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Hydrography Committee

BELGIAN CONTRIBUTION TO THE EXPERIMENT OF PLAICE EGG AND LARVAE DIFFUSION.

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ABSTRACT.

This study reports the preliminary results of a patch study in the Southern Bight. The observations indicate that the movement of eggs from the plaice spawning ground "Noord-Hinder" towards the Belgian coastal waters is mainly caused by resulting tidal streams.

RESUME.

Cette étude se rapporte aux résultats préliminaires d'une expérience de diffusion dans la partie méridionale de la Mer du Nord.

Les observations indiquent que le mouvement d'oeufs de la frayère de plies "Noord-Hinder" vers les eaux côtières belges est provoqué principalement par les courants à marée.

I. INTRODUCTION.

According to the C.Res. 1977/2:34 a Belgian multidisciplinary programme has been carried out. Due to limitations on accommodation on the vessels the area of investigation was confined to the Belgian coast.

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Former plaice tagging experiments indicated that part of the larvae hatched on the "Noord-Hinder" grounds migrates to the Belgian coast. Indeed from August onwards 0-group plaice is present in the coastal area (DE CLERCK R., 1975a and 1975b).

This paper reports on the salinity and temperature distribution in the area and on the egg observations. A preliminary discussion of the results is given.

II. MATERIAL and METHODS.

The Belgian contribution to the plaice egg and larvae diffusion experiment consisted of 10 cruises between January 31st and the February 17th, 1978, 6 of which successfully covered the entire or most of the sampling area. The latter comprised 28 stations regularly spaced on two tracks perpendicular to the coast, respectively off Oostende and off Zeebrugge (figure 1). All stations were usually sampled within 7-8 hours.

The hydrographical parameters (salinity, temperature, currents) were measured and plankton samples were collected.

1. Hydrography.

Salinity and temperature were determined by a conductivity-temperature probe attached to the zooplankton sampler. This instrument was frequently calibrated with direct thermometric measurements (precision : 1/10 °C) and laboratory determinations of salinity (Beckman salinometer).

Average values of temperature and salinity were calculated for the profiles between two stations.

2. Egg and larvae survey.

Samples were taken at a depth of about 2 m, using a multi-purpose high-speed zooplankton sampler (Beverton and Tungate, 1967) with a 180 µm mesh.

The volume of water filtered was calculated using a digital flowmeter which was calibrated with a TSK flowmeter.

The high-speed sampler was hauled between two stations at an average speed of 7 knots. Thus, about 200 m^3 were filtered for each sample. After collection the samples were preserved with neutralized formalin (5 %).

The first observations concerned the count and the size determination (diameter) of the fish eggs.

The identification of the eggs and their development stages as well as the identification of the larvae and other zooplanktonic organisms are at present in progress.

Results are grouped in tables 1-6. The figures are expressed as numbers/100 m^3 and rounded up to the nearest 0.1 mm class.

III. RESULTS.

1. Hydrography.

The main residual circulation is parallel to the coast (5 cm/sec on average). The tital streams are important (up to 2.5 knots). Furthermore, the hydrography of the area is strongly influenced by the Scheldt estuary. This can occasionnally cause a local gyre that has been calculated by the Mathematical Model of the North Sea (Nihoul and Ronday, 1975). Of course, the residences times are strongly increased in this particular area.

The isohalines (figure 2) show clearly how the Scheldt estuary is exerting an influence on the system (Picard, 1978). During the January and February 1978 cruises, this pattern was confirmed (figure 1). The temperature figures also match the general pattern.

However, a certain distortion in these patterns results from the spatial displacement caused by tidal streams during the sampling operations. Figure 3 shows (thick line) the position of the sampling track in relation to a water mass "frozen" at time t_o (starting time) and the position of the sampling track in relation to the bottom (thin live). The dotted lines show the water displacement occurring between t_o and the sampling time. These figures indicate clearly that, from one cruise to the other, there can be significant shifts in the sampling positions actually related to the water mass.

A simpler but more convenient way to take these distortions into account and to correct their effect is to rely on an environmental parameter that will suitably trace the water movements. Salinity as well as temperature can readily be used for this purpose. However the temperature seems to be a better indicator since it is a better tracer of recent water mass history and on the other hand the correlation with the fish eggs distribution fits far better (see below).

There is also a global cooling of the water mass, which must be taken into account. This cooling appears in the evolution of the distance-temperature regression lines (figure 4).

2. Spatial distribution of fish eggs.

Tables 1-6 give detailed results of the spatial distribution of fish eggs whereas table 7 summarizes the average values per zone. The plaice group stands out clearly from the other species not only as regards the diameter but also as regards the spatial distribution (more off-shore than the other species). The other group comprises various species such as Gadidae (Gadus luscus, Onos sp. and probably Gadus merlangus) as well as other Pleuronectidae (Pleuronectes flesus or Pleuronectes limanda). A diversity appears in the latter group. Indeed a difference in the distribution pattern of the size classes (at least two peaks are discernable) and in the spatial distribution (a small group near the coast and a larger one more off-shore) was observed.

