INTERNATIONAL COUNCIL FOR
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Pelagic Fish Committee/
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DISTRIBUTION AND MORTALITY OF PELAGIC EGGS OF BY-CATCH SPECIES IN THE 1989 EGG SURVEYS IN THE SOUTHERN NORTH SEA

by

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Abstract

In 1989 three egg-surveys were carried out by the RIVO to estimate the size of the spawning stock biomass (SSB) of cod and plaice and five surveys were carried out to estimate SSB of sole and horse mackerel in the southern North Sea. From a large proportion of the samples taken during these surveys all pelagic fish eggs were identified to species. This paper presents the results on the distributions of the by-catch species encountered in these samples. For sprat, estimates of egg mortality rates did not indicate significant differences between different periods within the spawning season.

1. INTRODUCTION

For a number of years the Netherlands Institute for Fishery Investigations has been carrying out or participating in ichthyo-plankton surveys to estimate the egg production of plaice, cod, sole and horse mackerel in the North Sea (Heessen and Rijnsdorp, 1989; Anon., 1986; van Beek, 1989; Iversen *et al.*, 1989). In 1989, an extensive survey programme was carried out covering the spawning period of cod and plaice from January through March as well as the spawning period of sole and horse mackerel from April through July in the southern North Sea. Although these surveys were aimed at the egg production of the species mentioned above, the objectives of the 1989 surveys were extended with a general study on distribution, timing and intensity of the spawning of all other commercial and non-commercial fish species in the area. The results on cod, plaice and horse mackerel are presented in other papers at this meeting: van der Land *et al.* (1990) and Eltink (1990). The results on sole will be presented at a later stage.
Studies describing the spawning of all species in a certain area of the North Sea are scarce; the results of an extensive program, including hydrography and the distribution of fish larvae in the area between the western edge of Dogger Bank and the English east coast in 1976, are described by Harding and Nichols (1987). Basic data on distribution, intensity and timing of spawning can form a background for future studies on changes in the North Sea ecosystem in relation to for instance ocean climate or anthropogenic effects.

Daily mortality rates of cod and plaice eggs were found to vary considerably between years (Heessen and Rijnsdorp, 1989). It is not known what causes are responsible for the mortality of fish eggs. Predation is generally believed one of the most important factors (Bailey and Houde, 1989; Jaworski and Rijnsdorp, 1989), but environmental factors such as water temperature, salinity, dissolved oxygen and wave action and the condition of the spawners can also play a role (Grauman, 1973; Dahlberg, 1979). For a better understanding of the factors causing egg mortality a study of differences in mortality rates within the spawning season might be useful. The large amounts of sprat eggs found in the course of this study provided an opportunity to try and study these fluctuations.

2. MATERIAL AND METHODS

2.1 Survey design

In 1989 eight egg surveys were carried out in the southern North Sea. The ships deployed in these surveys, the dates and the numbers of samples are given in table 1.
The surveys I, II, and III were designed to determine egg production of cod and plaice. The survey area was chosen to match the areas where previous surveys showed that the main part of the egg production of these species had occurred (figure 1). During these surveys six samples per ICES statistical rectangle were collected at every 15' and 45' longitude and 5', 15' and 25' or 35', 45' and 55' latitude.
The surveys IV - VIII aimed at the egg production of sole and horse mackerel. The station grid stretched from the Belgian to the Danish coastal area (figure 2). Two to eight samples were collected per ICES statistical rectangle, the density of the grid being larger in the areas nearest to the coast, where sole spawning activity is known to be highest (Anon., 1984; 1986).

2.2 Sampling methods

All samples were collected using a Dutch Gulf III plankton torpedo with a fishing speed of 5 nautical miles per hour. The mesh size of the net was 280 μ during the first three surveys, during the other five surveys mesh size was 500 μ to reduce clogging of the net by algae. The torpedoes were equipped with a calibrated flow-meter mounted in the nose of the torpedo to obtain a measure of the volume of water filtered by the net. At each station a (single or multiple) double oblique haul to within 5 meters from the bottom was made with a duration of at least ten minutes. At each station surface temperature and water depth were recorded.
All samples were fixed in 4% formaldehyde in sea-water buffered with 0.5% β-Disodium-glycerophosphate. All fish eggs and larvae were sorted from all the samples in the laboratory. Sub-sampling by means of a Folsom Splitter was limited to those samples containing exceptionally large numbers of eggs and/or larvae. In those cases half or a quarter of the sample was sorted. The eggs of plaice, cod, sole and horse mackerel were then sorted out and staged.
From one to three samples per half ICES statistical rectangle, all fish eggs were identified to species according to Ehrenbaum (1905-09), Heincke and Ehrenbaum (1900), Hiemstra (1962), Hoek and Ehrenbaum (1911), M'Intosh and Masterman (1897), Nichols (1971; 1976) and Russell (1976). Eggs from sprat, mackerel, whiting, flounder and dab (of which stage durations are known) were also staged according to Simpson (1959). Numbers of eggs per haul were converted into numbers under one square meter of sea surface by dividing the numbers by the volume of water filtered and multiplying by water depth.

