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On Haddock Spawning in the Northwest Atlantic Area

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In the Northwest Atlantic area haddock are distributed from Greenland to Cape Hatteras. But, more or less detailed studies of haddock spawning have been made only for the areas of New England and Georges Bank. For the other areas there are some data on distribution of mature haddock and only scrappy data on distribution of eggs and larvae (Walford, 1938; Bigelow and Schroeder, 1953; Chase, 1955; Marak, 1960; Colton and Temple, 1961; Miller, Colton and Marak, 1963; Colton, 1965).

The author has tried to study the location of spawning areas as well as the drift and habitats of young haddock off Newfoundland and the Scotian Shelf. Data on maturity stages obtained by research vessels of the Polar Research Institute of Fisheries and Oceanography (PINRO) in field conditions in 1954 and in 1957-1963 were used in this paper. The maturity stages were determined as recommended for cod by Sorokin (1957). Ichthyoplankton samples were also collected in 1959-1963 by the research vessels of PINRO and by those of the Prospective Fish Scouting Service. Conical egg nets with 80 cm diameter opening were mainly used during the experiments. Usually, a 15-minute vertical haul was made from the bottom to the surface and an oblique haul while drifting or circling. A total of 2000 stations were completed during the period of investigations in the Northwest Atlantic from Greenland to Georges Bank. Some haddock were caught in the cod and redfish fisheries near West Greenland, but they were scarce in number, and it was, therefore, impossible to obtain representative data on seasonal changes in gonad condition. Haddock eggs were observed in Greenland waters in April, May and June. The numbers are not high, no more than 11 per vertical haul.

In Labrador waters eggs were not observed, although the adult fish are found in trawl catches.

Off Grand Bank, the haddock fishery may be very effective in certain years. The possibility of haddock spawning in this area was suggested earlier by some scientists (Needler, 1930; Thompson, 1939; Grosslein, 1962). Haddock with gonads at the pre-spawning and spawning maturity stages were observed in this area from March to September. In June, the largest number of haddock with running eggs were observed in the southern part of the Grand Bank and on its southwestern slope and in May in the areas of Saint Pierre and Green Banks. Distribution of haddock eggs in the waters of Grand Bank indicate spawning in this area, but, as few eggs are observed, the spawning is not heavy. According to data on maturity stages and egg distribution, a mass spawning takes place in the areas of Saint Pierre and Green Banks. The spawning peak is observed in late May-early June. Shestov (1967) considers that the spawning takes place mainly on the southwestern slope, at the border of ICNAF Div.3O and 3N, at depths of 60-160 m and in temperatures of 3.0°-6.0°. According to Shestov, the western part of the southwestern slope of the Grand Bank is the second spawning area. None of the authors pays any great attention to spawning areas located on the southern slopes of Saint Pierre and Green Banks. But, from data on egg distribution, one can confirm that spawning in these areas is much heavier than in the areas of the Grand Bank. Main spawning areas near Saint Pierre and Green Banks can be observed at depths of 80-250 m, and spawning takes place in slope waters in temperatures of 3.0°-6.0°. The location of haddock spawning areas in the Grand, Saint Pierre and Green Banks is given in Fig.2.

In the period 1961-1966, PINRO conducted regular investigations on the distribution of young haddock off Newfoundland Banks. These investigations showed that the young haddock are observed on the southwestern slope of the Grand Bank (Nevinsky, 1962) and also that young haddock more than 15 cm in length were distributed over the area. Bulatova (1962) analysed the catches of young haddock for 1954-1961 and concluded that the young specimens were distributed only on the southern slopes of Grand Bank and on its southern part and on the southern slopes of Saint Pierre Bank. The young, up to 25 cm in length, are distributed at lesser

depths than fish 26-35 cm in length. Investigators, thus, concluded that the young haddock inhabit the southern part of Grand Bank and its southern slope and the southwestern slope of Saint Pierre Bank. The fingerlings were distributed mainly on the southern and southwestern slopes of Saint Pierre and Green Banks, with the greatest concentrations being observed in the southern part of Grand Bank (Fig. 3).

