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RESULTS OF THE JOINT USA-USSR GROUNDFISH STUDIES

Part II. Groundfish Survey From Cape Hatteras to Cape Cod

by

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Introduction

The recent development of Russian trawl fisheries along the U.S. Atlantic coast, south of the ICNAF area, has stimulated interest in monitoring the effects of fishing there on the stocks currently being exploited by both the USA and USSR. It was desirable to establish a mutually acceptable index of the distribution and relative abundance of groundfish, which was free of the potential sources of bias in the available commercial indices, and yet which could be related to the commercial fisheries of both countries. Furthermore it was considered desirable to obtain data on all the groundfish species (not just those currently being sought) in order to provide a more complete basis for assessing effects of changes in exploitation or environment, as well as the total harvest potential of the fish stocks in this area.

The above objectives called for a joint simultaneous survey by USA and USSR research vessels with close cooperation between the scientific parties of both countries, to facilitate comparison of results and promote mutual confidence in them. Such a survey was conducted in October 1967 by the Woods Hole Bureau of Commercial Fisheries research vessel, Albatross IV, and the Atlantniro research vessel Albatros, from Kaliningrad. A total of 202 otter trawl hauls were made by the two vessels from Cape Hatteras to 70° West (Nantucket shoals). This report summarizes the survey methods used, and includes a preliminary analysis of results.

METHODS

Survey Design

The basic idea underlying the selection of stations for the joint survey was to randomly pre-select locations in advance of the cruise, as opposed to searching for fish concentrations with echo sounders. Apart from the technical difficulties in interpreting echo trace records of fish near the sea bed, the rationale behind this choice is that:

(1) We were seeking data on the entire groundfish community throughout all parts of the survey area, and not just on those species and in those places with detectable fish schools.

(2) The size, density and behavior (particularly vertical distribution) of fish schools, and hence their acoustical detection, may be altered more by such rapidly changing factors as light, temperature or distribution of food organisms, than by total abundance of the fish; and, as far as possible we wanted to minimize that portion of variability in catches which is independent of absolute abundance.

Perhaps future surveys can provide more precise information on distribution and abundance of groundfish through a combination of fishing and echo traversing done simultaneously. However, this approach would require more technical and logistic capabilities than were available for the joint survey, and therefore a random pre-selection scheme was adopted.

The basic sample design chosen was the well known stratified random sampling design which is widely used for sample surveys in general (Cochran, 1953). The specific form of this design used on the joint survey was the same as that which has been used since 1964 for groundfish surveys conducted by the US Bureau of Commercial Fisheries Biological Laboratory in Woods Hole, A complete description and evaluation of the design is now being prepared for publication in another paper, therefore only the principal features will be described in this report.

The stratified random design embodies the following properties which were desirable from the standpoint of the joint survey:

(1) Provides for a fairly uniform distribution of stations throughout the survey area, thus ensuring about the same precision in estimates of abundance and species composition in one part of the area as in another.

(2) By virtue of random sampling within each stratum (subdivision), this design provides unbiased estimates of mean density of the available population for each stratum as well as for any set (included the whole set) of strata. Estimates are unbiased in the sense that the estimated mean density is equal to the true density (of fish available to the gear in use) apart from sampling error.

Note that an abundance index for any combined set of strata is computed by weighting the index of each stratum in the set according to its area.

(3) Provides valid estimates of the statistical precision (variance) of abundance indices, and has the potential for increased efficiency, over simple random sampling for example (in terms of smaller variance per unit cost), depending upon the success of choosing strata such that distribution of fish is homogeneous within a single stratum, but substantially different among different strata.

(4) Computations are simple and the design permits flexibility in analysis. For example, strata may be combined in many different ways, and for each combination a stratified mean index and associated variance can be computed.

Choice of Sampling Strata

The sampling strata used in the joint survey were chosen to facilitate comparisons with data obtained on previous surveys by Albatross IV (Figure 1). Strata 1-12 are identical to those used in previous Albatross IV groundfish surveys, except that in the joint survey the inshore boundary represents the 12-mile limit, and strata 9-12 were truncated on the eastern edge by the 70°W line. Strata 61-76 are new strata constructed for the joint survey, with depth zones identical to those for previous surveys to the north.

The strategy used to select stratum boundaries is not discussed in detail in this report. It will suffice to say that at our present state of knowledge, depth is the single most useful criterion for stratification because it is a precisely known static factor and because of its obvious correlation with the distribution of groundfish. Other factors such as temperature, benthic fauna and sediment types, undoubtedly are more important than depth per se in controlling groundfish distribution, but temperature is not static, and sediment types and benthic faun : are not so precisely known. Whatever the true significance of each of the above environmental factors, it is a fact that stratification by depth results indirectly in stratification by temperature (to the extent that the water column is thermally stratified) and also in a general way by sediment types and benthic fauna.

Random Selection of Stations

Random selection of stations within strata was accomplished essentially as follows. Each stratum was subdivided into rectangles of 5 minutes of latitude by 10 minutes of longitude, and each of these rectangles was regarded as a homogeneous sampling unit within which only one trawl haul would be necessary to characterize that unit. Each of the 5 x 10' rectangles were further subdivided into 10 smaller rectangles (each 2-1/2' Lat x 2' Long) and these were numbered throughout the entire stratum, with the 10 numbers within any one 5 x 10' rectangle being in consecutive order. Numbers were then drawn from a table of random numbers (subject to the restriction that no more than one number was chosen within any given 5 x 10' rectangle) until the required number of 5 x 10' rectangles was obtained, corresponding to the number of trawl stations specified for the given stratum. Numbering and random selections were done independently in each stratum. With the above procedure every possible trawling site in each stratum had an equal chance of being selected, and the probability of sampling a particular depth within the stratum was proportional to the area represented by that depth within the stratum.1/

Allocation of Stations to Strata

Except for the establishment of a minimum of two stations in any one stratum, stations were allocated to individual strata roughly in proportion to the area of each stratum. Analysis of previous Albatross IV surveys in New England waters (unpublished data) has shown that optimum allocation (based on stratum variances and areas) yields little gain in precision over proportional allocation (based on area alone).

Each vessel had an independent set of stations within each stratum (allowing the possibility that the same station could be occupied by both vessels). An initial attempt was made to synchronize vessel operations within each stratum so that both vessels occupied their stations in a given stratum on the same day and during the same time of day, i.e. daylight or darkness. This proved to be impractical, and therefore the two vessels operated independently of each other. Nevertheless the stations occupied by both vessels in any given area were seldom more than 12 hours apart. The cruise tracks are shown in figures 2 and 3.

Albatross IV was able to occupy 115 stations as opposed to 87 stations by the Soviet Albatros, because Albatross IV was faster and because it used a smaller trawl yielding substantially smaller catches. Positions of stations occupied by both vessels relative to sampling strata are shown in figure 4.

Gear Used

1/ Since stratum boundaries are irregular relative to lines of latitude and longitude, it is not possible to subdivide the entire stratum into uniform 5 x 10' rectangles. This is particularly true around stratum perimeters and in long narrow strata. The problem is largely circumvented by forming irregular - shaped blocks where necessary, with the area of each block equivalent to that of a 5 x 10' rectangle, and subdividing and numbering as before.

Albatross IV used its standard survey trawl (#36 Yankee otter trawl) and the Soviet Albatros used the 27.1 meter herring trawl commonly employed by Soviet scouting vessels. Trawl and vessel specifications affecting fishing power or trawl efficiency are given in Table 1.

Overall dimensions of the Soviet trawl were approximately 1/3 larger than the US trawl, but it is possible that the mouth area of the Soviet trawl was at least twice as great. Mouth area of the #36 trawl is approximately $30m^2$ as based on direct measurements of headrope height and wingspread while towed on Albatross IV, utilizing echo-sounding transducers mounted on the ends of the wings and center of headrope. 1/ Wingspread and headrope height measurements were also made on the Soviet trawl by the US Department of Interior's exploratory fishing vessel Delaware, a side trawler. The average headrope height of the 27.1 meter trawl as recorded on the Delaware was 4.7m, which corresponds closely with the estimate of 4-6 meters supplied by the fishing master aboard the Soviet Albatros. However a mean wingspread of only 11 meters was recorded for the Soviet Trawl on the Delaware as compared with the estimate of 22-24 meters supplied by the fishing master. The wingspread recorded on the Delaware is obviously low and might be attributed to slower towing speed and somewhat smaller doors as compared with operations on the Soviet Albatros. On the other hand a wingspread of 22-24 meters seems

1/ It has been assumed that the vertical spread at the wingends is half that of the center of the headline, and that the headline curve is a circle.

able 1. --Specifications of USA and USSR vess.ls and gear used on joint groundfish survey, October 1967.

