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The Spring 1978 Age Composition of Herring Stocks off the Northeastern USA

by

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INTRODUCTION

In this paper, data from research vessel surveys conducted between Cape Hatteras and Brown's Bank during the first quarter of 1978 are analyzed in order to determine the age composition of sea herring populations within this region. Data collected from commercial fisheries are also considered. This age composition data offers insight to the current status of herring populations of the region and the outlook for the future. The data may also indicate the stock structure of herring populations of the region.

MATERIALS AND METHODS

During January - April 1978, young herring surveys and other bottom trawl surveys using a stratified random design were conducted by research vessels from the USA (ALBATROSS IV), Poland (WIECZNO), USSR (ARGUS), and FRG (ANTON DOHRN). The offshore areas covered were Brown's Bank (Figure 1, Strata 31-32, 41-42), the Gulf of Maine (strata 24, 26-30, 33-40), Georges Bank (Strata 13-23), and Southern New England waters south to Cape Hatteras (Strata 1-12, 61-76). In addition the ALBATROSS IV surveyed the inshore areas (less than 15 fathoms as indicated in Figure 8, Strata 1-46) south of Cape Cod. A summary of the cruise activity is given in Table 1. The cruise track for each survey is given in Figures 2-7.

The total length (nearest centimer below) and age (by reading otoliths) of 2,047 herring caught during the surveys was determined. Age-length keys

are given in Table 3. In addition, 962 specimens were measured and aged from the US commercial winter fisheries in Cape Cod Bay[1] (744) and off Point Judith, Rhode Island (218).

Table 1. Vessels, gear type, number of tows, and strata fished during the January-April 1978 young herring and USA bottom trawl surveys.

Country/ Vessel	Gear type	No. tows	Strata fished
US			
ALB. IV (inshore)[1]	41 trawl	92	All Strata
US			
ALB. IV (offshore)[2]	41 trawl		All Strata
FRG			
ANTON DOHRN[2]	180' herring trawl	120	5-9, 10, 11, 13, 14, 16, 17, 19, 20, 24-29, 31, 32
Poland			
WEICZNO[2]	90' herring trawl	28	5, 9, 25, 26
USSR			
ARGUS (winter)[2]	hake 815	89	2, 3, 5, 6, 8-10, 12-15, 69, 70, 73-76

[1] Fig. 1
[2] Fig. 2

Table 2. Number of herring taken at each station (Fig. 7) on the ALB. IV winter inshore herring survey.

Station	No. of herring	Station	No. of herring	Station	No. of herring
1	382	35	1	65	3
2	18	36	3	66	7
3	35	37	1	67	51
4	51	39	1	68	3
5	4	41	1	69	5
6	17	44	3	70	1
7	6	52	28	71	2
12	2	53	67	72	48
13	2	54	40	74	3
14	2	55	2	75	9
23	1	56	6	76	3
24	2	57	1	77	1
25	3	60	1	85	153
27	3	61	3	86	21
29	3	62	2	87	287
30	2	63	3	88	24
31	2	64	1	89	8

Table 3. Age-length keys for herring: (A) from *Albatross IV*, *Anton Dohrn*, *Argus*, and *Wiecano* surveys on Georges Bank south to Cape Hatteras, March 1978; (B) from the *Albatross IV* inshore herring survey, Cape Cod to Cape Hatteras, Jan 1978; (C) from the *Albatross IV* survey in the Gulf of Maine, April 1978.

	Total Length (cm)	Year-classes 1976	1975	1974	1973	1972	1971	1970	1969-	Total
A.	14	4								4
	15	60								60
	16	138	5							143
	17	48	10							58
	18	4	12							16
	19	1	45							46
	20		81							81
	21		160							160
	22		150	1						151
	23		127	6						133
	24		93	6						99
	25		24	20						44
	26		1	47	1					49
	27			51	10					61
	28			31	49	2				82
	29			2	59		1			62
	30				29	2				31
	31				9	3	4	3		19
	32					2	2	9		13
	33							2		2
	TOTAL	255	708	164	157	9	7	14		1314
B.	16	7								7
	17	12								12
	18	3								3
	19		1							1
	20		2							2
	21		14							14
	22		22							22
	23		26	3						29
	24		17	7						24
	25		6	13						19
	26		1	17	2					20
	27			26	8					34
	28			13	27	1	1			42
	29			2	64	1	-			67
	30			-	56	11	3	3		73
	31			1	7	13	16	30	1	68
	32				1	7	17	69	1	95
	33						8	48	5	61
	34						1	11	5	17
	35							1	5	6
	36								3	3
	TOTAL	22	89	82	165	33	46	162	20	619
C.	12	1								1
	13	1								1
	14	4								4
	15	4								4
	16	2								2
	17	1								1
	18	2								2
	19	1	1							2
	20		-							-
	21		2							2
	22		1							1
	23		3							3
	24		3							3
	25		4	2						6
	26			2						2
	27			4	1					5
	28			4	7					11
	29				16	1				17
	30				11	1				12
	31				3	-	2	6		11
	32						3	12		15
	33							4	1	5
	34							1	2	3
	37								1	1
	TOTAL	16	14	12	38	2	5	23	4	114

RESULTS

Herring were caught in the offshore areas from Southwest Nova Scotia south to Delaware Bay as indicated in Figure 9. The largest concentrations of herring (numbers) were found on Cultivator Shoals, SW Georges Bank, and from Nantucket Island south to the central part of Long Island. In the inshore strata, the herring were widely distributed throughout the sampling area (Figure 8, Table 2).