Thus, the largest concentrations of eggs, larvae and fingerlings of haddock are found on the southern and southwestern slopes of Saint Pierre and Green Banks.

Analysis of the age composition of the young haddock showed that from Saint Pierre and Green Banks to the eastward, i.e. to the southern part of the Grand Bank, the numbers of older specimens of the young increase in the catches while the one-year-olds decrease (Shestov, personal communication).

A total scheme of haddock spawning is suggested as follows. A single stock of Newfoundland Bank haddock spawns on the southern and southwestern slopes of Saint Pierre and Green Banks and on southern part of the southwestern slope of the Grand Bank at depths of 80-25 m and at near-bottom temperatures, 3.0°-6.0°. Apparently, the eggs and larvae do either not drift from the spawning areas, or they drift to the southwest in the low velocity current and then are carried out to the areas adjacent to the spawning areas.

Correspondingly, the fingerlings settle to the bottom either in the spawning areas or in areas adjacent to them. The young move to Grand Bank, mainly its southwestern slope.

Some scientists consider that two independent haddock stocks inhabit the Newfoundland Banks (Grosslein, 1962), i.e. a Saint Pierre and Green Banks stock and a Grand Bank stock.

Sometimes Grand Bank haddock are found in good numbers. An insignificant spawning within the Bank waters can hardly ensure a great abundance for an independent stock. In addition, in the case of the availability of an independent stock, a great number of haddock fingerlings should be observed in this area.

Shestov has suggested that a single stock of haddock inhabits the waters of Grand, Saint Pierre and Green Banks, whose origin is from the spawning areas of the southern and southwestern slopes of Saint Pierre and Green Banks. Data obtained by the author confirm this suggestion.

Two stocks inhabit the waters of the Scotian Shelf, one of them is located in the northeastern part of the Shelf, north of the Scotia Deep, the other one on the southwestern part of the Shelf.

Spawning haddock are observed on the Scotian Shelf in April, May, June (Fig.1). Dannevig (1919) noted the distribution of larvae in the Sable Island area in May. Thompson (1939) showed the distribution of haddock fingerlings on Banquereau Bank. Young haddock are distributed over Misaine and Banquereau Banks, southeast of Sable Island over the Shelf slope and on Emerald Bank (Fig.3).

Grosslein (1962) showed that the peak of spawning on the Scotian Shelf is in April. The distribution of haddock eggs in May testifies to the fact that spawning probably takes place mainly in May. It should be said here that in April the survey program took place only partially on the Scotian Shelf.

Usually, haddock spawning takes place sometime later than that for cod in the same areas, and it is unlikely that the Scotian cod make an exception.

The drift of haddock eggs and larvae is determined by the direction and the speed of the current, flowing out of the Gulf of St. Lawrence and dominating the Scotian Shelf. The speed of this current is high - up to 94 cm/sec over Misaine and Banquereau Banks (Klimenkov, Pochorukov, 1962). In the case where the eggs are drifting in the upper 20 m water layer, they will be carried in the water masses to the southwest along the Shelf (Walford, 1938; Miller, Colton, Marak, 1963; Colton, 1965). But, sometimes the upper water layer (up to 100 m in depth) on the Scotian Shelf is freshened ($< 31‰$) and becomes cool (Klimenkov, Pochorukov, 1962). The density of this layer is, naturally, decreasing.

Kisljakov (1958) showed that the cod eggs are drifting with the deeper layers when the upper layer is freshened. The behaviour of haddock eggs should be the same in similar environmental conditions. Thus, it can be suggested that haddock eggs and larvae are drifting in the deep water layers. The rate of speed is less at great epths (Colton, 1961) and the temperature higher. Correspondingly, the rate of development is greater and the duration of the period of the pelagic development is less. This means that, in spite of a rather high current speed and low temperatures in the upper water layers over the Scotian Shelf, the eggs and larvae are not carried off the limits of the Shelf. In any case, such conclusions can be made for ICNAF Div.4V, 4W. It is possible that they are not carried far away from the spawning areas. This can be confirmed from the distribution of haddock fingerlings off Emerald Bank, in the areas where the greatest catches of eggs were taken.