ESSEL CHARACTERISTIC	USA (Albatross IV)	USSR (Soviet Albatros)
type trawler	stern trawler	side trawler
overall length	57m	51m
gross tons	1000	500
horsepower	1000	500
towing speed thru water	3.5 knots	3.5 knots
RAWL PART	**modified USA (#36 Yankee trawl)**	**USSR (27.1m herring trawl**
Overall length (wings to cod end)	31.6m	42m
Headrope (total length)	20.6m	?7.2m
Headrope hanging		
Bosom	4.8	3.0m
Wings	7.9	12.1m
Groundrope (total length)	24.4m	27.4m
Groundrope hanging		
Bosom	3.0m	3.0m
Wings	10.7m	12.2m
rawl Opening 1/		
Headrope height	3.0m	(4.7) 4-6 m
Wingspread	12.2m	(11) 22-24m
Approximate mouth area	30 m^2	"60-90 m^2"
aterial	#54 tan nylon (except cod end = #102 white nylon and liner = knotless white nylon)	Kapron (nylon)
esh sizes (stretch measure)		
Wings	129mm	160mm
Square	132mm	160mm
Bellies	114-130mm	80-160mm
Cod ends	95mm	32-40mm
Lines (in cod end and top belly)	13mm	None
ollers (hard rubber discs)	Total of 19 on center 35' section of footrope (each disc 12.7cm wide by 40.6cm in diameter)	None
rawl doors		
Type	OVAL (BMV)	OVAL (Matrosova)
Area	2.56 m^2	3 m^2
Weight	460 Kg	750 Kg
..und Cables	18.3m	20m

1/ See text for details.

TRAWL PART (Cont.)	USA (Albatross IV)	USSR (Soviet Albatros)
Bridle Wires (legs)		
Top	10.4m	50.0m
Center	none	57.8m
Bottom	10.4m	51.7m
Floats		
Type	Aluminum deep sea (20.3cm diam.)	Steel (20-25cm diam.)
No. on headrope bosom section	20	12
" " each wing	8	16
Total No. on headrope	36	44
Chafing gear	Mat of polyethylene strands covering aft half (and under-side only) of codend	1[illegible]mm (stretch measure) netting around entire codend
Cod end float	None	rubberized canvas float

high relative to the total length of the headrope and footrope of 27 meters. Using the Soviet estimates results in a mouth area about 3 times that of the #36 trawl, whereas using the Delaware measurements results in roughly the same mouth area. It seems likely that the actual area is intermediate between these values, but more definitive measurements will have to be made for confirmation. Besides the difference in size of the trawls it should be noted that the #36 trawl was fitted with rollers, and the cod end and upper belly had a fine mesh liner, whereas the Soviet trawl had neither of these features.

Towing speed through the water of both vessels was about 3.5 knots (speed of Albatross IV is monitored by a Litton log), and duration of all tows was 30 minutes. On the Soviet Albatros, a side trawler, the haul was 30 minutes from hook-up to haul back; whereas on Albatross IV, a stern trawler, the 30 minute period ranged from the moment all wire was payed out until haul back commenced. Since a stern trawler maintains greater forward speed during all phases of setting out and hauling back, the #36 trawl on Albatross IV probably covered a greater average linear distance on the bottom per haul. However more information than is presently available will be required to estimate total area swept by the two vessels.

Processing Catches at Sea

Some members of the scientific parties of both countries were aboard both vessels, and at least one member of the scientific staff from both USA and USSR took part in processing each catch on both vessels for the entire survey. The same logs for recording catch data were used on both vessels. Length frequency and weight of the total catch of each species was recorded for each catch whenever practical. When sampling was required, the size of sample and discard for each species was recorded and the estimated length frequency and weight of the total catch were based on appropriate expansion factors. Various collections of scales, otoliths, whole specimens, etc. were obtained on both vessels as directed by individual scientists.

Processing Data Ashore

At completion of the cruise, copies of the original logs of both vessels were made so that each party had a complete set. After audit checks of each log including expansion of samples, data were transferred onto IBM cards at the Woods Hole Laboratory. Preliminary analyses of the joint survey were made with a computer program designed especially to summarize groundfish survey data utilizing a stratified sampling design.

PRELIMINARY RESULTS

Composition of Groundfish Catches

Percentage species composition of trawl catches was computed to compare the catches of the two vessels as well as to describe the composition of the groundfish community in relation to latitude. Sampling strata were combined into five sets chosen to reflect north-south changes in species composition. Stratified mean percentage species compositions (by weight) were computed for each vessel and strata set, and the data are summarized in Table 2 and Figure 5. The strata sets at the southern and northern ends of the survey area were composed of 8 strata each (as compared with 4 strata each for the other 3 sets) chiefly because sampling was not as complete in certain strata at the extreme ends of the area.

Spiny dogfish represented the single most important component (1/3 to 1/2 by weight) in the northern half of the survey area, represented by strata sets 73-76, 1-4, and 5-12 (Figure 5). At the southern end (strata 61-68) smooth dogfish, sea robins and longfin squid were predominant, each contributing about 1/5 by weight. Silver and red hake, two species of particular interest in the joint survey, represented small to moderate components of the catches throughout the entire area.

The relative composition of catches for the two vessels was quite similar in each strata set and this similarity is important for two reasons. First it indicates that the intensity of sampling represented by only one vessel in the joint survey (roughly 100 stations distributed farily uniformly throughout 25,000 mi.^{2}) was adequate to provide a general quantitative picture of the relative abundance and distribution of groundfish. Second it indicates that the differences in trawl selectivity generated by such

Table 2. --Stratified mean percentage contribution (by weight) to total catch by predominant species in five areas (strata sets) of the Joint USA-USSR survey. 1/

Species		Strata 61-68		Strata 69-72		Strata 73-76		Strata 1-4		Strata 5-12	
		USA	USSR	USA	USSR	USA	USSR	USA	USSR	USA	USSR
Mustelus canis	Smooth Dogfish	19.27	17.62	3.67	4.72	.43	1.65	.13	.08	.01	-
Squalus acanthias	Spiny Dogfish	-	.05	3.33	2.21	55.62	45.28	61.37	57.41	38.17	29.66
Raja erinacea	Little Skate	-	.50	.11	8.93	1.04	4.05	.27	3.45	2.01	2.59
Merluccius bilinearis	Silver hake	1.64	3.48	5.26	8.06	1.52	8.05	4.07	7.96	5.43	12.95
Urophycis chuss	Red hake	.40	.29	.99	3.77	.13	3.99	.54	3.82	5.01	7.67
Urophycis regius	Spotted hake	5.43	6.72	2.96	1.82	1.03	.91	-	.65	.21	.72
Limanda ferruginea	Yellowtail fldr.	-	.02	5.51	1.65	4.03	2.99	8.19	2.96	9.37	2.92
Pseudopleuronectes americanus	Blackback fldr.	-	.11	4.22	10.11	1.26	2.03	.80	.30	.57	.19
Stenotomus chrysops	Scup	5.79	3.10	.20	1.14	,12	.04	.23	.31	.18	.36
Prionotus carolinus	Common Sea Robin	12.06	23.59	22.47	24.77	4.47	2.05	.40	-	.57	.03
Lophius americanus	Am. Goosefish	.38	.18	3.09	1.10	2.50	3.58	1.20	8.32	4.27	7.40
Homarus americanus	Lobster	1.65	.08	3.76	4.21	5.12	1.84	2.37	2.86	6.75	8.37
Placopecten magelanicus	Sea scallop	.11	-	6.57	-	2.65	.71	4.23	-	.12	-
Loligo pealei	Squid (Loligo)	26.67	17.75	21.24	12.45	9.80	15.51	1.56	2.55	3.76	5.27
Carcharhinus milberti	Brown Shark	2.75	6.54	-	1.35	-	-	-	-	-	-
	Total Above Species	76.15	80.03	83.38	86.29	89.72	92.68	85.36	90.67	76.43	78.13
	No. of trawl hauls	26	20	17	13	17	14	23	18	32	22

1/ Percentages less than .01 are indicated with a dash. The species excluded from this table represented < 5% by wt. in all vessel-strata set combination Stratified mean percentage compositions were computed as follows: All tows within each stratum were combined and the percentage species compositio by weight was computed; then the average percentage species composition for all strata within a set was computed, where all percentage values in a given stratum were weighted according to the area of the stratum.

factors as headrope height and presence or absence of rollers, were not so large as to produce major differences in the separate indices of species composition. This is encouraging from the standpoint of the potential for comparing data collected by different ships and trawls. Of course it does not eliminate the need for definitive comparative experiments such as described by Hennemuth (see Comparison Document, Part I) whenever it is desired to compare on an absolute scale, the abundance indices generated by different vessels and gear.

Hake and Dogfish Distribution vs. Depth and Temperature

Distribution of bottom water temperatures was characterized by two main features. South of 38°N, temperature and depth were positively correlated with temperature ranging from 9-20°C (Figure 6). North of 38° the inshore temperatures were lower (11-12°C) and the intermediate depths exhibited a relatively cool (8-9°C) mass of water extending almost to Nantucket Shoals, with slightly warmer water on both sides in greater and lesser depths.

Intensity of sampling on the joint survey was sufficient to yield a reasonably good indication of the relation between fish distribution and depth and temperature. Results are presented here for spiny and smooth dogfish, two principal components of the trawl catches whose movements are known to be related to seasonal changes in temperature. Distribution of catches is also shown for spotted, red and silver hake.

Spiny dogfish were found principally to the north of 38° in the cooler waters, with all but one catch taken where bottom temperatures were less than 14°C (Figure 7). Smooth dogfish showed essentially the opposite distribution, with catches primarily in the southern inshore areas where bottom temperatures were greater than 12°C.

South of 40°N the distributional limits of these two species tend to follow the bottom temperature contours. While this is consistent with a preferential temperature response it is by no means proof of such a response; interspecific competition may also play a part. On the other hand the presence of two apparently isolated groups of smooth dogfish off Long Island and Nantucket associated with the 12° isotherm, suggests rather more strongly the possibility of temperature control in the distribution of this species.

