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Stock structure of American plaice, witch and winter flounder in the Gulf of Maine area: implications for management

by

John D. Neilson and Peter Hurley[2]
Marine Fish Division
Fisheries Research Branch
Department of Fisheries and Oceans
Biological Station
St. Andrews, New Brunswick EOG 2XO

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[2]Marine Fish Division, Bedford Institute of Oceanography, Dartmouth, Nova Scotia B2Y 4A2

Abstract

The present knowledge concerning stock structure of winter flounder (*Pseudopleuronectes americanus*), witch flounder (*Glyptocephalus cynoglossus*) and American plaice (*Hippoglossoides platessoides*) in the Gulf of Maine area is reviewed. Ample evidence exists for the occurrence of separate stocks of winter flounder on Georges Bank and on the Scotian Shelf, although the stock structure in the western Gulf of Maine is less clear. Relatively few data pertaining to the stock structure of witch flounder and American plaice are available.

Résumé

Dans le présent texte, on examine les données dont on dispose sur la structure du stock de plie rouge (*Pseudopleuronectes americanus*), de plie grise (*Glyptocephalus cynoglossus*) et de plie canadienne (*Hippoglossoides platessoides*) dans la région du golfe du Maine. Il apparaît manifeste qu'il existe des stocks séparés de plie rouge sur le banc Georges et sur la plate-forme Scotian, la structure du stock dans la partie ouest du golfe du Maine étant moins claire. On dispose de relativement peu de données sur la structure du stock de plie grise et de canadienne.

Introduction and Problem Statement

The purpose of this document is to review the present knowledge concerning the stock structure of winter flounder (Pseudopleuronectes americanus), witch flounder (Glyptocephalus cynoglossus) and American plaice (Hippoglossoides platessoides) in the Gulf of Maine area. The utility of present management area boundaries are assessed in light of information on stock structure and several alternatives considered. Finally, potential topics for further research which would help address shortcomings in current understanding of stock structure in the Gulf of Maine area are suggested.

Given the ambiguity of meaning associated with the term "stock" we felt it was advisable to offer a definition which would be used in a consistent fashion throughout the paper. We subscribe to the view of Gulland (1983), who stated that for many purposes of stock assessment analysis, the choice and definition of a unit stock can be considered as essentially an operational matter. A group of fish can be treated as a unit stock if possible differences within the group and interchanges with other groups can be ignored without making the conclusions reached depart from reality to an unacceptable extent.

Gulland notes that a number of aspects can be examined to provide information on possible stock separation. These include:

1. Distribution of fishing. A gap in fishing suggests a gap in the distribution of fish, which may correspond to a separation of stocks.

2. Spawning areas. A genetic separation of stocks more or less requires a clear separation of spawning groups, even if the fish mix at other times of life. Surveys of mature fish and subsequent reproductive products are of obvious utility in this regard.

3. Values of population parameters. If there are stock differences, and if these differences are important, differences should exist in growth and mortality, for example.

4. Morphological or physiological characteristics. Characteristics that are genetically determined can provide clear evidence that two groups are distinct, but genetic separation can in principle exist without this being evident in the characteristics examined. Moreover, the effects of environmental variables on morphological or physiological characteristics can often render the interpretation of variability difficult.

5. Tagging. Gulland notes that in principle, this method can give the clearest evidence of stock separation or otherwise.

In attempting to assess the biological basis for management units, we addressed each of the five aspects identified by Gulland for evidence for discrete stocks in the Gulf of Maine region.

History of Management Area Definition

The history of the Subarea 4/5 boundary is discussed in Halliday et al. (MS 1985) and the interested reader is referred to that work for details. As noted by those authors, while the original location and subsequent modifications of the boundary lines were well documented, the biological basis for the lines is less clear. The Subarea 4/5 boundary probably reflected the current understanding of stock structure, particularly that of haddock (*Melanogrammus aeglefinus*).

Review of Biological Basis for the Definition of Unit Stocks

1. Distribution of the Resource and Fishing Effort

1.1 Winter flounder

To obtain plots of resource distribution in the Gulf of Maine area, we used results of the United States National Marine Fisheries Service (NMFS) research cruises conducted in spring and fall of 1982-1984. We chose to use the US data rather than Canadian sources due to the better coverage in the area in question. The distribution of sets are shown in Figs. 1 and 2 for the spring and fall surveys, respectively.

Winter flounder distributions show a clear association with shallow water (Figs. 3 and 4). Areas of concentration included the mouth of St. Mary's Bay, Browns Bank and Georges Bank. The fall distribution (Fig. 4) shows that fish in Subdiv. 5Ze were associated with the northern half of Georges Bank, whereas fish caught in the spring were in shallower water on the bank.

Canadian annual catches of winter flounder over the period 1979 to 1983 have averaged 1087 t in Div. 4X and 23 t in Subdiv. 5Ze. The unit areas associated with most of the catches have been the nearshore areas of 4Xq and 4Xr in Div. 4X and 5Zej in Subdiv. 5Ze. United States average annual catches was 3 t in Div. 4X and 8259 t in Subdiv. 5Ze over 1979 to 1983. All unit areas comprising Subdiv. 5Ze contributed to the total, with 5Zeg predominating. The US catch of winter flounder in Div. 5Y is also significant, with 2382 t taken over 1979-1983, mainly in 5Ye (1894 t).

1.2 Witch flounder

Witch distributions for the spring and fall cruises by NMFS are shown in Figs. 5 and 6, respectively. In contrast to winter flounder, this species shows no marked preference for the shallow water of the banks, nor were there significant concentrations of witch flounder in the vicinity of Canadian waters and the ICJ line.

Canadian annual catches of witch flounder over the period 1979 to 1983 have averaged 403 t in Div. 4X and 15 t in Subdiv. 5Ze. The unit areas associated with most of the catches have been 4Xo and 4Xr in Div. 4X and 5Zej in Subdiv. 5Ze. United States average annual catches was 58 t in Div. 4X and 985 t in Subdiv. 5Ze over 1979 to 1983. Unit areas comprising most of the US catch were 4Xp and 4Xq in Div. 4X and 5Zeg and 5Zeh in Subdiv. 5Ze, the relatively deep-water area on the north-west side of Georges Bank. Witch flounder in Div. 5Y are an important fishery, with 3073 t taken on average each year from 1979 to 1983. Unit area 5Yd is dominant, contributing 1640 t over the same period.

1.3 American plaice

American plaice distributions for the spring and fall cruises conducted by NMFS are shown in Figs. 7 and 8, respectively. The distributions are similar to those obtained for witch flounder, except that a concentration of fish was found on Browns Bank in spring. While there were some concentrations of fish on Browns Bank and in the mouth of St. Mary's Bay in spring, no substantial aggregations occurred in the immediate vicinity of the ICJ line.

Canadian annual catches of American plaice over the period 1979 to 1983 have averaged 542 t in Div. 4X and 27 t in Subdiv. 5Ze. The unit areas associated with most of the catches have been 4Xo and 4Xr in Div. 4X and 5Zej in Subdiv. 5Ze. United States average annual catches was 54 t in Div. 4X and 3044 t in Subdiv. 5Ze over 1979 to 1983. Unit areas comprising most of the US catch were 4Xp and 4Xq in Div. 4X and 5Zeg and 5Zeh in Subdiv. 5Ze. American plaice in Div. 5y are a very significant fishery, with 10,136 t taken on average each year from 1979 to 1983. Unit area 5Yd again contributes the most to the total.

2. Distribution of Spawners and their Reproductive Products

2.1.1 Reproductive ecology of winter flounder

As noted by Smith (1985) winter flounder spawn demersal eggs in shallow waters in late winter and spring. In the Gulf of Maine area, spawning peaks in April coincident with bottom temperatures of 3.3 to 5.5°C (Bigelow and Schroeder 1953). Spawning on the Scotian Shelf is also limited mostly to shallow coastal waters, with the seasonal peak usually occurring in May (Leim and Scott 1966). The eggs of winter flounder are demersal, and the larvae pelagic (Klein-MacPhee 1978).

2.1.2 Distribution of ripening, ripe and spent female winter flounder

The distribution of sets during spring (1979-1984) and summer (1978-1984) Marine Fish Division (MFD) cruises is shown in Figs. 9 and 10, respectively. Georges Bank was included only in the spring, 1984. The geographic distribution of catches of ripening, ripe and spent females at those stations is shown in Fig. 11 and 12 for spring and summer cruises, respectively. Notable concentrations of such fish were found during the spring surveys within the 50-fm contour on Browns Bank, the mouth of St. Mary's Bay and the upper Bay of Fundy. Some mature fish were also found on Georges Bank, although our coverage of that area was limited to one cruise only. Catches of mature fish during the summer series were less numerous, with most fish caught near the mouth of St. Mary's Bay. These comparatively recent observations are consistent with those of Scott (1983), who examined data from twelve research cruises conducted from 1971-1981. In summary, there is substantial evidence that spawning concentrations are contagiously distributed throughout the Scotian Shelf and Gulf of Maine region.

2.1.3 Distribution of winter flounder eggs and larvae

As winter flounder produce demersal eggs and the duration of the larval stage is very short, there are no studies available which deal with the geographic distribution of eggs and larvae.

2.2.1 Reproductive ecology of witch flounder

Witch flounder spawn in late spring and summer in the Gulf of Maine area and at water temperatures of 4 to about 9°C (Bigelow and Schroeder 1953). Spawning grounds are not well defined, but the species appears to spawn widely throughout the western Gulf of Maine (Marak et al. 1962a, b; Evseenko and Nevinsky 1975). The spawning season is protracted (Burnett and Clarke 1983). Colton et al. (1979) report peak spawning in May and June, while Bigelow and Schroeder (1953) and Evseenko and Nevinsky (1975) have found highest egg densities in July and August. The eggs and larvae are pelagic (Lange and Lux 1978), with the larval pelagic stage particularly lengthy (up to one year). Hence, the potential for dispersal is relatively great. Shelf water circulation transports some larvae south and westward, apparently accounting for the southern extension of witch flounder distribution along the continental shelf south of Georges Bank (Markle 1975).

2.2.2 Distribution of ripening, ripe and spent female witch flounder

Distributions of ripening, ripe and spent female witch flounder obtained from spring (1979-1984) and summer (1978-1984) MFD cruises is shown in Figs. 13 and 14, respectively. In contrast with winter flounder, mature witch flounder were not found in association with shallow water. Notable concentrations were found in the Fundian Channel and at the mouth of the Bay of Fundy, mostly in spring. Our results contrast with those of Evseenko and Nevinsky (1975), who found no evidence of witch flounder spawning in the Gulf of Maine area. In summary, the distribution of mature witch flounder appears less patchy than does that of winter flounder, for example.

2.2.3 Distribution of witch flounder eggs and larvae

The distribution of late stage witch flounder eggs is shown in Fig. 15. Only in late stages are the identifications of witch flounder eggs entirely reliable. The occurrences of witch eggs were limited to the region off St. Mary's Bay and German Bank, with only one occurrence on Georges Bank. This contrasts with the findings of Evseenko and Nevinsky (1975) who found eggs on Georges Bank but not on Browns Bank in a series of ichthyoplankton cruises conducted in May and June, 1959-1970 in the Gulf of Maine area. Very little coverage of Div. 5Y occurred during those cruises.

2.3.1 Reproductive ecology of American plaice

American plaice commence spawning in the Gulf of Maine area in February and continue through June (Smith 1985). Their eggs and larvae are pelagic. Peak spawning occurs in April and May (Bigelow and Schroeder 1953; Colton et al. 1979; O'Boyle et al. 1982; Sullivan 1981). O'Boyle et al. (1982) found eggs to be abundant on the Scotian Shelf in April and speculated that spawning there had occurred a month or more after the peak spawning period on Georges Bank. Smith (1985) contested the finding of O'Boyle et al. (1982), stating that other evidence suggested peak spawning on the Scotian

Shelf from mid-April through May, about the same period as that noted in the Gulf of Maine area (Powles 1965; Pitt 1966; Nevinsky and Serebryakov 1973).

2.3.2 Distribution of ripening, ripe and spent female American plaice

Distributions of ripening, ripe and spent female American plaice obtained from spring (1979-1984) and summer (1978-1984) MFD cruises is shown in Figs. 16 and 17, respectively. Considerable numbers of mature fish were found in spring in association with Browns Bank, with very few found in the Fundian Channel. Few fish were found during summer cruises. Nevinsky and Serebryakov (1973) also implied that a concentration of spawners occurred on Browns Bank, a view supported by the data of Scott (1983).

