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Proposal for a Coordinated ICNAF Environmental Research Program

by

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I. Introduction

For a long time ICNAF scientists have recognized that there is a need for more comprehensive oceanographic research over the continental shelf in order to improve our understanding of the manner in which environmental factors control the production and distribution of marine organisms. The need for better understanding is now greater than ever in view of the importance of predicting and maintaining the productive potential of the fisheries and the ever-increasing activities of man in the marine environment for exploitation of non-reusable resources of waste disposal. In order to achieve this understanding it will be necessary to study the ICNAF region as an ecosystem, i.e. to conduct comprehensive and coordinated studies of both physical and biological processes controlling organic production. We have made a good start on the biological phase but we have not made comparable progress in the environmental phase. Specifically, we need to consider the shelf circulation in the Northwest Atlantic as an integrated system, and establish a truly coordinated and expanded program of environmental research which will be continued in the future and become an integral part of the larger international program for studying the ecosystem on a global scale.

The purpose of this paper is to outline major elements of such a program as a basis for discussion in the Environmental Subcommittee, and as a guide to establishing and implementing a coordinated environmental research program for ICNAF by 1975. There are two basic phases of the program.

1. synoptic monitoring of large scale anomalies over the continental shelf and slope over the entire ICNAF area to describe seasonal changes in the water masses and position of coastal-slope water front; and

2. intensive studies in selected key areas to describe the dynamic physical processes which drive the circulation patterns critical to the production and distribution of marine organisms.

Major features of these two phases are described below including a restatement of certain minimum requirements for implementing the program which were outlined in Circular Letter 74/23. Details of the plan should be resolved in an appropriate working group of the Environmental Subcommittee.

II. Synoptic Monitoring of Large Scale Phenomena

Regular synoptic sampling is required to describe the boundaries and interrelationships of water masses. At present there are hydrographic studies being conducted throughout the ICNAF area and the year chiefly in conjunction with biological surveys, but they are generally uncoordinated and leave wide gaps in time and space. We propose that there should be monthly coverage of about 26 transects (representing a total of 338 hydrographic stations) extending to a depth of 1000 fathoms as shown in Figure 1. Four vessels dedicated to sampling only environmental parameters can cover the entire region in about 15 days each at sea. Minimum physical observations at each hydrographic station should include profiles of temperature, salinity and oxygen, and complete records on meteorological conditions. In between the hydrographic transects, there should be criss-cross coverage of the frontal zone at least with surface salinities and BT's (bathythermographs) to describe the positions of the fronts.

In order to implement this program, it will be necessary to allocate significant ship time dedicated to regular hydrographic cruises, and to develop standardized methods of data collection, processing and analysis. Included among requirements will be a standard data format for environmental observations (e.g. temperature, salinity, oxygen, nutrients, meteorological records, etc.) and computer procedures for processing, analysis and summary of environmental conditions in terms of anomalies relative to some base period. The standardized hydrographic data should be maintained in a central data archive administered by ICNAF and readily available to all member countries. These and other requirements are treated briefly in Circular Letter 74/23.

In the future satellite coverage and/or moored instrument stations may substitute for some surface vessel operations, but for the time being conventional methods will be required until the potential of remote sensing methods is evaluated. Commercial ship-of-opportunity routes should be explored as a relatively inexpensive way of monitoring temperature and surface parameters in strategic locations.

In addition to physical parameters, it is highly desirable to describe concurrently the structure and distribution of planktonic communities including some measure of primary production (e.g. chlorophyll index). For example, oblique plankton hauls using standard plankton gear and towing procedures should be an integral part of the environmental monitoring program. Development of plankton sorting centers in Europe, and North America is expected to facilitate the processing of these samples on a routine basis.

III. Intensive Studies in Key Areas

Although the first part of the research effort will provide a description of large-scale conditions, the smaller-scale dynamics of water movement may be the more critical factor in the early life of various species. In comparison with the monitoring program, these studies will require much higher sampling intensity in both time and space scales probably concentrated in one season at a time. Vessel operations shall have to be augmented with various moored and drifting instruments, to permit direct measures of current velocity at least on the scale of miles per day. Three areas are suggested for more intensive study of the dynamics of circulation, and effects on planktonic organisms. These are indicated in Figure 2.