Data on the age composition of survey and commercial catches are given in Table 4a indicate that in the offshore areas (15-60 fathoms) the 1975 year-class (age 3) was the most abundant contributing 57.6% of the catch in numbers, followed by the 1976, 1974, and 1973 classes. The remaining year-classes accounted for only 1.9 percent. On the other hand, the 1970 year-class comprised 22.1% of the ALBATROSS IV inshore catch as compared to 0.7 for offshore surveys (overall average). Juveniles (1975-1976 year-classes) accounted for only 21.6% of the ALBATROSS IV inshore catch whereas the offshore juvenile catch was 72.9% of the total. The age composition of the Cape Cod Bay (5Y) and Point Judith (5Zw) commercial fisheries are both similar to the inshore ALBATROSS IV survey age composition. In fact, the inshore average age composition (ALBATROSS IV, Cape Cod Bay commercial and Point Judith commercial) is virtually identical to the inshore research vessel survey age composition (the percent at any age never differ by more than about 1%). Furthermore, the age compositions from (1) the Gulf of Maine research vessel survey (ALBATROSS IV), (2) both commercial fisheries, and (3) the inshore research vessel survey (ALBATROSS IV) are remarkably similar. Herring of 5 years and older (1973 and older year-classes) were dominant in each of these data sets (64-70%).

DISCUSSION

The similarity between the age composition of research vessel survey catches from the Gulf of Maine (SA 5Y) and inshore areas of SA 5Z+6, and between commercial catches off Point Judith and in Cape Cod Bay suggest significant winter migration from the Gulf of Maine (and perhaps southern Nova Scotia) to the inshore waters of Southern New England and the Mid-Atlantic area. This hypothesis is supported by results of international tagging studies

[1]This is the area of exploitation in the Gulf of Maine adult fishery during the winter.

conducted in the spring of 1977 (Almeida and Burns 1978) and by the results of tagging studies conducted by Canada in the summer-autumn of 1973-1974 (Stobo 1976) and 1977 (Stobo 1977). The tagging programs indicate some intermixing between herring along the coast from SW Nova Scotia to the SE end of Long Island (Figure 10). Information on intermixing between Georges Bank and other areas is lacking because of the minimal amount of fishing (and therefore low probability of returns) on Georges Bank in recent years. ICNAF herring working groups have assigned catches in the winter fishery off Point Judith to the Georges Bank stock based on earlier information which indicated only a small amount of intermixing with the Gulf of Maine stock. The evidence presented here indicates that the Point Judith fishery may be strongly dependent on the Gulf of Maine stock at present. The age composition on Georges Bank, in the first quarter of 1978, was radically different from the age composition of the Point Judith fishery and inshore research vessel catches in SA 5Z+6. The radical difference between the age composition on Georges Bank and in the Point Judith fishery as well as catches from inshore research vessel surveys could reflect an increased probability of winter migrations for older or larger fish. If this was the case, the inshore age composition would not necessarily be in such close agreement with the Gulf of Maine age composition data.

During the period 15 August to 30 September 1977 the distant water fleet was allocated 21,000 MT of herring, to be taken in the so called "herring window." This is the area which, since 1973, has been heavily fished for Georges Bank spawning and pre-spawning herring. The 1977 catches in the "window" amounted to less than 310 MT, thus indicating the degree of collapse of the fishery. The data presented in this paper suggest an explanation for the failure of the Georges Bank autumn spawning fishery.

The spawning stock in 1977 would have been dependent on the 1973 and older year-classes since herring typically mature at age 4. As indicated by the 1978 survey data, the 1970 year-class had apparently been fished out. The poor representation of the 1971-1972 year-classes in the survey has two possible explanations. Either, the size of these year-classes at age, as assumed by the Herring Workshop Group (ICNAF, Redbook 1976, pp. 45) were too high (550 million fish for both year-classes), or the fishing mortality on Georges Bank herring was higher in these age groups than previously assumed (ICNAF, Redbook 1976, pp. 45, Table 9). In either case, the result is a lower

abundance of older fish, i.e., 5 years and older in the autumn of 1977, the 6 years and older in the spring of 1978 on Georges Bank and Mid-Atlantic areas as indicated by research vessel surveys. Thus, the 1977 autumn Georges Bank spawning ground fishery was nearly totally dependent on the 1973 year-class which had also been assumed to be poor by the ICNAF herring working group.

There is considerable evidence that the scarcity of herring in the autumn of 1977 was not limited to the herring "window." Research vessels from the FRG (ANTON DOHRN), Poland (WIECZNO), USA (DELAWARE II), and the USSR (YUBILEINIY), failed to find any concentrations of pre-spawning or spawning herring on Georges Bank. Only a small concentration of spawning herring was located 12 miles east of Chatham, Cape Cod, by the R/V YUBILEINIY involved in the international herring tagging program. Lough (1978) has shown that the number of larvae produced on Georges Bank in 1977 was the second lowest on records since 1968, only the 1976 estimates of larval abundance was lower. Age composition data from commercial and research vessel catches can be used to colaborate stock assessments.

Since the autumn 1977 failure of the Georges Bank fishery, three different stock assessments for Georges Bank sea herring have been considered. The assessments differ with respect to the strength of the 1971-1974 year-classes at age 3. The strength of the year-classes comprising the stock at age 3 since the 1970 year-class and the corresponding age composition of the stock at the beginning of 1978 are given in Table 4b for all three assessments.

By convention, ICNAF Herring Working Groups made the apparently conservative assumption that all year-classes are equal in strength to the weakest year-class previously observed (1969 year-class) unless there is evidence to the contrary. The "poor recruitment" assessment follows this convention. The 1971-1974 year-classes are all assumed equal in strength to the 1969 year-class. The "poor recruitment assessment approximately corresponds to the 1976 ICNAF Herring Working Group assessment. The 1975 year-class is assumed to be equal in size to the 1969 year-class in all three assessments. The strength of the 1970 year-class at age 3 was estimated by VPA for for all three assessments.

The "good recruitment" assessment corresponds to Anthony (1977). Based on the strength of the 1973 and 1974 year-classes in the juvenile Maine catch, these year-classes were estimated to be larger than in the "poor recruitment" assessment. Historically, the strength of year-classes in the

juvenile Maine catch has corresponded to the size of the year-class at age 3 when it recruits to the adult fishery.

