RESTRICTED

INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

Serial No. 1661
(D. c. 9)

ICNAF Res. Doc. 66-49

ANNUAL MEETING - JUNE 1966

# Distribution of Georges Bank herring

by V. N. Zinkevich

Herring from Georges Bank was one of the main fish species in the Soviet fishery in the ICNAF area from 1961 to 1964. A quantity of herring was also caught in 1965, mostly as a by-catch in fisheries for other species.

The Soviet herring fishery in the area of Georges Bank in previous years was described in the works of Chukshin, Vyalov (1963), Bryantsev (1964), Benko (1964), Pahorukov, Wilson, Benko (1962), Iudanov (1963) and others. At that time herring was fished almost solely in the area of Georges Bank.

Data obtained to the present make it possible to widen the scope of knowledge on the problem.

This paper summarizes the results of observations made on herring distribution in the years 1963-1965 using the materials collected by fishing and scouting vessels. Materials collected in 1961-1962 and some data on the distribution of plankton and temperature in waters within the investigated area were used in part.

Distribution of the fleet and observations made by scouting vessels indicate herring distribution. In a given case, herring distribution is shown for the period from April to October when fishing was intensive and in the other months when fishing was less intensive (Fig. 1-3).

Winter herring are distributed over the greatest area. From November to March, herring was fished from 36°N on the Shelf, to the northern extremity of Georges Bank. In that period herring were active and did not form stable commercial concentrations. In February and March, the bulk of fish was observed in areas of Long Island, Hudson Canyon and farther south. For instance, in March 1964 the bulk was found in the area 36°-38°N.

In the spring period, herring moved from the area of Wilmington and Hudson Canyons to the southern parts of Georges Bank, where they gradually increased in numbers, whereas they decreased to the south of 40°N.

From May to October, the bulk of fish was found on Georges Bank where it fed and spawned.

The annual distribution of herring is, probably, related to seasonal changes in water temperature and in the amount of zooplankton. Water masses in the area in question have been investigated by a number of investigators.

The distribution and characteristics of the water masses are taken from the work of Bryantsev (1964) and are given in Fig. 4 and Table 1.

Comparing that scheme of distribution of water masses with herring distribution in 1963-1965, one can see that herring from Georges Bank are distributed in coastal waters. But, their largest concentrations and, consequently, their fishery is mostly concentrated in the area of the hydrological front formed by the coastal and the Labrador waters, from the side of coastal waters (Fig. 4).

Fig. 5 shows a typical distribution of herring concentrations in various seasons in relation to distribution of temperature in the near-bottom layers.

Seasonal development of zooplankton in the frontal zone, apparently determines herring migrations from Wilmington and Hudson Canyons to Georges Bank and back, as well as their summer distribution on the Bank.

It is known that winter waters of Georges Bank are poor in plankton. Riley (1947) points to a mass development of phytoplankton in April and of zooplankton by mid-May. At the same time, some investigators indicate a great biomass of plankton in areas of Nantucket Island and of Hudson Canyon. For example, Grise and Hart (1962) state that the greatest numbers of zooplankton containing 60% of copepods, the main food item for herring, are found on the Shelf between New York and Bermuda.

According to unpublished 1965 material from AtlantNIRO, primary development of Calanus finmarchicus is found in the northwestern part of Georges Bank and the southern part of the Gulf of Maine, also Centropagus typicus on the Shelf south of Nantucket Island (Fig. 6).

Spring herring migration are connected with the development of zooplankton in the southern part of the Georges Bank. The relationship between herring concentrations on the southern slopes of the Bank in April-May is confirmed by research conducted by Shkinder (1963), Pavshtics and Gogoleva (1964), who pointed to a high biomass of zooplankton (more than 1000 $mg/m^3$) in this area. The greatest biomass of Calanus finmarchicus was 657 $mg/m^3$ and of Pseudocalanus elongatus, 327 $mg/m^3$. The authors also showed that in June, July the greatest biomass of zooplankton was found on the northern and northwestern slopes of the Bank.

Plankton investigations conducted by AtlantNIRO showed that the general tendency in the development of plankton on the Georges Bank also held in 1963-64. For instance, in April-May 1963, a high biomass of zooplankton and feeding herring were observed on the southern part of the Bank and in June there was a reduction of biomass to the south and an increase to the north and northwest. In March 1964, there was an appreciable development of phytoplankton on the shallows of the Bank and a high biomass of zooplankton (400-600 $mg/m^3$) on the northern slopes.

Thus, the summer distribution of plankton over Georges Bank can be represented by a general scheme (Fig. 7).

It has to be noted that, as the waters become warmer, the zone with a high biomass of zooplankton shifts to the north and a primary development of zooplankton was observed in the zones of the hydrological fronts and that of phytoplankton in shoals of the Bank.

The observations conducted during the 1962 summer period (from May to August) show some of the regularities in herring distribution on Georges Bank.

From the data on plankton distribution and on the distribution of the fishing fleet for each five-day period from May to August, it was ascertained that herring concentrated in zones of the hydrological front where a high biomass of zooplankton was found.

