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Preliminary Results of the R/V *Atlant* Research of Short-finned Squid, *Illex illecebrosus*, in NAFO Subarea 4 between 3 March and 4 May, 1981

by

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Introduction

During the joint Soviet-Canadian cruise on board the RTM Belogorsk, 1979, in the region between the Nova Scotia shelf and the Gulf Stream young short-finned squid, Illex illecebrosus, concentrations were located (Froerman, 1980; Amaratunga, et al., 1980; Fedulov and Froerman, 1980). The methods of this program encouraged further research and at the NAFO Meeting in September 1980 a large scale program was planned to study distribution of the young short-finned squid in relation to water masses within the NAFO Subareas 5 and 4 in spring.

The Soviet R/V Atlant participated in this survey from 3 March to 4 May 1981. Preliminary results of the cruise are presented in this paper, along with some preliminary observations on young short-finned squid spatial distribution in spring of 1981.

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Materials and Methods

A total of 99 stations were occupied during the cruise (Fig. 1). The research activities carried out and the number of squid in the catches at each station are presented in Tables 1 and 2. These are preliminary data, prepared in haste for the June 1981 Meeting, and are subject to subsequent correction.

To analyse spatial distribution of the young short-finned squid within the various water masses, stations were spaced along transects oriented perpendecular to the Nova Scotia shelf edge and running from the continental slope towards the Sargasso Sea waters beyond the Gulf Stream. It was assumed that the 50-mile distance between the transects would provide a sufficiently distinct separation of the meso-scale features of water masses (such as rings and meanders). Standard distance between stations along transects was also 50 miles. At the bondaries of different water masses this distance was reduced to 10-25 miles depending on the width of the temperature gradient zone (Fig. 1).

In general, at the stations 50 miles apart, a full complement of research activities was conducted consisting of: hydrographic station down to 1000 m, a step (10-5-1 m) and two oblique (200-0 and 50-0 m) hauls using plankton samplers "Big" and "Small" Bongoes, and 5 hauls with Engel Midwater Trawl (EMT) at 50, 100, 200, 300 and 500 m depths. When squid were absent in EMTs at 100 and 300 m depths, the ship proceeded to the next station. When a significant number of squid were caught at either of these depths, the hauls were made at all other depths (Table 1).

The EMT trawl has a 6.5 m vertical opening and a calculated horizontal spread - 8.5 m. Mean area covered by one 15-minute tow is approximately 0.003 sq. miles.

Squid catch (numbers) in the EMT trawl varied considerably depending on the time of the day. A time coefficient was therefore introduced for 100, 200, 300 and 500 m depths. (Almost all the hauls at 50 m depth were made during the dark hours of the day.)

The time coefficient was calculated based on the data collected at the stations where short-finned squid was caught. Methods of calculation was similar to those described in Froerman (1980). The EMT trawl catchability coefficient for the period 19.00-4.00 was taken 1.0. (Table 3).

The short-finned squid from each catch were measured to the nearest 1 mm and grouped in 5 mm intervals for analyses. For example, a length-group of 10.0 cm comprised specimens with a mantle length ranging between 95 and 99 mm and a length-group of 10.5 cm, between 100 and 104 mm respectively.

At each hydrographic station temperature measurements and water samples for salinity, dissolved oxygen and nutrient determinations were taken at 0, 10, 20, 30, 50, 75, 100, 150, 200, 300, 400, 500, 600, 800, and 1000 m depths. Water samples for salinity and dissolved oxygen content were treated aboard the ship while those for nutrients were frozen and taken ashore to be treated in the laboratory. Between hydrographic stations, additional temperature measurements were taken with XBT down to 1800, 750 or 450 m depths for the purpose of more accurate location of boundaries between water masses of different origin.

To analyse horizontal and vertical water mass patterns, temperature, salinity and dissolved oxygen sections were constructed for each transect. Four most typical sections (II, III, V and VI) for illustration and discussion are presented in the paper (Fig. 2, 3, 4, 5).

Results and Discussion

Main features of water mass distribution in the area investigated were similar to the results obtained during the RTM Belogorsk cruise in 1979 (Fedulov and Froerman, 1980). All types of water masses observed in the investigated area were clearly seen in all transects. Cold shelf water (temperature < 6°C and salinity < 35°/₀₀) occupied the upper 100-m layer in the area adjacent to the shelf and penetrated into the deep ocean as far as 100 miles.