Red and silver hake were present throughout the entire latitudinal range of the survey, but abundance was noticeably lower in the southern part, especially in the warm shoal areas (Figure 8). Silver hake were caught everywhere except in the warmest shoal water (about 16°C), but red hake were more restricted to areas of cooler water (<12°C). An interesting contrast is shown in the distribution of spotted hake, which were more abundant in the southern part of the survey area and which were largely absent from the 8-10°C mass of water at intermediate depth to the north, even though they extended all the way to 70°W at depths greater than about 60 fathoms (Figure 9).

These figures not only document the general distribution of some of the more important species on the joint survey, but they also demonstrate the potential of such a survey for determining large scale patterns of fish distribution and their relation to environmental factors. Obviously the results of just one survey cannot be definitive, but a series of such surveys covering different seasons and years could go a long way toward an understanding of the role of temperature in controlling fish distribution.

Catch Rate Comparisons on Linear Scale

A comparison of the relative efficiencies of the vessel-gear combinations used on the survey is given by the ratios of mean catch (lb) per 30 minute haul for the same 5 species groups discussed in the comparative experiment described by Hennemuth (Table 3). While these data leave no doubt as to the greater fishing power of the Soviet gear it must be emphasized that these catch ratios can be used only as a rough indication of relative efficiency. This is because they have a large variance which arises from the well known fact that individual catches have a highly skewed distribution. This large variance is evident in the variability of ratios for a given species group among different strata sets (Table 3); and as will be shown in the next section a quite different result is obtained for dogfish on a log scale for all strata combined.

In spite of the variability it may be noted that the catch ratios reflect some of the same differences in relative fishing power which were observed in the comparative experiments. In particular, relative efficiency of the Soviet gear was greater for skates and groundfish than for the other

Table 3. Stratified mean catch (lb) per 30 minute haul of USA and USSR Research vessels, and their ratio (USA/USSR) for certain strata sets and species groups, on joint US-USSR survey.

Species Group [1/]	Strata 61-68			Strata 69-72			Strata 73-76			Strata 1-4			Strata 5-12			All Strata Combined		
	USA	USSR	USA/USSR	USA	USSR	USA/USSR	USA	USSR	USA/USSR	USA	USSR	USA/USSR	USA	USSR	USA/USSR	USA	USSR	USA/USSR
Dogfish	38.5	37.2	1.03	13.1	14.0	.94	358.3	272.5	1.31	426.9	1475.7	.29	140.9	565.9	.25	193.0	522.0	.37
Skates	0.6	3.0	.20	0.1	27.2	.004	2.6	20.8	.12	0.6	21.4	.03	10.6	34.1	.31	3.5	21.8	.16
Groundfish	5.3	49.9	.11	7.0	24.1	.29	2.9	64.5	.04	17.2	93.0	.18	34.6	173.9	.20	15.8	91.1	.17
Pelagic	33.6	22.6	1.49	0.2	13.7	.01	1.5	17.0	.09	16.2	45.3	.36	9.2	11.8	.78	13.3	22.4	.59
Flounder	4.6	4.7	.98	22.1	46.1	.48	31.0	41.9	.74	31.8	41.3	.77	37.1	34.9	1.06	25.9	32.7	.79
All Species Combined	766.6	227.3	3.37 [2/]	165.2	307.6	.54	451.8	495.9	.91	525.3	1749.6	.30	254.8	881.3	.29	436.1	785.7	.56

1/Species in each group are listed in Table 4, Part I by Hennemuth.

2/ One unusually large catch of sea robins by US vessel was responsible for this unusual ratio.

species groups, and this difference was observed for the entire survey area taken as a whole, as well as for strata set 5-12 within which the comparative experimental areas fell (Table 4). The major difference between the survey and experiment results was that in the survey catches, the relative efficiency of the Soviet gear appeared greater for dogfishes than for pelagics, and the reverse was observed in the experiment. Again however these differences may only reflect sampling error. The catch ratios for all species combined are about what would be expected with a trawl mouth-area ratio of approximately 2. Note that the joint survey ratios in Table 4 come directly from Table 3, and the comparison experiment ratios were computed from total catches (lb) of each vessel using its own gear as listed in Table 4 of Part I by Hennemuth, in order to make them as comparable as possible.

Catch Rates on Log Scale

Catches of red and silver hake, spiny dogfish, and all species combined were transformed to logarithms to improve precision and comparability of catch rate comparisons. On the transformed scale the relative ranking of abundance of the three individual species (and all species combined) by the two vessels is quite consistent among and within strata sets (Table 5, Figure 10). That is, each vessel yielded roughly the same quantitative picture of abundance from the standpoint of distribution and the relative availability of the several species. Also we note here the fact that the level of total abundance (all species combined) was about the same in all strata sets, although as shown earlier there was a considerable difference in species composition between strata sets 61-68 and 69-72, and those to the north (Figure 10).

From the standpoint of estimates of relative efficiency of the USA and USSR gear, several points are noteworthy. For both red and silver hake the Soviet gear showed greater fishing power in all individual strata sets as well as in the ratios for all strata combined (Table 5). The within strata-set differences generally were significant as indicated by the non-overlap of 95% confidence intervals shown in Figure 10. Also the difference for all strata combined is significant as indicated by the confidence interval for the overall ratio (USSR/USA) for these two species

Table 4. Ratios of mean (Joint Survey) or total (comparison experiments) catches of USA and USSR vessels (each using its own gear), for certain species groups and all species combined.[1/]

Species Group	USA/USSR Catch Ratios (lb, orig. scale)		
	Joint Survey		Vessel and Gear Comparisons, All Experiments Combined
	All Strata	Strata 5-12	
Dogfish	.37	.25	.54
Skates	.16	.31	.27
Groundfish	.17	.20	.36
Pelagics	.59	.78	.43
Flounder	.79	1.06	.96
All species combined	.56	.29	.50

1/ Ratios for joint survey taken from Table 3, and ratios for comparative experiments computed from data given in Table 4, Part I.

Table 5. Stratified mean abundance indices (lb. per 30 minute haul, $\log_e$ scale) and their coefficients of variation, and catch ratios of two vessels in original units. Joint US-USSR Survey.

Strata Set	Silver Hake				Red Hake				Spiny Dogfish				All Species Combined			
	Stratified Mean, $\log_e$ scale, and (CV)		Catch Ratios, Orig. Units		Stratified Mean, $\log_e$ scale, and (CV)		Catch Ratios, Orig. Units		Stratified Mean, $\log_e$ scale, and (CV)		Catch Ratios, Orig. Units		Stratified Mean, $\log_e$ scale, and (CV)		Catch Ratios, Orig. Units	
	US	USSR	USSR / US	US / USSR	US	USSR	USSR / US	US / USSR	US	USSR	USSR / US	US / USSR	US	USSR	USSR / US	US / USSR
61-68	.3086 (.08)	.5880 (.06)	1.3	.77	.1301 (.50)	.1681 (.35)	1.03	.97	0	.0401 (.18)	1.04	.96	4.9837 (.08)	5.0541 (.04)	1.07	.93
69-72	.3780 (.24)	1.3207 (.27)	2.6	.38	.0616 (1.00)	.4690 (.83)	1.5	.67	.6232 (.58)	.8086 (.49)	1.2	.83	4.4312 (.05)	5.3074 (.04)	2.4	.42
73-76	.6045 (.40)	2.5687 (.24)	7.1	.14	.1046 (.90)	1.8436 (.28)	5.7	.18	4.6501 (.11)	4.6895 (.13)	1.04	.96	5.6563 (.04)	5.8257 (.05)	1.2	.83
1-4	1.3044 (.24)	2.9628 (.18)	5.2	.19	.6347 (.30)	2.0742 (.18)	4.2	.24	4.8444 (.05)	5.7545 (.04)	2.5	.40	5.5083 (.03)	6.5749 (.03)	2.9	.34
5-12	1.9970 (.05)	3.1516 (.11)	3.2	.31	1.5333 (.14)	2.5772 (.16)	2.8	.36	3.7261 (.06)	3.6125 (.13)	0.9	1.11	5.0011 (.03)	5.2803 (.05)	1.3	.77
All strata combined Mean / CV	1.0373 / .08	2.2015 / .08	3.2	.31	.6069 / .12	1.5268 / .11	2.5	.40	2.8354 / .04	3.0438 / .06	1.02	.98	5.1151 / .02	5.5967 / .02	1.6	.62
Approx. 95% confidence Int.			2.1-4.8				1.7-3.6				0.8-1.9				1.2-2.2	
Comparative experiments combined[1/]				.18				.18				.63				.40

1/ Catch ratios for experiments 1 and 2 combined, were derived from a pooled estimate of net effects (Table 2, Part I), weighting each effect according to its degrees of freedom.

shown at the bottom of Table 5; in both cases the lower limit of the confidence interval was greater than one.

Assuming that mouth area is the principal difference between the two trawls, the catch ratios for red and silver hake are consistent with what has been assumed about the relative size of mouth areas. However it should be noted that the relative efficiency of the Soviet gear was greater at higher levels of abundance. This is shown in Figure 10 by the larger differences between vessel means in the strata sets with higher hake abundance, and in Table 5 by the corresponding catch ratios. Apparently catch per unit mouth area of one or both trawls changed with abundance of hake or more generally in response to the change in species composition.

In contrast with hake, there was no significant difference in fishing power of the USA and USSR gear for spiny dogfish (Table 5). This implies that the catch per unit mouth area was greater for the USA vessel-gear combination - roughly twice as great in view of our assumption about the trawl sizes. In this case although there appears to be a rather large difference in absolute efficiency between the trawls, there was no change in the relative efficiency over a wide range of dogfish abundance.