An analysis of distribution of catcher vessels leads to the assumption that fish move against the permanent current, along the hydrological front from the southern to the southeastern slopes of the Bank, then to the northern slopes and along the northern to the northwestern slopes of the Bank. In the latter area, a decrease in commercial concentrations of herring was often observed.

That is, apparently, due to lack of a well-defined frontal zone in that area. At the same time, the formation of stable concentrations of fish is observed in the frontal zone to the south and southeast. This leads to the assumption that fish came to that area from the northwest.

The scheme of herring feeding migrations in the summer of 1962 is given in Fig. 8.

Similar migrations were observed on Georges Bank during May, June and July. The centre of fishing shifted successively from the northwestern to the southern area in May, then extended to the northeast, the north and to the southeast in June, then to the eastern area in July.

Some peculiarities in the distribution of herring for that period are:

1. When herring carried out their feeding migrations on the southern slopes of Georges Bank, where silver hake, Merluccius bilinearis, spawned, herring were found at lower temperatures (Fig. 9).

However, the situation can occur when the temperature limits are moved away or washed by the inflow of warm waters from the Atlantic. As a result, there will be changes in the density of fish concentrations, and the herring will shift to the north.

2. Labrador waters came to the northeastern extremity of the Bank (Fig. 5b, isotherm 6°), where the frontal zone is apparently the most dynamic. In certain periods that area can be occupied by waters with temperatures below those given above which involves changes in the distribution of herring concentrations.

3. As mentioned above, the hydrological front in the extreme northwestern part of Georges Bank is feebly marked which results in decreasing the density of commercial herring concentrations and in changes in their distribution during certain periods (late May, late June, late July 1962).

4. In the southern and southeastern plateau, herring is distributed over a vast area. During the spring-summer period, fish are found between zones of "blooming" on the shallows of the Bank (below 50 m) and the hydrological front in the area of the slopes (the 6-7° isotherm). However, the greatest herring concentrations lie in the zone of the hydrological front. In the northern slopes, the area between the zone of the hydrological front and "blooming" area, due to the distinctive configuration of the Bank, is quite narrow.

Feeding herring avoid zones of an intensive development of phytoplankton and are distributed over a small area along the northern slopes where they form dense concentrations.

From the above, it follows that the area of the southeastern slopes of the Bank, mainly the zone of the hydrological front and the northern slopes of the Georges Bank are considered to be the most favourable places for the formation of feeding herring concentrations.

In August, the bulk of herring is distributed along the hydrological front on the northern slopes of the Georges Bank and make short movements.

In September and early in October, pre-spawning and spawning herring concentrations keep to the northern slopes until the termination of spawning. During the spawning period, fish concentrations occupied a small area and had a high density. Spent herring left their spawning grounds and were fished to some extent, mainly on the extreme western area of the Bank. Later on their concentrations divided into small shoals.

During October and November, some species of zooplankton are rather numerous and favour herring feeding (Fig. 6). Separate feeding shoals were seen on most of the Bank. Short-term formation of commercial concentrations in frontal zones was also observed.

Later on, as water temperature fell and plankton disappeared, the bulk of herring shifted westward. In December herring were often fished in the Cape Cod area and south of Nantucket Island where the fish could still carry out feeding migrations. In January and February, the herring spread over a vast area and in the spring they concentrated in the region of Hudson Canyon.

Vertical migrations of the bulk of fish are strongly pronounced throughout the season. During the daytime, herring shoals settled to the near-bottom layers and at night they rose in the water and to the surface. But when it is foggy, herring are often observed up in the water and near the surface, and on moonlit nights - near the bottom.

Diurnal vertical migrations are hardly ever seen in young immature herring since they prefer to stay at the surface of water.

Herring shoals were often seen at the surface of the sea on sunny days. However, the reason for this phenomenon has not been discovered since no special research was conducted.

For a number of years, herring from 14 to 35 cm have been found annually in the catches. The 23-27 cm specimens, with a 25-26 cm mode, and an age of 3-6 years, formed the bulk (60 to 80%) of the stock.

Herring length compositions, however, differ slightly by season and by area. In winter and early spring, herring of any size are found both south of 40°N and on Georges Bank. In summer there are only two areas, where larger or smaller herring are predominant.

In the first area, the southeastern part of the Bank, larger herring (modes of 27, 28, 29 cm) are predominant and, in the second, the northwestern area, small herring (modes from 18 to 22 cm) are the more common.

The seasonal and area distribution of the most typical size groups of herring during 1964 is given in Fig. 10.

A similar distribution of size groups of herring in two areas was observed during 1961-65.

It should be noted that herring of two, or of several size groups, were almost not taken in the same trawl haul. This shows that herring shoals, even in concentration, keep to their size structure.

Since fish migrate, different size groups redistribute by areas. Thus, samples from catches indicate fish size composition in each area only for a certain period of time. During the autumn period, all size groups of mature herring are found on the spawning ground. Hence, samples from fish caught on the spawning grounds are most indicative of the age/length composition of the mature part of the population.

The distribution of herring which have reached sex maturity for the first time can be seen from the 1963 materials (Fig. 11). Here the strong 1960 year-class was recruited into the fishery and the abundance of the other year-classes dropped due to natural and fishing mortality.