Although the tables give a good insight into the spatial distrib ution, the movement of the water masses can interfere significantly. In order to distil more correct information on this distribution pattern and especially on its evolution in time (advection and diffusion) an attempt was made to find correlations with environmental parameters. Two types of regressions were tested (linear and exponential) for the two environmental variables (salinity and temperature) and this for the total number of eggs and for the plaice eggs separately.

Table 8 indicates clearly that the correlation with the temperature is the better one and that the relation is rather of the exponential type.

To facilitate the comparison between the curves, the function $\log_e$ Numbers = f (temperature) was taken into account. Figure 5 reveals a shifting in time of the regression lines. This shifting is unfortunately not very clear for the plaice eggs probably due to the too small number of observations and to the metamorphosis. The hypothesis is made that the behaviour of the patch of plaice eggs is to a large extent comparable to the patch of the total number of eggs.

Such a shifting may be due to a movement of the patch towards the coast or to a gliding of the temperature gradient (effectively a global evolution in time of the temperature was observed).

The relation temperature-distance to the coast can be given by the equation :

$$T = \zeta D + d_o$$

with T = the water temperature (°C)

ζ = the constant

D = the distance from the coast (km)

d_o = the ordinate at the origin equal to the temperature on the coast at time zero (31.1.78)

Consequently, in the general formula giving the distribution of the numbers in function to the temperature :

$$N_t = a\ c^{b\ (T_t\ +\ c)}$$

with N_t = the number of eggs/100 m^3 at time t

a, b = the constants

T_t = the temperatue at time t

c = the increment of the constant temperature at the origin $(d_t - d_o)$

The regression lines of figure 6 reveal an amplified displacement of the patch of fish eggs. Based on these results the movement in the direction of the coast can be estimated at 1 to 2 km per day.

On the other hand there is no measurable diffusion of this patch as the correlation coefficients r (table 8) do not show any significant diminishing trend. This would imply a greater dispersion of the data with respect to the temperature.

The preliminary results seem to confirm that the greater part of the recruitement of juvenile plaice in the Belgian coastal waters as from the month of August onwards arises from the spawning-area "Noord-Hinder".

The data from the larvae study now in progress should soon produce supplementary information so as to verify this hypothesis.

References.

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Table 1 - Distribution of fish eggs per size classes (31.01.78).

	AA (1)	BB (1)	CD	DE	EF	FG	GH	HI	IJ	KL	MN	OP	PQ	QR	RS	ST (1)	TU (1)	UV (1)	WX	YZ (1)
T°C	4.9	5.35	5.95	6.35	6.45	6.55	6.70	6.80	7.05	7.20	6.65	6.50	6.50	6.50	6.10	-	-	-	4.2	-
S‰	33.85	34.05	34.5	34.5	34.75	34.8	34.7	34.7	34.65	34.90	34.90	34.40	34.5	34.15	34.15	-	-	-	32.9	-
Size class																				
0.6															1					
0.7										1	1									
0.8						1	1	3	9	17	4	1								
0.9		1	3	1			3	11	16	30	8	1	3	1						
1.0		1	4	1	3	2	1	5	14	33	9	1	1		3					
1.1			2	2	3	1	7	16	21	24	21	9	7	3	3					
1.2			1		2	7	13	35	68	80	17	3	6		1					
1.3								1	6	16	2		1	1						
1.4								2	5	8	1	2								
1.5							1		1	6	1	1								
1.6									1	5										
1.7								1	0	5					1					
1.8							1	5	5	8	3	2	1		1					
1.9							1	5	5	19	6	1	1							
2.0									7	4	5		1	1						
2.1							1		2	1										
2.2									1											
Tot. fish eggs	0	-	8	5	8	10	29	70	146	261	78	19	20	4	6	-	-	-	0	-
Tot. plaice eggs	0	0	0	0	0	1	3	10	21	35	15	3	3	1	1	-	-	-	0	-

(1) Not sampled

Table 2 - Distribution of fish eggs per size classes (01.02.78)

