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Resource and Fishery Distributions in the Gulf of Maine Area in Relation to the Subarea 4/5 Boundary

by

R. G. Halliday, J. McGlade, R. Mohn, R. N. O'Boyle and M. Sinclair*

Fisheries Research Branch, Scotia-Fundy Region, Department of Fisheries and Oceans
P. O. Box 550, Halifax, Nova Scotia, Canada B3J 2S7

* Authors in alphabetical order.

Introduction

At its June 1985 meeting, the NAFO Scientific Council was informed of the recent International Court of Justice (ICJ) decision regarding the maritime boundary between Canada and the USA in the Gulf of Maine Area. The Council agreed to consider the appropriate location of the NAFO Subarea 4/5 boundary, in light of this decision, at its September 1985 meeting. Subsequent to the June Council meeting, Canada has put a proposal before the September 1985 meeting of the General Council (NAFO MS 1985) to modify the Subarea 4/5 boundary. The proposal reads "Given the establishment of the Maritime Boundary between Canada and the USA, it would be appropriate to adjust the 4/5 line to coincide with this boundary. This would facilitate reporting for all concerned. ..."

To support its considerations, the Scientific Council has requested a review of relevant data based on the guidelines for boundary change developed by ICES and approved by the Coordinating Working Party on Atlantic Fishery Statistics (CWP), and which are given in Annex I of the June 1985 STACRES report. This Research Document addresses that request. The main part of the document addresses the advantages and disadvantages of changes in the light of administrative, biological, fishery and statistical considerations, and takes into account the possibilities of subdividing previous statistical areas rather than moving boundary lines to create completely new statistical areas. This meets the criteria (a) to (d) of the CWP guidelines. The supporting documentation required under (e) of the CWP guidelines follows as appendices with Appendix 1 giving a brief description of the topography and oceanography of the Gulf of Maine Area, Appendix 2 giving the distributions and migrations of the exploited phases of a comprehensive list of species, and Appendix 3 giving distributions of fisheries in the area and an analysis of the effects of boundary changes on long-term series of commercial catch and fishing effort data.

History of the Subarea 4/5 boundary

An understanding of the basis for the present Subarea 4/5 boundary line, and of its history, gives a perspective on its current attributes. The relative merits of a proposed new boundary line can then be assessed against these.

The first statistical boundary line dividing the Gulf of Maine Area was established by the North American Council on Fishery Investigations (NACFI) in 1932. The line was drawn north along longitude 65° 41' W to 42° 13' N, then west along this latitude (through the Fundian Channel) to 67° 00' W, thence due north to latitude 44° 10' N at the mouth of the Bay of Fundy, thence up the middle of the Bay of Cape Chignecto. This line was revised in 1936 to run north at 65° 40' N then (with a couple of 10' x 10' steps) west at 42° 20' W, thence north at 67° 40'. These lines are identical to those of the present Subarea 4/5 boundary (except that a rhumb line replaces the 10' x 10' steps). The northern end of the 1936 line still went up the Bay of Fundy from 44° 20' N to Cape Chignecto. NACFI ceased to function after 1939 but a unilateral change was made by the USA in 1943 which modified the northern end of the line, bringing it east at 43° 50' N from the 67° 40' W line and north to the international land boundary between the USA and Canada, thus placing all of the Bay of Fundy on the eastern side of the line.

The line between Subareas 4 and 5 in the present NAFO Convention (Fig. 1), which is identical to that contained in the ICNAF Convention established in 1949, is defined as follows: "beginning at the terminus of the international boundary between the United States of America and Canada in Grand Manan Channel, at a point at 44° 46' 35.346" north latitude; 66° 54' 11.253" west longitude; thence due south to the parallel of 43° 50' north latitude; thence due west to the meridian of 67° 40' west longitude; thence due south to the parallel of 42° 20' north latitude; thence due east to a point in 66° 00' west longitude; thence along a rhumb line in a southeasterly direction to a point at 42° 00' north latitude and and 65° 40' west longitude; and thence due south to the parallel of 39° 00' north latitude. The present Subarea 4/5 line is, therefore, almost identical to that of NACFI as modified by the USA in 1943 which, in itself, was in the same general location as the original NACFI line of 1932.

Although the location of the lines used is well documented by NACFI (1935) and by Rounsefell (1948), the reasons for the precise positions chosen is less so. It can be surmised with confidence that the contemporary results of haddock stock separation research (Huntsman and Needler, 1927; Needler, 1930) and preoccupation with biostatistical analysis of the haddock fisheries (Rounsefell, op. cit.) had a profound influence on the NACFI decision to run their boundary line between Browns and Georges banks and up the middle of the Bay of Fundy.

Rounsefell's account of the development of fishery statistics concentrates on development of the Unit Area system designed to define discrete commercial fishing grounds. Rounsefell states that the 1936 modification to the NACFI line was to achieve a closer correspondence between it and the boundaries of the Unit Areas. Since, up to that point, these Unit Areas had been designed to describe the haddock fishery, it appears that haddock resource and fishery distributions continued to dominate thinking about boundaries. Rounsefell's account of the basis for the 1943 changes in the NACFI line is cryptic. He states "Placing the catches of the two sides of the Bay of Fundy in the same area is more logical than the former division." It appears, therefore, that this change was an administrative convenience.

It is quite clear from Rounsefell, for example, that the intention in devising boundaries was for statistical purposes, and that the boundaries should separate biological stocks, and on a smaller scale, the major fishing grounds. The statistics were to be used to determine the population dynamics of the major species, and this knowledge was to be used for conservation purposes. NACFI was a purely scientific organization without fishery regulatory authority. ICNAF provided the first regulatory authority for high seas fisheries in the Gulf of Maine Area. The ICNAF Convention divided the Convention Area into Subareas. These Subareas were used to define the geographic areas of responsibility of subgroups within the ICNAF Commission called Panels. Panels were the basic organizational entities for consideration and recommendation of conservation measures. Utilization of the NACFI boundary in the Gulf of Maine Area as the dividing line between the responsibilities of Panels 4 and 5 destined it to be a major line of delimitation for conservation purposes.

The ICNAF Panel system for Subareas 4 and 5 became defunct in 1977 with extensions of coastal state jurisdiction. The Subarea 4/5 line continued to be used for some time by USA authorities, and continues to be used by Canadian authorities, for domestic regulatory purposes.

The new maritime boundary between Canada and the USA

On 12 October 1984, the International Court of Justice in The Hague rendered its judgement on delimitation of the maritime boundary between the USA and Canada in the Gulf of Maine Area. The decision was that the boundary be defined by geodetic lines connecting the points with the following coordinates:

	Latitude North	Longitude West
A.	44° 11' 12"	67° 16' 46"
B.	42° 53' 14"	67° 44' 35"
C.	42° 31' 08"	67° 28' 05"
D.	40° 27' 05"	65° 41' 59"

This boundary originates in the northeastern corner of Div. 5Y, approximates the Div. 4X/5Y boundary at 67° 40' W then cuts diagonally across the northeastern portion of Subdiv. 5Ze (Fig. 1). It ends over deep water within 1' 59" of the Subdiv. 5Ze/Div. 4X boundary at 65° 40' W.

Canadian and USA jurisdictional claims both originate at the land boundary terminus in the Grand Manan Channel, coincident with the terminus of the Subarea 4/5 line. These claims overlap until they reach Point A, where they cross (Fig. 2). The dispute referred to the ICJ involved only those parts of the claims of the two parties which were seaward of Point A. Thus, the Court's decision does not extend landward of Point A, and claims in that area remain unresolved.

With regard to the Unit Area system (Fig. 3), which will be used subsequently in data analysis, the ICJ line transects six Unit Areas, 4Xp and q, 5Yb and f, and 5Zj and m. (These latter Unit Areas could, perhaps more correctly, be referred to as 5Zej and 5Zem as both are in Subdiv. 5Ze. However, for brevity, and as there is no danger of confusion, the terminology 5Zj and 5Zm is used here.) The Unit Areas shown in Fig. 3 are those currently in use by Canada which are closely similar, though not quite identical, to those defined by Rounsefell (1948) as applying from 1943 to the USA statistical system.

Canadian proposal for revision of Subarea 4/5 boundary

The Canadian proposal to adjust the Subarea 4/5 boundary to coincide with the ICJ line (NAFO MS 1985) although clear in that all areas to the east of the ICJ line would be in Subarea 4 and all areas to the west of it would be in Subarea 5, leaves open the question of precisely how this is to be accomplished, in addition to the question of the impact that adoption of such a proposal would have. Indeed, the impacts will depend to a significant degree on the precise changes to be adopted. The following framework has been used for the evaluation of potential impacts of a change in the boundary.

It is necessary to connect Point A to the international land boundary terminus, the origin of the present Subarea 4/5 boundary as well as an agreed point in the jurisdictional claims of Canada and the USA. It is presumed that the connecting line will not proceed to the terminus in a direction taking it west or south of Point A. Thus, it is considered below for the purpose of providing illustrative examples of potential impacts that the "maximum" and "minimum" area of Unit Area 5Yb which would be reassigned from Div. 5Y to Div. 4X would be defined by the Canadian claim line (approximating a line due north from Point A) and by a line due east from Point A, respectively (Fig. 3).

South of Point A, the ICJ line cuts off small portions of 4Xq and 4Xp, and of 5Yf, which would become parts of Subarea 5 and Subarea 4 respectively. The ICJ line then cuts off large portions of 5Zj and m which would become part of Subarea 4. In keeping with CWP working principle (c), it is necessary to consider whether these reassigned areas are large and important enough to merit creation of new Divisions or Subdivisions to maintain statistical continuity, or whether they become part of adjacent Divisions/Subdivisions within their new Subarea.

Finally, the course of the Subarea boundary seaward of Point D will have to be decided upon. The proximity of Point D to the present Subarea 4/5 boundary suggests that the ICJ line should be extended in some fashion to join the present boundary at 65° 40' W and thence due south to 39° 00'N. Point D is well off the Continental Shelf and the solution adopted cannot affect historical fisheries records in a significant way, with the possible exception of those for large pelagic species. If the ICJ line is joined to the present Subarea 4/5 line in the immediate proximity of Point D, statistics for these species will not be significantly affected either.

With regard to the application of CWP working principle (C), the practicalities of the two possible courses of action, i.e. creation of new statistical units or simple transfer of part of one existing area to another, becomes clear from inspection of the areas involved (Table 1) and the general distribution of fisheries (Figs. 4 and 5). The areas of the portions of present Divisions/Subdivisions which would be reassigned as to Subarea under the Canadian proposal are mostly small: from 5Yf, 40 sq. naut. mi; from 4Xp, 161 sq. mi.; from 4Xq, 193 sq. mi.; from 5Yb, about 350-700 sq. mi.. These areas represent from 0.3 - 5.5 % of the Divisions to which they presently belong, which are average-sized NAFO Divisions. Indeed, these areas are small in relation to the size of the Unit Areas used by Canada and the USA as the minimum geographical unit for offshore fisheries data collection. Even using a 10' square collection system, only three such squares would fit in the (minimum) part of 5Yb reassigned, one in each of 4Xp and q, and none in 5Yf. These areas are clearly too small to be established as Divisions/Subdivisions in the NAFO statistical grid. The Canadian proposal can only be implemented in a practical way by reassignment of these areas to become parts of the adjacent Divisions of their new Subarea. Thus, these parts of Div. 5Y reassigned would become integral parts of Div. 4X and vice versa.

The area of Subdiv. 5Ze proposed for reassignment is substantially larger. Together, the parts of 5Zj and m reassigned are about 2,400 sq. naut. mi. which is about 14% of Subdiv. 5Ze. This is about the size of a Unit Area and on the small end of the size scale of present NAFO Divisions/Subdivisions. It is intermediate in area between Subdivisions 3Pn and 4Vn, however, which indicates that it is a practical size to allow for the collection of separate statistics. Figures 4 and 5 indicate that the area in question on northeast Georges Bank is one of the most intensely fished parts of the Gulf of Maine Area. It is clear, therefore, that reassignment of this area to Subarea 4 as an integral part of Div. 4X would create a major discontinuity in the statistical records from both areas. (These same figures, on the other hand, suggest that the other areas discussed above are not the focal points of intense fishing.) Taking these two points together, then, the northeastern part of Georges Bank clearly needs to be identified separately from Div. 4X to maintain continuity of statistics and it is of sufficient size for establishment of a separate Division/Subdivision of Subarea 4 to be practical.

These considerations simplify the assessment of the impact of adopting the Canadian proposal. This now amounts to examining the effect of transferring four small areas between Divisions 4X and 5Y on historical statistical series, and of creating a new Division/Subdivision of Subarea 4 from what is presently the northeastern portion of Subdiv. 5Ze, and to assessing the advantages, and disadvantages arising from such actions.

<u>Administrative Considerations</u>

The present Subarea 4/5 line acquired much of its administrative significance through its embodiment in the ICNAF Convention as a boundary between the jurisdiction of Panels. The ICJ line has become the primary jurisdictional boundary in the Gulf of Maine Area, delimiting the administrative regimes of the USA and Canada.

The utilization of statistics on fishing operations and catch is ubiquitous in the administration of fisheries. As matters now stand, it is not possible to generate separate statistics on fishing operations in USA and Canadian waters of the Gulf of Maine Area directly from NAFO statistics. However, as these areas pertain to the separate jurisdictions for fisheries, the demand for separate statistics is axiomatic.

<u>Biological Considerations</u>

The principle biological consideration in locating statistical lines is to place lines between stocks of the primary species so that statistics for areas contained within the lines relate to biological units. The key issue here, then, is whether the changes in lines proposed improve or worsen the position of statistical lines in relation to perceived stock boundaries.

In the case of the northeastern part of Subdiv. 5Ze, since a statistical line is to be added giving a new statistical area, the correspondence of the statistical grid with biological divisions cannot be worsened. In fact, opportunities are created for defining resource and management units in more detail than before. The distributional data in Appendix 2 and associated figures suggest the possibility of benefits in more closely defining concentrations of pollock, argentine, redfish, cusk and scallops.

In the central part of the area (4Xp and q, 5Yf) the lines in question run across deep water. This area is not inhabited by shallow water species such as winter flounder, yellowtail, haddock, red hake and scallops, and species such as cod, pollock and <u>Illex</u> are not common there.

The area is of some importance to redfish, lobster, argentine, silver hake, white hake, cusk, American plaice, witch, angler and dogfish. There is no indication for any of these species, from the data in Appendix 2, that the changes in lines proposed would relocate significant proportions of major concentrations from one Subarea to the other. Given the small size of the areas involved, this conclusion is not surprising.

In 5Yb the line from Point B to Point A runs through deep water, but any line from Point A to the land boundary terminus must cross shallow water regions. The deeper area appears to be relatively significant in terms of the distribution of white hake and witch, but not for the other deep water species, redfish, silver hake, cusk or argentine. The line landward from point A will cross areas of some local importance to the distribution of cod, pollock, haddock and herring, and also to lobster and small scallop stocks. In relation to the overall distribution of stocks of these finfish species, the proportion of the stock, or stock complex, occurring within the area in question is small, and in relation to management areas in use for the finfish, the area involved in relocation is again a small part of the total involved. For localized resources such as scallops and lobster, the small areas being dealt with here are of potential importance. However, it is also true that the scale of the NAFO Statistical Grid is too coarse to be of value in their management. These resources are managed based on geographic units other than the NAFO system, e.g. Statistical Districts defined on the basis of lengths of coastline.

Fishery Considerations

One of the key concerns about moving statistical grid lines is the potential disruption of historical data series on catches and fishing activity which would create difficulties for stock assessment and related management efforts. In considering fishery distributions, then, the important issue is whether major parts of fisheries which have been in one NAFO Division would be relocated into another Division as a result of changing the position of statistical lines.

It has been concluded above that the northeastern sector of Subdiv. 5Ze has been the focus of major fishing activity (see Figs. 4 and 5), but that it would be practical to deal with this situation by creating a new statistical Division/Subdivision. Attention can be focused, therefore, on the areas north of Subdiv. 5Ze (Appendix 3).

The central basin areas (4Xp and q, 5Yf) are areas of generally low fishing activity (Figs. 4 and 5). There were some restrictions on fishing areas during the period to which Figs. 4 and 5 applies (Fig. 6) but these do not invalidate this conclusion. The Canadian groundfish fishery, which has concentrated on haddock, cod and pollock, has been prosecuted in shallower, more eastern, areas. The USA fisheries for redfish and silver hake have been conducted primarily in more western parts of the basin.

Herring and scallop fisheries are shallow water fisheries, and the areas in question are of no importance. Although the lobster resource extends into these areas, the Canadian fishery at least, has historically been conducted further to the east.

In 5Yb, there has been Canadian groundfish fishing by the small-vessel fleet on the Grand Manan Banks. In recent years a small scallop fishery has occurred on these banks and in coastal Grand Manan waters. These banks have also, in some years, supported substantial Canadian herring purse seine fisheries. The fleets prosecuting these fisheries are wide ranging (with the exception of some local scallop draggers), and the fisheries tend to be extensions of larger fisheries undertaken in adjacent Div. 4X.

Statistical Considerations

Creation of a new statistical Division/Subdivision from the northeast sector of Subdiv. 5Ze, by permitting more detailed description of fishing activities, could confer advantages. Moving lines, as will be necessary in more northern areas if the Canadian proposal is followed, runs the risk of disrupting historical data series. The important issue, then, is how much of a disruption might result.

Based on the resource and fishery distribution data presented above, commercial catches from the areas to be reassigned would be expected to be low and to be a small proportion of the total in Div. 4X or Div. 5Y. To obtain an estimate of the quantities which may be involved in the case of groundfish, a method was developed to pro-rate commercial catches for larger areas based on research vessel bottom trawl survey data (Appendix 3). The key assumption of the method is that commercial catch within Unit Areas is distributed in proportion to resource abundance as described by surveys. These calculations (Tables 2 and 3) confirm that the catches likely to be reassigned from one Division to another are small. The largest estimates are for pollock involving transfer of about 500 t from Div. 4X to Div. 5Y, and 140 t from Div. 5Y to Div. 4X. In both cases the amount transferred is about 3% of the Division total.

The calculations for groundfish include 5Yb. In the case of Canada, since essentially all of its Div. 5Y groundfish catch has come from 5Yb, the impact on the statistics from that fleet is large. However, since the total Canadian Div. 5Y catch is small, the overall impact of the transfer is not great. In the case of scallops, a similar situation applies. The maximum Canadian scallop catch from Div. 5Y (all from 5Yb) was 1220 t (round) in 1983, or 14% of the total Div. 5Y catch. In other years the amount has been much smaller and the proportion trivial. In the case of herring, significant fisheries have periodically been prosecuted on the shoals south of Grand Manan and on the Grand Manan Banks. Annual catches of 25-30,000 t have been documented as taken by Canadian purse seiners in 1972 and 1973 (Miller and Halliday, MS 1974: Miller and Iles, 1975). These catches were reported, and occur in the ICNAF Statistical

Bulletins, as Div. 4X catches although they occurred partly in Div. 5Y (Fig. 7). They were also counted as catches against allocations and TACs for the Div. 4X stock and included in Div. 4X stock assessments. This reflected the view that the present Subarea 4/5 line was not well placed with regard to herring population structure and that the Grand Manan Banks catches should be associated with Div. 4X. While the validity of this view may well be open to challenge, the fact of the matter is, for herring, a revised line which placed Grand Manan Banks in Div. 4X would more closely correspond to historical practice than does the present line.

Conclusions

The present Subarea 4/5 line has origins which can be traced back to the considerations of NACFI in the late 1920s and early 1930s. Offshore fisheries in those days were "banks" fisheries, and the precursor of the Subarea 4/5 line was one of a relatively small number used to divide the entire northwest Atlantic into groups of major fishing banks.

When the first version of this line was drawn in 1932, biological knowledge of stock relationships of the major species in the area was largely confined to haddock. With embodiment of this line in the ICNAF Convention as the dividing line between the areas of regulatory responsibility of Panels, it took on a major role as a delimiter of management areas. The importance of the Subarea 4/5 line in historical management practices has stemmed, therefore, as much or more from its administrative usage as from its importance as a delimiter of biological populations.

The new jurisdictional situation in the Gulf of Maine Area divests the Subarea 4/5 line of its administrative importance and makes the ICJ line the primary administrative boundary in the area. It is clear that, for administrative purposes alone, statistics on fisheries will be required which relate directly to the two administrative regions, - the Canadian and USA zones. The present statistical system does not provide these. It is also highly desirable that the solution to one problem does not create another; in this case that the implementation of the Canadian proposal does not create important discontinuities between past and future statistical series which have become the basis for stock assessment and fisheries management.

The ICJ line approximates the present Subarea 4/5 line in its northern part, but diverges in its southern part. The most practical adjustments to make the ICJ line the Subarea 4/5 boundary are, for the northern part, to subsume the small parts of the present Subareas 4 and 5 "cut-off" by the ICJ line into the adjacent Divisions of these Subareas. For the southern part, the northeast sector of the present Subdiv. 5Ze cut-off by the ICJ line is large enough to be established as a separate Division/Subdivision.

Based on resource and fishery distributions in the area, this solution to the proposed line change would result in disruptions to historical data series which are considered to be trivial. Some statistical advantages could accrue from having an additional statistical area which would allow a more detailed description and analysis of fisheries events in the Gulf of Maine Area.

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Table 1. Sizes of areas proposed for reassignment in relation to sizes of present statistical areas.

Area of Div. 4X (sq. naut. mi.)	=	18,200 (<200 fm)
Area of Div. 5Y (sq. naut. mi.)	=	13,200
Area of Subdiv. 5Ze (sq. naut. mi.)	=	17,100 (<200 fm)
Area of 4Xq (sq. naut. mi.)	=	3,414
Area of 4Xq to be reassigned to Subarea 5 - in sq. naut. mi.	=	193
- as % of 4Xq	=	5.7
- as % of Div. 4X	=	1.1
Area of 4Xp (sq. naut. mi.)	=	3,192
Area of 4Xp to be reassigned to Subarea 5 - in sq. naut. mi.	=	161
- as % of 4Xp	=	5.0
- as % of Div. 4X	=	0.9
Area of Div. 4X to be reassigned to Subarea 4 - in sq. naut. mi.	=	354
- as % of Div. 4X	=	2.0
Area of 5Yb (sq. naut. mi.)	=	1,624
Area of 5Yb to be reassigned to Subarea 4 - in sq. naut. mi.	=	max. 726, min. 357[1]
- as % of 5Yb	=	max. 44.7, min. 22.0[1]
- as % of Div. 5Y	=	max. 5.5, min. 2.7[1]
Area of 5Yf (sq. naut. mi.)	=	3,689
Area of 5Yf to be reassigned to Subarea 4 - in sq. naut. mi.	=	40
- as % of 5Yf	=	1.1
- as % of Div. 5Y	=	0.3
Area of 5Y to be reassigned to Subarea 4 - in sa. naut. mi.	=	max 766, min. 397[1]
- as % of Div. 5Y	=	max 5.8, min 3.0[1]
Area of 5Zj (sq. naut. mi.)	=	2,063
Area of 5Zj to be reassigned to Subarea 4 - in sq. naut. mi.	=	1,435
- as % of 5Zj	=	69.6
- as % of Subdiv. 5Ze	=	8.4 (<200 fm)
Area of 5Zm (sq. naut. mi.)	=	3,000 (<200 fm)
Area of 5Zm to be reassigned to Subarea 4 - in sq. naut. mi.	=	924 (<200 fm)
- as % of 5Zm	=	30.8 (<200 fm)
- as % of Subdiv. 5Ze	=	5.4 (<200 fm)
Area of Subdiv. 5Ze to be reassigned to Subarea 4 - in sq. naut. mi.	=	2,359 (<200 fm)
- as % of Subdiv. 5Ze	=	13.8 (<200 fm)

[1] Maximum is based on Canadian jurisdictional claim line. Minimum is based on a line due east from Point A. See text.

Table 2. The resource estimated to be in the area proposed for reassignment as a percentage of the total resource in each of the Unit Areas of Div. 4X and 5Y affected, and the percentage area to be reassigned.

Species	4Xp	4Xq	4Yb[1]	5Yf[2]
Angler	14	14	40	-
Argentine	5	3	53	-
Cod	2	2	35	-
Cusk	3	8	45	-
Haddock	2	1	45	-
Halibut	0	0	12	-
Plaice	11	16	29	-
Pollock	6	11	50	-
Redfish	9	20	42	-
Red hake	1	4	30	-
Silver hake	15	16	38	-
Skates	6	10	37	-
Spiny dogfish	8	8	46	-
White hake	24	21	32	-
Winter flounder	0	0	22	-
Witch	6	7	40	-
Wolffish	1	1	74	-
Yellowtail	0	0	0	-
Reassigned area as % of Unit Area[3]	5	6	45	1

[1] Maximum area, as defined in Table 1, used as an example.

[2] Too small to calculate.