2.3 Sprat egg mortality rates

On the basis of surveys IV - VIII production curves for sprat eggs were made, following the method described by Milligan (1986). From these curves the total seasonal production by developmental stage was estimated. Beginning and end of the spawning season were arbitrarily set at day numbers 80 and 200 respectively. From the estimates of seasonal production a mortality curve (Ln (abundance) against average age in days of the stages) was constructed. Daily mortality rate Z was estimated from the linear regression:

$$\text{Ln}\,(N_{age}) = \text{Ln}(N_0) - Z * \text{age}$$

In addition, mortality rates were calculated for each of the surveys separately, for the whole area surveyed and for the areas east (fig. 2; area A) and west (fig. 2; area B) of 6°EL separately. These calculations were based on daily egg production of each of the egg stages, instead of total seasonal production. The assumption was made that Z-values were not biased too much by the phase (rising or declining egg production) of the spawning season at the time of the respective surveys because the duration of the surveys (± 10 days) is long relative to the time it takes a sprat egg to develop until hatching (2 - 6 days at prevalent temperatures).

3. RESULTS AND DISCUSSION

3.1 Surface temperatures

Because of the difference between the survey areas of the first three surveys and the last five, average surface temperature was calculated per survey from the stations that were sampled in all surveys. These average temperatures are plotted against against day-number of the midpoints of the respective surveys (fig. 3). Average surface temperature was rather constant around 7.5°C between January and the end of April. Subsequently, surface temperatures quickly rose by more than 8°C to 16.7°C within two months. Bottom temperature measurements did not indicate the presence of a significant thermocline in the relatively shallow, well-mixed coastal areas sampled from March onwards.

Monthly average surface water temperatures in 1989 and averages over 1860 - 1980 from Den Helder are also plotted in fig. 3. Because these temperatures were measured closely inshore, fluctuations are more extreme than at sea. It is clear however that in winter and early spring 1989 water temperatures were much higher than average.

3.2 Fish eggs

Table 2 shows that at least 28 fish species producing pelagic eggs spawned in the area surveyed in 1989. Figs. 4 a-s shows the distributions of eggs of the species during the survey at which their distributions expressed in numbers beneath one square meter were maximal. Whenever the eggs were staged the distribution of stage I eggs is presented, otherwise total egg numbers were used.

Figure 5 shows the seasonal variation in abundance of the eggs (all stages) of most species, expressed as mean number of eggs per square meter and calculated over the whole area surveyed.

The spawning seasons of the species were found earlier in the year than the spawning seasons described in general literature (Ehrenbaum, 1905-09; Russell, 1976), probably due to the high water temperatures observed in 1989. Peak egg production of most species was observed about one month earlier in the 1989 spawning season than off the English east coast in 1976 (Harding and Nichols, 1987). Average water temperature near

Den Helder over the first four months of 1989 was 3°C higher than over the first four months of 1976. Wahl and Ahlheit (1988) studied the spawning of the sprat in the German Bight in 1987, when water temperatures were below average until June, and found peak spawning to occur in June. In the same area in 1989, sprat spawning was already decreasing in June.

Sprat (*Sprattus sprattus*)

The spawning period of the sprat in the North Sea is quite long. In 1989 sprat spawned from February until July. In the Southern Bight egg production was high from March to May. In the German Bight egg production was high from April to June. Highest numbers of eggs were found in the area around Helgoland in the German Bight and between 51°N and 52°N in the Southern Bight (figs. 4 a and b).