Discussion of Results

In the northwest part of the Atlantic Ocean haddock are spread from Labrador to Cape Hatteras, they can also be observed near Greenland. In the ICNAF Area, haddock are most abundant off Nova Scotia and New England. Some local stocks of haddock are observed in these areas, they are characterized by different number of vertebrae. Previously, scientists supposed that two haddock stocks existed off Newfoundland. From the above data it is possible to say that only one haddock stock inhabits the Newfoundland Banks area. This stock originates from the spawning areas located in the southwestern and southern slopes of Saint Pierre and Green Banks and in the western part of the southwestern slope of the Grand Bank. Because of drift conditions, haddock of Newfoundland Banks are isolated from the Scotian Shelf. Stocks of adult fish of these areas probably mix very little, as the number of vertebrae differs great enough. The location of spawning areas on the one hand and the drift pattern of eggs and larvae on the other hand suggest that there are two haddock stocks inhabiting the northeastern and southwestern parts of the Shelf respectively. The number of vertebrae for haddock of these two stocks differs, though not greatly, a fact which suggests there is considerable mixing of these two stocks. It is characteristic that the greatest number of vertebrae (54.19) are from haddock inhabiting the shores of the Cape Breton Island, the area of the lowest water temperature during the spawning period. An independent haddock stock inhabits the area of Georges Bank, the number of their vertebrae is almost the same as for haddock of the Newfoundland Banks.

In the Northwest Atlantic haddock spawn from February to July. The spawning peak does not coincide in time for different areas. Off Newfoundland Banks, spawning is observed late in May-early in June. In the Nova Scotia area, spawning takes place in May. On Georges Bank, spawning reaches its apogee in May-April, though haddock spawn there in January and even in December, and some spawning individuals and eggs are observed in July and in August.

Thus, in the Northwest Atlantic the length of the spawning period for haddock is greatest in southern areas, on Georges Bank. In the northern areas, the spawning period begins earlier and is shorter. Haddock spawning is observed at dpeths from 40 m to 250 m in 3°-6° temperature. As noted above, the lowest temperatures were registered for the Scotian Shelf. Comparing the location of the spawning areas to the distribution of near-bottom temperatures during the spawning or pre-spawning periods, it can be concluded that the time of haddock spawning in the various areas is determined by the meandering of the warm currents. This is especially apparent on the southern slopes of Saint Pierre, Green Banks and on the western part of the southwestern slope of Grand Bank.

The haddock eggs and larvae drift is unique for each different area of the northwestern Atlaantic. In the areas off Newfoundland Banks, eggs and larvae are carried off the spawning grounds to the southeast. Their drift pattern is like that of an incomplete circle. The shorter the distance from the spawning area to the centre of the circular water motion, the shorter is the drift of eggs and larvae from their spawning area. The centre of the current is probably displaced in different years and, in this connection, the picture of eggs and larvae drift changes as well. But, those changes probably do not affect the general character of the drift.

In the Nova Scotia area, the drift may be determined by a strong Cabot Current, as was shown earlier. In this case, eggs and larvae of the Scotian Shelf are carried from the northeastern part of spawning areas to the southwest, and from the spawning grounds off Browns and LaHave Banks northwesterly, i.e. to the eastern part of the Gulf of Maine and Passamaquoddy Bay. When eggs and larvae are not in low salinity surface water layers, but in deeper layers with an oceanic salinity, they will not be carried a great distance. In all cases, the extent of drift in space and time is not too great, being much less than that for cod in the northern areas.

During the passive pelagic period of life, survival depends greatly on the whole complex of different conditions and on the areas, where larvae have been carried at the fingerling stage, when the bathypelagic and near-bottom mode of life begins. It can be supposed that this process is determined by the current intensity, when the eggs and larvae are being carried by powerful currents like that in the North Atlantic.