A. Georges Bank-Gulf of Maine. This system can be considered as a semi-enclosed basin with two channels, one shallow and one deep, open to the ocean. The boundaries of the system are important for understanding the circulation and are defined as follows:

1) Across the continental shelf from Southwest Nova Scotia to the shelf break;

2) Across the continental shelf from south of Nantucket to the shelf break;

3) Across Northeast Channel at its sill;

4) Across South Channel at its sill;

5) Along the continental shelf break at the southern edge of Georges Bank;

6) The air-sea interface throughout the system;

7) The coastal boundary with fresh water inflow.

The first five boundary conditions can be determined by direct Eulerian measurements at moorings placed along each of these boundary lines. The sixth can be determined by consistent weather observations made by all ships in the area and the seventh by monitoring the river's outflow, by sea level measurements in open areas of the coast, and coastal meteorological observations. These last two boundaries can probably be adequately estimated with present resources.

We propose that Eulerian measurements extend initially over the fall season, since it coincides with the ICNAF larval herring survey when intensive hydrographic coverage is already scheduled.

The interior flow, i.e. the circulation over Georges Shoals and interior Gulf of Maine, could be determined by the Eulerian method but this would be cost-prohibitive. Therefore, we propose that Lagrangian methods be used to determine current trajectories in the interior regions. Drogues or other suitable equipment should be tracked over Georges Bank and within the Gulf of Maine concurrent with the Eulerian measurements of the boundary conditions. The lengths of tracking would depend on the speeds and directions of non-tidal flow.

A numerical model of the autumn circulation of the region could then be synthesized. This model is needed as a framework for constructing and evaluating hypotheses about the role of larval dispersal in the ecology of sea herring.

B. Cabot Strait. Boundaries of this region, chosen to understand the flow and mixing of various waters, are as follows:

1) Across the continental shelf from St. Lawrence Harbors, Newfoundland to the continental shelf break;

2) Across the continental shelf from south of Cape Breton Island to the continental shelf break;

3) Across the Cabot Strait from Cape North to Cape Ray;

4) Across Cabot Strait at the edge of the continental shelf;

5) The air-sea interface throughout the system;

6) The coastal boundary with fresh water inflow.

These six boundary conditions and the interior flow can be determined in an analogous way to the conditions in the Goerges Bank-Gulf of Maine area.

In this region the flow of water formed in the Gulf of St. Lawrence and mixing with waters that flow across the Grand Banks and onto the continental shelf will produce conditions that may be unsuitable for various species. Studies of the ratios of the waters involved and the steadiness of the mixing process may lead to an understanding of some fishery fluctuations within the region. Spring may be the most appropriate season to study this area because of the considerable runoff and melting of ice.

C. Grand Bank. This may be the most difficult of the three areas because of the confluence of two major oceanic currents, the Gulf Stream and the Labrador Current, near major fishing grounds. The United States Coast Guard, in support of the International Ice Patrols, has investigated the area for a number of years. A report by Soule, 1964 provides the mean normal dynamic topography during the period of the Ice Patrols. The dynamic topographies relative to the 1000 decibar surface for April and May are shown (Figures 3 and 4). The contours suggest that the Labrador Current, continuous along the eastern edge of the Grand Banks, reverses direction about 51° W. The possibility that Labrador water flows along the Scotian Shelf, and the possibility of the Gulf Stream impinging on the Grand Banks are important questions to answer not only for the Grand Bank fishery but also the fisheries further west along the continental shelf.

Since the area is mostly oceanic in depth, short-term variations caused by weather passage, and local topography are probably secondary to the geostrophic force balance. Therefore, intensive hydrographic sampling with various nutrient chemistry analyses and Lagrangian methods for the determination of current trajectories may be sufficient to provide an understanding of the relationship and variability of the current systems in the upper layers. This understanding may be related to fluctuations of the fisheries, not only in the immediate area but further west on the continental shelf.

IV. Logistic Requirements

Logistic requirements for both the large-scale monitoring and intensive study phases of the proposal are shown in Tables 1 and 2, in terms of numbers of stations and moorings, ship-days, etc. Clearly, this represents a major commitment of resources even on an international scale, and it is essential that we give very careful consideration to the optimum mix of large-scale monitoring versus "small-scale" studies. Nevertheless, we are convinced that this is approximately the level of effort required to achieve a quantitative understanding of the general dynamics of shelf circulation both in the short-term and long-term sense. Obviously there is a need for a coordinated program and it is essential that we take immediate steps to establish a basic plan within the Environmental Subcommittee.

REFERENCE

Soule, Floyd M. (1964). The Normal Dynamic Topography of the Labrador Current and Its Environs in the Vicinity of the Grand Banks of Newfoundland during the Iceberg Season, Woods Hole Oceanographic Institution, Ref. No. 64-36, 21 pp.