Slope water mass (t° = 10°-15°C, salinity = 35.5°/₀₀ - 36.10°/₀₀) occupied the area between shelf waters and the Gulf Stream. This water mass underlies shelf waters at 100-200 m depths and reaches the continental slope (Fig. 2, 3, 4, 5) which is clearly seen at the transects II, III and V (Fig. 2, 3, 5). Towards the Gulf Stream the lower boundary of this water mass deepens. Below the slope water a practically homogeneous water mass (t° < 5°C, S ≈ 35°/₀₀) extends between shelf and the Gulf Stream. A layer of minimum oxygen content was pronounced in all transects (Fig. 2, 3, 4, 5). Its position generally coincided with lower boundary of slope water.

The existence of a well defined Warm Core Eddy observed in the area during the field studies in 1981 is the main feature of water mass dynamics contrasting the situation of 1979 (Fig. 2, 3). This Eddy was observed in the western portion of the survey operations throughout the survey period. Its diameter was 120 miles. During the period from 30 March to 4 May the eddy moved 90 miles southwestwards. The eddy is well defined by its water temperature at transect II (Fig. 2) which ran almost through the eddy's centre. Water temperature inside the eddy was >17°C with a maximum being observed close to the centre at 17.6°.

At the periphery of the eddy a narrow zone with high temperature gradients was formed. These gradients were characterized by their highest values (about 1.2°C per 1 mile) in the area between the northern edge of the Eddy and Shelf waters (Fig. 2). The depth of the Eddy was 450 m. There was a narrow zone (10-12 miles wide) of cool water between the southern edge of the eddy and slope water, which was probably formed by mixing shelf water (entrained by the eddy along its external edge) with the surrounding slope water.

In the area under investigation young Illex were caught at 69 out of 99 stations at depths ranging from 50 m down to 500 m. Juvenile Illex prior to gonadal development, as well as the specimens with the gonads at their first development stage, were found in the EMT catches; mantle lengths ranged from 1.0 cm to 15.0 cm.

Some observed features of Illex illecebrosus distribution are listed below.

1. Largest abundance of young Illex during the cruise 81-05 was observed in a zone of 50-70 miles wide close to the northern edge of the Gulf Stream (Fig. 2-5).

2. A total of 11 stations were occupied in the Warm Core Eddy zone (Belogorsk cruise in 1979 did not encounter this eddy). Illex wree caught in limited numbers at 4 stations, one of which was occupied in the centre of the eddy and 3 others at its southern periphery. No Illex were caught at other 7 stations in the eddy (Fig. 2).

3. Mantle length of squid caught in the eddy correspond to those of young Illex from the Gulf Stream edge.

4. An uneven vertical distribution of Illex was observed at some stations (e.g. at stations 2, 42, 44, 68, 30, etc.). Most often, the lowest abundance was at 200 m, and within the 50-70 mile zone, close to the northern Gulf Stream edge where Illex abundance was recorded (stations 2, 31, 35, 38, 42, 44, 68, 76, 81, 83 and 90). The mean numbers of squid by depth were as follows: 28.5 specimens at 50 m, 30.2 at 100 m, 13.6 at 200 m, 20.3 at 300 m and 9.0 at 500 m.

5. Illex abundance during the day decreased with depth between 100 and 300 m but this was insignificant at the 500-m depth. This trend is seen in the time against depth of catch relationship (Table 3).

6. Poly-modal size distribution of Illex was observed for the area between the eddy and the Gulf Stream (Fig. 2). The length of young increased from the Gulf Stream to the shelf as was the case in 1979, while no significant changes in the length composition was recorded in the southwest-northeast direction (Fig. 2-5).

Only remnants of some food (fat globules and small particle of non-identified origin) were found in the stomachs of Illex with a mantle length less than 4.0 cm. Illex of 5 cm and larger fed mainly on euphausiidae, Meganyctiphanes and Thysanoessa, shrimps and amphipods.

Conclusion

Largest abundance of young Illex was observed in the slope water zone adjacent to the northern Gulf Stream edge, and there were no significant changes in Illex mantle lengths in the southwest-northeast direction. This may serve as evidence for a hypothesis on the mechanism responsible for the transport of Illex eggs and larval from spawning grounds (presumably along the continental slope) towards the Gulf Stream. The absence of large numbers of Illex larvae (as opposed to large numbers of juveniles present) in waters adjacent to the Scotian Shelf suggests that they may have been transported by water mass movements into this area before they reached the sizes observed in this area. The hypothesis thus suggests that this movement is a result of egg and/or larvae being transported from spawning grounds by the Gulf Stream. The spawning ground then may be considered to be located in areas south of the Scotian Shelf. The eddies separated from the Gulf Stream and rotating anti-clockwise may entrain some portion of these squid and they will grow and develop along the external periphery of the eddy. This portion of squid withdrawn from general transport of the squid north-eastwards, can then move southwestwards with the eddy. If the hypothesis is true the power and frequency of eddy formations can significantly affect the squid abundance and distribution over the species habitat area. Further surveys to locate spawning stock or egg and larvae are necessary to verify this hypothesis. An uneven vertical distribution of the young Illex is also a complicated phenomenon to be enterpreted. This phenomenon is likely to be related indirectly to the depth of the oxygen minimum (Fig. 2-5). More accurate analysis of the young squid vertical distribution should be carried out and the nature of the oxygen minimum in the survey area determined.

