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PROPOSAL

ICNAF GEORGES BANK SURVEYS

(ICNAF - GBS)

A study of the processes of recruitment in an international marine fishery

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LETTER OF TRANSMITTAL

Bureau of Commercial Fisheries
Biological Laboratory
Woods Hole, Mass. 02543

28 April 1966

Dr W. Templeman, Director
Biological Station
Water Street East
St. John's, Newfoundland, Canada.

Dear Temp:

In accordance with recommendations of the last annual meeting (Recommendation 28, Redbook 1965, p. 55) herewith is a proposal for environmental surveys of Georges Bank and surrounding waters. This has the endorsement of Dr Studenetsky who has asked me to submit it to you.

Dr Studenetsky indicates that the USSR is prepared to contribute two vessels to the surveys provided that other member countries participate. It now appears that the U.S. will be able to contribute at least two vessels.

I have sent a copy of the proposal and a copy of this letter to the Executive Secretary so that he can be preparing to make the necessary circulation.

We look forward to discussing this further with you at the annual meeting.

Sincerely yours,

(signed) Herbert W. Graham
Laboratory Director

Enclosure

PROPOSAL

ICNAF GEORGES BANK SURVEYS

(ICNAF - GBS)

A study of the processes of recruitment in an international marine fishery

Need for the Study

The International Commission for the Northwest Atlantic Fisheries (ICNAF) is responsible for the management of the offshore fisheries of the Northwest Atlantic Ocean from the West Coast of Greenland to Rhode Island. The primary objective of ICNAF is to manage the fisheries in this region in order to make possible maximum sustained yields from the stocks of fish occurring in the Convention Area.

Clearly there is a very real limit to the productive capacity of the natural marine environment and from the standpoint of exploiting certain members of a marine community there will be some optimum strategy which will yield a maximum harvest. Determination of the optimum management tactics requires knowledge of the basic population processes of recruitment, growth and natural mortality. Knowing the growth rate and natural mortality rate one can calculate the various combinations of fishing effort and ages at first capture that will provide the maximum yield per recruit. ICNAF regulatory measures to date have taken into consideration only the two parameters, growth rate and mortality rate, and have regulated only the age of first capture. This is accomplished by setting minimum mesh sizes in trawl nets. Such regulations are designed to provide the maximum yield from the recruited population of fish. The assessments of the probable maximum yields of ICNAF fisheries that have been made so far do not take recruitment into consideration but are based on the assumption that the long term average number of recruits is constant and not related to number of spawners over the range of stock sizes that have obtained. However, we are by no means certain that this is true, and if average recruitment declines with the decrease in adult stock which always accompanies exploitation, then the assessments tend to overestimate the optimum level of fishing intensity and underestimate the desirable mesh size.

However, recruitment varies widely from year to year and so landings also vary widely unless there are sufficient year classes among the recruited ages to damp out the fluctuations in incoming year classes.

Fishing effort on ICNAF stocks of fish is now reaching a point where increasing mesh size is no longer a feasible conservation measure and the Commission is turning its thoughts toward catch limitations. Such regulations will have the effect of maintaining stock size including the number of spawning fish. Or at least the Commission will then be regulating stock size and can hold it at whatever level it deems desirable.

This raises the very serious question of the relation of stock size to recruitment, a question about which we know very little in marine fisheries.

The nature of this relationship is of fundamental importance both with respect to the optimum level of exploitation and to the intrinsic stability of the population. For most fishes with pelagic eggs a single female can produce enormous numbers of eggs and it is obvious that for any reasonable abundance of spawners only an extremely small fraction of the eggs spawned can survive to become reproducing adults if the population is to remain stable. This plus the fact that extreme annual variations in recruitment can be derived from a given size of spawning stock has led to the common idea that recruitment is independent of the size of spawning stock for a rather wide range of adult stock sizes, but this is far from proven and may be erroneous.

It is in this area of fishery biology in which the greatest ignorance prevails. We do not know when in the early life history of a species the greatest mortality normally occurs nor much about the causes of this mortality. Is the initial number of eggs important? Are there density dependent factors operating? What are the factors in the environment which are important to survival? How and when do they operate? Is the initial number of viable eggs related to the size and condition of the spawning stock? These questions must be answered before we can understand the processes of recruitment; an understanding which is necessary to a proper knowledge of the dynamics of fish populations.

