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# Breeding and development of witch flounder (*Glyptocephalus cynoglossus* L.) in the Northwest Atlantic Ocean

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## Abstract

Description is given of the development of witch flounder from egg to larva at the stage of metamorphosis.

The eggs are pelagic, spheric in shape, without lipid droplet, diameter: from I.IO mm to I.45 mm. Scattered pigment cells appearing on the embryo body at the end of II stage of development are groupped into three distinct postanal lines at the IV stage of development. Before hatching the eyes of embryo are not pigmented. Metamorphosis takes place with the larvae being about 20 mm long.

Eggs of witch flounder in the North-West Atlantics are found from May to September, in the area from the North slopes of the Big Bank to the South-West part of the Georges Bank. Larvae are found mainly in the places of eggs distribution. Small larvae are found above deeper waters than begger size larvae.

Spawning of witch flounder in the North-West Atlantics is rather long and it stretches from March to September. Spawning grounds are located at the bourder of South Labrador and North Newfounland Bank, of Nova Scotia and on the Georges Bank. In the Northern regions the most intensive spawning takes place probably in March-April, and in the South in July-August.

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The main drift of eggs and larvae of witch flounder is directed Southward and South-Westward. Pelagic larva stage is very long and it can be up to one year.

Introduction

Witch flounder has become recently one of the most important commercial products of trawl fisheries in the North-West Atlantics, particularly in the area of Newfounland and at the Banks of Nova Scotia. In I970-I97I total catch of witch flounder along the Atlantic coast of Canada (within the ICNAF zone) amounted to 40381 tons and 60052 tons respectively.

However the biology of witch flounder is hardly known, especially, its spawning and early periods of development. There are no papers on multiplication and development of this species in the area of North-West Atlantics. Some scattered information could be found on this subject in Canadian and American literature (Bigelow and Kennedy, I967, Powles and Kohler, I970)

Certain cases of eggs and larvae of witch flounder occurance in the waters of North-West Atlantic have been mentioned in the papers by Bigelow, I9I4,I9I7 - Gulf of Maine; Danerig, I9I9-Saint Lawrence Bay, Newfounland; Fish and Johnson, I937 - Gulf of Main and Fundy; Frost, I938 - Newfounland; Bigelov and Schroeder, I953 - Gulf of Maine and Fundy; Alvarino, I956 - Nova Scotia; Legare and Macclellan, I960 - Passamakawdy Bay:, March et al. I962a, I962b - Gulf of Maine; Bergeron and Lacroix, I963 - Saint Lawrence Bay; Lacroix and Bergeron, I964 - Saint Lawrence Bay; Graham and Boyar, I965 - Gulf of Maine; Serebryakov, I962, I965 - Newfounland and Nova Scotia; Lacroix, I966 - Saint Lawrence Bay.

Most of the publications mentioned above are related mainly to witch flounder from the territorial and coastal waters and bays of Canada and USA,and the authors of these publications do not dwell upon the problems of witch

flounder multiplication, development and distribution of the early stages of this species.

Investigation into the problems, pertaining to the multiplication of witch flounder is very important for practical purposes, for efficient fisheries. On the other part, from theoretical point of view information on development and distribution of eggs and larvae of witch flounder is also significant.

Material and Methods

The material on development and distribution of eggs and larvae of Gl. cynoglossus, used in this paper, was collected by expedition vessels of the Polar Scientific Institute of Marine Fisheries and Oceanography (PINRO) during spring and summer season of I959-I970. There were made 3I27 stations all together from the Northern regions of Labrador to Nova Scotia Fig.I. The total number of samples is 3400. The material was collected according to standard methods (Rass and Kasanova, I966) at the stations of standard hydrological sections and in trawling operations The fishing gear used consisted of : fish egg net of cone shape, the area of aperture being 0.5 sq.m., the number of eggs and larvae is given for I catch of the net. Information on gonads maturity stages of the mature fishes was obtained in I960-I972 on the basis of field analyses of trawl catches made by the research vessels of PINRO and scouting vessels of the Northern fishing survey. In the field work for the purposes of maturity rate estimation 6-point maturity scale was used (Sorokin, I957). The discription and drawings of fish eggs and larvae were made on fixed material. The drawings were made with the of projection microscope "Promar". For the estimation of eggs and larvae development stages the periodicity of development after Rass (I949) was used.

Description of Fish Eggs and larvae of Witch Flounder

Information on the development of witch flounder living at the coast of North America is rather scarce (Bigelow and Schralder, I953, Dennevig, I9I9).

Fish eggs are pelagic, spherical in shape, with narrow perivitellin space, without lipid droplet. The diameter of fish eggs is I.I-I.45 mm, average - I.27 mm. Yolk diameter is 0.95-I.05 mm. Egg sheath is rather thick, grooved, with many creases.

A fish egg of II development stage (Fig.2a). In the embryo body there are 34 myotomes. Pigmentation of the embryo is rather weak, melanophores have the form of scatterd points, they are located mainly on the back part of embryo body, certain number of them can be found in the head section.

A fish egg of IY development stage (Fig. 2b). In the embryo body there are 47 myotomes. Olfatic capsule can be seen. Pigment cells are still scattered over the whole body of embryo, but two rows of melanofores on the sides became rather distinct. The crease and yolk bag have no pigment.

A fish egg of IY development stage (Fig. 2c). In the embryo body there are 47 myotomes (I2-35). Bowels has the shape of straight pipe. On the sides at the boarder of I and 2 myotomes - rudinets of pectoral fins. One mass of melanophores is in the anus area, and there belt - shape masses - are in post annal part of the body (Fig. 2d). The larvae hatch with the length being about 4.9 mm (Bigelow and Schroeder, I953).