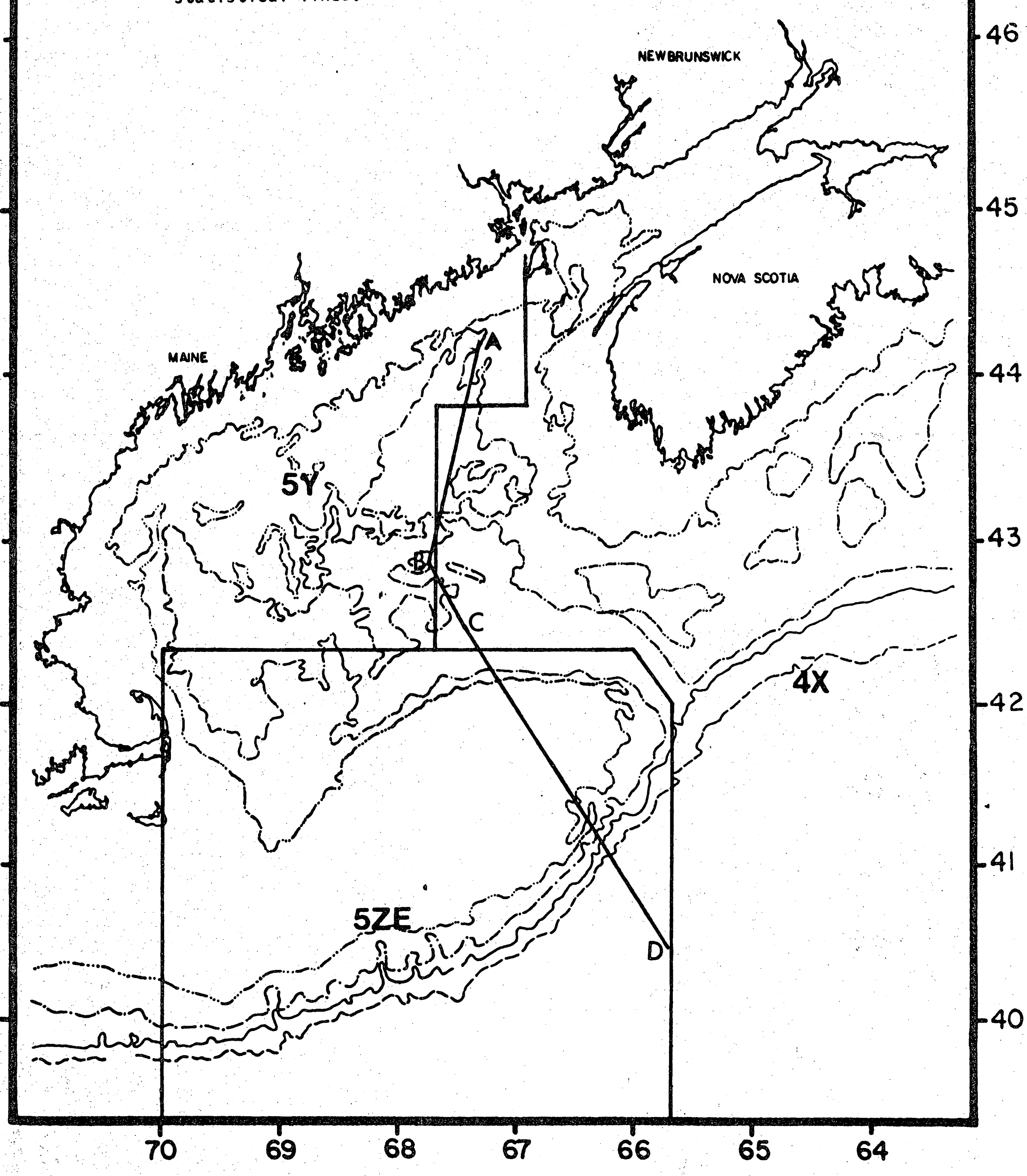
[3] From Table 1.

Table 3. Average catches of various groundfish species by Canada and USA in Div. 4X and 5Y, 1968-78, and estimated amounts taken in areas of these Divisions proposed for relocation as tonnes and as percentages of total catch in that Division, based on resource distributions in Table 2 (+ means less than 0.5 t or 0.05 %).

	Div. 4X						Div. 5Y[1]					
	CANADA			USA			CANADA			USA		
	Average	Relocated		Average	Relocated		Average	Relocated		Average	Relocated	
SPECIES	Catch (t)	t	%	Catch (t)	t	%	Catch (t)	t	%	Catch (t)	t	%
Angler	17	+	0.8	1	-	-	-	-	-	276	-	-
Argentine	-	-	-	-	-	-	-	-	-	-	-	-
Cod	21213	95	0.5	434	4	1.0	99	33	33.6	8556	58	0.7
Cusk	3698	42	1.1	32	1	3.4	2	+	22.5	716	2	0.3
Haddock	18591	89	0.5	1345	13	1.0	128	57	44.3	1948	25	1.3
Halibut	442	-	-	3	-	-	1	-	-	33	+	0.7
Plaice	467	14	3.0	36	2	4.8	4	1	29.0	2058	3	0.1
Pollock	14465	459	3.2	395	18	4.7	213	106	49.5	4524	31	0.7
Redfish	2103	85	4.0	2723	101	3.7	30	13	42.0	8597	20	0.2
Red hake	-	-	-	8	+	0.5	-	-	-	478	+	0.1
Silver hake	12	-	-	2	+	15.5	-	-	-	10024	-	-
Skates	25	+	1.1	-	-	-	-	-	-	80	-	-
Spiny dogfish	-	-	-	-	-	-	-	-	-	-	-	-
White hake	2609	63	2.4	49	5	10.1	12	4	32.0	2031	11	0.6
Winter flounder	978	-	-	12	-	-	-	-	-	1292	+	+
Witch	494	3	0.6	31	1	2.8	8	3	40.0	1218	13	1.1
Wolffish	921	3	0.3	38	+	0.7	1	1	74.0	146	1	0.5
Yellowtail	211	-	-	13	-	-	1	-	-	1417	-	-

[1] Maximum area, as defined in Table 1, used as an example.

Figure 1. The ICJ line in relation to NAFO statistical lines.



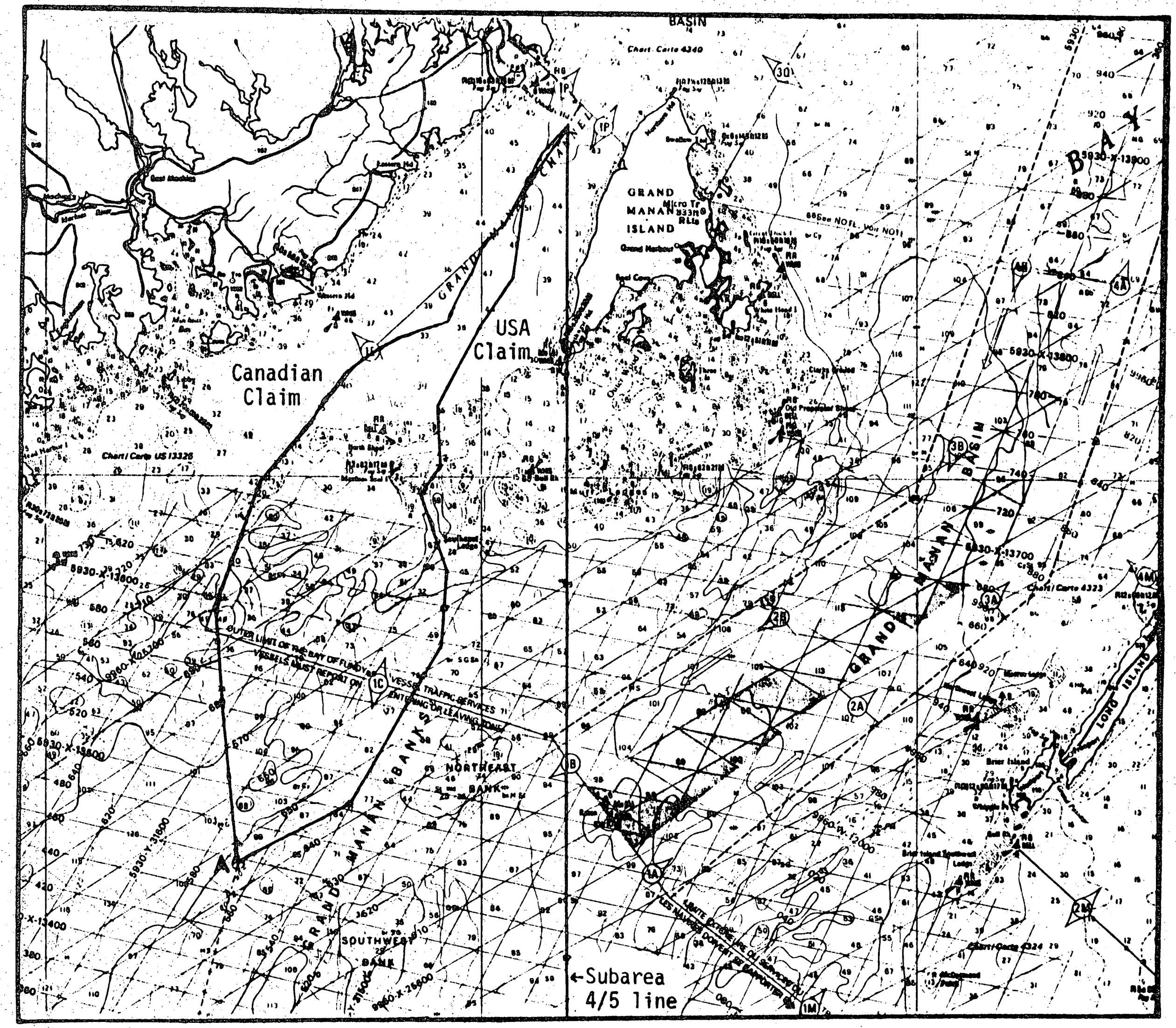


Figure 2. The location of Point A, unresolved jurisdictional claims of Canada and USA landward of Point A, and the present Subarea 4/5 boundary line, in relation to bottom topography.

Figure 3. NAFO Div./Subdiv. and Canada/USA unit areas in the Gulf of Maine area. The ICJ line is also shown with extensions north and east from Point A as used in analysis (see text).

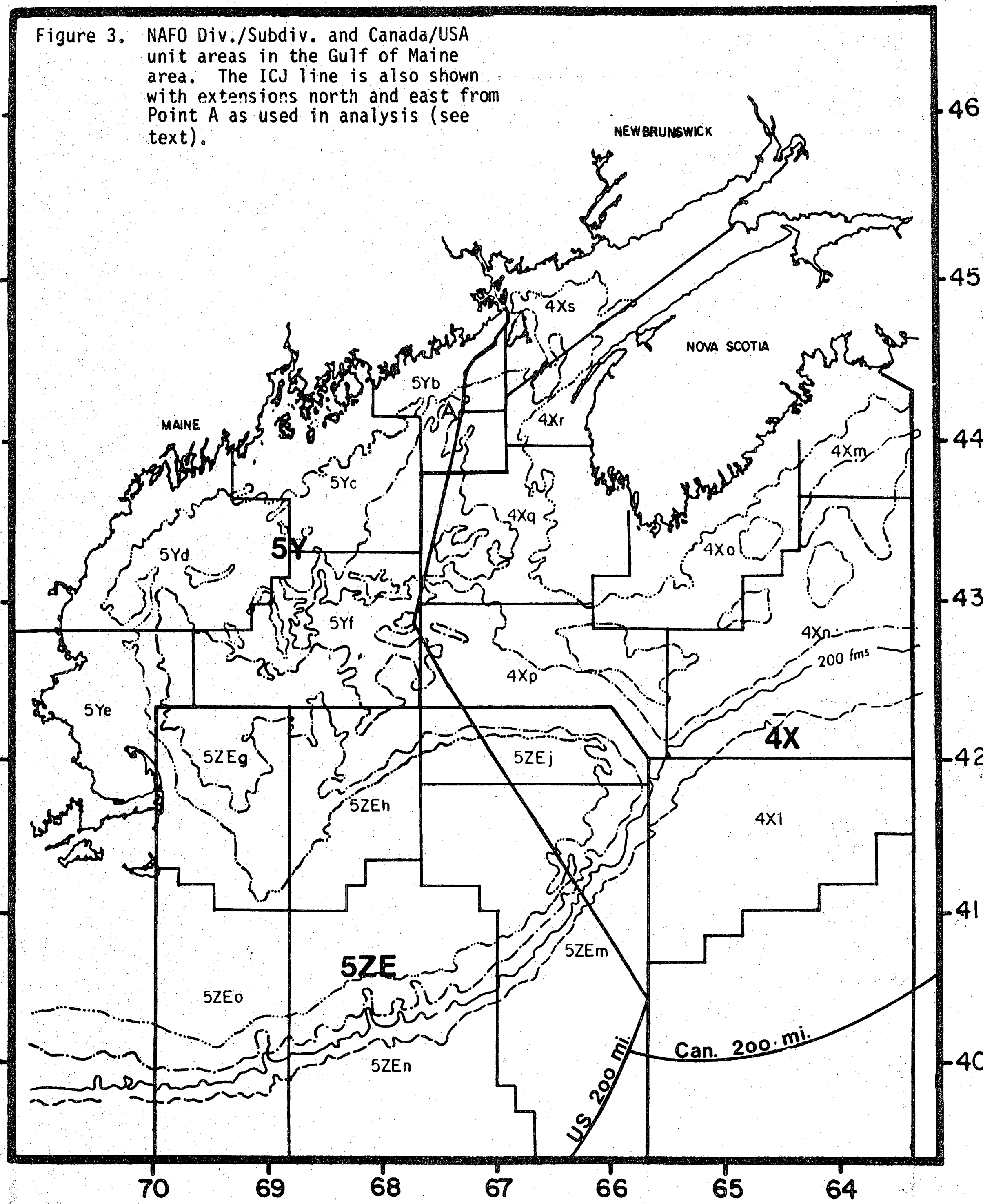


Figure 4. Gulf of Maine Canadian surveillance of Canadian vessels.

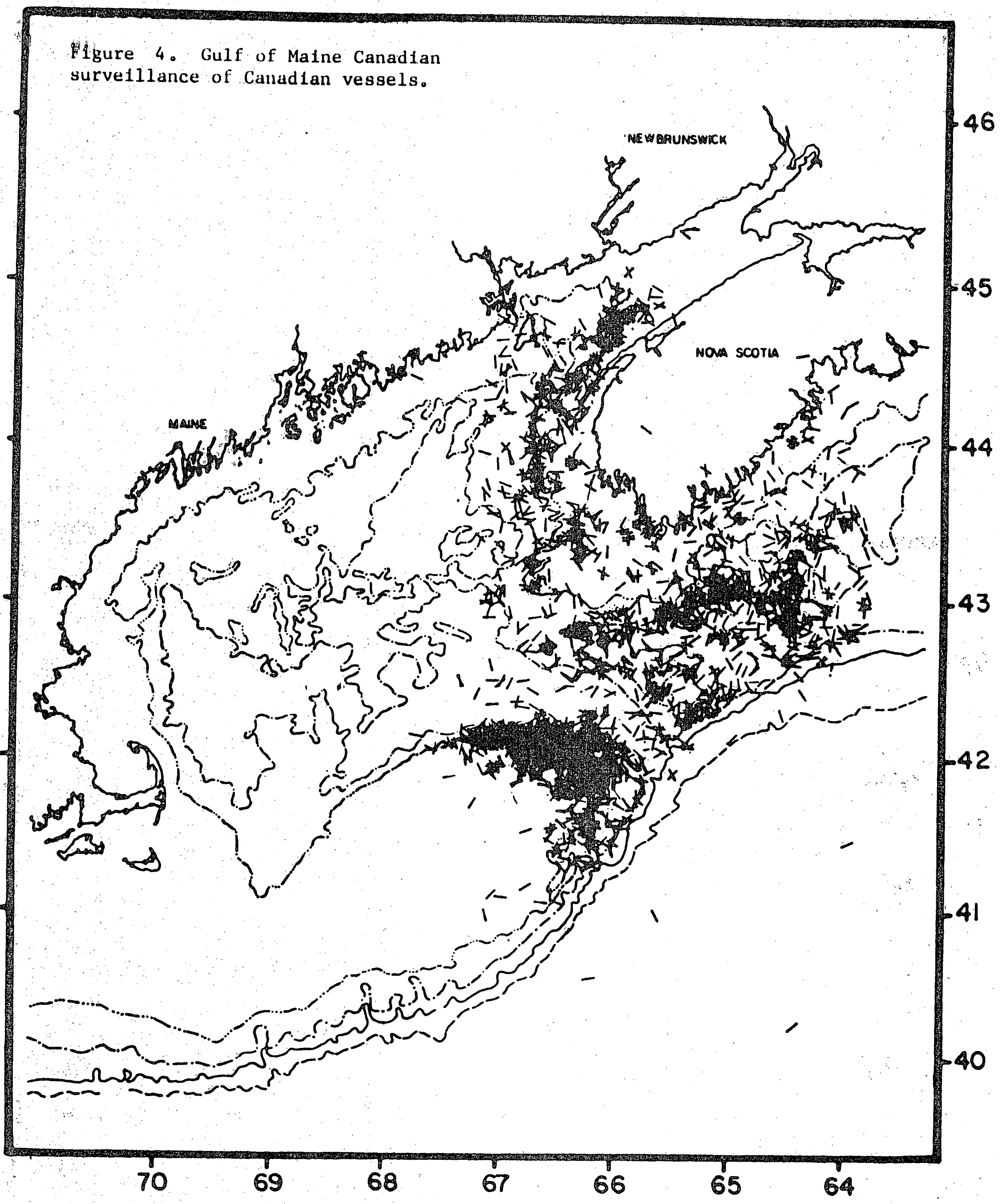


Figure 5. Gulf of Maine US surveillance of US vessels.

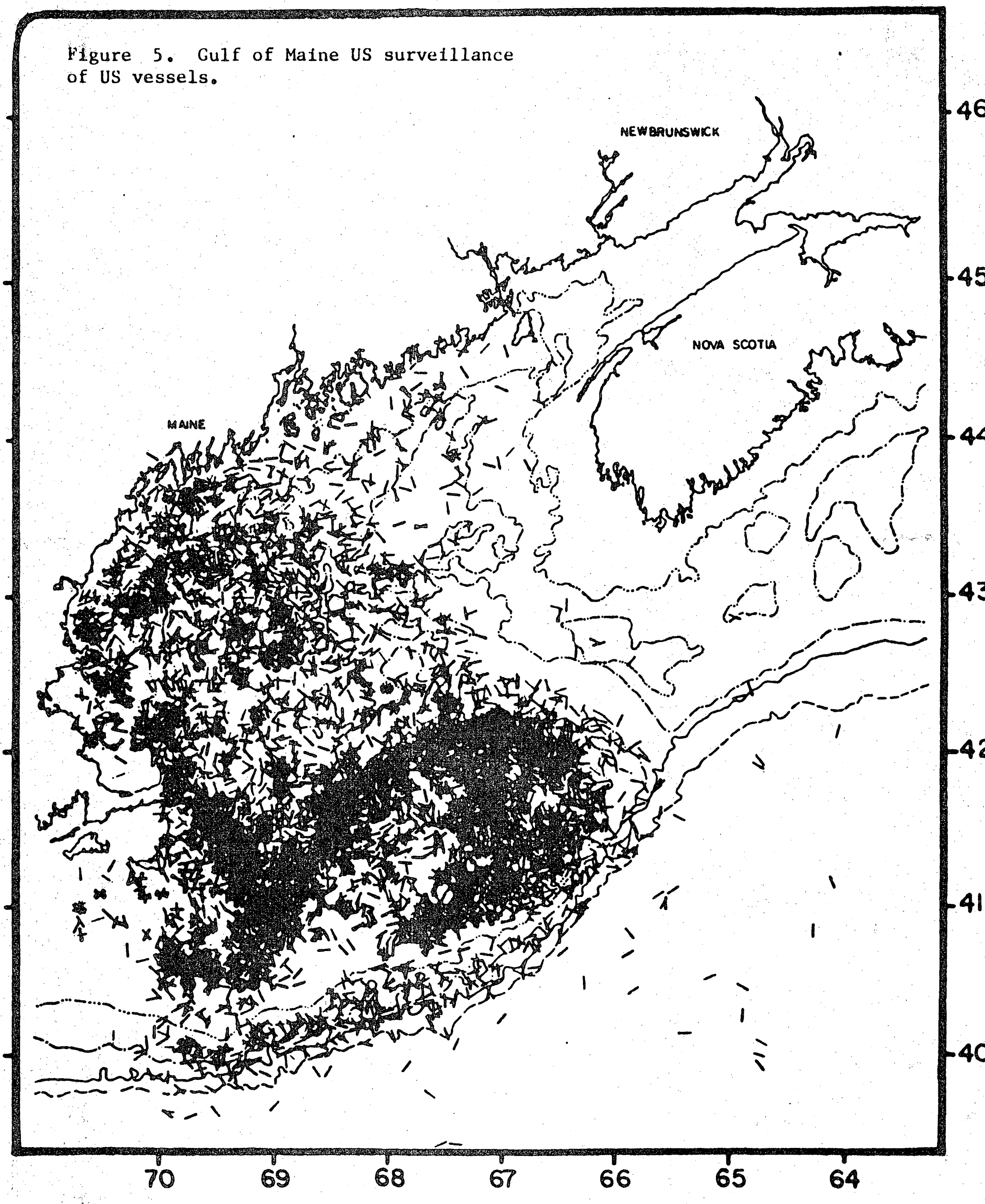
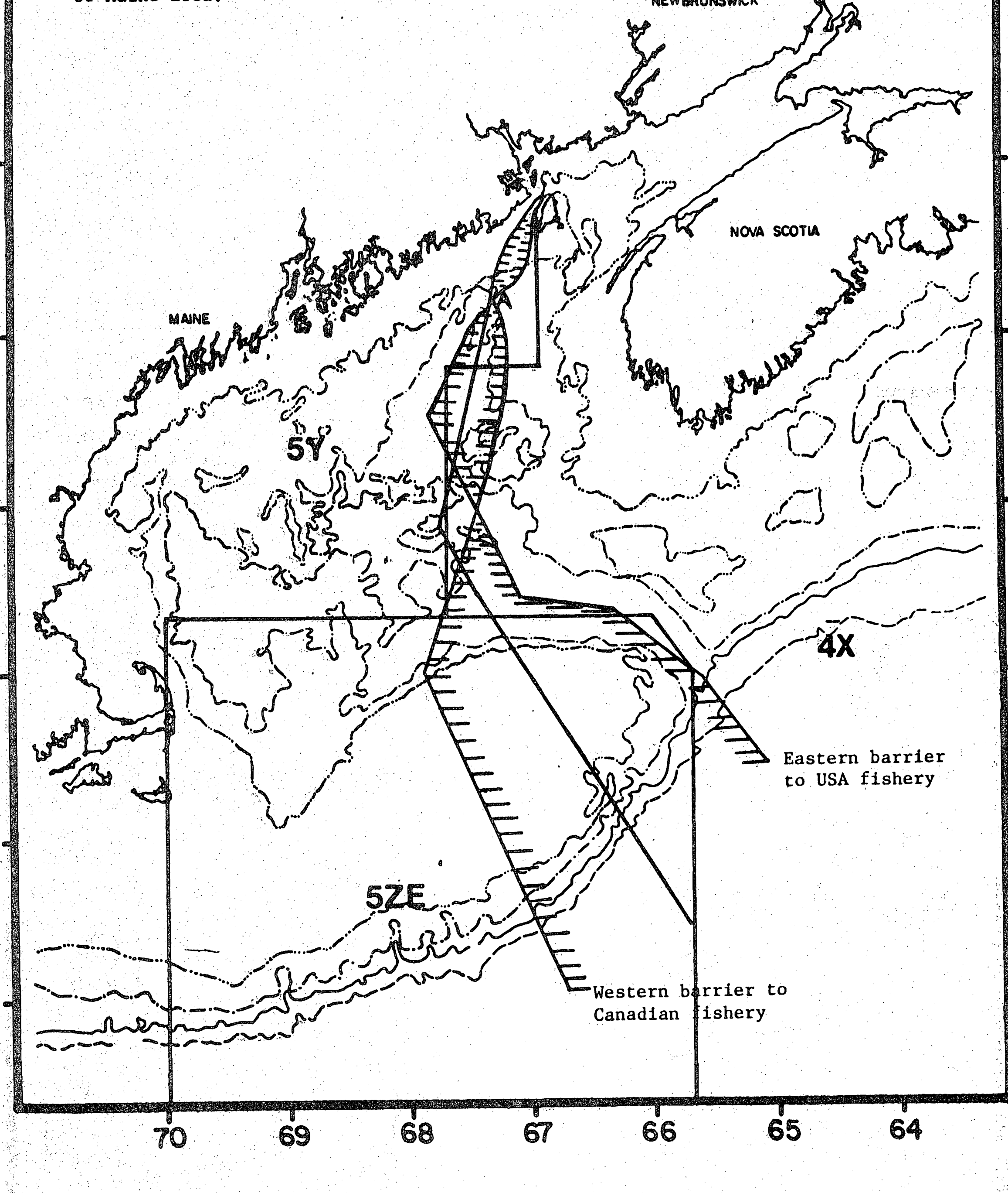


Figure 6. The limits of fishing for national fleets agreed to by the USA and Canada subsequent to termination of reciprocal fishing agreements and prior to ICJ decision on jurisdiction in the Gulf of Maine area.