Obtaining the necessary information for a particular stock of fish involves a concentrated study of the growth and mortality of the early stages of the year classes, and concurrent observations of related environmental factors. Such a study requires a high frequency sampling over a considerable area for several months for each stock of fish. A multi-ship operation of considerable magnitude is necessary to insure adequate sampling.

Background

Realizing the importance of environmental studies in marine fishery research, ICNAF has for many years been active in planning and coordinating such studies in the Northwest Atlantic. The Environmental Subcommittee of ICNAF's Committee on Research and Statistics held a special one-week meeting in Aberdeen, Scotland, in 1961 planning long range environmental studies in the ICNAF area. Two important projects have already been completed as a result of this Committee's deliberations and recommendations.

First, a symposium on environmental studies was held in Rome, Italy, in 1964 at which world experts in the field reviewed the status of marine environmental studies today and indicated the direction in which environmental research should take in the next few years.

Secondly, an international cooperative survey was conducted in the waters between Greenland and Labrador to trace the drift of cod eggs and larvae in that area, and to determine the relation of the cod stocks in this region. This operation, known as NORWESTLANT, has produced valuable information on the hydrography of the entire area as well as biological information relative to the fisheries. The reports on these surveys are in press.

With this experience behind it, ICNAF is now ready to embark on a more sophisticated study of fishery problems in relation to environmental conditions. The Assessment Subcommittee of ICNAF's Committee on Research and Statistics has recommended that the environment be studied in relation to recruitment in order to understand the processes of recruitment, and to determine, if possible, the relation of stock size to recruitment as indicated above.

At the last Annual Meeting in June, 1965, in Halifax, the ICNAF scientists discussed the possibility of conducting such studies on Georges Bank. The idea was raised by the U. S. and strongly supported by the USSR. Canada and U. K. endorsed the idea in principle and the other countries expressed considerable interest. As a result of these discussions the following recommendation was presented by the Research and Statistics Committee and approved by the Commission:

> "that the USA and USSR (i) draw up a plan for an environmental survey of the Georges Bank area in relation to the recruitment of the commercial fish stocks of that area, (ii) indicate the resources which they have at their disposal for carrying out this survey and the additional assistance which they will need from other countries, (iii) submit the plan to the Chairman of R&S for discussion at the 1966 meeting of the Committee, the submission being made so that the plan can be circulated to members of the Committee well in advance of that meeting in order to allow them ample time to consider it and discuss it within their own countries."

The present proposal is prepared in response to that recommendation.

Selection of Study Area

In a program of this sort it is important to choose populations of fish which are well known, which are in an area in which the general aspects of the circulation are well known, and which are close to supply and repair bases ashore in order to minimize the logistic problems.

Georges Bank satisfies these requirements. It is one of the richest fishing areas of the world, producing about one-third the tonnage of fish landed from the ICNAF Convention Area. Several species contribute to these landings, some of which have been intensively studied for many years and are now under international regulation.

The Georges Bank haddock stock is the best known, having been under intensive study by the United States for a great many years. It is a distinct population confined to a comparatively small area. Age and length compositions and relative abundance indices of the recruited sizes have been maintained for many years and the abundance of demersal stages of pre-recruits (age groups O and I) is monitored by research vessel surveys each year. Sufficient egg and larval surveys have been made in the past to outline the time and location of spawning concentrations and to indicate the surface current patterns that probably control the drift of eggs and pelagic larvae. Of all the ICNAF stocks this is probably the most suitable one to select for the study of recruitment processes because of the rich background of information available for it.

Herring is another important species in the Georges Bank area. There are three so-called stocks to be considered. Canada and the United States have for many years exploited immature fish in inshore waters; the USSR is exploiting a stock of mature fish on Georges Bank itself; and a third spawning stock occurs off the tip of Nova Scotia. The relation of these various "stocks" is now known. Although herring have not been so intensively studied as the haddock, all three countries concerned now have active research programs directed toward this species. The proposed surveys as outlined here would provide information on the relation of the stocks concerned as well as on the recruitment processes involved.