Table 4a. Percent herring age composition (numbers) from the 1978 winter/spring surveys and US commercial fisheries

	Year-class								
	1976	1975	1974	1973	1972	1971	1970	1969+	Total
ALBATORSS IV (offshore)	6.02	73.8	7.2	9.3	0.5	0.7	2.2		100.0
ANTON DOHRN	22.3	54.5	13.6	8.1	0.7	0.5	0.3		100.0
ARGUS	0.3	57.7	23.4	15.8	1.0	0.5	1.3		100.0
WIECZNO	-	67.2	17.8	15.0					100.0
Average all vessels[1]	15.3	57.6	15.1	10.1	0.7	0.5	0.7		100.0
ALBATROSS IV (inshore)	3.4	18.2	14.2	27.7	4.7	7.1	22.1	2.7	100.0
Cape Cod Bay (commercial)	1.5	15.0	14.8	28.1	4.8	6.4	24.0	5.4	100.0
Point Judith (commercial)	0.9	37.8	12.8	31.3	3.7	2.4	11.2	0.2	100.0
Inshore average[1]	2.4	19.1	14.3	28.2	4.6	6.3	21.7	3.5	100.0
Gulf of Maine (ALB. IV)	4.8	13.7	11.8	36.3	2.0	4.9	22.6	3.9	100.0

Table 4b. Percentage age composition for herring in numbers in the beginning of 1978 for the Georges Bank and Gulf of Maine herring stocks from the prediction estimates.

	Year-class							
	1975	1974	1973	1972	1971	1970	1969+	Total
Georges Bank stock								
good recruitment[2]	20.6	43.3	17.7	10.8	6.6	1.0	0.2	100.0
poor recruitment[3]	30.0	24.2	19.5	15.5	9.4	1.5	0.3	100.0
very poor recruitment[4]	38.6	31.4	25.2	1.4	1.2	1.9	0.4	100.0
Gulf of Maine[5]	18.5	50.5	14.2	3.4	1.1	11.6	0.7	100.0

[1] Weighted sample size in numbers

[2] 1971-1972 year-class = 607×10^{-6} fish age 3, 1973 year-class = 779×10^{-6} fish at age 3, 1974 year-class = 1564×10^{-6} fish at age 3, 1975 year-class = 607×10^{-6} fish at age 3.

[3] 1971-1975 year-class = 607×10^{-6} fish at age 3.

[4] 1971 year-class = 219×10^{-6} fish at age 3, 1972 year-class = 62×10^{-6} fish at age 3, 1973-1975 year-class - 607×10^{-6} fish at age 3.

[5] 1971 year class = 78.3×10^{-6} fish at age 3, 1972 year-class - 77.7×10^{-6} fish at age 3, 1973 year-class = 133.7×10^{-6} fish at age 3, 1974 year-class - 269.3 fish at age 3, 1975 year-class - 73.4×10^{-6} fish at age 3.

The "very poor recruitment" assessment was considered at a USA-Canada scientific meeting in November 1977 (Anonymous 1977). This assessment is the same as the "poor recruitment" assessment except that the strength of the 1971 and 1972 year-classes was estimated by VPA.

Table 4b indicates that the percent age composition of the predicted stock on Georges Bank at the beginning of 1978 based on "very poor recruitment" provides the closest comparison to the offshore survey data (Table 4a). In this assessment, the 1971-1972 year-classes were estimated to be weaker than any other year-classes previously observed as indicated by virtual population analysis. The estimated size of the 1970 year-class was the same for all three predictions (ICNAF, Redbook 1976, pp. 45) and this estimate fits well with observed 1978 offshore data. The observed data indicate that the 1975 year-class may be stronger than was assumed in any of these assessments, but on the other hand, the 1973-1974 year-classes may be weaker.

The predicted age composition at the beginning of 1978 for the Gulf of Maine, based on estimates of year-class strength that correspond to the ICNAF herring working group assessment of 1976, corresponds fairly well to the trend (i.e., high percentage of 1970 year-class fish) shown in the inshore survey and commercial data. The age composition data does indicate that the assumed strength of the 1974 year-class may have been optimistic.

Based on the above hypothesis, it can be concluded that in 1978, the Georges Bank herring spawning stock was small again, depending predominately on the 1973 and 1974 year-classes. If, however, a significant number of 1975 year-class (age 3) fish became sexually mature, as previously observed for age 3 fish of the 1966 year-class (Boyar 1968) and the 1970 year-class (Schubert 1974), a substantial increase in the 1978 spawning stock size would have occurred.

In the 1977 Maine juvenile herring fishery, the catch of age 1 (1976 year-class) and age 2 (1975 year-class) fish was the highest catches at these particular ages recorded since 1971 (1970 year-class, age 1) and 1968 (1966 year-class, age 2), respectively. Catches of both the 1975 and 1976 year-classes in the Maine juvenile herring fishery have remained high in 1978. This, in conjunction with the results of the 1978 winter/spring surveys, suggests that both the 1975 recruiting and 1976 year-classes are larger. To date, reasonable correlations have existed between inshore juvenile catches and the strength of the corresponding year-class at age 3 in the Georges Bank fishery (Anthony 1977).

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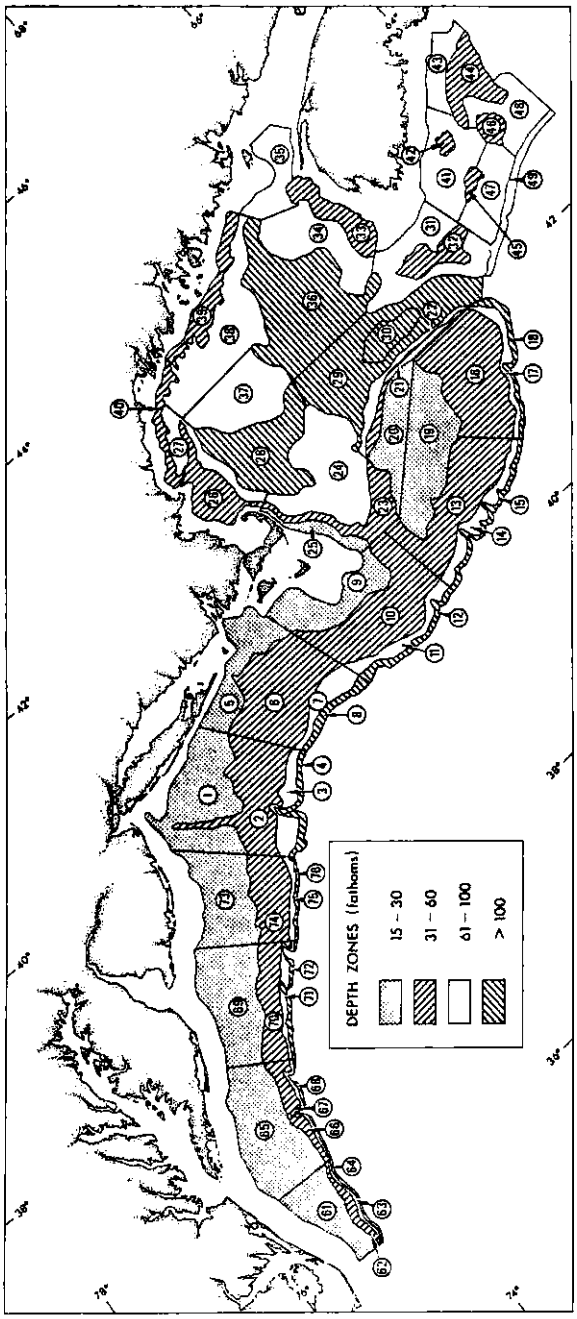