The shape of prelarva body 5.8 mm long (Fig. 3a) is thread - like, antennal aperture is 25.9% of the length of the body. Anus islocated at the edge of the fin crease. Bowels pipe makes a loop in the middle and the end of it has the shape of sharply bent down wards discharge in testine in the back part of the body. Right after

cleithrum fragments of yolk bag can be seen. Brain is differentiated into main parts. Pectoral fins are fan like. Pigmentation is spot belt like. In the area of anus branch type melanophores are seen in a mass. Pigment cells of similar shape make three postannal belts. Besides, between myomeres I7-I8, 32-33 and 48-5I in ventral part of the vody spot like melanophores form small groups. At the edges of postannal part of the fin crease, in the places above pigment masses on the body of prelarvae and under them (except the 3 belt) groups of very small spot like malanofores can be seen.

Larvae of I6.7 mm (Fig.3b) is symetric, thin. The body is encircled with fin crease. Antennal distance is only 29.3% of the body length. Myomeres 57 (I2-45). Behind the bowels the fragments of big bladder can be seen, and behind thebladder - free space of triangular shape, where at later stages gonads develop. Cleithrum can be elearly seen, in front of it - double chamber heart. Maximallary apparatus is formed. On the precover, small prickles can be seen, on the lower side of it there are three big prickles,on the upper side - 5 small prickles directed forwards. Between the upper and the lower sides of the precover there is one more prickle . In the place of dorsal and annal fins there can be seen rudiments of pterigiophores, in dorsal - 85, in annal - 68, from the pteriogiophores rudiments of fin rays stretch, 3I - in dorsal and 4I - in annal. Wrostyle is bent, under it, from stillunderdeveloped hypubals rudiments of I8 rays stretch. The picture of pigmentation is mainly the same, also the intensity of it is higher.

Larvae 22.5 mm long (Fig. 3c) - Description of the structure of the right side of larvae body. Beginning of metamorphosiss process. The left eye started migration towards the right side, the upper part of the projects from the head profile. Candal part is still long, the

body is short, anteannal distance is 35.I% of the whole body length. Number of myomeres is 54-55 (II+43-44). On the upper and lower jaws 3 teeth can be seen from each side. Pectoral fins are still of larvae character. On the top part of the precover 4 prickles can be seen that are stretched forward, on the bottom part - 7 prickles, of larger size, between the top and bottom edges of precover 6 prickles directed differently. In the dorsal fin there are III ray, in annal - 95, in candal fin - 20 rays. Right after the bootom part of the cleitrum rudiment of abdominal fin with 4-5 rays can seen. The character of pigmentation did not change, although the contours of postannal belts as compared to earlier stages of development are rather vague. Larvae 22.5 mm long (Fig. 3d) - Description of the left side of the body. Olfactory capsule is located almost on the head profile, however it can not be seen from the right side. The number of prickles on the precover (I7-left side) is different from the number of prickles on the right side of the body (I9). Very interesting modifications are witnessed in the characters of pigmentation on the left side of the body as compared to the right side; there are much less pigment cells on the bowels loops and then are mainly located on the bootom part of the bowels loops, pigmentation of outlet vowels at annal aperture is different. Above the middle cerebrum there are 2 pigment cells, which are not found on the right side.

Distribution of Fish Eggs and Larvae of witch flounder

I Fish eggs Distribution

Bigelow (I9I7) was the first to find the fish eggs of witch flounder at the Atlantic coast of the North America, he indicated their distribution in the Gulf of Maine. Then Bigelow and Schraeder (I953), Marak and Kolton (I962a, I962b) described the distribution of witch flounder fish eggs in the Gulf of Maine, Fundy and at the

Georges Bank, Alvarino (1956) and Serebryakov (1965) in the regions of Newfounland and Nova Scotia.

We have at our disposal the samples of fish eggs and larvae of Gl. cynoglossus from the North - West Atlantics, taken in 1959-70 expeditions. The information has been compiled for these years and represented in the form of charts of fish eggs and larvae distribution (Fig.4).

In May only one egg at the II stage of development has been found in shallow water at Bankero Bank (65 m depth) at the temperature of surface layer of water 4.38°C; and two fish eggs of the I and II stages of development in the South-West part of the Georges Bank above the depth of 85 m (Fig.4)

In June separate fish eggs of witch flounder (1-8 pieces per catch) have been found in the area of South and South-West slopes of the Big Bank above the depth of 65-350 m (water temperature at the surface being 6.12-7.14° C), in shallow water of Georges Bank (depth 50-65m), as well as above ocean depths more than 5000 m to the South from the Big Bank (Fig.5). The fish eggs caught in these regions were mainly at the I and II stages of development and only two of them - at the III and IV stages of development.

In July fish eggs were found in the south part of the Big Bank and above ocean depths in the region of South-West slope of the Bank (Fig.6). The biggest number of eggs was caught (from 130 to 290 piecies per catch) in the area of South-West slope of the Big Bank. Maximum catch of the fish eggs (290 pieces per catch) was registered at 44°13' N. and 52°20' W. In the region of Newfounland Bank there are found eggs mostly of the I and II stages of development, and among the fish eggs caught above the ocean depths 35% were the eggs of the IV stage of development (Table I).

Table 1.

