A PRELIMINARY REPORT ON THE JOINT USSR-USA GROUNDFISH SURVEY FROM CAPE HATTERAS TO CAPE COD

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INTRODUCTION

The primary objective of the joint survey was to determine the distribution and abundance of groundfishes throughout the specified area, in order to establish a firmer biological basis for assessing the harvest potential of the fish stocks. To obtain this objective it was desirable to choose a survey plan with the following general characteristics:

(1) A station pattern which provides abundance indices as closely related to true absolute abundance of all species of groundfish as is possible for any specified type of gear.

(2) Types of gear comparable to gear used in past surveys by both countries.

(3) Close cooperation between scientific parties of both countries and use of uniform procedures for sampling catches to facilitate comparison of results and promote mutual confidence in them.

These characteristics are developed in greater detail in the following sections.

SELECTION OF STATIONS

Objectives

The basic idea underlying the selection of stations for the joint survey was to randomly pre-select locations in advance of the cruise, and not to search for fish concentrations with echo sounders. The rationale behind this choice is that;

(1) We are seeking data on the entire groundfish community and not just on those species forming detectable schools.

(2) The size, density and behavior (particularly vertical distribution) of fish schools may be altered more by such rapidly changing factors as light, temperature or distribution of food organisms, than by total abundance of the species.

With respect to the first point, it is clear that choosing stations on the basis of dense echo traces alone would confine fishing only to those places (and times) where species forming detectable schools occur; and it was our intention to obtain indices of the biomass and species composition of the entire survey area. With regard to the second point, fishing only on aggregations of fish tends to maximize that portion of the variability among catches which is independent of absolute abundance; and in fact we wanted to minimize such variability.

Choice of Survey Design

Perhaps the ideal survey technique would involve both fishing and echo traversing done simultaneously but independently by different vessels. However this would have required more ships than were available for the present survey and therefore a random pre-selection procedure was adopted.

The specific sample design chosen was the well known stratified random sampling design which is widely used for sample surveys in general (Cochran, 1953). The stratified random design embodies the following properties which were desirable from the standpoint of the joint groundfish survey:

(1) Provides for a fairly uniform distribution of stations throughout the entire survey area.

(2) Provides unbiased abundance indices for each subdivision as well as for any set (including the whole set) of subdivisions. Estimates are unbiased in the sense that every trawlable part of each subdivision has an equal chance of being trawled, and an abundance index for any combined set of subdivisions is computed by weighting the index of each subdivision in the set according to its area.

(3) Provides valid estimates of the statistical precision (sampling error variance) of the mean abundance indices of each subdivision as well as the precision of any set (including the whole set) of subdivisions.

All the above features were achieved by (subdividing) stratifying the total survey area into subdivisions (hereafter referred to as strata) and sampling randomly within each stratum. The strata used are shown in figure 1. The depth boundaries and the inshore-offshore boundaries for strata 1-12 were kept identical to those used in previous Albatross IV surveys to facilitate comparisons.

The desirability of achieving rather uniform coverage over the entire survey area arises because we want to have as much confidence in the estimates of abundance and species composition in one part of the area as in another. More specifically we want the abundance index for each stratum (or set of strata) to be representative of the whole stratum (or set), and we want a quantitative measure of the confidence we can place on the indices. Thus we require random sampling within each stratum to insure unbiasedness and to provide estimates of statistical precision (variance). Finally it might be noted that insofar as strata represent different hydrographic subdivisions of the area, the stratified random design sets up statistically valid comparisons for estimating the degree of influence of hydrographic factors on distribution of groundfish.