2.3.3 Distribution of American plaice eggs and larvae

The distribution of American plaice eggs obtained in cruises conducted in March and April of 1984 are shown in Figs. 18 and 19, respectively. Interestingly, there were two sets where substantial numbers of American plaice eggs were found in the Fundian Channel in March. Given that very few mature fish were found in the Fundian Channel, the occurrence of eggs there is somewhat surprising given our appreciation of current regimes in the area (Perry MS 1986). It may be that winter storm action displaced those eggs from Georges Bank. In April, the majority of sets made off south-western Nova Scotia yielded plaice eggs whereas the few sets made on Georges Bank did not. It may be that the timing of egg production differs between Georges Bank and the Scotian Shelf.

Nevinsky and Serebryakov (1973) found concentrations of American plaice eggs in association with Browns Bank in their analyses of ichthyoplankton data obtained from 1959-1970. An aggregation of eggs was also found in slope waters just south of the Northeast Peak of Georges Bank. Results presented by Sullivan (1981) showed similar distributions of eggs of American plaice to those obtained by Nevinsky and Serebryakov. She also noted that larvae were found in much the same areas as eggs, and were most abundant during April and May.

3. Values of Population Parameters

3.1 Winter flounder

Lux (1973) described the growth of winter flounder from Georges Bank, and found that fish from eastern Georges Bank grew slightly faster than those from western Georges Bank. His data were obtained from both commercial and research vessel samples. He provided von Bertalanffy growth curves (fish $>$ 3 years old) for eastern Georges Bank fish as follows:

$$l_t = 550(1-e^{-0.37(t+0.05)}) \quad \text{(male)}$$
$$l_t = 630(1-e^{-0.31(t-0.05)}) \quad \text{(female)}$$

We generated a von Bertalanffy relationship for winter flounder from Subdiv. 4X by combining commercial samples taken from 1984 (all gear types). The resulting equations are:

$$l_t = 397(1-e^{-0.45(t-0.41)}) \quad \text{(male)}$$
$$l_t = 463(1-e^{-0.30(t-0.92)}) \quad \text{(female)}$$

As indicated by the above relationships, the length at age of winter flounder originating from Subdiv. 5Ze are usually greater than corresponding lengths at age for fish from Subdiv. 4X (Table 1).

3.2 Witch flounder

No published data are available for Div. 5Y witch flounder.

3.3 American plaice

Mean length at age data are available from Lux (1970) and Sullivan (1981) for the Gulf of Maine area, and from Halliday (1973) and recent MFD research vessel collections for the Scotian Shelf (Table 2). The von Bertalanffy equations corresponding to those data are given below:

$l_t = 450(1-e^{-0.27(t+0.41)})$ (Lux, W. Gulf of Maine, males)
$l_t = 675(1-e^{-0.15(t+0.10)})$ (Lux, W. Gulf of Maine, females)
$l_t = 598(1-e^{-0.17(t+0.04)})$ (Sullivan, Gulf of Maine, males)
$l_t = 642(1-e^{-0.17(t+0.12)})$ (Sullivan, Gulf of Maine, females)
$l_t = 446(1-e^{-0.11(t-2.16)})$ (Halliday, Scotian Shelf, males)

Many of the above relationships, including others for comparative purposes, are summarized in Fig. 20.

However, whether such differences are significant in ascribing stock structure is difficult to say. As noted by Ihssen et al. 1981, because of their high sensitivity to extrinsic factors, such population parameters tend to characterize the environment occupied by the population as well as the stock itself. Use of population parameters to ascribe stock discreteness without reference to other independent methods is therefore probably inadvisable.

4. Morphological and Physiological Characteristics

4.1 Winter flounder

In 1912, Kendall described the Georges Bank winter flounder as a new species *Pseudopleuronectes dignabilis*. He indicated that the most conspicuous differential characteristics of the species were shorter head, greater number of fin rays, colour and larger size. Spawning season also differed compared with inshore populations of *P. americanus*. However, the differences that Kendall described have since been attributed to racial rather than specific differences (Bigelow and Schroeder 1953). The localized occurrence of abnormally pigmented winter flounder on Georges Bank in 1959 substantiates the view that winter flounder populations do not intermingle to any great extent. The incidence of the abnormally pigmented form was limited to one small area of the bank (Anon. 1964).

Perlmutter (1947) compared counts of winter flounder north and south of Cape Cod and from Georges Bank. He indicated that Georges Bank winter flounder had significantly different dorsal, pectoral and anal fin ray counts showing there was little mixing of this stock with other winter flounder stocks.

Lux et al. (1970) compared dorsal and anal fin ray counts on winter flounder from inshore waters off Massachusetts north and south of Cape Cod and from Georges Bank. Fish from south of Cape Cod had more fin rays than those from north of the Cape, and fish from Georges Bank had more fin rays than those from either inshore area. An examination of water temperature at spawning time revealed that temperature at time of spawning was greater on Georges Bank than at the more inshore sites. Klein-MacPhee (1978) suggests that higher counts of fin rays may be associated with the higher water temperature at time of spawning on Georges Bank.

4.2 Witch flounder

No published studies of witch flounder morphological and physiological characteristics exist which are relevant to a discussion of stock structure in the Gulf of Maine area.

4.3 American plaice

No published studies of American plaice morphological and physiological characteristics exist which are relevant to a discussion of stock structure in the Gulf of Maine area.

5. Tagging Studies

5.1 Winter flounder

Apart from a seasonal onshore-offshore migration (see Klein-MacPhee (1978) for a detailed review), winter flounder are known to be a generally sedentary species. Howe and Coates (1975) reported results of a 10-yr tagging study off Massachusetts. Flounder tagged at 21 locations showed the following movements: north of Cape Cod they were localized and confined to inshore waters, south of Cape Cod seasonally dispersed in a southeast direction beyond the territorial limit, and little mixing between Georges Bank and inshore areas. Movements appeared to be related to water temperature. Saila (1961) showed that winter flounder return to the same area each year to spawn.

Conclusions Regarding Stock Structure

We summarize our conclusions regarding the stock structure of Gulf of Maine flatfish in Table 3. We attempted a subjective rating of how well the various flatfish species met the criteria of Gulland (1983) for ascribing the occurrence of separate stocks. While this method relies heavily on our qualitative judgement of the merit of the available evidence, it provides a comparison of the strength of our conclusions and indicates the type of information upon which they were based.

The case for separate stocks (5Ze and 4X) of winter flounder seems clear. Evidence supporting this assertion is available for all five criteria identified by Gulland. However, the situation for witch flounder and American plaice is equivocal. For the former species, the stock status may soon become more clear with the release of a Ph.D. thesis on witch flounder stock structure in the Gulf of Maine to be defended at the University of Rhode Island in March, 1986.

Recommendations for Future Research

The southern limit of the Georges Bank winter flounder stock appears to be poorly understood. However, this may not represent a serious deficiency in our understanding, as it appears unlikely that recruitment to the offshore population is linked to the more inshore populations in the Cape Cod vicinity, given the limited dispersal potential of early life history phases and the comparatively sedentary habits of adults.

While the rather sedentary nature of winter flounder movement with respect to between bank migration in the Gulf of Maine area is fairly well documented, their movement on Georges Bank is poorly understood. The extent of winter flounder movement throughout the bank has ramifications for possible joint Canada/USA management of the resource. The deficiency in our understanding could be addressed with a tagging program specially designed to gain a better appreciation of intrabank movement of winter flounder.

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Table 1. Comparison of winter flounder lengths at age, Subdiv. 5Ze and Div. 4X.

Source Sex Year Region Season	MFD combined 1984 4X commercial samples throughout year	Lux, 1973 male 1963-1966 5Z Spring	Lux, 1973 female 1963-1966 5Z Spring
Age			
1		8.2	8.4
2	20.0	25.5	25.1
3	25.6	37.3	38
4	29.5	43.3	45.4
5	33.9	46.4	50.1
6	36.8	48.4	52.8
7	39.6	49.9	55.1
8	42.5	52.6	56.7
9	44.6	52.2	57.7
10		52.7	59.5
11		50.8	59.6
12			67.4
13			
14			
TOTAL N	312	184	163

Table 2. Comparison of American plaice lengths at age, Divs. 4X and 5Y.

Source Sex Year Region Season	Lux male 1958-1959 5Yd and 5Ye April-June	Lux female 1958-1959 5Yd and 5Ye April-June	Sullivan male 1980 5Y (only?) Spring	Sullivan female 1980 5Y (only?) Spring	MFD male 1980 4X Spring	MFD female 1980 4X Spring
Age						
1			8.25	8.25	8.25	
2	17.9	18.1	18.64	17.87	12	15
3	23.9	24.5	24.5	25.65	20.86	17.93
4	29.4	30.8	29.97	30.08	24.45	24.41
5	35	37.4	34	35.25	29.21	31.07
6	33	40.1	39.05	40.75	32.44	33.9
7		43.5	44	44.36	39.63	39.81
8		41.7	44.875	48.1	34.15	43.3
9		49.9	47.125	51	47	43.58
10				52.13	36	44.96
11				53		48.5
12				46		
13				61.5		
14				56.17		
15				60		
16						
TOTAL N	55	125	228	349	56	123

Table 3. Subjective rating of the extent to which Gulf of Maine flatfish meet Gulland's criteria for stock discreteness. In the case of winter flounder, the comparison was between Subdiv. 5Ze and Div. 4X. For American plaice and witch flounder, the comparison was between Divs. 5Y and 4X. The criteria for scoring is given below:

- 5 - strong evidence supporting the occurrence of separate stocks
- 3 - some evidence supporting the occurrence of separate stocks
- 0 - no evidence, or conflicting findings
- -3 - some evidence supporting the view that only one stock occurs in the Gulf of Maine area
- -5 - strong evidence supporting the view that only one stock occurs in the Gulf of Maine area

Criterion for stock discrimination	Winter	Witch	American plaice
1. Distribution of resource and fishing	5	-3	0
2. Separation of spawning areas and reproductive products	3	-3	3
3. Values of pop. parameters	3	0	3
4. Morphological or physiol. characteristics	3	0	0
5. Movements and migrations	3	0	0
Total Score	17	-6	6

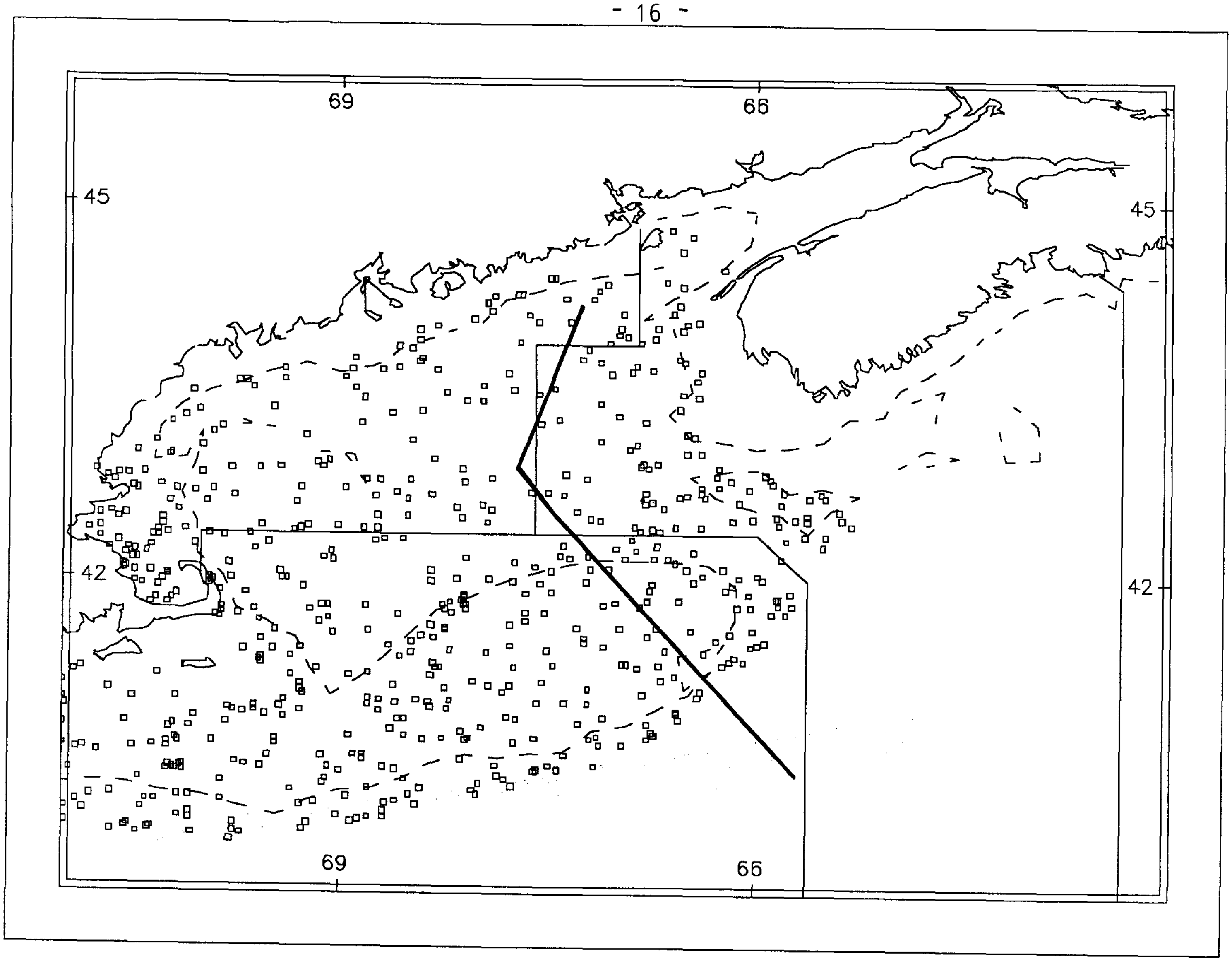


Fig. 1. Distribution of sets during United States National Marine Fisheries Service research vessel surveys, Gulf of Maine area, 1982-1984 (spring). The NAFO management boundaries and the ICJ line are also shown.