Composition of Development stages and Occurance conditions of witch flounder eggs in the area of Big Newfounland Bank in July

| Depth m | Water temperature at the surface C° | Stages of fish eggs development % I | II | III | IY | Number of eggs |
|---|---|---|---|---|---|---|
| 58-200 | I0.59° - I4.39° | 62.7 | 25.6 | 8.4 | 3.3 | 302 |
| above 3000 | II.76° | 30.6 | 30.I | 34.6 | 4.7 | I07 |

In August in the area of the Big Bank witch flounder eggs (I-I00pieces per catch) are distributed over the whole aquatic zone from shallow water to the depths of shelf slope (Fig.7). The main mass of eggs was caught in the North of the Big Bank. Maximum number of eggs (I00 pieces per catch) was found at the coast of Awalon peninsula, at the place of 46°35' N. and 53°00' W. Among the Iole Dab eggs caught in the waters of the Bank there are eggs of all stages of development (Table 2). Eggs of the III and IY stages of development prevail only in the region of Awalon peninsula, while in the bigger part of the aquatic zone of the Big Bank there prevail fish eggs of the I and II stages of development.

Table 2.

Comparision of Development Stages and Occurance Conditions of witch flounder Eggs in the area of Big Newfounland Bank in August

| Areas | Depth m | Water temperature at the surface °C | Development stages of fish eggs I | II | III | IY | Number of eggs |
|---|---|---|---|---|---|---|---|
| North part of Bank | 65-540 | 9.0-I2.0 | 58.0 | 36.I | 5.0 | 0.9 | 2I9 |
| awalon pen. | 70-I60 | I2.I0-I3.20 | 25.2 | I4.0 | 28.4 | 32.4 | I94 |
| South part of Bank | p60-250 | I4.I3-I7.48 | 45.7 | 35.7 | I3.5 | 5.I | 62 |

Small amount (I-II pieces per catch of witch flounder eggs was also found in shallow water of Saint Peter Bank and in Nova Scotia shelf area (Fig.7). At Saint Peter Bank several eggs of the I and II stages of development and one of the IIIrd stages were caught above the depth of 45-65 m at the temperature of surface layer of water I2.9°-I5.I2°C. In the waters of Nova Scotia fish eggs of all stages of development were caught at the Bankero Bank near Sable Island and at the Scattery Bank above the depths of 50-I00 m. Total number of eggs caught here is not significant, and the number of eggs of the III and IY stages does not exceed I0 eggs.

In September there were caught only 9 eggs of witch flounder of all stages of development at the Avalon peninsula above the depths of 70-II5 m and in the area of South-East slope of the Big Bank (depth 50-70 m) Fig.7. Water surface layer temperature in the places of eggs catch was from I0.86°C to I4.34°C.

2. Larvae Distribution

Cases of witch flounder larvae catches in the waters of Atlantic coast of the North America were described in papers by Bigelow (I9I7) Dannevig (I9I9), Fish and Johnson (I937), Frost (I938), Bigelow and Schraeder (I953) Legar and Macellan (I960), Marak et al ( I962a,I962c), Serebryakov (I962,I965), Bergeron and Lacroix (I964), Graham and Boyard (I965), Lacroix (I966).

In our collections witch flounder larvae were found in the areas of survey from May to September, mainly in the places of eggs destribution (Fig. 4,7). In may-June (Fig. 5-6) three larvae 4,9-7 mm long were found in the South-West part of the Georges Bank above the depths of 48-65 m. In the course of July survey the larvae were found in the middle part of the Eastern coast of Newfoundland Island, and in the South-West slope of the Big Bank (Fig.6). The dimensions and number of larvae caught in the areas of North-West Atlantics are given in Table 3.

Table 3.

Number, Dimensions and Occurance Conditions of Larvae in the Areas of North-West Atlantics

| Areas | Months | Number of larvae | Length of larvae | average length of larvae | Depth m | Temperature of surface layer of water °C |
|---|---|---|---|---|---|---|
| South Labrador | Aug. | I | 4.9 | - | I85 | - |
| North Newfounland Bank | July-Aug. | I0<br>I | 7.7.I0.3<br>5.0 | 6.40<br>- | I60<br>300 | -<br>9.0 |
| North-west slope of the big Bank | Aug. | 8 | 5.0-7.5 | 6.56 | II0-250 | 9.7-II.8 |
| Awalon pen. area | Aug.-Sept. | 26 | 4.7-I8.3 | 7.3I | 70-I60 | I2.I-I3.2 |
| South-East slope of the Big Bank | Aug.-Sept. | 2<br>4 | 4.8-6.5<br>5.8-26.5 | -<br>- | I60-I66<br>50-70 | I2.2-I2.4<br>II.28-I4.34 |
| South-West slope of the Big Bank | July-Aug. | I<br>46 | 6.5<br>4.9-25.6 | -<br>- | I90<br>76 - I06 | I5.4<br>I4.48-I5.4€ |
| Saint Peters Bank | Aug. | I | 6.9 | - | 45 | I4.66 |
| Bankero Bank | Aug. | I4 | 6.5-I3.4 | 9.0 | 28-96 | I7.68-I8.83 |

In August witch flounder larvae were caught at the coast of South Labrador in the area of Hamilton Bank, in the waters of North Newfoundland Bank, near Awalon peninsula at Saint-Peter Bank and at the Nova Scotia shelf (Fig.7). The biggest number of larvae at that time was found at the South-West slope of the Big Bank and near Awalon peninsula (Table 3). Separate larvae were found also above very deep waters (above 1000m) in the area of South-West slope of the Big Bank. Several larvaes were caught in September near the coastal of Awalon peninsula and in the area of South-East slope of the Bank (Fig.7).

Witch flounder larvae were mainly caught in the upper layers of water which were sufficiently heated. As

Basing on the information on distribution of fish eggs of different stages of development and mature spawning fishes, it is possible to make a supposition that the spawning period of witch flounder in the survey region of North-West Atlantics is rather spread in time and it takes place from March to September. The duration and time periods of witch flounder depend on geographical position of the spawning grounds.