The changes taking place in the size composition depend on the predominance of old or young age/length groups (Fig. 12).

To describe the fishery during the different periods, the data on fishery statistics for 1962 and 1964 were used as most characteristic (Tables 2, 3).

In both years, the fishery was conducted over a considerable period of time. In 1962 drift net fishing was predominant and the 1956 strong year-class formed the main part of the catch. In 1964 the trawl fishery was introduced and the bulk of the catches was represented by the abundant 1960 year-class.

The increase in catch per haul from February to August 1962 indicates a decrease in the area of herring distribution and an increase in the density of fish concentrations for that period.

The decrease in catch per haul observed in August 1962 was due to the introduction of trawl or combined fishing methods by the majority of the vessels and the figure (68 kg) is therefore not significant. Catch per trawling hour from April to August 1964 changed slightly.

Those changes are less indicative of the magnitude and density of feeding concentrations and are, apparently, due to the specific character of the trawl fishery. However, both the drift net and trawl fishery indicate great concentrations of pre-spawning and spawning herring and maximum catches.

Summary

1. Since 1961 herring have been fished by the Soviet fleet from the northeastern slopes of Georges Bank to 36°N. on the Shelf. During the winter the bulk of the fish are distributed from 37° to 40°N and during the summer and autumn on Georges Bank.

2. Herring migrations within the area are connected with the development of zooplankton. The greatest biomass of zooplankton was observed in the zone of the hydrological front, formed by coastal waters and waters of the Labrador origin from the side of coastal waters.

3. The formation and redistribution of commercial herring concentrations is connected with fluctuations in the borders of the hydrological fronts which, apparently, influence the distribution of zooplankton.

4. Herring from 14 to 33 cm in length were found in annual catches but the bulk of fish (60-70%) included individuals from 23 to 27 cm, mode 25-26 cm.

5. There were annual seasonal and area changes in the size composition of herring, depending on the predominance of old or young age-groups.

Two areas can be noted. One of them - the northwestern part of Georges Bank, where a great percent of small herring was observed. The second - the southeastern plateau of the Bank, where larger herring were predominant.

6. Analysis of the autumn catches in the spawning area is the best indicator of the age/length composition of the mature herring.

References

Benko, Iu. K. 1964. Taxonomic position of herring from the Banks of Georges and Bankero. "Problems of ichthyology", Vol. 4, iss. 1.

Bryantsev, V. A. 1964. The Influence of Water Masses of the New England and Nova Scotia Shelf on the Formation of Commercial Concentrations of Herring. ICNAF Environmental Symposium Contribution No. E-4.

Chukshin, Iu. and Iu. Vyalov. 1963. Herring from the Northwest Atlantic and their fishery. Kaliningrad.

Pakhorukov, V. I., A. T. Wilson and Iu. K. Benko. 1962. The conditions for herring fishery on the Georges Bank. Murmansk.

Pavshtics, E. A. and M. A. Gogoleva. 1964. Distribution of plankton on the Banks of Georges and Browns in 1962.

Shkinder, V. K. 1963. Some results of hydrobiological observations made on Georges Bank from 1960 to 1961. AtlantNIRO trudy, iss. 10.

Uidanov, I. G. 1963. Some characteristics of the biology of herring from the Northwest Atlantic "Rybnoe Khozyastvo", No. 4.

Grise, D. D. and A. Hart. 1962. The abundance seasonal occurrence and distribution of epizooplankton in the area between New York and Bermuda Islands. "Ecological Monograph", Vol. 32, No. 4.

Riley, G. 1947. A theoretical analysis of the zooplankton population of Georges Bank. Journal of Marine Research, Vol. VI, No. 2.

Table 1. W ;r Masses in the Area of Georges Bank.

| Water masses | Water Layer | Depth (m) | Extreme value of temperature (°C) and salinity (‰) | | | |
|---|---|---|---|---|---|---|
| | | | Winter | Summer | Autumn | Summer 1962 |
| Coastal | Upper | 0-50 | 4°C | 16°C | 14-7°C | 6-16°C |
| | | 0-75 | 30‰ | 30‰ | 31-32.5‰ | 30-32.5‰ |
| Labrador | Inter-mediate | 50-150 | -1°C | -1°C | 3-7°C | 1-16°C |
| | | 75-150 | 33‰ | 33‰ | 32.5-33.5‰ | 32.5-33.5‰ |
| Bottom modi-fication of Gulf Stream | Near-bottom on the shelf | 170-bottom | 8°C | 8°C | 7-9°C | 6-8°C |
| | | 200-bottom | 35‰ | 35‰ | 33.5-35.0‰ | 33.5-35.0‰ |

Table 2. Catch per effort by Soviet vessels of the SRT and SRT-R types for herring in the Georges Bank area in 1962 and 1964.

| Month | February | March | April | May | June | July | August | September | October | November | December |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of operating vessels | 1 | 4 | 48 | 93 | 101 | 108 | 89 | 48 | 38 | 23 | 5 |
| 1962 Catch per haul (kg) | 12 | 21 | 62 | 83 | 102 | 110 | 68 | 192 | 54 | 35 | 36 |
| No. of operating vessels | | | 5 | 48 | 89 | | 94 | 85 | 31 | 5 | |
| 1964 Catch per trawling hour (tons) | | | 0.55 | 0.69 | 0.68 | | 0.97 | 1.25 | 7.1 | 12.3 | |

