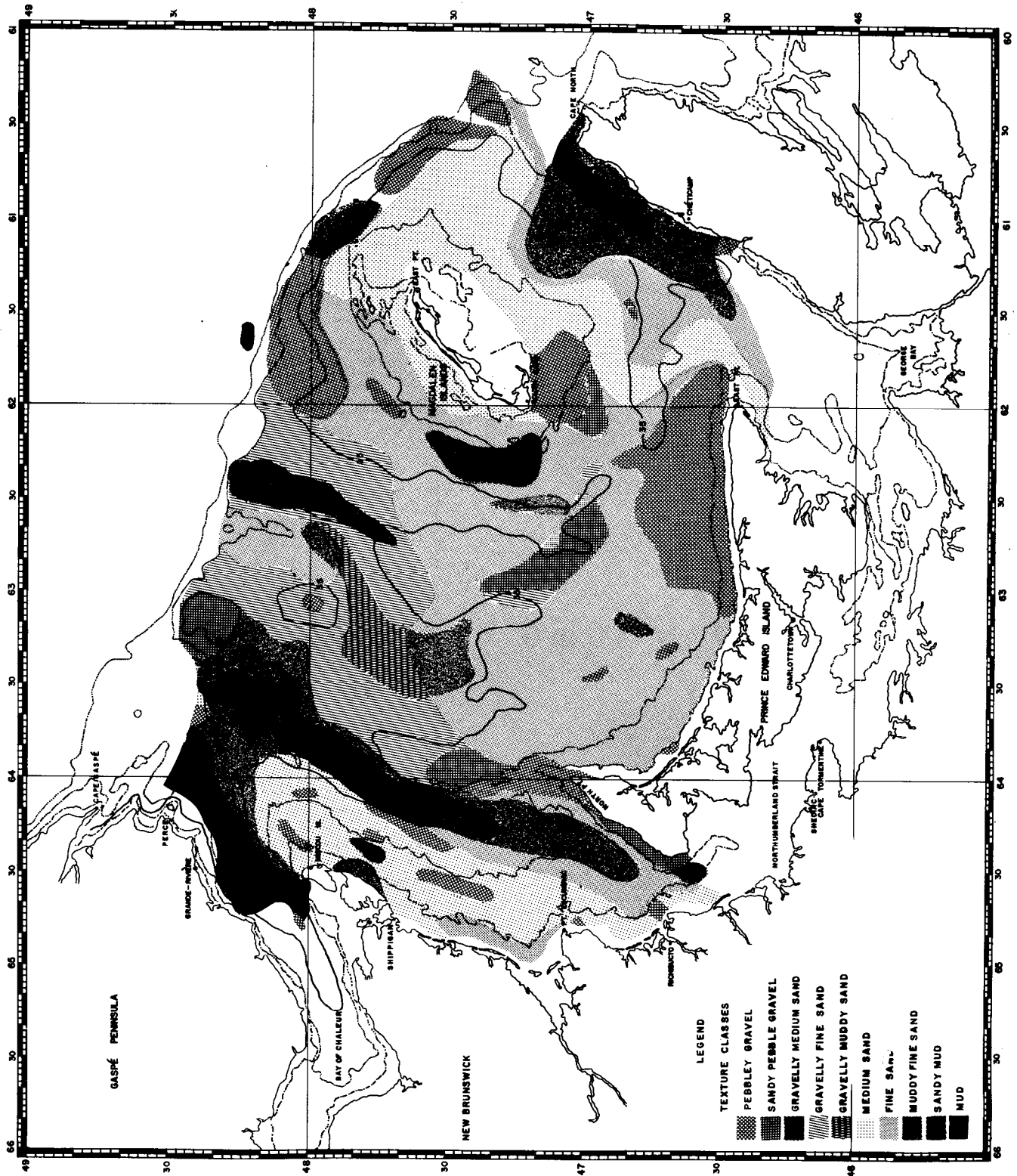


Figure 7 Distribution of sediments in the southern Gulf of St. Lawrence

ABBREVIATIONS

G, GRAVEL; **g**, GRAVELLY;

