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Distribution and Peculiarities of Allometric Growth of Larval *Illex* in the Northwest Atlantic

by

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Abstract

The Illex larvae inhabit the epipelagial of the shelf waters, the continental slope and the Gulf Stream where the temperature and salinity range from 11.2 to 20.10°C and from 34.50 to 36.56‰, respectively. The largest recorded aggregations were in the continental slope area of the Mid Atlantic Bight (MAB) between 35° and 38°N, and in the northern periphery of the Gulf Stream to 65°W.

Illex illecebrosus spawn in the pelagial of the continental slope between the Florida Peninsula and 40°N. The spawning period extends from September to May, with December-February as peak spawning months. Egg masses found in the spawning ground have a positive bouyancy. The larvae are transported by the Gulf Stream to the north-eastern parts of the area, thus greately influencing the abundance of the species in Subareas 3 and 4.

The development of the larvae can be divided into three stages. At the first (1.1-1.5 mm) and second (1.6-5.0 mm) stages the linear mantle growth predominates. The third stage is characterized by the intensive development of catching apparatus, splitting of the proboscis and formation of habits of an active predator.

Similarity of morphogenesis in larval Illex, Todarodes and Nototodarus is indicative of the fact that these genera are akin in terms of phylogenesis.

Introduction

First data describing the larval stage of Illex ontogenesis in the Northwest Atlantic were published in 1978. Rhynchoteuthion of C type was identified as a larval Illex (Roper, Lu, 1978), the data on occurrence of larvae above the shelf and continental slope of the eastern US coast to the southern edge of Georges Bank were presented, and morphological changes in larvae and juveniles in the range of 1.5 to 21.1 mm considered (Roper, Lu, 1978; Vecchione, 1978). Then first evidence on the spawning, egg masses, development of eggs and larvae of Illex illecebrosus in captivity appeared (Durward et al., 1979; O'Dor et al., 1980, 1982 a, b).

A directed research carried out in the feeding ground of the juvenile Illex illecebrosus has resulted in new information on the distribution, length frequency and migration mechanism peculiar to larval Illex in the Northwest Atlantic (Dowe, Beck, 1982; Dowe et al., 1982; Hatanaka et al., 1982; Trites, 1982; Dubinina, Froerman, 1983; Froerman, 1983).

In the present report the allometric growth and the distribution of the larvae are considered, the authors' and literary data on the ecology of the larval stage of the investigated species are summarized, and an attempt is made to infer the boundaries of the reproductive part of the area, where the species ranges, in space and time, and to evaluate their functional role in the evolutional strategy of the species.

Materials and Methods

The data were collected during the 1974 to 1983 period in the area ranging from Cape Hatteras to Flemish Cap. The sampling was made with the Bongo net 60 cm in diameter, 0.505 and 0.333 mm mesh size. In February 1979, the conical net with 1 mm mesh size was fitted to the bottom trawl warp to sample the near-bottom water during the towing.

The data on investigated areas, dates, amount of samples, etc., are detailed in Table 1.

The larvae were identified in a manner used by Roper and Lu (1978). Length measurements to within 0.01 mm were taken of the larvae preserved in 4% formalin. Mantle lengths presented in Table 2 were averaged to 0.1 mm.

The immature larvae from some especially successful catches made in March 1978 above the continental slope of the Mid Atlantic Bight (Fig. 1) were examined for the purpose of analysis of the allometric growth. Dorsal mantle length, mantle width, length and width of the head, length of arms I-IV and of proboscis were measured in each larva. Dorsal mantle length was taken as the main character because it is strictly controlled by the chitin gladius.

Results

Allometric growth.

With the change of the length from 2.4 to 6.00 mm relative mantle length decreases from 60 to 50%. The larvae with 6.1-7.0 mm ML show a distinct negative allometric growth of mantle in width (Fig. 2A). Relative mantle length of 40% persists to the end of larval stage of development.

The width of the head in the larvae with 3.1-5.0 mm ML makes up 50-60% of mantle length on the average, and exceeds the length of the head owing to slightly protruding eyes (Fig. 2B). This feature is typical of the squid larvae on the whole. During the growth of mantle from 5.1 to 6.0 mm the head of a larva grows more intensively in length, while in a larva with ML of 6.1-7.0 mm and more the growth of the head in length and width is isometric, and is characterized by a small negative allometry relative to mantle length (Fig. 2 B, C).

With the increase of mantle length from 1.8 to 5.0 mm the growth of arms I is isometric to mantle growth, the growth of arms II and III lags behind the mantle growth, and the growth of arms IV is marked by a small positive allometry (Fig. 3). In the larvae with 5.1-6.0 mm ML the rate of growth of all arms sharply increases. With 6.1-7.0 mm ML, and to the end of larval stage of development arms I, II and III show isometric growth or a slight positive allometry, and the growth of arms IV is positively allometric (Fig. 3). The order of arms for larvae with 1.8-6.0 mm ML is 2.1.3.4., and at completion of the larval stage it is 2.3 ≥ 1.4.

The length of proboscis (Fig. 3) during the growth of the larvae changes insignificantly (1.2-1.6 mm). Splitting of a proboscis begins when the larvae are 4.6-5.0 mm in mantle length, and terminates when the mantle length reaches 7.5-8.8 mm.

Based on the peculiarities of arms growth, and splitting of a proboscis several stages in the development of larval Illex can be distinguished.

I - stage of two pairs of arms (Fig. 4-I). These are newly hatched larvae, which can be identified by the literature data (Durward et al., 1979). Mantle length is less than 1.5 mm. A larva has arms I and II, the length of a proboscis exceeds that of arms. Arms III begin to grow at the end of this stage.

II - stage of unsplitted proboscis (Fig. 4-II). Mantle length ranges from 1.6 to 4.6-5.0 mm. The length of a proboscis exceeds that of arms or equals the length of arms I and II. A longitudinal groove runs the entire length of the proboscis; the latter has eight equal-sized suckers. Arms order is 2.1≥3.4. Suckers on arms are arranged in two rows. Arms IV are not developed and are represented as short papillas at the base of the proboscis. 6 large chromatophores are located on the head, mantle chromatophores are small and numerous.

III - stage of splitting proboscis (Fig. 3-III). Larvae are 4.6-8.8 mm in ML. Splitting of proboscis begins from appearing of a triangular slit at its base. Later the tip of the proboscis also begins to split into two lobes. 6 large chromatophores are located on the head. Arms order is 2.3 ≥ 1.4. Arms III have swimming keels. Mantle grows slender, the shape of fins being changed from rounded to elliptical. Larval features absent from the individuals with mantle length exceeding 8.8 mm.

Distribution.

In August-September 1974, on the USA shelf and in the Nova Scotia area the sampling was made in the shelf waters above depths ranging from 15 to 150 m. Oblique tows were made from the horizon of 50 m or less depending on the depth of the location. The water temperature in the sampling area fluctuated between

18 and 21°C (Table 1). No larvae of shortfinned squids were found.

The attempts to catch larvae above the northern part of the USA shelf and on Georges Bank in November 1977 and in January 1978 were also of no avail (Table 1).

Of 1086 tows made during the period from February to May 1976 and during 1979-1983, 49 larvae of Illex were found in 24 samples captured in the area between the continental slope and the Sargasso Sea (Fig. 1).