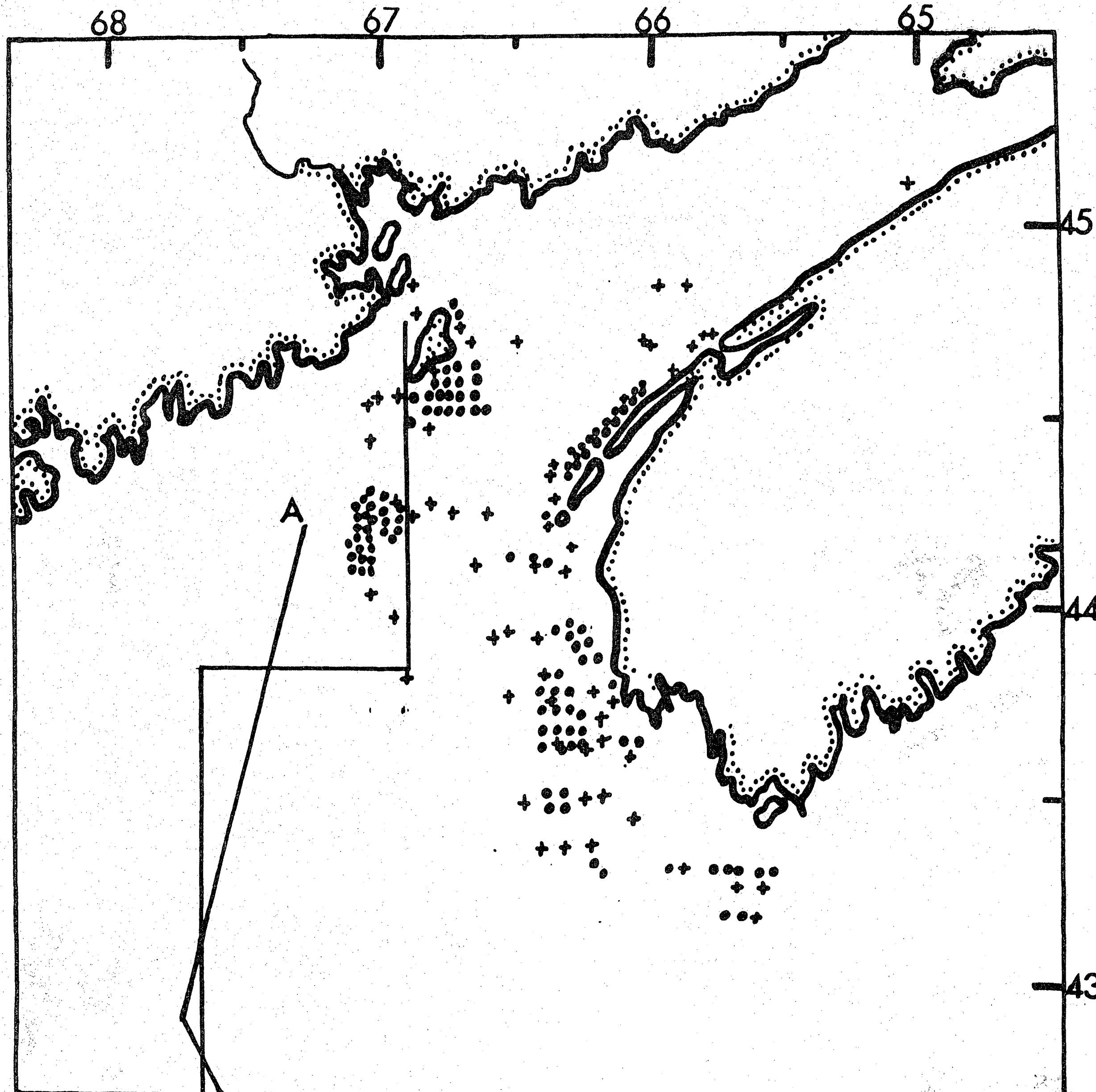


Figure 7. Distribution of herring catches in 1972 and 1973 by the portion of the Canadian purse seine fleet which provided log records. Each dot represents 1000 tons, each cross represents a catch of less than 1000 tons.

APPENDIX I

Description of the Bottom Topography and Circulation in the Gulf of Maine Area.

The physical geography of the Gulf of Maine area is shown in Fig. 8. On the seaward side of the Gulf of Maine is a shallow rim which lies off the coasts of Nova Scotia and Masssachusetts, between Cape Sable and Cape Cod. This rim is formed by a series of banks and shoals, pierced by two depressions on either side of Georges Bank: the Northeast Channel about 250 meters deep, separating Georges Bank from Browns Bank and the shoal areas off southwestern Nova Scotia: and the Great South Channel, about 80 metres deep, separating Georges Bank from the Nantucket Shoals off southeastern Massachusetts. Georges Bank is a large, detached, oval-shaped bank defined by the Great South Channel and the Northeast Channel and variously by either the 50 fm (91 metres) or 100 fm (183 metres) contours to the north and south. The Gulf of Maine itself has an average depth of 150 metres. Its floor consists of a series of shallow basins separated by low sills and flat-topped banks. The deepest of these basins, Georges Basin, which lies at the western end of the Northeast Channel immediately north of Georges Bank, has a maximum depth of 206 fm (377 metres).

The average surface circulation in the Gulf of Maine Area is shown in Fig. 9. The flow of the surface layer south-westward along the Nova Scotia coast splits into two as it approaches the Gulf of Maine Area. Part of the offshore component recirculates around Browns Bank in a clockwise direction, whereas the inshore component moves directly past Cape Sable, joining a generally northwestward flow along the eastern side of the Gulf of Maine Basin. Some of this water crosses the mouth of the Bay of Fundy, and some moves rapidy into that Bay on the Nova Scotia side and thence outward on the New Brunswick side before joining the general flow southwestward along the New England coast. Near Cape Cod the flow splits, with part flowing around the Cape by way of the Great South Channel and continuing southwestward, whereas the remainder moves northeastward along the southern side of the Gulf of Maine Basin and onto the northern flank of Georges Bank, where a relatively narrow, high-velocity jet develops. Here again the flow splits, with some moving back towards Nova Scotia and the rest curving southward and thence southwestward along the southern flank of Georges Bank.

At the southwestern part of Georges Bank, some of the flow turns northward in the eastern part of the Great South Channel and recirculates around the Bank, whereas the remainder crosses the Great South Channel in its progressive southwestward movement over the shelf. The Nantucket Shoals form a "leaky" boundary between the western Gulf of Maine and the East Coast Shelf. Most of the water flowing south and southwestward over the shoals originates in the western Gulf of Maine and subsequently mixes with Nantucket Sound water and shelf water near the great South Channel before joining the general southwestward flow over the mid- and outer East Coast Shelf. Although the direction of the mean flow is nearly parallel to the bottom contours throughout much of the Gulf of Maine area, there is a small but significant offshore surface flow along most of the outer edge of the continental shelf throughout the area. Also, there is a tendency for water to recirculate around the banks and basins, and thus a single parcel of water may make more than once circuit of the Gulf of Maine or Georges Bank before continuing its southwestward journey.

Current speeds generally diminish with depth. In basins, the circulation and source of deep subsurface water usually differ appreciably from those of overlying waters. In those like Emerald Basin in the central Scotian Shelf and Georges Basin, the deep water originates from offshore, through subsurface penetration of Slope Water, whereas the upper water layer is part of the southward moving Coastal Water. Computations of the mean annual influx into the Gulf of Maine through the Northeast Channel implies a replacement time of about one year for the deep water of the Gulf of Maine. The current pattern in the Gulf of Maine is not static and different pictures emerge depending on seasons as well as depths.

In addition to the average circulation, the tidal circulation is also important in the Gulf of Maine Area, examples of which are shown in Fig. 10. It is to be noted that the whole Bay of Fundy-Gulf of Maine-Georges Bank region forms a single tidal system. Based on a numerical model for the Georges Bank-Gulf of Maine-Bay of Fundy system, it appears that many of the persistent features of the observed mean flow are caused largely by the action of the tides (Fig. 11). The clockwise gyre on Georges Bank, including the jet along the northern flank, and the gyres on Nantucket Shoals and Browns Bank, all bear a similarity to the average circulation pattern (Fig. 9).

APPENDIX 2

Distribution of the Fisheries Resources in the Gulf of Maine Area

The distribution and migration of the exploited phases of the species fished in the Gulf of Maine Area are briefly described in this section. The maps of distribution given are composite interpretations of data gathered from many sources, particularly from research vessel bottom trawl survey data (for groundfish especially) and from commercial fisheries.

Groundfish species

Atlantic Cod (*Gadus morhua*) (Fig. 12).

Coastal cod do not perform extensive migrations but form many localized stocks among which there is limited mixing. A discontinuity has been identified between Gulf of Maine and Cape Cod-South Channel cod and cod in these areas are recognized as separate stocks. The most southern group of coastal cod, called the New Jersey cod, spend the summer in the Cape Cod-Nantucket area mixed with local cod but, in contrast to other coastal cod, migrate quite extensively to overwinter in more southern US waters, particularly along the coast of New Jersey. Offshore cod are quite separate from inshore cod, although there is evidence of some contribution to stocks in southwest Nova Scotia coastal waters from the offshore banks. This does not appear to be a seasonal migratory movement but more of a drift of non-returning individuals, and it is unlikely to be sufficiently extensive to be significant to management. A more important inter-relationship exists between Georges and Browns Bank cod between which there are quite extensive, apparently seasonal, movements.

There is extensive spawning of cod in many coastal regions supporting the concept that these areas contain a complex of inshore cod stocks. A major spawning area of cod also exists on the northern part of Georges Bank. There is some evidence of spawning on Browns Bank, although this is fragmentary. Thus, the past conclusion that there is a spawning stock or stocks inhabiting the offshore banks of Div. 4X needs to be re-examined.

Haddock (*Melanogrammus aeglefinus*) (Fig. 13).

Available evidence suggests the presence of distinct haddock populations in Div. 4X, on the eastern end of Georges Bank and in the Nantucket Shoals-Western Gulf of Maine area. Egg and larval surveys have defined concentrations of spawning products at these three locations during the March-May period. These correspond to the closed areas defined for management purposes. Tagging studies have shown that there is little migration of adults between Georges Bank and the Gulf of Maine. Historical tagging studies have also shown little movement between the Georges Bank and Browns Bank populations. The primary migrations involve northern movements by coastal Maine and Browns Bank populations which bring these into the western and eastern sides of the Bay of Fundy respectively in summer, with a return movement in autumn.

Pollock (Pollachius virens) (Fig. 14)

Pollock occurs from Newfoundland to New Jersey but is most abundant in the Gulf of Maine Area. Spawning occurs in winter, in areas surrounding shoals, throughout the Scotian Shelf and Gulf of Maine, but it is not clear how temporally discrete these spawning aggregations are. Juvenile pollock appear in inshore areas around coastal Maine, Massachusetts, New Brunswick, and Nova Scotia during the summer, and then migrate offshore with the onset of winter. The extent of trans-shelf migrations is unknown. However, it would appear from recent work on the stock structure of pollock in this area that some discreteness between those of the Scotian Shelf and Northeast Peak of Georges Bank, and those of the inner Gulf of Maine does exist.

Yellowtail (Limanda ferruginea) (Fig. 15).

Yellowtail flounder is a species with limited migratory habits. In the Gulf of Maine Area, there appear to be four relatively discrete aggregations: (i) on southern Georges Bank; (ii) in the Nantucket Shoals area; (iii) in the Cape Cod area; and (iv) on Browns Bank. The Nantucket Shoals stock, extends southwest to the Mid-Atlantic Bight. The Georges Bank yellowtail stock is concentrated on the southern part of Georges Bank and does not occur in strength on the northern or eastern parts of the Bank. The Cape Cod and particularly the Browns Bank stocks are small. Movement of yellowtail among these aggregations is limited.

Redfish (Sebastes spp.) (Fig. 16).

Redfish is a deepwater species occurring in basins and along the shelf edge in depths of 150-700 m (80-275 fm). It occurs throughout the Gulf of Maine Basin and highest commercial catches have been obtained in its central part in the vicinity of Cashes and Fippinies Ledges and Jeffreys Bank. The southern limit of distribution appears to be the northwestern edge of Georges Bank from the South Channel to the western Fundian Channel. There are very few redfish found around the Northeast Peak of Georges Bank and the Southeast Peak of Browns Bank. Rather, they occur in commercial quantities along the outer edge of the Scotian Shelf and in the basins between the offshore Scotian banks and the coastal region.

Redfish move into deeper water as they grow larger but there is no evidence for extensive seasonal migration or of long-distance movement of adult redfish. This sedentary habit combined with internal egg fertilization and release of young at the larval stage, which greatly reduces the length of time that the early life history stages are subject to dispersion by currents, suggests that redfish form many highly localized populations.

There is an area defined by German and Browns Bank, the eastern Fundian Channel and Georges Bank where redfish are scarce. These relatively shallow water areas may serve as a partial barrier between redfish in the Gulf of Maine Basin and those on the Scotian Shelf to the east of Browns Bank. In this case, the Gulf of Maine Basin, i.e. Subarea 5 and the western part of Div. 4X, may contain a semi-isolated stock complex.

White hake (Urophycis tenuis) (Fig. 17).

White hake is common on muddy bottoms; juvenile fishes are found in shallow areas, whilst adults occur in depths of 110 m and more. The adults move into shoal areas for spawning in late winter and spring, and there appears to be some inshore movement in autumn. The stock structure of this species is unknown. Largest concentrations of white hake occur in the deeper waters of the Gulf of Maine Basin, and in the inner areas especially at the mouth of the Bay of Fundy. Populations in these areas may thus be distinct from those further to the east.

Cusk (Brosme brosme) (Fig. 18)

Cusk is a deepwater species which is found throughout the Gulf of Maine at depths exceeding 150 m. Spawning occurs in spring and early summer. There have been no studies on the stock structure of cusk, but it would appear from surveys that the species is distributed fairly evenly, except for areas of high concentration in the inner part of the Gulf of Maine.

Atlantic argentine (Argentina silus) (Fig. 19).

The argentine is a shelf edge species with a predominantly temperate distribution pattern. There is evidence to suggest that there is not much mixing of populations along the edge of the shelf but there are short migrations associated with spawning. In addition to the known spawning population associated with Emerald Basin, spawning also appears to occur in the Fundian Channel. There could prove to be other spawning locations, however, and firm divisions among spawning stocks cannot be drawn with present knowledge.

Although recorded as far south as New Jersey, the southern limit of fishable concentrations is the northeastern edge of Georges Bank. The densest concentrations of argentine occur in the northern Fundian Channel along the southwestern slope of Browns Bank extending eastward around the southern tip of Browns Bank and along the edge of the Scotian Shelf. They occur throughout the Gulf of Maine but sparsely except along the western slope of German Bank.

Silver hake (Merluccius bilinearis) (Fig. 20).

Silver hake, although widely distributed, ranging from Newfoundland to South Carolina, is most abundant off the New England coast. The species inhabits a wide range of area and depth moving in relation to oceano- graphic conditions, food availability, and spawning cycle; it overwinters along the outer continental shelf and slope and in deeper waters of the Gulf of Maine, and moves to shallower waters during March to November to spawn. The major spawning grounds for silver hake include the coastal areas of the Gulf of Maine, southern and southeastern Georges Bank, areas off Massachusetts, and further north on the Scotian Shelf. The most recent studies on stock structure indicate that there are two stocks in the Gulf of Maine Area, divided by a line from east to west across Georges Bank: the southern stock thus occupies the southern half of Georges Bank and the shelf as far down as Cape Hatteras, and the northern stock occupies the northern part of Georges Bank, the inner part of the Gulf of Maine, and the south-western slopes of Browns Bank. The dividing line between the northern stock and the central Scotian Shelf stock probably lies to the east of Browns Bank.

Red Hake (Urophycis chuss) (Fig. 21)

Red hake are found throughout the area bounded by the Gulf of St. Lawrence down to North Carolina, but occur in greatest numbers from Georges Bank down to New Jersey. During winter they are found in the deeper waters of the Gulf of Maine and along the slope and outer continental shelf off Georges Bank, whereas from May to November they migrate into shallower and inshore waters to spawn. A peculiarity of the juveniles, which is pertinent to their survival, is the fact that they often reside within live sea scallops, apparently using this behavioural characteristic as protection against predation. The stock structure of red hake is not well understood. However, from earlier studies by USSR scientists and from distribution of research vessel catches, it would appear that there is a north-south discontinuity separating the red hake in the inner Gulf of Maine and those on the southern portion of Georges Bank. Larval distributions also indicate that there is no discontinuity between Browns Bank and Georges Bank, but rather one which occurs to the east of Browns Bank.

American plaice (Hippoglossoides platessoides) (Fig. 22)

Stock structure has not been defined. Groundfish survey information indicates that plaice are concentrated in the deep waters of the inner Gulf of Maine.

Witch (Glyptocephalus cynoglossus) (Fig. 23)

As with American plaice, stock delineation has not been resolved. The species is ubiquitous in the inner Gulf of Maine, predominantly in the moderately deep areas.

Winter Flounder (*Pseudopleuronectes americanus*) (Fig. 24)

Movements of winter flounder are localized. In the southern part of their range, they migrate during winter to estuaries, embayments and salt-water ponds to spawn and move from these locations to deeper water during summer. In colder Canadian waters spawning is later and summer is spent inshore with movement to deeper, warmer, water in winter months. There is evidence that winter flounder tend to return to the same spawning locations in consecutive years. Restricted movement and differences in meristic and morphometric characteristics suggest that relatively discrete local groups exist. It is primarily a shallow coastal species but a substantial resource also occurs on the shallows of Georges Bank.

Angler (*Lophius americanus*) (Fig. 25)

Angler is a demersal fish found at a wide range of depths from the Gulf of St. Lawrence south to North Carolina. It spawns in inshore waters from June to September, producing sheets of eggs connected by a mucous film that is up to 12 m long. The stock structure of this species is unknown. It is broadly distributed throughout Divs. 4X, 5Y, and Subdiv. 5Ze, with concentrations in the inner Gulf of Maine and mouth of the Bay of Fundy.

Spiny Dogfish (*Squalus acanthias*) (Fig. 26)

Spiny dogfish is a long lived and slow growing species whose reproductive capacity is limited by late maturity, a long gestation period, and low fecundity. Distributed in the western North Atlantic from Florida to Newfoundland, they are highly migratory and travel in schools which segregate by size, and by sex as they mature. The species is distributed across the continental shelf and undergoes a seasonal migration occupying the northern and inshore portions of the range during the summer, and the southern and offshore portions during the winter months. Reproduction occurs in southern waters. Dogfish in the Northwest Atlantic probably comprise one stock with migrations becoming more extensive as the fish grow to maturity.

Other groundfish

Other groundfish of less commercial importance in the Gulf of Maine Area are the skates (*Raja* spp.), tilefish (*Lopholatilus chamaeleonticeps*), summer flounder (*Paralichthys dentatus*) and windowpane flounder (*Scophthalmus aquosus*).

Pelagic Species

Atlantic Herring (*Clupea harengus*) (Fig. 27 a.b.)

Atlantic herring is highly migratory. During the summer feeding phase of the adult annual migration, herring are aggregated in only three areas in significant concentration: along the fringes of Georges Bank, off southwest Nova Scotia, and south of Grand Manan Island. Spawning occurs during mid-summer to mid-autumn at several well defined locations. Subsequent to summer feeding and spawning, adult herring migrate to two overwintering areas: off Cape Breton and southwest of Cape Cod. The migration routes between the summer and winter distributional areas are not well described. Juveniles are distributed in coastal waters from western Maine to southwest Nova Scotia.

Atlantic mackerel (*Scomber scombrus*) (Fig. 28)

Tagging studies and other biological research have shown that the mackerel population in the NAFO area is comprised of a northern (spawning in the Gulf of St. Lawrence) and southern (spawning in the Atlantic Bight-Gulf of Maine) contingent. The relative size of the two contingents has not been satisfactorily determined. Both contingents overwinter in Subareas 5 and 6 (mainly Subdiv. 5Zw + Subarea 6). It is not known what proportion of the northern contingent remains in Subarea 4, although it appears to be small. Only a minor portion of the southern contingent appears to move farther north than Subdiv. 5Ze during the summer feeding period.

Swordfish (*Xiphias gladius*) (Fig. 29)

Swordfish is a highly migratory species occurring in all world oceans between 45°N and 45°S. In the Northwest Atlantic, swordfish spawn in the Caribbean and their occurrence in Canadian waters in warmer months is a feeding phase. Migration patterns are not known but dispersal of juveniles by the Gulf Stream and movement of larger fish into shelf waters directly from warm Gulf Stream waters are the favoured hypotheses, rather than an along-shelf migration.

The above suggests that swordfish in the Northwest Atlantic, and possibly a broader area, belong to a single stock or stock complex. Superimposed on this broad pattern is what appears to be a localization of distribution. The same groups of fish seem to occur in the same fishing areas each year i.e. there appears to be a degree of "homing" on northern feeding grounds.

Other Pelagic Species

Other pelagic species of less commercial importance in the Gulf of Maine Area include bluefin tuna (*Thunnus thynnus*), large pelagic sharks such as the porbeagle (*Lamna nasus*), butterfish (*Peprilus triacanthus*), Atlantic saury (*Scomberesox saurus*), alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), Atlantic salmon (*Salmo salar*), and American shad (*Alosa sapidissima*). All of these species are highly migratory, the Gulf of Maine Area providing only a small part of their distribution (e.g. see migration pattern of shad, Fig. 30).

Invertebrate species

Sea Scallop (Placopecten magellanicus) (Fig. 31).

The stock structure of sea scallops is not well understood. There are persistent patterns of aggregations of scallops in the Gulf of Maine Area. At commercial size, say after age 3 or 4, scallops are not migratory and each area could be managed independently. However, the eggs and larvae spend approximately 2 months in the water column and may be carried considerable distances. It is not known if or how the parental stock size affects future recruitment, and in particular, whether parent stock size in one area could affect recruitment in other areas. There exists an unfishable portion of the resource, in refugia, which represents an unknown factor in the recruitment process.

American Lobster (Homarus americanus) (Fig. 32)

Commercial quantitites of offshore lobsters are found on Browns and Georges Banks and, in the winter months, in the basins of the inner Gulf of Maine (Georges and Crowell basins). It appears that lobsters move out of these basins onto Browns Bank and possibly German Bank for summer and fall periods. Similarly, on Georges Bank mature lobster appear to migrate from the slope (100-500 m) where they spend the winter and spring, onto the shallow part of the bank (<100m) for summer and fall. Lateral movements by large animals also occur along the slope in the form of long distance nomadic wanderings with no apparent goal or return movement. Some mixing of lobsters occur throughout the Gulf of Maine Area, but a clear account of stock structure and recruitment relationships has not yet been developed.

Long-finned Squid (Loligo pealei) (Fig. 33)

The long-finned squid, (Loligo), is distributed from the Bay of Fundy and Browns Bank as far south as the Gulf of Mexico, but fishable concentrations are generally limited to the area between Cape Hatteras and southern Georges Bank. Within the fishing areas, there is a overall decrease in abundance from south to north.

Loligo undergoes seasonal migrations of up to 1200 km, overwintering along the continental shelf edge and moving inshore in the mid-Atlantic and New England areas in the spring and summer. Spawning takes place inshore between May and October, resulting in most years in two cohorts from a major spawning peak in May and a smaller peak in October. Spawning occurs at 18-36 months of age, after which the squid are assumed to die. The life cycle is not fully understood, and it may be that two overlapping reproductive cycles are responsible for the extended spawning season and apparently variable age at spawning. It appears that there is only one stock of Loligo throughout its range.

Short-finned Squid (Illex illecebrosus) (Fig. 34)

The short-finned squid is distributed from Greenland to Florida with fishable concentrations found from Newfoundland south to Cape Hatteras. Within the fishing areas, abundance and distribution vary greatly both seasonally and annually.

The biology and life cycle of Illex are very poorly understood, nothing being known of the spawning distribution and little known of the early life stages and their distribution. Spawning is believed to take place pelagically in the Gulf Stream/Slope Water Frontal Zone somewhere to the south of Delaware Bay, most probably over the the Blake Plateau. The period of spawning is protracted, extending from roughly December through June, and generally resulting in two or more cohorts. The bulk of the population in most years has been made of squid from the first cohort. Larvae and juveniles have been found for a distance of more than 1,500 km along the Gulf Stream Frontal Zone and it appears that the stream plays an important role in their transport to the areas off Georges Bank, the Scotian Shelf, and Grand Banks. In the late spring and summer, the rapidly growing juveniles migrate from the Frontal Zone to the fishing areas of the continental shelf between Cape Hatteras and Newfoundland. There they grow rapidly and are found in fishable concentrations from roughly June to November. Illex leave the Shelf areas in late fall and apparently migrate several thousand kilometers southwestward to as yet unknown spawning areas. They are believed to live no more than 12-18 months and to die after spawning; hence, the adult squid of each generation are available only once to the fishery. Illex, throughout its range, is believed to be a single stock.

Northern Shrimp (Pandalus borealis) (Fig. 35)

Northern shrimp has a northern, cold water distribution and the Gulf of Maine represents the southern limit of fishable quantities. Therefore warming trends are believed to seriously affect the ability of shrimp to survive in the Gulf of Maine and this accounts to some degree for its variable abundance. During periods of high abundance the distribution of northern shrimp will extend beyond its normal limits eastwards in the Gulf of Maine and up into the Bay of Fundy. The stock structure is not well understood.

Other Invertebrate Species

Other invertebrate species of less commercial importance in the Gulf of Maine Area include red crab (Geryon quinquedens), Jonah crab (Cancer borealis) and ocean quahogs (Arctica islandica).

APPENDIX 3

Distribution of Fisheries and the Effect of Boundary Changes on Long-term Series of Catch and Fishing Effort Data.

Introduction - The ICJ line transects three NAFO Divisions, 4X, 5Y and 5Z, and six Unit Areas in the NACFI system, 4Xq and p, 5Yb and f, and 5Zj and m (Fig. 3). If the proposal for modification of the statistical grid is dealt with by addition of a line across Georges Bank based on the ICJ line, creating an additional statistical area on the northeast part, there need to be no concern about comparability with historical NAFO data series in this area. Although statistics on catch and fishing effort would be collected separately for two areas comprising the northeastern and southwestern parts of what is presently Subdiv. 5Ze, addition of statistics for the two areas would reconstitute the area used historically. Thus, the distribution of fishing in the present Subdiv. 5Ze is not an issue in relation to the present proposal which would, in fact, result in more geographically detailed information on fisheries in the area being made available. The important concerns are, therefore, the implications to historical data series for Divs. 4X and 5Y of moving the boundary between them.

The areas it is proposed to transfer between Div. 4X and 5Y are not large in terms of absolute area or as percentages of the area of these Divisons (Table 1). Thus, the impact on historical fisheries data series would not be expected to be large unless fisheries proved to be highly localized in the areas to be reassigned.