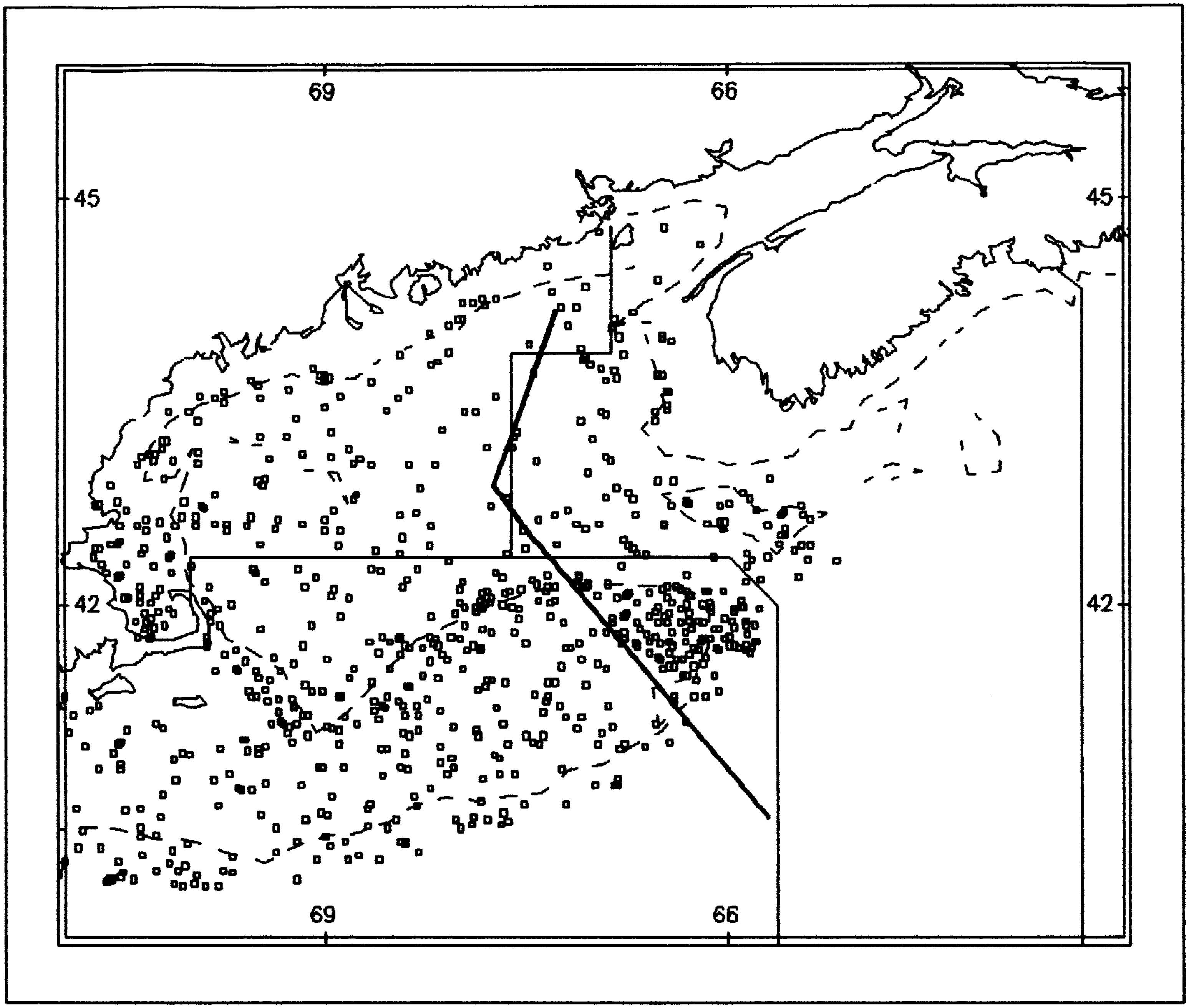


Fig. 2. Distribution of sets during United States National Marine Fisheries Service research vessel surveys, Gulf of Maine area, 1982-1984 (fall). The NAFO management boundaries and the ICJ line are also shown.

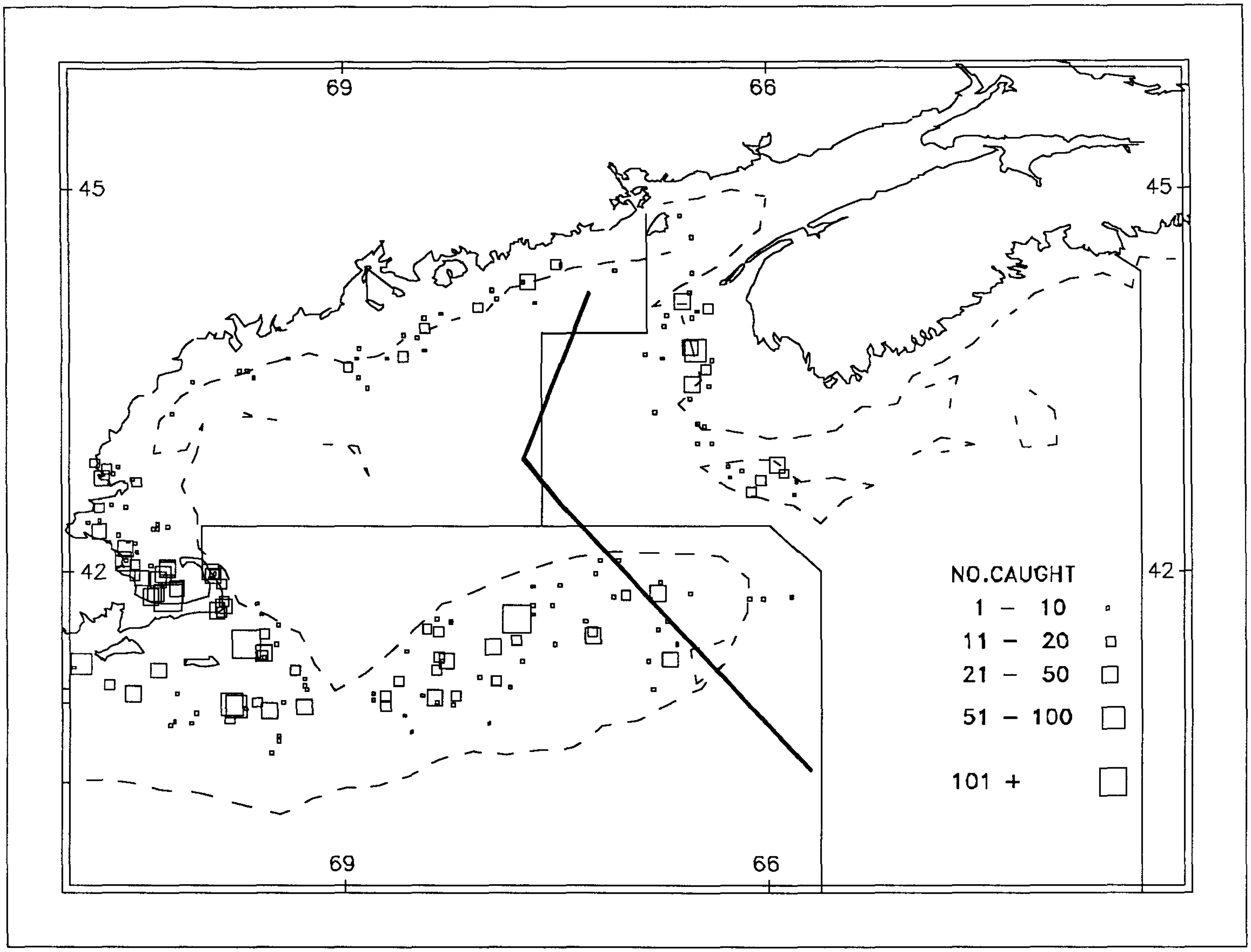


Fig. 3. Distribution of catches of winter flounder observed during National Marine Fisheries Service spring cruises conducted from 1982-1984.

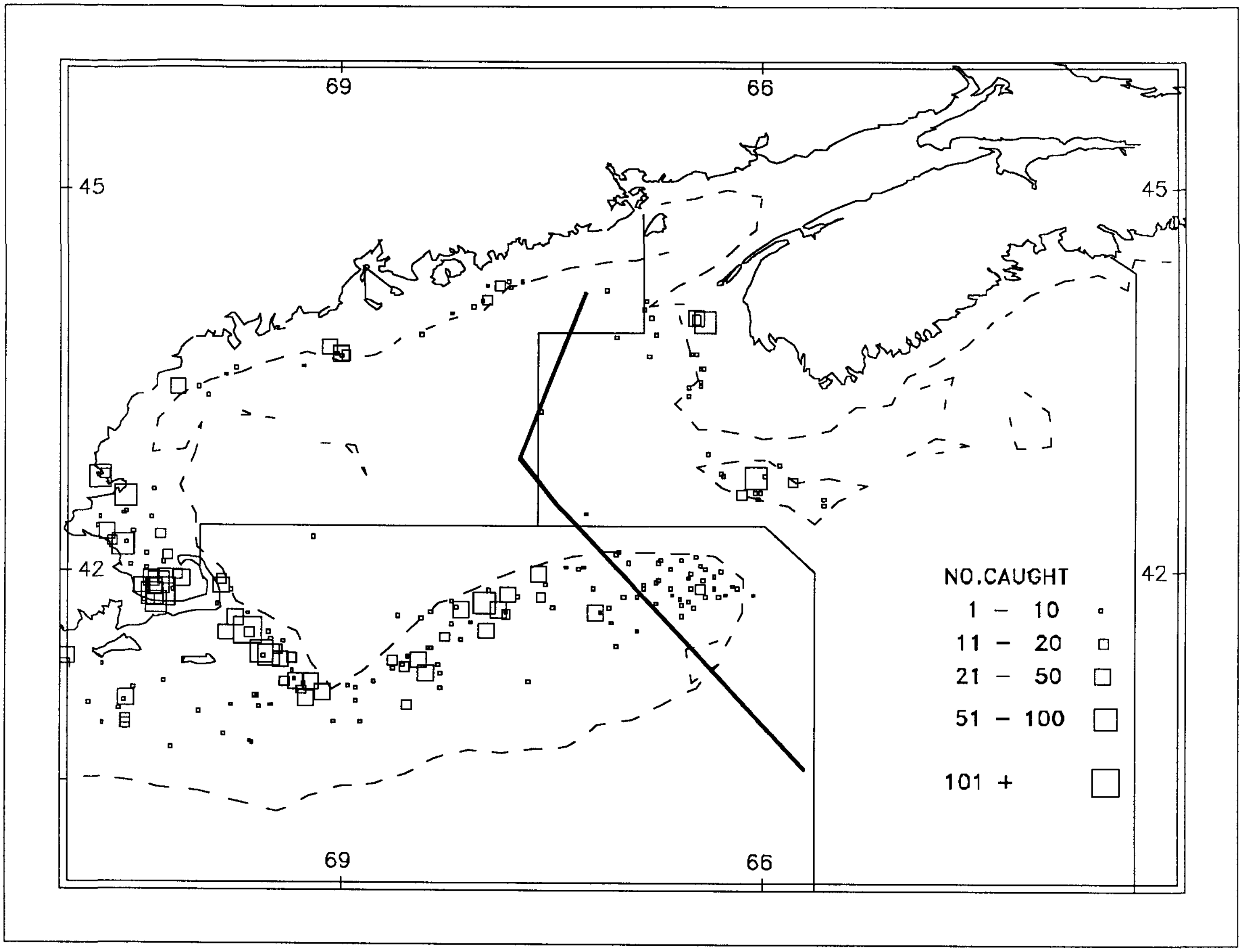


Fig. 4. Distribution of catches of winter flounder observed during National Marine Fisheries Service fall cruises conducted from 1982-1984.