In the North regions spawning of witch flounder take plame, evidently, in shorter time periods, than in the South. Spawning period in the areas of South Labrador and North Newfoundland Bank continues from March to July however a just hatched larvae was was caught at the coast of South Labrador in the middle of August. By analysing the distribution of fishes at spawning stage, it is possible to make a conclusion that the most intensive spawning of witch flounder in the above regions takes place mainly in March-May. Pechenick and Troyanovsky (1970) indicate that in the areas of South Labrador and North Newfoundland Bank mass spawning of witch flounder takes place in March-April at the depth drop of 570-700 m and it stops in May. However fish eggs of witch flounder in these areas were not found and the supposition based on the distribution of spawning fishes is not always true, and only the presence of eggs at early development stages can testify to the location of spawning grounds.

In the areas of the Big Bank, judging from the occurance of early - stage eggs and distribution of spawning fishes , the spawning of witch flounder continues up to September. The most intesive spawnigng, evidently, falls on July-August. although earlier peak, say, in April is also possible, Table 4. Witch flounder spawns in the waters of the Big Bank more widely, than neer Labrador and on the North Newfoundland Bank. Its spawning, evidently, takes place over the whole area of the Bank from shallow water (50-100) to depths

e rule small larvaes were found above deeper waters than bigger larvae.

Witch flounder spawning

Witch flounder at the coast of the North America is distributed from Newfoundland Saint Lawrence Bay Gatteras Cape (Bigelow and Schroeder, I953).

The season of its multiplication is long, spawning take place late in spring and in summer at rather higher temperature. (Bigelow and Schroeder, I953). It is proposed that the main spawning grounds of this species in the w ter of Atlantics are located deep in South regions of the area (Pertseva - Ostroumova, I96I). Canadian scientists (Powles and Kekler, I970), who studied witch flounder distribution in Saint Lawrence bay and at the coast of Nova Scotia indicated that mature fishes in summer time (May-October) were found in big number at the depth of 92-I62 m and II6-325 m in winter time (November-April). According to our knowledge, in the waters of Labrador-Newfoundland fishing area mature spawn fishes are found in trawl catches during year-time from shallow water (50-80) to depth drop (900-I000m), and according to some other authors (Pechenik, Troganovsky, I970) to I500 m. Spawning fishes with leaking reproductive products were found in the waters of Labrador and North Newfoundland Bank from March to July Table 4.

Table 4.

| Areas | March | April | May | June | July | August | September | Number of fish |
|---|---|---|---|---|---|---|---|---|
| South Labrador and Newfoundland Bank | I9.0 | 3.3 | 40.I | 3.8 | I4.0 | - | - | I607 |
| Big Bank and Saint Peter Bank | I6.4 | 37.7 | 8.9 | I6.3 | - | 6.2 | 4.3 | 626 |

drop (500 and deeper), Fig.8. The most intensive spawning evidently takes place in differnt areas of the depths drop of the Newfoundland Bank, which is prooved by the accumulation of earlier stage eggs and newly hatched larvae.

On the Saint - Peter Bank witch flounder eggs were found in the zone of shallow water to 100 m isobath, where probably, witch flounder spawns.

Eggs occurance in the waters of Nova Scotia shelf and on the Georges Bank at the end of May give an opportunity to suppose that spawning start in these areas in May and probably even earlier.

American scientists (Bigelow and Schroeder, 1953), who studied witch flounder of the Gulf of Maine indicated that in the water of the Gulf of Maine witch flounder spawns late in spring and in summer, up to the middle of October (judging from the fact of occurance of small larva). Spawning peak is witnessed in July and August. Probably, there are no distinct differnces in time of witch flounder in spawning in the Gulf of Maine, coastal waters of Georges Bank and in the area of Nova Scotia so it is possible to suppose that the time periods of spawnign season in these regions are almost similar. So far witch flounder of North-West Atlantics rather spread in time spawning period is characteristic. Significant fluctuation in size is of larvaes (Table 3), marked in August-September also proves this. In different years, depending on hydrological condition time periods and places of witch flounder spawning, may probably slightly drift.

Fish eggs and larvae Drift

By means of comparision of eggs and larvae distribution diagrams, currents charts (Fisheries Record, 1962) and spawning grounds chart it is possible to trace the main routes of eggs and larvae of witch flounder drift. General diagram of earlier stages of this species development in the North-West Atlantic is similar to the diagram of eggs and

larvae drift of some other commercial species in this area (cod, haddock, long rough dab, common dab).

From the Northern spawning grounds witch flounder eggs and larvae drift Southward to the areas of Newfoundland island and Big Newfoundland Bank, where hydrological conditions are more favourable for the development of larvae and living of juveniles. Taking into account rather high velocities of the current (Ø, from 0.5 to 2 knots) near Labrador and Newfoundland it is possible to suppose that fish eggs and larvae of this flounder from the areas of North spawning grounds are brought away to quite considerable distances. In the waters of the Big Bank witch flounder eggs and larvae, evidently, do not travel to long distance because they can stay at the spawning grounds due to whirl of slow speed currents (0.I-0.2 knots). However, in certain seasons small portion of the fish eggs is taken beyond the boundaries of the Bank to the oceanic waters.

Pelagic larvae stage of witch flounder is the longest among the representatives of dab-family. According to Bigelow and Schroeder (I953) it may continue for 4-6 months, and according to recent information obtained by Powels and Kokler (I973) up to one year .

Canadian scientists (Powels and Koklers, (I970), who stidied the distribution of larvae, juveniles and nature fishes near Nova Scotia and in Saint Lawrence Bay indicated their ecological isolation. It was found out that juveline and mature fishes in these areas concentrate at quite different depths I80-290 m and 35-430 m respectively. Deep water distribution of the juveniles, according to these authors, eliminates direct food competition with the juveniles of more numerous species of cod and long rough dab.