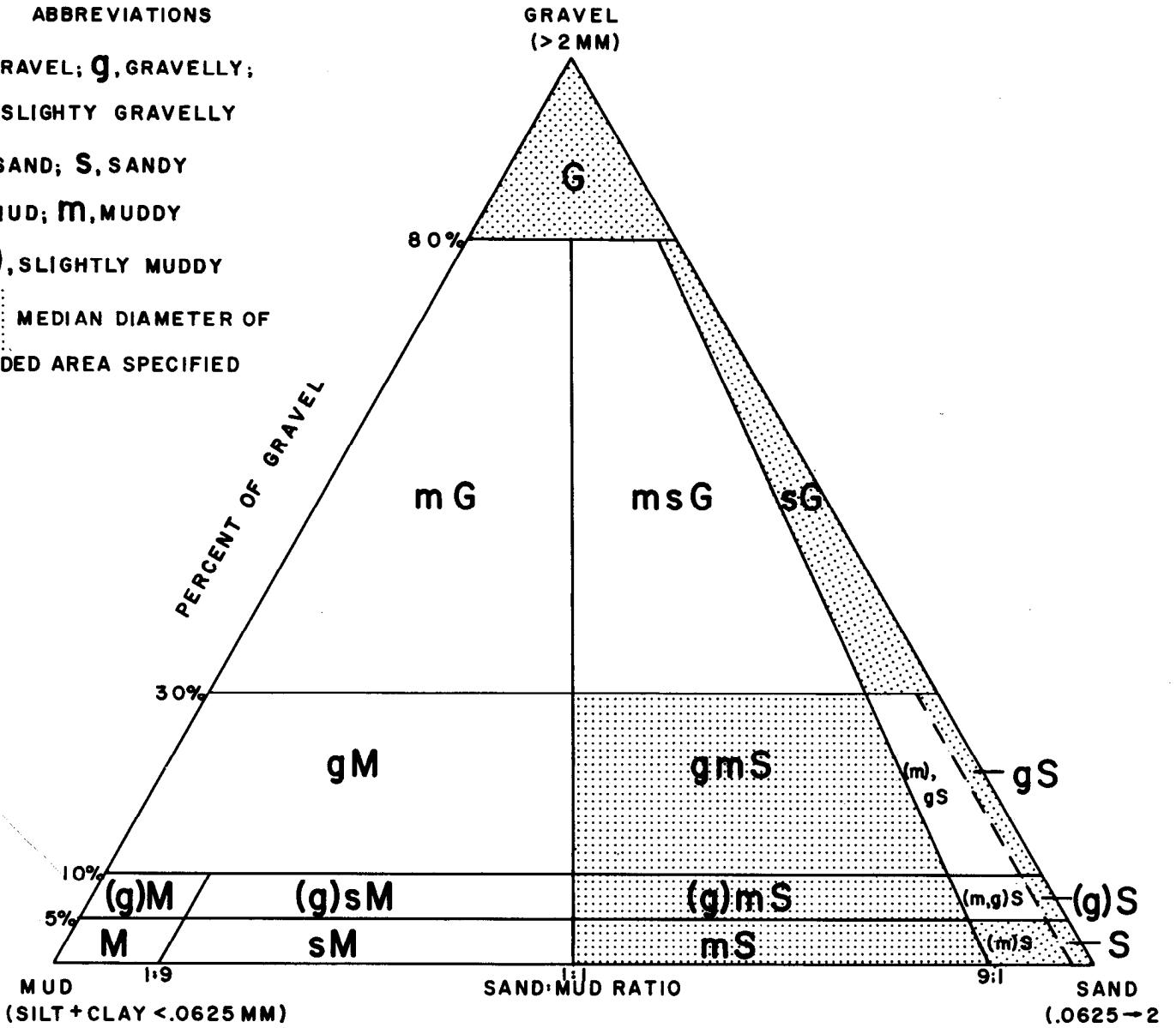
(g), SLIGHTY GRAVELLY

S, SAND; **s**, SANDY

M, MUD; **m**, MUDDY

(m), SLIGHTLY MUDDY

 MEDIAN DIAMETER OF SHADED AREA SPECIFIED



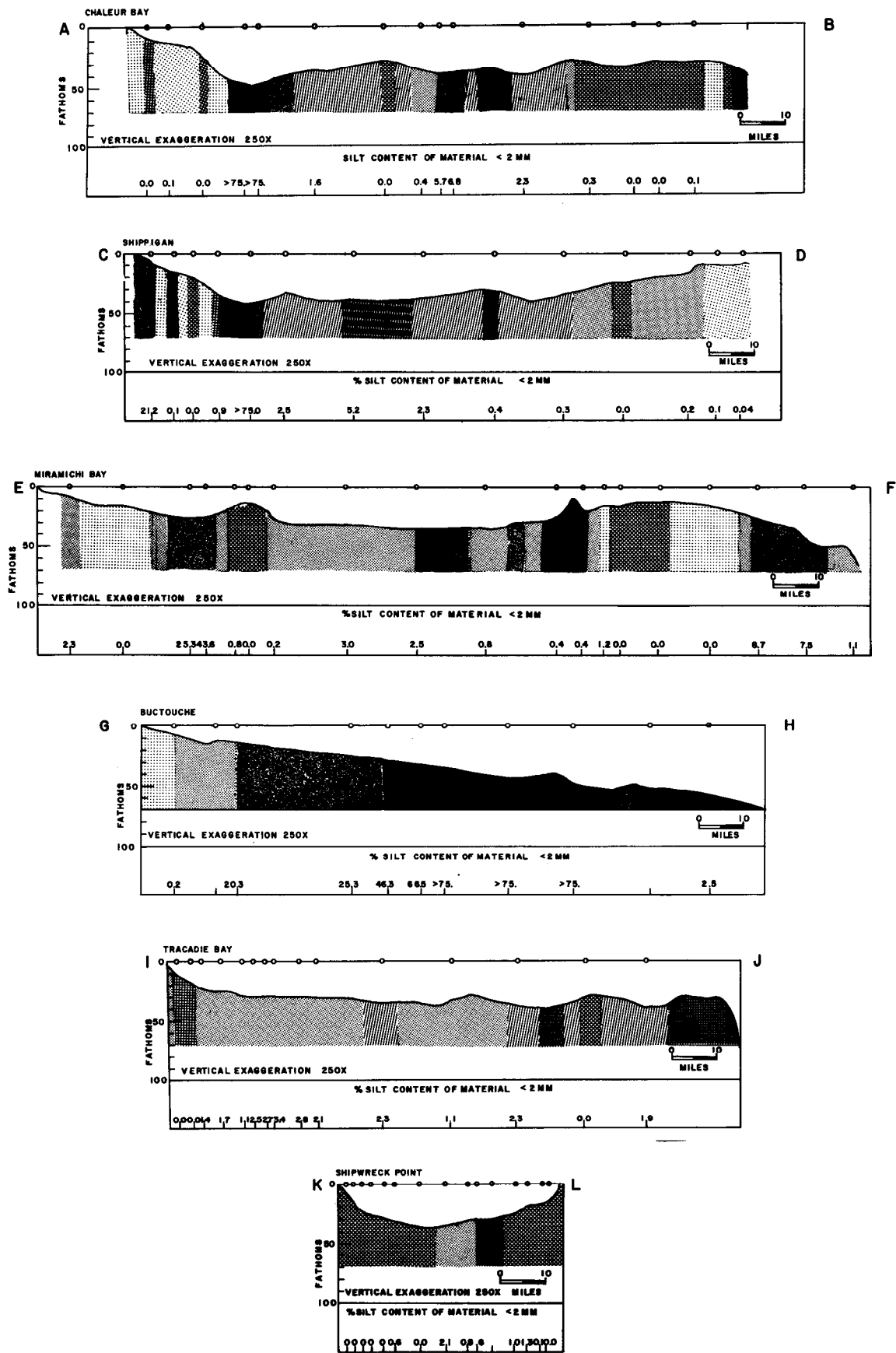
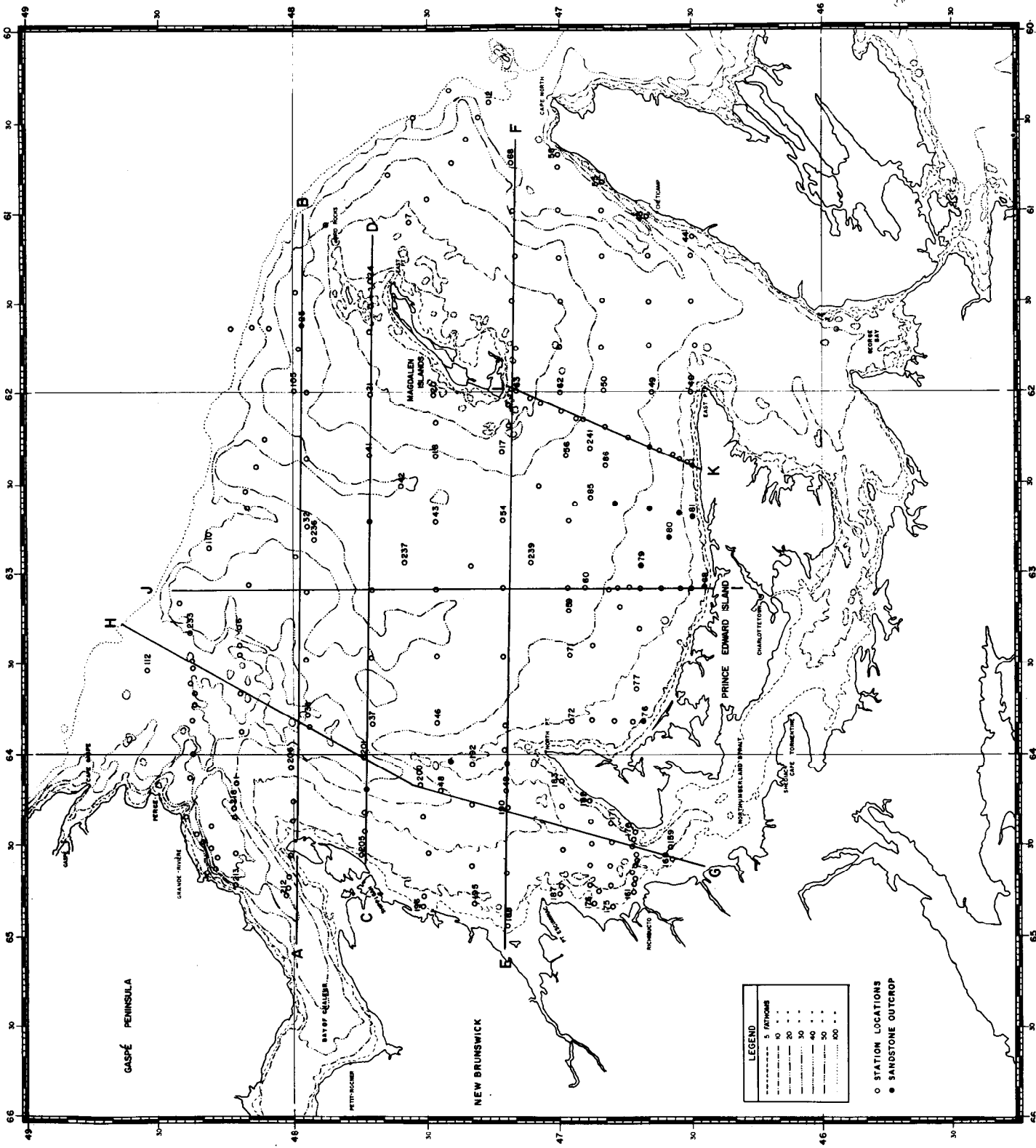