Rocklings

Rockling eggs were not identified to species. The eggs of different species of rockling are much alike and have not been very well described. There could be eggs of three-, four- or five-bearded rockling (*Gaidropsarus vulgaris*, *Rhinonemus cimbrius* or *Ciliata mustela* respectively) present in the samples collected. Owing to the uncertainty in the identification of the eggs reliable information about the spawning periods of the different species is not available. According to Russell (1976) some of these eggs could be attributed to the right species from the areas and distances from the shore that these eggs occurred in largest numbers; *C. mustela* is a shore-living or intertidal species, *G. vulgaris* and *R. cimbrius* live off-shore. In survey III rockling eggs were found over the whole area investigated, the largest numbers occurred well off-shore (fig. 4 c). In surveys IV and V (April) still many rockling eggs were found, also at inshore stations (fig. 4 d). Since the inshore stations were not sampled during the first three surveys and the stations further off-shore were not sampled after survey III our data do not provide a sufficient basis to determine spawning areas or spawning periods of the different species. Rocklings as a group of species however can be said to spawn over the whole area investigated from January to June.

Whiting (*Merlangius merlangus*)

The whiting is a very widely distributed species spawning over the whole of the North Sea. Whiting had already started spawning in January and its eggs were found until June. Highest densities of whiting eggs were found in March and April, in the Southern Bight and around Dogger Bank (figs. 4 e and f).

Lesser weever (*Trachinus vipera*)

Lesser weever eggs were only found in surveys VI to VIII and hardly any above 54°N. Highest numbers were found in June (fig. 4 g) although egg production was still high in July and may have continued after that month.

Dragonet (*Callionymus lyra*)

The dragonet started spawning in the southern North Sea in February in 1989. In the English Channel dragonet eggs were already caught in January. In March they were present at most stations between 51°N and 54°N (fig. 4 h), in the German Bight numbers were still low. In April and May densities of dragonet eggs were highest; they were found almost everywhere (fig. 4 i).

Reticulated dragonet (*Callionymus reticulatus*)

Very little is known about the distribution and abundance of this species in the North Sea, probably due to its small size and the similarity of female specimens to small *C. lyra*. Demir (1972) describes the development, distribution and abundance of postlarvae of this species off Plymouth and states that it is generally found in shallow waters of 20 - 40 m. Boer (1971) records its presence in the Southern Bight. He studied the area between 51°30'N, 53°30'N, 3°E and the Dutch coast and found *C. reticulatus* to be most abundant

(even more abundant than *C. lyra*) in the deeper parts of this area, corresponding to a depth of 20 - 30 m.
In 1989, eggs of this species were found from April onwards almost exclusively in the area studied by Boer (1971). Highest numbers were found in May (fig. 5). In the Southern Bight, numbers of reticulated dragonet eggs were in the same order of magnitude as numbers of dragonet eggs. This suggests that in this area adult *C. reticulatus* are probably more abundant than adult *C. lyra*, which are much larger and should have a higher fecundity. Very few eggs of *C. reticulatus* were found in the German Bight, where it must be a rare species (fig. 4 j).

Gurnards (Triglidae)

The two species of gurnard common in the area are the grey gurnard (*Eutrigla gurnardus*) and the tub gurnard (*Trigla lucerna*), the former being the more common one. According to Ehrenbaum (1905-1909), the eggs of these species are much alike and it is impossible to identify them to species. Therefore, no attempt was made here. Small numbers of gurnard eggs were found in each survey except the first and over the whole survey area except at the stations closest inshore. In March, largest numbers occurred well off-shore (fig. 4 k). Thereafter, largest numbers of gurnard eggs were found in the German Bight in June (fig. 4 l). This pattern probably reflects a migration from deeper to more shallow parts of the North Sea of grey gurnards (*Eutrigla gurnardus*) during their spawning period (Hertling, 1924; Sahrhage, 1964). At the last survey still considerable numbers of eggs were found, indicating that gurnards as a group have a very prolonged spawning period, starting in February and lasting till at least July.

Dab (*Limanda limanda*)

The dab, like whiting, can be found spawning over the whole of the North Sea. Highest densities of eggs occurred in the German Bight north-west of Helgoland, around Dogger Bank and off the northern part of the Dutch coast around 53°30'N (figs. 4 m and n). This is in agreement with Bohl (1959), who studied the spawning of the dab and found its eggs to be most abundant in these areas in waters with a depth of between 20 and 40 meters. Egg production had already started in January, remained on a high level from February until April and dropped back to the January level in May (fig. 5). In July no dab eggs were found anymore.