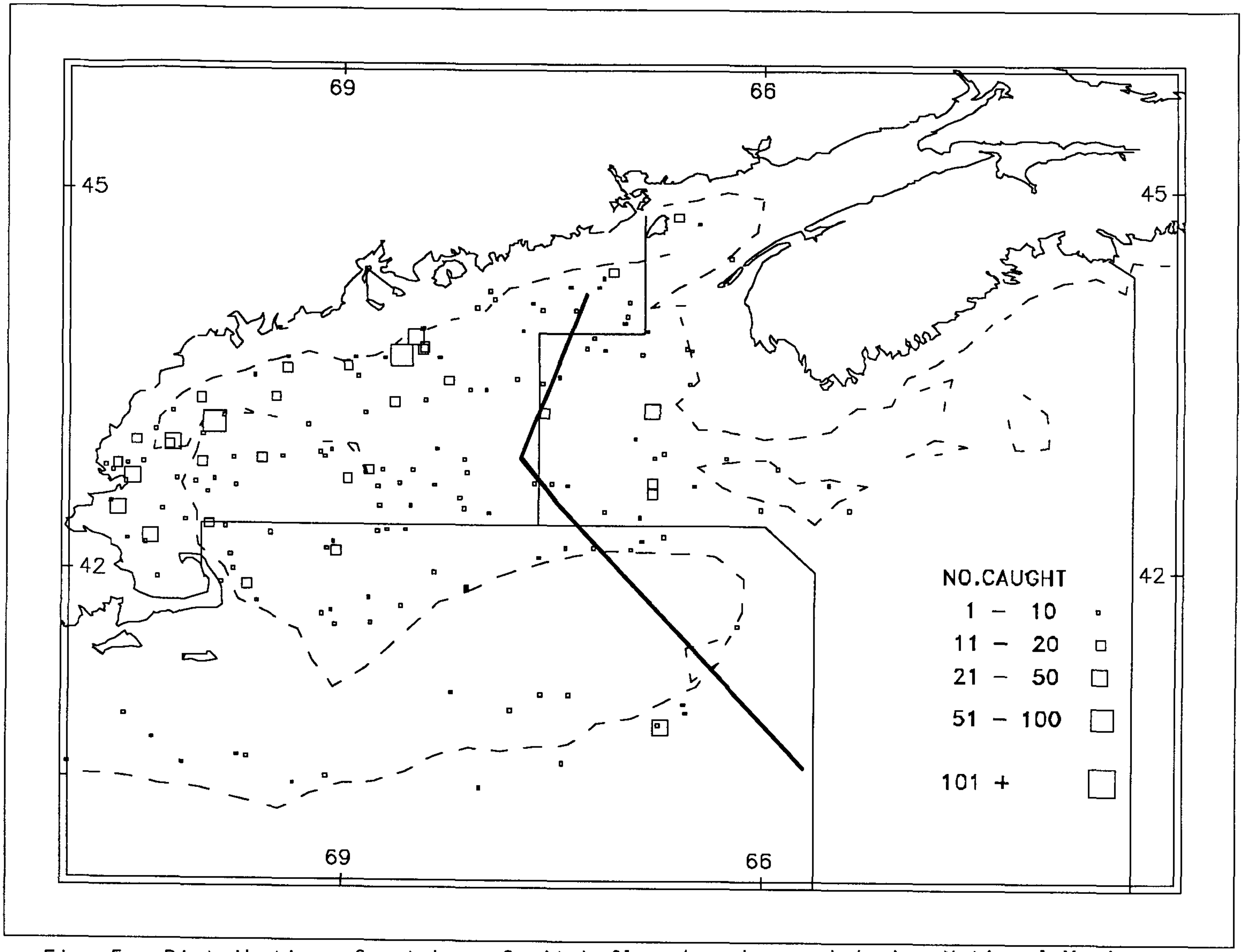


Fig. 5. Distribution of catches of witch flounder observed during National Marine Fisheries Service spring cruises conducted from 1982-1984.

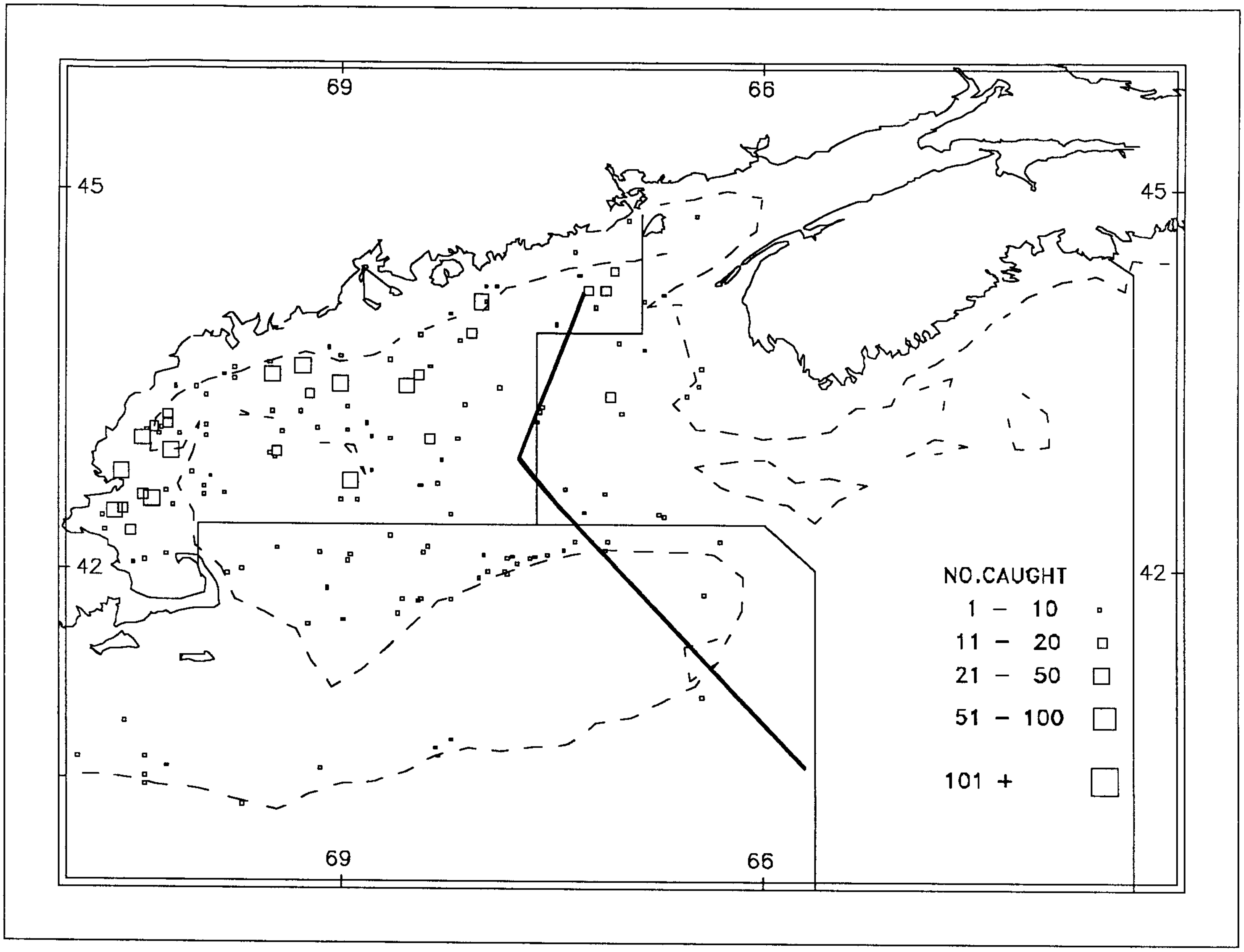


Fig. 6. Distribution of catches of witch flounder observed during National Marine Fisheries Service fall cruises conducted from 1982-1984.

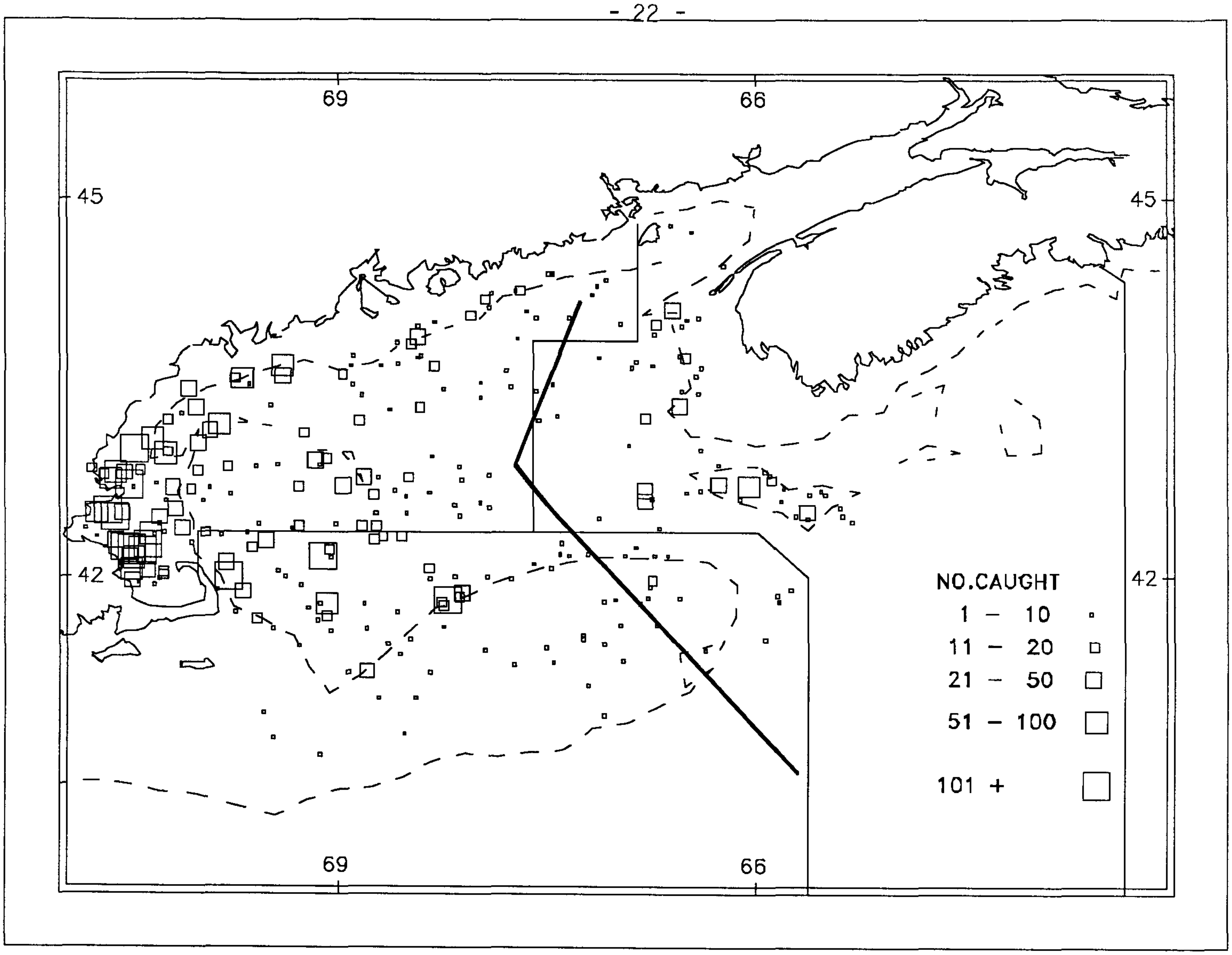


Fig. 7. Distribution of catches of American plaice observed during National Marine Fisheries Service spring cruises conducted from 1982-1984.