Data available in NAFO statistical series are amalgamated by present statistical Divisions and Subdivisions and hence can give no insight into smaller scale fishery distributions. Both Canadian and USA national statistical systems historically have used the Unit Area system as the smallest geographical unit recognized in data compilation. These areas are too large, however, to approximate the areas proposed for reassignment. In the Canadian Statistical System, the original information on fishing areas of offshore vessels is collected through a log book system. These log books often contain data on fishing location on a tow by tow basis. Some subsets of these data have been analysed for particular (usually research) purposes and give insight into areas fished. Operations of components of the Canadian fleet also have been studied under a domestic observer programme which provides detailed information on location of fishing of these components. Finally, surveillance programmes provide data on locations where fishing vessels have been observed. Both Canadian and USA surveillance data, based primarily on aerial reconnaissance, are available for several recent years in computer analysable form. These suffer from a number of limitations in relation to present purposes, however. In particular, surveillance observations are not random in relation to fleet distribution and all vessels do not have the same probability of being observed. Designation of type of gear fished (which would allow some influence to be made of species or species group fished) and activity of vessel (i.e. fishing or in transit) is not comprehensive, also restricting value for present purposes.

In summary, because the areas proposed for reassignment are small, regular statistical data series do not provide data in sufficient geographic detail to describe fisheries distributions in relation to them. Specialized data sets established for other purposes have to be used and these have various limitations. Log book and observer data relate to components of the Canadian fleet, and surveillance data to components of both Canadian and USA fleets. No suitable data are available for other countries fisheries, but no significant amount of fishing by third parties has taken place anywhere in the general vicinity of the Subarea 4/5 line since extensions of coastal state jurisdictions in 1977. The modifications to the line proposed cannot, therefore, have any implications in relation to third party statistics at least for the last 9 years.

General Distribution of Fishing - Surveillance data give the most general account of fishing vessel activity in the whole Gulf of Maine Area. These data (for the period 1979-84) indicate that the central part of the area adjacent to the Div. 4X/5Y boundary is an area of relatively low activity for both Canadian (Fig. 4) and USA (Fig. 5) fleets. During the period covered by these data, the USA fleet could not fish the eastern part of 5Yb, and the Canadian fleet could not fish the northwestern part of 4Xp (Fig. 6), as to do so would have placed them in waters subject to the undisputed claim of the other party. Taking these restrictions into account does not invalidate the inference from these data that the areas adjacent to the Div. 4X/5Y boundary have no general importance to the fisheries of the Gulf of Maine Area.

Groundfishing - The Canadian groundfish fleet which operates in the Gulf of Maine Area has three readily identifiable components; highly mobile large trawlers greater than 150 gross registered tons (GRT), and smaller trawlers and longliners which are more localized in their areas of fishing. A subset of fishing log records are available for the large trawler and longline sectors for the periods 1960-72 and 1973-77, i.e. prior to any restrictions on area fished resulting from jurisdictional claims. These indicate (Figs. 36-39) that, in 1960-72, the areas of Div. 4X and 5Y proposed for transfer were not important to the fishery, although in 1973-77 the southeastern part of 5Yb was fished more intensively. The impression is, however, that the fishing in 5Yb was an extension of the more extensive fishing being conducted in adjacent parts of Div. 4X. The data on which these plots are based is fairly comprehensive for the large trawlers but that for longliners is scanty and hence less reliable. Logbook data from the small trawler sector for these periods is not adequate to produce comparable plots but a special observer programme provided quite extensive data on areas fished by these vessels during 1982 (Fig. 40). These data indicate that there is a component of the fishery which occurs in southeastern 5Yb, on the Grand Manan Banks.

The primary species in the Canadian groundfish fishery in the area are haddock, cod and pollock.

<u>Herring Fishing</u> - Herring fisheries are characteristically highly localized on feeding, spawning and overwintering concentrations as illustrated in Fig. 27. On Georges Bank, herring fishing concentrated along the northern edge, an area which is transected by the ICJ line. No fisheries have occurred over the deeper basin areas north of Georges Bank, however. At the northern end of the Subarea 4/5 boundary, the important fixed gear, mainly weir, fisheries are shore based and would not be affected by any line changes offshore. There have, however, been persistent fishing activities on the shoals around Grand Manan and on the Grand Manan Banks. Catches of 25-30,000 t were recorded by Canadian purse seiners fishing this area in 1972 and 1973 (Fig. 7). The part of 5Yb which could be subject to reallocation to Div. 4X has therefore, at least on occasion, been a focal point for important herring fisheries.

<u>Invertebrate Fishing</u> - The major invertebrate fisheries in the area are specialized ones for scallops and lobsters. Fishing locations of the Canadian offshore scallop dragger fleet can be described in detail based on comprehensive log record coverage. The data for 1983 (Fig. 41), used here as an example, indicate that fishing does not occur to any extent in the areas proposed for reassignment. A small amount of effort was expended on Grand Manan Banks (5Yb) by the offshore fleet in 1983. In addition, small boat fleets, particularly the fleet from Grand Manan, fished the shoals to the south of the island and as far as the Grand Manan Banks in most recent years (Fig. 42). The Canadian ofshore lobster fishery in the period 1973-79, which was largely prior to any restrictions due to jurisdictional claims on areas fished, did not occur in the areas proposed for reassignment (Fig. 43). The inshore fishery lobster fishery extends south and west of Grand Manan in shoal waters as far as Machias Seal Island in Div. 5Y. There is also a deeper-water fishery in Grand Manan Basin but this does not extend as far south and west as the present Subarea 4/5 boundary. The inshore fishery is managed not on the basis of NAFO Divisions but by a specially defined Canadian "Lobster District No. 2".

<u>Distribution of Groundfish Catches</u> - It is clear from the fragmentary nature of the information which can be compiled on the detailed distribution of fishing that a description of the detailed distribution of catches, based on direct observation, is not possible. It has already been demonstrated (Table 1) that the areas involved in proposed reassignments between Div. 4X and Div. 5Y (about 350 sq. naut. mi, or 2% of Div. 4X) and reciprocally between Div. 5Y and Div. 4X (about 400 sq. naut. mi, or 3% of Div. 5Y), are not large. Thus, catches from these areas would not be expected to have been large. Knowledge of resource distributions allows some refinement to this inferential approach.

Bottom trawl surveys have been conducted throughout most of the Gulf of Maine Area by the USA in spring and autumn and in Div. 4X by Canada in summer, for a number of years. In the present analysis, data from all three series in the period 1968-80 for the USA surveys and 1970-80 for Canadian surveys have been combined to provide an estimate of average resource distribution for each of the major groundfish species. A computer programme was written which calculates the average abundance for each species in each 10 minute square of latitude and longitude. It then estimates the proportional abundance on either side of any defined line, based on the abundance in all the squares and parts of squares on each side of the line.

Resource distribution tends to be quite closely proportional to area for 5Yb in the particular case (i.e. maximum area relocated) shown in Table 2. In 4Xp and q, the areas proposed for reassignment are deep water areas and, not surprisingly, tend to contain a higher proportion of deep water resources such as white hake, silver hake and redfish, and less cod and haddock, than would be expected based on area considerations only. If it is assumed that catch distribution has been proportional to resource distribution, the proportions of catch likely to be reassigned from Unit Areas 4Xp, 4Xq and 5Yf are small in most cases. Exceptions are the deep water species already mentioned. However, NAFO statistics are summarized on a larger geographic scale and it is necessary to estimate the impact of a line change on Divisional catches.

To estimate impacts on Divisional catches, Canadian and USA catches by Unit Area were used, along with the data in Table 2, to estimate the proportion of the groundfish catch from the Division as a whole which may have come from the area to be reassigned. Average catches for the period 1968-78 were used and thus these are from the period prior to jurisdictionally-based restrictions on areas fished. As an example of the calculation performed, the average Canadian redfish catch in 4Xp multiplied by 0.09 and the average catch in 4Xq multiplied by 0.20 (both proportions from Table 2) were summed, and compared to the average Canadian redfish catch from Div. 4X as a whole. The results support earlier conclusions that the impact of a line change is minor (Table 3).

In Div. 4X the largest quantities involved in potential relocation involve pollock at rather less than 500 t and between 3.0% and 3.5% of the catch. Redfish is next at about 200 t and 3.5-4.0% of catch. In Div. 5Y, the largest quantity is about 140 t of pollock which is about 3% of catch. This is followed by cod and haddock at about 90 t and 80 t, and 1% and 4%, respectively. While percentages of Canadian Div. 5Y catches calculated to be relocated are high, the absolute amounts are trivial.

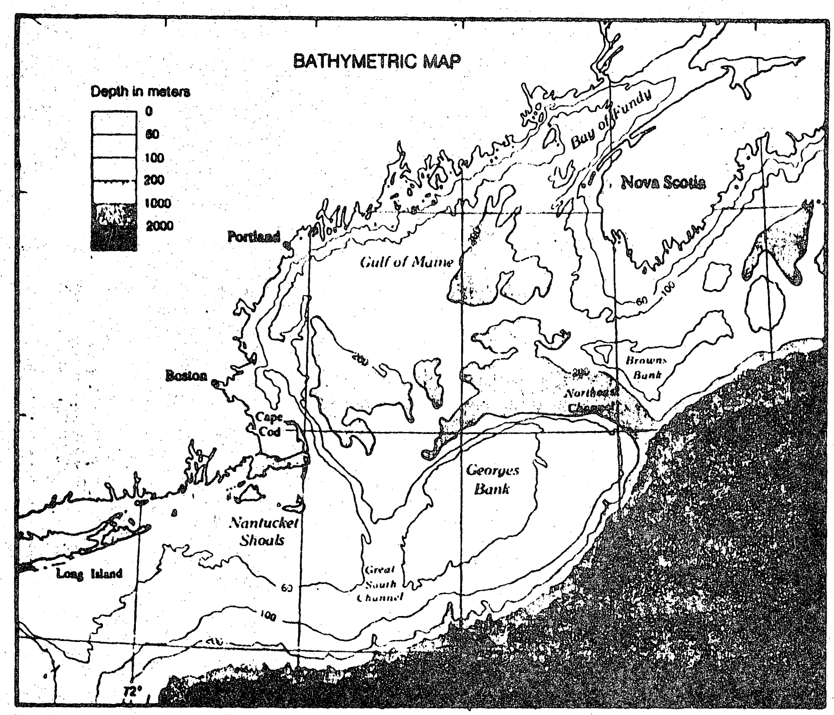


Figure 8. Physical geography of the Gulf of Maine Area.

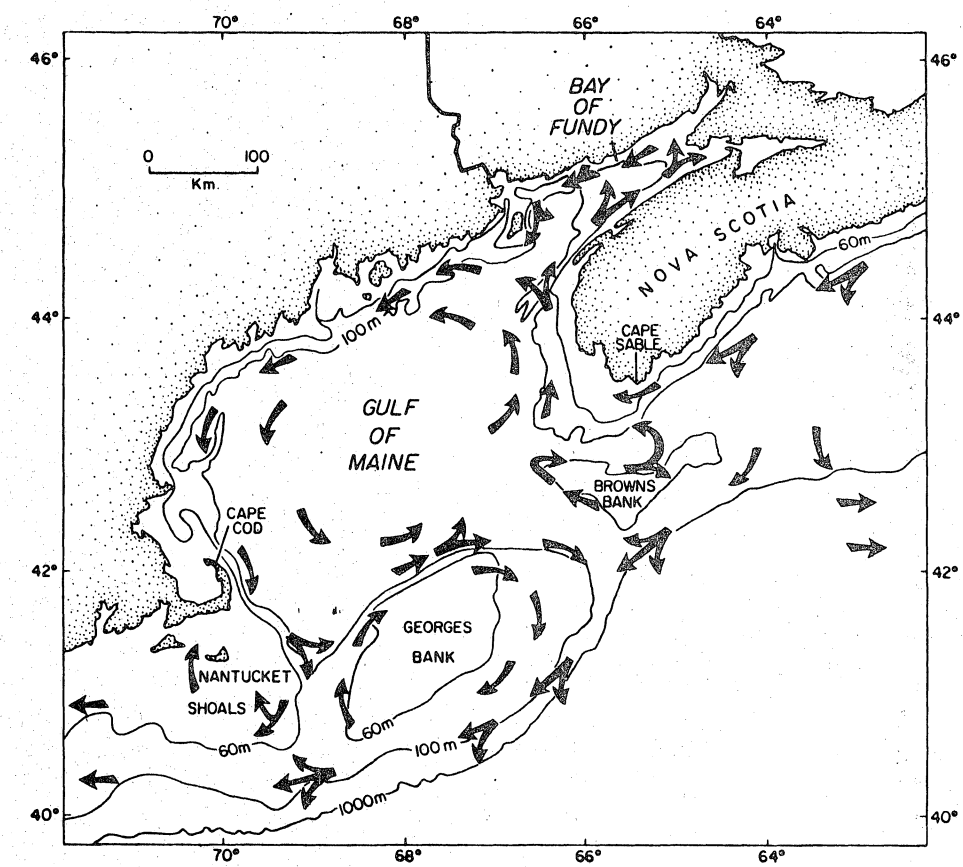
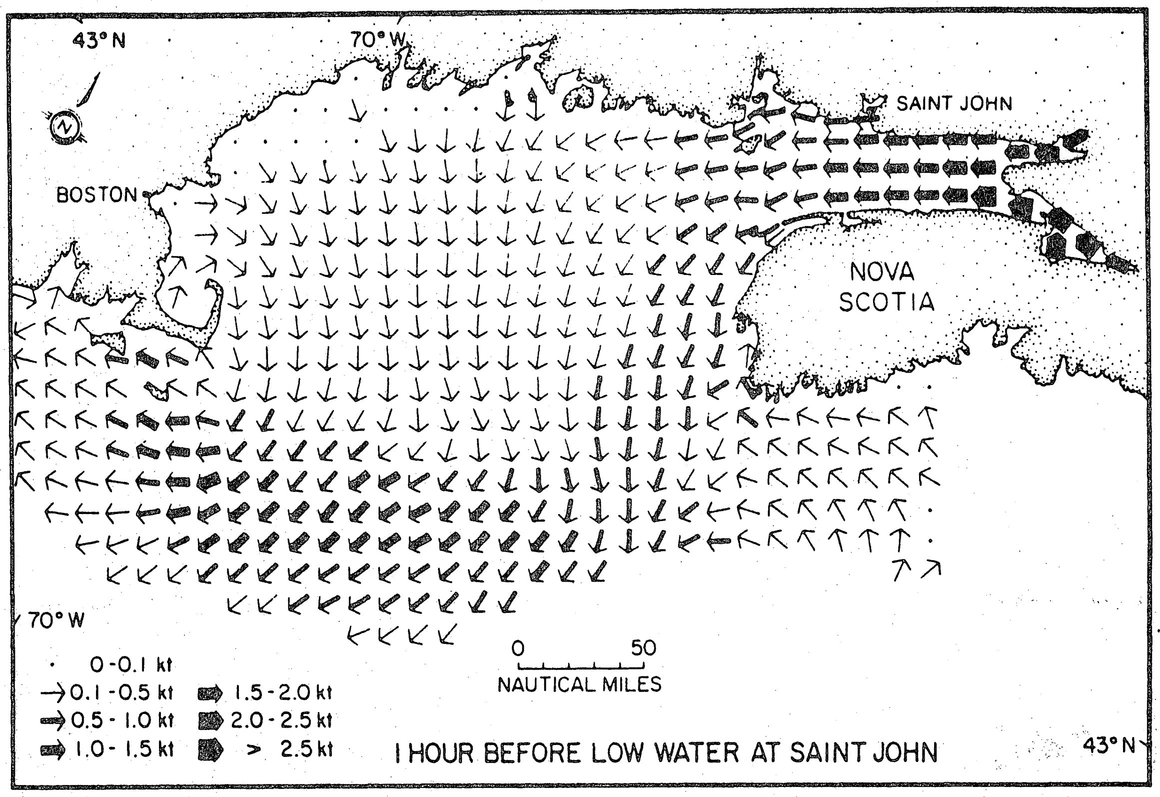


Figure 9. Average surface circulation in the Gulf of Maine Area.



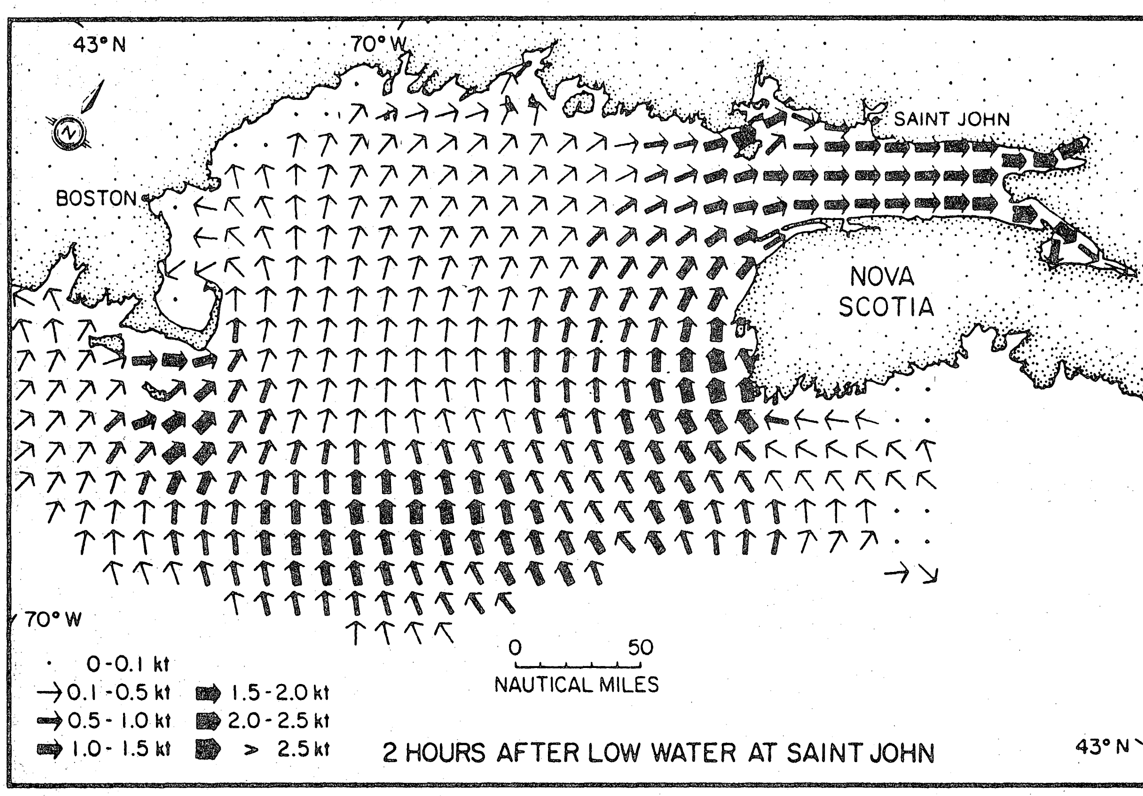


Figure 10. Strength and pattern of tidal currents in the Gulf of Maine area. (Source: Data from Atlas of Tidal currents Bay of Fundy and Gulf of Maine. Canadian Hydrographic Service, 1981.)

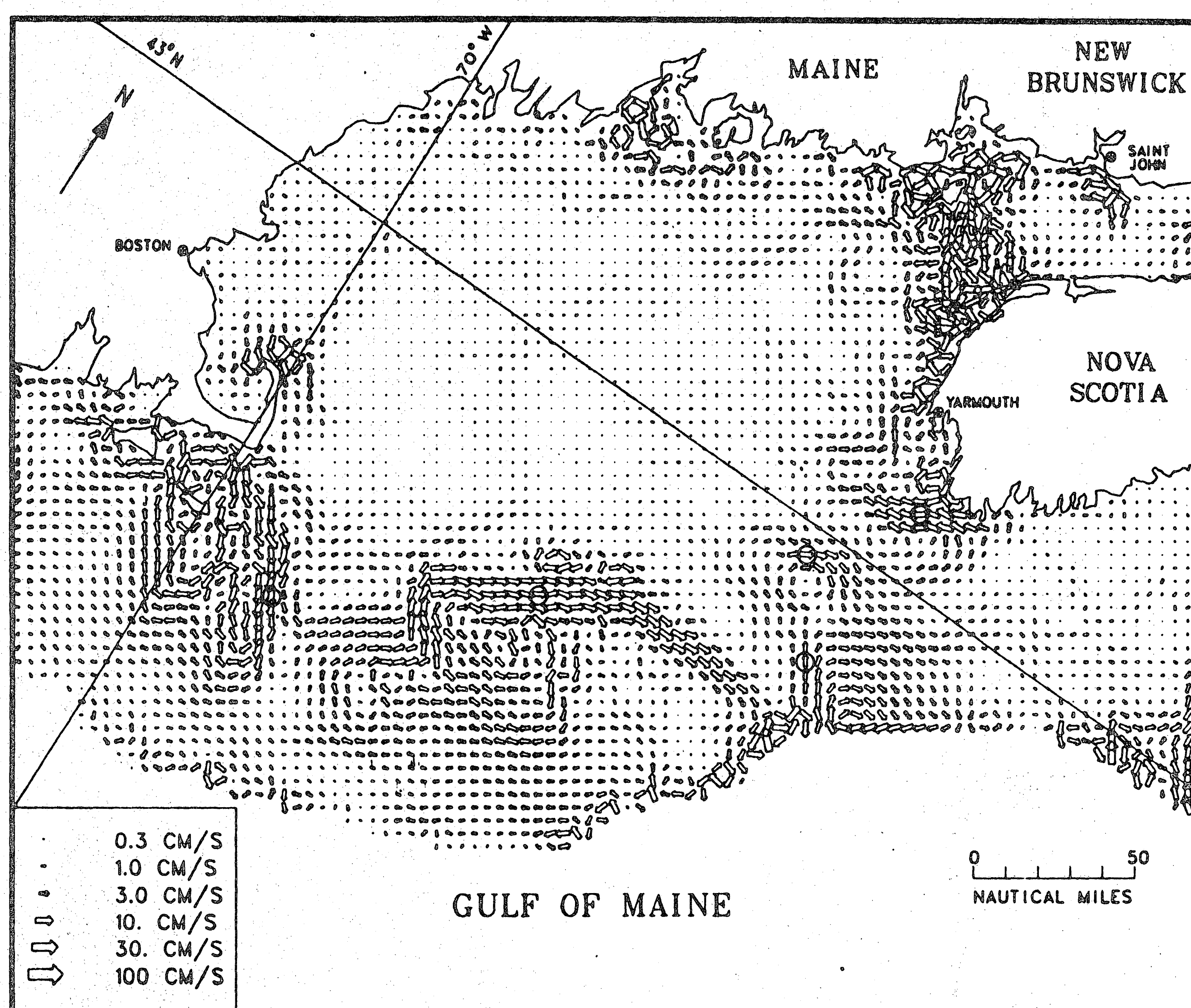


Figure 11. Tidally driven residual currents in the Gulf of Maine area, showing the clockwise gyre on Georges Bank with strongest currents along its northern edge.

Figure 12. Resource distribution of cod.

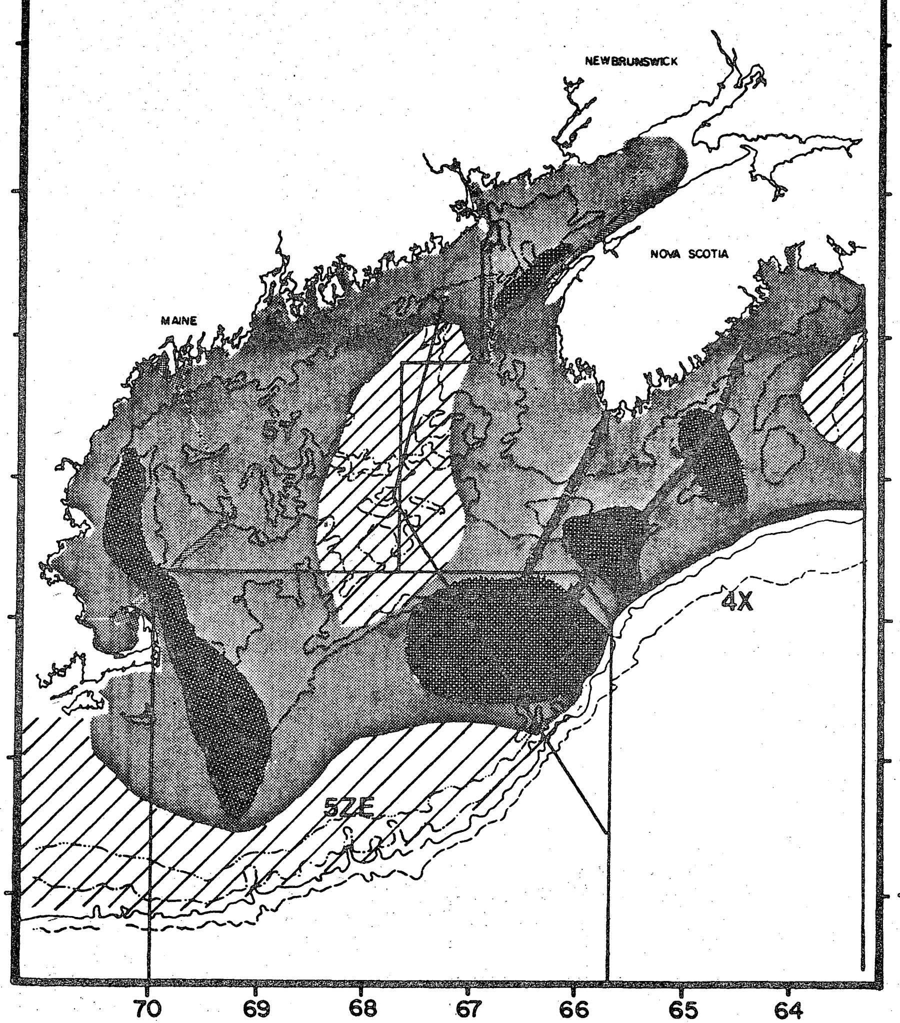
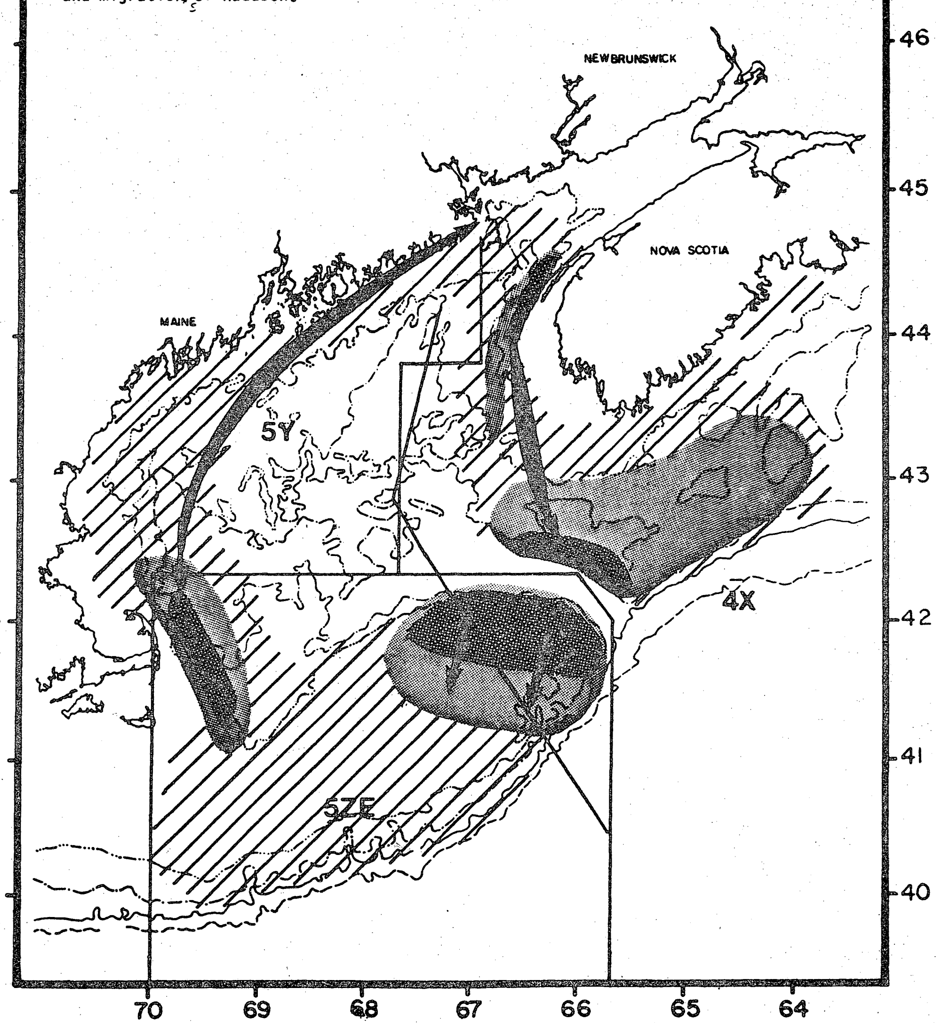


Figure 13. Resource distribution and migration of haddock.