Figure 9 Sediment distribution along cross-section and longitudinal bottom profiles of the Magdalen Shallows



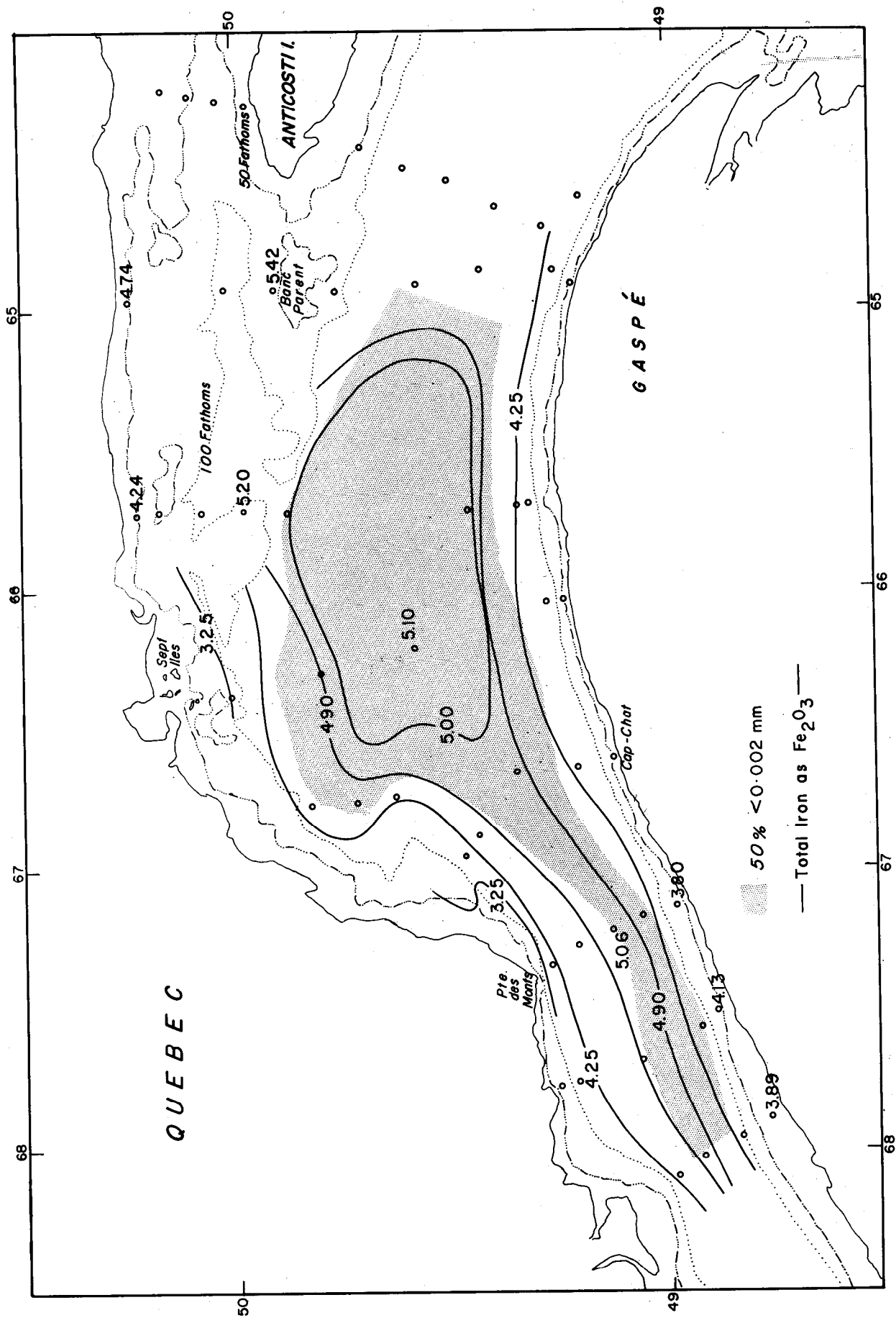


Figure 11 Geographic distribution of total iron in the sediments of the St. Lawrence estuary