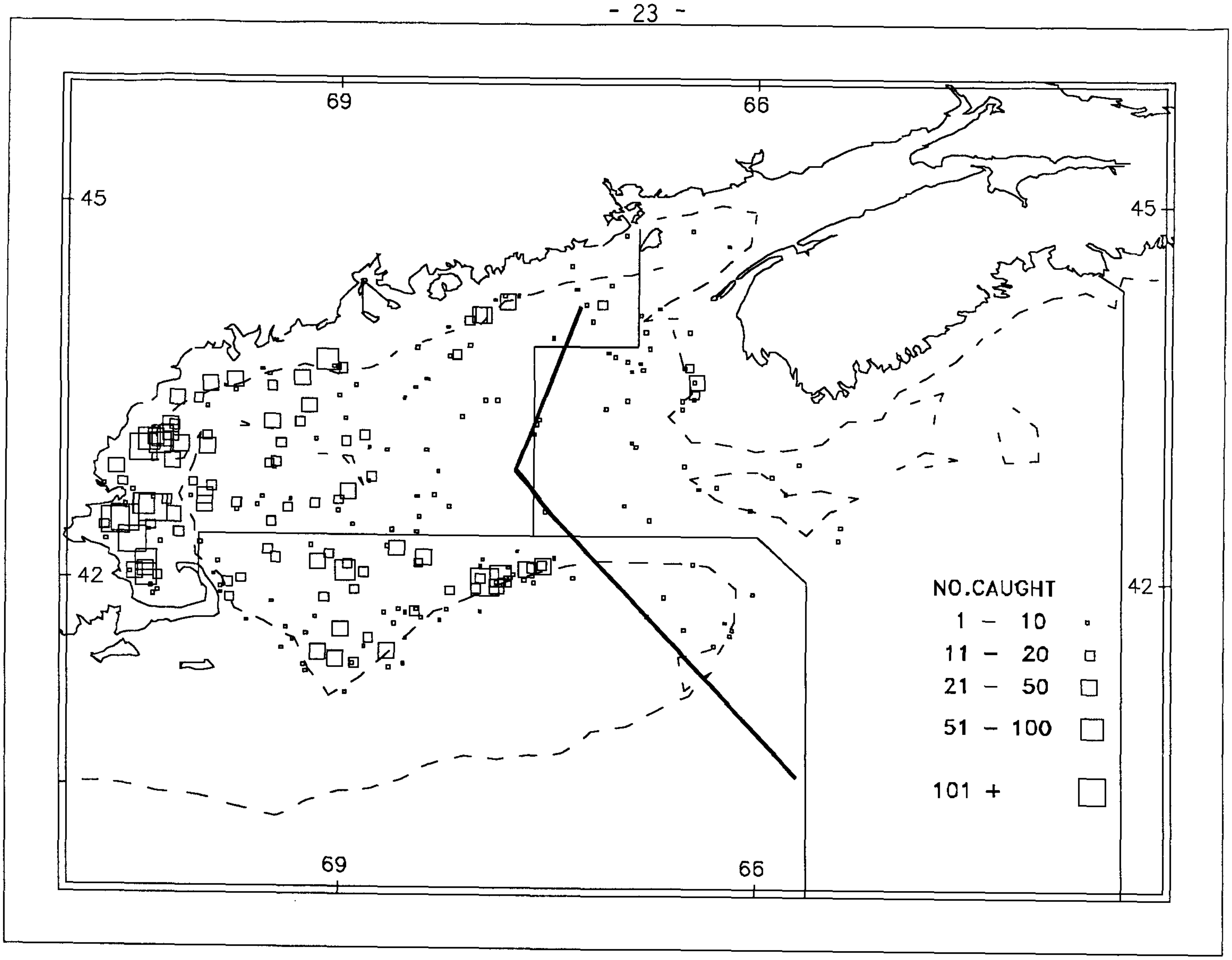


Fig. 8. Distribution of catches of American plaice observed during National Marine Fisheries Service fall cruises conducted from 1982-1984.

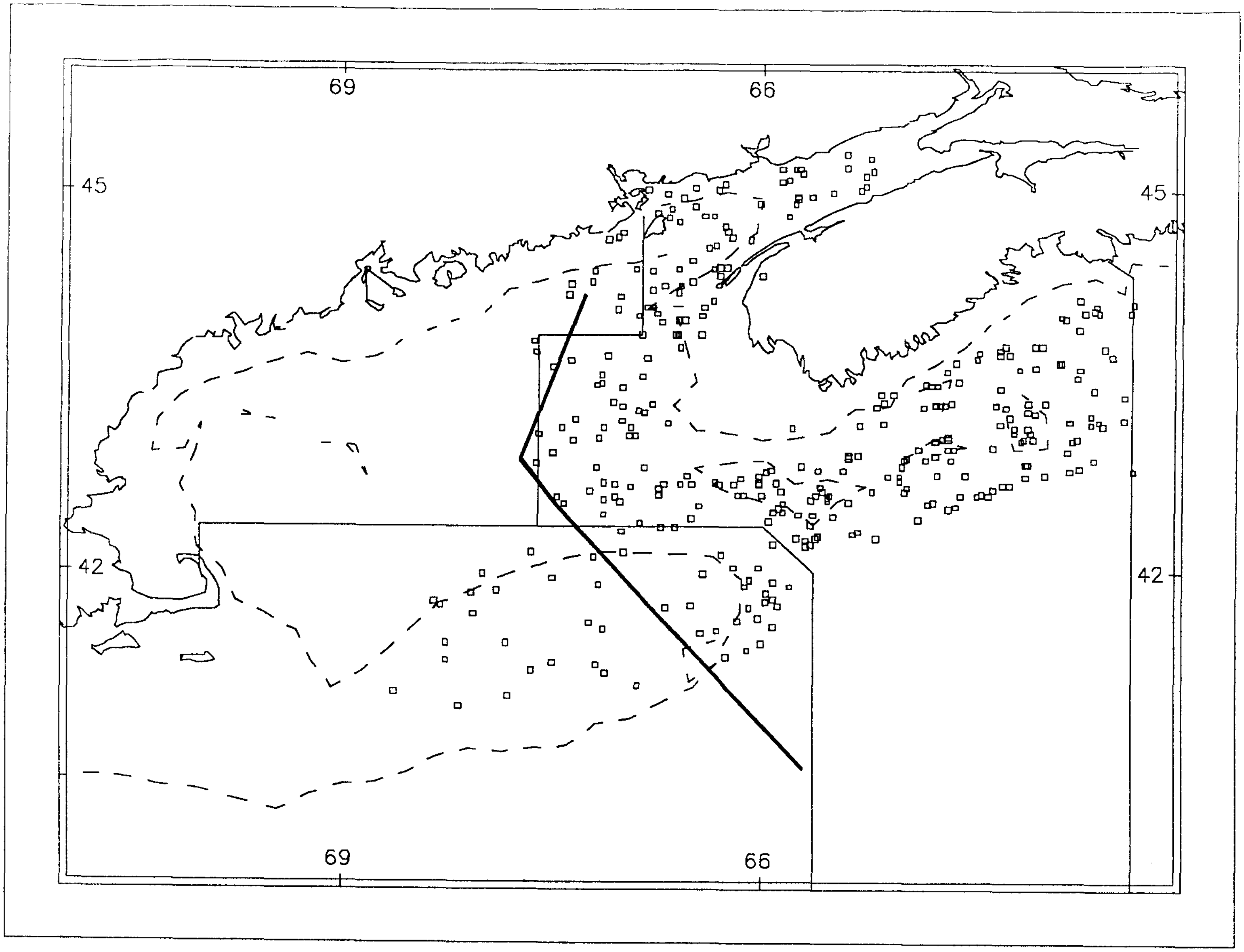


Fig. 9. Distribution of sets during Marine Fish Division research vessel surveys, Gulf of Maine area, 1979-1984 (spring). Coverage of Georges Bank was obtained only during the 1984 survey.

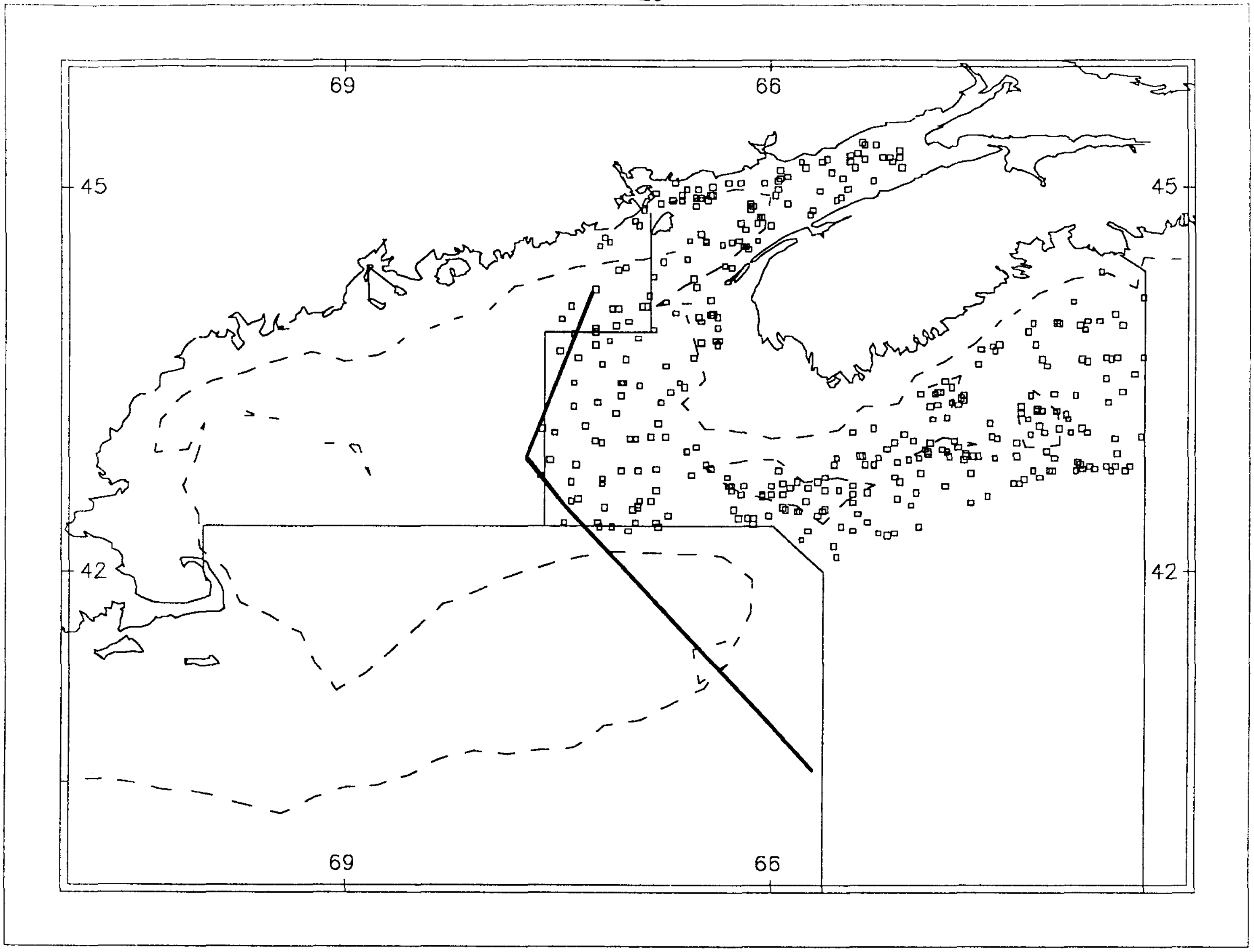


Fig. 10. Distribution of sets during Marine Fish Division research vessel surveys, Gulf of Maine area, 1979-1984 (summer).