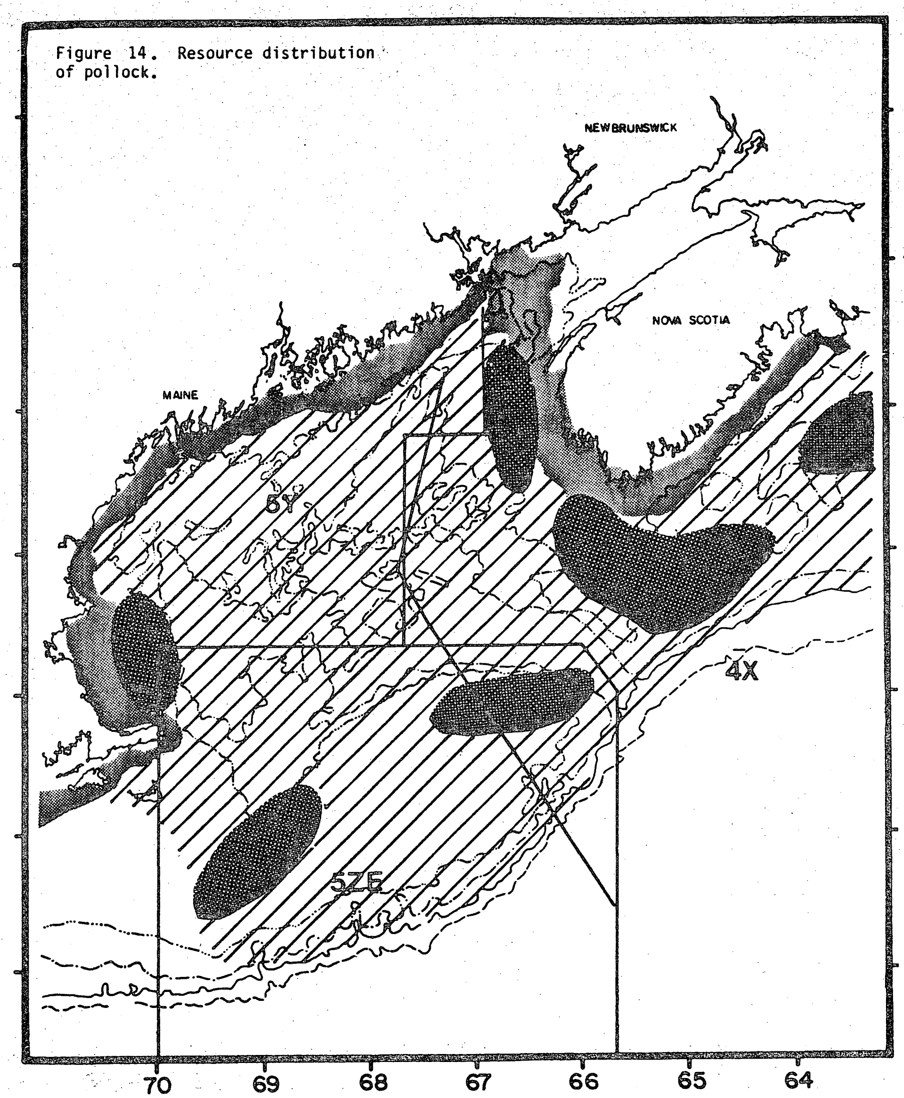


Figure 14. Resource distribution of pollock.

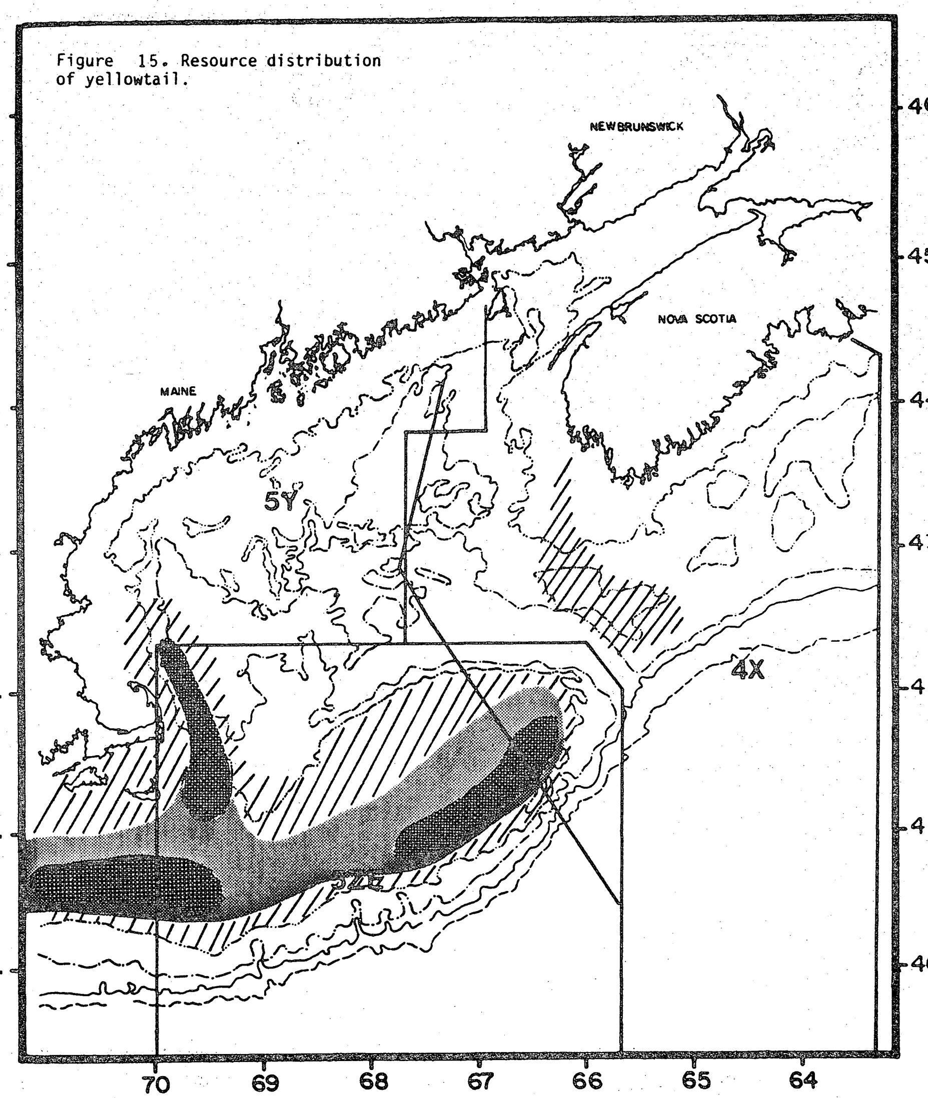


Figure 15. Resource distribution of yellowtail.

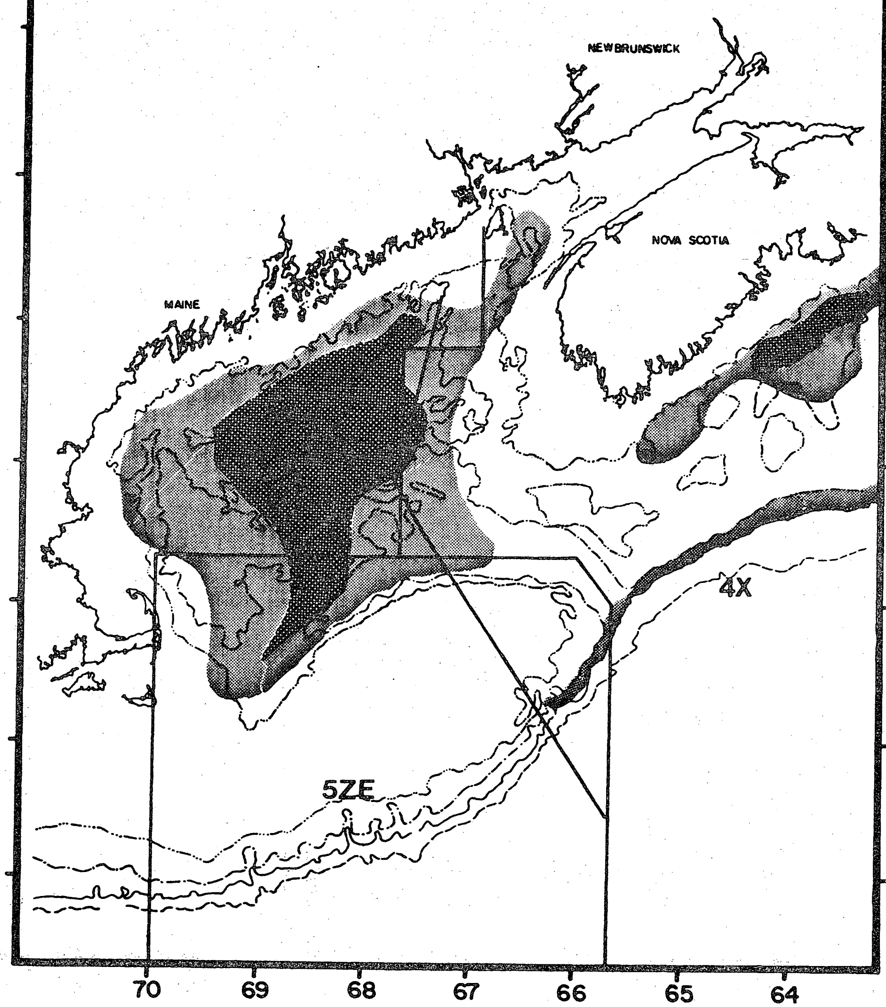


Figure 16. Resource distribution of redfish.

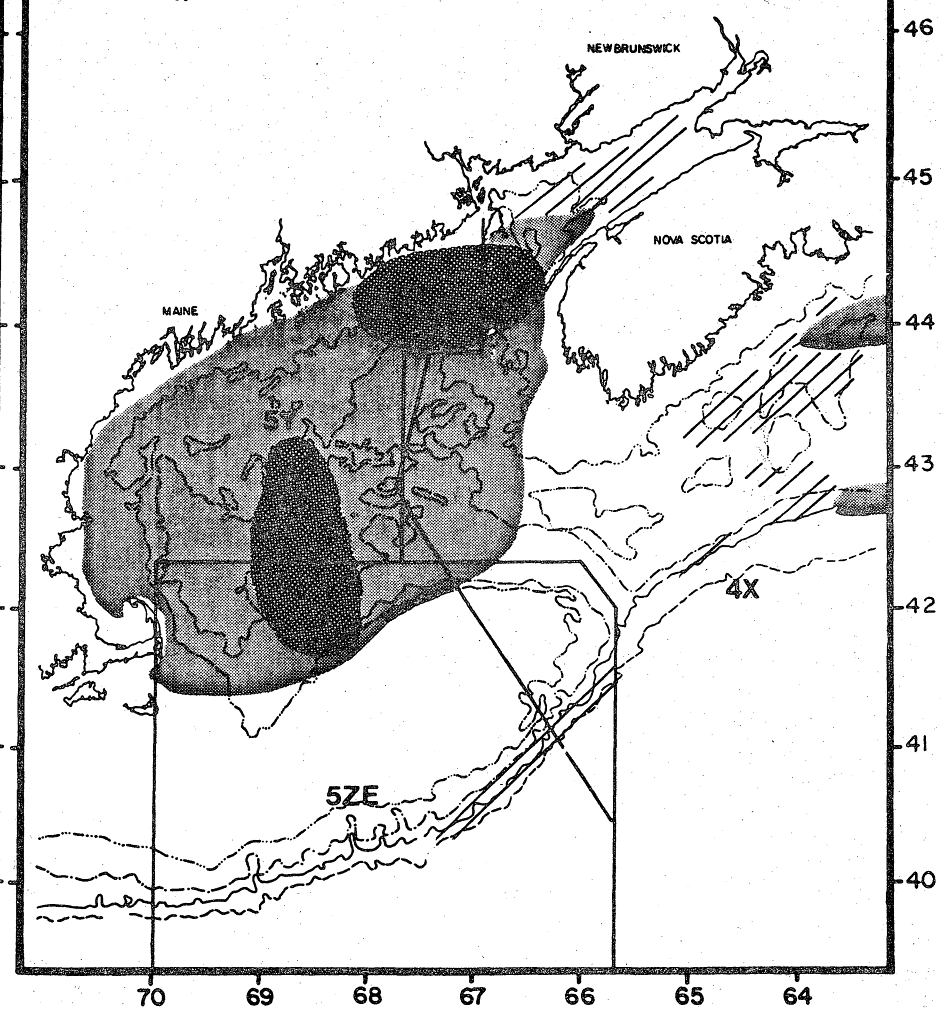


Figure 17. Resource distribution of white hake.

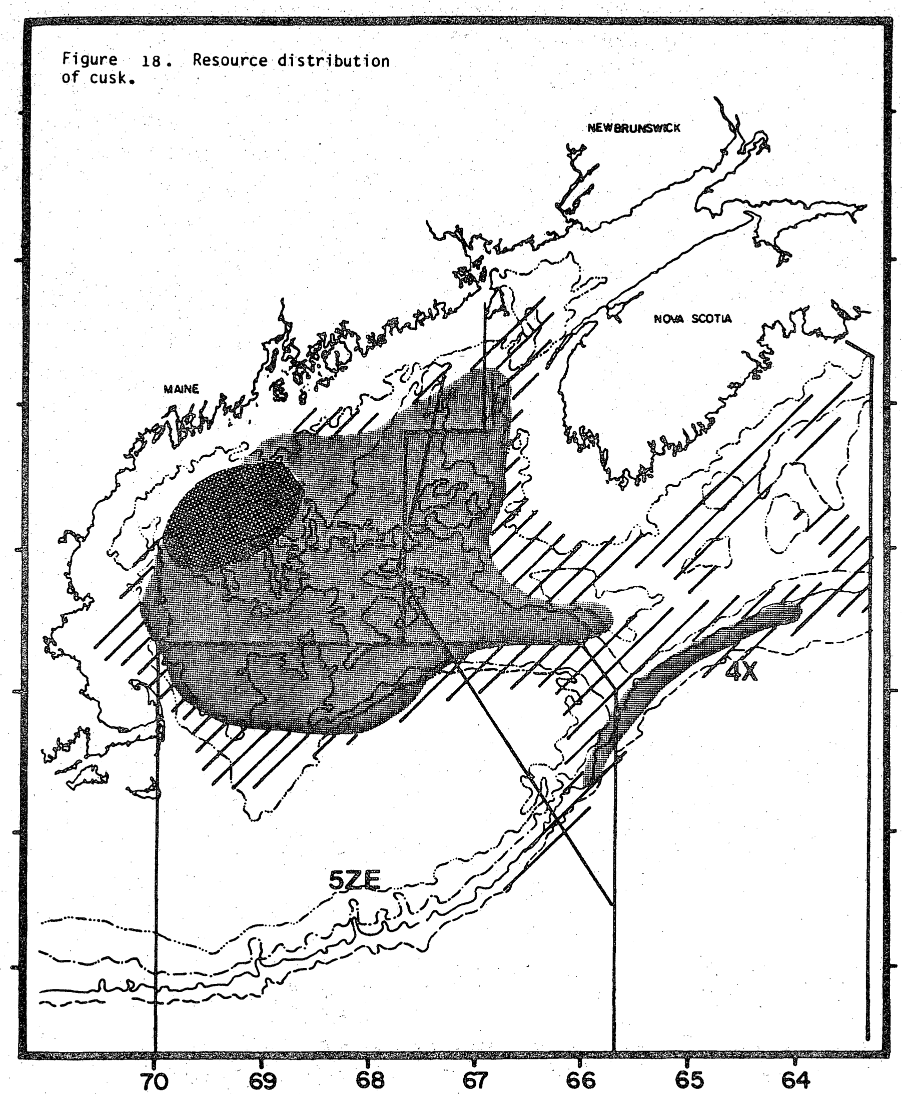


Figure 18. Resource distribution of cusk.

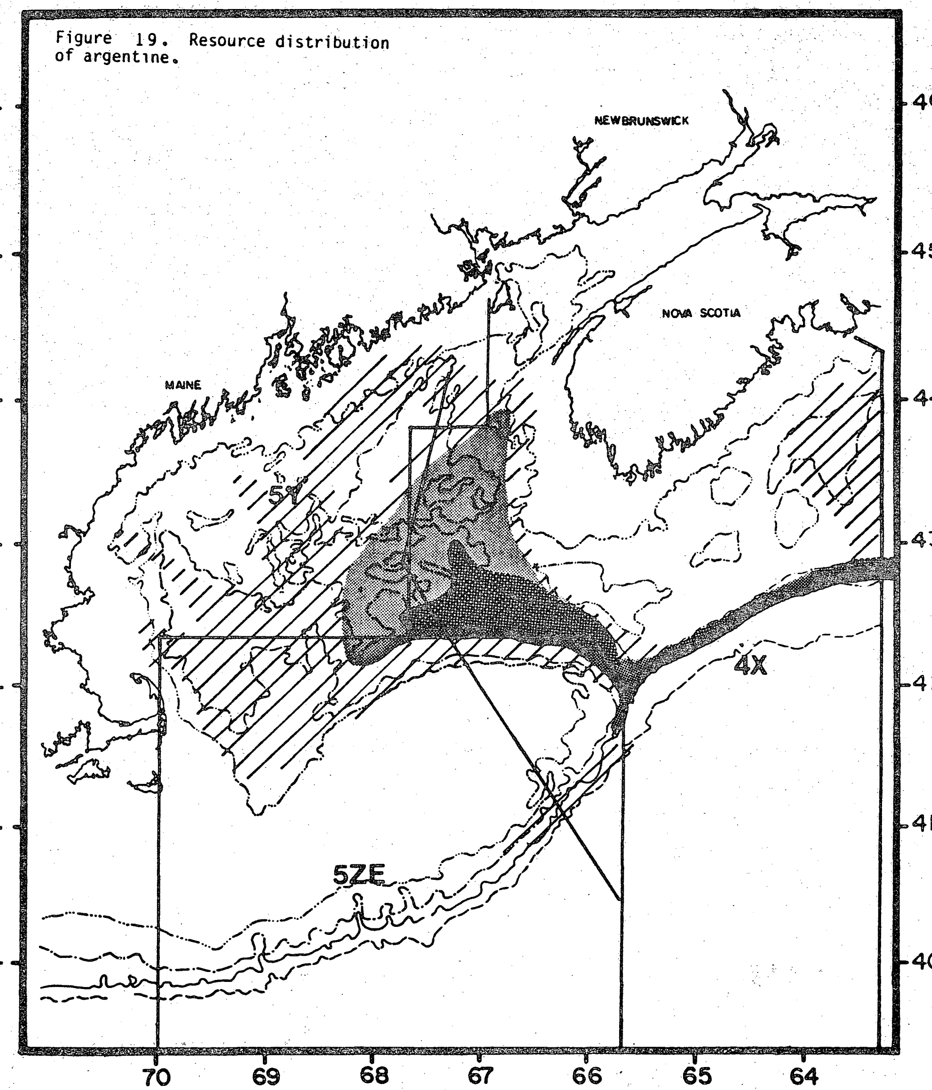


Figure 19. Resource distribution of argentine.

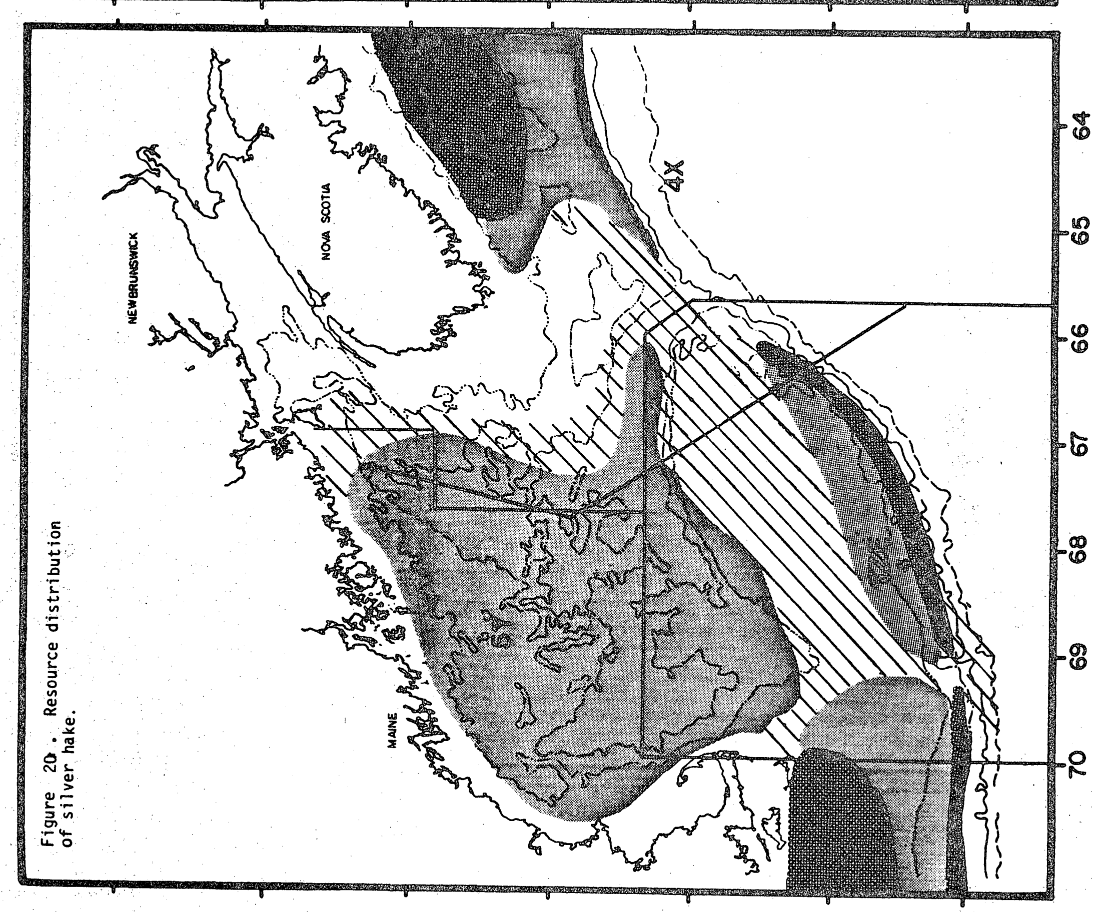


Figure 20. Resource distribution of silver hake.