With respect to our ability to compare estimates of change in abundance based on data from different vessels and gear, a change in relative efficiency as noted for hake would seem to be potentially the most troublesome. The data at hand will not disclose whether the observed change in relative efficiency was due solely to change in hake distributions or to a more complicated interaction of species. Whatever the true explanation, it is important to note that such interactions will not be detected in comparative vessel-gear experiments unless the experimental design includes various levels of abundance and species composition.

LITERATURE CITED

Cochran, W.G. 1953. Sampling Techniques. 330 pp. John Wiley and Sons, Inc., New York.

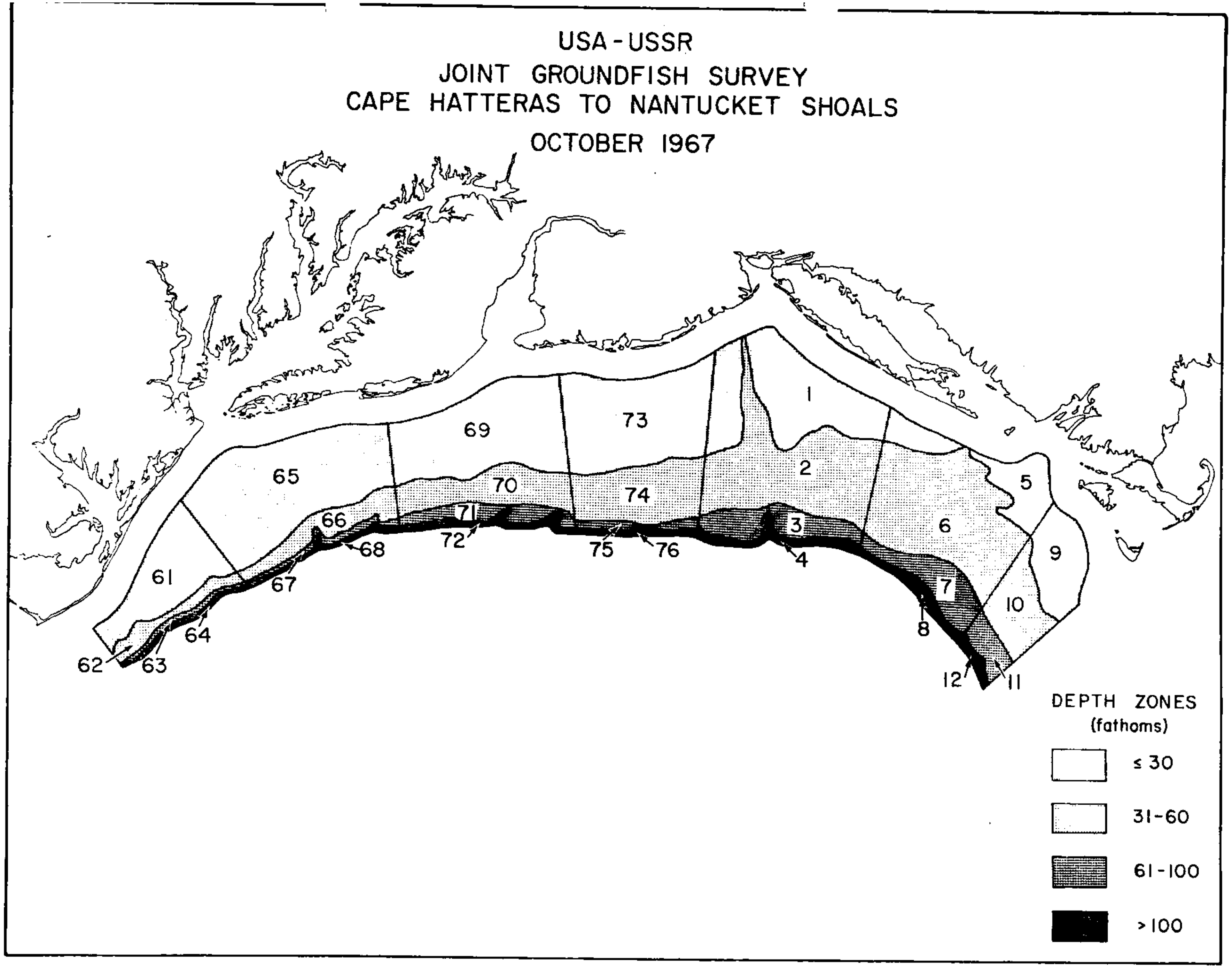


Figure 1. Sampling strata used in joint US-USSR survey.

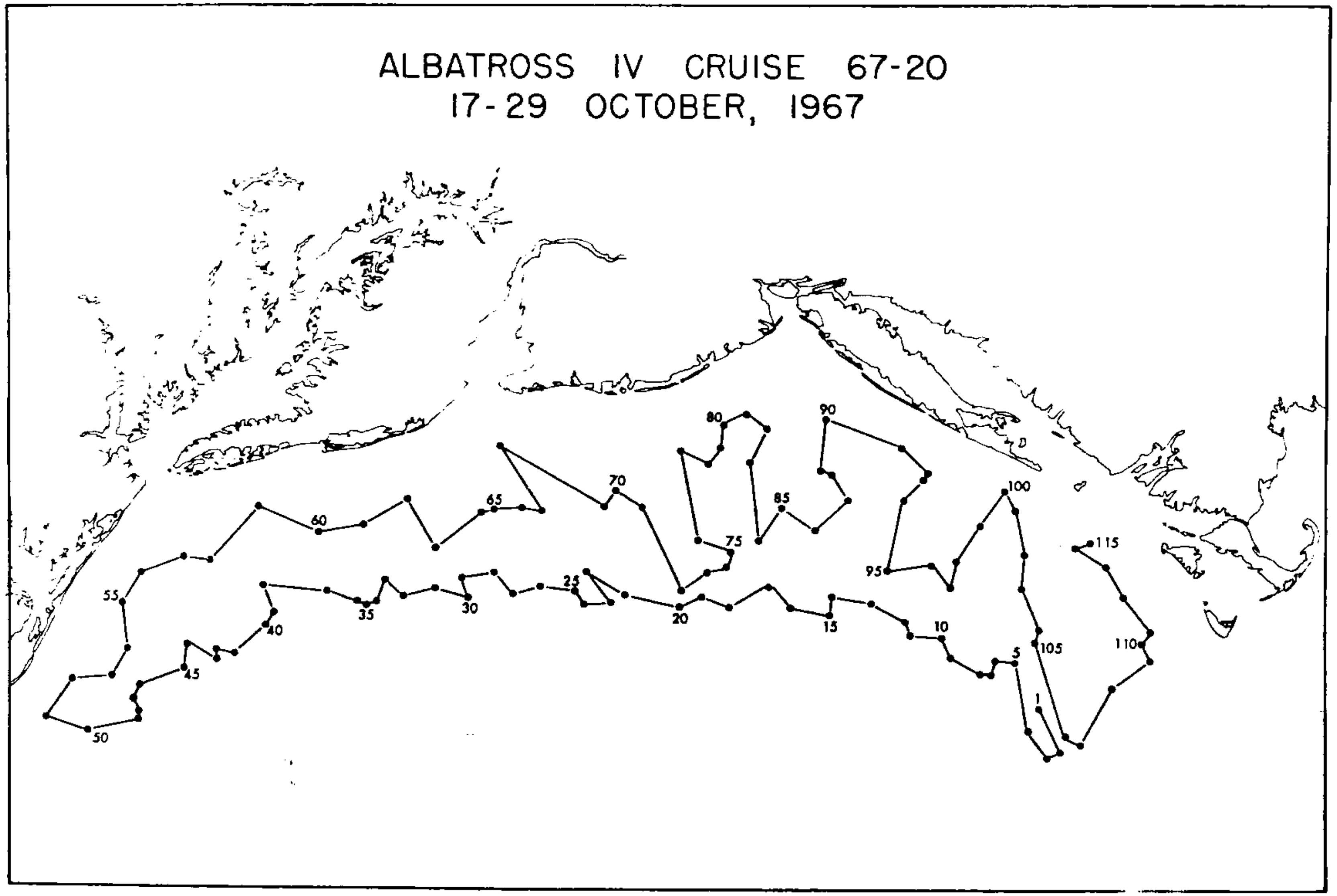


Figure 2. Cruise track of US research vessel Albatross IV on joint US-USSR survey.