Another aspect of vertical distribution is diurnal vertical migration. It is evident that this migration is not significant and this is indicated by gradual decrease in a time coefficient with depth. There is also no large variation in the diurnal abundance of Illex at 500-m depth. Diurnal varitions in the Illex abundance caught at 50 and 100 m depths are likely indicated mainly by different catchability of trawl in daytime and night time.

A comparison of Illex composition in the area of feeding with the data on growth rates (O'Dor et al., 1977) suggests a prolonged spawning which may occur during a period of 5-6 months.

References

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Table 1. Research activities carried out during the Atlant cruise 81-05.

Station No.	EMT depth (m)						Bongo tows (m)						Hydrographic Stations		
	50	100	200	300	500		0.165 0-200	0.505 200-0	50.0	0.333 200-0	50-0	10-5-1	Bathy.	XBT	
81-05															
01(28)		+		+			+	+	+	+	+	+	939	750	Transect I
02(29)	+	+	+	+	+								-	750	"
03(30)		+											-	750	"
04(31)		+											-	750	"
05(32)		+											-	750	"
06(33)		+		+			+	+	+	+	+	+	928	400	"
07(34)	+	+	+	+	+		+	+	+	+	+		1129	270	"
08(35)	+	+	+	+	+		+	+	+	+	+	+	687	750	"
09(36)	+	+	+										-	750	
10(37)	+	+	+	+	+		+	+	+	+	+	+	1161	750	Transect II
11(38)		+											-	750	
12(39)		+											-	750	
13(40)		+											-	750	
14(41)		+											-	750	
15(42)		+		+			+	+	+	+	+	+	1026	750	
16(43)		+											-	750	
17(44)				+									-	750	
18(45)		+											-	750	
19(46)		+											-	750	
20(47)		+		+			+	+	+	+	+	+	1240	750	
21(48)			+										-	750	
22(49)		+											-	750	
23(50)		+											-	750	
24(51)		+											-	750	
25(52)	+	+	+	+	+								813	750	
26(53)		+											-	750	
27(54)		+											-	750	

Table 1. Continued

	50	100	200	300	500		0-165	0-505		0-333					
							0-200	200-0	50-0	200-0	50-0	10-5-1			
28(55)		+											–	–	
29(56)		+												600	
30(57)		+		+			+	+	+	+	+	+	1078	750	
31(58)	+	+	+	+	+								–	750	
32(59)		+											–	750	
33(60)		+											–	750	
34(61)		+											–	750	
35(62)	+	++	+	++	+		+	+	+	+	+	+	1001	750	
36(63)		+											–	750	
37(64)		+											–	750	
38(65)	+	++	+	+	+								–	750	
39(66)		+		+									–	750	
40(67)		+		+				+		+			1202	750	Transect III
41(68)		+											–	750	
42(69)	+	+	+	+	+		+	+	+	+	+	+	1249	750	
43(70)		+											–	750	
44(71)	+	+	+	+	+		+	+		+			956	–	
45(72)		+											–	750	
46(73)		+	+	+	+		+	+		+			878	–	
47(74)		+											–	450	
48(75)	+	+	+	+	+		+	+		+			966	450	
49(76)		+											–	450	
50(77)	+	+	+	+	+		+	+		+			1052	450	
51(78)		+											–	450	
52(79)	+	+	+	+	+		+	+		+			1108	–	
53(80)	+	+	+	+			+	+		+			380	–	
54(81)	+	+	+				+	+		+			150		Shelf 2
55(82)	+	+	+				+	+		+			171		– " –
56(83)	+	+	+				+	+		+			200	–	– " –
57(84)	+	+	+				+	+		+			232	–	– " –
58(85)	+	+	+				+	+		+			123	–	– " –
59(86)	+	+	+	+	+		+	+		+			–	450	Transect IV
60(87)	+	+	+										–	450	
61(88)		+											–	450	
62(89)	+	+	+	+	+								1142	–	
63(90)		+											–	450	