Silver hake (whiting) is heavily exploited by both the U.S. and the USSR. Here again scientific data on the populations are available for only a few years, but the Georges Bank Surveys will provide valuable information on time and place of spawning and relationship of stocks, and possibly on the recruitment processes themselves.

The present proposal is designed primarily with these three species in mind. However, if the surveys extend throughout the year, all species would be included in the collections. Without additional effort very important information would be obtained on all the other species spawning in the area such as cod, redfish, and flounders. Interspecific relations may be important in survival of any one species. Data pertinent to this problem would be at hand without additional sampling.

Primary Objectives

The primary objectives are to study the processes which determine the recruitment to the fishery of haddock, herring, and silver hake. Some hypotheses to be examined are:

1. That the density, abundance, and condition of the spawning fish govern the number of viable eggs produced.

2. That the survival of eggs and planktonic larvae depends upon the time and location of spawning and upon the current patterns during the planktonic stages.

3. That the survival of larvae depends upon the availability of suitable food.

4. That the greatest mortality of larvae occurs at certain critical stages of development.

5. That mortality during the juvenile stages in midwater is comparatively low.

Intermediate Objectives

In order to arrive at the primary objectives, a number of intermediate or secondary steps must be taken involving analyses which are substantial research projects in themselves. These are:

1. Estimation of relative size of the spawning stock for each year of study.

2. Determination of fecundity of spawning stock for each year of study.

3. Monitoring of non-tidal current patterns throughout the period of study, measuring speed and direction throughout the water column.

4. Monitoring the temperature regimes throughout the period of study.

5. Determination of mortality rates of the planktonic stages at frequent intervals.

6. Determination of mortality rates throughout the post-planktonic stages at certain intervals.

7. Determination of relative year class strength of pre-recruits in the demersal stage for haddock and at corresponding ages for the other species.

8. Estimation of abundance of suitable food for all fish stages from early larva to post juvenile.

Observations to be Made

1. Number of spawners
2. Condition of spawners
3. Fecundity of spawners
4. Number of eggs by species and stages
5. Number of planktonic larvae and postlarvae
6. Lengths of planktonic larvae and postlarvae
7. Stomach contents of planktonic larvae and postlarvae
8. Condition index of larvae and postlarvae
9. Number of potential larval food
10. Number of postlarvae in midwater
11. Number and age of pre-recruits in demersal or corresponding stage
12. Vertical distribution of temperature
13. Vertical distribution of salinity
14. Vertical distribution of oxygen
15. Vertical distribution of chlorophyll
16. Current patterns
17. Meteorological conditions

Sampling Program

In order to make the observations listed above, four types of samples will be required:

1. Bottom trawl collections for samples of the spawning stock and of demersal stages of pre-recruits.

2. Plankton collections for samples of fish eggs and larvae and larval food.

3. Midwater collections for samples of post planktonic stages.

4. Water samples for hydrographic studies.

Sampling Pre-Spawning and Spawning Fish

The spawning areas of haddock, silver hake, and herring are shown in Figure 1 along with the dates over which sampling for pre-spawning and spawning must extend for each species. It is obvious that sampling for these purposes must extend throughout the year. It is estimated that these surveys will require the full time of two vessels.

Sampling Pre-recruits

In the post planktonic stages all three species are in mid-water. At about 6 months of age the haddock become demersal, the herring remain pelagic, and the silver hake probably are off the bottom. It will probably require the equivalent of one vessel full time to provide adequate sampling of the pre-recruit stages of the three species.

Plankton Sampling

Plankton sampling will be required for the collection of fish eggs and larvae and larval food. In the early period of spawning sampling for eggs might be concentrated in the spawning areas, but dispersal and drift of the eggs and larvae will necessitate much wider sampling soon after spawning starts. The general current patterns are shown in Figure 3.

It is apparent that plankton sampling will have to be conducted over a wide area if the larvae are to be adequately sampled during their planktonic existence. Provisional limits might be established eastward at 64°W longitude and westward to a line cutting across the shelf along Hudson Canyon (see Figure 2). Offshore collections would be made to the edge of the shelf water which in the western part of the area would be to depths of 2,000 meters, and in the eastern part to about the 3,000 meter contour.