Flounder (*Platichthys flesus*)

Most flounder eggs were observed in February in the area west and northwest of the Dutch west coast, the English Channel and the area northwest of Helgoland (fig. 4 p). This observation agrees well with the observations of Ehrenbaum and Mielck (1910) who found that flounder spawn in water with depths between 20 and 40 meters to about 60 nautical miles off-shore. In January and March, only a small number flounder eggs were observed. It appears that the flounder is a species with a well defined spawning period and spawning area. If the survey grid would have included the area around Helgoland, it might have been possible to estimate the total seasonal egg production of the flounder.

Long rough dab (*Hippoglossoides platessoides*)

Spatial distribution of long rough dab eggs was almost complementary to that of flounder eggs (fig. 4 q). The eggs of this species were only found in deeper waters in the area around the Dogger Bank, the southern edge of the main distribution area of long rough dab, predominantly during survey II (February).

Solenette (*Buglossidium luteum*)

The solenette started spawning in March in 1989, highest egg numbers were found in May (fig. 5). Densities had decreased considerably in June and in July egg production had almost ceased. Few solenette eggs were found in the English Channel and North of Helgoland. Highest densities were found between 52°N and 54°N (fig. 4 r). This is in agreement with the distribution of adult solenette (Sahrhage, 1964) in a broad zone between Texel and the southwestern edge of the Dogger Bank.

Scaldfish (*Arnoglossus laterna*)

In March and April no eggs of this species were found yet. Highest numbers of scaldfish eggs were found in May, in roughly the same area as the solenette eggs were found (fig. 4 s). Densities were still high in June and in July eggs were still present in lower numbers in much the same area as in May. There was no indication of a northward shift in distribution.

Other species

The anchovy (*Engraulis encrasicolus*) in the south-eastern North Sea spawns in inshore areas, like the Dutch Zuiderzee before it was closed (Russell, 1976). Indeed, the eggs of the anchovy were found at some inshore stations and off the Belgian coast. The number of positive stations, however, was very small.
Patches of pilchard (*Sardina pilchardus*) eggs were found off the Belgian coast and around 7°EL off the Ems-Dollard part of the Wadden Sea.
Aurich (1953) studied the planktonic stages of these two species in the Southern North Sea around 1950 and found both to be quite abundant, in contrast to the period before 1930. Pilchard then was absent and anchovy was rare. He states that both species reach the northern edge of their distribution in the North Sea and relates their changes in abundance to climatic changes. Densities of eggs of both species observed in 1989 were intermediate between densities in the two periods described by Aurich (1953).

The spawning stock of the mackerel (*Scomber scombrus*) in the North Sea is very small. Some spawning was observed in the German Bight in May and June; in the Southern Bight hardly any mackerel eggs were found. The most important spawning area of the mackerel (*Scomber scombrus*) in the northern North Sea was covered once in 1989 by a Norwegian vessel (Anon., 1990).

The eggs of the gadoids pout (*Trisopterus luscus*), poor cod (*Trisopterus minutus*) and haddock (*Melanogrammus aeglefinus*) were occasionally identified. Some haddock (stage IV) eggs were identified from the Northern part of the area surveyed for cod and plaice eggs, around the Dogger Bank. Ling (*Molva molva*) eggs were found in low numbers off the Danish coast in the northern part of the area sampled in June and July.
We found it extremely difficult to discriminate between formalin fixed eggs of whiting and pout. In some cases, pout eggs which had been positively identified from recently collected samples could not be recovered when the sample was studied again after a few months. Apparently differences in pigmentation between the eggs of the two species are only visible in recently fixed samples and become obscured after a relatively short period of fixation. Therefore it remains possible that part of the eggs identified as belonging to whiting were in fact pout eggs. Since whiting greatly outnumbers the pout in the North Sea densities of whiting eggs are probably not influenced much by a possible confusion with pout eggs. In areas where pout is abundant one should be careful in interpreting egg survey data on these species.
Poor cod eggs were never found in any numbers. It is not very likely that these eggs were confused with those of another species; dab and flounder eggs are comparable in size, but in general the difference between a flatfish egg and a gadoid egg is quite obvious in the later stages of development.