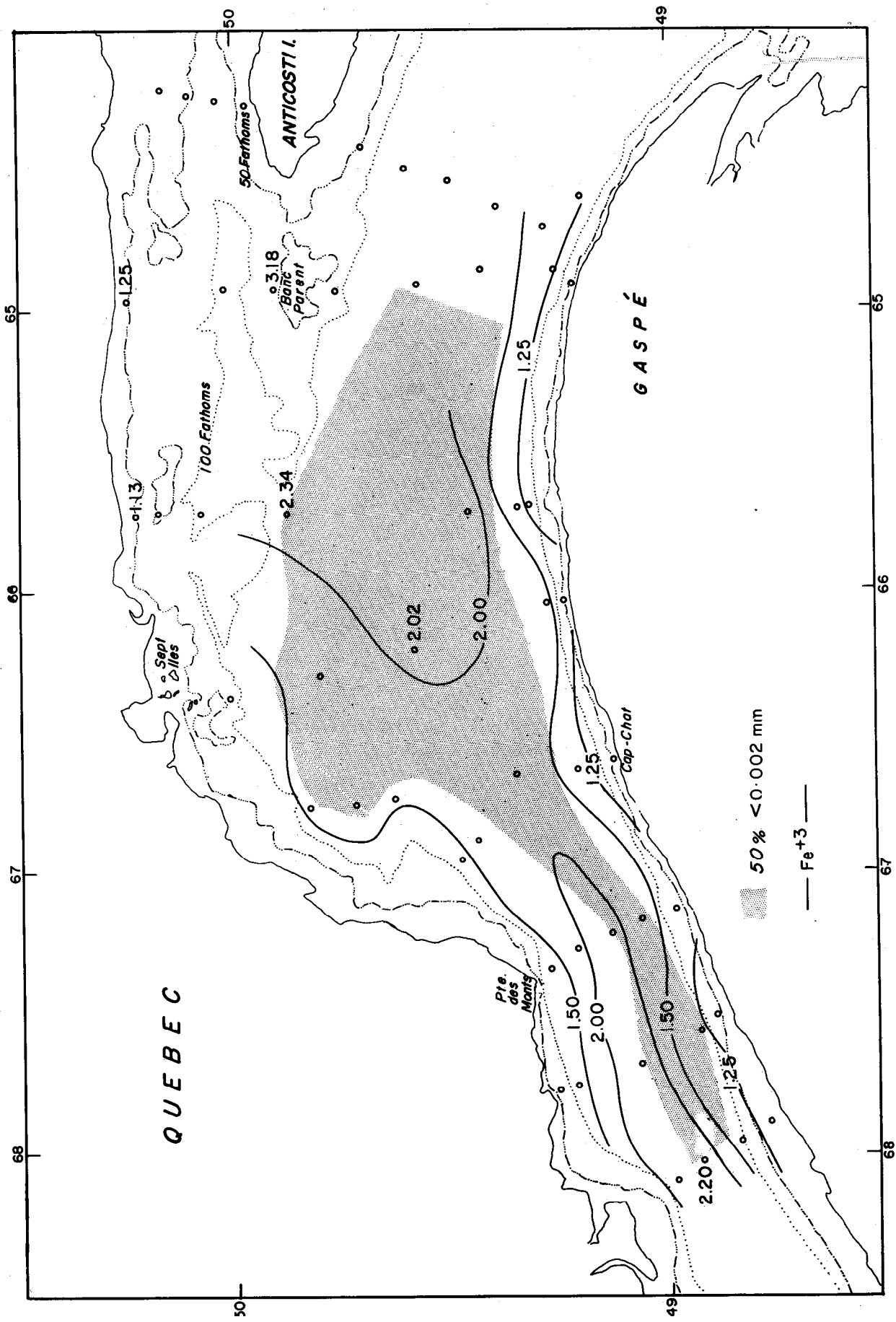


Figure 12 Geographic distribution of ferric iron in the sediments of the St. Lawrence estuary

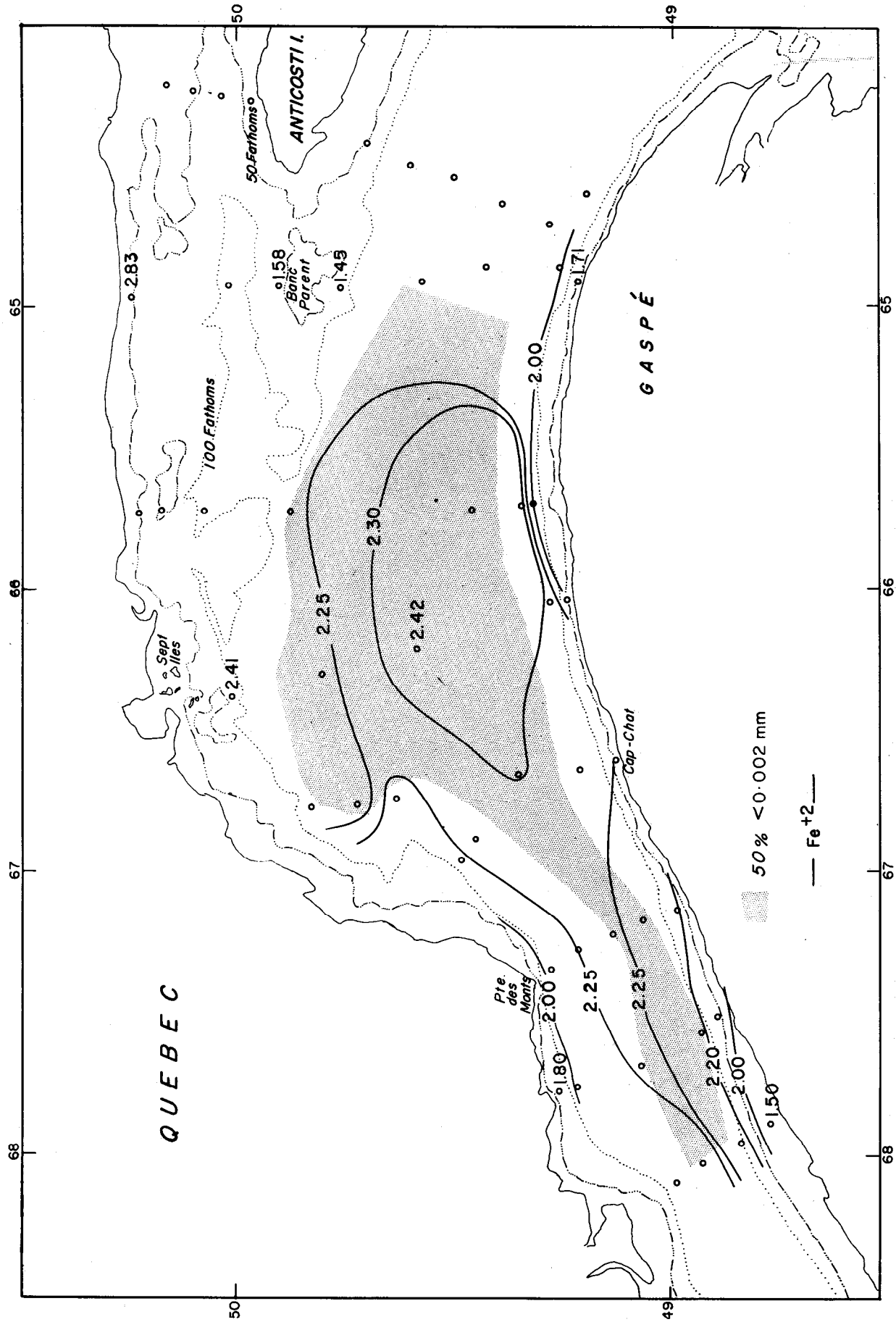


Figure 13 Geographic distribution of ferrous iron in the sediments of the St. Lawrence estuary