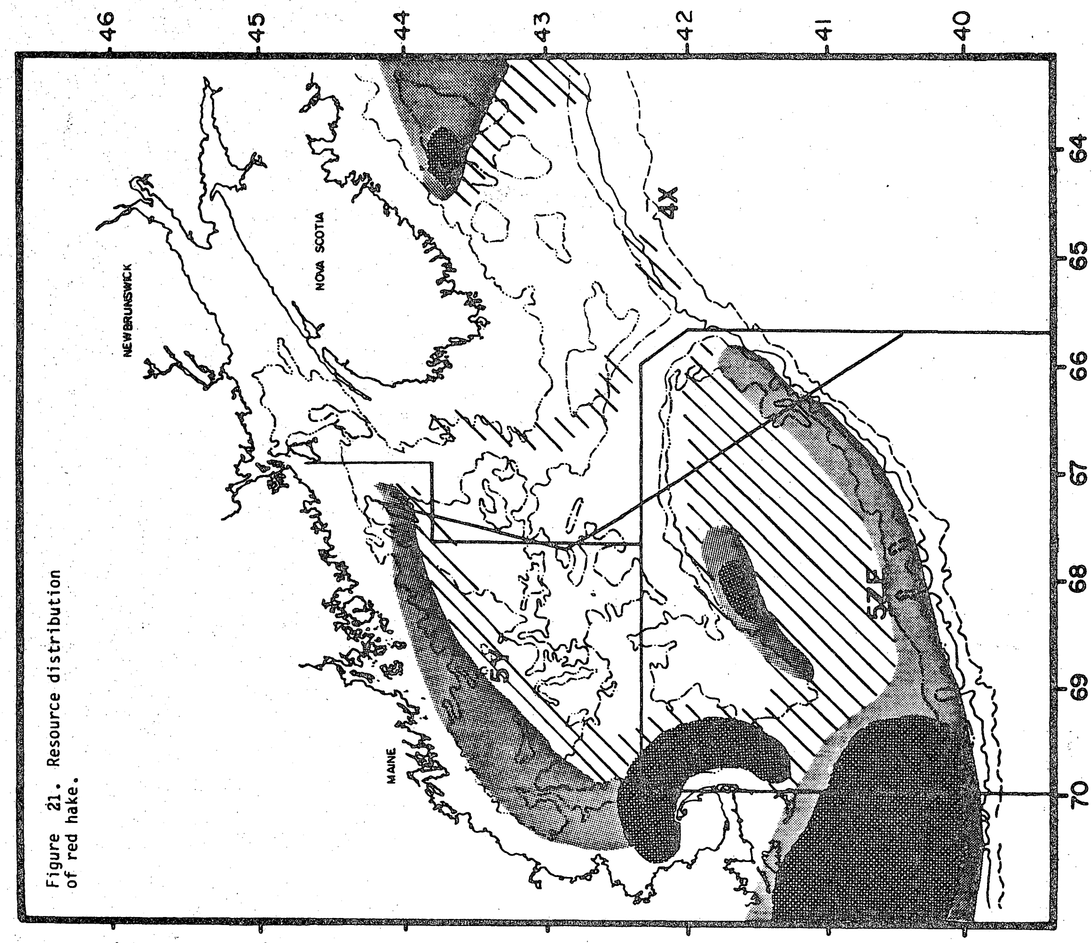


Figure 21. Resource distribution of red hake.

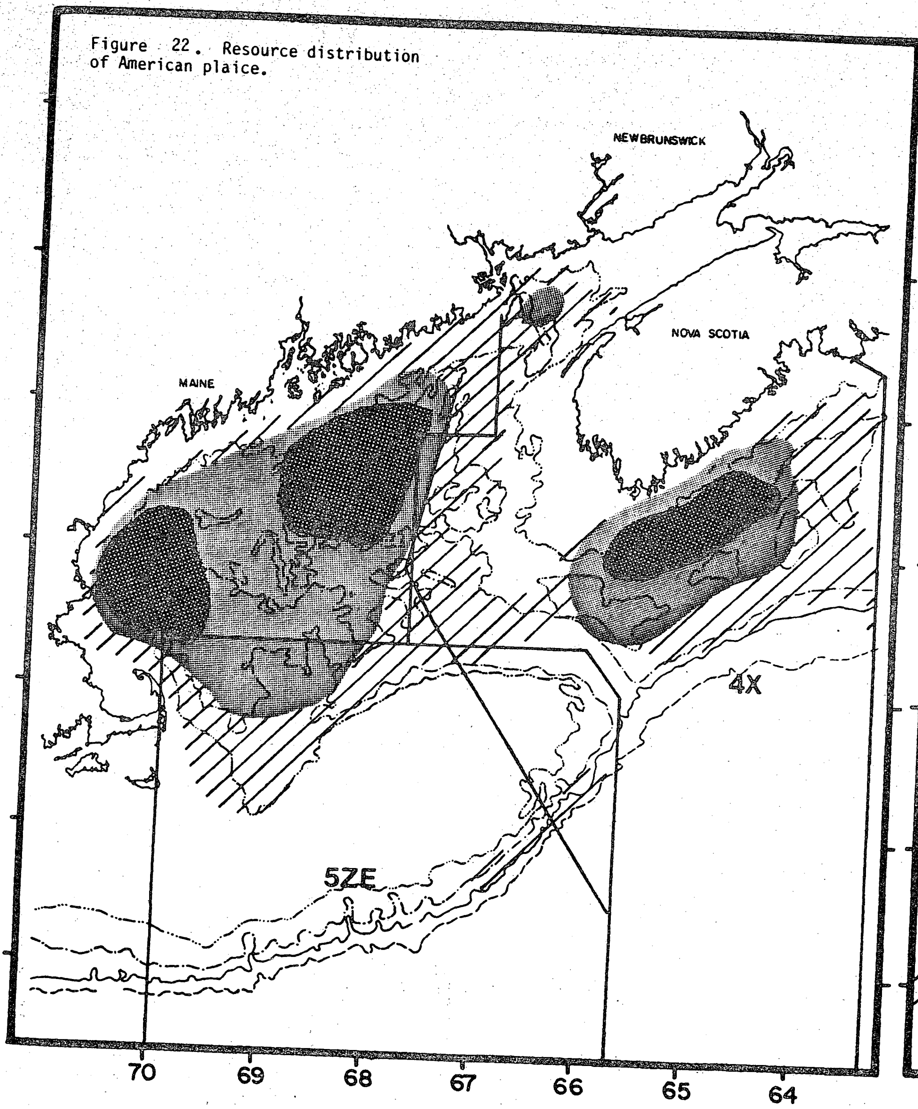


Figure 22. Resource distribution of American plaice.

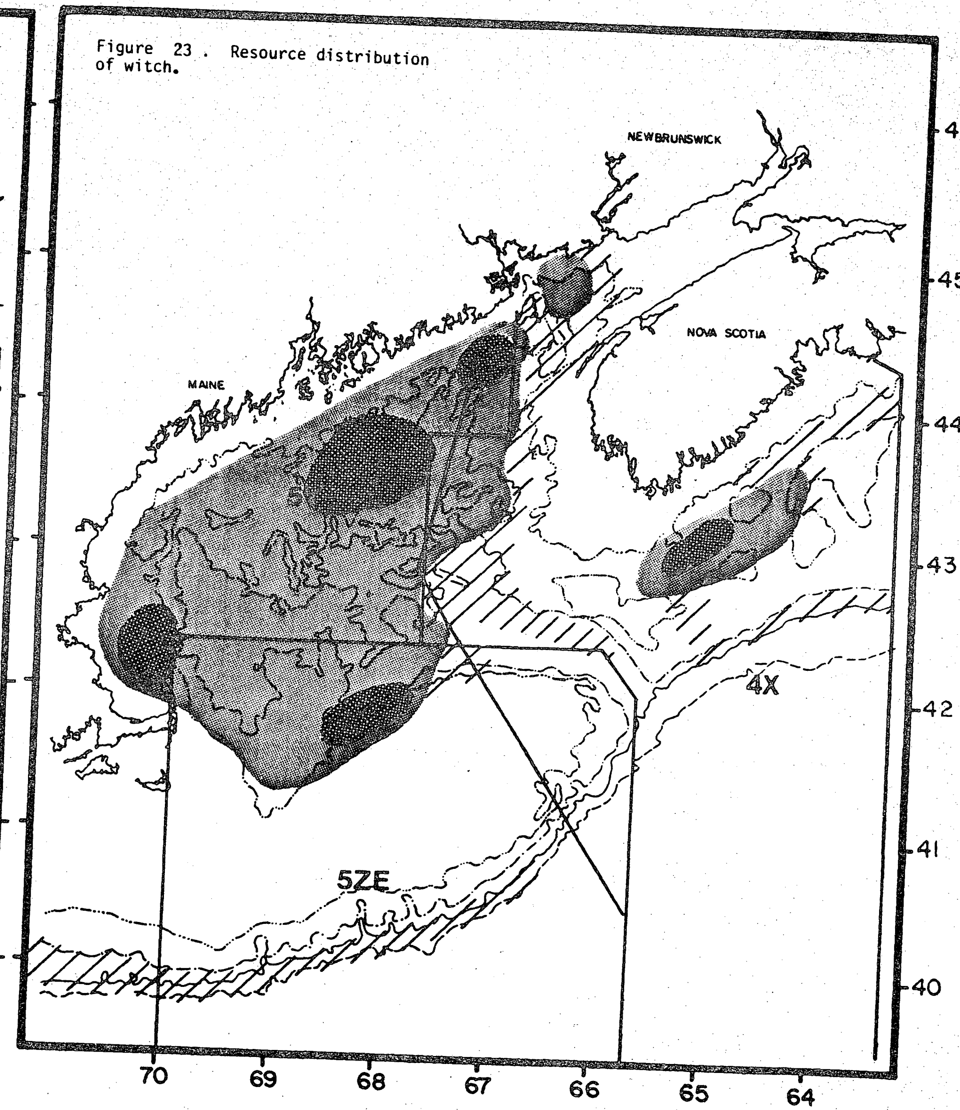


Figure 23. Resource distribution of witch.

Figure 24. Resource distribution of winter flounder.

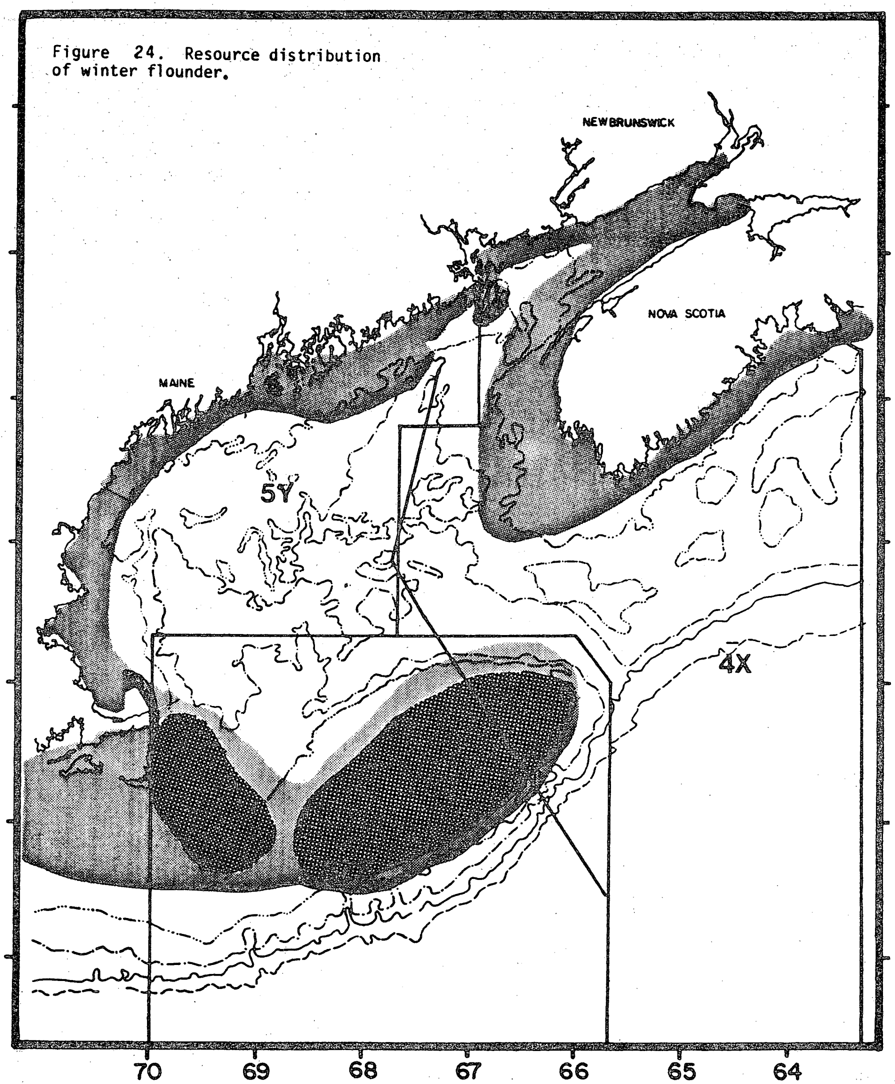


Figure 25. Resource distribution of angler.

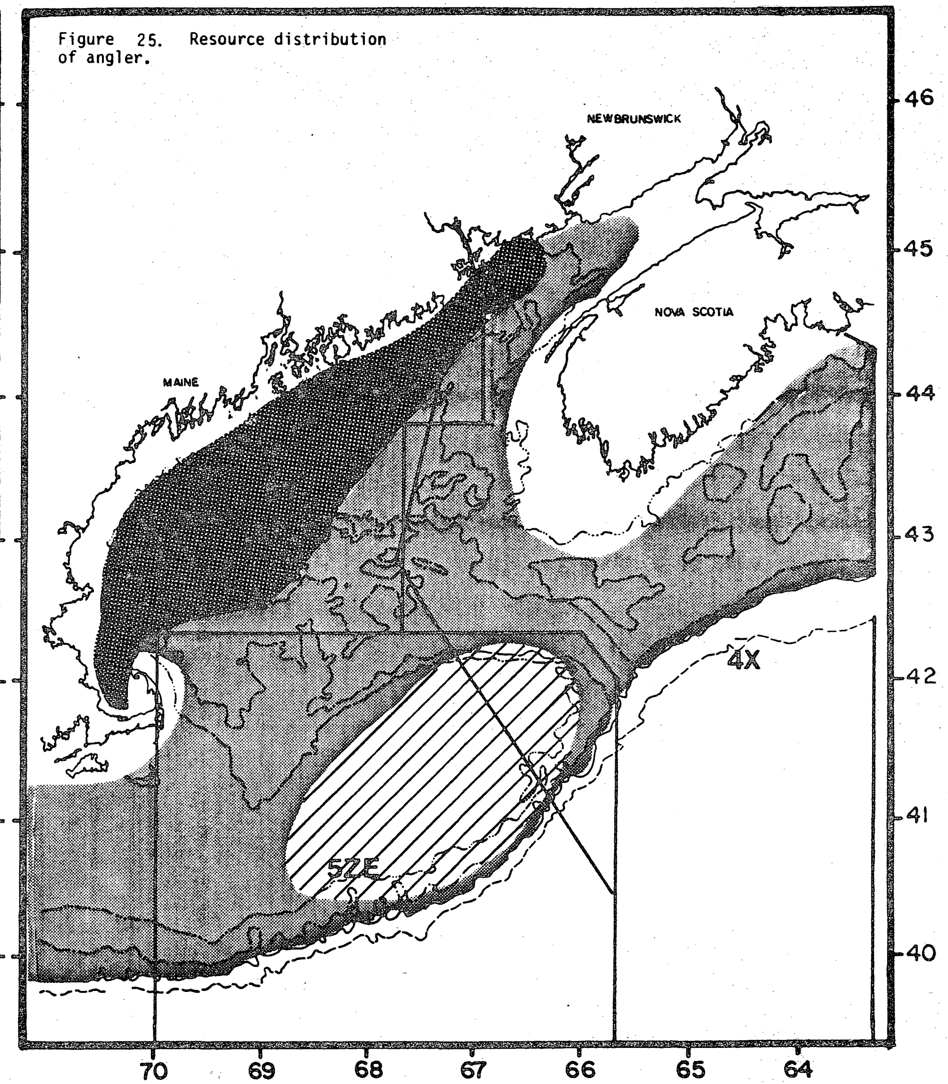
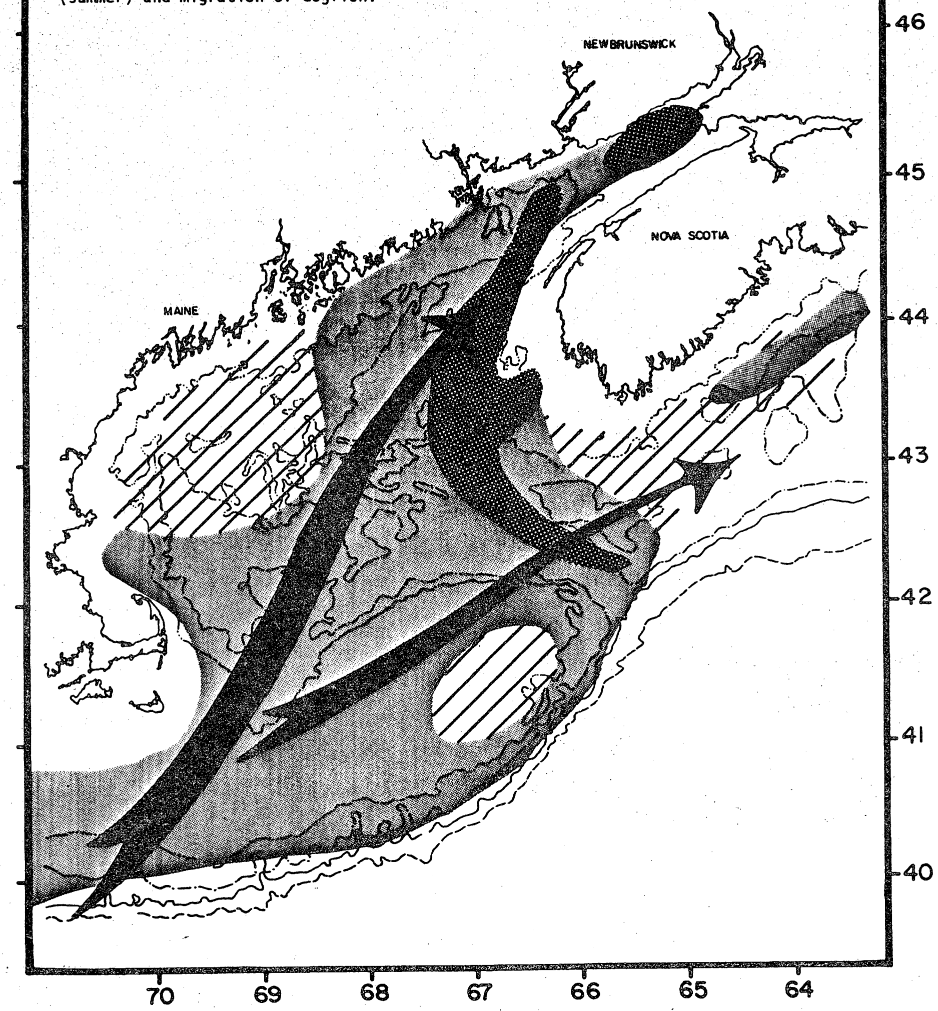


Figure 26. Resource distribution (summer) and migration of dogfish.



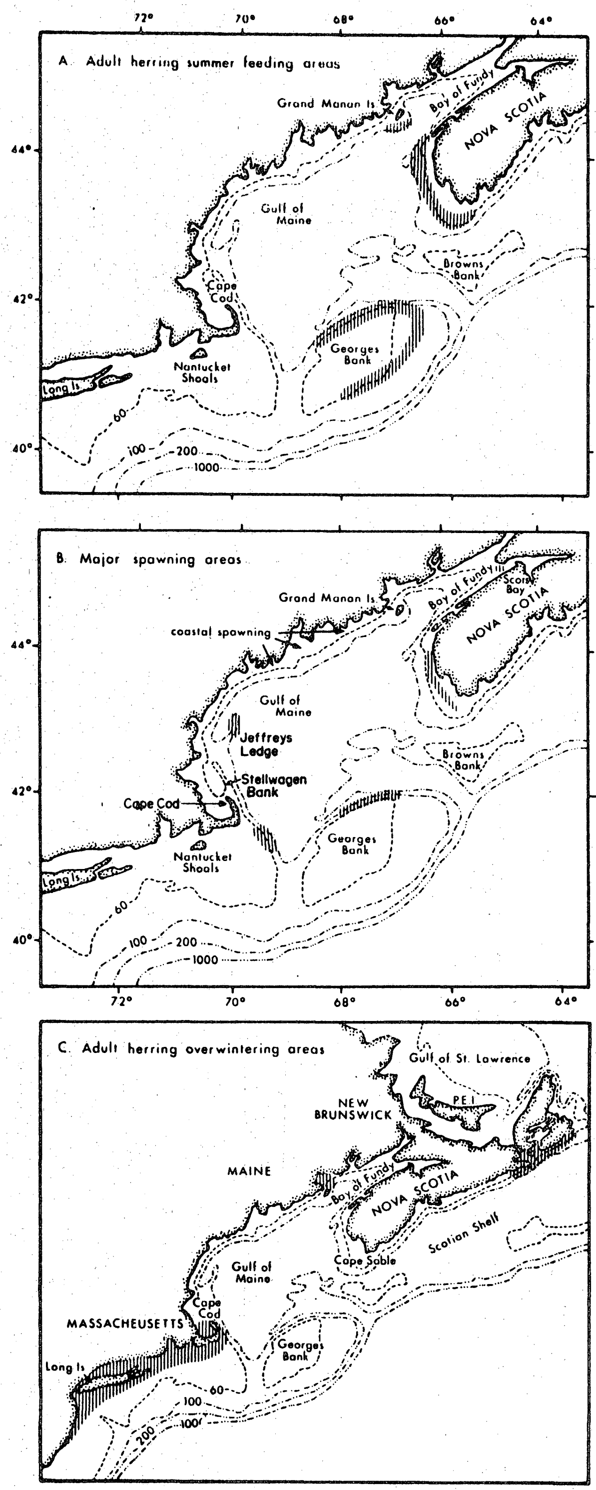


Figure 27a. Adult herring distribution during A. Summer feeding, B. spawning, and C. overwintering.

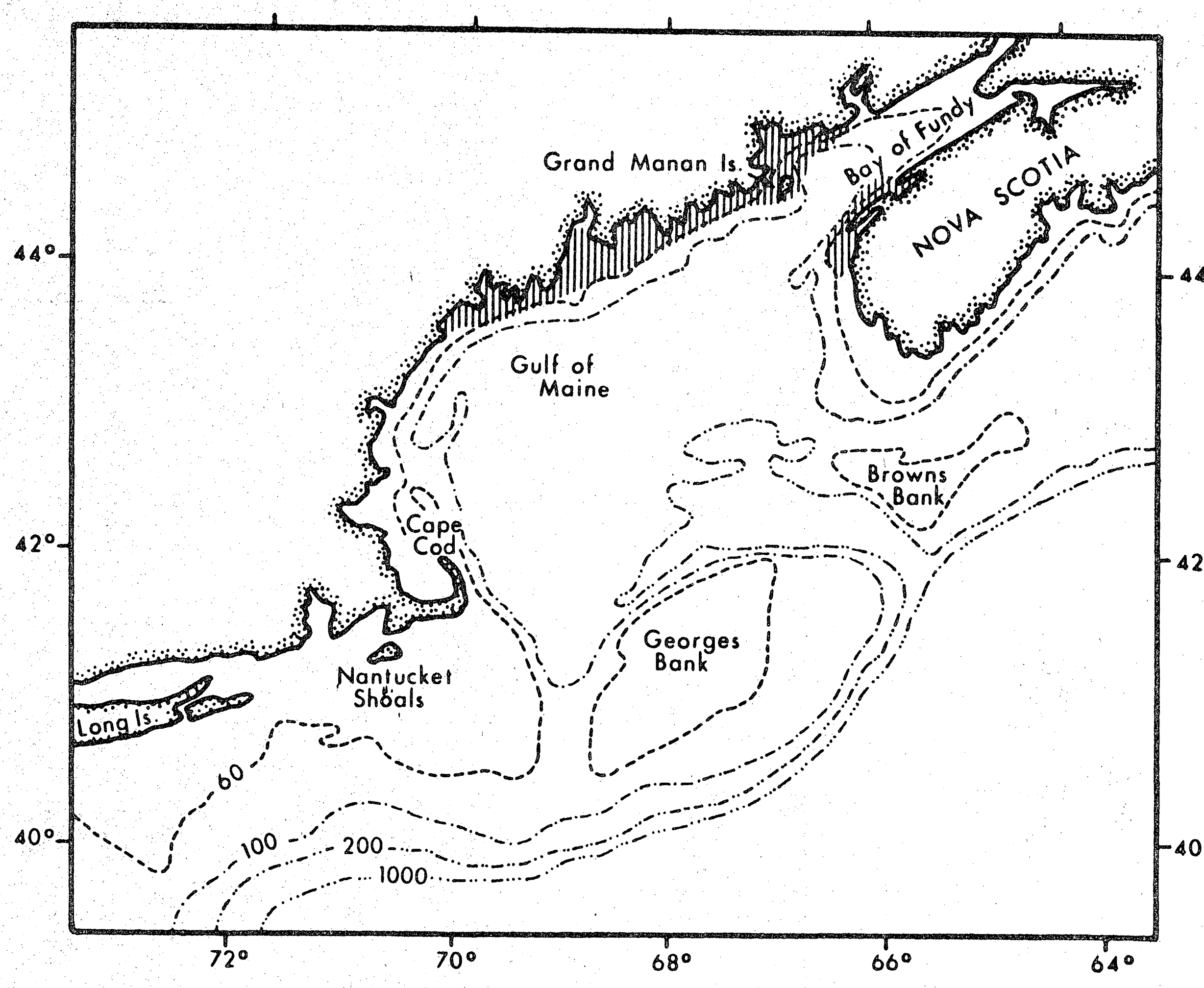


Figure 27 b. Juvenile herring distribution (age 2,3).

Figure 28. Resource distribution and migration of mackerel.