The drift of eggs and larvae may depend on wind currents. This is observed, when they are drifting in waters with slow current speed, i.e. in turbulences and rotations, which, in their turn, depend on wind conditions. Carruthers (1951) investigated the influence of the wind conditions on the abundance of haddock year-classes in the North Sea for the period 1929 to 1949. It appeared that relatively rich year-classes prevailed in the years when northerly and easterly winds dominated, but they were poor in the years with mainly northerly and westerly winds. Of 20 year-classes only two (1946 and 1947) were exceptions to this regularity.

In the Northwest Atlantic, analogous investigations were made for Georges Bank haddock. Chase (1955) obtained a correlation coefficient of 0.766 ± 0.057 between the size of haddock year-classes and favourable winds for the period of investigations 1928 to 1952.

Of course, the strength of a year-class is determined not only by the wind regime and this factor is of great significance only under certain conditions.

It can be considered that the survival of eggs, larvae and fingerlings is more closely related to wind when the spawning grounds are adjacent to areas with environmental conditions unfavourable to their development, and if they are brought there they will die. This conclusion can be related to the haddock spawning areas off Faroes (Saville, 1965) and Georges Bank. The spawning areas located on Saint Pierre, Green Banks and on the southwestern slope of Grand Bank are affected by the factors described above.

The winds from the south and southwest provide favourable conditions for haddock development on Newfoundland Banks during their spawning and drifting periods, and those from the north and northeast - the unfavourable ones. Thus, it is possible to make some preliminary conclusions. If the winds blow from the south, the year-classes will be abundant in April-October, if they blow from the north - they will be poor.

In conclusion, it may be said that some other conditions for survival are overlapping the effect of wind, especially those of extremely warm or cold years.

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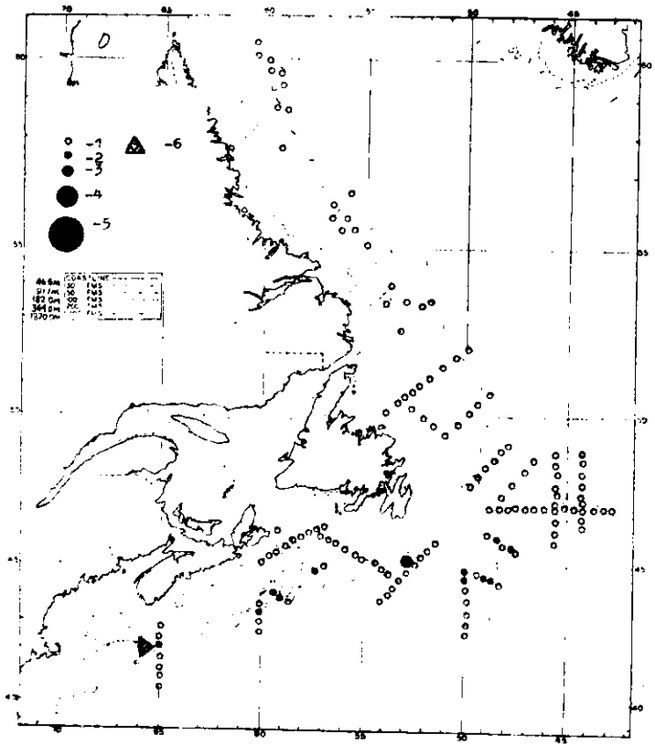