Table 3. Soviet catches (tons) of herring on Georges Bank in 1962, 1964.

| Month Year | January | February | March | April | May | June | July | August | September | October | November | December |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1962 | 41 | 5,699 | 1,894 | 13,151 | 22,736 | 24,669 | 26,142 | 22,636 | 28,079 | 11,112 | 3,219 | 922 |
| 1964 | 736 | 65 | 72 | 1,530 | 9,711 | 14,720 | 17,551 | 22,928 | 44,713 | 7,821 | 1,716 | 348 |

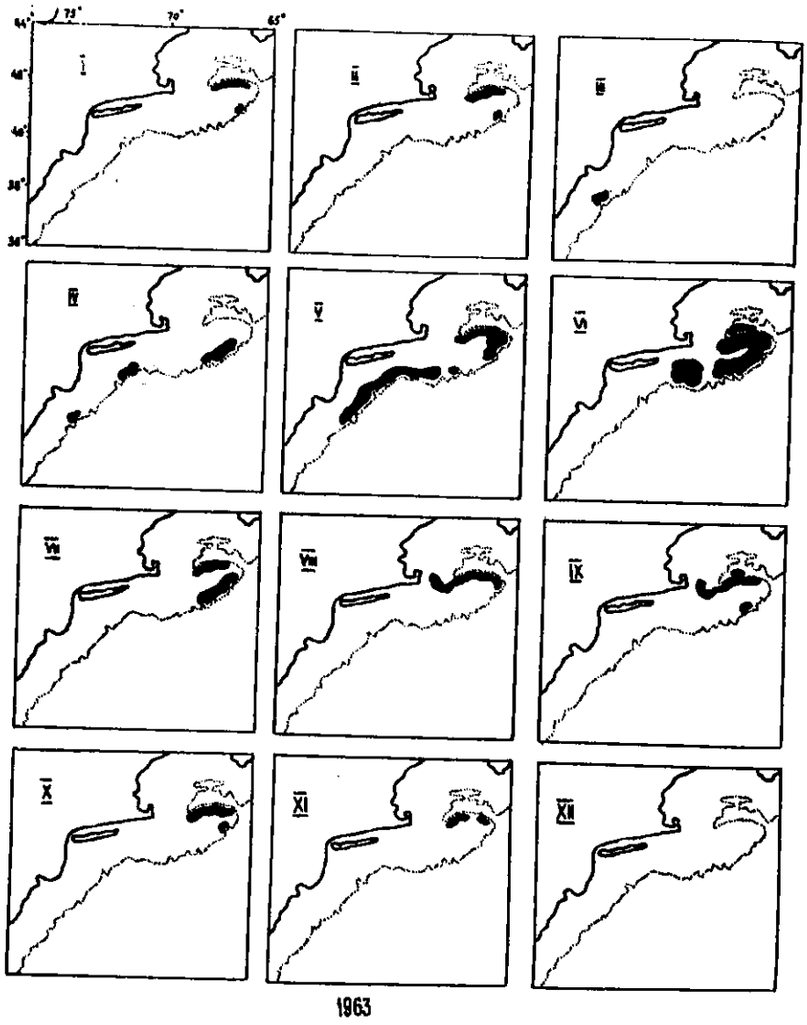


Fig. 1. Distribution of herring (Clupea harengus L.) in 1963.