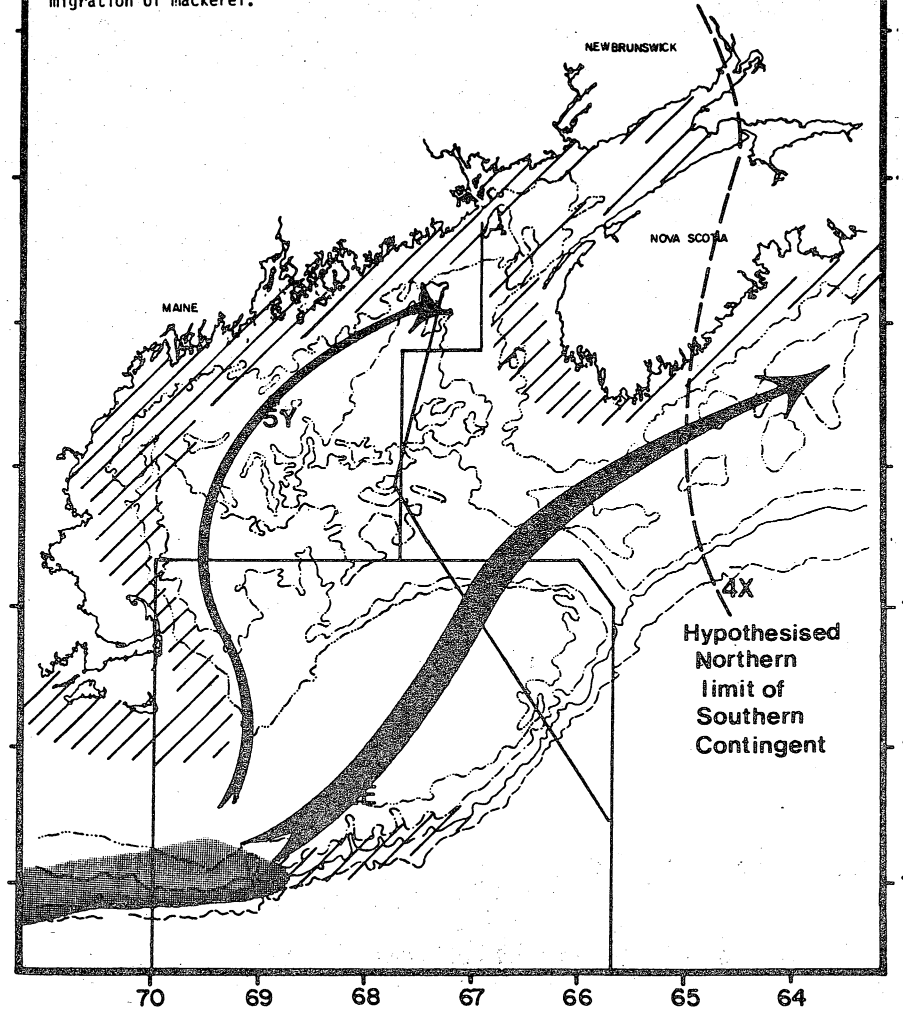


Figure 29. Distribution of Canadian catches of swordfish. Arrows indicate hypothesised migration route.

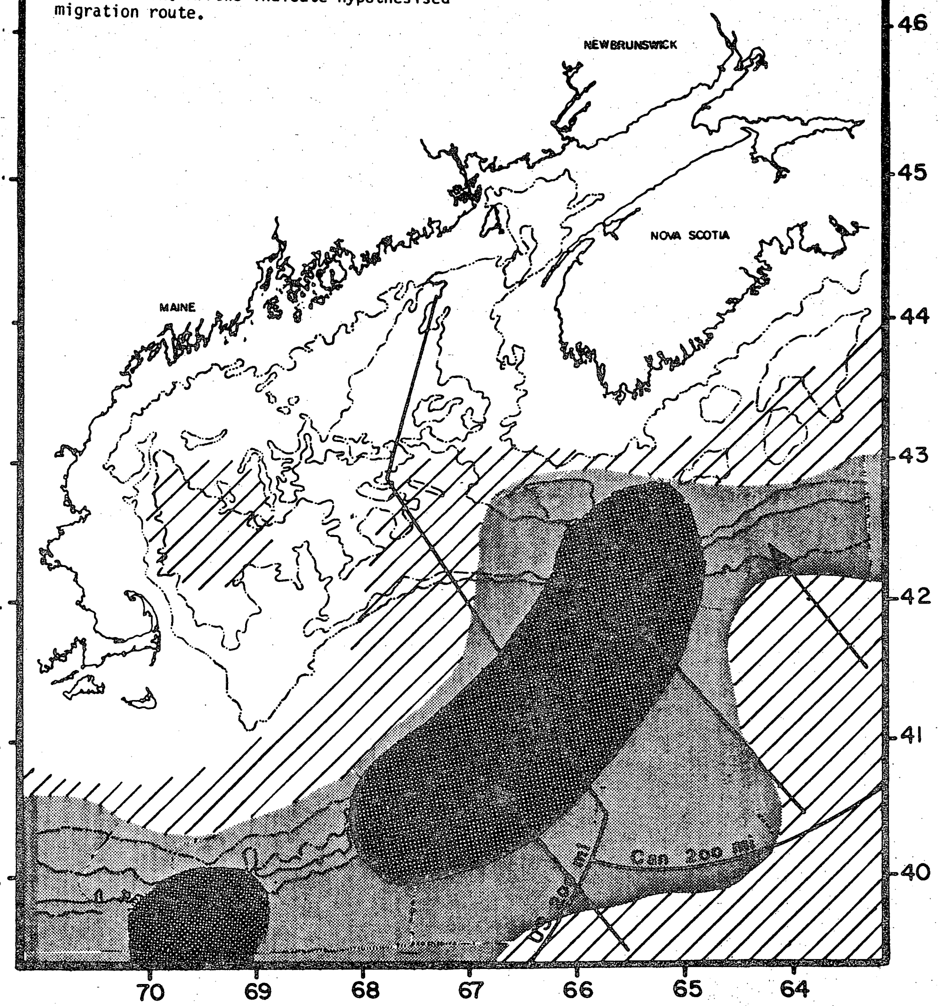


Figure 30. Migration of American shad.

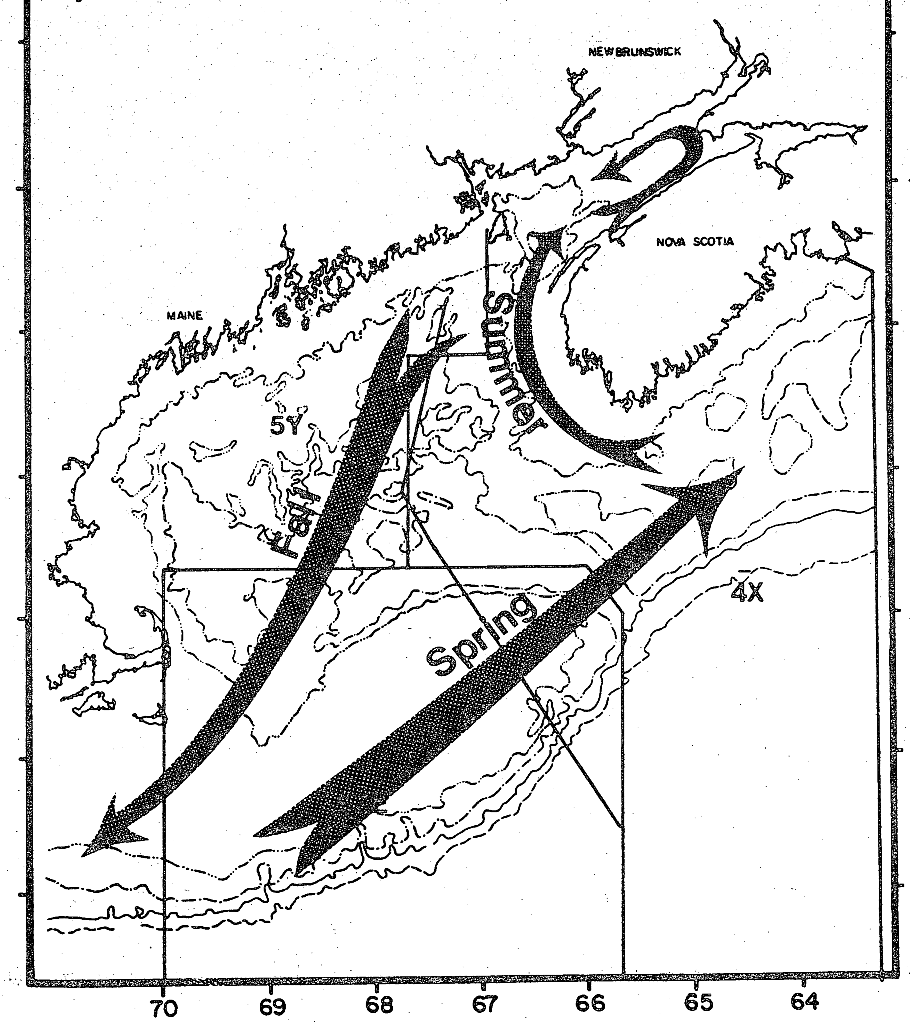
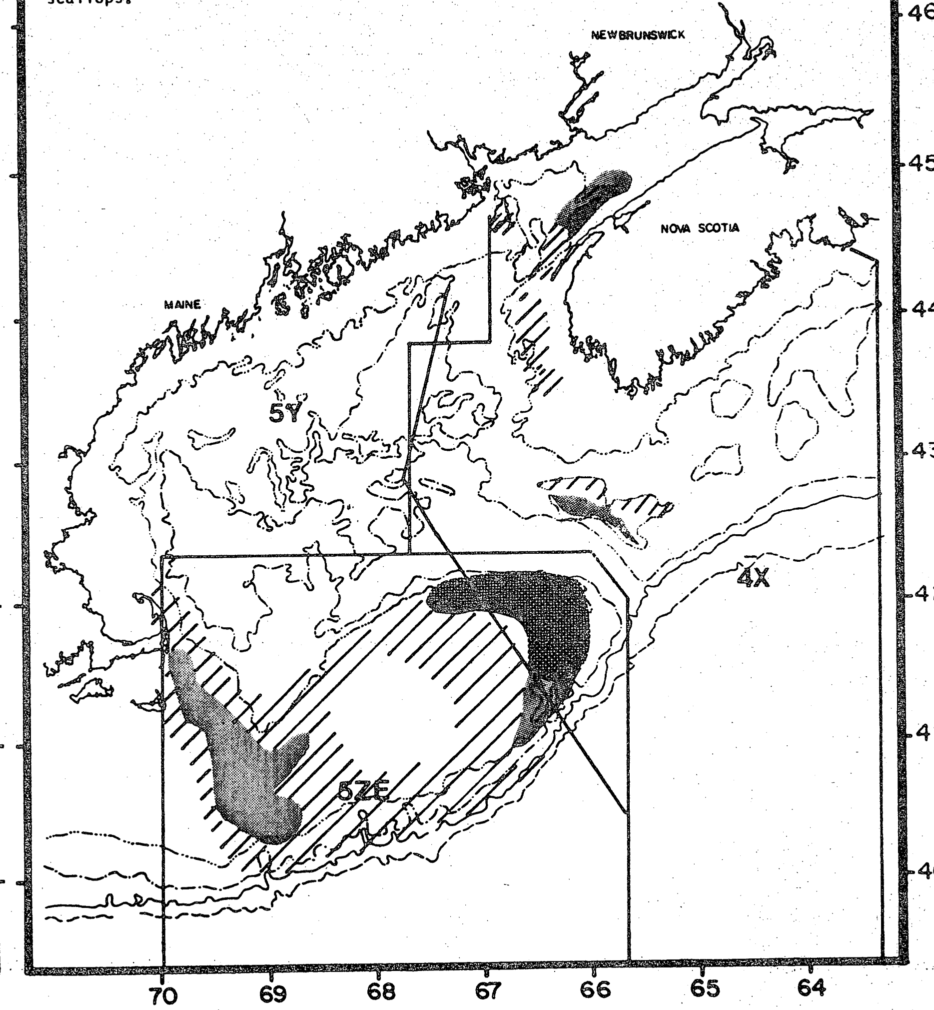


Figure 31. Catch distribution of sea scallops.



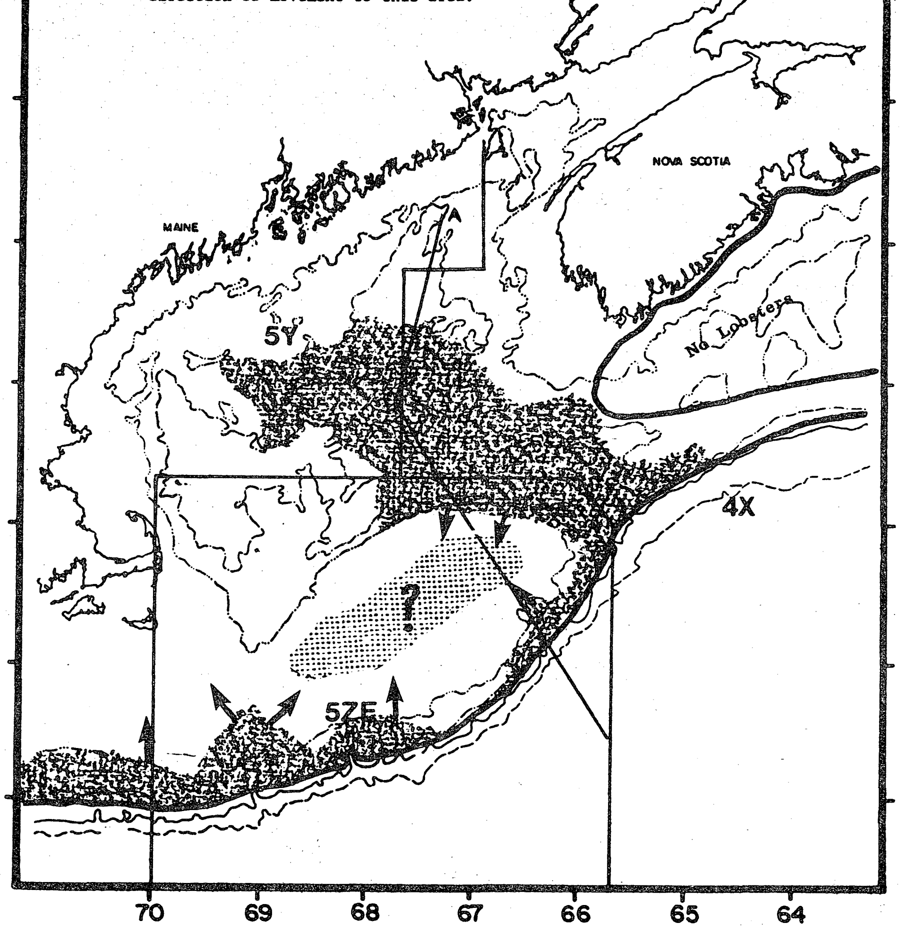


Figure 32. Lobster distribution. Lobsters occur over entire area north and west of the demarkation lines shown. ( ) denotes distribution of known concentrations capable of supporting commerical trap fisheries. ( ) indicates hypothesised summer concentrations in shoal water, with arrows suggesting direction of movement to this area.

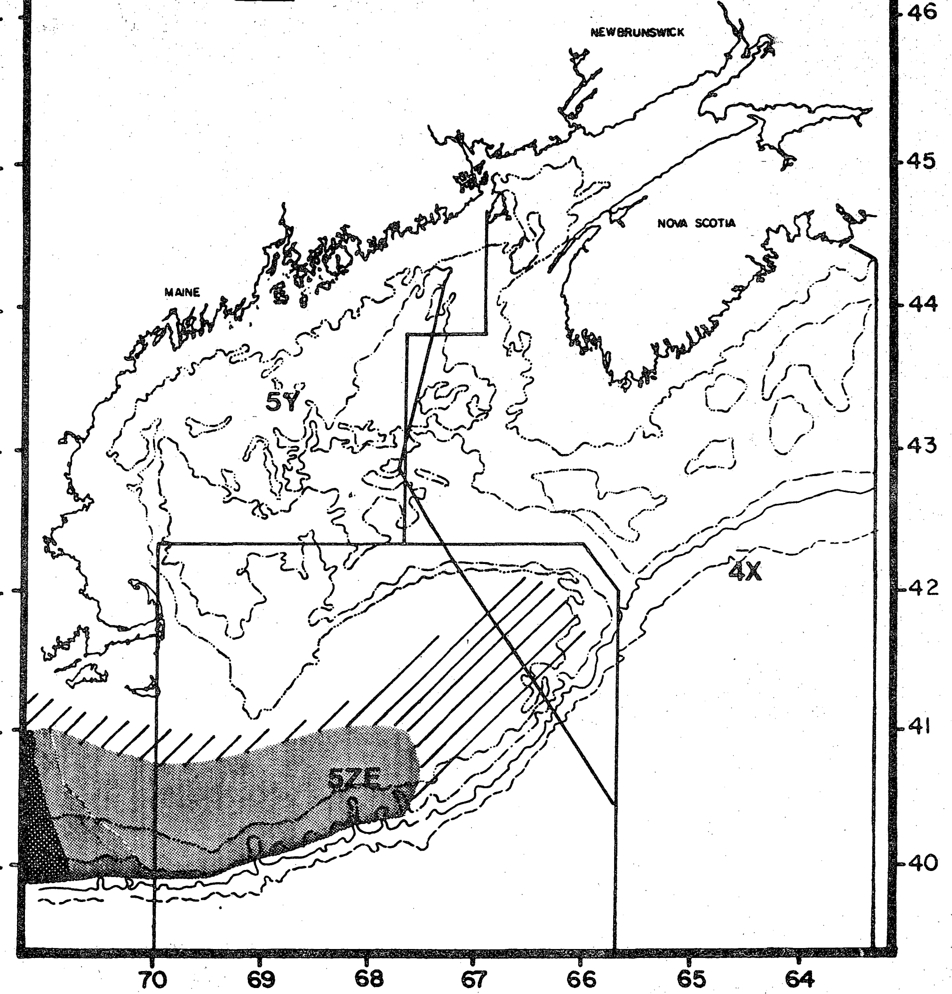


Figure 33. Resource distribution of long-finned squid (Loligo).

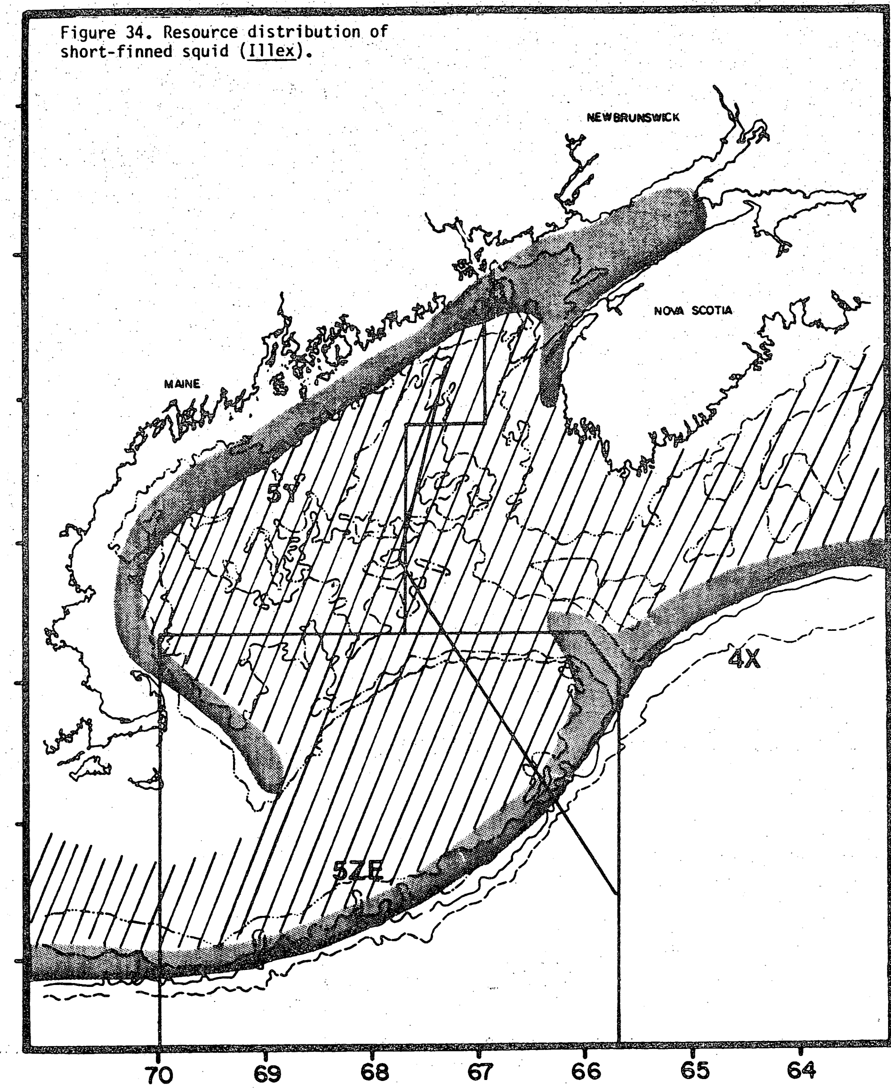


Figure 34. Resource distribution of short-finned squid (Illex).

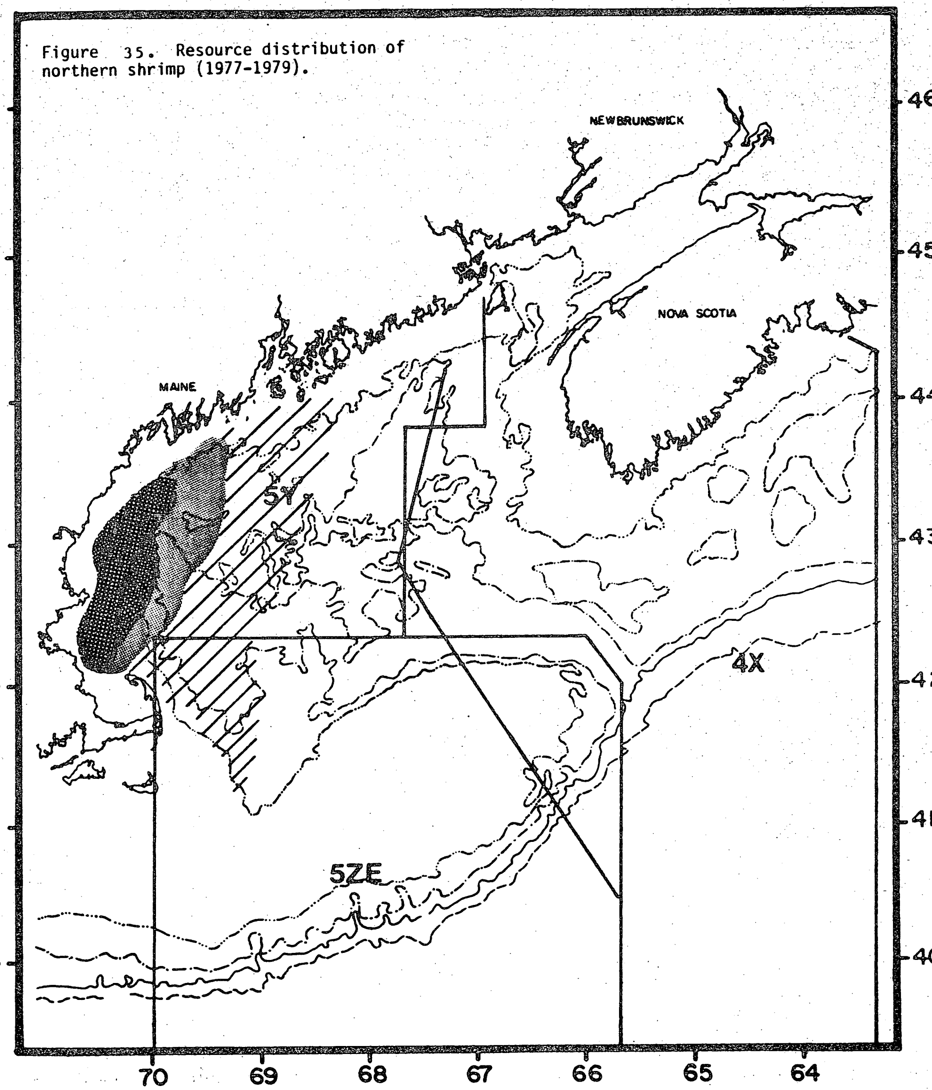


Figure 35. Resource distribution of northern shrimp (1977-1979).