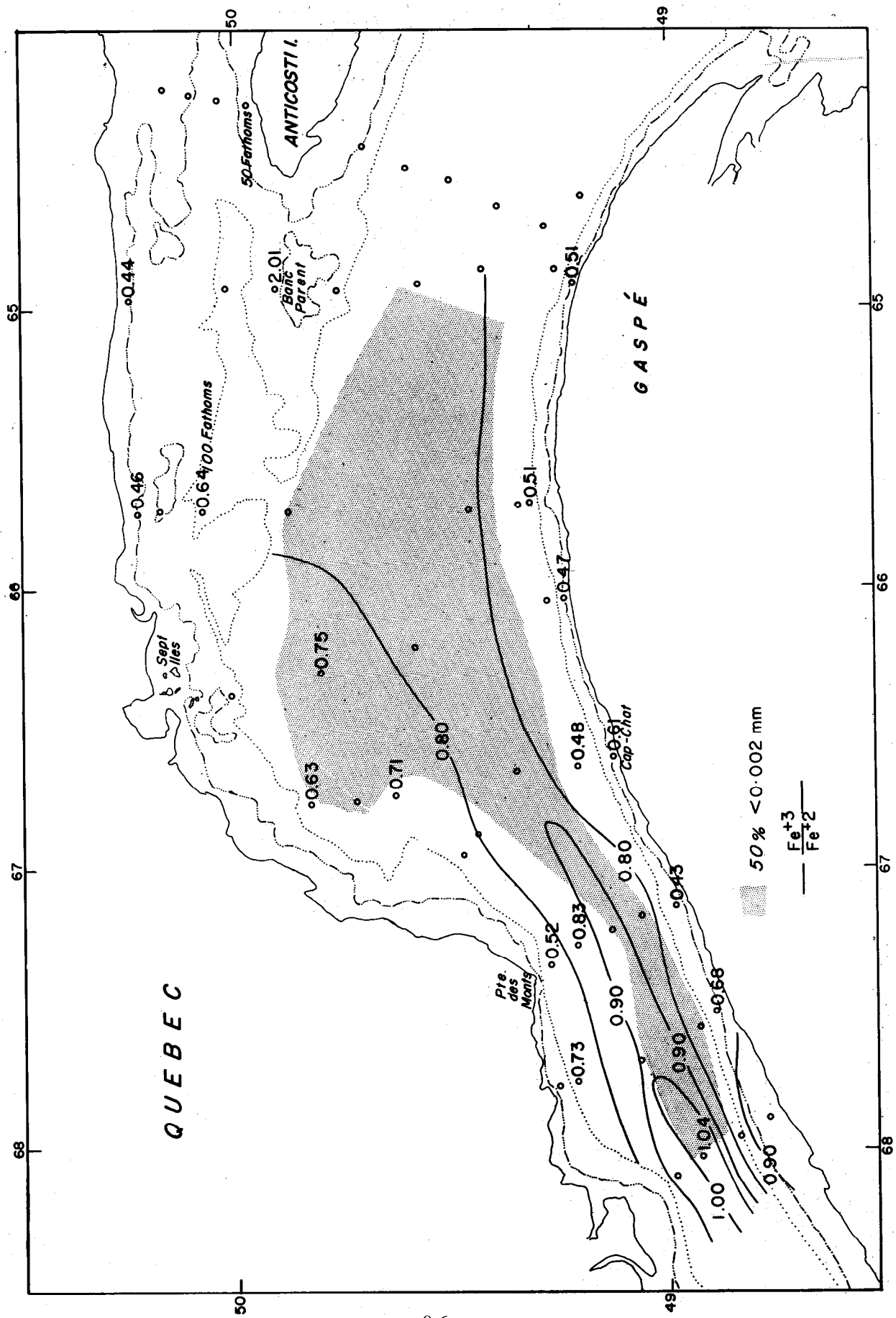


Figure 14 Geographic distribution of the ratio of ferric iron to ferrous iron

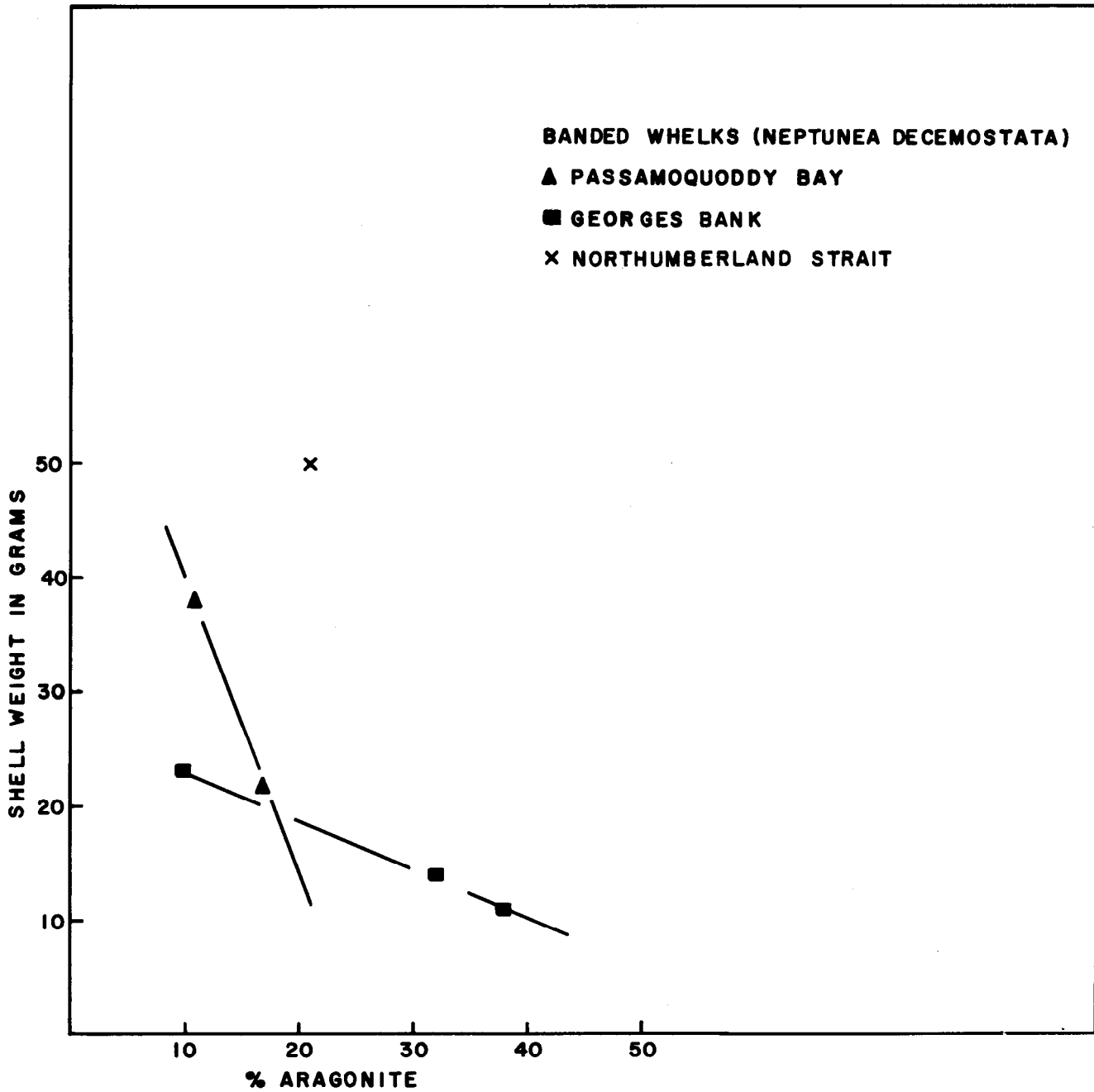


Figure 15 Relation between shell weight and percent-aragonite