Table 1. Continued

	50	100	200	300	500		0.165	0-505		0-333					
							0-200	200-0	50-0	200-0	50-0	10-5-1			
64 (91)	+	+	+	+	+		+	+		+			1038	–	
65 (92)		+												450	
66 (93)		+		+			+	+		+			1093	–	
67 (94)		+											–	450	
68 (95)	+	+	+	+	+		+	+		+			1036	–	
69 (96)		+											–	450	
70 (97)		+		+			+	+		+			1167	450	Transect V
71 (98)		+											–	1830	
72 (99)		+		+			+	+		+			1034		
73 (100)		+											–	1830	
74 (101)	+	+	+	+	+		+	+		+			1183	–	
75 (102)		+											–	1830	
76 (103)	+	+	+	+	+		+	+		+			1148		
77 (104)	+	+	+	+	+		+	+		+			1054		
78 (105)	+	+	+	+	+		+	+		+			980		
79 (106)		+		+			+	+		+			1028		Transect VI
80 (107)	+	+	+	+	+		+	+		+			986		
81 (108)	+	+	+	+	+		+	+		+			–	450	
82 (109)		+											–	1830	
83 (110)	+	+	+	+	+		+	+		+			813		
84 (111)		+		+									–	1830	
85 (112)	+	+		+								+	981		
86 (113		+		+			+	+		+			1032	–	Transect VII
87 (114)	+	+	+	+			+	+		+			423	1830	
88 (115)	+	+	+	+	+								–	1830	
89 (116)		+		+									–	1830	
90 (117)	+	+	+	+	+		+	+		+			994	–	
91 (118)	+	+	+	+	+		+	+		+			1065	–	
92 (119)	+	+	+	+	+		+	+		+			548	+	
93 (120)	+	+	+	+	+		+	+		+			1073	–	Transect VIII
94 (121)	+	+	+	+	+		+	+		+			926	–	
95 (122)	+	+	+	+	+		+	+		+			640	–	
96 (123)	+	+	+	+	+	–	+	+		+					
97 (124)		+											–	450	
98 (125)	+	+	+	+	+								892	–	
99 (126)	+													450	

Table 2. Number of Illex caught by EMT during the Atlant cruise 81-05.

STN NO.	50 m			100 m			200 m			300 m			500 m		
TIME OF DAY	12-19	19-04	04-12	12-19	19-04	04-12	12-19	19-04	04-12	12-19	19-04	04-12	12-19	19-04	04-12
TIME COEFFICIENTS	-	-	-	2.5	1.0	4.4	2.2	1.0	1.3	2.1	1.0	1.2	1.8	1.0	1.1
01				0						0					
02		50			48			19			44			2	
03					18										
04						12/53*									
05						0									
06				0						1/2					
07		0			4			3			7				1/1
08		9			40			14		14/29				8	
09		4			0				10/13						
10		0		0				1		1/2				0	
11					3										
12					2										
13					2										
14						0									
15						0				0					
16				0											
17				0											
18				0											
19					0										
20					0						0				
21						6/26									
22						0									
23					0										
24					2										
25		0			5			1			3				5/6
26						0									
27				1/3											
28				0											
29				9/23											
30					2										
31		0			44			12			19			8	
32						1/4									
33						0									
34						5/22									
35		15		11/28		6/26			8/10	5/11					5/6
36						3/13									
37				21/53											
38		26			78			0			0			0	
39						1/4									
40				1/3							6				
41					140										
42		47			12				1/1			16/19			5/6
43				15/38											
44		36		12				15			8			18	
45					2/9										
46				0			0			4/8			1/2		
47					0										

Table 2. Continued

STN No.	50 m			100 m			200 m			300 m			500 m		
	TIME OF DAY														
	12-19	19-04	04-12	12-19	19-04	04-12	12-19	19-04	04-12	12-19	19-04	04-12	12-19	19-04	04-12
	TIME COEFFICIENTS														
	-	-	-	2.5	1.0	4.4	2.2	1.0	1.3	2.1	1.0	1.2	1.8	1.0	1.1
48		9			1			6			2			15/17	
49						0									
50		16			2			6		1/2			0		
51					6										
52			13/-			7/31			0			0			1/1
53		4			5		0/			5/11					
59		2			1			6			2			2	
60			0			0			0						
61				0											
62		0			0			0			3		17/31		
63		6			12			3			3			9	
64															
65						5/22									
66						0				0					
67				10/25											
68		8			68			5			22			6	
69						0				0					
70					0										
71					0										
72					0					0					
73						0									
74		17		14/35			0			1/2			5/9		
75					0										
76		8			6				9/12			2/2			33/36
77		0			0		2/4			4/8			6/11		
78			0			2/9			0			0			2/2
79						0						0			
80		29			17			17		2/4				8	
81		75			21			10				43/52			0
82						1/4									
83	1			3/8			14/31			14/29			7/13		
84					1							0			
85		1			0							0			
86				0						0					
87		2			9			2		0					
88		6			3			6				3/4			0
89						0				3/6					
90		47			8			4		8/17			2/4		
91		13			2			8				2/2			4/4
92		0			0			1			0		4/7		
93			0			0			0			0			0
94		0			0			1			2			0	
95	0			0			0					0			4/4
96		7			2			2			3			14	
97						0									
98		0			0			0			0		0		
99		27													