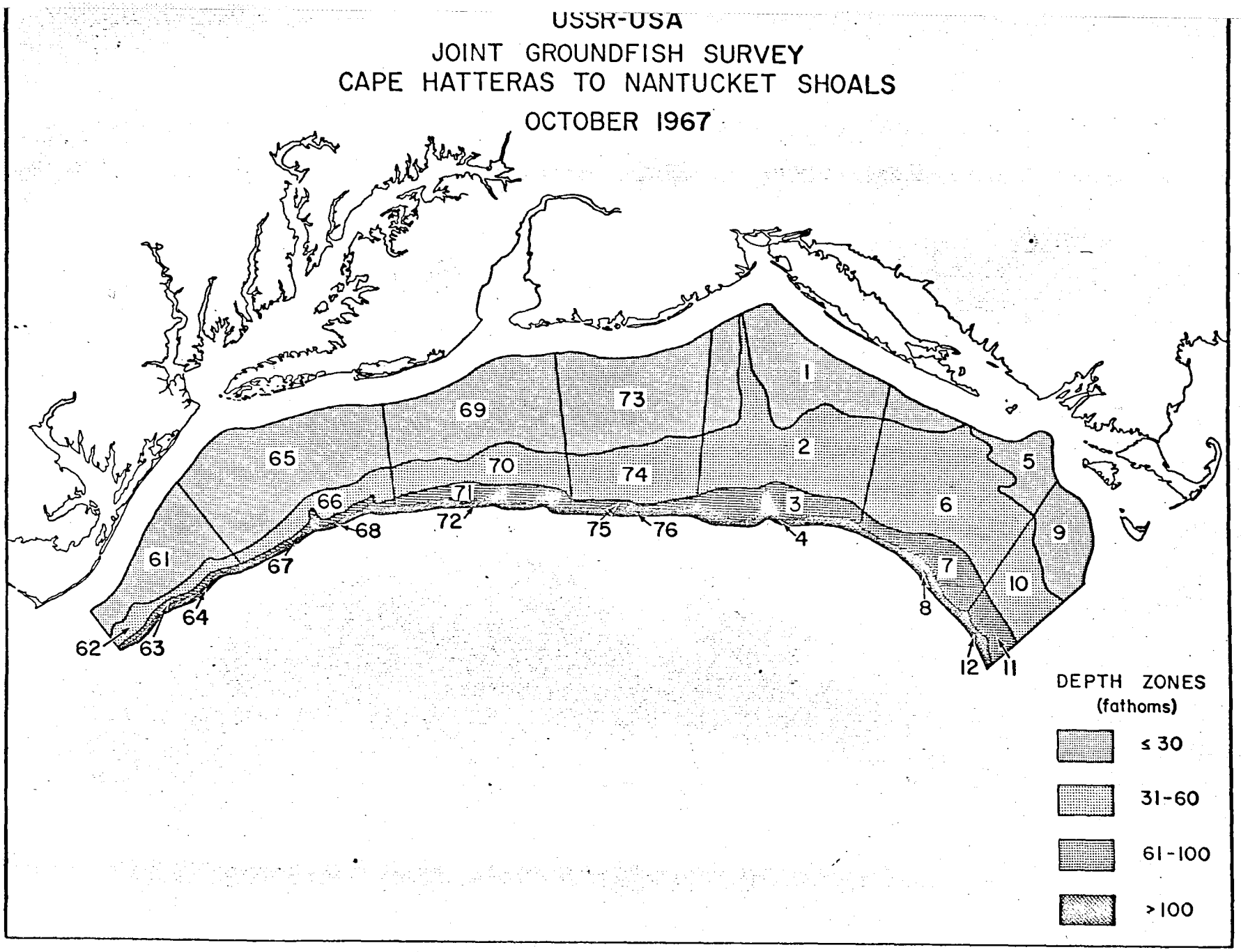

Figure 1. Sampling strata for joint USSR-USA groundfish survey.

Criteria for choosing strata

The general strategy is to try to choose strata such that each is homogeneous with respect to the distribution and abundance of fish. If the stratum is homogeneous then catches will be quite similar from station to station and relatively few stations will be required to adequately reflect the abundance and species composition in that stratum. On the other hand if the stratum is heterogeneous, then catches will be highly variable, and many more stations will be required to characterize the heterogeneous stratum with as much statistical precision as the homogeneous stratum. Since fish populations move about freely in response to hydrographic changes, homogeneity is a very relative matter; and in a statistical sense stratification can be expected to yield substantial gains in precision only when comparing strata from widely different hydrographic regimes.

There are two characteristics of stratification criteria which are essential if the criteria are to be very useful. First and most important, the set of criteria must bear a fairly close relationship to the distribution of fish; and second, criteria should be relatively static or fixed through time and space to permit comparisons among different cruises. Depth and bottom temperature are both clearly related to groundfish distribution but depth is the more useful criterion for constructing strata because temperature varies widely, and furthermore precise temperature data is not generally available in advance of a cruise. Of course when the water column is thermally stratified, then depth and temperature are closely correlated, and stratification

(subdivision of the survey area) by depth indirectly results in stratification by temperature.