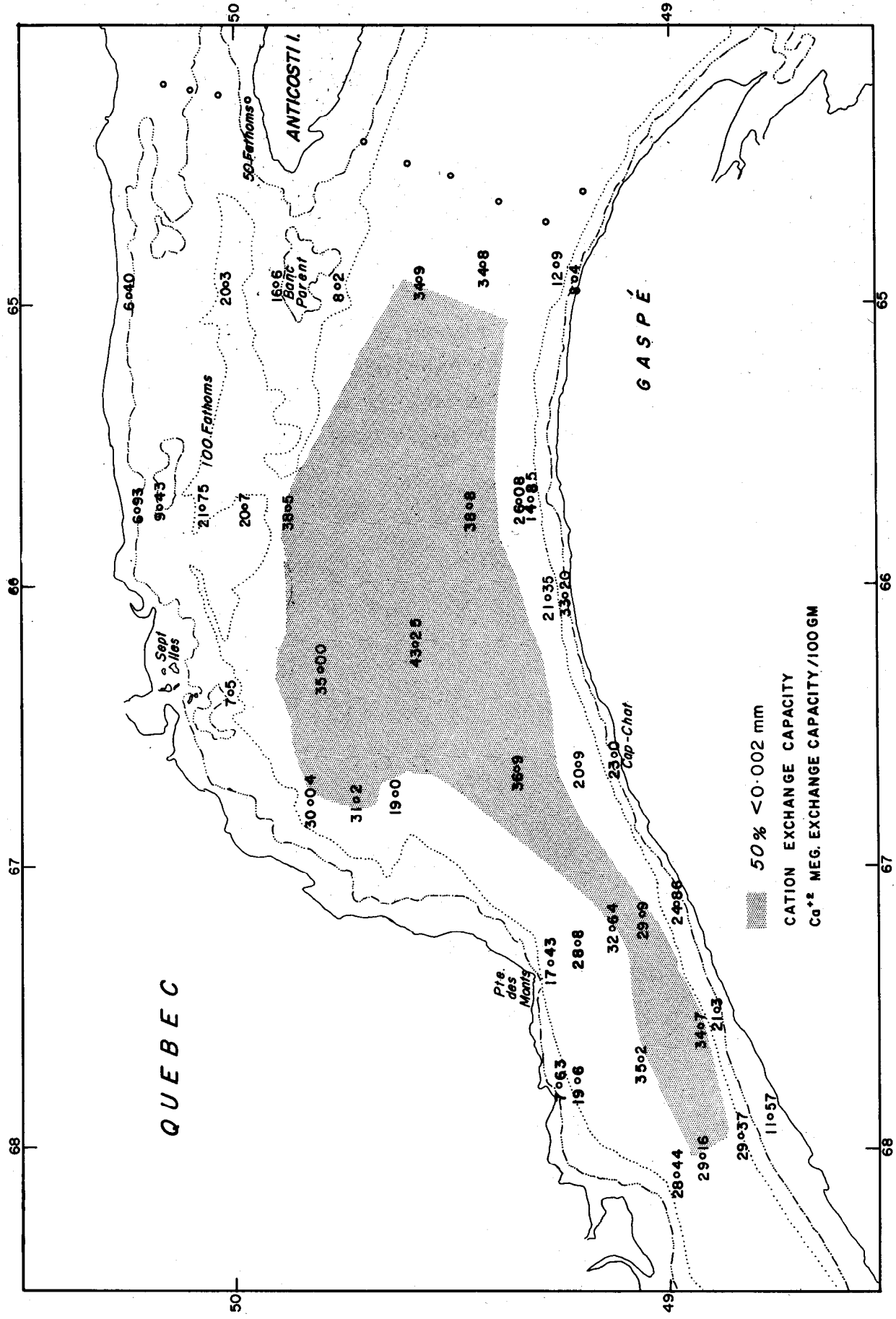


Figure 16 Geographic distribution of the cation exchange capacity in the St. Lawrence estuary

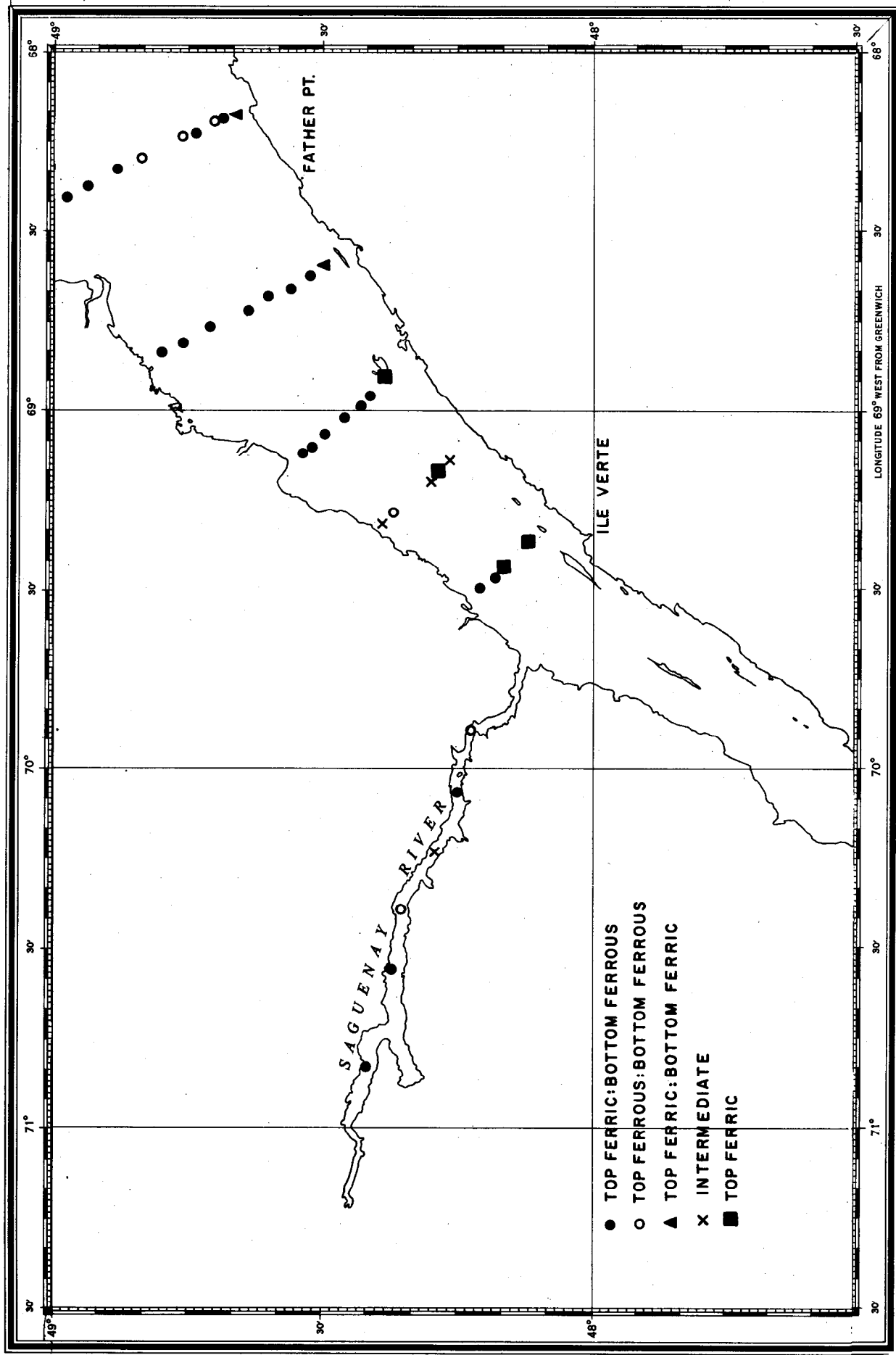


Figure 17 Sampling locations for ferric and ferrous iron tests, cruise S-79, 1964