* Ratio of number of squid caught to number adjusted by time coefficient.

Table 3. Catchability coefficients by towing depth and time of day.

Time of day	Towing depth (m0			
	100	200	300	500
12.00 - 19.00	2.5	2.2	2.1	1.8
04.00 - 12.00	4.4	1.3	1.2	1.1

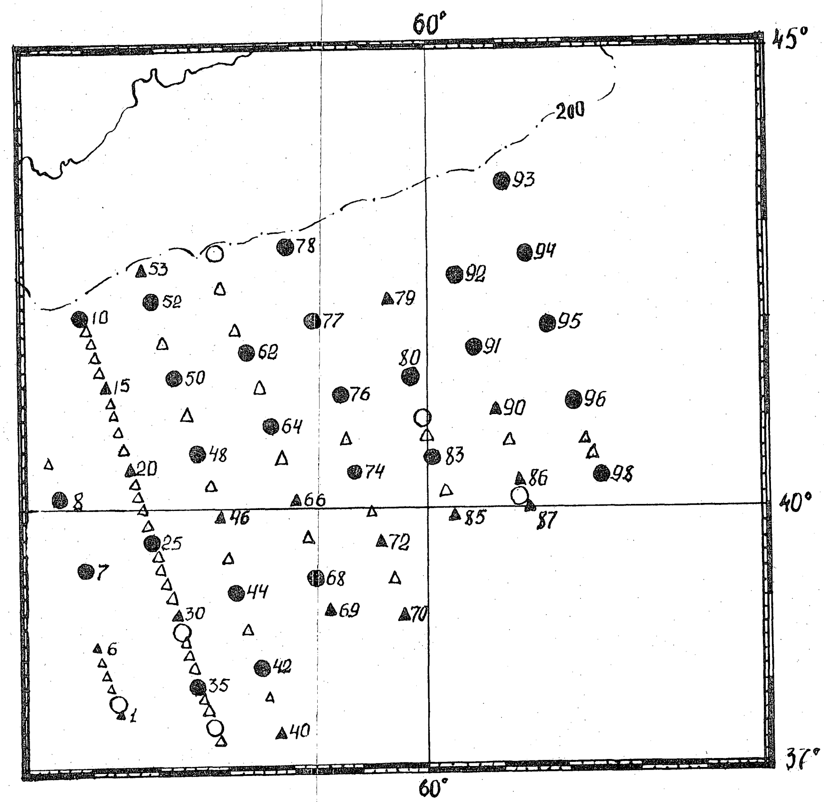

Fig. 1. Stations occupied during the R/V Atlant cruise 81-05:

● - stations with 5 EMT tows and hydrocasts

O - stations with 5 EMT tows and XBT casts

⊕ - stations without hydrological activities with 5 EMT tows

▲ - stations with less than 5 EMT tows and hydrocasts

△ - stations with less than 5 EMT tows and XBT casts

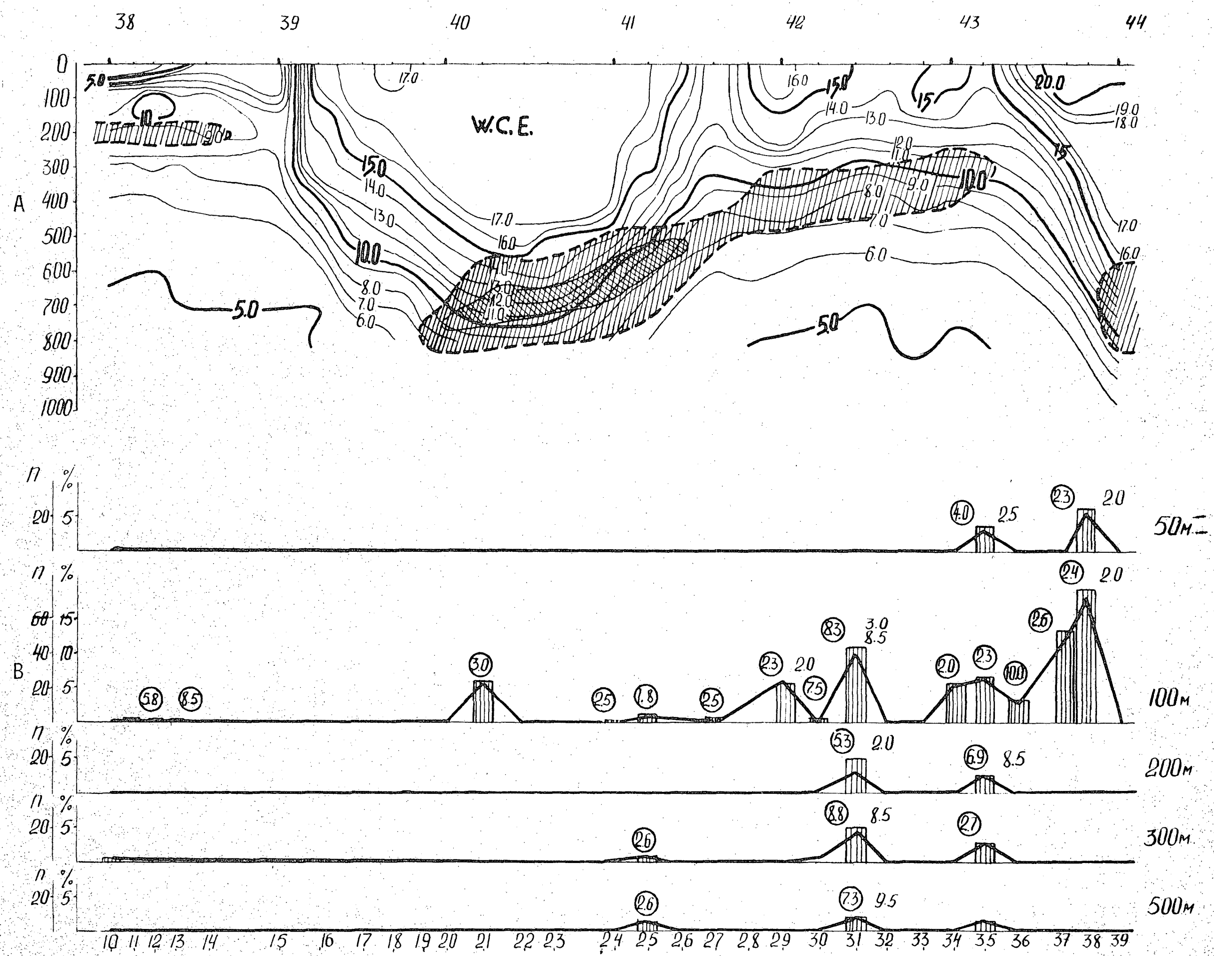

Fig. 2. Distribution of temperature and oxygen minimum (A) and distribution of young Illex (B) along Transect II during Atlant cruise 81-05. The numbers at the top of the diagram are hydrographic stations, and those at the bottom are trawling station numbers.

——— - Percent proportion of Illex caught at a given depth of the total Illex number caught at all depths along the transect.

- Numbers of Illex.

- Layer of oxygen minimum (< 4.0 ml/L).

- Layer of oxygen minimum (< 3.5 ml/L).

(30) - Mean mantle length (mm) of Illex in EMT catches. Numbers not circled are modal lengths.