Figure 1. Offshore strata between Cape Hatteras and Nova Scotia by depth zones.

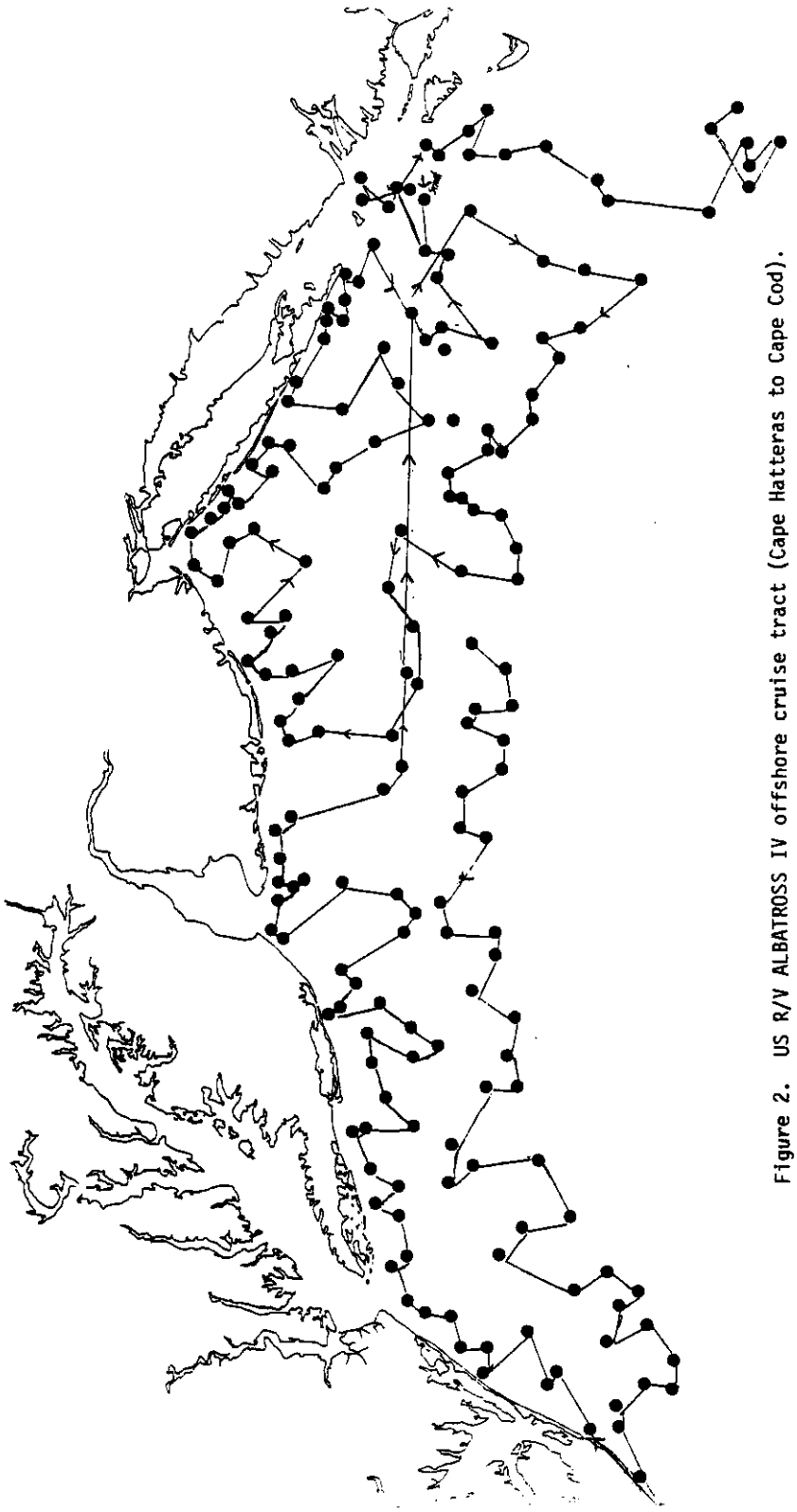

Figure 2. US R/V ALBATROSS IV offshore cruise tract (Cape Hatteras to Cape Cod).