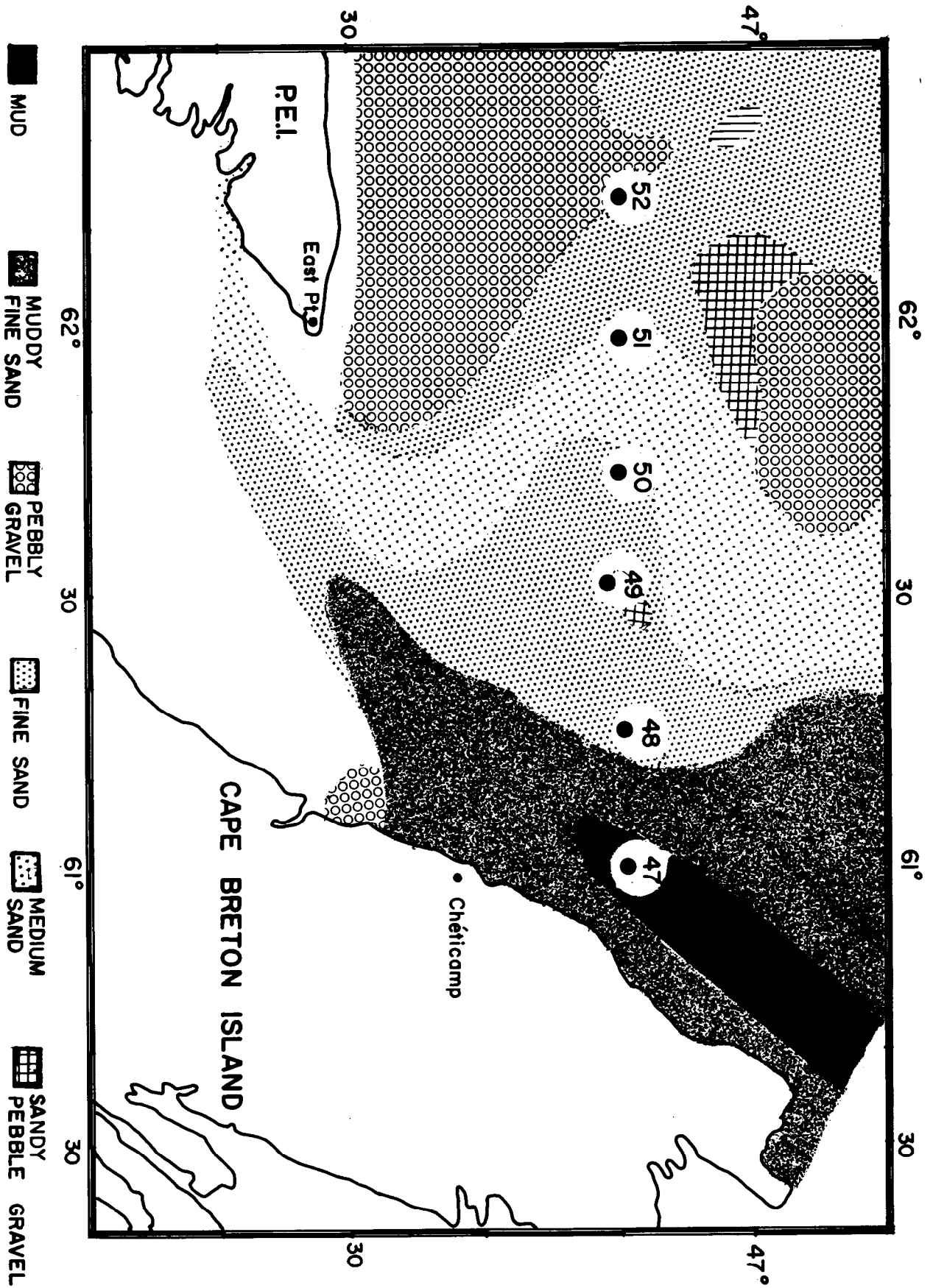


Figure 18 Location of multiple benthic sampling stations, cruise S-67

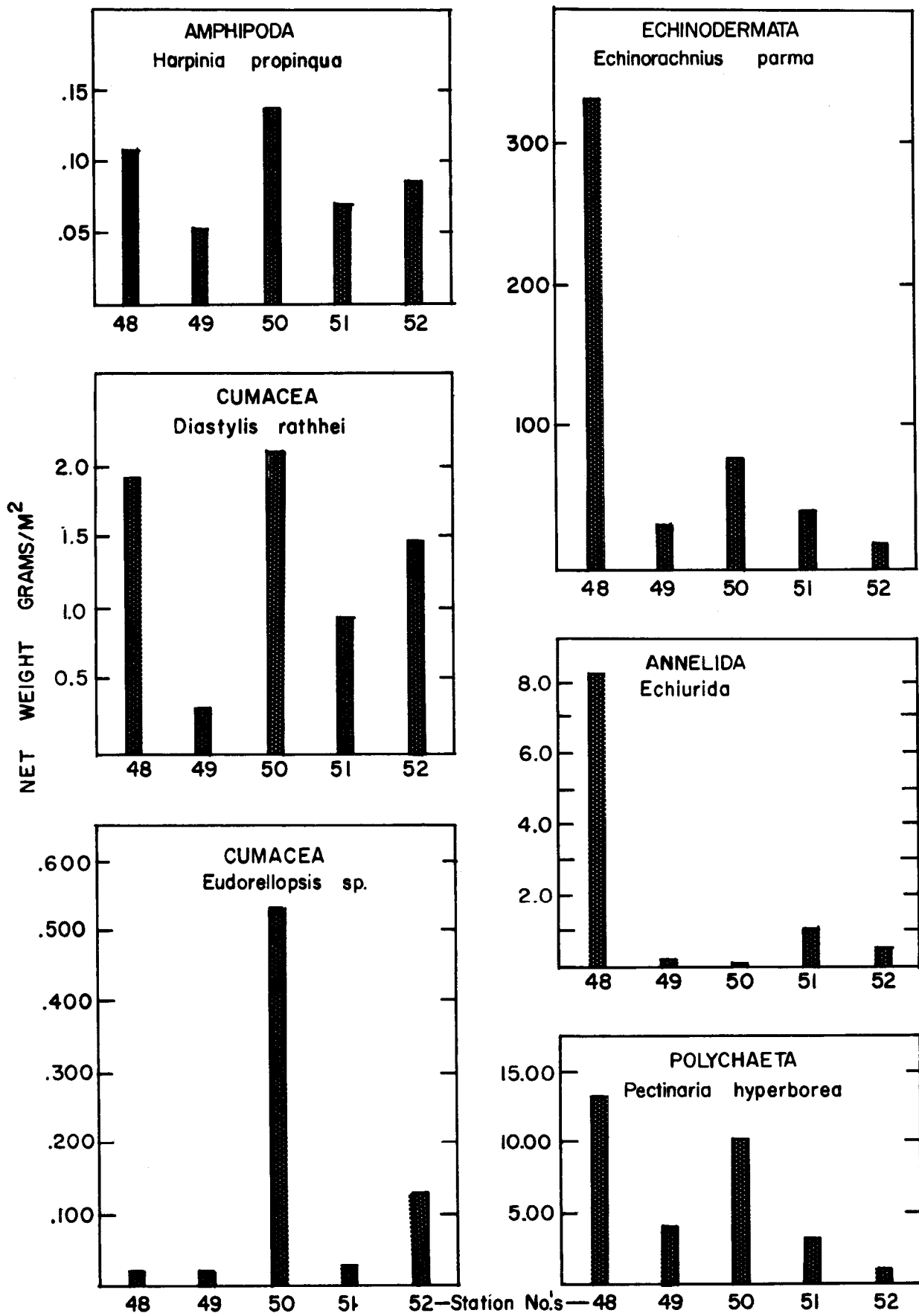


Figure 19 Diagram showing biomass for six species found to have significant differences between stations