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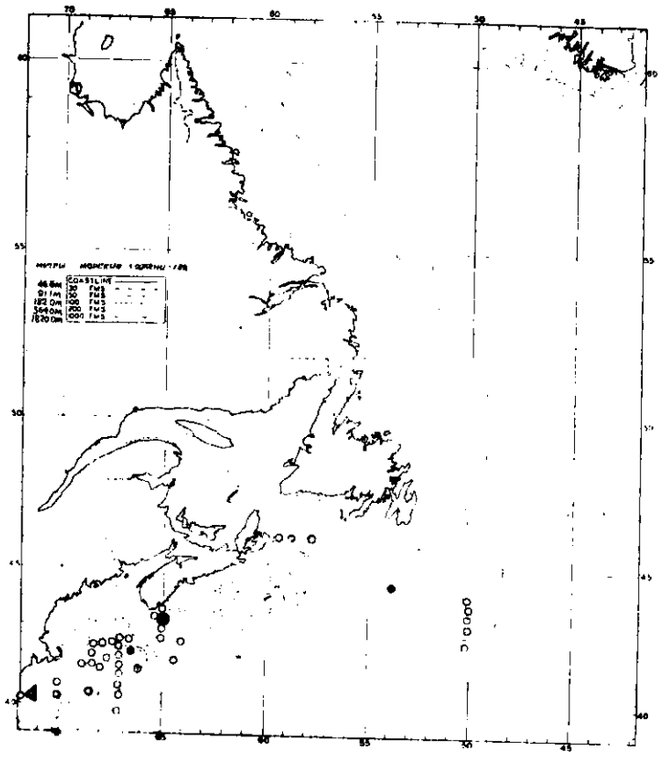

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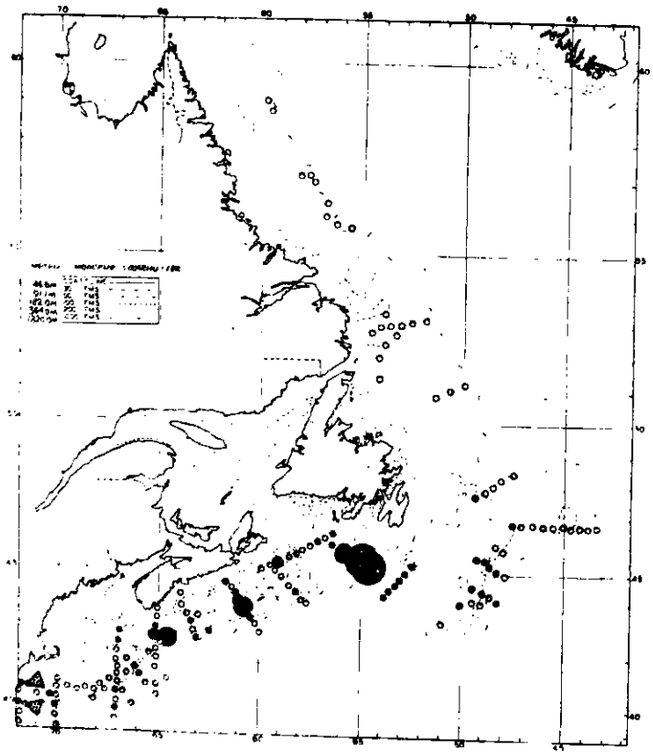

c

Fig. 1. Distribution of haddock eggs and larvae

a) in April
b) in May
c) in June

Conventional signs: 1 - no eggs, 2 - 1-5 eggs, 3 - 6-10 eggs, 4 - 11-20 eggs, 5 -21-50 eggs, 6 - larvae