In the areas of Nova Scotia the tendency of eggs and larvae drift, evidently, depends on the dominating here current with high velocities, moving along the coast in South-West direction.

Conclusions

I. Description is given to the development of witch flounder from fish egg to larvae at the stage of metamorphosis.

2. Gl. Cynoglossus eggs occur in North-West Atlantics from May to September from the North slopes of the Big Bank to South-West part of Georges Bank.

3. Witch flounder larvae were mainly flound in the places of eggs distribution. small larvae were found above deeper waters, than big size larvae.

4. Witch flounder spawning in North-West Atlantics is rather spread in time and it continues from March to September. Spawning grounds are located at the boarder of the regions of South Labrador and North Newfoundland Bank, in the waters of the Big Bank, in the regions of Nova Scotia and on Georges Bank. In the North regions more intensive spawning takes place, evidentely, in March-April, and in the South - in July-August.

5. Main direction of witch flounder eggs and larvae drift is South and South-West pelagic larvae stage is very long and it can continue for about a year.

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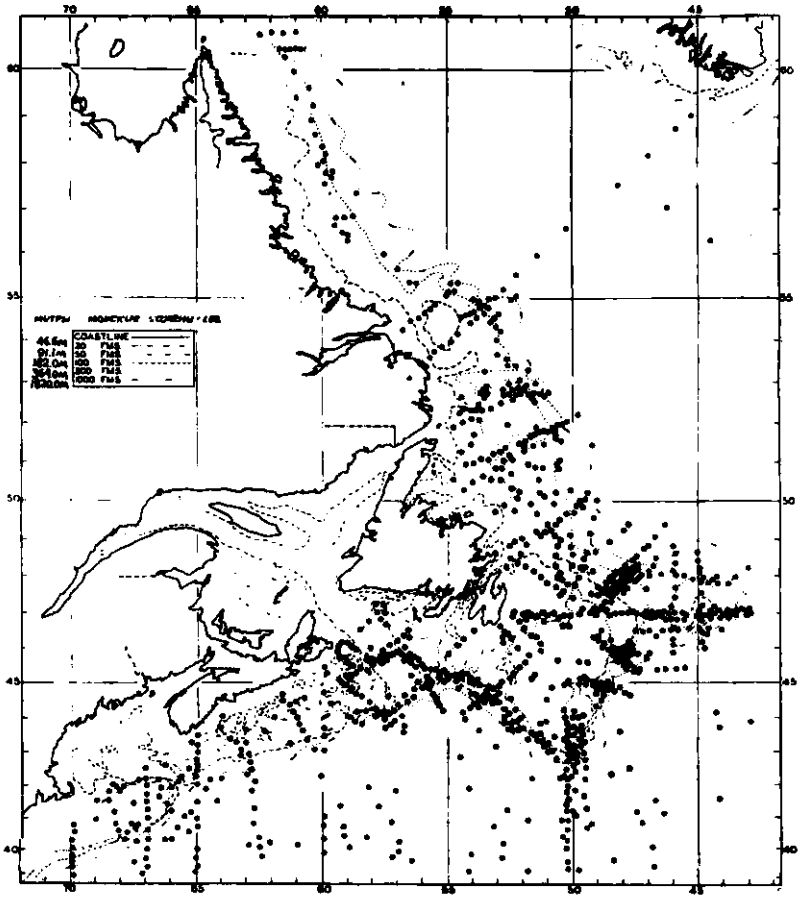
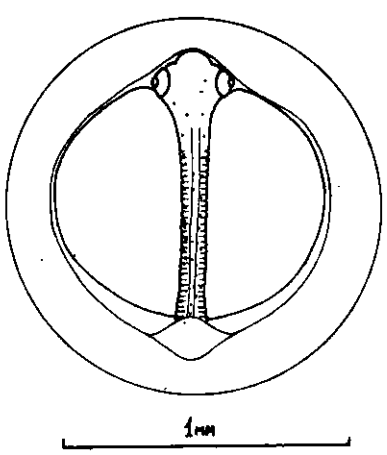
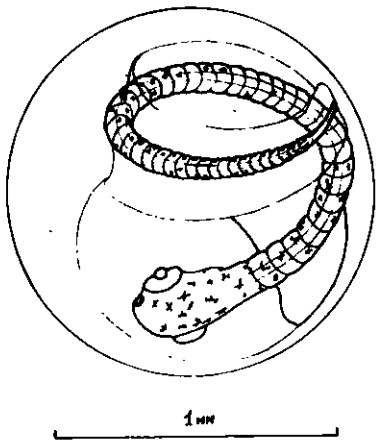


Fig. 1. Diagram of stations where samples of ichthyoplankton were taken in 1959-1970.




(a)

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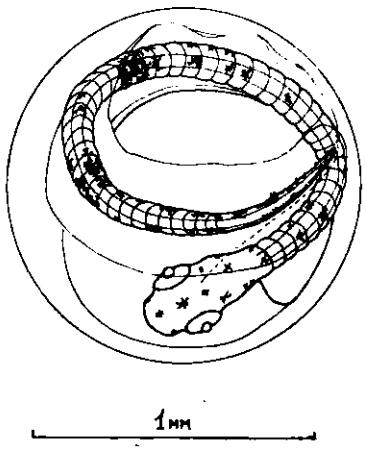
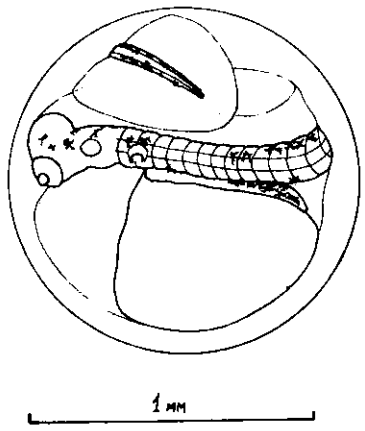



(c)




(d)

Fig. 2. Fish eggs of witch flounder:

(a) II stage of development;
(b) beginning of the IV stage of development;
(c)
& (d) end of the IV stage of development.