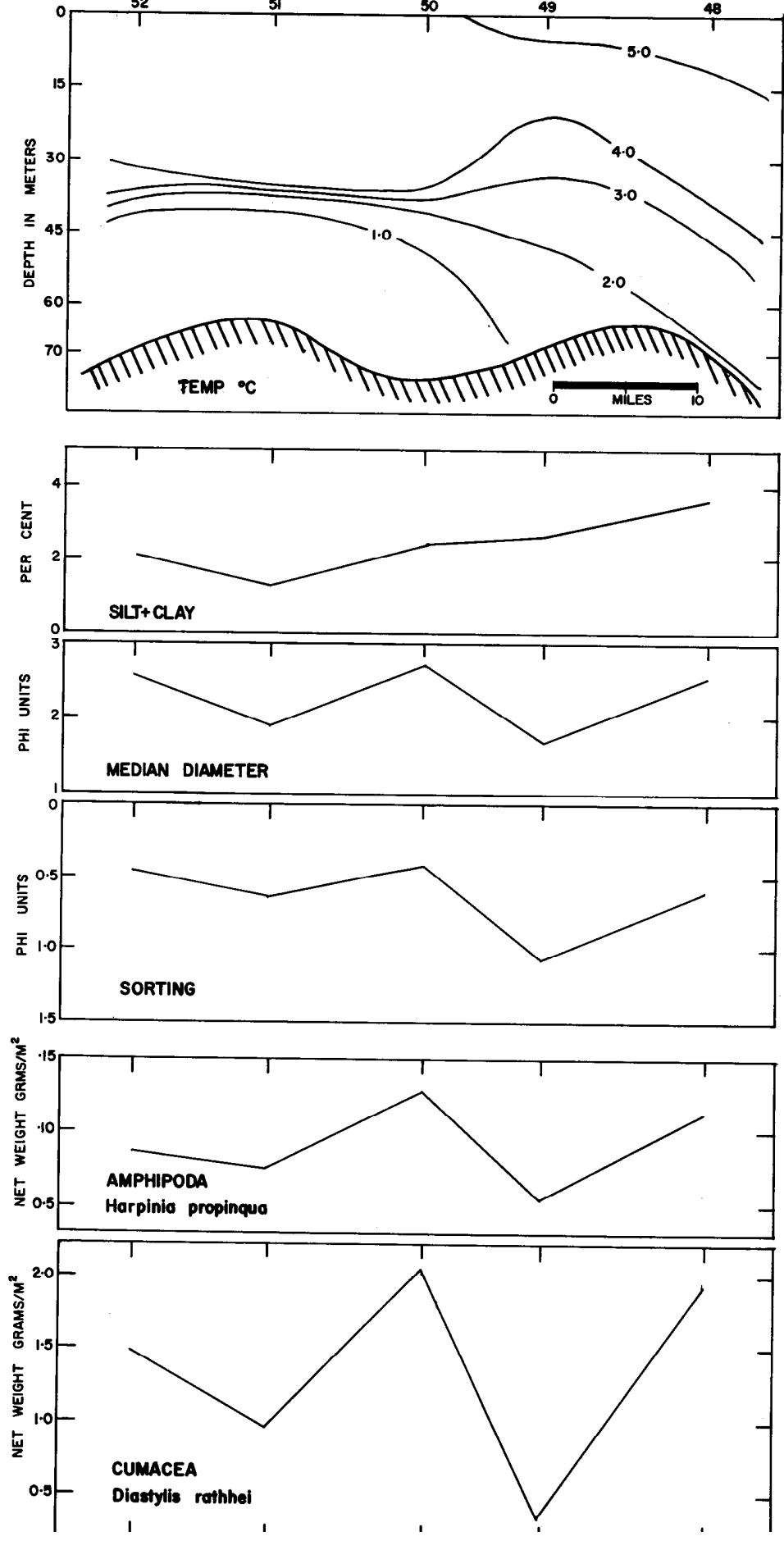


Figure 20 Diagram illustrating horizontal variation in temperature
 102
 sediment characteristics and two species of crustacea

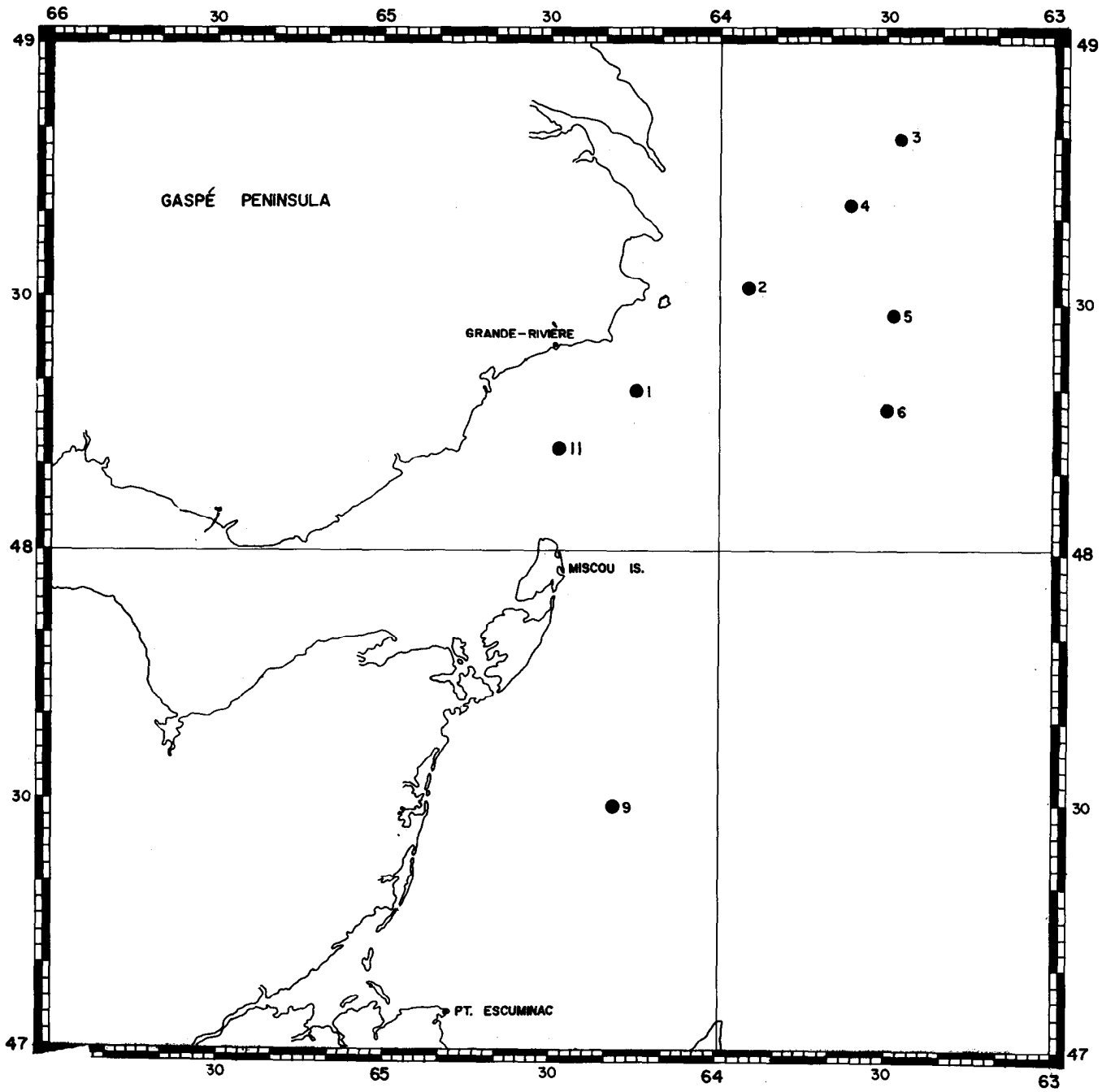


Figure 21 Benthic fauna sampling stations for "Harengus" cruise, GRF-52

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