Four catches taken in March 1978 from the 10 m surface layer on the continental slope of the Mid Atlantic Bight above the depths of 300 to 800 m, between 36° and 38°N, contained 147 larvae of Illex (Fig. 1).

A variety of hydrographic structures at the stations, where the larvae of Illex were caught, can be classified into three types.

1. Zone of mixed shelf and slope waters above 300-800 m. The slope water masses were prevalent. The positions were 36°30'-38°00'N and 73°30'-74°40'W (Fig. 1). The surface and near-bottom (100-300 m) temperatures were 8-14°C (Fig. 5A) and 8.0-12.°C (Fig. 5B), respectively. Vertical profiles of the water temperature on 5-15 March 1978, are depicted in Figures 6 and 7. The larvae were captured in the near-surface 10 m layer, from stations Nos. 122-117 and 105-102.

2. Shelf water and a zone of mixed shelf and Gulf Stream water (Fig. 8). The larvae occur at the water temperature of 12-17°C and at the salinity of 35.40-36.10‰.

3. Gulf Stream water masses with the temperature of 15-20°C and the salinity of 35.10-36.50‰ (Fig. 9). The larvae are more often observed between the central zone with strong currents and the northern periphery of the Gulf Stream (Fig. 10A), and are less common in the central and southern zones (Fig. 10B).

In all three cases conditional density of the water masses (σ_T) exceeds the values of 25.9-27.8. This is considerably higher than the maximum σ_T values (approximately 21.4-24.33) of the water used in Aquatron Laboratory of the Dahlhousie University in Halifax. Therefore, egg masses, which have neutral boyancy in captivity (Durward et al., 1979; O'Dor, 1980, 1982) are expected to have positive boyancy and to ascend to near-surface water layers in the areas with the above-stated hydrographic conditions. This assumption is supported by the fact that horizontal catches are more successful in near-surface water layers than oblique catches in 200-0 m depths.

In the Gulf Stream (case 3), and in the zone of mixed Gulf Stream and slope water (case 2) the larvae with mantle length below 2.0 mm were not found east of 70°W. Modal and mean lengths increased in the north-east direction (Table 2). The larvae of all sizes, from the smallest to the largest, occur above the continental slope of the Mid Atlantic Bight (Table 2).

Discussion

At the third development stage the *Illex* larvae with mantle length of 4-6 mm or more proceed to habits of an actively hunting predator. It shows in a changed mantle outline from cask-shaped to slender, and in pronounced growth of catching apparatus. Evidently, it is a transitional stage from feeding on microplankton to predation on mezoplanktonic organisms, that is the larvae change to consuments of the 2nd and 3rd orders.

The analysis of changes of morphological features in larval *Illex* compared with the morphological characteristic of the larvae of other genera of *Ommastrephidae* given in a review by Nesis (1979) showed that *Illex*, *Todarodes* and *Nototodarus* are akin in terms phylogenesis. This has been reflected in a phylogenetic scheme by Wormuth (1976). Wormuth also included *Ornitoteuthis* in this group. We feel, however, that *Ornitoteuthis* should be included into the other group of *Ommastrephidae* because of the presence of photophores on eyes, rectum and intestine in the *Ornitoteuthis* larvae. We believe that the Nesis' suggestion (1979) to regard *Ornitoteuthis* as a separate subfamily because of incompatibility of its larval characters with the lower and higher *Ommasrephidae* is better grounded.

Using both our material on occurrence and size of the larvae and the data reported by Roper and Lu (1978), Vecchione (1978), Dawe and Beck (1982) and Hatanaka et al. (1982) we have drawn a scheme of the geographic distribution of Illex in a larval stage of the ontogenesis (Fig. 11).

The larvae of minimum sizes can be found in the epipelagial of the shelf and continental slope, mainly between Cape Hatteras and 40°N in autumn, winter and in spring (our data, Table 2; Roper and Lu, 1978; Vecchione, 1978). The large catches of the larvae at early development stages have also occurred in the shelf area between the Florida Peninsula and Cape Hatteras (Dawe and Beck, 1982). Results of the research carried out by the RV "Kaiyo Maru" during January-March 1982 are consistent with our data on occurrence of larval Illex in the waters described in hydrographic cases 2 and 3. Besides, these results support a suggestion that the Gulf Stream originated eddies exert a great influence on the distribution of the larvae (Hatanaka et al., 1982). Unfortunately, the continental slope of the Mid Atlantic Bight was not covered during that cruise. In that very area, in March 1978, the Soviet scientists found the aggregations of the larvae similar to those which were recorded by the "Kaiyo Maru" in 1982 in the northern edge of the Gulf Stream. The north-eastern boundary of the larvae distribution (55-56°W) has been determined from the data by Dawe and Beck (1982). The mode for the larvae from that area is 4.1-4.5 mm, and the minimum size is 2.4 mm.

Observations on the spawning, development of eggs and hatching of the larvae in captivity have shown that egg masses were fertilized at the temperature of 7°C and more; the incubation proceeded normally at the temperature over 10°, and it required 8 to 16 days at the temperature of 18-21°C (Durward et al., 1979; O'Dor et al., 1982a). The hatched larvae crawled on the bottom of the pool for 4-5 days after they were spawn, and then easily swimmed in the water feeding on the protozoa. The longevity of their life in captivity was 8-10 days at the most after which time they died. During this time period their mantle length changed from 1.1 to 1.25 mm (Durward et al., 1979). In our opinion, the crawling of newly hatched larvae on the bottom of the pool, a retarded rate of growth, and early death can be related to a difference between the parameters of the pool conditions and those in the wild, namely in the spawning area, where the water has a greater boyancy, and, probably, a different microfauna composition.

As reported by O'Dor et al. (1982 b), the only case of spawning of a female in the pool took place when the water had a higher density. This is indicative of the fact that in the wild, in the areas with a high enough density ($\sigma_T > 25.00$) of the water, the spawning occurs in the pelagial. Extensive material on the pelagic spawning of Illex argentinus above the continental slope of the Patagonian shelf was obtained by Nigmatullin (verbal communication). The only explanation to the fact that the females having gonads at development stages IV and V actually do not occur in the catches taken with the bottom trawl can be that they spawn in the pelagic waters. In the catches taken with the bottom fishing gears in the area between the Florida Peninsula and Cape Hatteras the mature females were also missing (Whitaker, 1980). Therefore, the only obvious way to determine the location and dates of the Illex spawning in the Northwest Atlantic would be the analysis of the distribution of the larvae at present.