T°C	4.95	5.75	6	6.1	6.3	6.5	6.7	6.8	6.8	6.9	6.95	6.85	6.7	6.45	6.25	6.1	5.9	5.1	4.25	4.1
S%	33.8	33.7	34.2	34.3	34.45	34.5	34.55	34.65	34.7	35.0	35.2	35.2	34.5	34.6	34.5	34.7	34.6	-	-	-
Stations	AA_1	BB_1	CD	DE	EF	FG	GH	HI	IJ	KL	MN	OP	PQ	QR	RS	ST	TU	UV	WX	YZ
Size class																				
0.6										1	1									
0.7								5	5	14	8									
0.8								6	7	14	8	2	1	1						
0.9	1	1	4			1	3	16	13	29	37	14	2	0	1	2	4			
1.0	3	3	6	1	4	1	4	8	4	13	16	8	2	1	1	1	4			
1.1	1	2		4	4	2	3	50	52	78	54	45	9	1	1	1	1			
1.2					2	1	10	45	33	54	49	33	6	1	2		1			
1.3						1		5	8	9	7	5	1	4						
1.4								5	8	19	10	3			1					
1.5						1		1	2	9	8	2								
1.6								1		2		1								
1.7						1				6	2	2	1	1						
1.8								1	3	6	2	2	1							
1.9						2	3	2	8	15	4	9	5							
2.0							2	1	3	3	1	4	1	1						
2.1						1				1	1	1	1							
Tot. fish eggs	5	6	10	5	10	9	24	147	143	275	208	129	28	8	5	4	10	0	0	0
Tot.plaice eggs	0	0	0	0	0	4	5	5	14	34	10	19	9	2	0	0	0	0	0	0

Table 3 - Distribution of fish eggs per size classes (0.3.02.78).

T°C	4.95	5.75	6.0	6.1	–	–	6.65	6.80	6.80	6.90	6.95	6.85	6.70	6.45	-	-	-	-	-	-
S%	33.8	33.7	34.2	34.3	–	–	34.5	34.7	34.7	35.0	35.15	35.15	35.0	34.6	-	-	-	-	-	-
Stations	AA	BB_2	CD	DE	EF (1)	FG (1)	GH	HI	IJ	KL	MN	OP	PQ	QR	RS (1)	ST (1)	TU (1)	UV (1)	WX (1)	YZ (1)
Size class																				
0.6																				
0.7								3		3		4								
0.8			1				1	4	1	2		4								
0.9	1	1	2	1				7		7	1	23	6	5						
1.0	1	1	1				1	4	1	9		15	6	4						
1.1	1	2	1	1			1	32	2	33		45	14	3						
1.2							1	17	2	20		36	7	7						
1.3								6		14		1	1							
1.4								24	2	24		5								
1.5				1				14	1	9		7	1	1						
1.6								1												
1.7			1					7		2										
1.8								4		8		1								
1.9								25		8		4	1							
2.0				1				9	1	8		1								
2.1								1												
Tot. fish eggs	3	4	5	4	-	-	4	149	11	144	1	145	36	20	-	-	-	-	-	-
Tot. plaice eggs	0	0	1	1	-	-	0	47	1	26	0	6	1	0	-	-	-	-	-	-

(1) Not sampled.

Tab. 4 - Distribution of fish eggs per size class (0. 7. 02. 78).

	AA	BB	CD	DE	EF	FG	GH	HI	IJ	KL	MN	OP	PQ	QR	RS	ST	TU	UV	WX	YZ
T°C	4.45	4.85	5.50	5.75	5.9	6.20	6.45	6.60	6.8	6.7	6.7	6.75	6.55	6.7	-	5.0	-	-	4.55	-
S%°	32.6	33.6	34.3	34.15	34.7	35.1	34.8	34.9	34.9	35.15	35.15	35.1	3.50	34.95	-	34.75	-	-	33.2	-
Stations	AA	BB	CD	DE	EF	FG	GH	HI	IJ	KL	MN	OP	PQ	QR	RS	ST	TU (1)	UV (1)	WX	YZ (1)
Size class																				
0.6																				
0.7								11	14	8	6									
0.8						1		11	27	23	23	1								
0.9		1	15	5	1	8	14	59	152	83	100	11			+					
1.0		4	15		4	15	5	32	87	90	37	7	1	+						
1.1		1	15	5	5	21	40	207	271	256	114	55			++					
1.2				1	1	36	37	112	250	316	102	38	2	+	+					
1.3						3	10	27	20	83	23	11	1							
1.4								32	102	158	40	13	1							
1.5							1	16	61	68	23	16								
1.6									14											
1.7												4		+						
1.8									14		6	4		+	+					
1.9							1	11	7	15	6	24			+					
2.0							1		7	8	3	2	1	+	+					
2.1													1	+						
Tot. fish eggs	0	5	47	11	12	85	103	485	1084	1107	480	187	8	8	17	0	-	-	1	-
Tot. plaice eggs	0	0	0	0	0	0	2	11	42	23	15	34	2			0	-	-	-	-

(1) Not sampled.

Table 5 - Distribution of fish eggs per size classes (15.02.78).