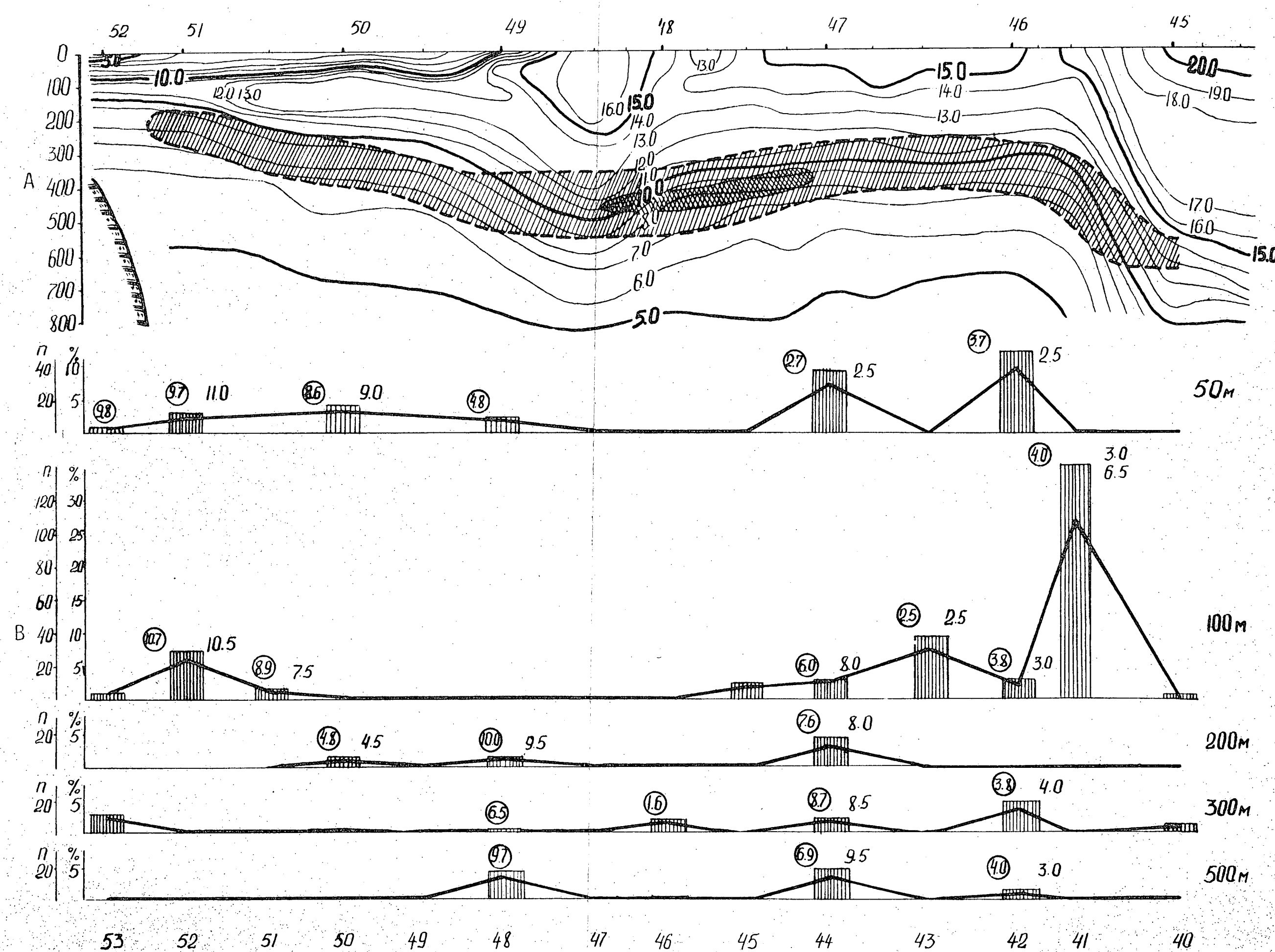

Fig. 3. As in Fig. 2, but for Transect III.