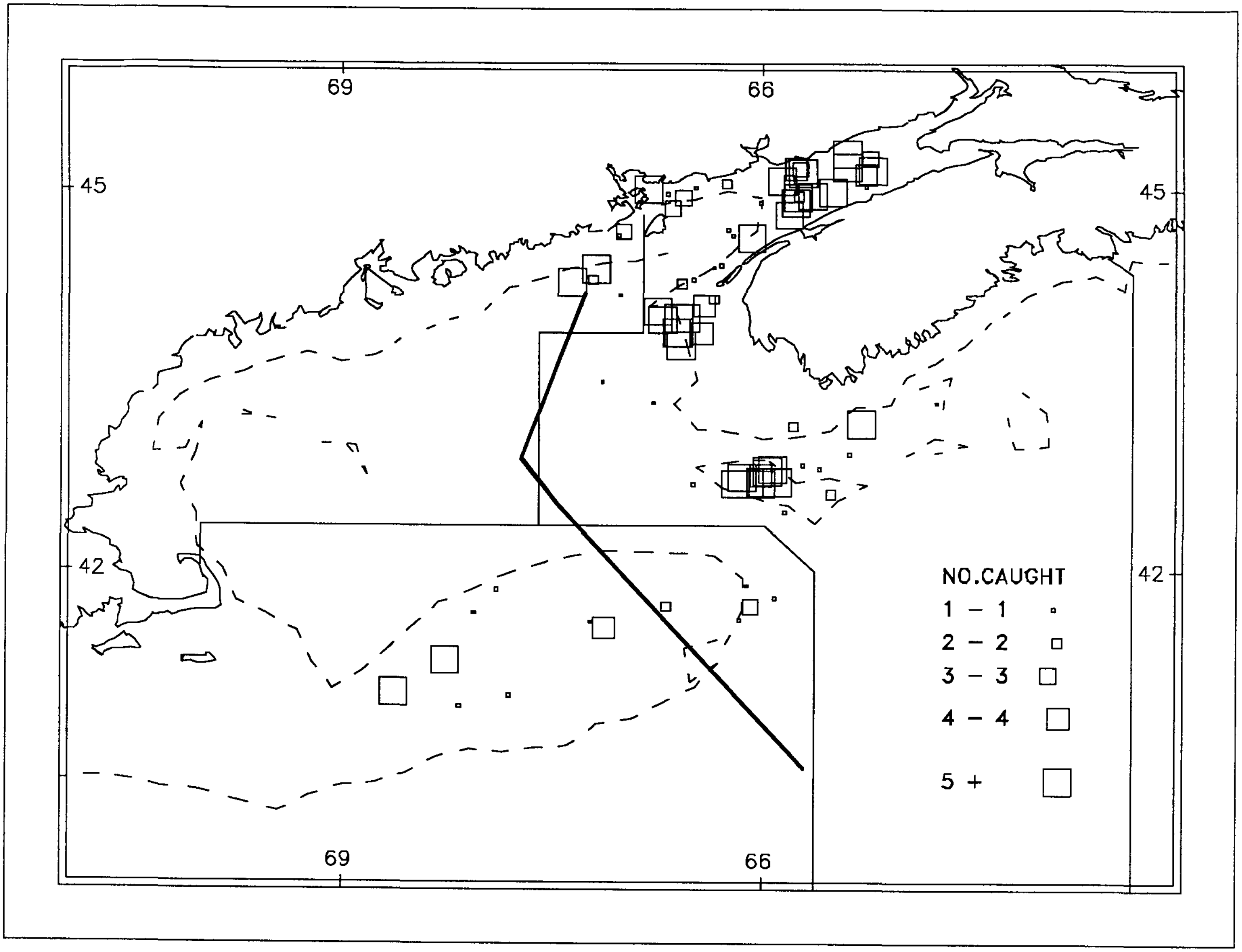


Fig. 11. Distribution of ripening, ripe and spent female winter flounder caught during MFD spring surveys, 1979-1984.

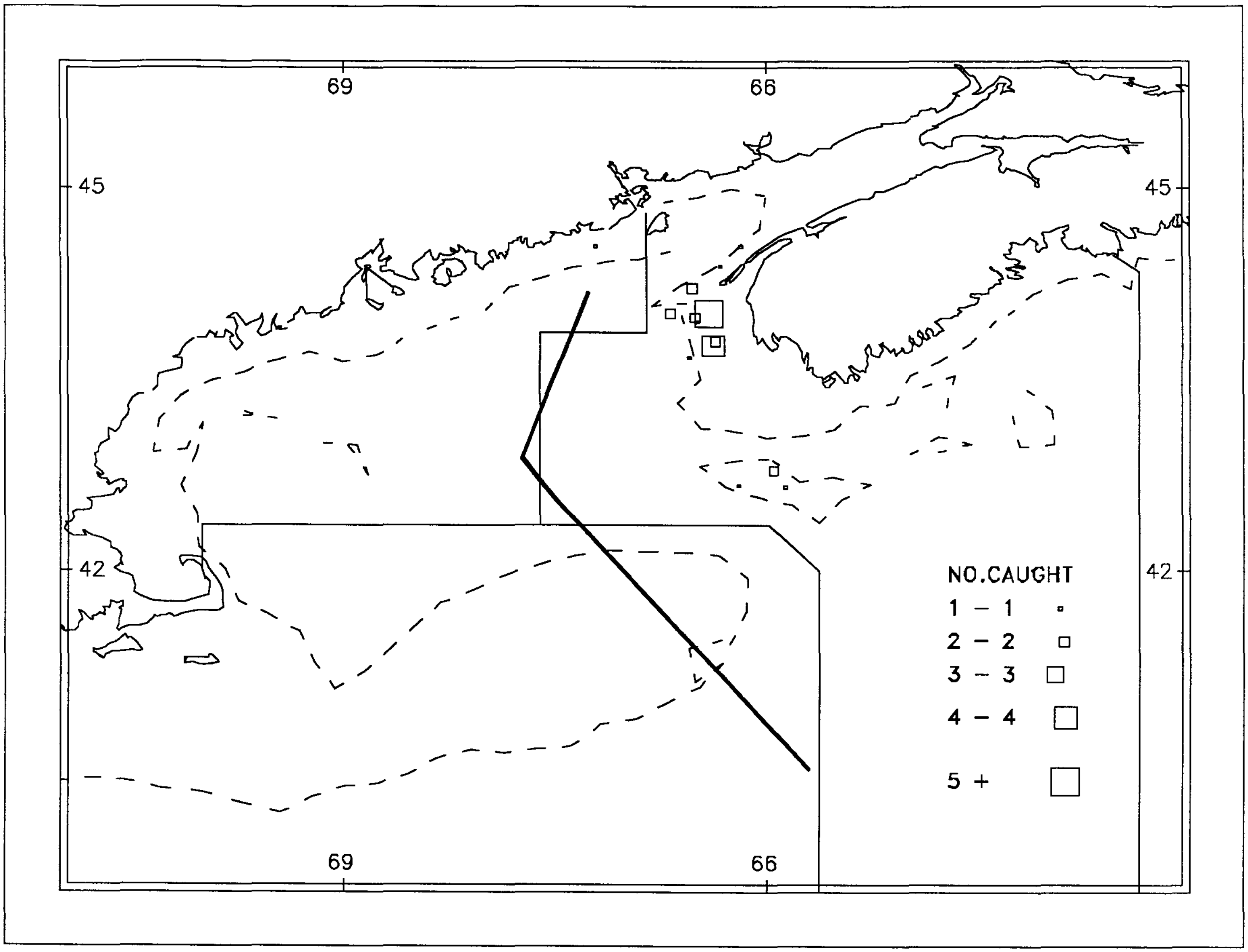


Fig. 12. Distribution of ripening, ripe and spent female winter flounder caught during MFD summer surveys, 1978-1984.

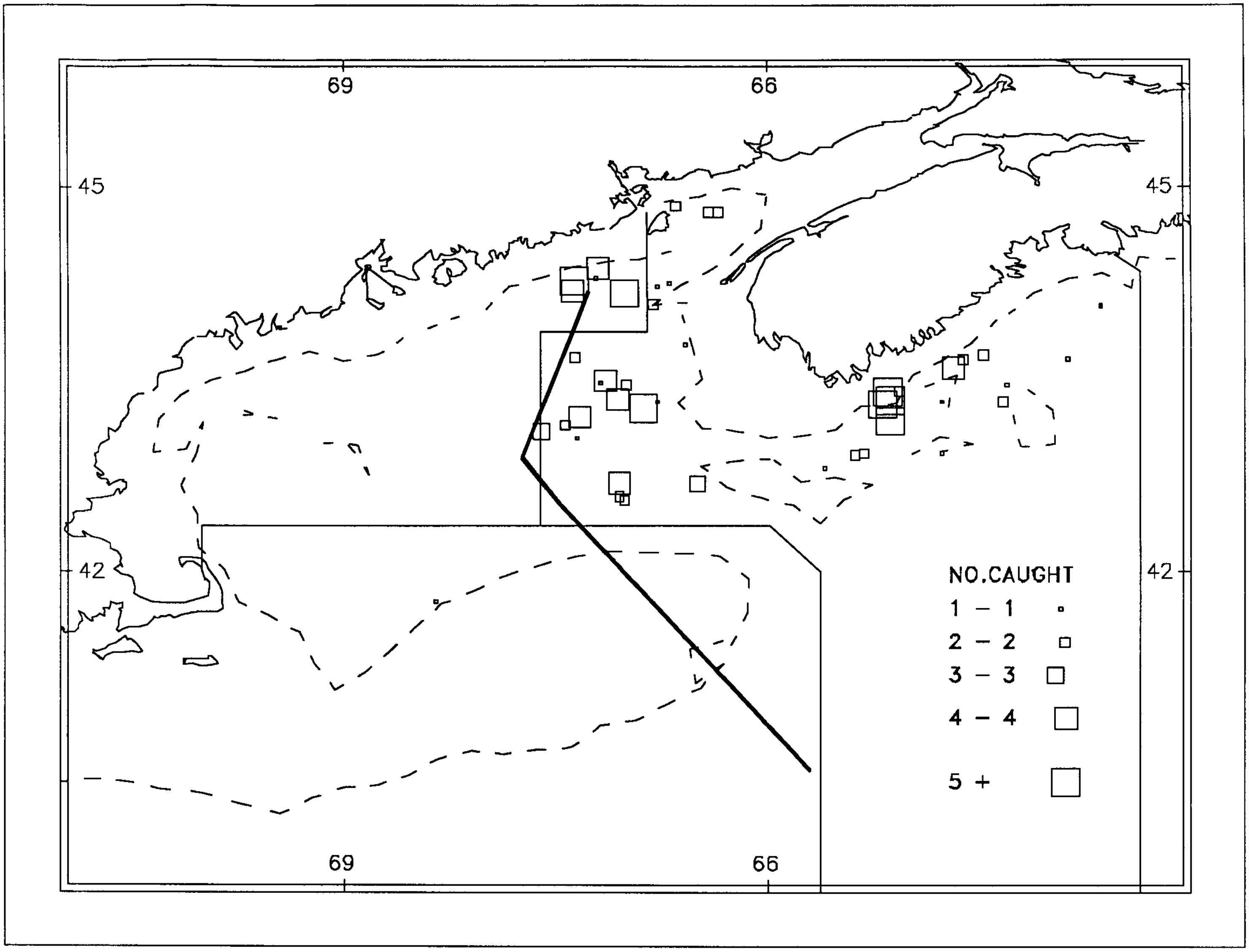


Fig. 13. Distribution of ripening, ripe and spent female witch flounder caught during MFD spring surveys, 1979-1984.