T°C	2.7	3.5	4.3	4.45	4.8	5.2	5.6	5.8	5.9	5.85	5.75	5.7	5.35	5.3	5.0	4.5	3.95	3.35	2.85	1.65
S‰	32.25	39.8	33.6	33.95	34.2	34.45	34.65	34.75	35.8	34.8	34.8	34.85	34.75	34.55	34.05	33.6	33.1	32.6	32	31.5
Stations	AA	BB	CD	DE	EF	FG	GH	HI	IJ	KL	MN	OP	PQ	QR	RS	ST	TU	UV	WX	YZ
Size class																				
0.6																				
0.7			1		1			7	38	32	4	2	1							
0.8			1			1		14	98	57	17	6	1		1					
0.9		1	1	3	8	8	8	72	395	195	44	38	10		1					
1.0		2	3	8	7	9	9	53	117	45	18	22	4		1	1	1			
1.1			5	5	5	14	63	200	361	261	80	47	16		2	2	2			
1.2						6	12	146	332	190	115	80	15		1					
1.3						2	1	11	38	34	12	10	1							
1.4							1	4	16	41	1					1				
1.5							1	3	1	18	4	1	2							
1.6							1			2			1							
1.7							1		1				0							
1.8								1			1		1							
1.9						1	1	3	10	14	4		1							
2.0							1	1	1				1							
2.1																				
Tot. fish eggs	0	3	11	16	20	40	129	504	1462	897	301	205	53	0	6	5	4	0	0	0
Tot. plaice eggs	0	0	0	0	0	1	4	5	12	16	5	0	4	0	0	0	0	0	0	0

Table 6 - Distribution of fish eggs per size classes (16.02.78).

T°C	3.3	3.4	3.7	4.4	5	5.25	5.2	5.25	5.4	5.45	5.15	5.05	4.85	4.35	3.9	3.45	2.8	2.3	2.2	-
S‰	31.4	32.15	33.9	33.95	33.85	34.2	34.8	34.95	34.8	34.75	35.05	35.1	35.05	34.95	34.6	34.1	33.25	32.6	32.5	-
Stations	AA	BB	CD	DE	EF	FG	GH	HI	IJ	KL	MN	OP	PQ	OR	RS	ST	TU	UV	WX	YZ (1)
Size class																				
0.6																				
0.7								4	10	9	1	3	1	1						
0.8									30	29	5	7	3							
0.9		1	6	1	4	4	1	74	308	174	23	20	8	4	4	1	1			
1.0		3	8	1	3	8	15	30	149	64	11	6	5	1	7		1	1		
1.1		2	8	5	3	11	14	148	615	258	78	66	33	8	8	4		1		
1.2					1	3	59	163	487	200	62	59	28	5	1	1				
1.3							38	22	60	38	3	5	3	1	1					
1.4							2	8	20	50	1	1	1	0	1					
1.5							2	4	10	26	1	2								
1.6									10		1			1						
1.7												1	1	1						
1.8							1					1		1	1					
1.9									10	3	2		1							
2.0											1		1							
2.1																				
Tot. fish eggs	0	5	21	7	10	30	131	450	1718	864	195	167	83	25	20	6	2	2	0	-
Tot. plaice eggs	0	0	0	0	0	0	1	0	20	3	4	2	3	3	1	0	0	0	0	-

(1) Not sampled

Table 7 - Mean value of fish eggs (1) and plaice eggs (2) concentrations in different area (in number of eggs per hundred cubic meter).

Date	Area I Station H to N		Area II Station E to H and O to S		Area III Station A to E and S to Y	
	(1)	(2)	(1)	(2)	(1)	(2)
31.1.78	138	2	14	2	3	0
01.2.78	193	15	30	6	4	0
03-2.78	76	19	51	2	4	0
07.2.78	790	23	60	5	7	0
15.2.78	791	10	75	2	4	0
16.2.78	806	7	67	1	5	0

Table 8 - Regression and correlation coefficients.

	Lineair $(y = ax + b)$						Exponential $y = ae^{bx}$					
	T°C			S‰			T°C			S‰		
	a	b	r	a	b	r	a	b	r	a	b	r
01.01.78												
Tot. fish eggs	-678.9	112.2	0.7	-4952	144.77	0.62	$5.29\ 10^{-7}$	2.68	0.85	$3.51\ 10^{-57}$	3.85	0.73
Tot. plaice eggs	-198.9	31.31	0.87	-843.57	24.66	0.61	$1.22\ 10^{-10}$	3.65	0.85	$5.09\ 10^{-49}$	3.26	0.68
01.02.78												
Tot. fish eggs	-616.73	106.58	0.65	-4946.18	144.96	0.68	1.66	2.21	0.76	$2.28\ 10^{-39}$	1.66	0.71
Tot. plaice eggs	-241	37.55	0.64	-725.8	21.2	0.61	$7.59\ 10^{-12}$	4.11	0.81	$1.26\ 10^{-29}$	1.97	0.66
03.02.78												
Tot. fish eggs	-276.36	49.96	0.48	-2262.21	66.71	0.52	$2.41\ 10^{-3}$	1.34	0.48	$9.36\ 10^{-26}$	1.74	0.5
Tot. plaice eggs	-131.22	21.7	0.46	-345.41	10.29	0.2	$9.16\ 10^{-8}$	2.65	0.59	$1.31\ 10^{-30}$	2.02	0.44
07.02.78												
Tot. fish eggs	-1655.73	316.62	0.6	-1011.15	297.21	0.47	$1.59\ 10^{-5}$	2.48	0.84	$2.17\ 10^{-44}$	3.02	0.77
Tot. plaice eggs	-651.07	100.46	0.88	-1016.35	29.57	0.26	$5.33\ 10^{-25}$	8.75	0.93	$1.00\ 10^{-62}$	4.15	0.46
15.02.78												
Tot. fish eggs	-1466.08	339.03	0.62	-13062	388.13	0.73	$1.87\ 10^{-4}$	2.47	0.91	$4.14\ 10^{-35}$	2.42	0.92
Tot. plaice eggs	-75.76	14.63	0.74	-267.56	7.87	0.65	$3.45\ 10^{-7}$	2.93	0.87	$1.35\ 10^{-21}$	1.42	0.69
16.02.78												
Tot. fish eggs	-746.59	219.56	0.48	-5716.44	173.3	0.35	0.016	1.77	0.84	$9.42\ 10^{-26}$	1.79	0.77
Tot. plaice eggs	-19.02	4.81	0.41	130.22	-3.6	0.1	0.04	0.86	0.49	$1.4\ 10^{-14}$	0.94	0.17