Table 1. Logistic requirements for each month in the synoptic monitoring of large scale phenomena.

Ship	Area	Approximate steaming(NM)	Approximate Hydrographic Stations	Additional BTs
1	Cape Hatteras-Gulf of Maine	2300	71	160
2	Gulf of Maine-Cabot Strait	2200	75	150
3	Grand Banks	2500	107	100
4	Labrador-West Greenland	2500	85	40

Table 2. Logistic requirements for an intensive study area (one season at a time).

	Areas of Intensive Study Suggested Sampling Methods and Intensity							
Area	Current Meter Moorings	Drifting Buoys and Ship Requirement	Hydrographic Sampling	Meteorological Observations	Water Run-off	Nutrient Sampling	Plankton Sampling	Hydrographic & Plankton Ship Requirements
Gulf of Maine-Georges Bank	24 moorings	as needed throughout the duration of the experiment to define the current pattern	150 stations bi-monthly	150 observations bi-monthly	Data from river outflow (existing)	75 stations monthly	150 stations bi-monthly	5 ships sampling for 15-20 days each.
Cabot Strait	24 moorings	as needed throughout the duration of the experiment to define the current pattern	150 stations monthly	150 observations monthly	Data from river outflow (existing)	75 stations monthly	150 stations monthly	3 ships sampling for 15-20 days each
Tail of Grand Banks	no moorings initially	as needed throughout the duration of the experiment to define the current pattern	130 stations monthly	130 observations monthly	not needed	65 stations monthly	130 stations monthly	3 ships sampling for 15-20 days each