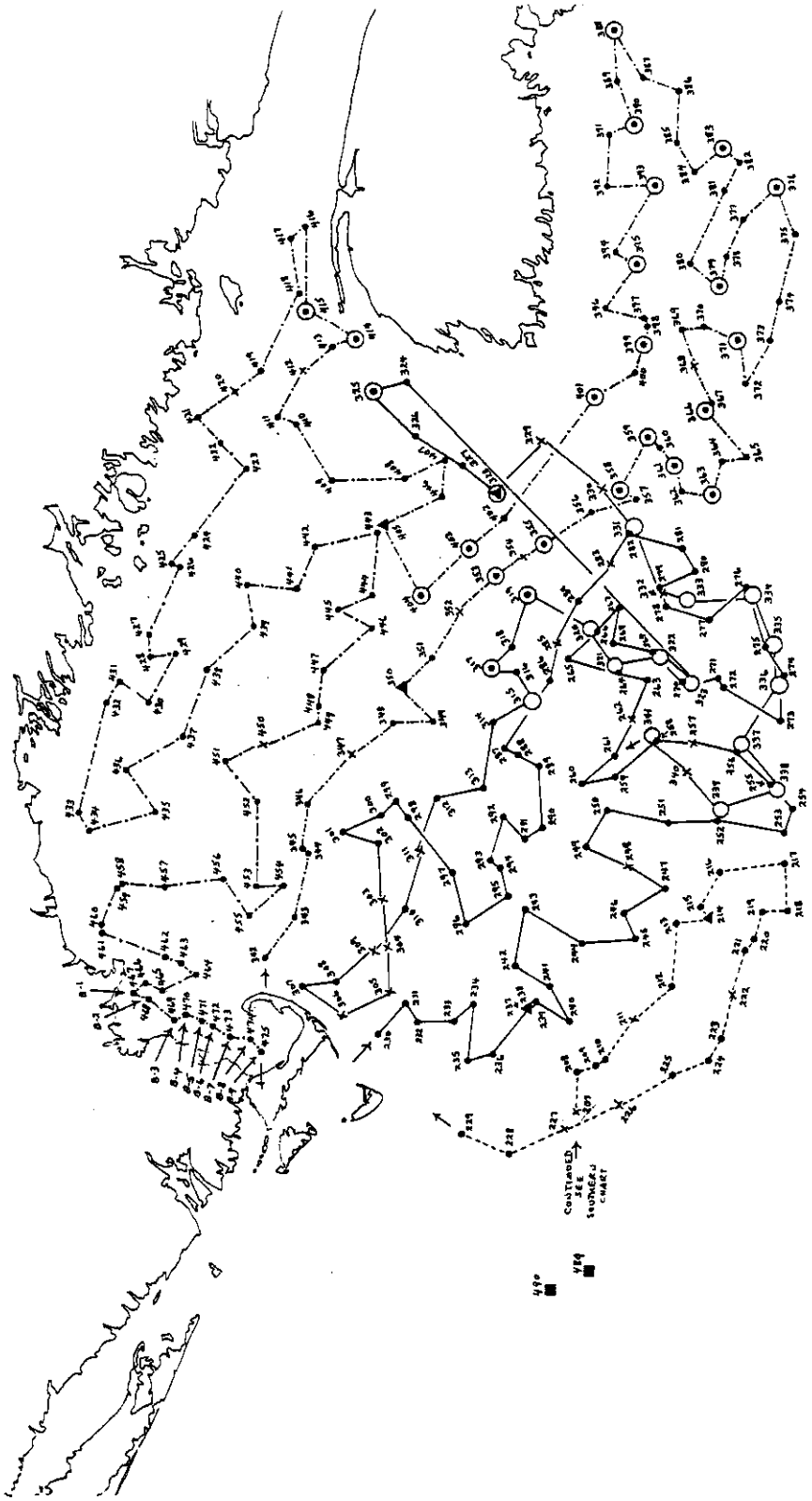

Figure 3. US R/V ALBATROSS IV offshore cruise track (Cape Cod to Browns Bank).