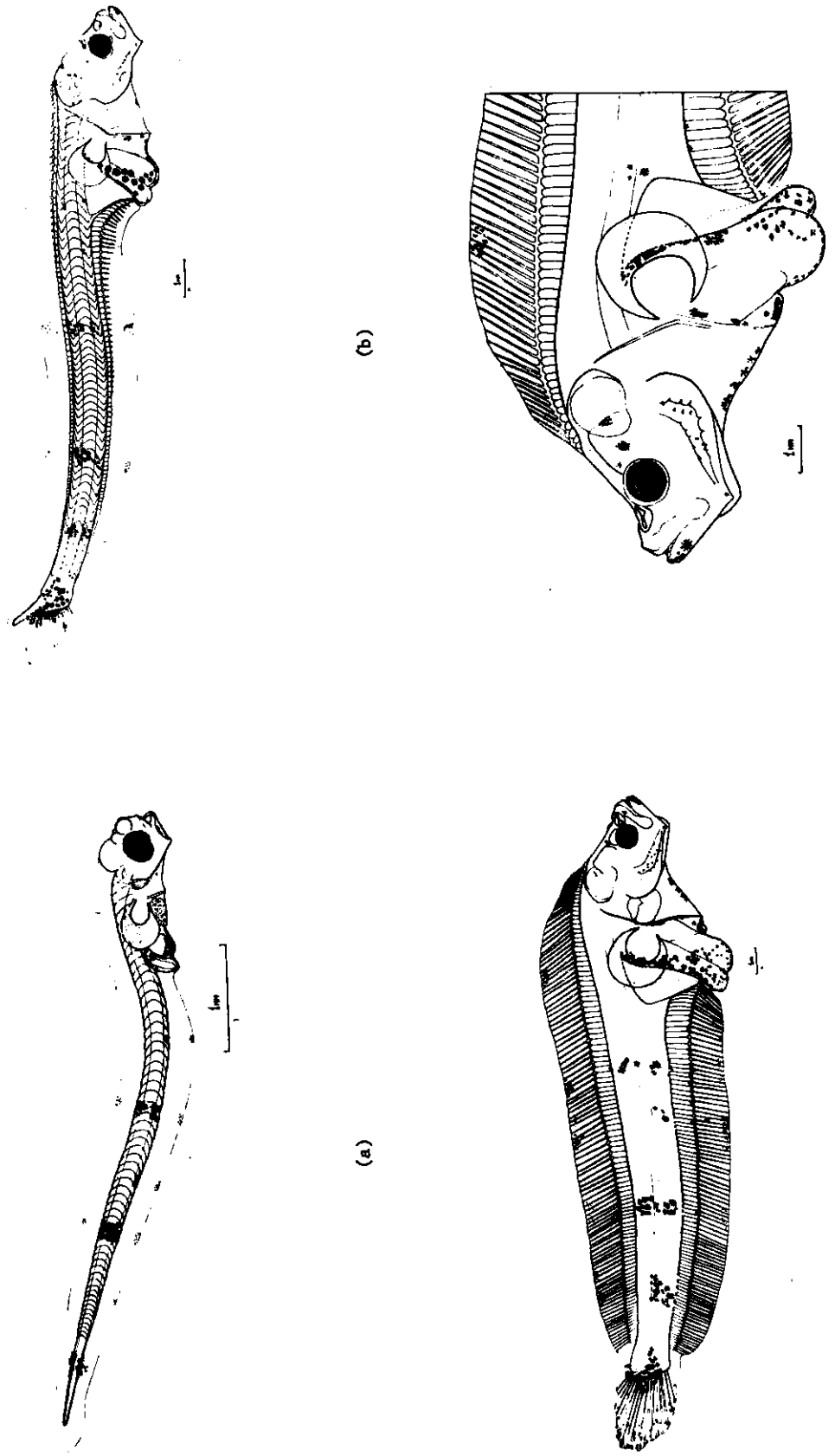



Fig. 3. Larvae of witch flounder:
(a) length - 5.8 mm;
(b) length - 16.7 mm;
(c)
& (d) length - 22.5 mm.