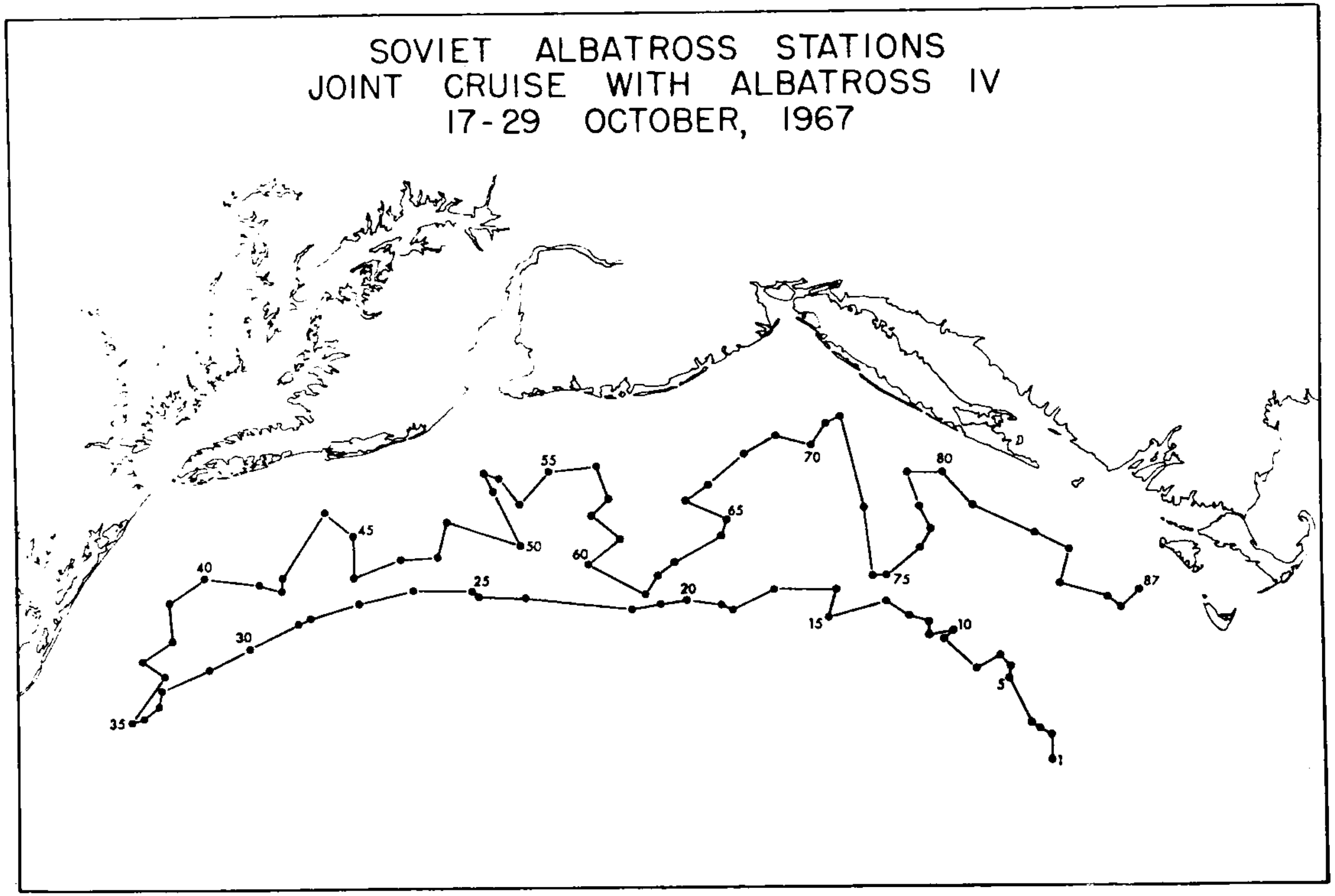


Figure 3. Cruise track of Soviet research vessel, Albatros, on joint US-USSR survey.

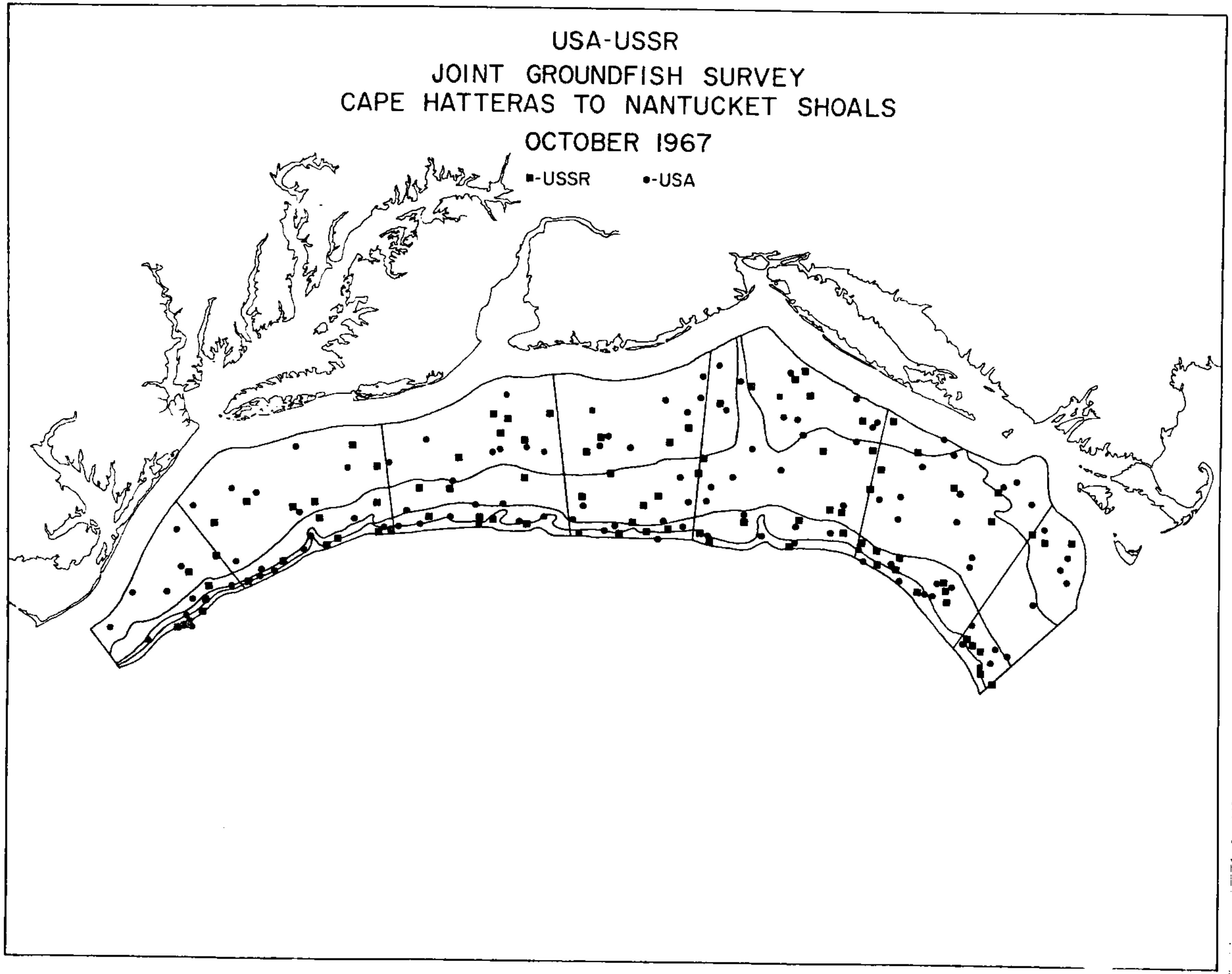


Figure 4. Distribution of otter trawl hauls on joint US-USSR survey.

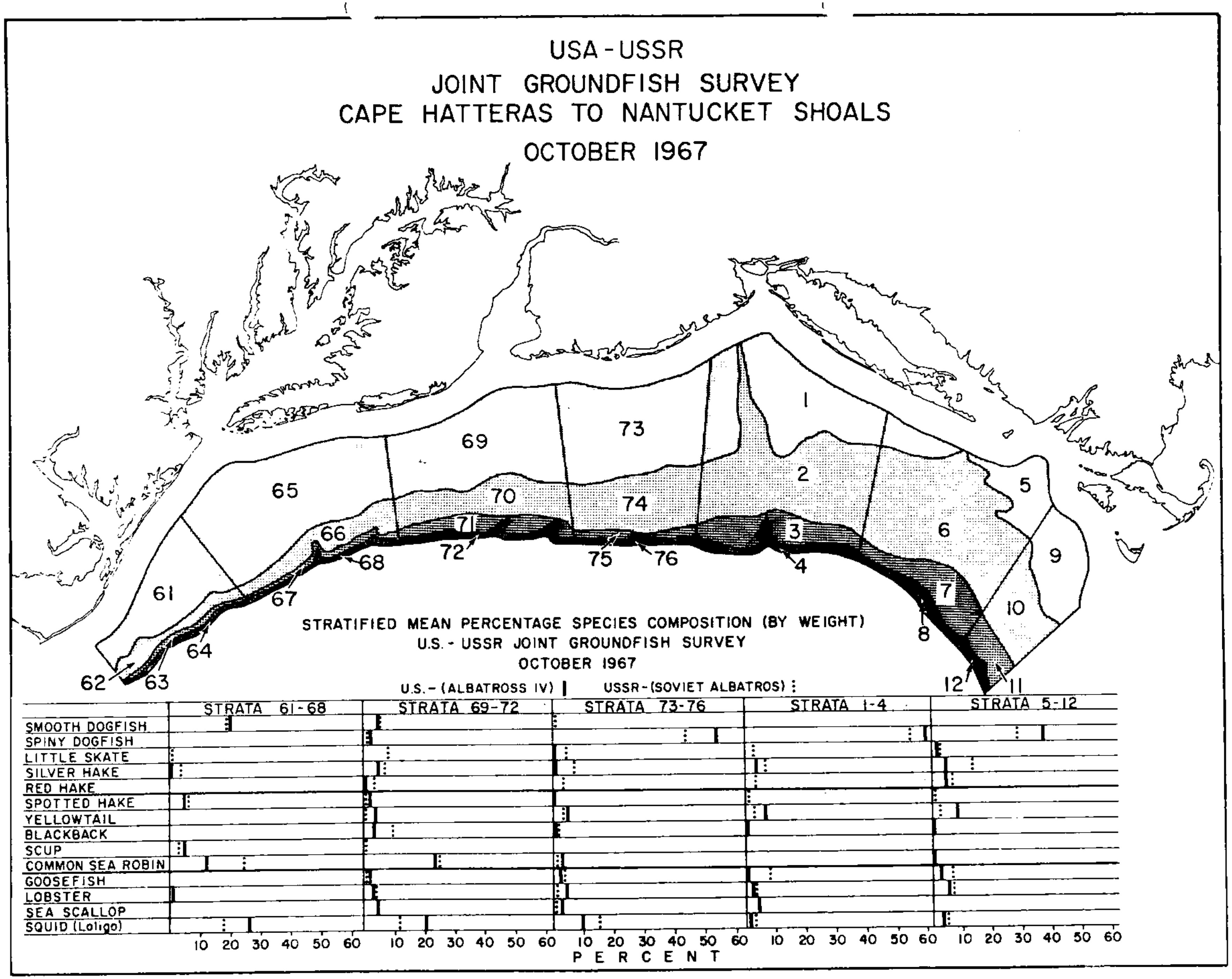


Figure 5. Percentage species composition (by weight) of trawl catches on joint US-USSR survey.