Numbers of turbot (*Scophthalmus maximus*) eggs found were low and little can be said about their distribution. It is quite clear however that this species does not spawn abundantly in the inshore areas sampled. Numbers appeared to be highest in May and June in the German Bight and off the Danish coast, well off-shore. Hardly any turbot eggs were found in the Southern Bight below 52°30'N.
Occasionally one or two brill (*Scophthalmus rhombus*) eggs were found in a sample, most of them between April and June. The eggs of the flatfish species lemon sole (*Microstomus kitt*), Norway topknot (*Phrynorhombus norvegicus*) and witch (*Glyptocephalus cynoglossus*) have been positively identified from a small a number of samples.

3.2 Sprat egg mortality rates

Figure 6 shows sprat egg production curves for the 1989 spawning season. Stages IV and V were combined to ensure sufficiently high numbers to allow estimates of mortality for each of the surveys separately. Mortality rate Z calculated over the whole season was 0.420 day^{-1}, resulting in a total seasonal egg production estimate (intercept) of 213 * 10^{12} eggs (fig. 7).

Daily mortality in percentage 34 %, resulting in a survival through incubation (3.01 days) of 28 %. No attempt was made to estimate the size of the spawning stock, since this requires a reliable estimate of total fecundity of the sprat. Since annual fecundity of the sprat varies considerably between years (Alheit, 1986), using a published value would not be realistic.

The daily mortality rate of 34 % calculated over the whole season is comparable to the value of 42 % per day found by Milligan (1986) for sprat in the English Channel in 1981. Alheit et al. (1987), however, found a daily mortality of only 4 % in the German Bight in May 1986. In both studies numbers of eggs per square meter were in the same order of magnitude as the densities found in this study. Since the intensity of sprat spawning is closely related to temperature (Wahl and Alheit, 1988), it is unlikely that these differences can be explained by sea-water temperature.

For comparisons daily mortality of sole eggs in 1989 calculated from total seasonal egg productions per stage was estimated as 32 % (van Beek, pers. comm.).

For the two subareas A and B and the whole area for each of the surveys separately mortality rates Z and percentage mortality per day are presented in table 3. When an analysis of variance (Anova) was carried out on the data used for the calculation of these Z-values, this revealed no significant differences in mortality rates (age effects) between surveys or between the two subareas (table 4).

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Table 1. Survey periods, midpoints, numbers of hauls and ships deployed in the surveys.

Survey number	Ship	Date 1989	Midpoint	N hauls	N hauls analyzed for this study
I	RV Isis	10-1 / 20-1	19-1	73	128
	KW 34	16-1 / 20-1		55	
II	KW 34	13-2 / 3-3	23-2	157	98
	RV Isis	20-2 / 23-2		37	
III	RV Isis	28-3 / 6-4	30-3	96	90
	RV Tridens*	28-3 / 5-4		83	
IV	RV Isis	10-4 / 18-4	14-4	55	27
V	RV Isis	24-4 / 2-5	27-4	86	40
	RV Tridens*	25-4 / 27-4		17	
VI	RV Isis	22-5 / 7-6	29-5	117	51
VII	RV Isis	19-6 / 28-6	23-6	71	44
VIII	RV Isis	10-7 / 18-7	13-7	64	64
			Total:	911	542

* RV Tridens was replaced by a new vessel of the same name in 1990.

Table 2. Species of which pelagic fish eggs were identified in samples from the 1989 North Sea egg surveys (excluding the English Channel). A question mark in the third column indicates that insufficient data are available to complete the table.

Species	Common English name	Surveys	Maximum distribution
Sardina pilchardus	Pilchard	V - VIII	May
Sprattus sprattus	Sprat	II - VIII	May
Engraulis encrasicolus	Anchovy	?	
Merlangius merlangus	Whiting	I - VII	March - April
Trisopterus luscus	Pout	?	
Trisopterus minutus	Poor cod	?	
Gadus morhua	Cod	I - III	February
Melanogrammus aeglefinus	Haddock	?	
Molva molva	Ling	VII - VIII	July
	Rocklings	I - VII	March - April
Trachurus trachurus	Horse mackerel	VI - VIII	June
Trachinus vipera	Lesser weever	VI - VIII	June - July
Scomber scombrus	Mackerel	V - VIII	May
Callionymus lyra	Dragonet	II - VIII	May
Callionymus reticulatus	Reticulated dragonet	III - VIII	May
Triglidae	Gurnards	II - VIII	May - June
Scophthalmus maximus	Turbot	III - VIII	May - June
Scophthalmus rhombus	Brill	IV - VIII	May
Phrynorhombus norvegicus	Norway topknot	?	
Arnoglossus laterna	Scaldfish	III - VIII	May
Limanda limanda	Dab	I - VII	April
Platichthys flesus	Flounder	I - IV	February
Pleuronectes platessa	Plaice	I - III	February
Microstomus kitt	Lemon sole	?	
Glyptocephalus cynoglossus	Witch	?	
Hippoglossoides platessoides	Long rough dab	I - III	February
Solea solea	Sole	III - VIII	April
Buglossidium luteum	Solenette	III - VIII	May