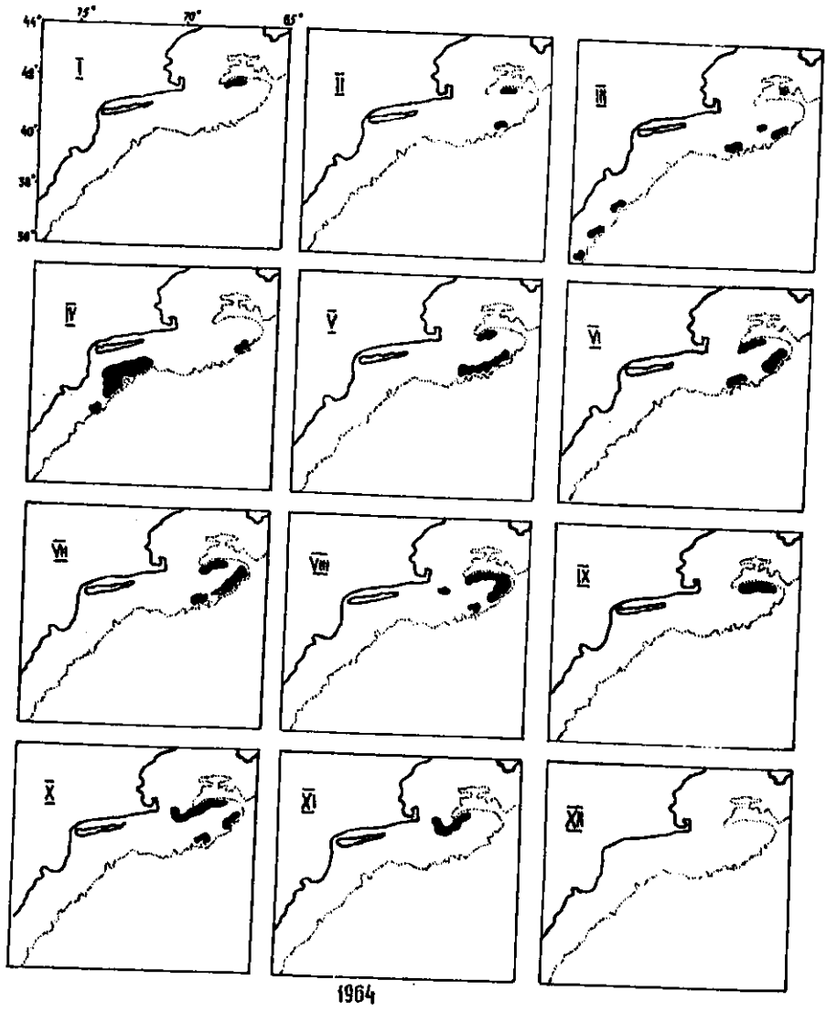


Fig. 2. Distribution of herring (Clupea harengus L.) in 1964.

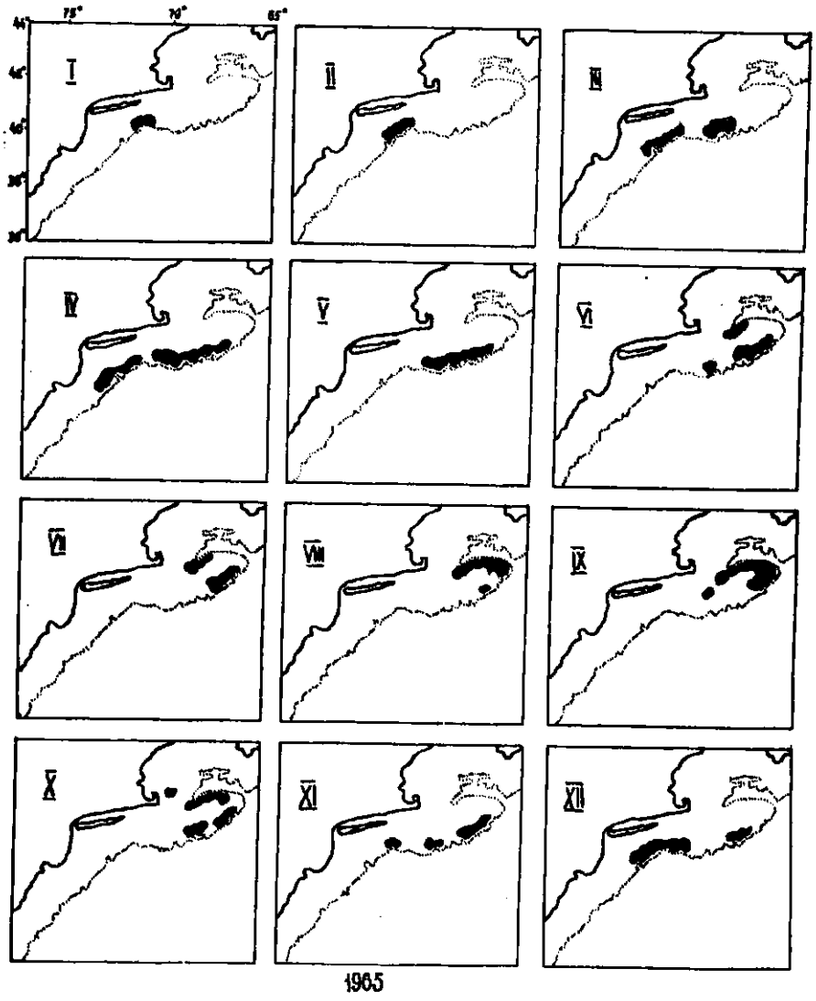


Fig. 3. Distribution of herring (Clupea harengus L.) in 1965.

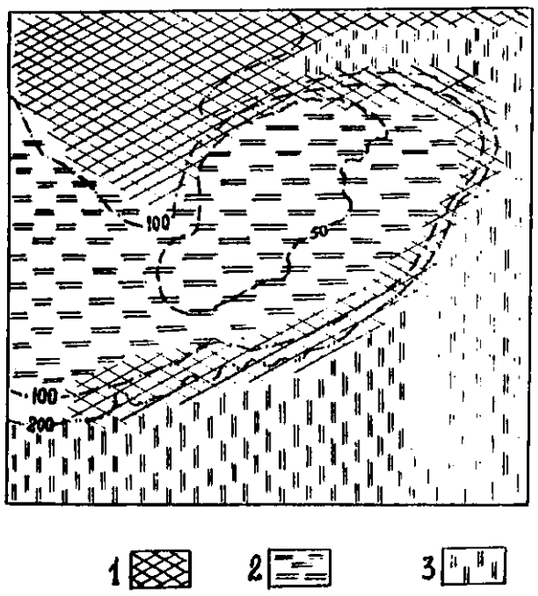


Fig. 4. Scheme of distribution of water masses on Georges Bank.
1. Water of Labrador origin.
2. Coastal water.
3. Gulf Stream water.