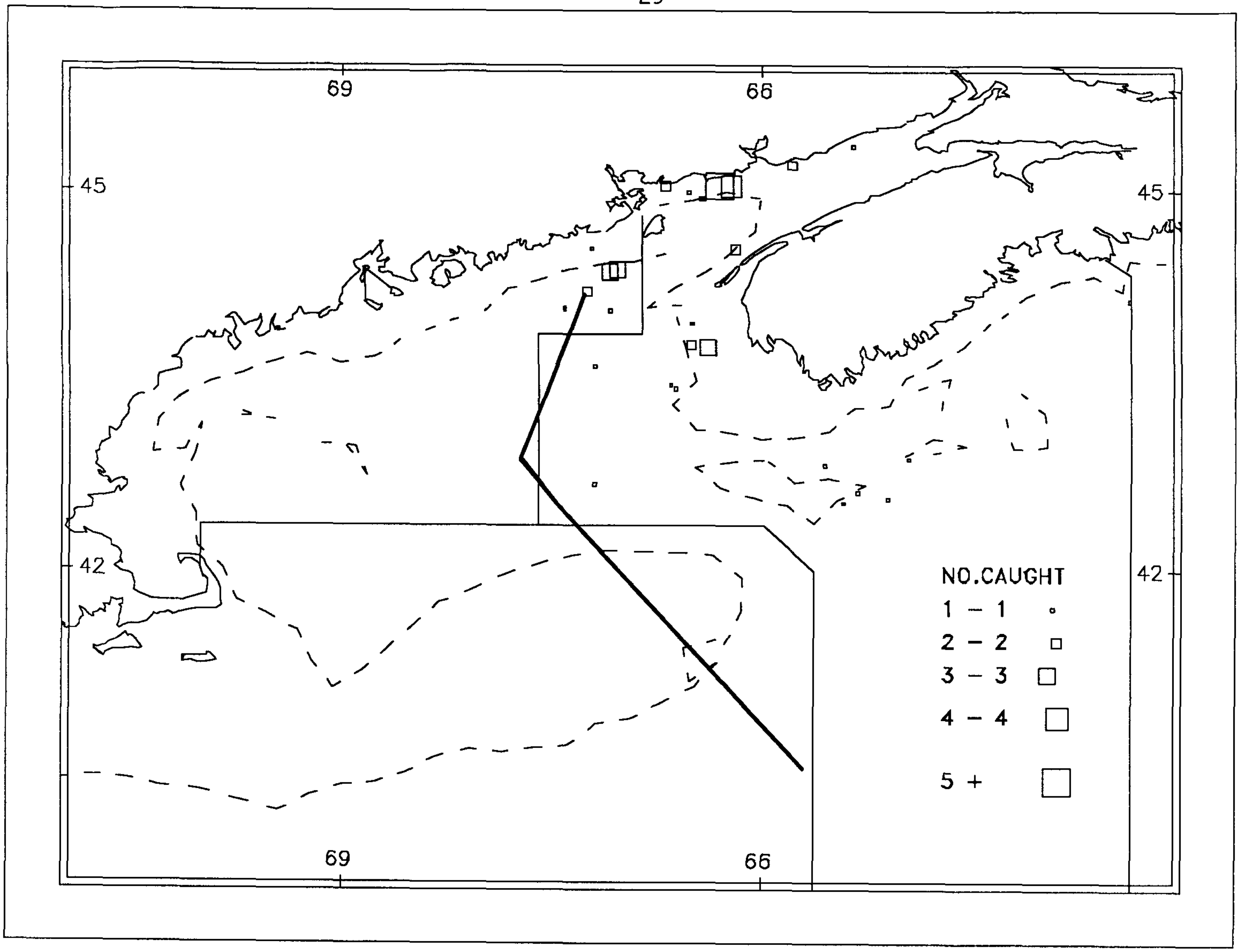
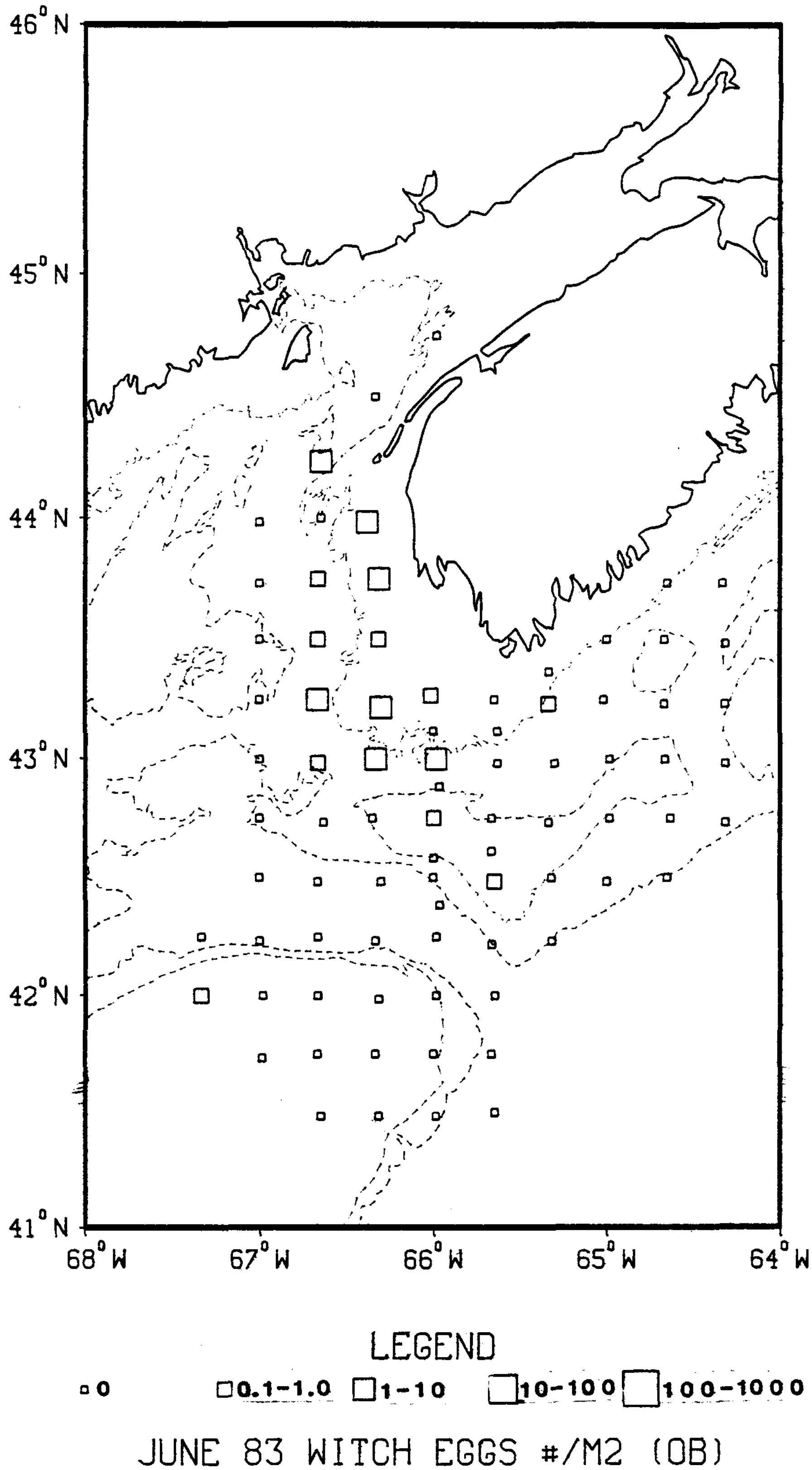


Fig. 14. Distribution of ripening, ripe and spent female witch flounder caught during MFD summer surveys, 1978-1984.

Fig. 15. Distribution of late stages of witch flounder eggs during a MFD ichthyoplankton cruise conducted in June 1983.



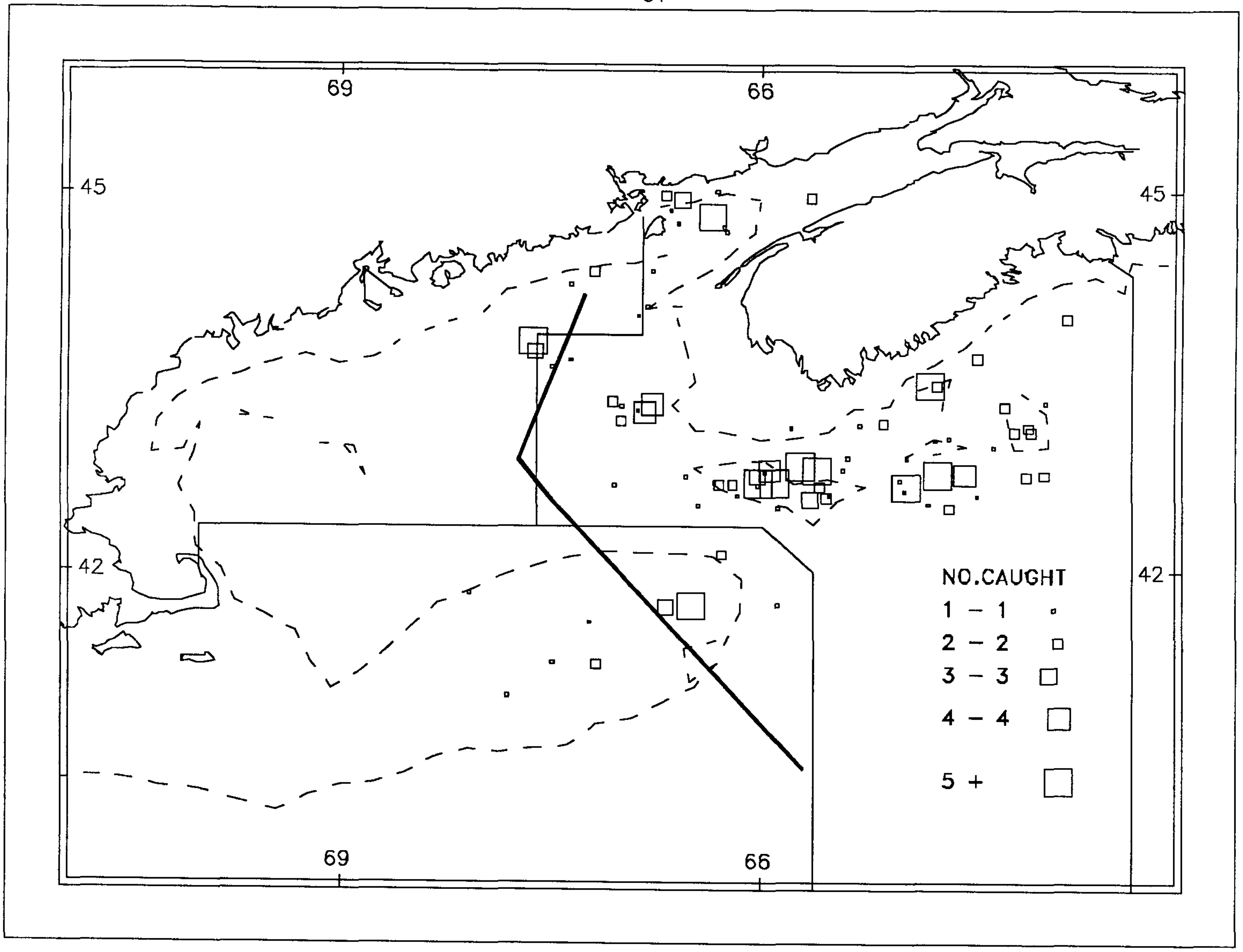


Fig. 16. Distribution of ripening, ripe and spent female American plaice caught during MFD spring cruises, 1979-1984.

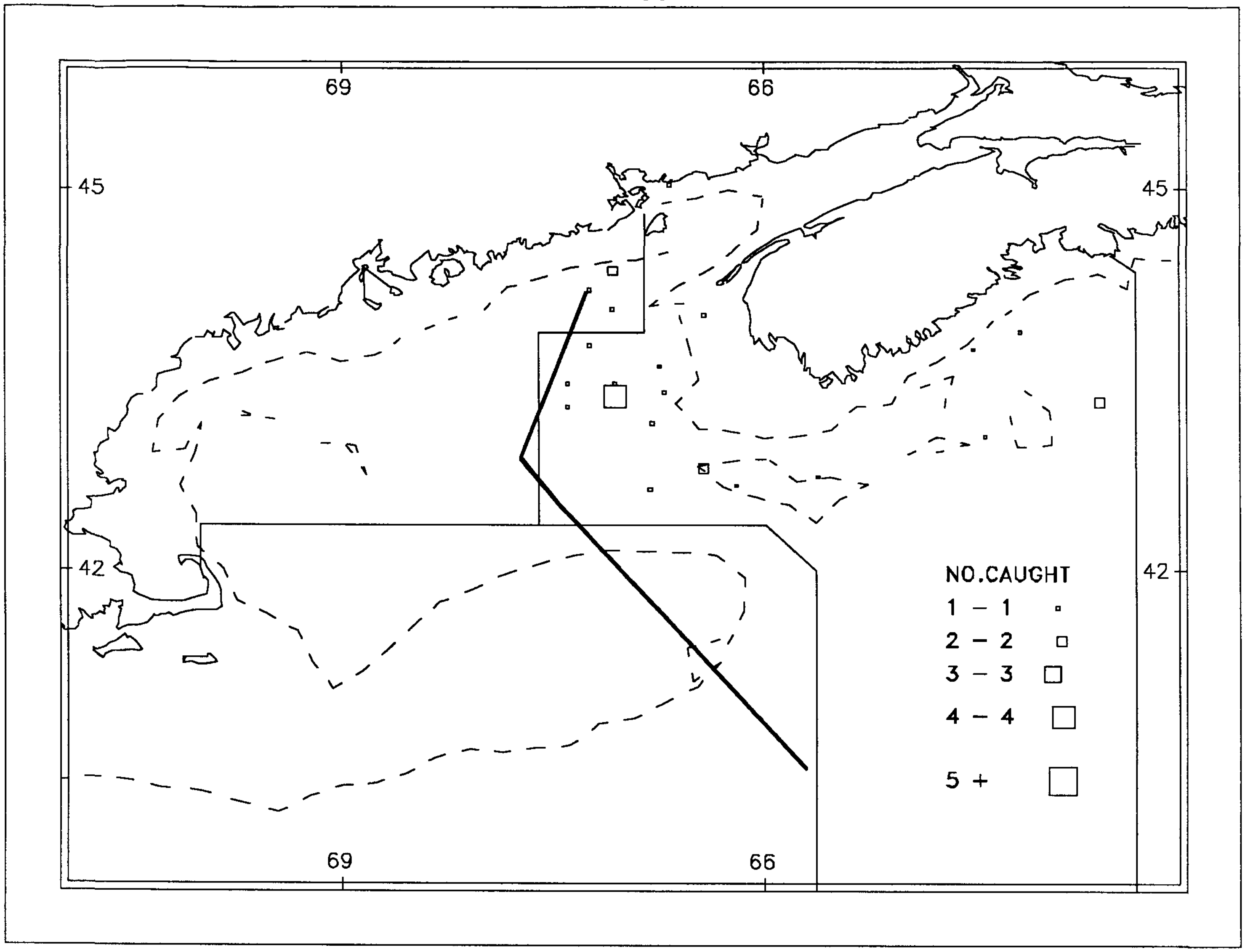


Fig. 17. Distribution of ripening, ripe and spent female American plaice caught during MFD summer cruises, 1978-1984.