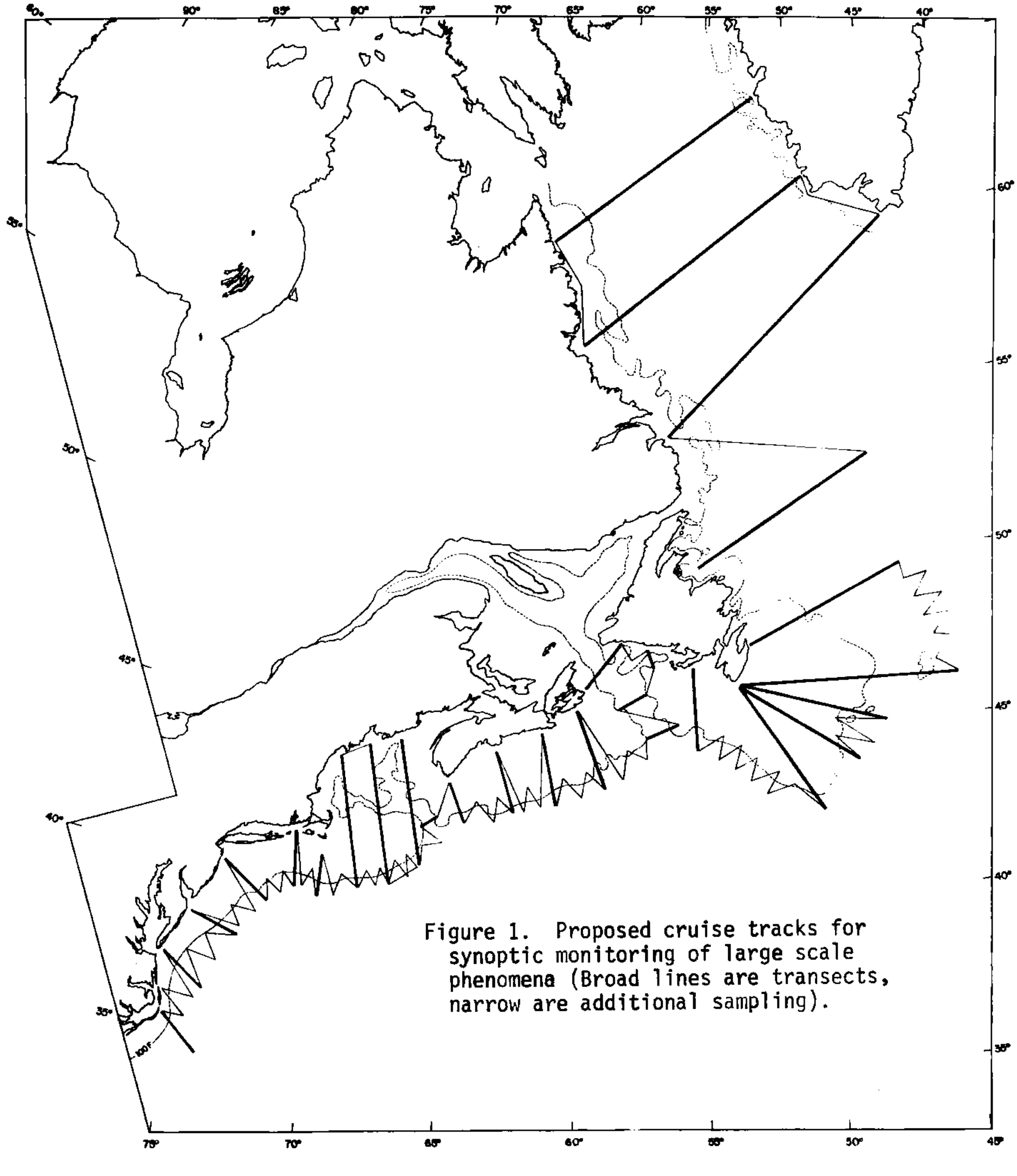

Figure 1. Proposed cruise tracks for synoptic monitoring of large scale phenomena (Broad lines are transects, narrow are additional sampling).