Captures of the small-sized larvae from the shelf and slope water between 80° and 69°W strongly suggest that the short-finned squids spawn there. Large numbers of the larvae in the northern edge of the Gulf Stream and in adjacent slope waters (cases 2 and 3) in the winter time, when the current comes closest to the continental slope, indicate that the eggs are transported by the Gulf Stream in the north-east direction. It is obvious that in the area between the Florida Peninsula and Cape Hatteras, where the stream intrudes into the shelf and slope waters in winter, a part of pelagic egg masses can be drawn into the Gulf Stream and trasported in the north-east direction. If the speed of the egg mass trasportation is compared with that of a buoy with the neutral buoyancy drifting in the Gulf Stream (Kirwan et al., 1976), it will be seen that the distance from the Florida Peninsula to 67°W will be covered by the egg mass in approximately 10 days (excluding a possible delay due to eddies). A distance from Cape Hatteras to 67°W will be covered in 5 days, and to 55-56°W in 14-16 days. The mantle length of the larvae between 67° and 55°W is usually over 2.00 mm, and the modes are 3.5-4.9 mm. It means that either 5-10 days were reguired for the development of the eggs and growth of the larvae to 2-5 mm in the Gulf Stream, which is considerably faster than in captivity, or the larvae captured at 67°W were mainly born in the slope water of the Mid Atlantic Bight, because in that area the eggs are transported into the Gulf Stream shortly after they are spawn. Egg masses, having a positive bouyancy, ascend to the surface water, and are transported towards Cape Hatteras at the speed of 10-20 cm/sec by the water moving in the south-west direction (Trites, 1982). If it is assumed that the spawning occurs above the continental slope of the Mid Atlantic Bight between 35° and 38°N, where we found large numbers of the larvae (Fig. 1), then the transportation of the eggs to the northern edge of the Gulf Stream (around Cape Hatteras) will require 1 day, if the spawning occurs around Cape Hatteras or 20 days, if the spawning occurs at 38°N. In the latter case both the egg and the larvae in different development stages may occur in the Gulf Stream. However even the rates of the growth of the eggs originating from the Cape Hatteras water, and occurring in the Gulf Stream in 24 hours or less, are not consistent with the rates of growth in captivity, otherwise northward of 67°W we might have found the minimum-sized larvae.

The results of the investigation into the distribution of the juvenile short-finned squids in the Gulf Stream, in its eddies, and in the slope water indicate that the stage of a passive plankter ends with 25-30 mm ML (Dawe et al., 1982). Having attained this length, the juvenile <u>Illex</u> begin to actively move from the zones of passive transporation (the Gulf Stream, eddies) towards the continental slope. In the area between the Florida Peninsula and Cape Hatteras the range of <u>Illex illecebrosus</u> overlaps that of <u>Illex oxygonius</u>. <u>Illex oxygonius</u> also occurs in the Mid Atlantic Bight water and on Georges Bank (Froerman, unpublished data). If the <u>Illex</u> larvae found in the area westward of 67°W were the spawning product of two species from the area south of Cape Hatteras, the specimens of <u>Illex oxygonius</u> would have been found on the Scotian shelf and GNB during the longterm investigation period. No such findings have been reported so far.

From the aforementioned data on the rates of development of the eggs and larvae, on the transportation speed in the Gulf Stream and spawning areas two contradictory conclusions can be derived.

1. The velocities of the transportation of the egg masses, the larvae and juveniles ranging from 25 to 30 mm in length, and of a buoy with the neutral bouyancy are similar. 10-15 days are required for the eggs to develop into actively swimming juveniles.

In this case the larvae and juveniles found to the east of 65-67°W mainly originate from the slope water of the Mid Atlantic Bight, where the spawning takes place between 36° and 37°N. In the area ranging from 33° to 36°N no spawning occurs.

2. The majority of egg masses and the larvae is transported by the Gulf Stream water in its northern edge, where the velocity of the stream is considerably lower, and the transportation from Cape Hatteras to 65-67°W requires 15-20 days (Trites, 1982). The transportation takes more time from the area south of 33°N. 20-25 days are required for the egg mass to develop into actively swimming juveniles.

The spawning occurs in the pelagial of the continental slope, everywhere between the Florida Peninsula and 40°N. In this case a major part of spawning products drawn into the Gulf Stream between 33° and 36°N as eggs and the first stage larvae would reach the area east of 65°-67°W when the larvae attain stages 2 and 3, and the juveniles are at the planktonic stage. They develop into actively swimming juveniles there. The majority of the larvae hatched from the egg masses spawn south of 33°N,and north of 36°N achieve the stage of actively swimming juveniles west of 65°-67°W, that is they accumulate in the US shelf area and on Georges Bank for feeding. In our opinion, the second assumption is more probable.

The basic scheme of the transportation mechanism for the larvae in the Gulf Stream is given by Trites (1982). The geographic distribution of the larvae according to the data from field collections is in a close agreement with the theoretical calculations made by Trites. The only disagreement with these data consists in the assumption made by Trites that the spawning occurs in the near-bottom layer at depths less than 200 m, and that the development of the egg mass proceeds in the near-bottom water.

The time of the larva captures from the shelf, slope and Gulf Stream water shows that the spawning extends from September to May with December-February as peak spawning months. Undoubtedly, the macro-, meso- and micro-scale fluctuations in the Gulf Stream meandering influence the conditions, duration and extent of the spawning ground. There exists a direct dependence of the Illex abundance in the Nova Scotia and GNB areas on the length of the egg masses, larvae and juvenile transportation by the Gulf Stream. The more meanders and eddies in the Gulf Stream west of 67°W, the longer the transportation of the larvae. That is, they develop into active swimmers and migrate towards the shelf from the point closest to transportation origin in the Gulf Stream, i.e. from around Georges Bank or the south of Nova Scotia, while the number of squids reaching the GNB is insignificant. This might be the reason for larger fluctuations of abundance in the Newfoundland area compared with the more southern areas of the species range.

Summary

Three stages can be distinguished in the development of the larval Illex: 1 - stage of two pairs of arms. The mantle length is less than 1.5 mm; 2 - stage of unsplitted proboscis. The larvae have 1.6 to 4.6-5.0 mm ML. 3 - stage of splitting proboscis. The larvae has a gabitus peculiar to actively swimming and attacking predator. The mantle length is 4.6-8.8 mm. Morphological similarity of the Illex, Todarodes and Nototodarus larvae is indicative of the phylogenetic closeness between these Genera.

From the analysis of the distribution of the Illex larvae in the north-western part of the Atlantic Ocean a reproductive zone in the distribution range of Illex illecebrosus was determined. It covers the continental slope of the North America between the Florida Peninsula and 40°N. The major spawning period extends from September to May with December-February as the peak months.

The spawning of Illex illecebrosus occurs in the pelagial of the continental slope. The egg mass has a positive bouyancy. The spawning products are transported by the Gulf Stream from the area between the Florida Peninsula and Cape Hatteras in the north-east direction. The egg masses and the larvae are first transported from the spawning ground (between 35° and 38°N) in the south direction, and then are involved into a general north-easterly transport in the Gulf Stream. Seemingly, 15-20 days are required for the development of eggs and completion of a larval stage. A correlation between the spawning periods and spawning intensity in the area between 33° and 36°N, as well as above the shelf and continental slope south of 33°N and north of 36°N, and the Gulf Stream activity are responsible for the macro-scale distribution of Illex illecebrosus and its abundance in various parts of the feeding ground. The range of abundance fluctuations is minimum in the US shelf area where the reproductive and feeding zones coincide, and is the largest in the northern edge of the feeding ground. The velocity and time of transportation of the egg masses and larvae in the north-east direction are controlled by the dynamics of the Gulf Stream water and can be roughly calculated according to the methodology suggested by Trites (1982), provided that the spawning occurs in the pelagial and the egg masses have a positive buoyancy.