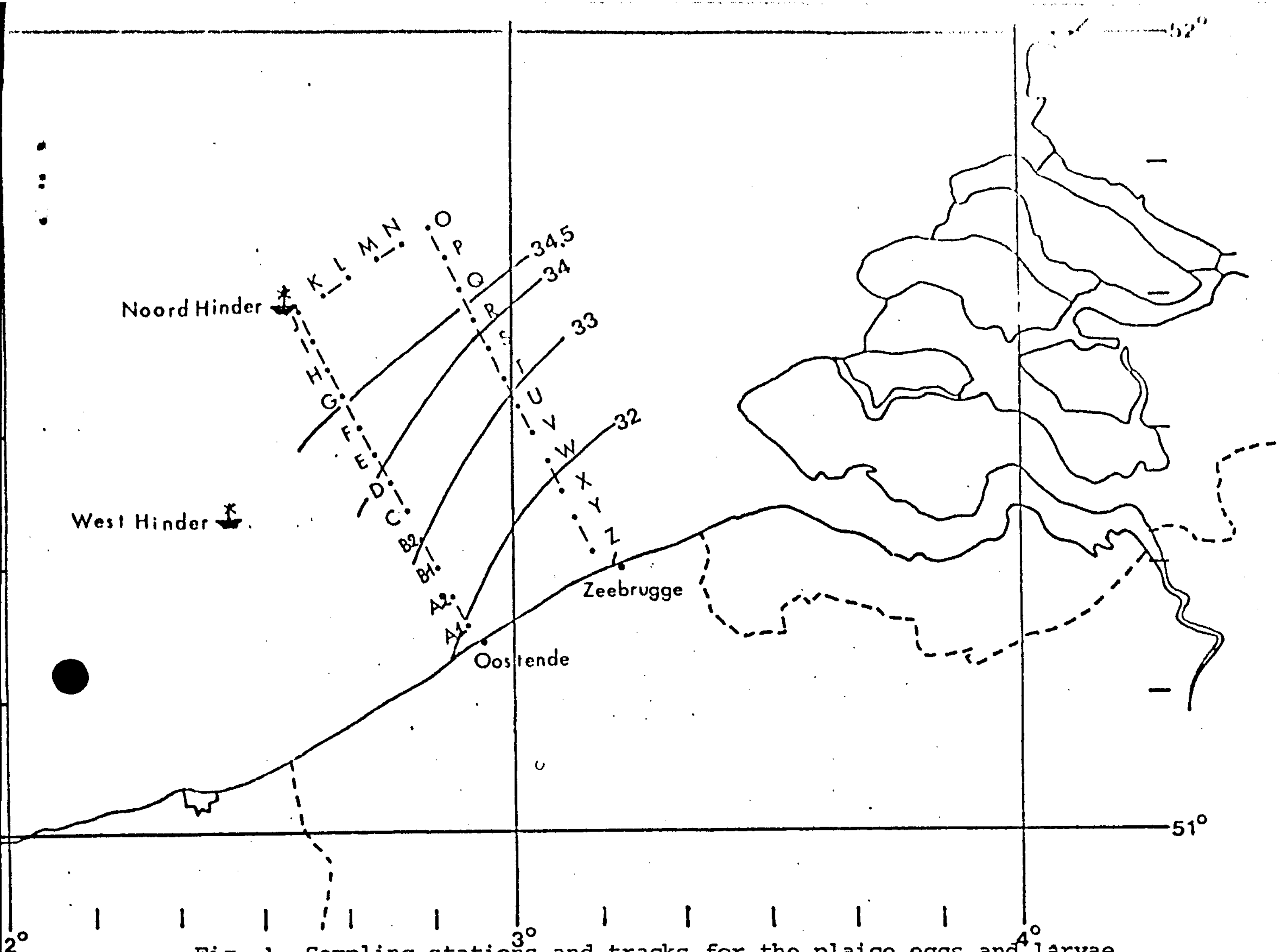


Fig. 1. Sampling stations and tracks for the plaice eggs and larvae diffusion experiment . Salinity isopleths on 14.02.1978 .