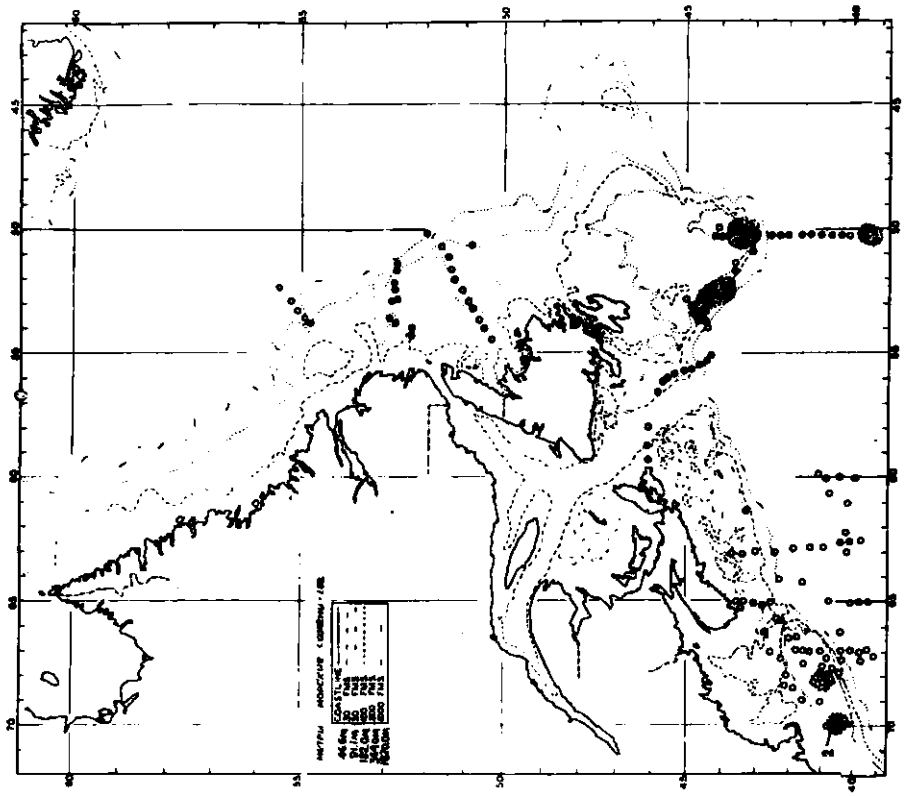


Fig. 5. Distribution of fish eggs and larvae of witch flounder in June.

Legend: (see Fig. 4)

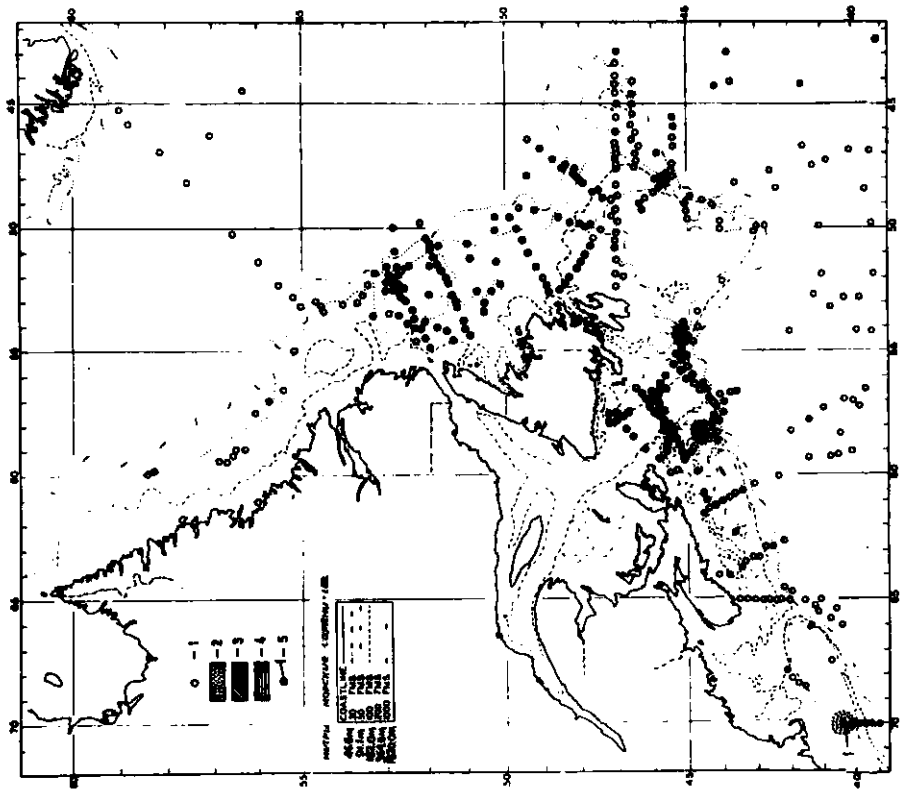


Fig. 4. Distribution of fish eggs and larvae of witch flounder in May:

Legend: 1 - station
2 - 1-10 fish eggs per catch
3 - 11-100 fish eggs per catch
4 - 101-500 fish eggs per catch
5 - number of larvae at the station.

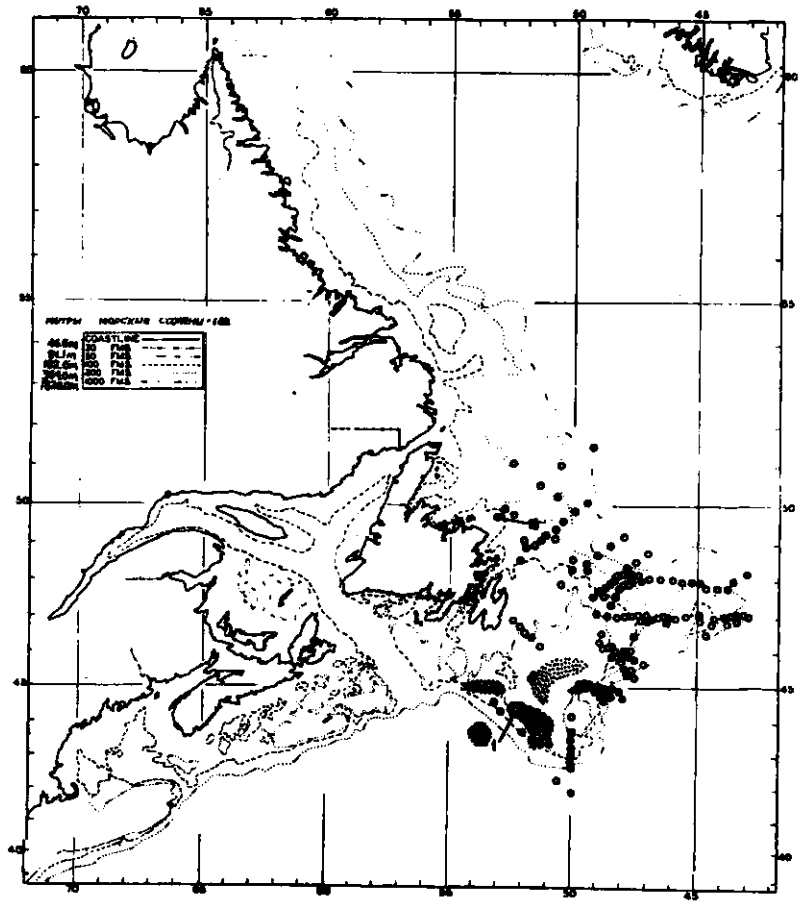


Fig. 6. Distribution of fish eggs and larvae of witch flounder in July.