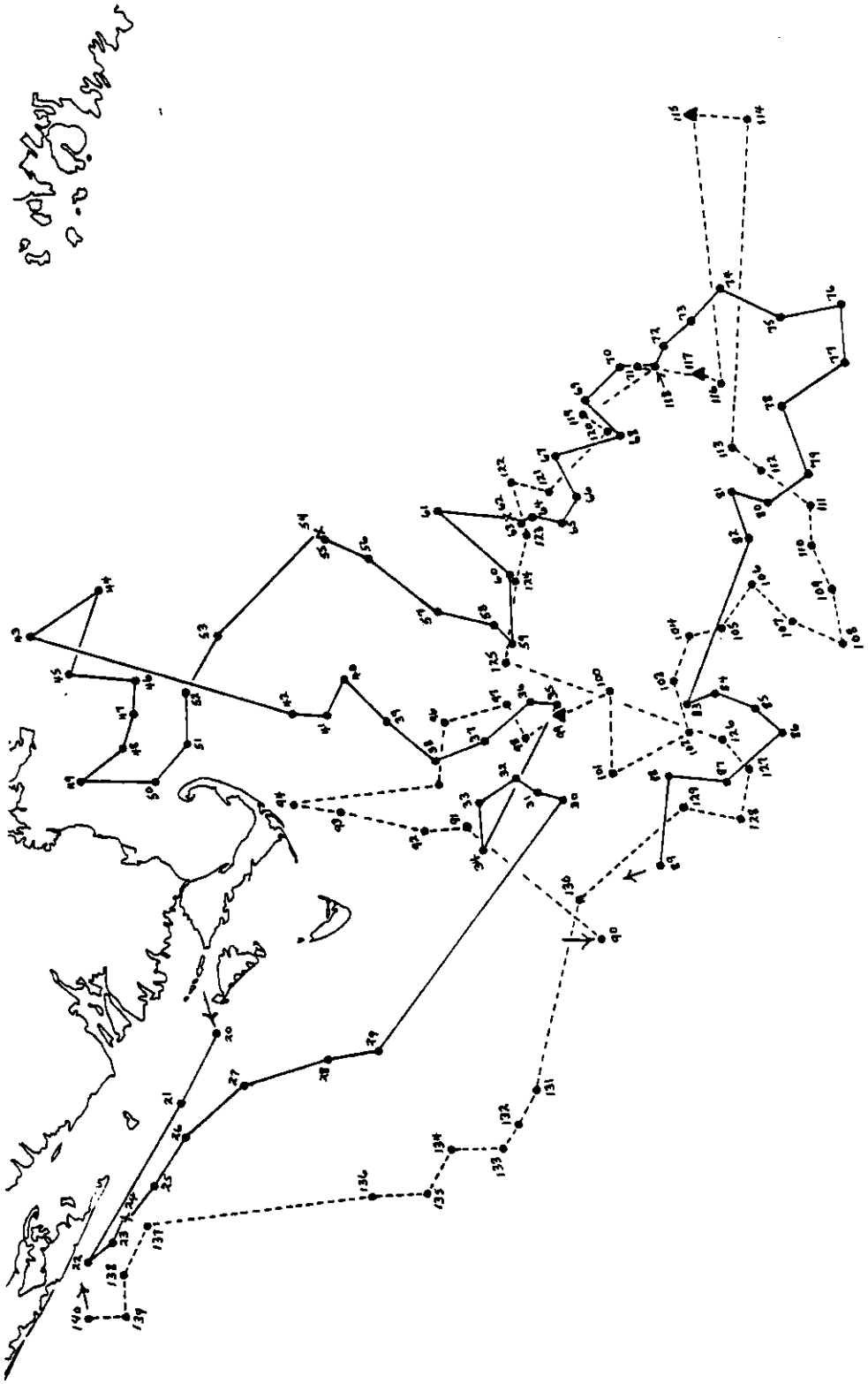

Figure 4. FRG R/V ANTON DOHRN cruise tract.

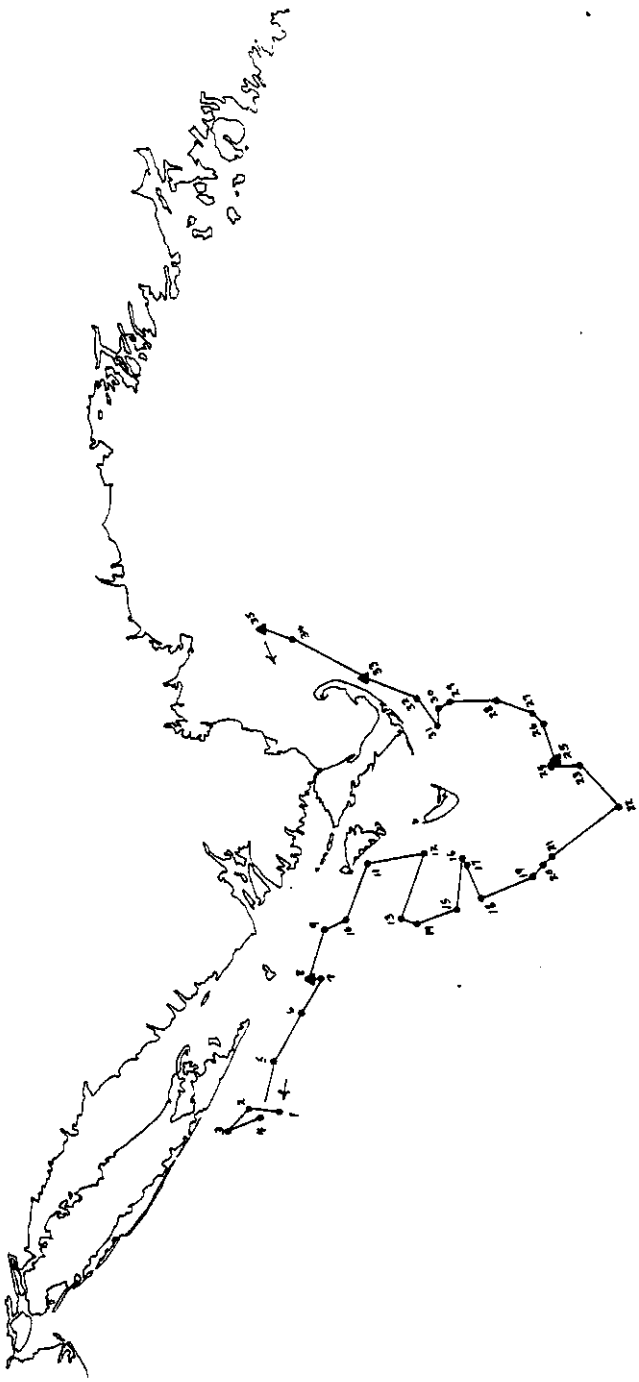

Figure 5. Polish R/V WIECZNO cruise tract.