It is both possible that the Illex illecebrosus larvae may be transported by the Gulf Stream to the north-east or stay in the spawning ground. Thus, the mixing occurring in the population geno fund annually should support a stabilizing selection form as a dominant one. This may be the main reason for the presence of a single Illex illecebrosus population in the Northwest Atlantic.

The data in the increased range of abundance fluctuations in the north-east direction, as compared with the direction and pattern of feeding migration and localization of the spawning grounds, have contributed to identification of the Nova Scotia and GNB areas as an adaptive zone, and to an assumption that the center of the distribution area was shifting to the north-east from the Gulf of Mexico and the Carribean Sea. Therefore, it seems likely that the expansion of the reproduction area of Illex illecebrosus in the north-east direction during the phylogenesis could be caused by the intensification of the Gulf Stream and slackening of the Labrador Current.

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Table 1 Data for distribution of short-finned squid in the Northwest Atlantic

Years	1974	1976	1977	1978	1978	1979	1981	1982	1983	Total
Area of plankton sampling	N36-43°	36-45°	40°22 - 40°23	39°52 - 40°10	36°44 - 37°55	38-44°	37-44°	37-46°	38-46°	35-46°
	W63-74°	40-73°	67°26 - 67°31	70°25 - 69°56	74°36 - 74°54	66-50°	69-56°	67-38°	65-47°	75-38°
Time of plankton sampling	25 Aug 10 Oct	17 Feb 30 May	21-22 Nov	29-31 Jan	5-17 Mar	20 Feb 13 Apr	15 Feb 30 May	07 Feb 30 Apr	13 Mar 31 May	25 Aug 31 May
Water types sampled	SH	SL SA ST	SH SL	SH SL	SH SL	CSH SH SL, SA WE, ST	SH, SL WE, ST SA	LC SH SL, ST WE, SA	NAW, SA SH , ST SL WE	NAW WE LC SA SH ST CSH SL
Number of plankton samples	143	188	5	8	8	159	344	280	115	1 250
Types of plankton hauls	Oblique from 15-0m to 50-0	Oblique 50-0 m 100-0 m	Stepped 10-5-1 m	Stepped 10-5-1 m	Stepped 10-5-1 m	Oblique 200-0 m Stepped 10-5-1 m Near-bottom	Oblique 200-0 m 50-0 m Stepped 10-5-1m	Oblique 200-0 m Stepped 10-5-1 m	Oblique 200-0 m Stepped 50-25 m 10-5-1 m	
Number of captured larvae	0	19	0	0	147	17	5	7	1	196
T°C in the area of larva captures	16.0-21.0	15.0-18.0	10.3-12.0	6.4-13.5	11.2-13.7	13.75-17.20	14.32-20.01	12.00-20.10	18.70-18.79	11.20-20.10
S‰ in the area of larva captures	-	-	-	-	34.50-35.70	about 35.50-36.10	36.01-36.56	35.43-36.52	36.17-36.25	34.50-36.56

Table 2 Length frequency of Illex larvae caught in different areas of the Northwest Atlantic

Mantle length, mm	Areas of larva captures		
	36° - 38°N 70° - 75°W	37° - 41°N 65° - 70°W	38° - 42°N 60° - 65°W
1.8 - 2.0	4	-	-
2.1 - 3.0	34	2	-
3.1 - 4.0	42	5	1
4.1 - 5.0	60	8	6
5.1 - 6.0	16	7	3
6.1 - 7.0	10	2	1
7.1 - 8.0	3	-	1
8.1 - 8.8	1	2	-
Total number	138	26	12
Minimum ML	1.8	2.8	2.6
Maximum ML	8.8	8.1	7.6
Mean ML	4.0	4.6	5.3
Modal ML	3.1-4.9	3.5-5.3	4.5-5.3

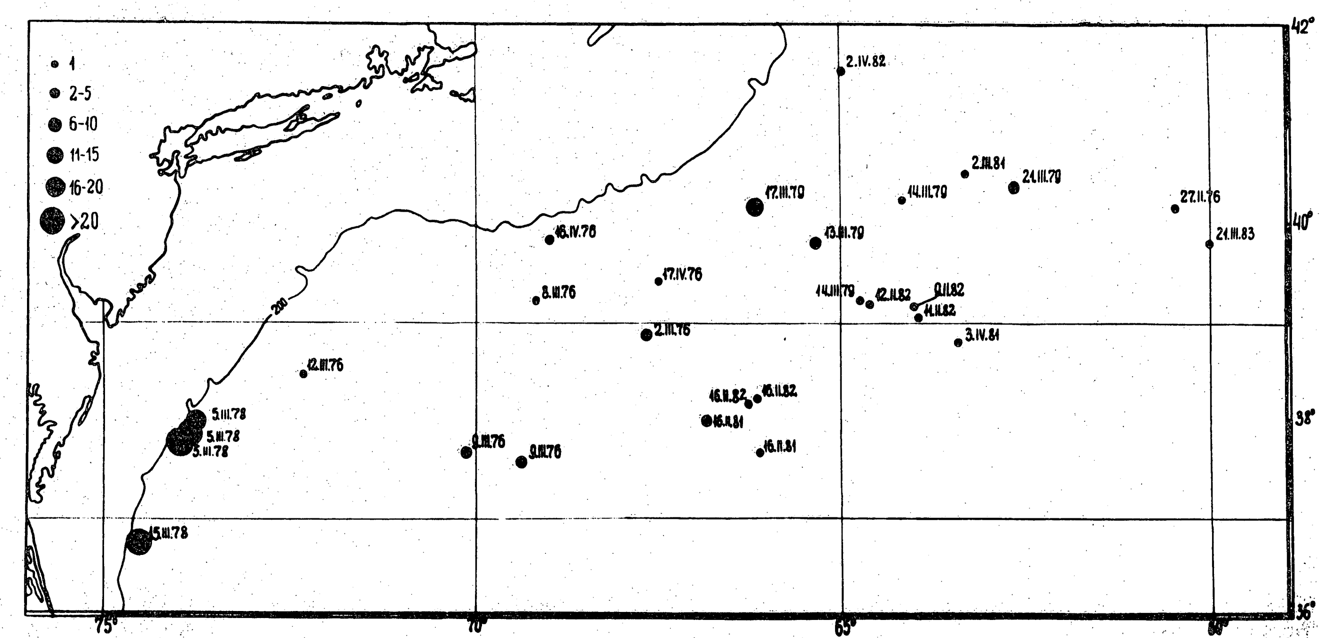

Fig. 1. Geographic distribution of Illex larvae in February - April 1976-83 in the Northwest Atlantic.