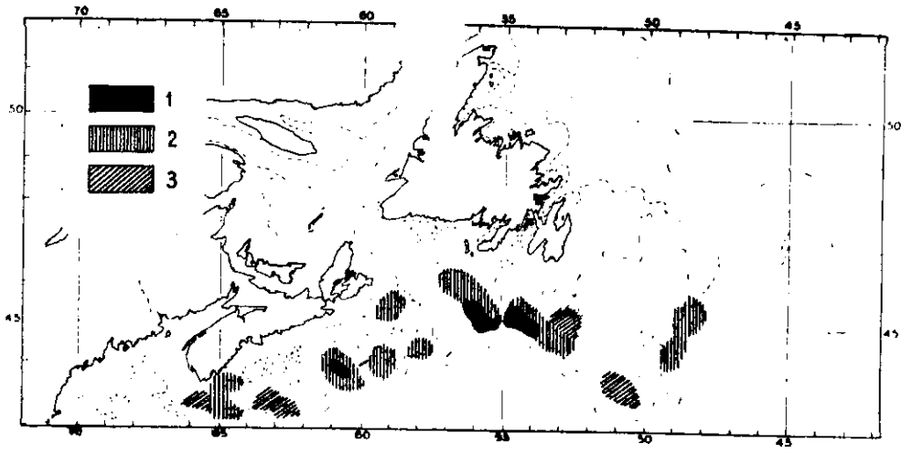

Fig. 2. Distribution of haddock spawning areas.
Conventional signs:
1. Intensive spawning
2. Not intensive spawning
3. Spawning areas, preliminary determination

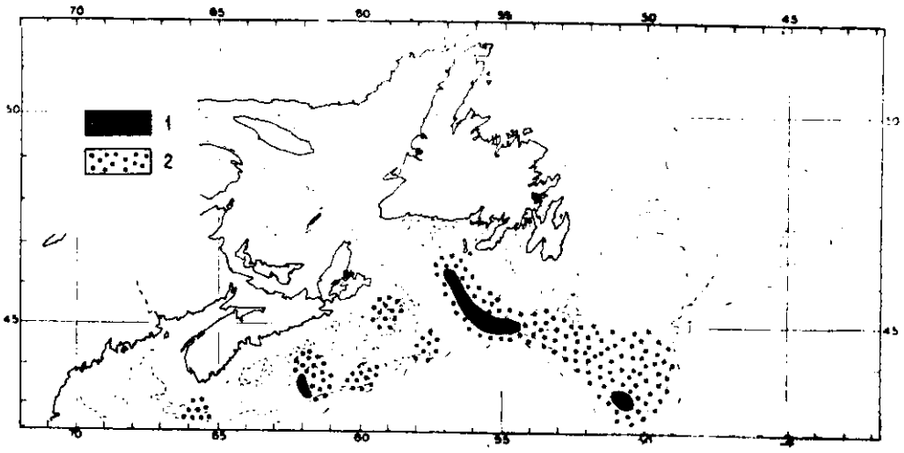

Fig. 3. Distribution of young haddock
Conventional signs:
1. Distribution of fingerlings and one-year-olds
2. Distribution of young specimens

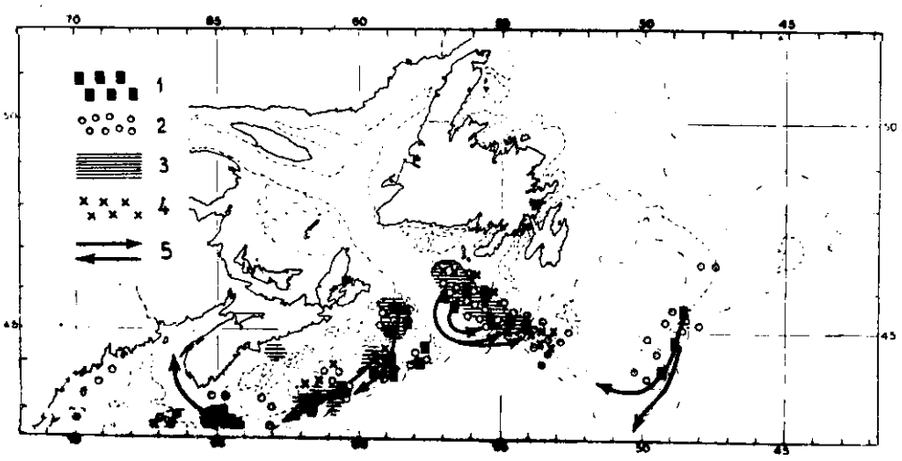

Fig. 4. Distribution of spawning grounds, eggs, larvae, fingerlings and migration paths of haddock
Conventional signs:
1. Spawning grounds
2. Egg distribution
3. Larvae distribution
4. Fingerling distribution
5. Drift paths