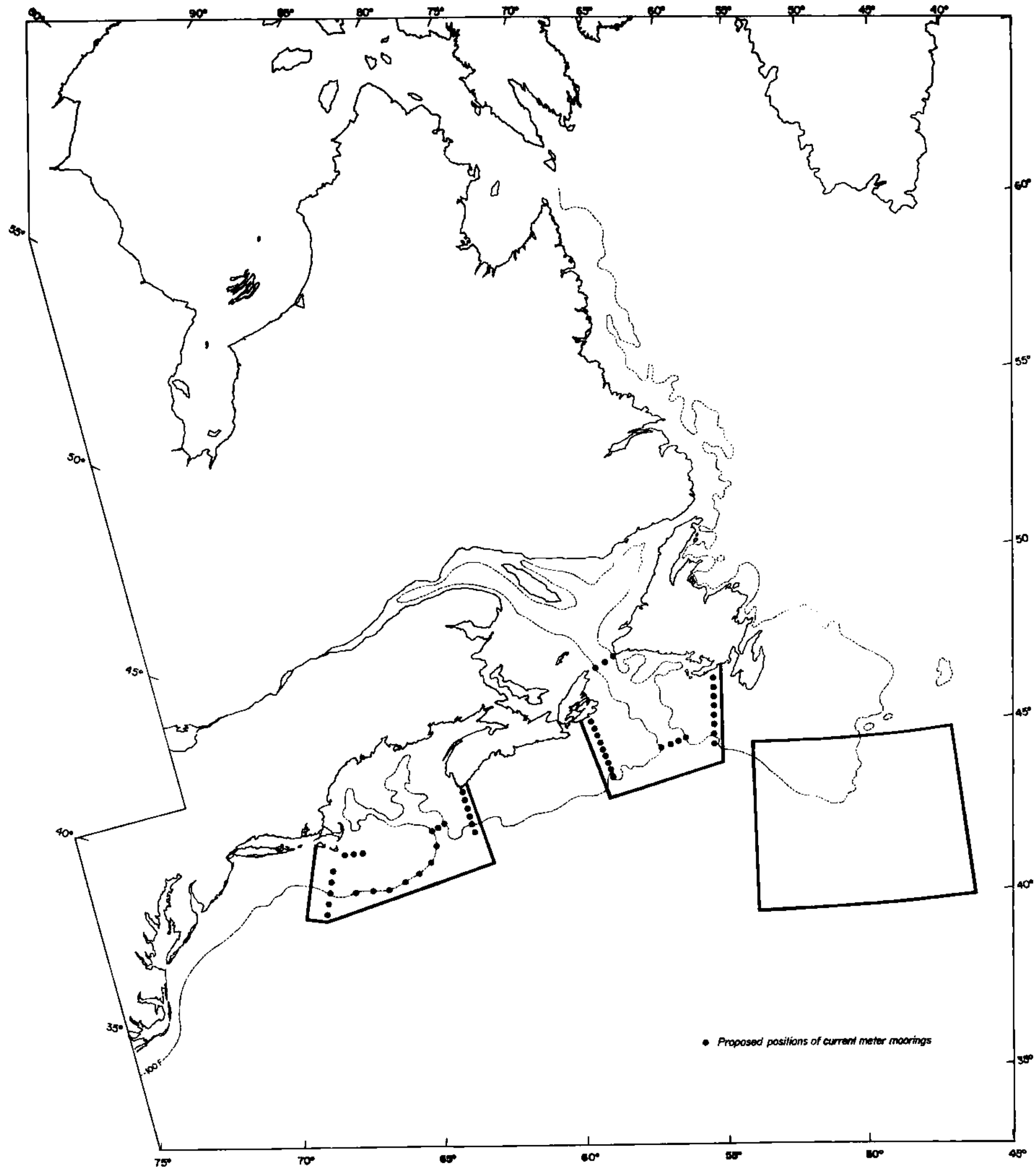

Figure 2. Proposed areas for intensive
study to determine water movement.

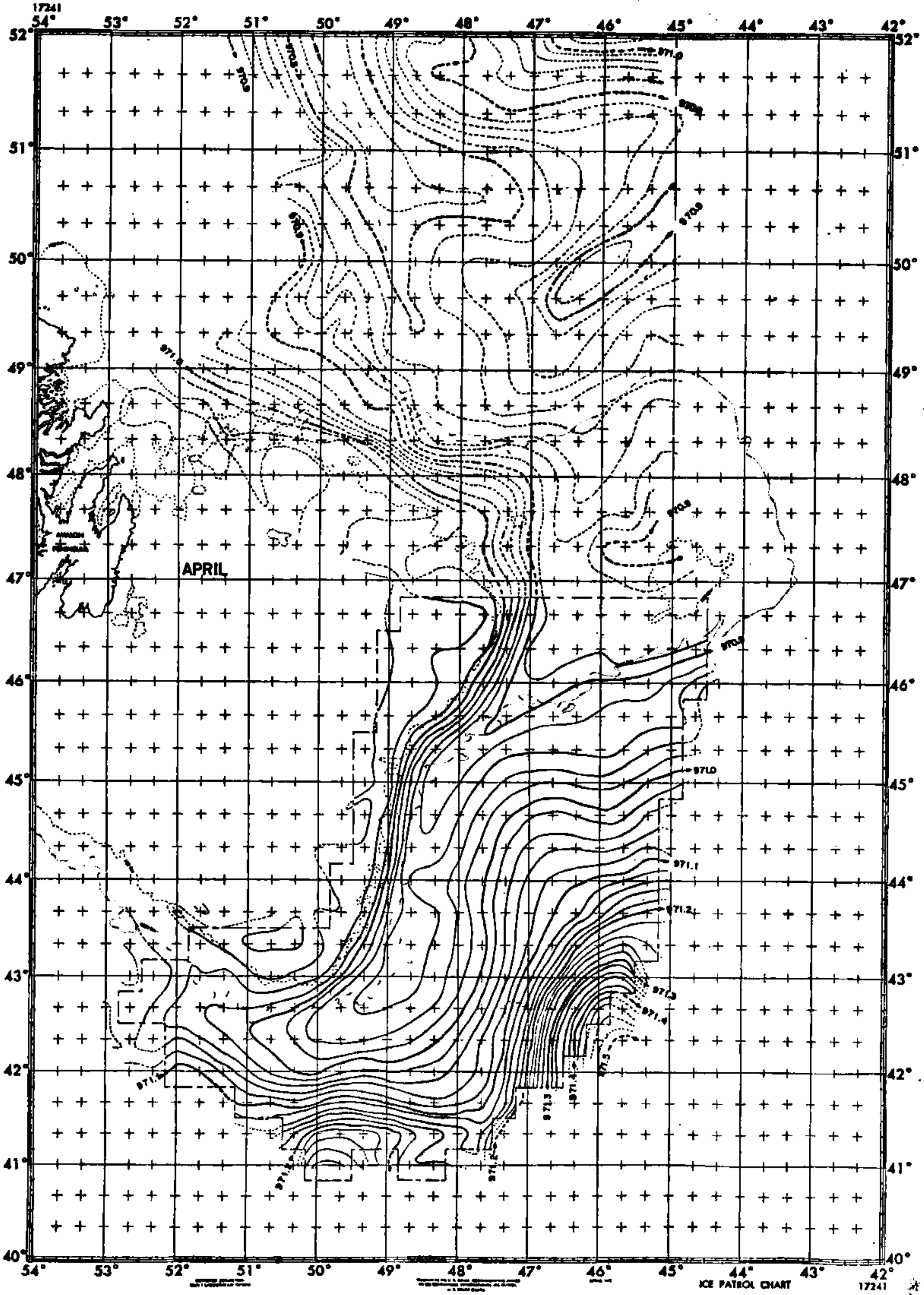

Fig. 3. April monthly normal dynamic topography of the sea surface relative to the 1,000-decibar surface. Contour interval 2 dynamic centimeters. (after Soule 1964)