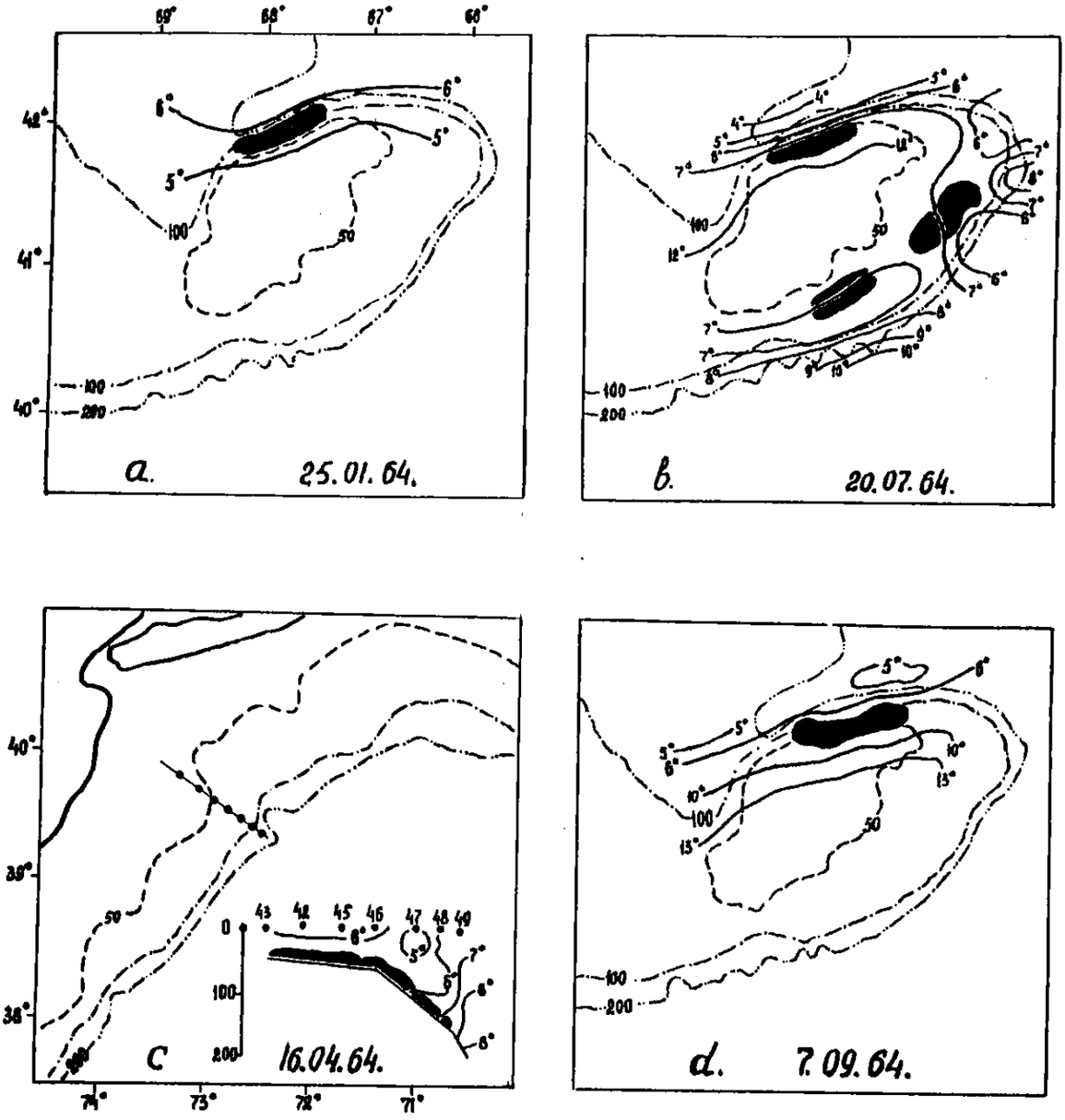


Fig. 5. Typical distribution of near-bottom temperatures and of herring concentrations, Georges Bank (a, b and d) and Hudson Canyon area (c), 1964.

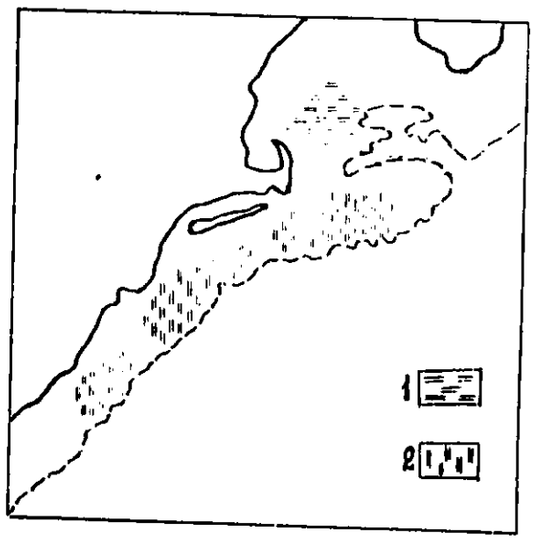


Fig. 6. Areas of high biomass of zooplankton, October-November 1965, BMRT Atlant.
1. Calanus finmarchicus.
2. Centropagus typicus.