Legend: 1 - station
2 - 1-10 fish eggs per catch
3 - 11-100 fish eggs per catch
4 - 101-500 fish eggs per catch
5 - number of larvae at the station.

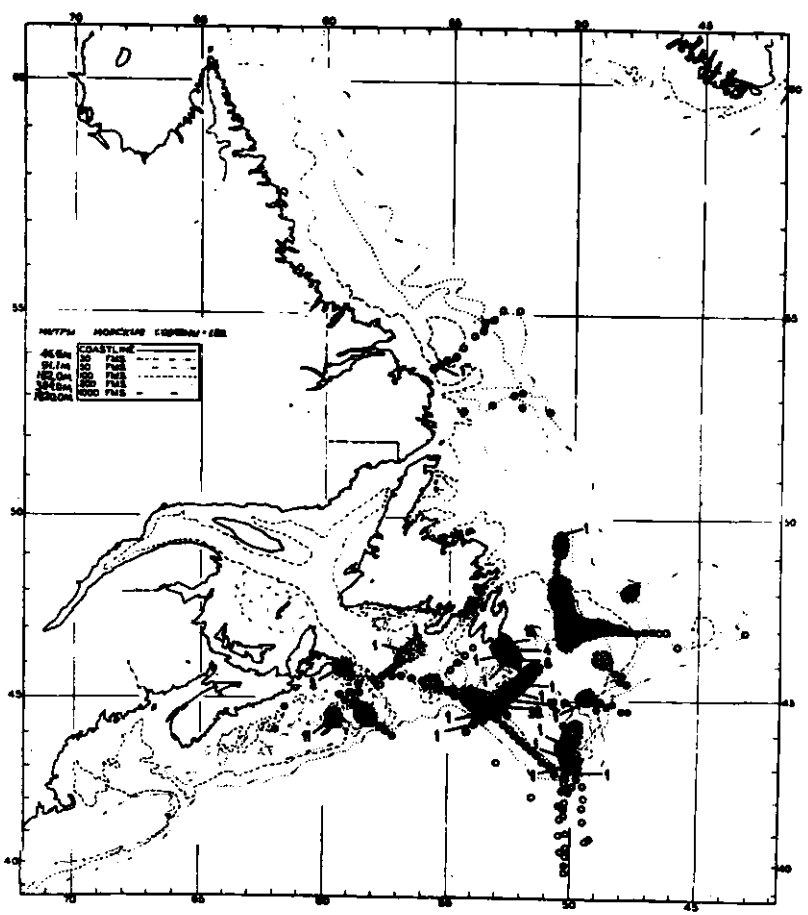


Fig. 7. Distribution of fish eggs and larvae of witch flounder in August-September.

Legend: (see Fig. 6)

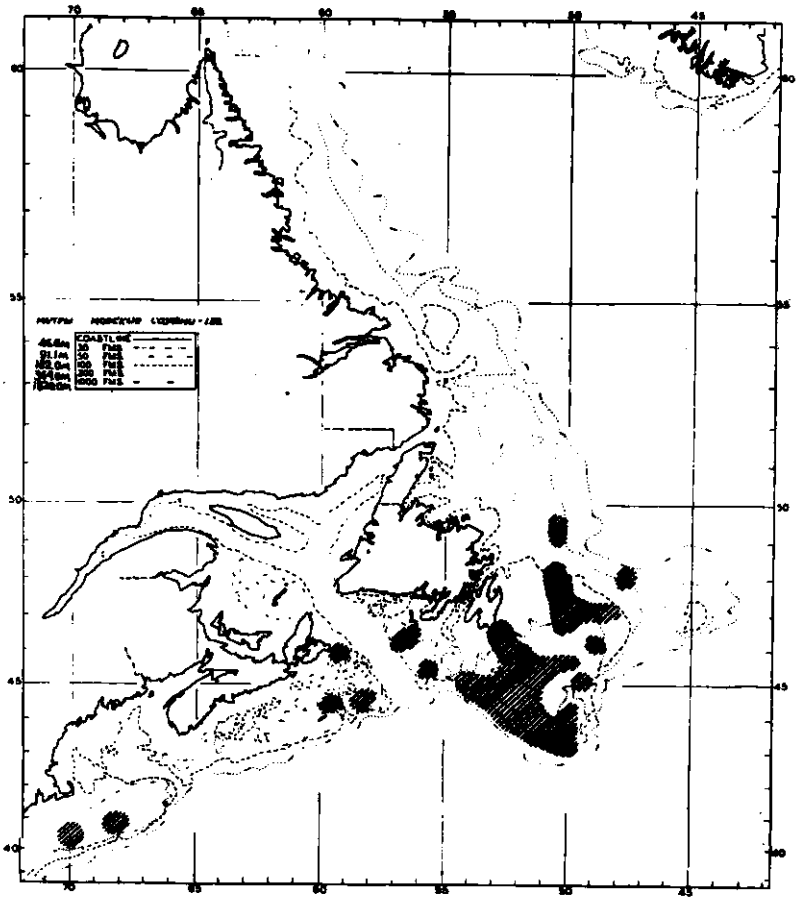


Fig. 8. Proposed places of witch flounder spawning.