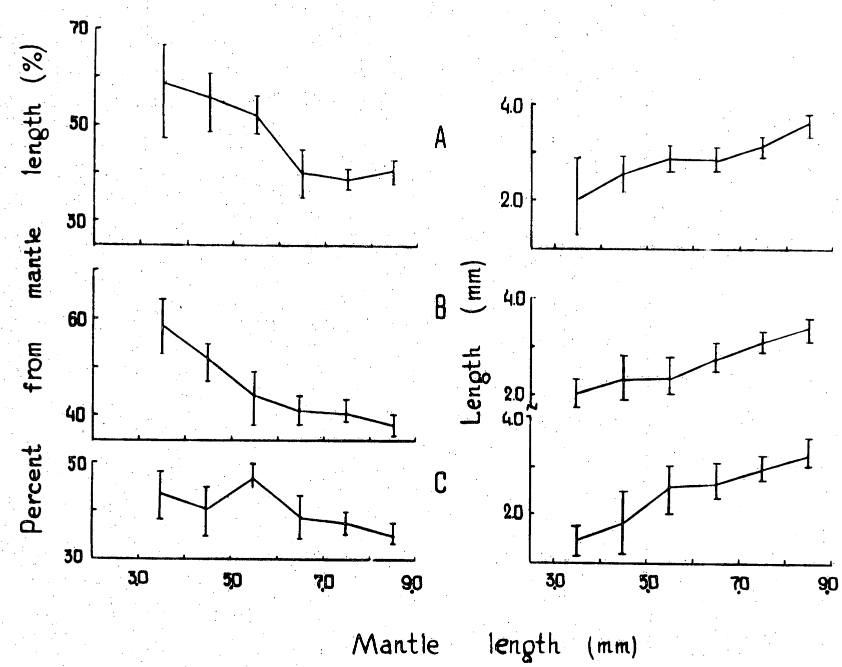

Fig. 2. Allometric growth of mantle and head of Illex larvae in the Northwest Atlantic (A - mantle width; B - width of the head; C - length of the head).

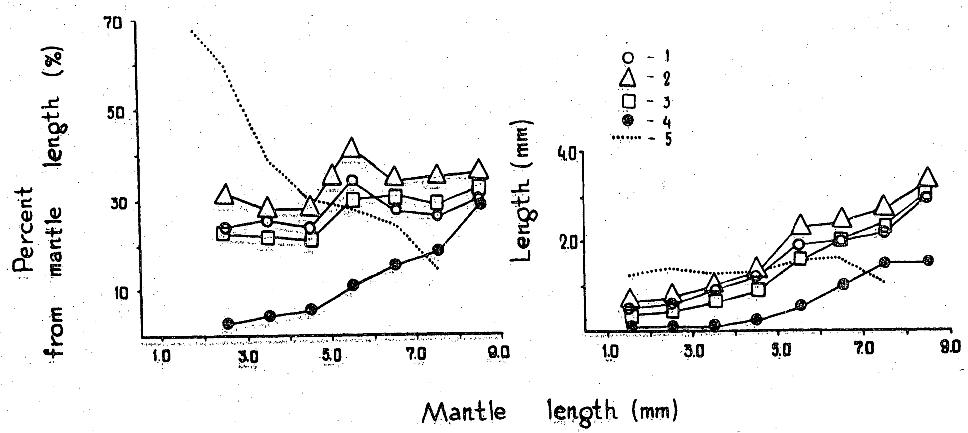

Fig. 3. Allometric growth of arms and proboscis of Illex larvae in the Northwest Atlantic. (1-4 depict arms I, II, III and IV; 5 - proboscis).

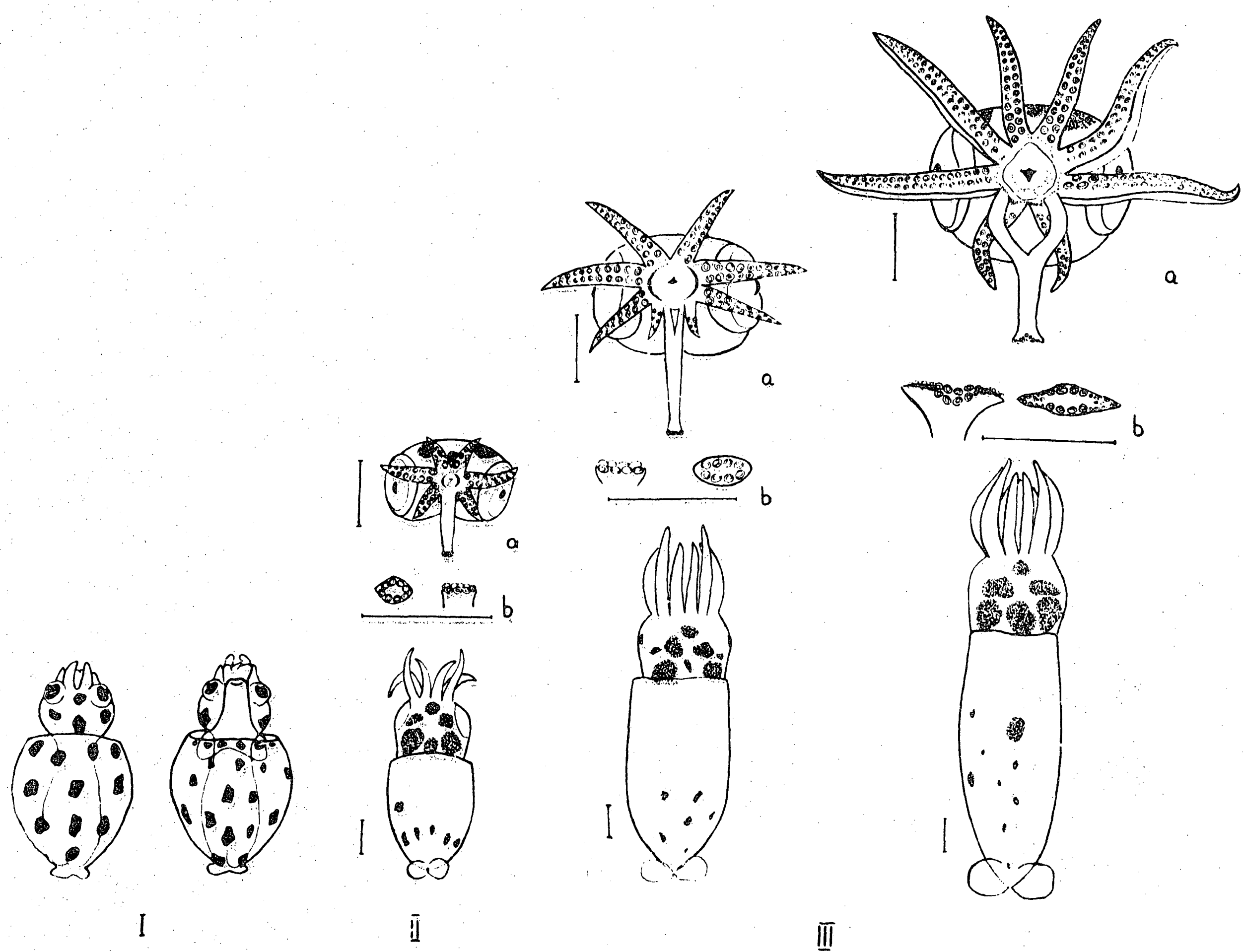

Fig. 4. Development stages of Illex larva in the Northwest Atlantic; I, II, III - development stages of larva; a - development stages of catching apparatus; b - development stages of tentacular dactyls. Scale - 1 mm.