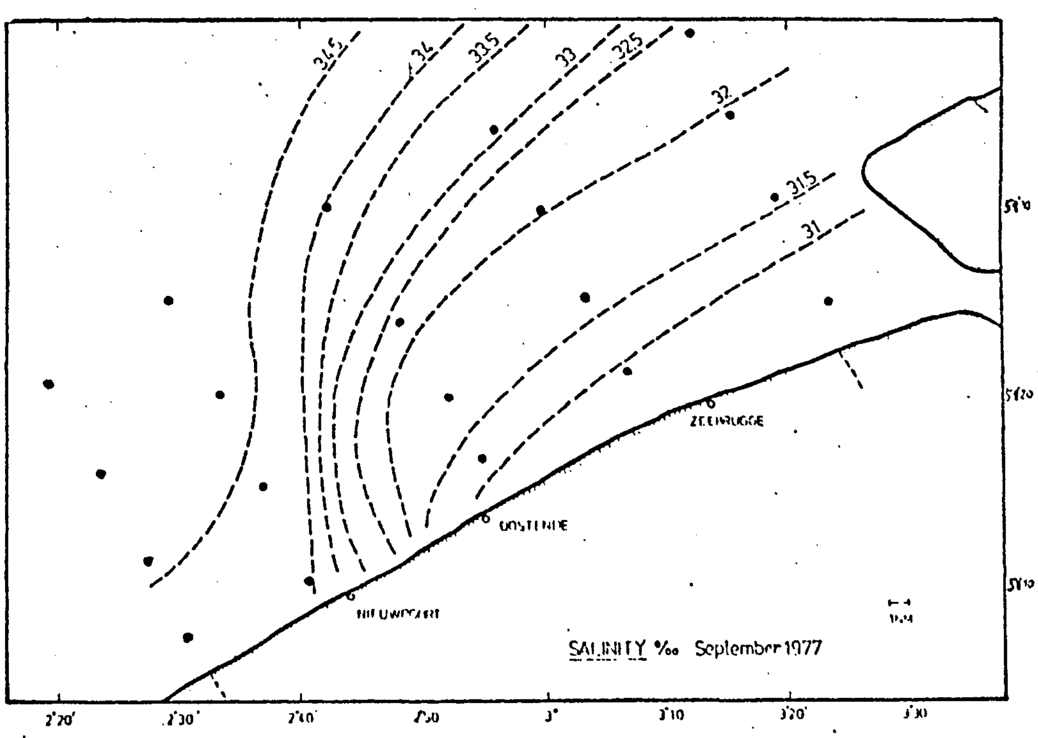


Fig. 2 . Typical salinity distribution in the coastal waters of Belgium (sampling network of the Unité de Gestion Modèle Mer du Nord)