The season of sampling for planktonic stages is determined by the spawning time and duration of the planktonic existence. Unfortunately, the spawning periods extend over a number of weeks and the planktonic life even longer.

Following are the periods during which plankton samples would be required for each of the three species and for forage organisms.

1. Haddock eggs and larvae - February 1 to June 1.
2. Silver hake eggs and larvae - June 1 to ?
3. Herring larvae - September 1 to March 1.
4. Food of larvae - Concurrent with collections of larvae.

It is obvious that plankton samples must extend throughout the year if all three species are to be investigated. Furthermore, the entire area shown in Figure 2 would have to be covered in order to record the time and location of spawning, the number of eggs produced, the subsequent drift and dispersal of the larvae and postlarvae, and the kinds and quantities of forage organisms. To cover this area adequately would require a grid of 200 stations spaced at 20-mile intervals to be occupied every seven days. It is estimated this sampling would require six ships assuming that each ship spent 180 days on the program.

Although this sampling program will provide the information listed above it is unlikely to provide statistically significant measures of the rates of mortality of the eggs and larvae. For this purpose a grid of stations five miles apart probably would be necessary. Since increasing the density of sampling to this extent over the entire area is logistically impossible we propose that intensified sampling be conducted only for Georges Bank haddock, the species for which a greater amount of information is available on spawning and recruitment and which is currently under regulation. This sampling would cover the Georges Bank area from February through July. About 400 stations would be involved requiring three to four ships for six months of each year.

Hydrography

Hydrographic studies are an integral part of the environmental research and will require special sampling designs. The general circulation of the surface waters off New England and Nova Scotia is fairly well known (Figure 3). However, the seasonal and secular variations that are known to occur are poorly documented. The prevailing circulation at any time of the year may be temporarily disrupted for reasons which are at present obscure and the changes in conditions at any particular position can be relatively rapid.

Some of the factors which are believed to affect the position, movement, and relative volumes of coastal, slope, and offshore waters in the area are: the temperature and salinity regimes, wind patterns, volume of river runoff, mass transport of the Gulf Stream, tidal currents, and internal waves.

The interaction of the three main water masses can have profound biological effects. When the Gulf of Maine and Georges Bank eddies are strong and well established, planktonic organisms are retained in the area and intrusion of water of a different type is resisted. When the eddies are weak or diffuse, the plankton may be carried away or intrusions may cause heavy mortalities. Primary productivity of the area is affected to some degree by the characteristics and volume of the water entering from the Scotian Shelf.

Two types of studies are needed to determine the degree to which the recruitment of marine fishes is affected by the circulation. The first is an extended time series of synoptic observations on the characteristics of the water masses and the factors which are believed to control them. This will necessarily involve a large network of observations probably involving unmanned fixed and drifting recording-transmitting stations as well as multiple ship surveys.

The second is a series of short-term studies of the movement and modification of small water masses within the area.

It is estimated that two vessels would be required for the hydrographic aspects of the program.

Summary of Vessel Needs

For sampling pre-spawning and spawning fish -	2 vessels
For sampling pre-recruit fish -	1 vessel
For plankton sampling -	8 vessels
For hydrographic observations -	2 vessels
Total	13 vessels

Manpower Requirements for Manning the Vessels

It can be assumed that countries contributing research vessels would include the necessary scientific staffs to make the scientific observations and collect the samples pertinent to the program although there might be an exchange of personnel between countries to increase the communication between countries in respect to methods used by various countries in the conduct of the work. The number of persons on a cruise would depend upon the nature of the cruise and the watch system practiced by the vessel concerned.