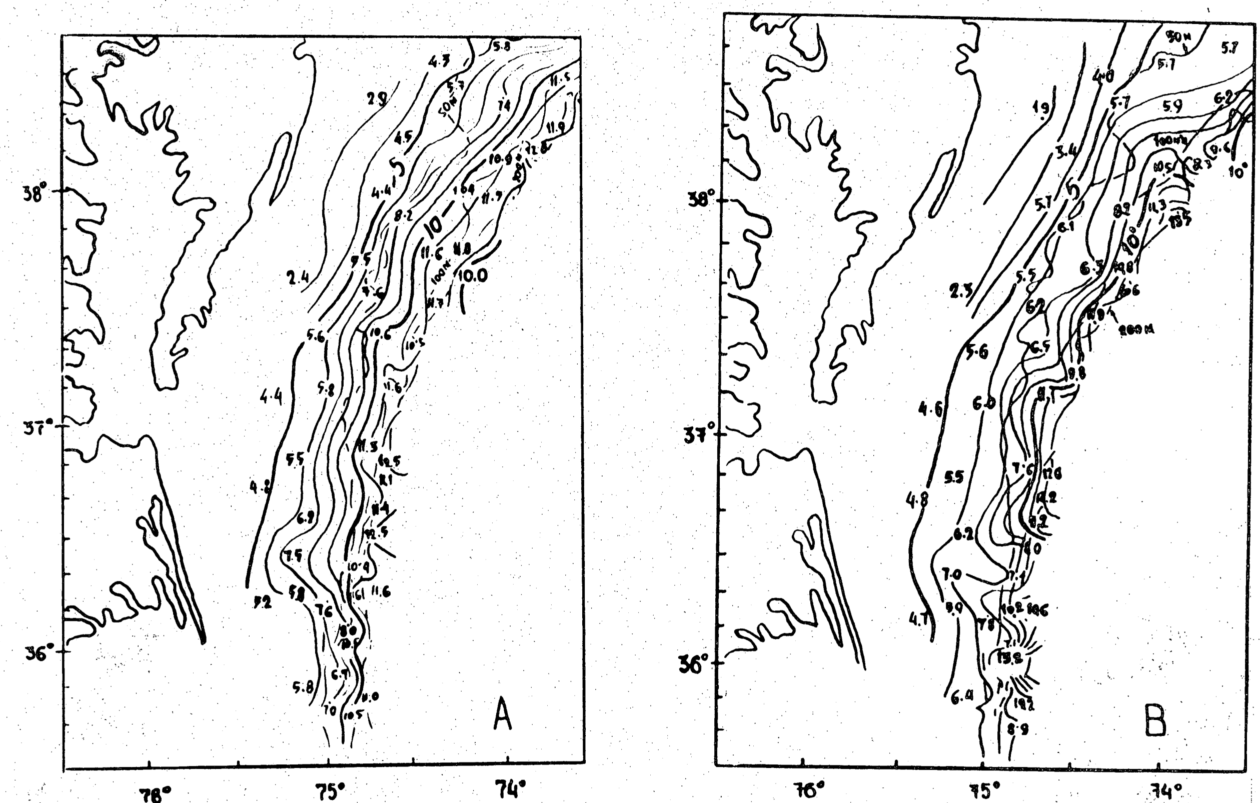

Fig. 5. Near-bottom (A) and surface (B) temperatures on 5-15 March 1978 in the area of large catches of <u>Illex</u> larvae.

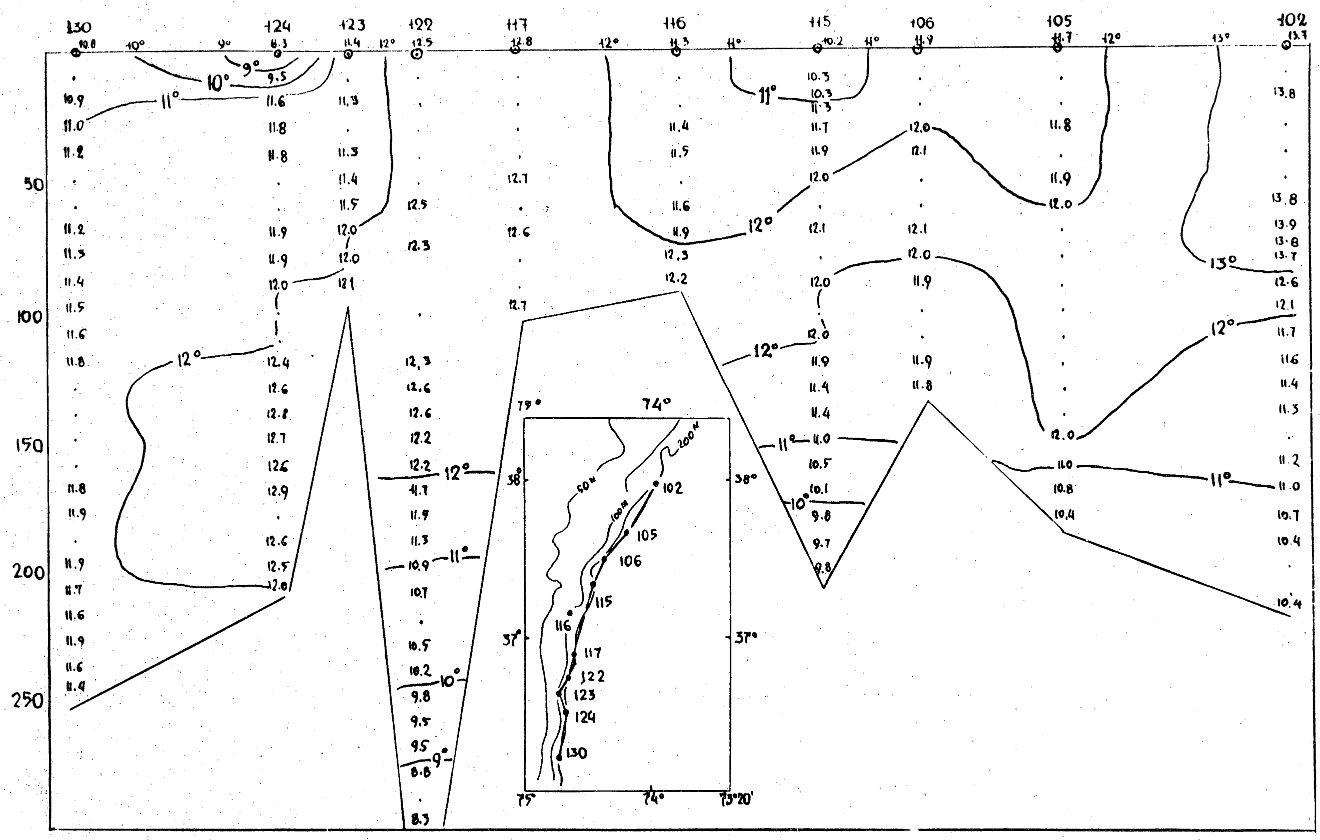

Fig. 6. Vertical temperature distribution above continental slope of the Mid Atlantic Bight in March 1978 (larvae caught at 10-0 m depths from stations 122-117 and 105-102).