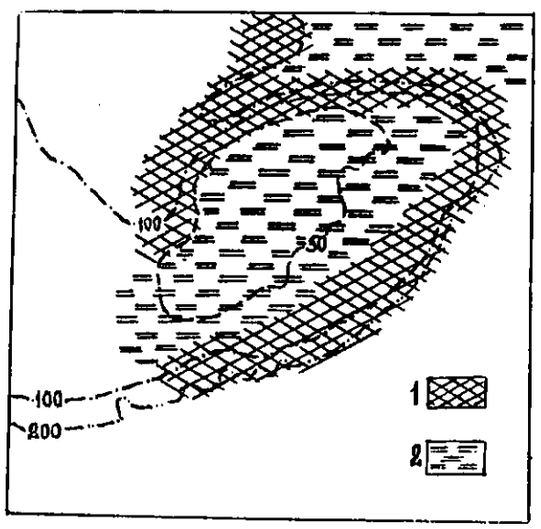


Fig. 7. Distribution of plankton on Georges Bank in summer.
1. Primary development of zooplankton.
2. Primary development of phytoplankton.

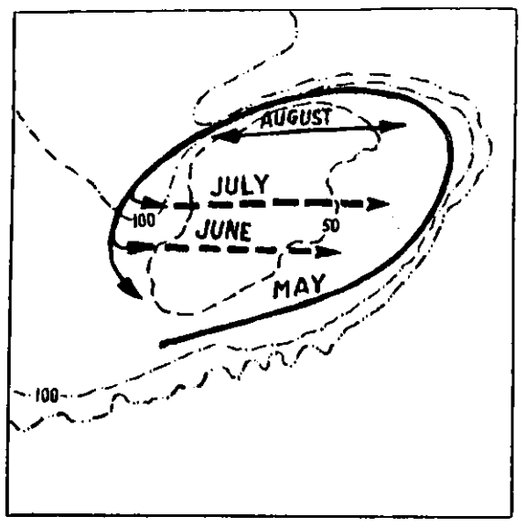


Fig. 8. Scheme of herring migrations on Georges Bank, 1962.

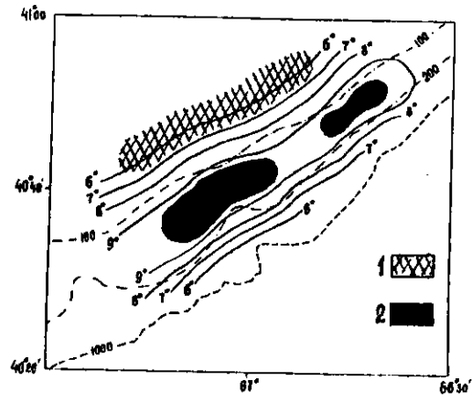


Fig. 9. Near-bottom temperatures and distribution of feeding herring and spawning silver hake on the southeastern part of Georges Bank, June 1963. 1. Herring. 2. Silver hake.

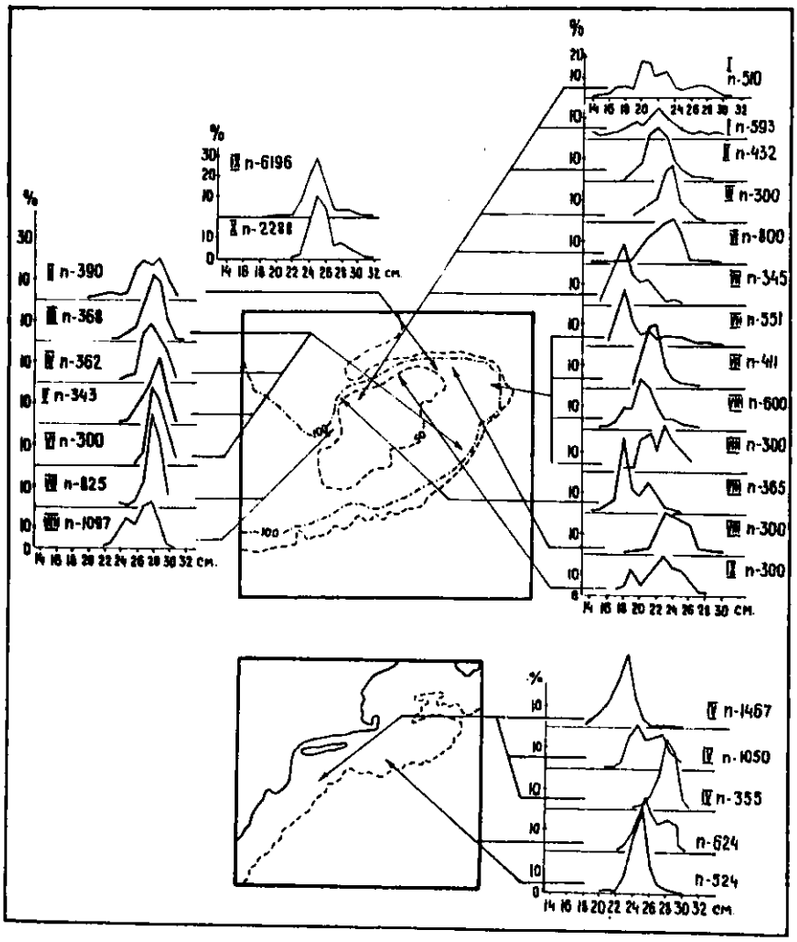


Fig. 10. Size composition of herring by areas and season, 1964.