Approximate Manpower Needs for Analyzing the Samples

1. Fecundity studies

   About 500 ovaries from each species will be required. Number of persons required for analysis - 6

2. Midwater pre-recruit studies

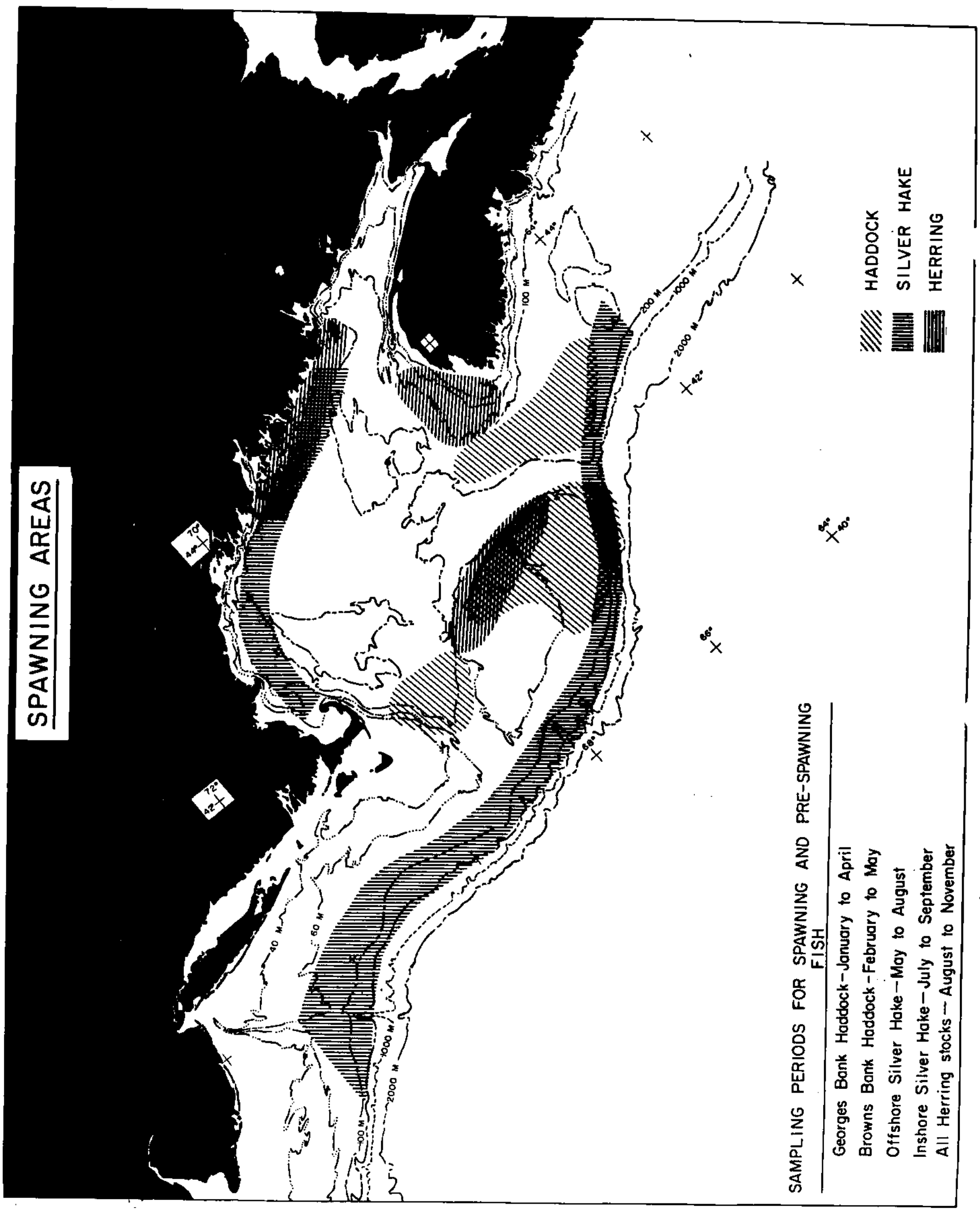
   About 200 stations would be occupied. Persons required for analysis of samples - 2

3. Plankton studies

About 13,000 samples would be taken in the general surveys and 2,400 in the intensive haddock studies, making a total of 15,400. Number of persons required for preliminary sorting - 75

4. Hydrographic studies

Analysis of data - persons required - 20


SPAWNING AREAS
HADDOCK
SILVER HAKE
HERRING
SAMPLING PERIODS FOR SPAWNING AND PRE-SPAWNING FISH
Georges Bank Haddock-January to April
Browns Bank Haddock-February to May
Offshore Silver Hake-May to August
Inshore Silver Hake-July to September
All Herring stocks-August to November
40 M
60 M
100 M
200 M
1000 M
2000 M