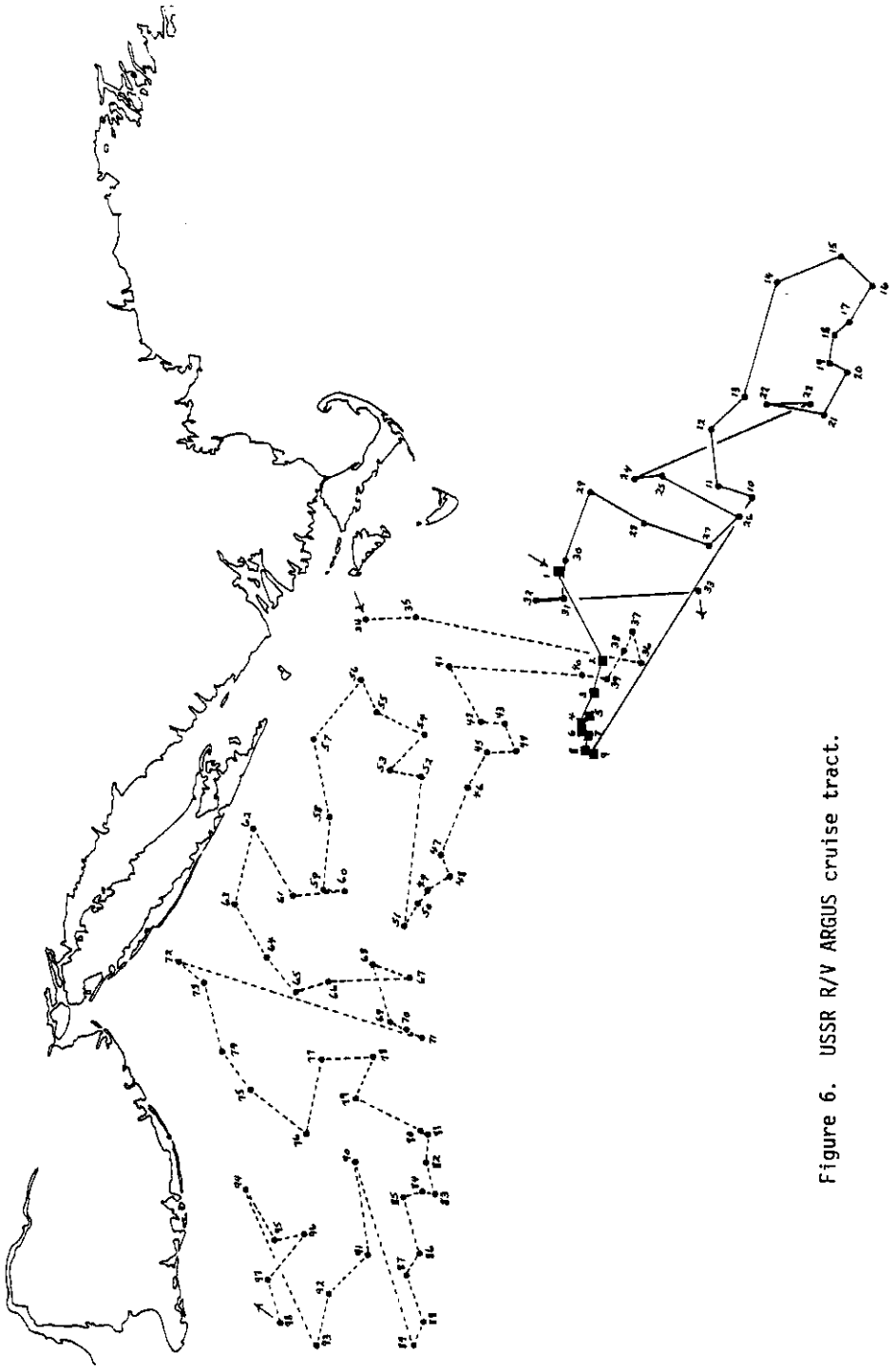

Figure 6. USSR R/V ARGUS cruise tract.

Figure 7. US R/V ALBATROSS IV inshore cruise tract.

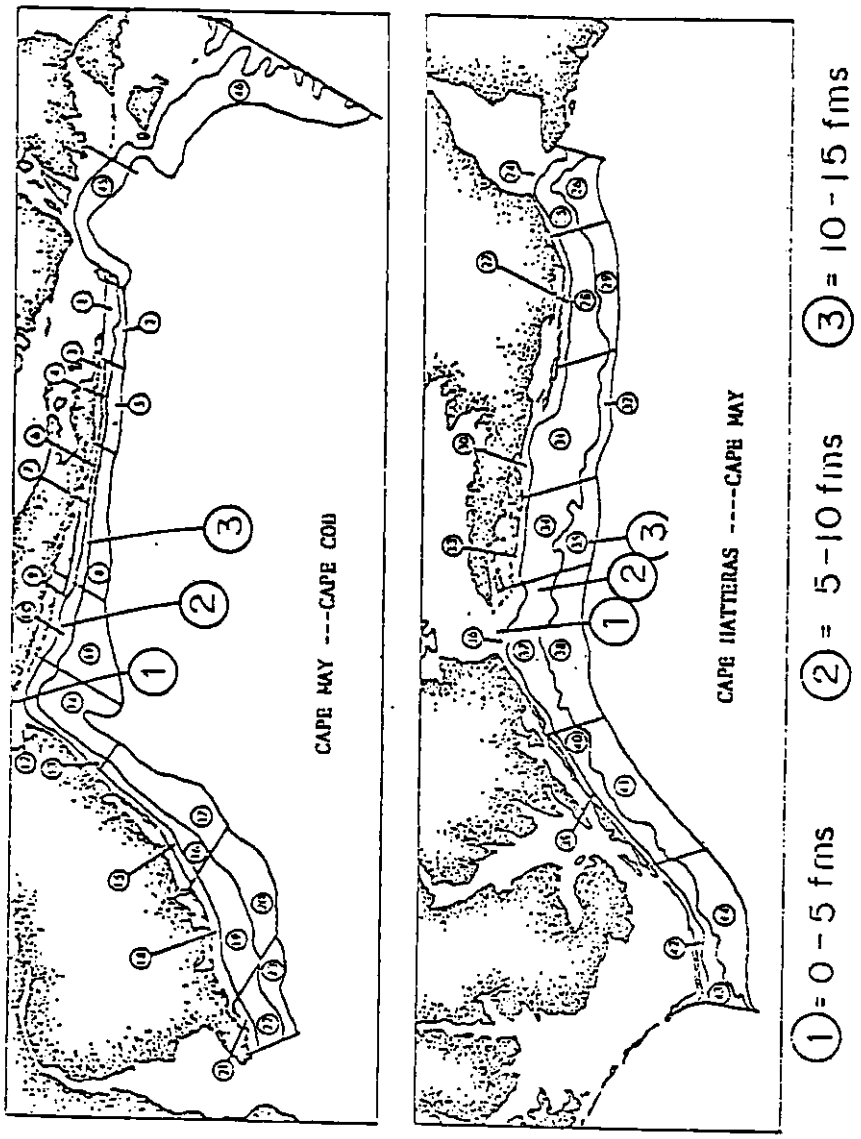

Figure 8. Inshore strata from Cape Hatteras to Cape Cod by depth zones.