Bottom sediments and benthic fauna are two relatively fixed hydrographic factors which are undoubtedly important factors controlling groundfish distirbution. However, we do not yet have sufficient data on the relation of these factors and fish distribution to utilize them directly in constructing sampling strata. Here too, bottom sediment types and benthic fauna are correlated in a general way with depth, and thus stratification by depth also results indirectly in stratification by sediment type and benthic fauna.

As noted earlier, depth boundaries of strata were made identical to those used on previous Albatross IV surveys to facilitate comparisons. Originally these particular depth boundaries were chosen to correspond approximately to depth zones used in summarizing landings statistics of the U.S. groundfish fleet, and these in turn were chosen according to the depth distribution of fishing effort by the fleet chiefly on Georges Bank (Rounsefell, 1957). In particular, the 60 fathom contour represented a natural break in fishing activity; the bulk of fishing occurred in 30-50 fathoms, very little was done in 60 fathoms, and some was done in depths greater than 60 fathoms (significantly more than at 60 fathoms but considerably less than in 30-50 fathoms).

Aside from the convenience of comparing research vessel data with back commercial statistics, the 60 fathom boundary was a desirable choice from the standpoint of temperature stratification. The usual fall stratification on Georges Bank and southern New England

grounds, results in a linear correlation between bottom water temperature and depth down to 60 fathoms but below 60 fathoms temperature changes very little down to the maximum depth (about 175 fathoms) fished by Albatross IV. Whether the specified depth zones which are useful for the Georges Bank area in autumn will prove to be as suitable for the area covered by the Joint Survey, cannot be determined until after analysis of the Joint Survey data.

Random selection of stations within strata.

Each stratum was subdivided into rectangles of 5 minutes of latitude and 10 minutes of longitude (hereafter referred to as 5 x 10' rectangles) each of which is regarded as a homogeneous unit within which no more than one station will be occupied. However the 5 x 10' rectangles are large enough so that in areas of steep depth contours, a single rectangle can contain a rather wide depth range. Thus it was desirable to establish an objective basis for specifying a precise trawling location within the rectangle. This was accomplished by subdividing each 5 x 10' rectangle into 10 smaller rectangles (each 2-1/2' Lat x 2' Long), and assigning a number to each small rectangle. Another complication is that stratum boundaries are irregular relative to lines of latitude and longitude and therefore it is impossible to subdivide the entire stratum into uniform 5 x 10' rectangles. This is particularly true around the perimeters of strata and in long narrow strata. To circumvent this problem, irregular-shaped blocks were formed where necessary, with the area of each block approximately equivalent to that of a 5 x 10' rectangle. Then each block was subdivided into 10 small blocks each of which had an area approximately equal to a 2-1/2 x 2' rectangle.

After subdivision of each stratum as described above, the small rectangles were numbered from 1 to n (where n equals the total number of 2-1/2 x 2' rectangles in the stratum), with the restriction that the numbers within each block (5 x 10' rectangle) of ten small rectangles were in consecutive order. For example, the first block would have numbers 1-10, the second block 11-20, etc.. Numbers were then drawn from a table of random numbers until the required number of different blocks were obtained, subject to the restriction that no more than one small rectangle was chosen within any one block. The above procedure insures that virtually every possible trawling site in the entire stratum has an equal chance of being chosen, and the probability of sampling a particular depth within the stratum will be proportional to the area represented by that depth within the stratum.

A few exceptions to the above procedures should be noted. In some of the very narrow strata of the southern portion of the survey area (strata 63, 64, 67, 68, 72 and 76 - see figure 1) the basic sampling unit was reduced to one-half of a 5 x 10' rectangle. This was necessary because in some cases the total area of the stratum in terms of the number of 5 x 10' rectangles was less than the number of proposed stations. Another modification in certain narrow strata with steep depth contours, was that the total depth interval of the stratum was subdivided into several equal sub-intervals of depth, and one sub-interval was randomly chosen for the trawling depth. For example, sub-intervals used in the 101-175 fm strata were: 101-115, 116-130,

131-145, 146-160, 161-175 fm. This modification was required because in cases of steep contours, navigation alone is not sufficiently precise to specify depth accurately. Note that with this procedure each depth had an equal chance of being selected in each stratum.