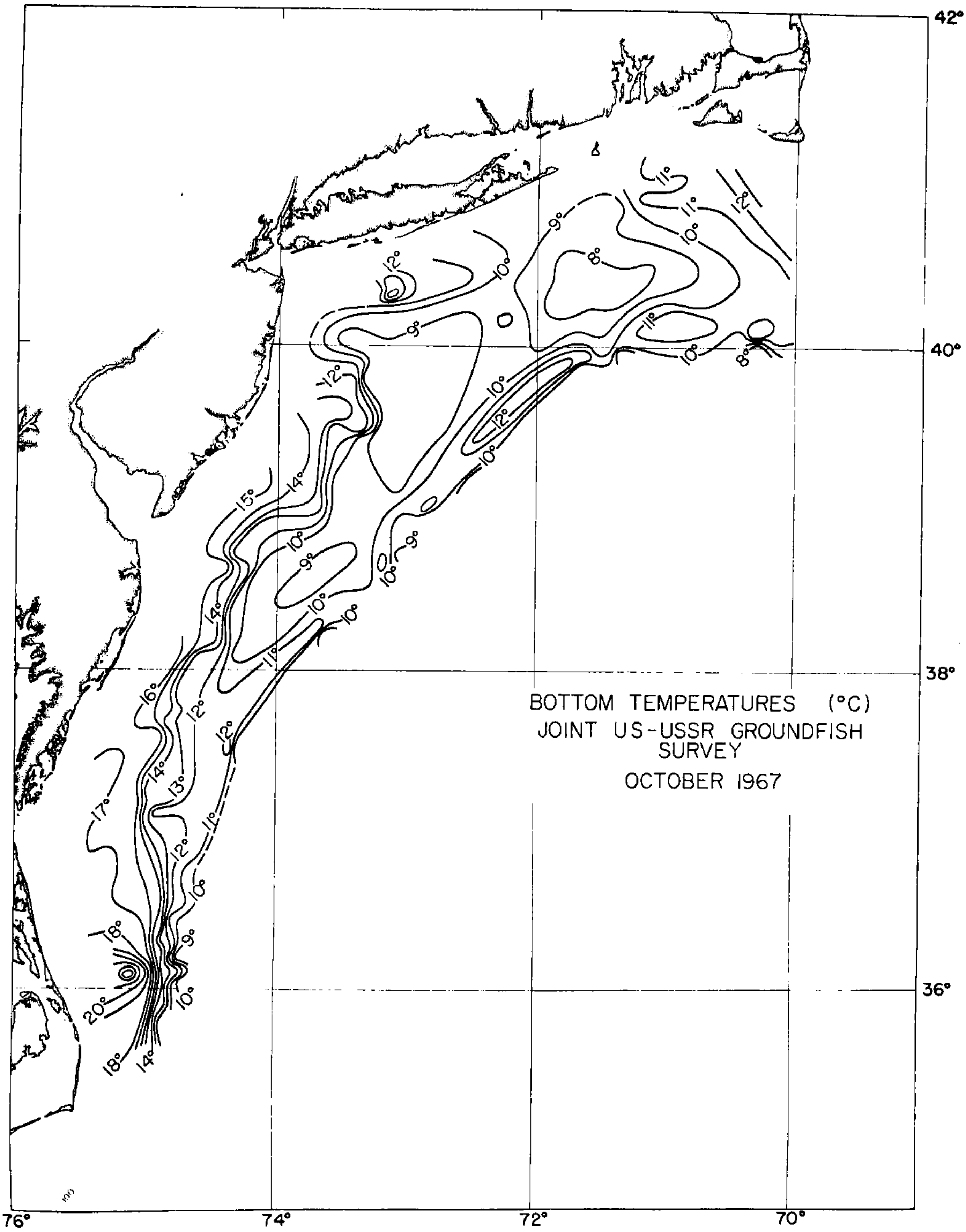
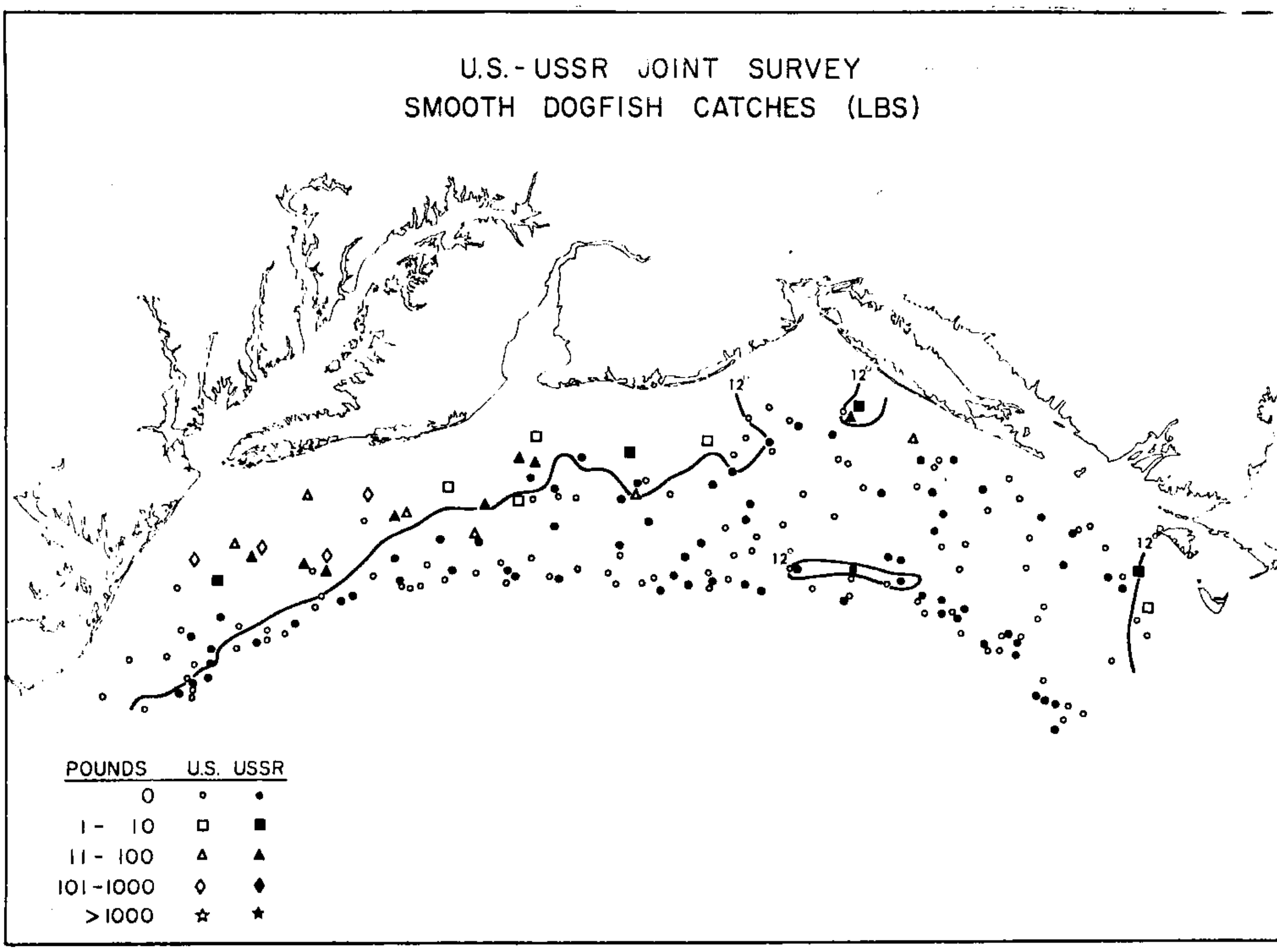


Figure 6. Distribution of bottom temperature on joint US-USSR survey.