Fig. 18. Distribution of all stages of American plaice eggs during a MFD ichthyoplankton cruise conducted in March 1984.

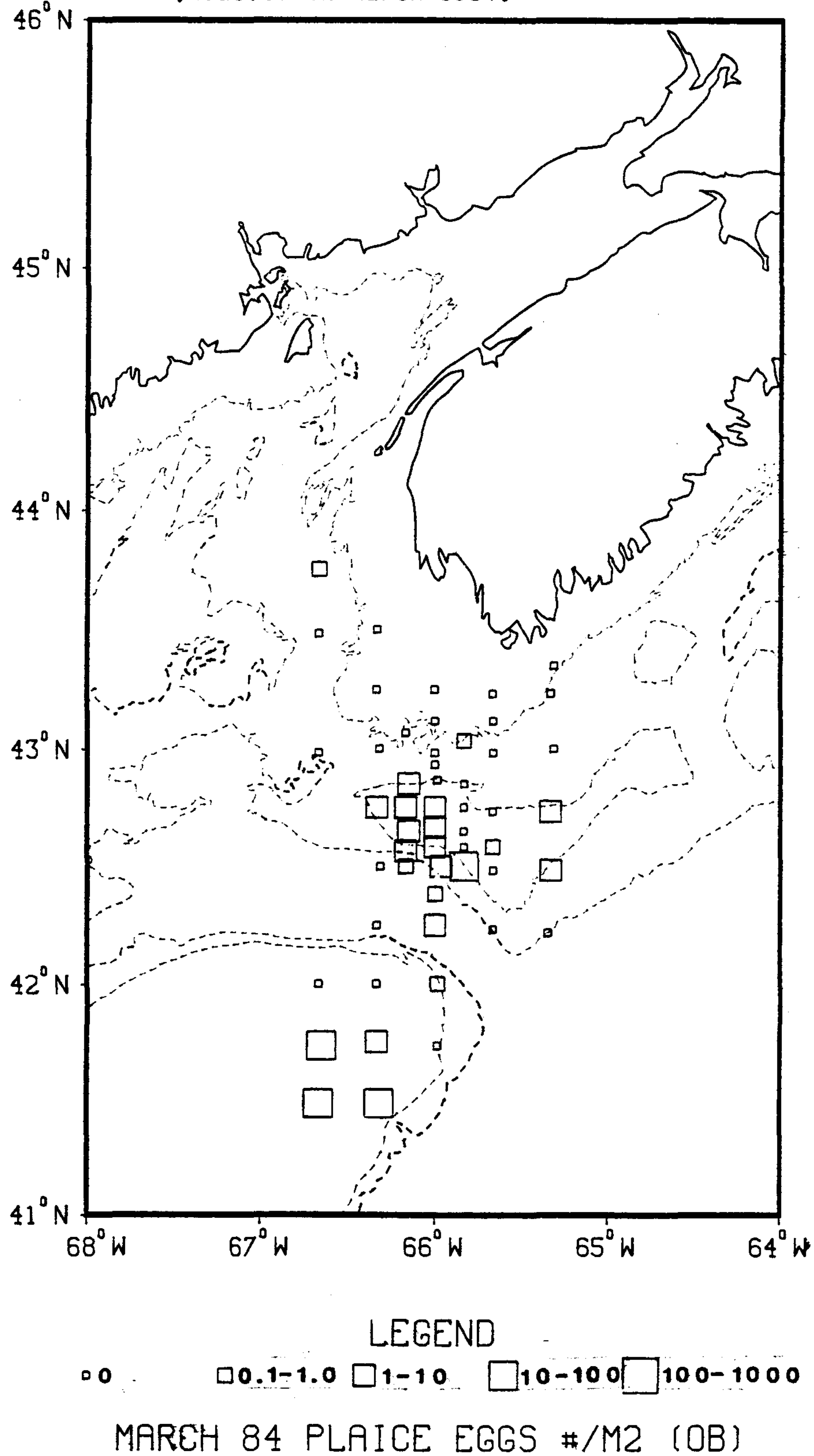
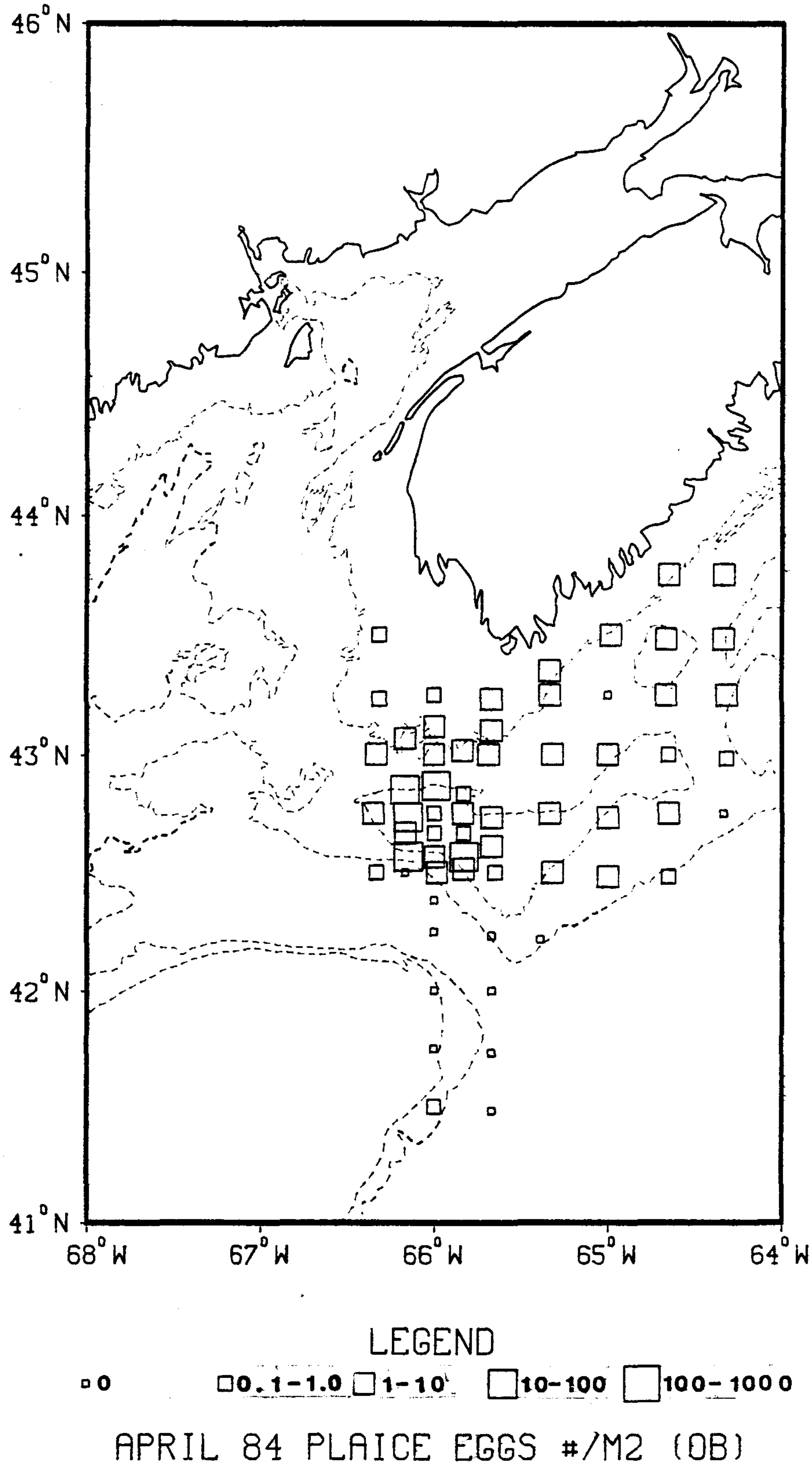


Fig. 19. Distribution of all stages of American plaice eggs during a MFD ichthyoplankton cruise conducted in April 1984.



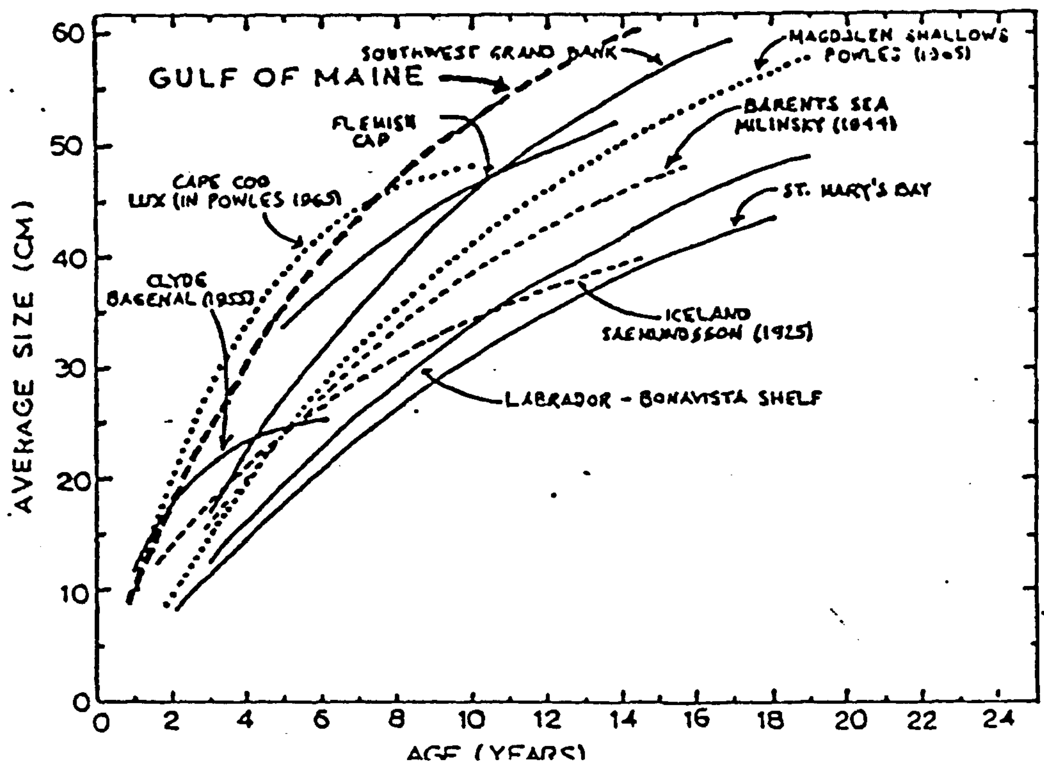


Fig. 20. Growth curves for several North Atlantic American plaice populations. (L. Sullivan, University of Rhode Island, unpublished data)