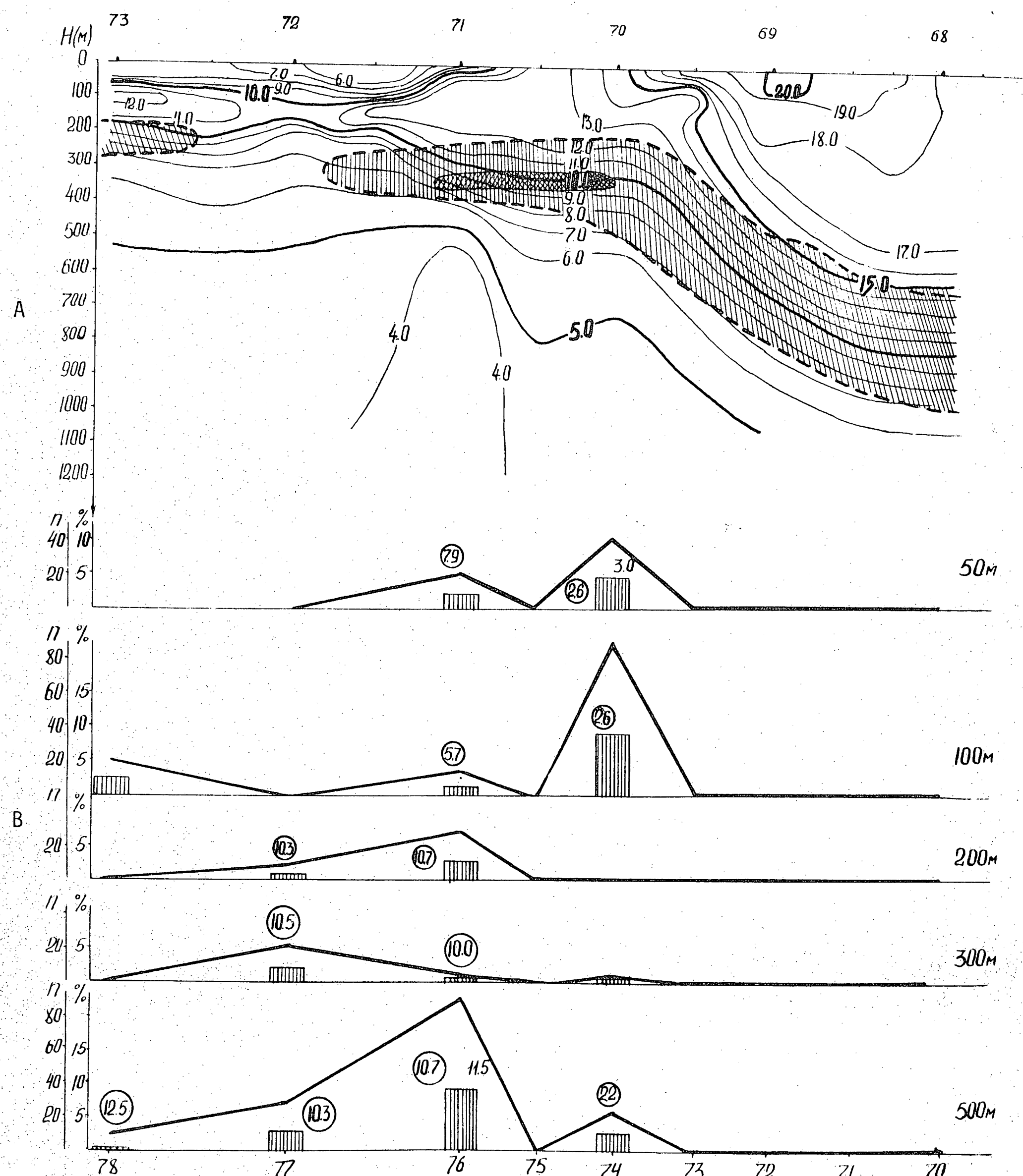

Fig. 4. As in Fig. 2, but for Transect V.

A

B

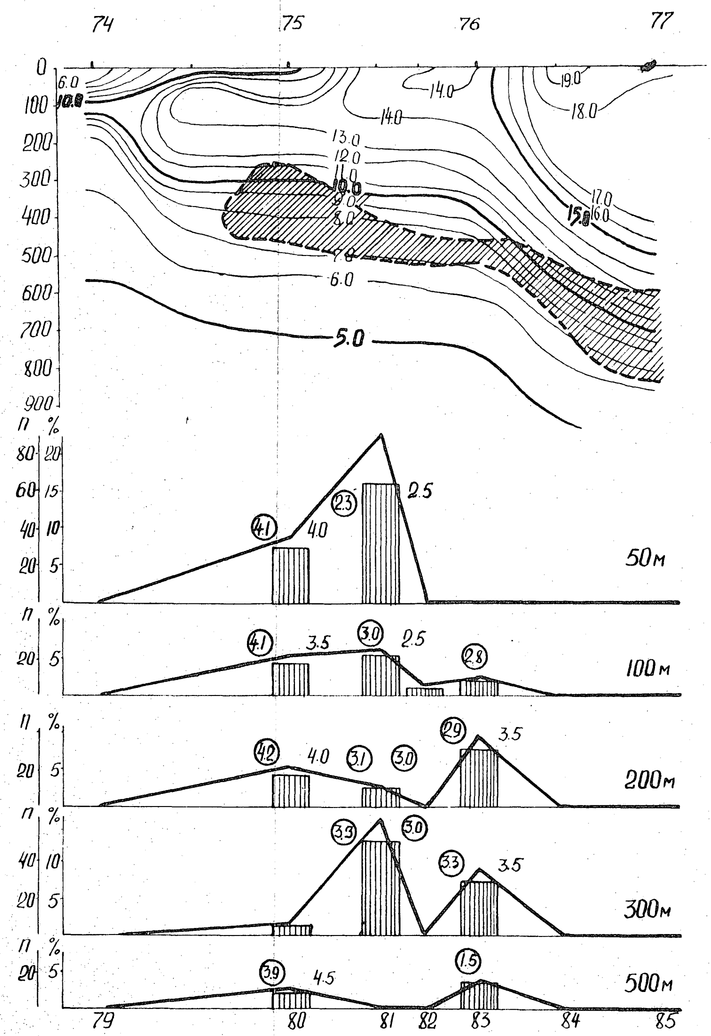

Fig. 5. As in Fig. 2, but for Transect VI.