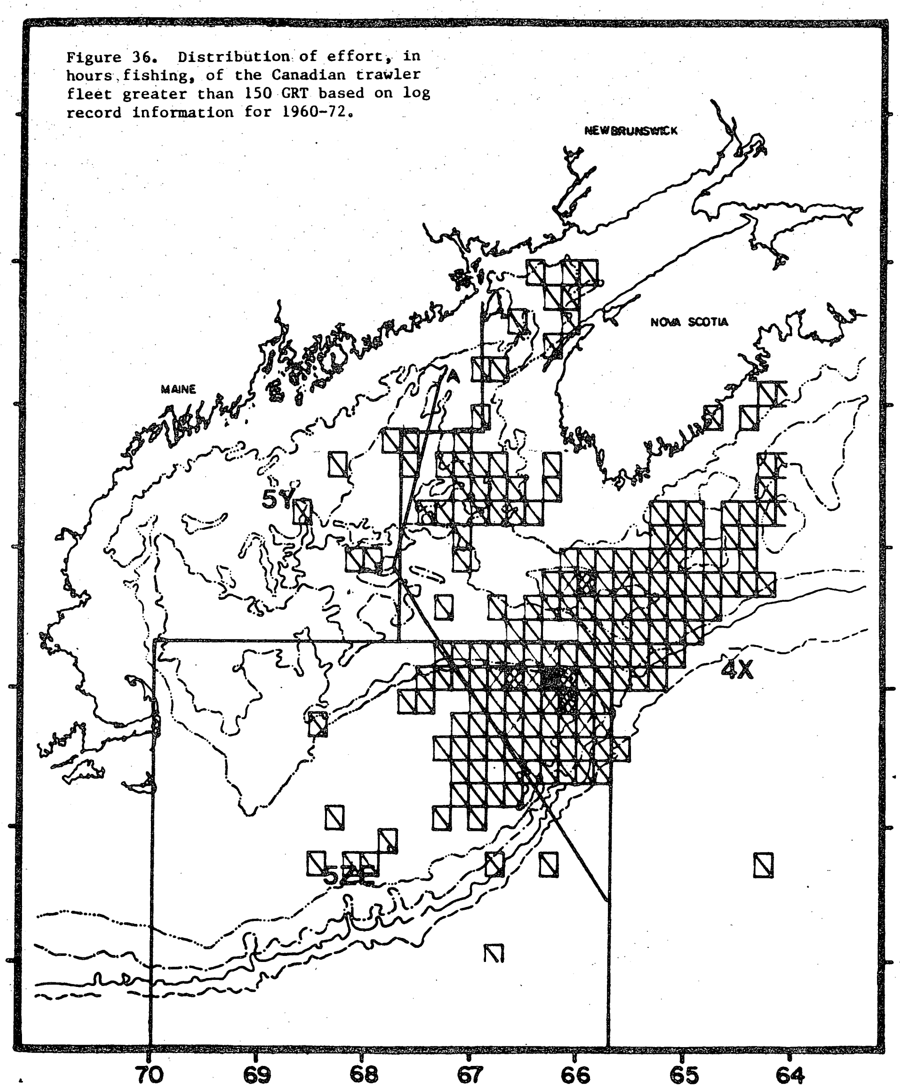


Figure 36. Distribution of effort, in hours fishing, of the Canadian trawler fleet greater than 150 GRT based on log record information for 1960-72.

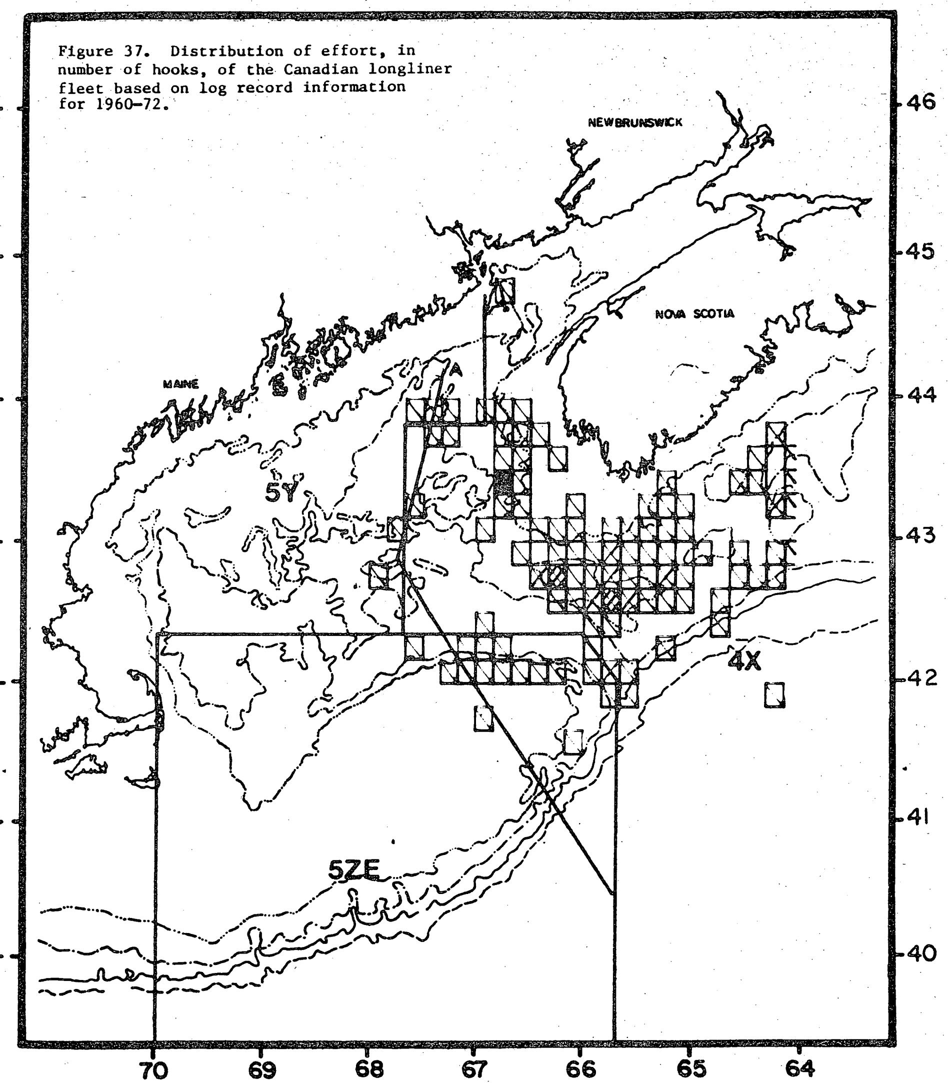


Figure 37. Distribution of effort, in number of hooks, of the Canadian longliner fleet based on log record information for 1960-72.

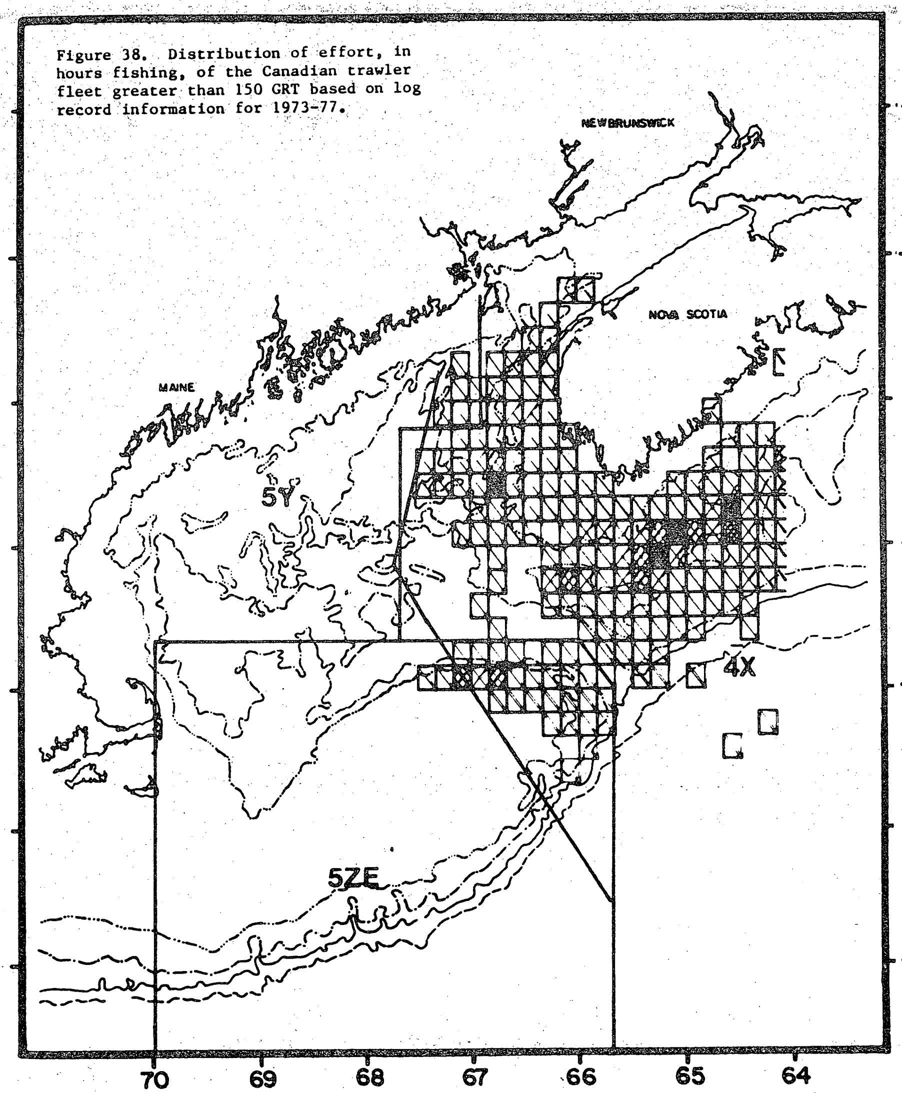


Figure 38. Distribution of effort, in hours fishing, of the Canadian trawler fleet greater than 150 GRT based on log record information for 1973-77.

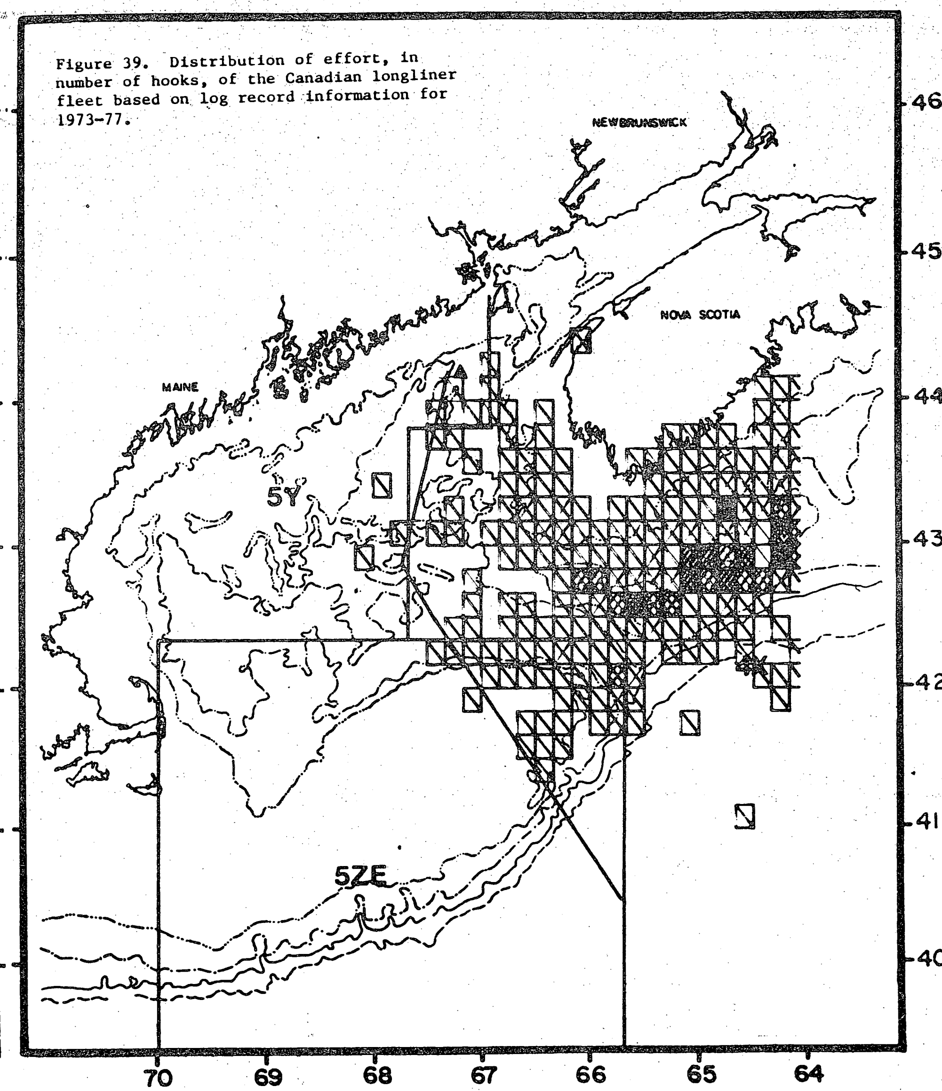


Figure 39. Distribution of effort, in number of hooks, of the Canadian longliner fleet based on log record information for 1973-77.

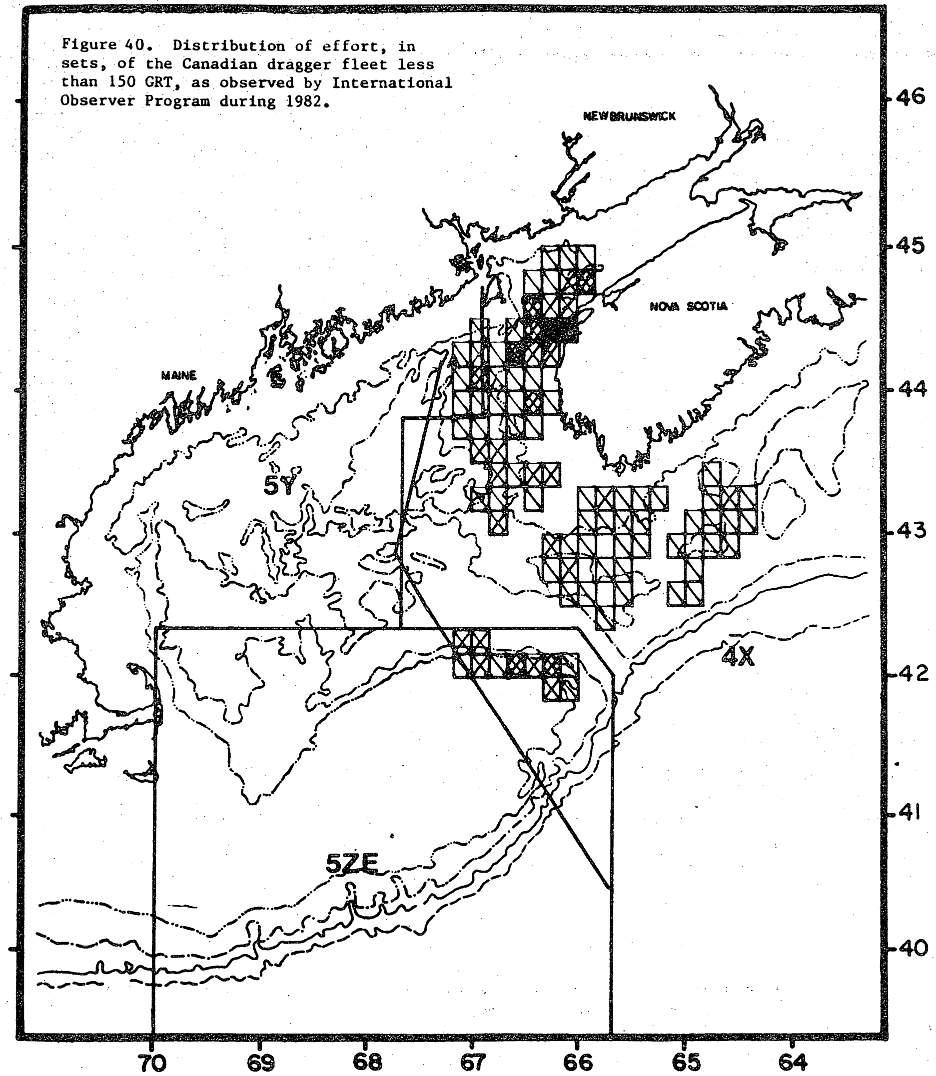


Figure 40. Distribution of effort, in sets, of the Canadian dragger fleet less than 150 GRT, as observed by International Observer Program during 1982.

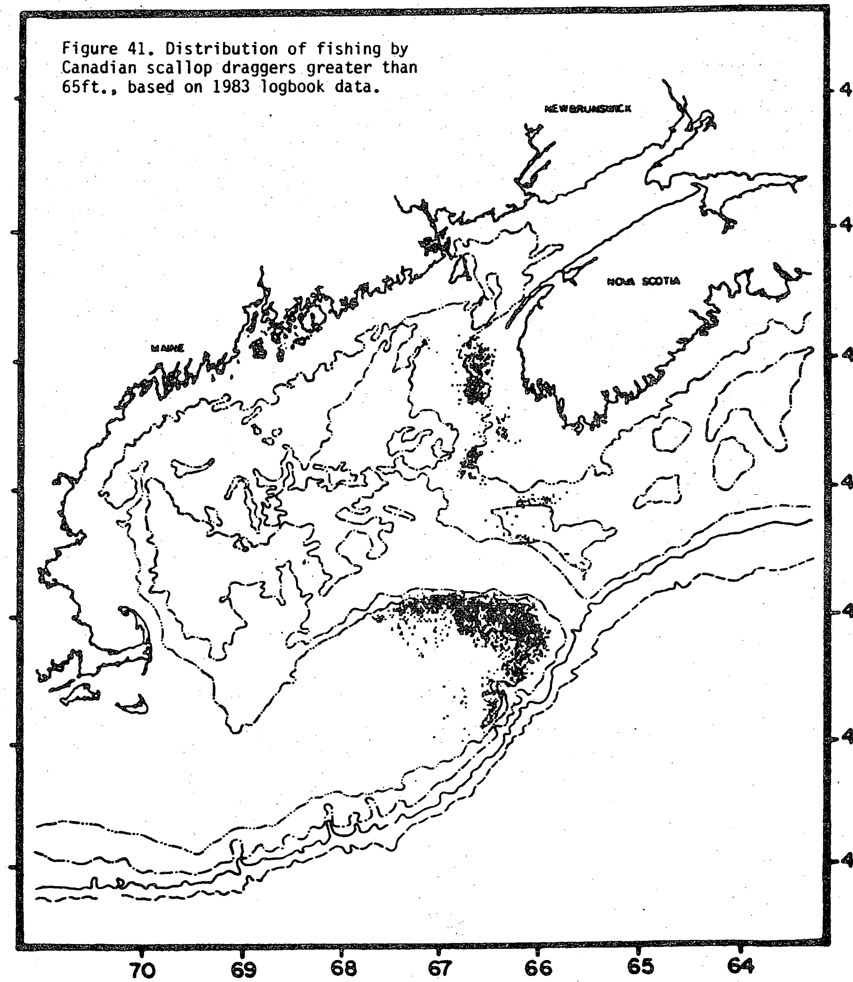


Figure 41. Distribution of fishing by Canadian scallop draggers greater than 65ft., based on 1983 logbook data.

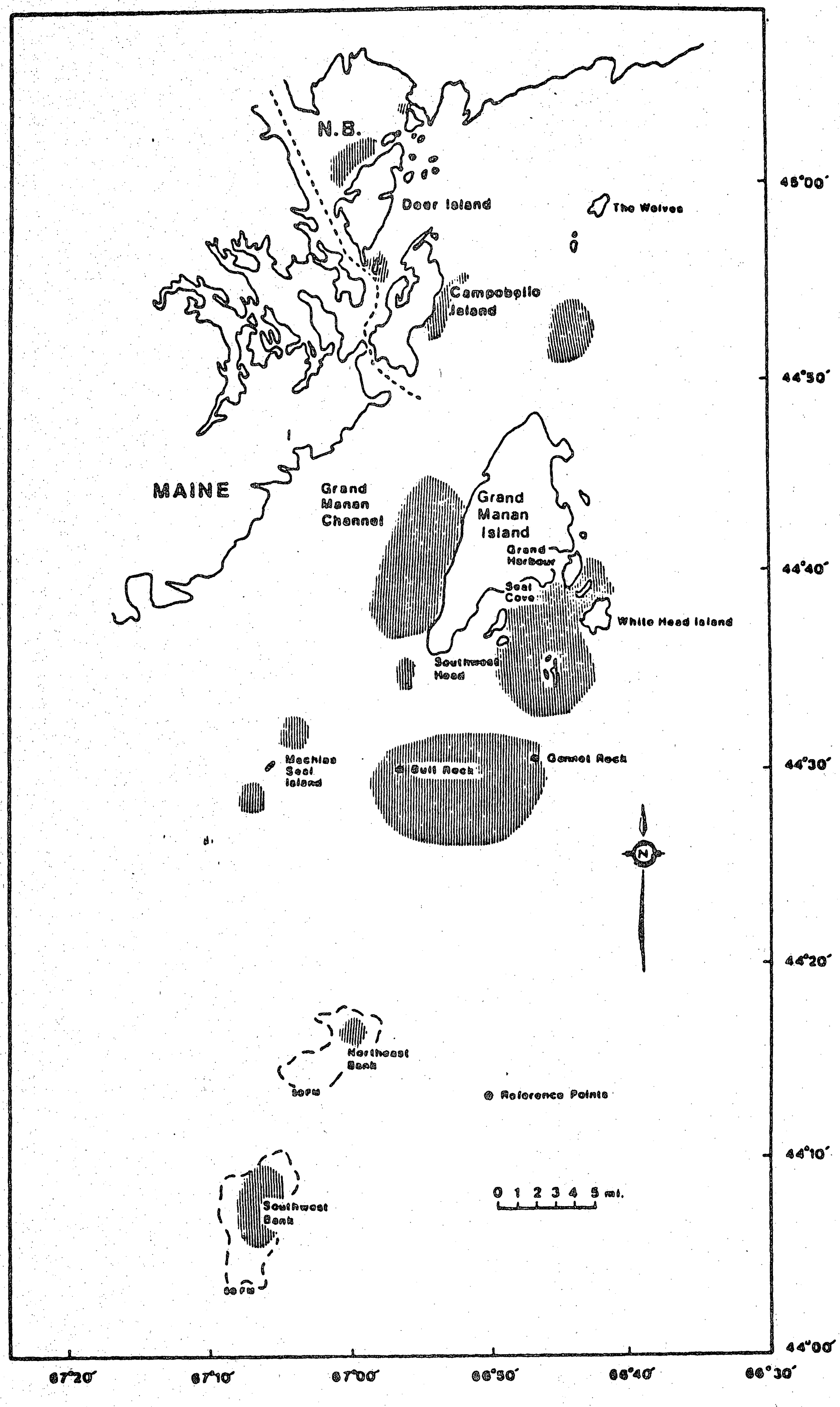


Figure 42. Estimated location of scallop fishing grounds exploited by New Brunswick-based vessels, mainly from Grand Manan Island. (From: Robert, G. and M. J. Lundy, CAFSAC Res. Doc. 85/29.)

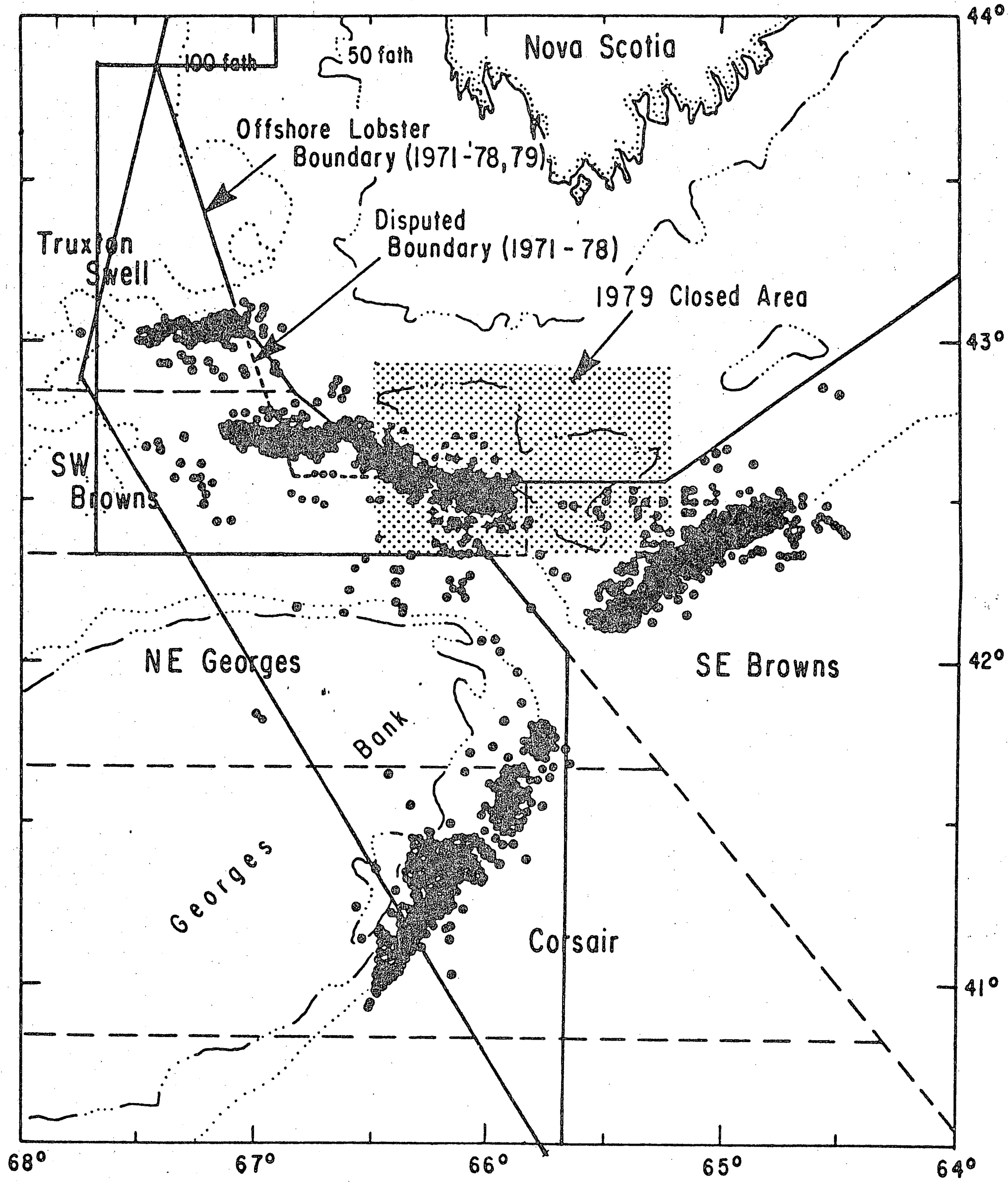


Figure 43. Canadian offshore lobster fishing areas 1973-1979 showing the closed area. (From Stasko and Pye, CAFSAC Res. Doc. 80/56. ICJ line and Subarea 4/5 line added.)