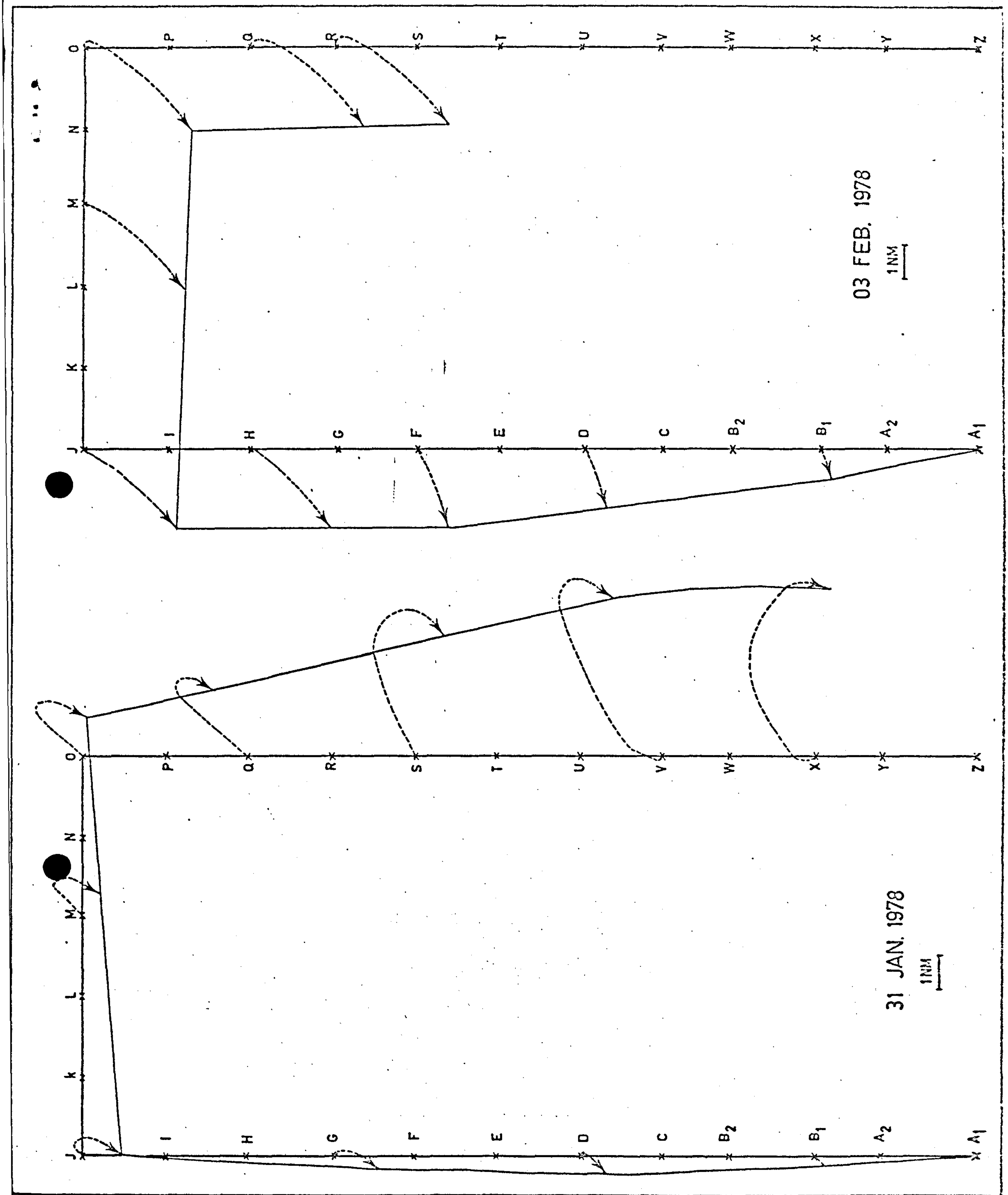
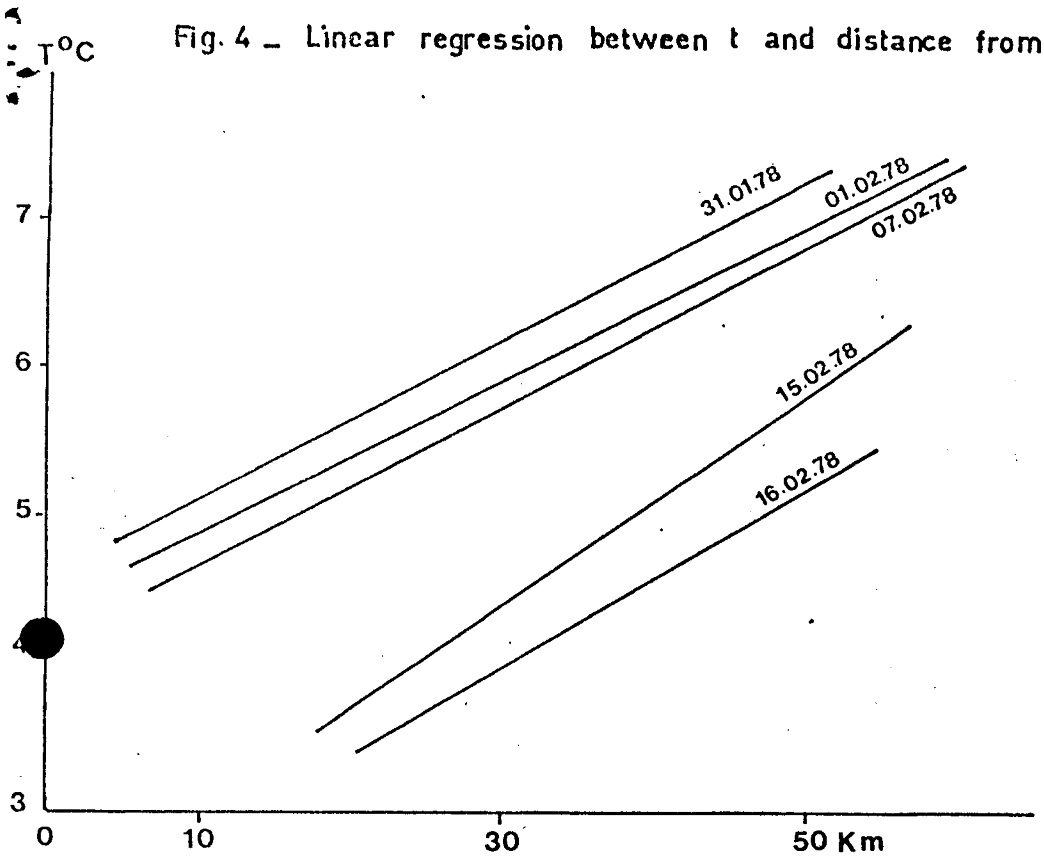


Fig. 3 . Examples of distortion due to water movements : estimation of the actual profiles in a water mass "frozen" relative to station A1 sampling time .