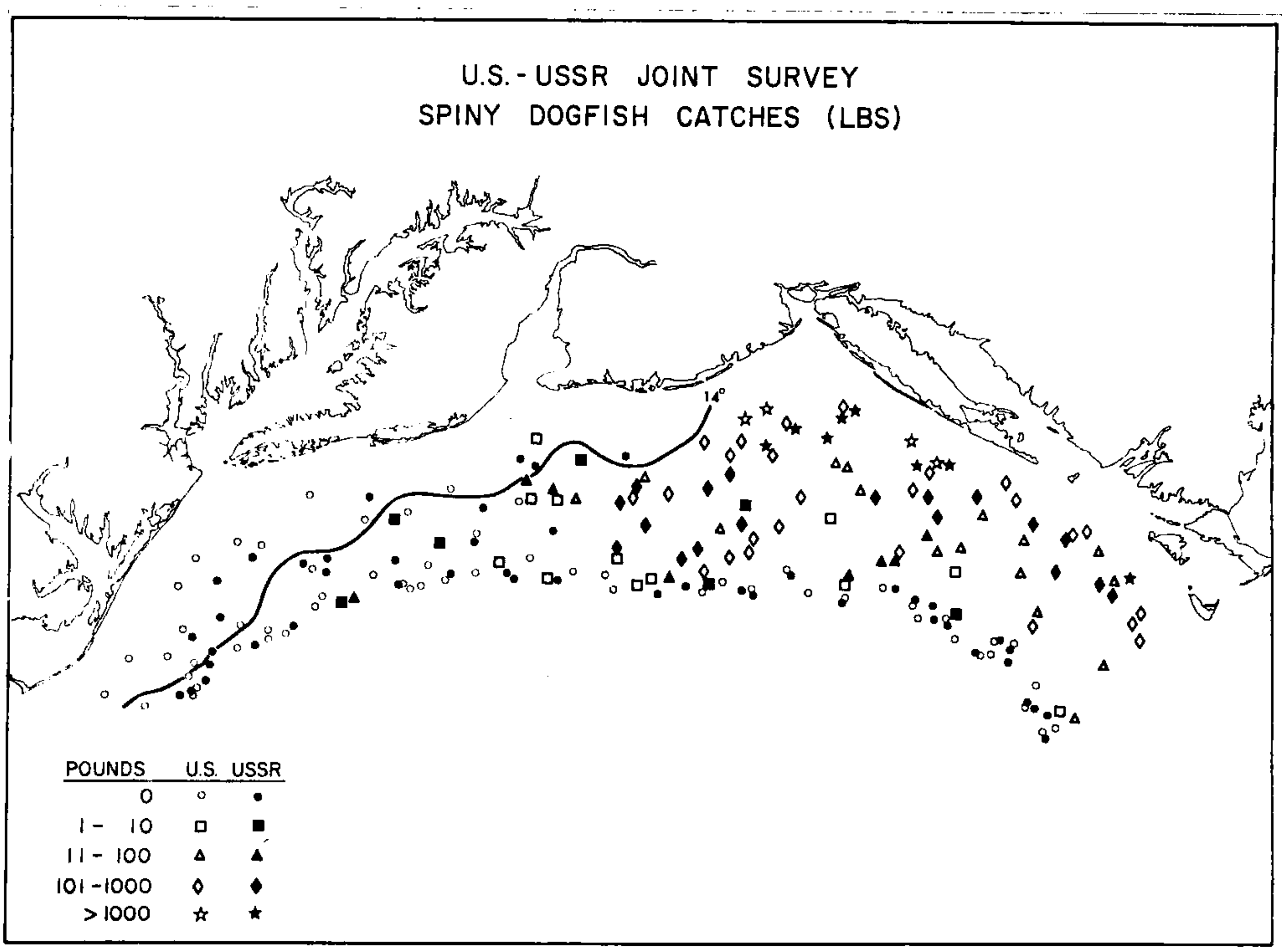
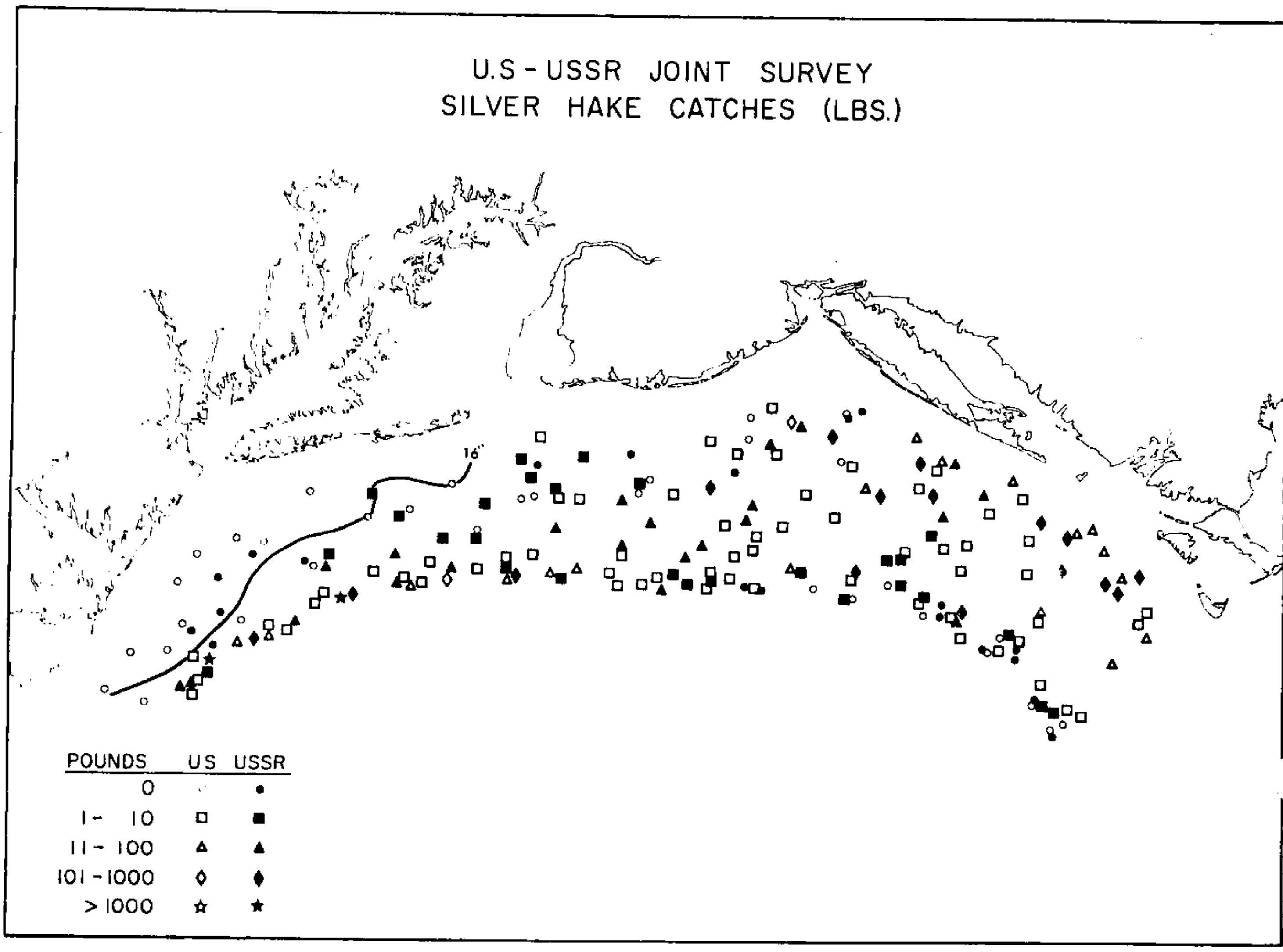


Figure 7. Distribution of smooth and spiny dogfish catches on US-USSR survey.