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. This type of allocation is commonly used in sample surveys in general and it is known as proportional allocation. Previous Albatross IV surveys in New England waters have shown that the optimum allocation is very nearly the same as proportional allocation, and therefore it has been assumed that this may also be the case in the present survey area.

It is outside the scope of this report to describe fully the theoretical basis for determining the optimum allocation within the framework of stratified random sampling. It will suffice to say here that the optimum allocation is that allocation which provides the smallest sampling error variance for any fixed total sample size. More specifically in the context of the joint survey, for any fixed total number of stations, optimum allocation will yield a stratified mean abundance index with minimum variance.

The original survey plan was for each vessel to occupy a total of 100 stations. It is important to note that each vessel had an independent set of stations within each stratum. However an initial attempt was made to synchronize 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 essentially independently of each other.

Albatross IV was able to occupy 115 stations as opposed to 87 stations by the Soviet Albatros, because Albatross IV used a smaller trawl and because it is faster. The extra stations occupied by Albatross IV were randomly selected in the same way as described earlier. A plot of stations occupied by both vessels is shown in figure 2.

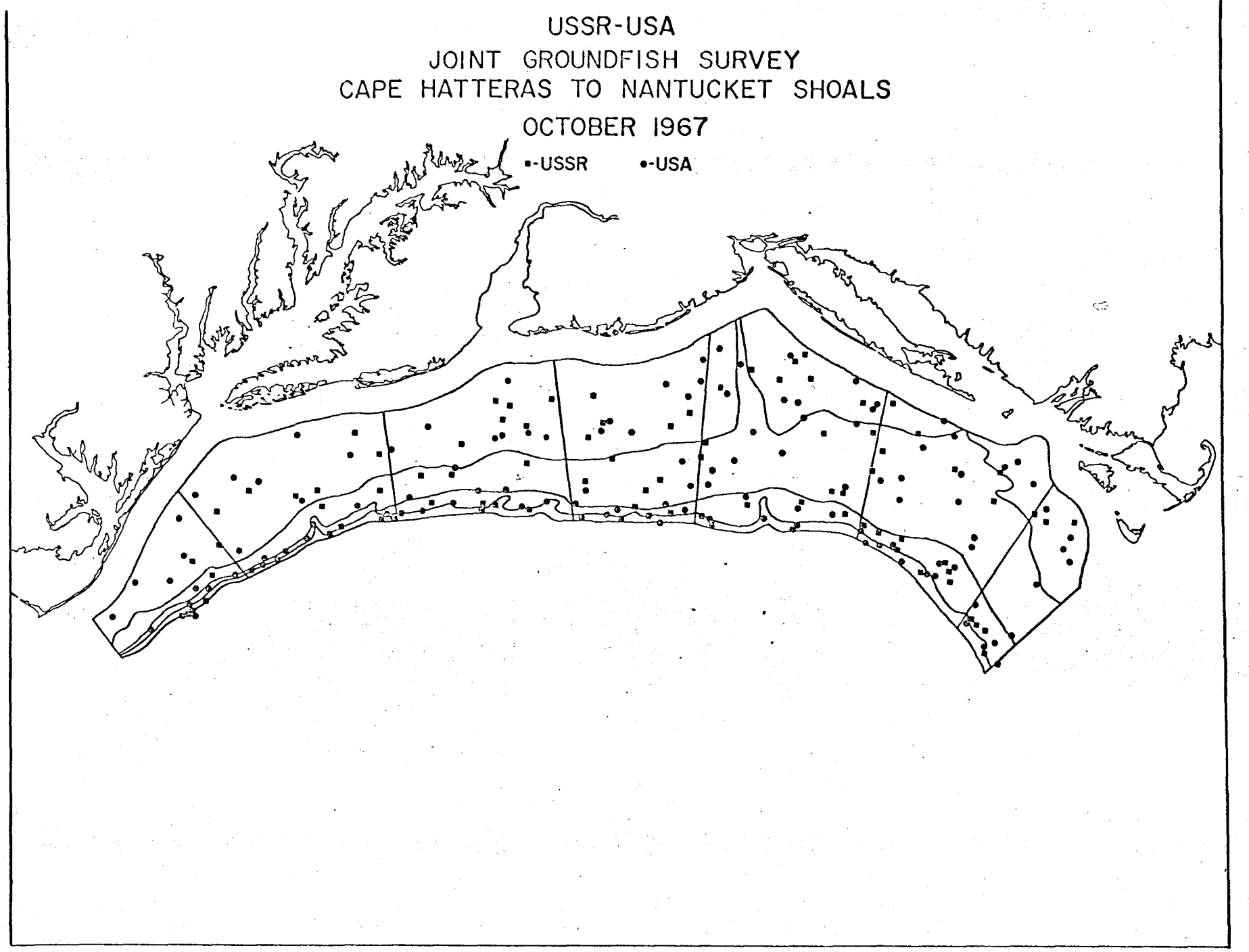

Figure 2. Stations occupied in joint USSR-USA groundfish survey.

GENERAL METHODS

Trawls used

Albatross IV used its standard survey trawl (#36 Yankee otter trawl) and the Soviet Albatros used the 27.1 meter herring trawl commonly used by Soviet scouting vessels. Major differences between the trawls were overall size, headrope height, presence or absence of rollers, and wingspread. Comparative specifications of these and other parts of the trawls are shown in Table 1. Further details including drawings of each trawl are given in the appendix.

Operations at Sea

With respect to interchange of scientific parties, at least one member of the scientific staff from both USA and USSR took part in processing each catch on both vessels throughout the entire survey. There were frequent radio contacts between the two vessels while at sea.

A list of the scientific personnel aboard each vessel, the general cruise plan, and the routine operations at each station are briefly summarized in the sailing orders for Albatross IV cruise 67-20 (appendix, page). An additional feature not mentioned in the sailing orders was that the vessels were to obtain a tracing with their echo sounder simultaneously with the trawl haul.

PROCESSING OF CATCHES