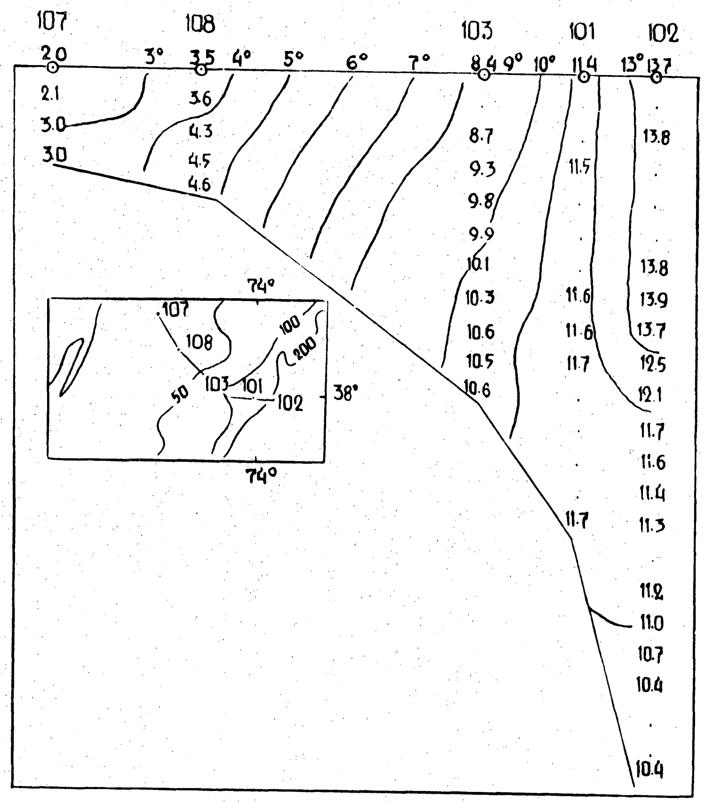

Fig. 7. Vertical temperature distribution on 5-7 March 1978 in Baltimore Canyon.

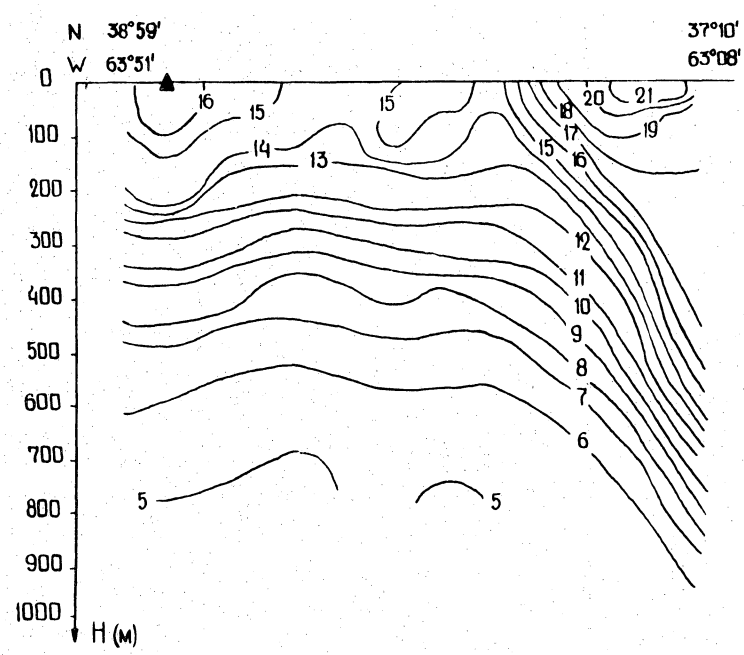

Fig. 8. Hydrological conditions in case of catching <u>Illex</u> larvae in slope water at the northern edge of the Gulf Stream (3-6 Mar 1981).

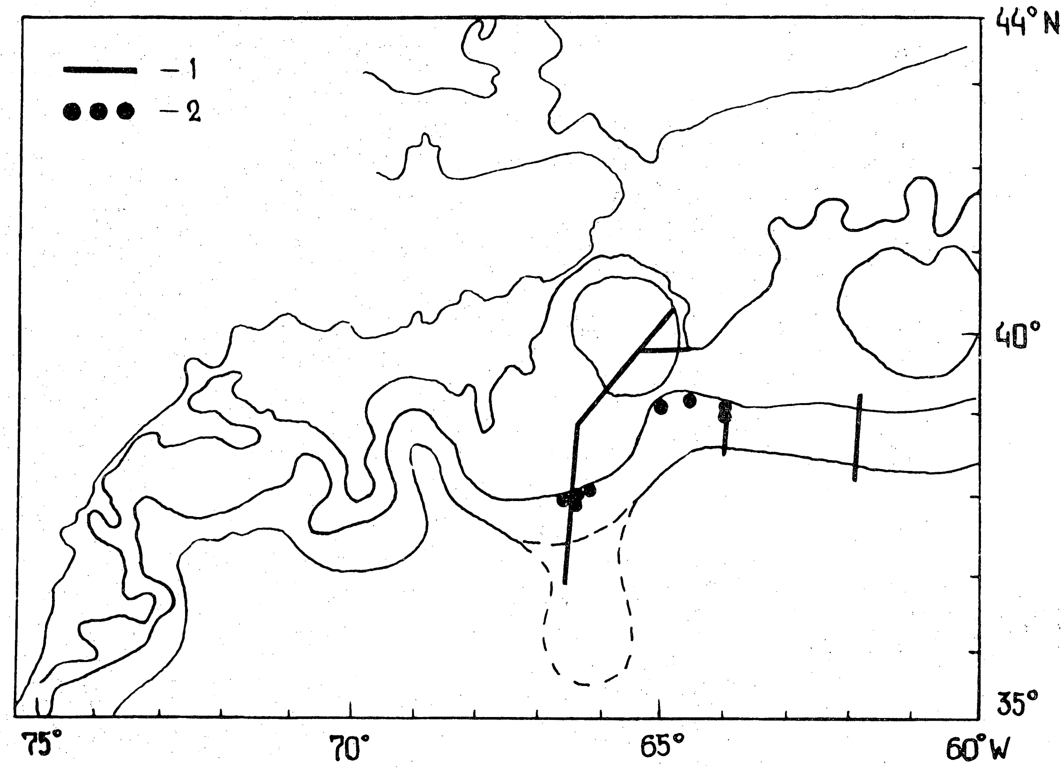

Fig. 9. Occurrence of Illex larvae in the Gulf Stream and adjacent waters on 7-19 February 1982 (1 - zones where larvae were absent; 2 - stations where larvae were found).