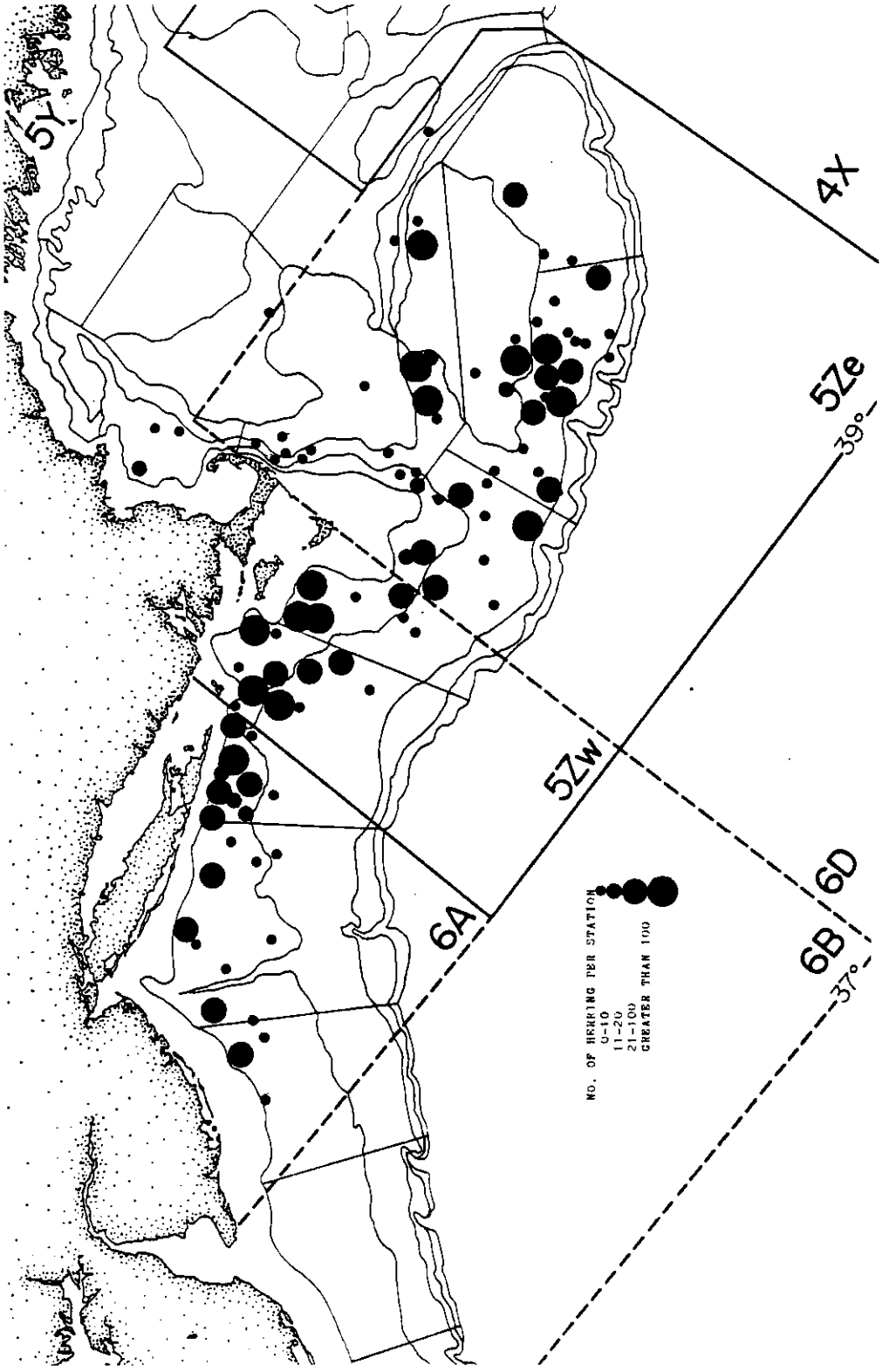

Figure 9. Distribution of numbers of herring caught during the 1978 winter-spring young herring surveys by the R/V's ANTON DOHRN (FRG), WIECZNO (POL), ARGUS (USSR), and the ALBATROSS IV (US).

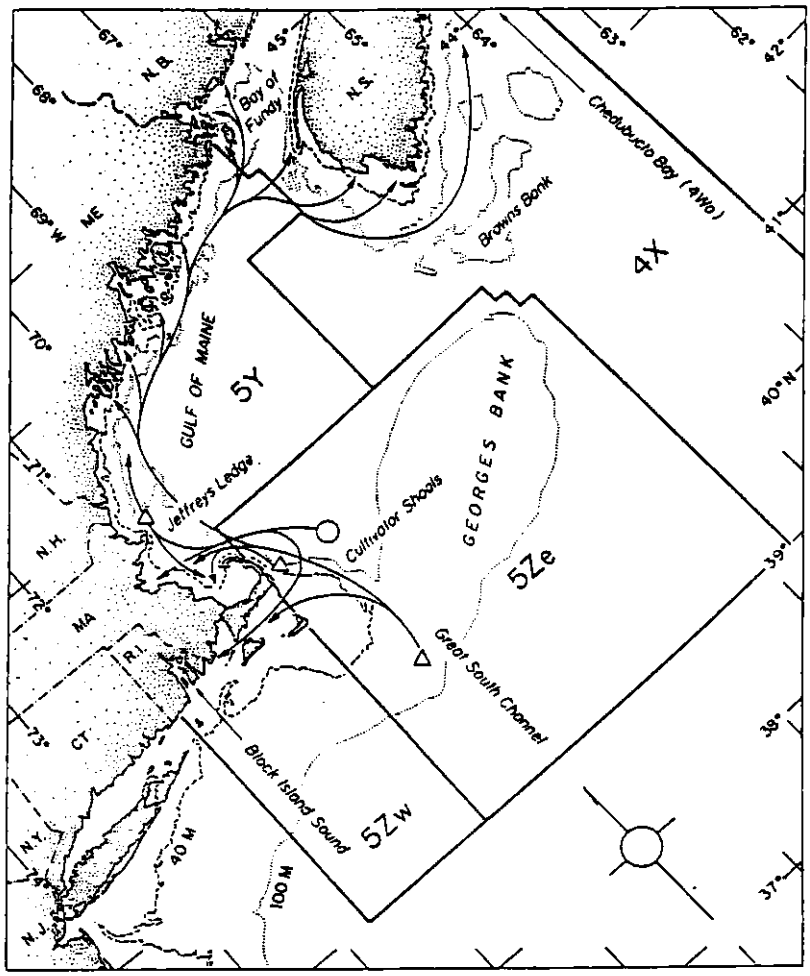

Figure 10. Distribution of recaptured herring tagged in 1976 circle (o) and 1977 triangles (Δ) by the international Herring Tagging Program.