On both vessels routine data at each station such as date, time, position, temperature, etc. were recorded on a trawl log used for previous Albatross IV groundfish surveys (see appendix, page). The same log was used to record total length frequency and total weight of each species in the catch. Whenever only a sample of the catch was weighed and (or) measured, the size of sample (volume and weight) as well as volume of discard was recorded on so-called rough logs shown on pages and of the appendix. Estimates of the total length frequency and total weight of each species were then based on appropriate expansion factors. The units of length, weight and volume used were centimeters, pounds (avoirdupois) and bushels (steel baskets with capacity of 1 and 2 bushels; one bushel is equivalent to 35.2 liters). Fork lengths were recorded for all species with forked tails except for sea herring (*Clupea harengus*) where total length was recorded. Total length was recorded for species without forked tails.

Whenever practical, catches were to be processed in their entirety with respect to length frequency and weight. When sampling catches, the objective was to obtain reasonable accuracy in estimates of length frequency and weight of each species in the catch, with due consideration for cost in terms of time required to process the catch. Thus whether a catch was to be sampled or completely processed was to depend upon total bulk of catch, species composition and sizes of fish.

The most important requirement is that sample estimates should be unbiased and this required that:

(1) volumetric units be sampled at random

(2) accurate records be kept of the size of sample (weight and volumetric units) and the amount of discard (volumetric units)

Basically there are two ways of sampling a catch: one may first sort the catch into species and then sample each species, or one may sample the unsorted catch. Occasionally part of the catch might be sorted and the remainder unsorted. A brief outline of the suggested procedures is given in the following two sections.

Sampling catches sorted by species

To estimate weight of total catch of each species (after catch sorted by species) randomly select a minimum of 3 volumetric units and record the weight of each unit as well as the number of volumetric units discarded. For estimating length frequency, randomly select a sufficient number of volumetric units to yield minimum sample sizes as follows:

Range of lengths (cm)	Sample size (number of fish)
10	25
10-20	50
20-40	100
40	150-200

Sampling unsorted catches (or portions of catch)

The suggested procedures were:

(1) randomly sample sufficient volumetric units to yield numbers of each species in accord with table of length range versus sample numbers shown above.

(2) record weight of each unsorted volumetric unit and number of unsorted volumetric units discarded.

(3) sort total sample into species and then record weight and length frequency of each species.

Special collections

Collections of scales, otoliths, whole specimens, etc. desired by all parties were discussed prior to the cruise and necessary arrangements were made to obtain these samples on both vessels.