Fig. 4 _ Linear regression between t and distance from the coast.



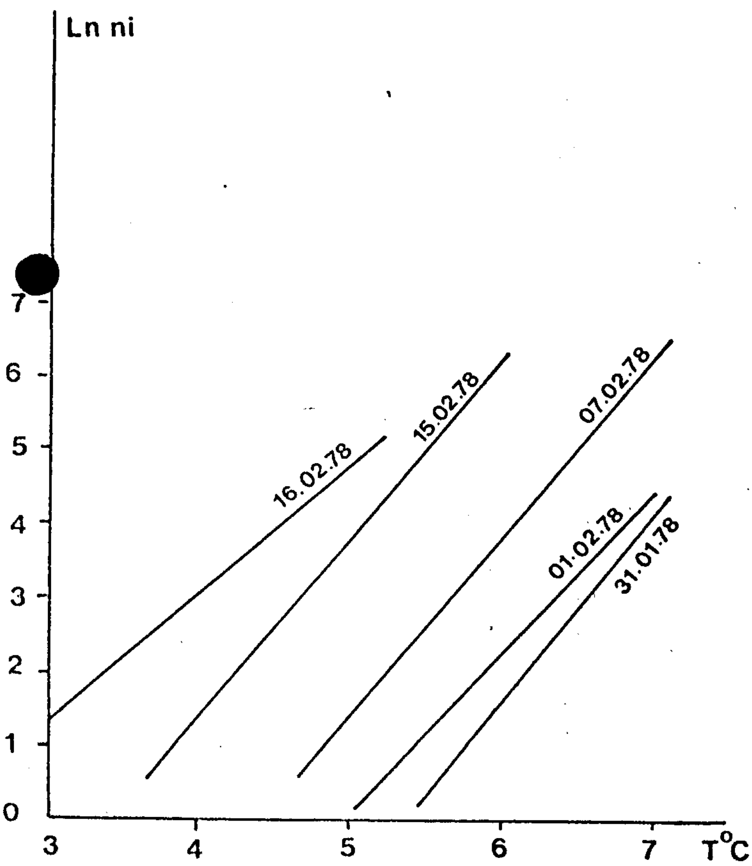


Fig. 5 _ Regression between total number of fish eggs per 100 m^3 (expressed in ln) and t

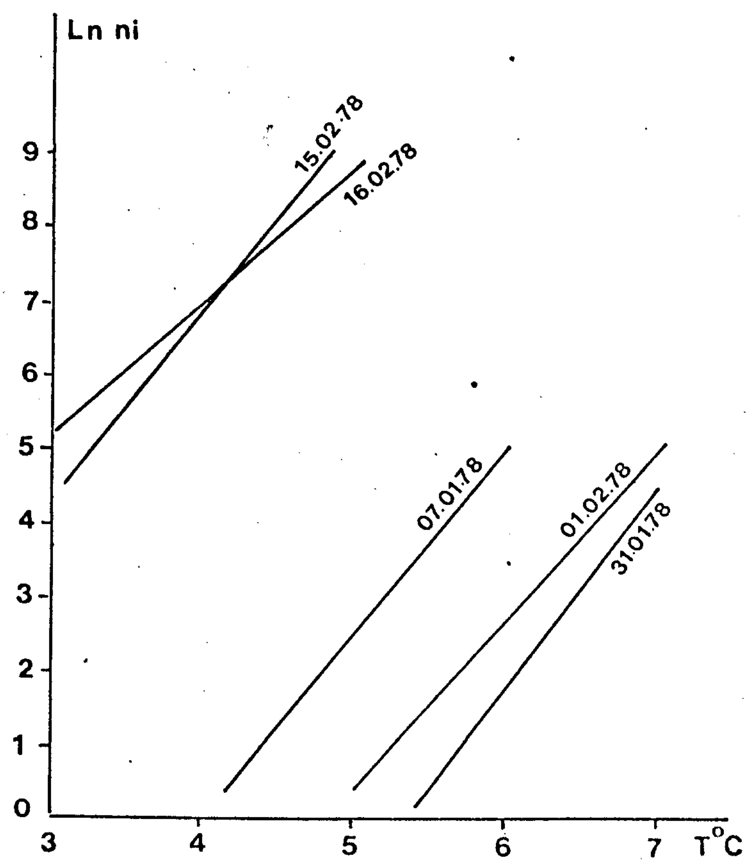


Fig. 6 _ Regression between total number of fish eggs per 100 m^3 (expressed in ln) and corrected temperature.