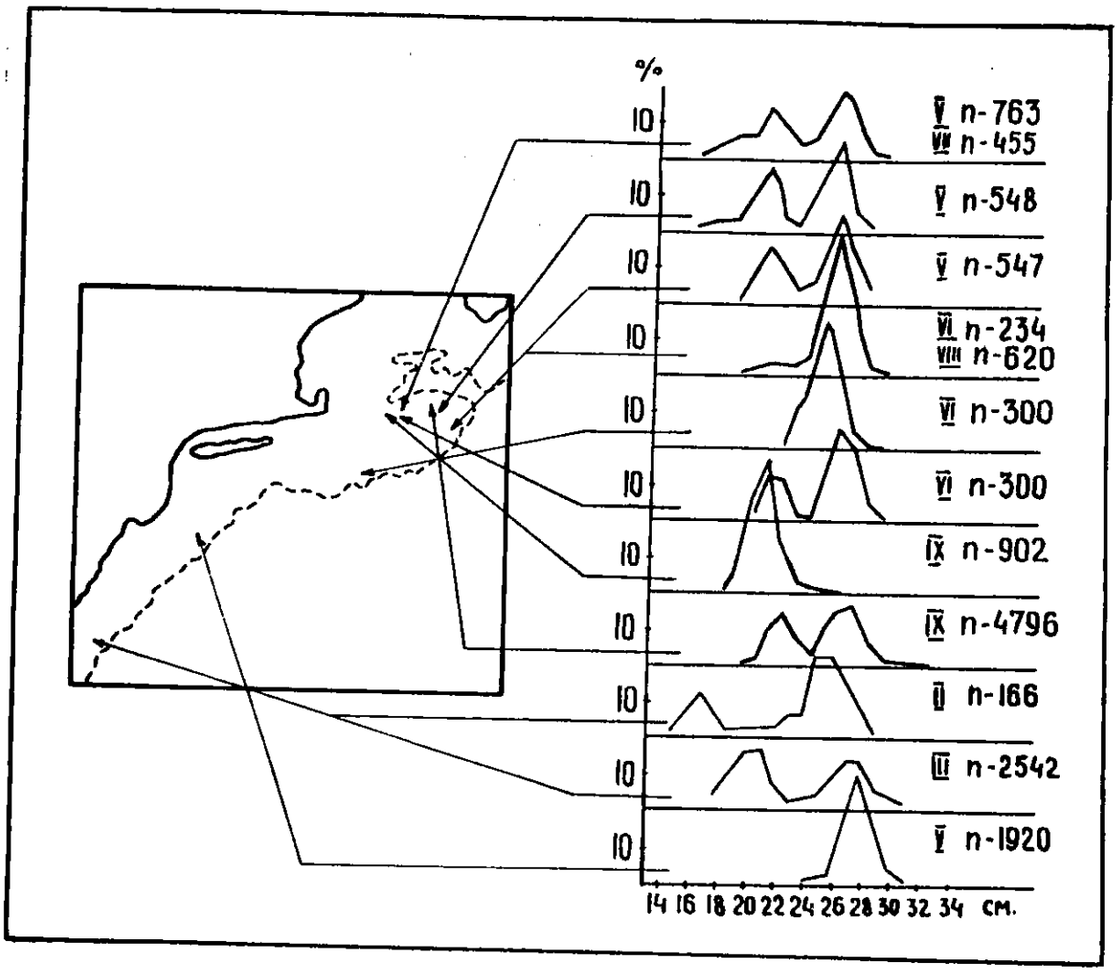


Fig. 11. Size composition of herring by areas and season, 1963.

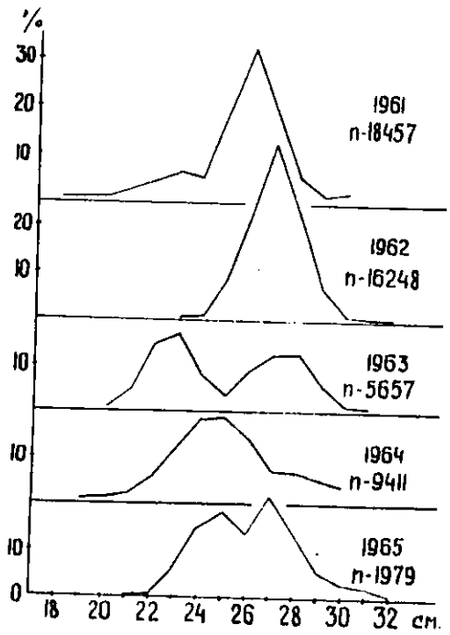


Fig. 12. Size composition of herring during 1961-1965 on the spawning grounds in September.