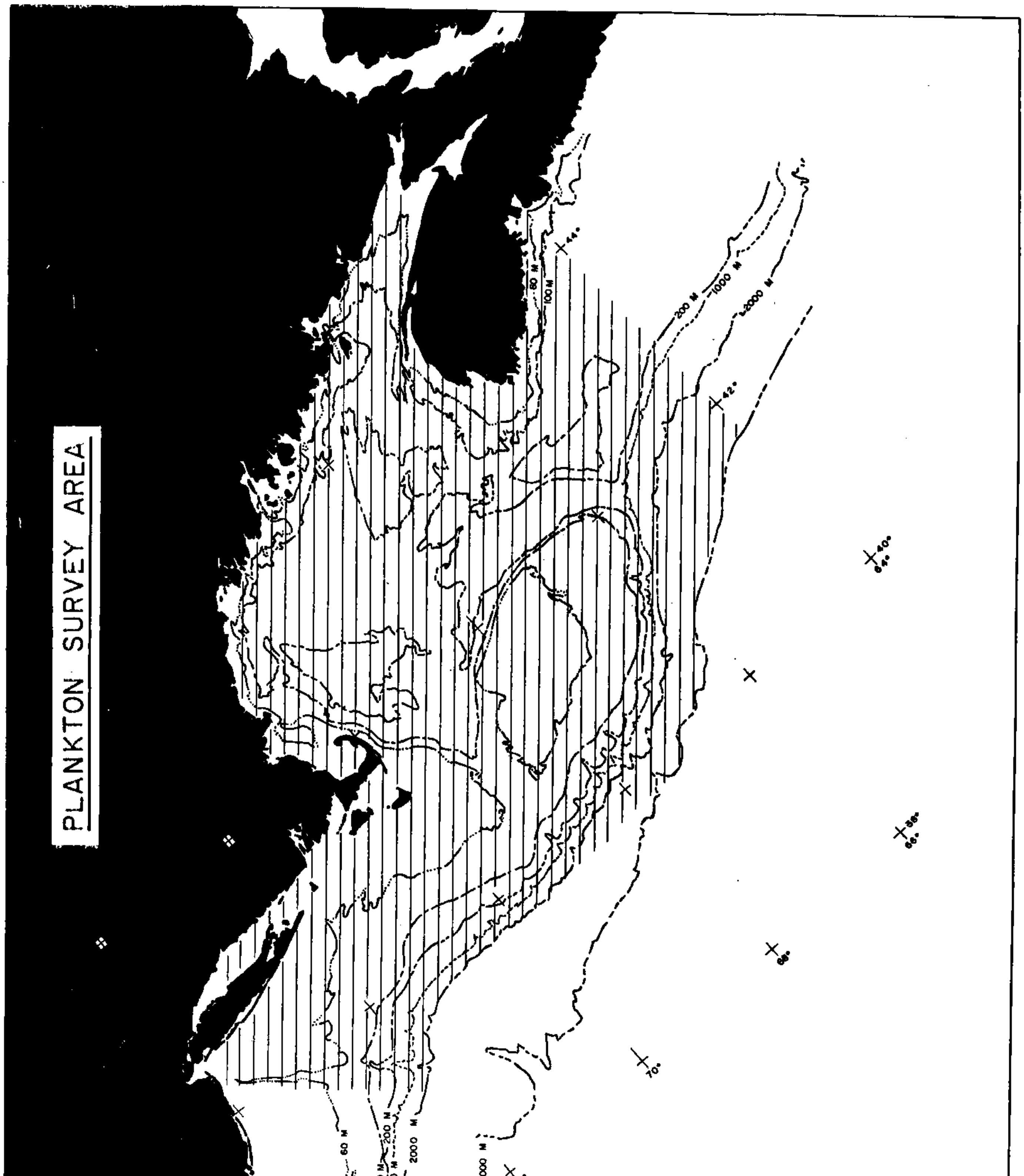

PLANKTON SURVEY AREA
60 M
100 M
200 M
1000 M
2000 M
3000 M
44°
42°
40°
64°
38°
66°
68°
70°
72°

Fig. 2