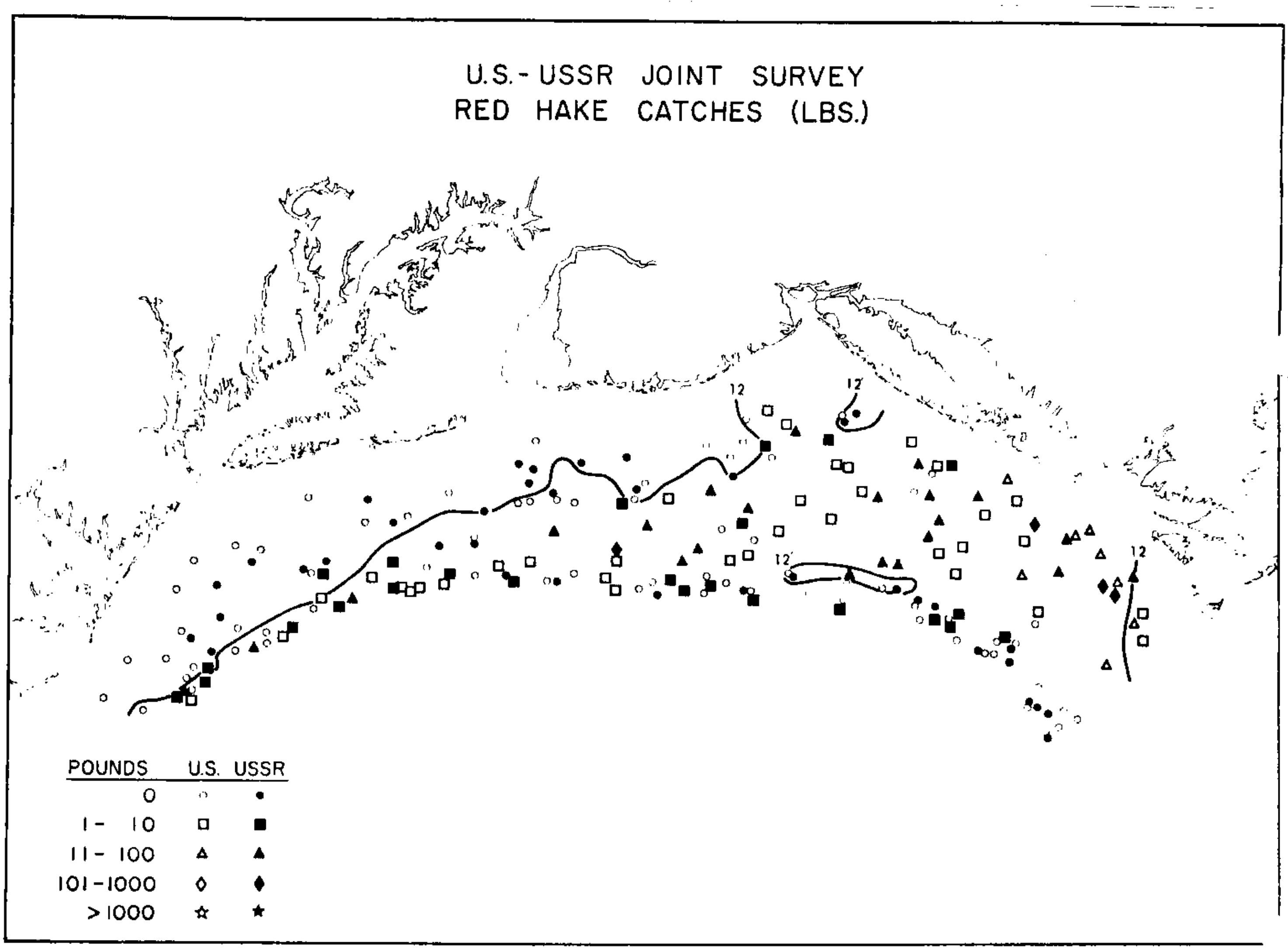


Figure 8. Distribution of red and silver hake catches on US-USSR survey.

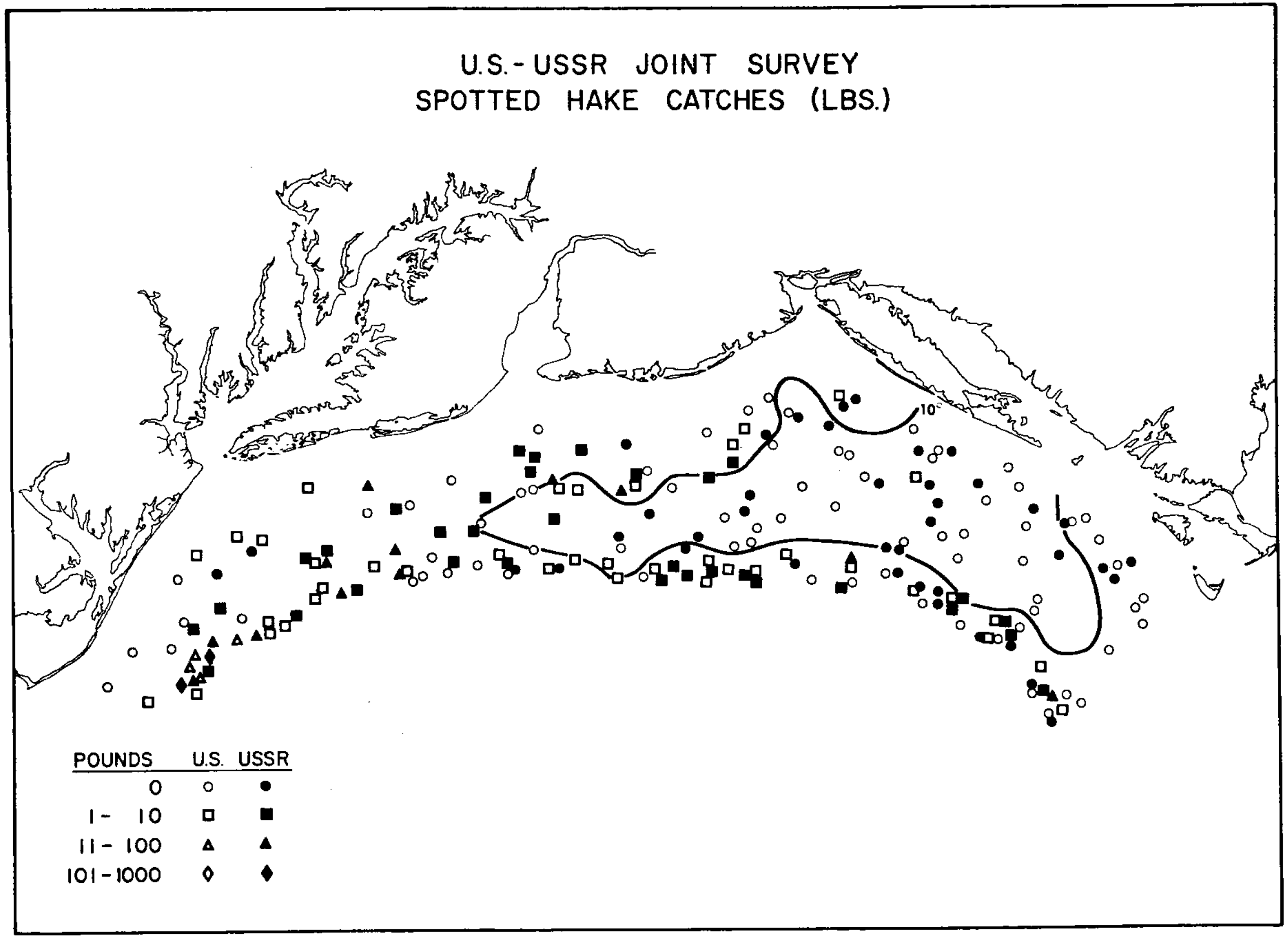


Figure 9. Distribution of spotted hake catches on US-USSR survey.

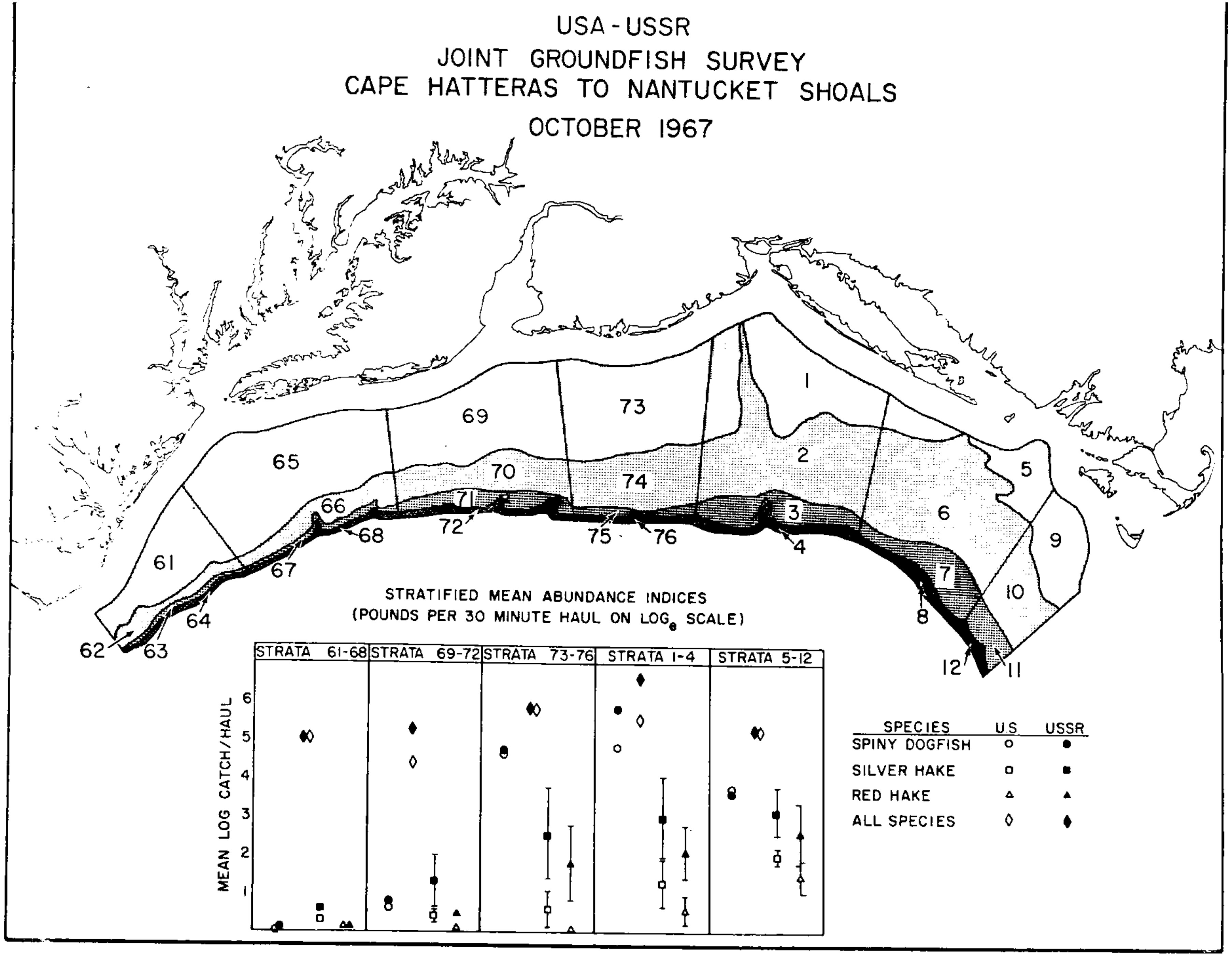


Figure 10. Mean abundance indices on $\log_e$ scale for several species, and for all species combined on US-USSR survey.