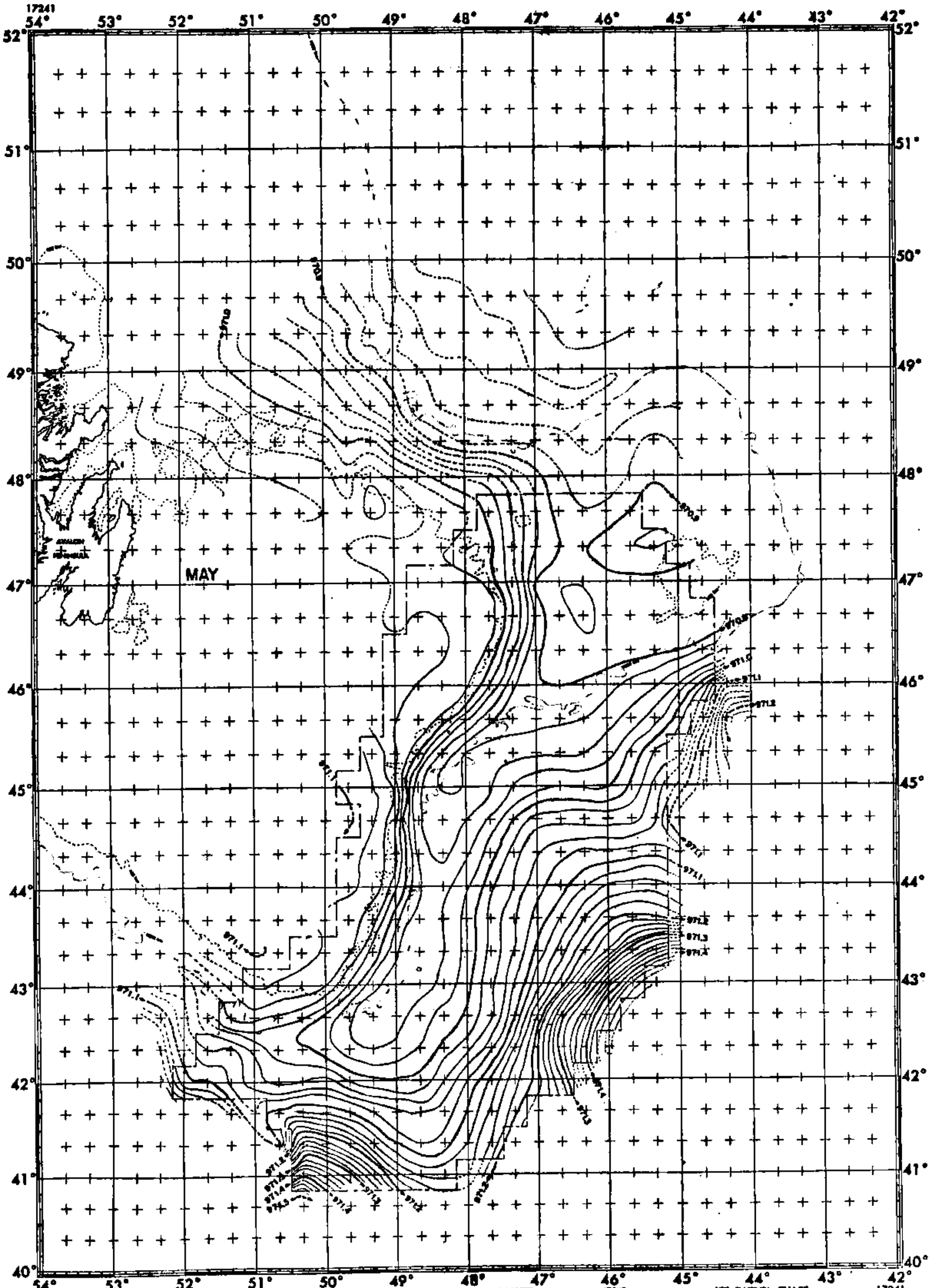

Fig. 4. May monthly normal dynamic topography of the sea surface relative to the 1,000-decibar surface. Contour interval 2 dynamic centimeters. (after Soule 1964)