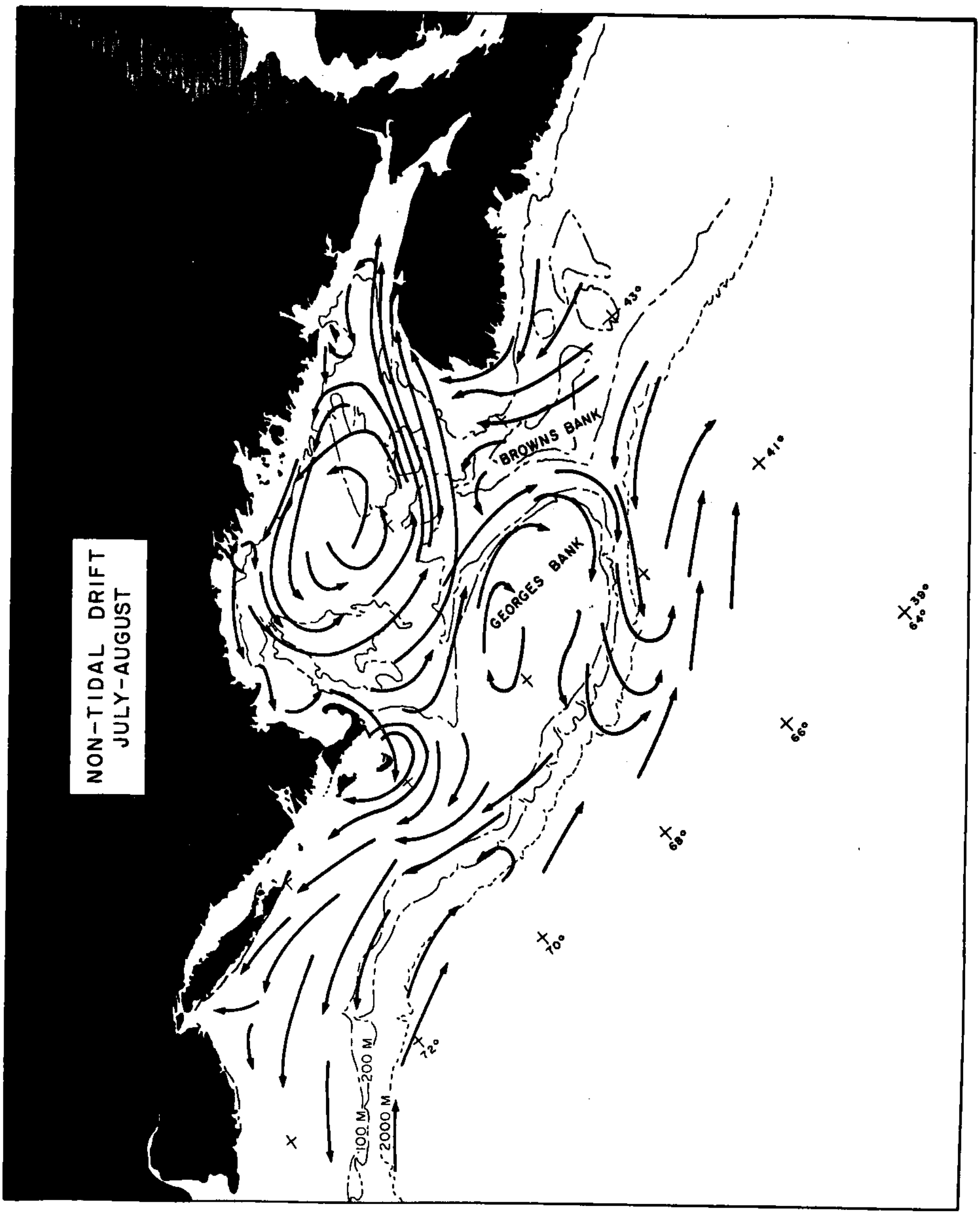

NON-TIDAL DRIFT
JULY-AUGUST
BROWNS BANK
GEORGES BANK
100 M
200 M
2000 M
43°
41°
39°
64°
66°
68°
70°
72°

Fig. 3