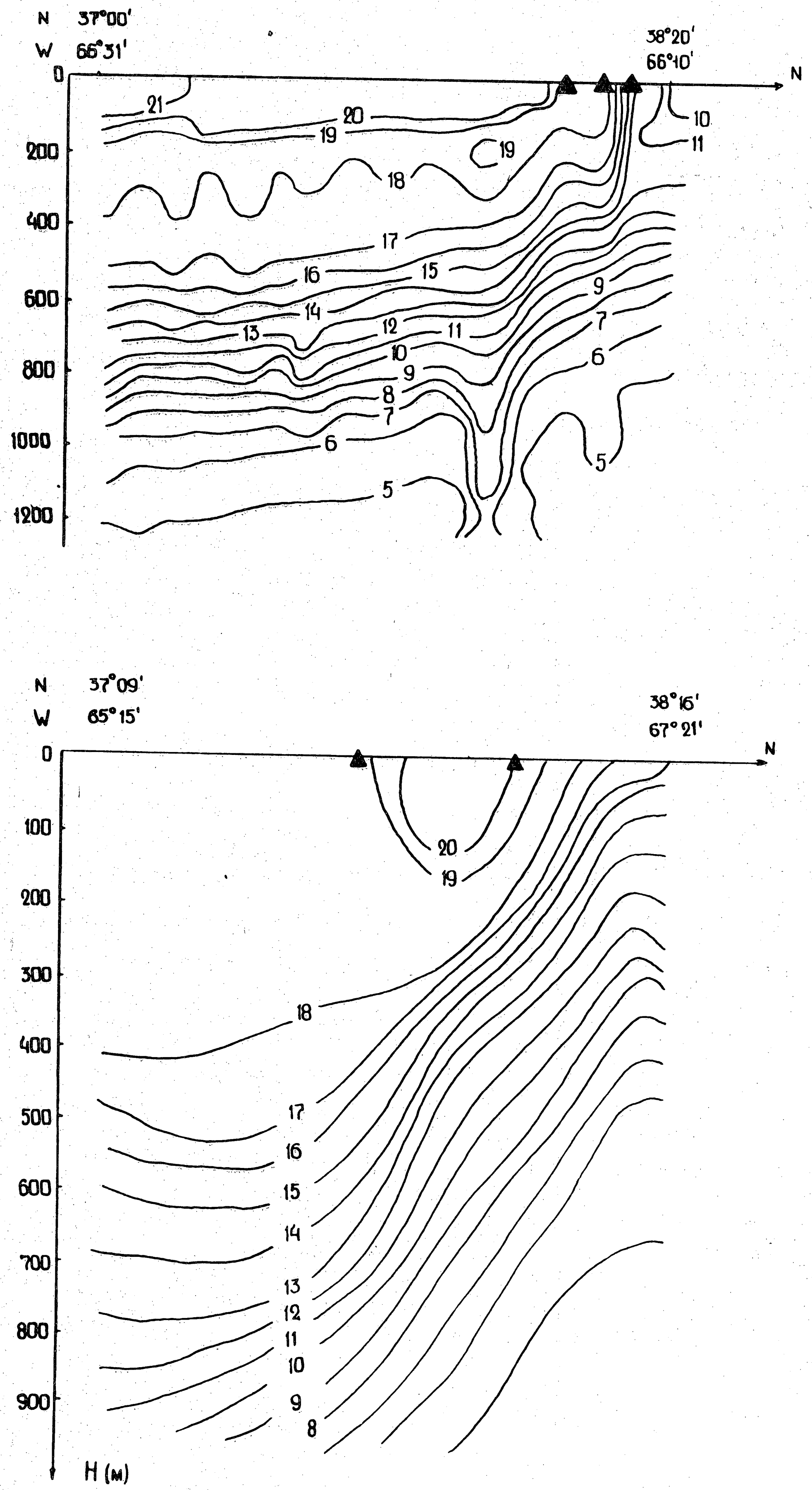

Fig. 10. Occurrence of <u>Illex</u> larvae in the northern edge (above) and in the center (below) of the Gulf Stream.

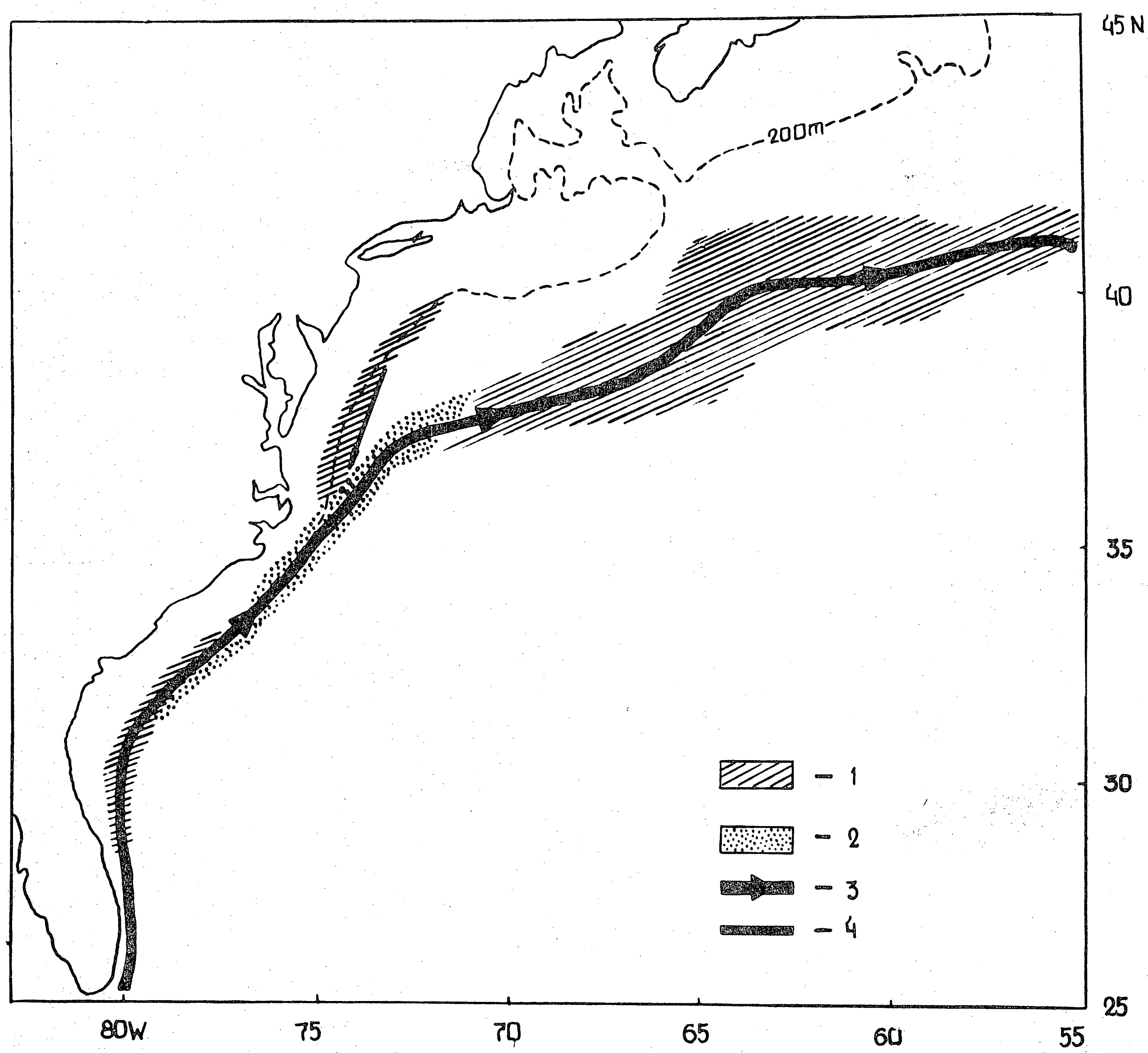

Fig. 11 A schematic map of geographic distribution of Illex larvae in the Northwest Atlantic.
(1 - areas with larva findings; 2 - areas of possible larva findings; 3 - mean long-term position of the Gulf Stream; 4 - direction of larvae and egg masses transport at the surface above continental slope of the Mid Atlantic Bight).