Table 3. Mortality rates sprat eggs in different parts of the spawning period and spawning area.

	Total area			Area A			Area B		
Survey	Z day^{-1}	R	% mort/day	Z day^{-1}	R	% mort/day	Z day^{-1}	R	% mort/day
4	0.309	0.98	27	0.334	0.99	28			
5	0.391	0.99	32	0.433	1.00	35	0.311	0.90	27
6	0.495	0.91	39	0.173	0.77	16	0.546	0.91	42
7	0.060	0.17	6	0.359	0.44	30	0.032	0.10	3
8	0.438	0.54	35				0.421	0.54	34

Table 4.Results of the ANOVA on sprat egg mortality data according to the model: Log (daily egg production) = Age + Survey + Area + interaction terms.

	SS	df	Mean Square	F	P
Age#	4.083	1	4.083	39.26	**
Survey.area#	11.760	2	5.880	56.54	**
error	2.392	23	.104		
Area.age	.007	1	.007	.055	n.s.
Survey.age	.072	4	.018	.139	n.s.
Survey.area	8.952	2	4.476	34.698	**
error	2.320	18	.129		
total	37.960	31			

Taking account of main effects of survey and area separately.
** P < 0.01

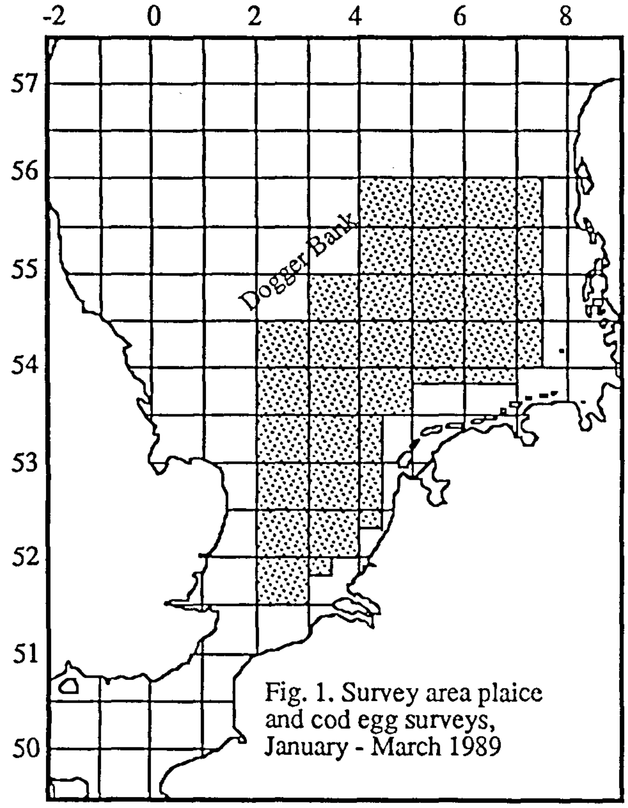


Fig. 1. Survey area plaice and cod egg surveys, January - March 1989

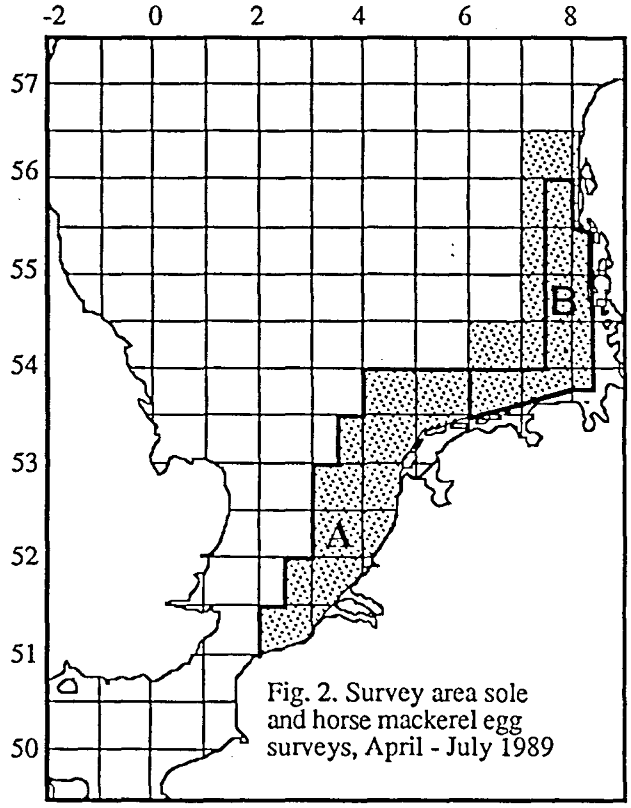


Fig. 2. Survey area sole and horse mackerel egg surveys, April - July 1989

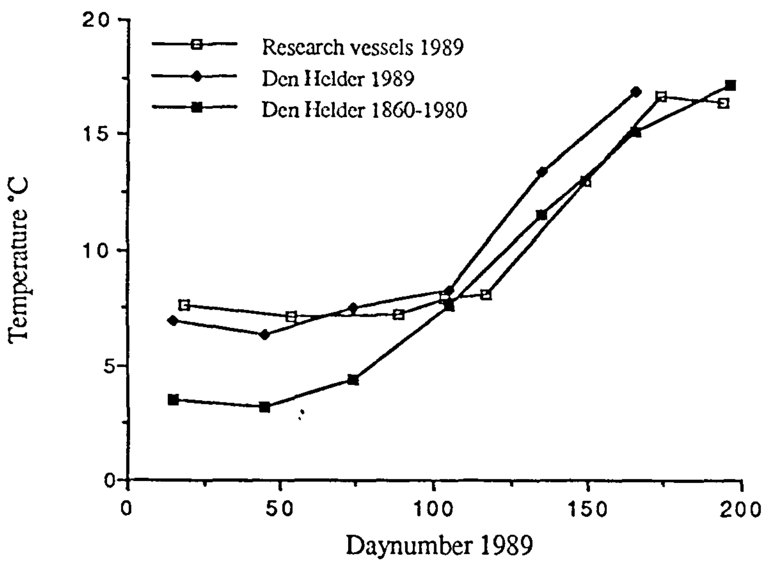


Fig. 3. Average surface water temperatures at stations sampled during the 1989 surveys and from Den Helder

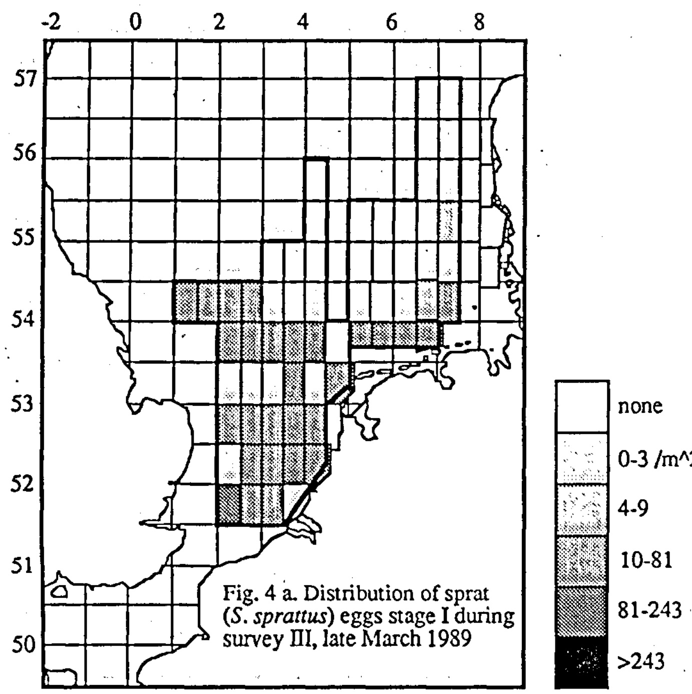


Fig. 4 a. Distribution of sprat (*S. sprattus*) eggs stage I during survey III, late March 1989

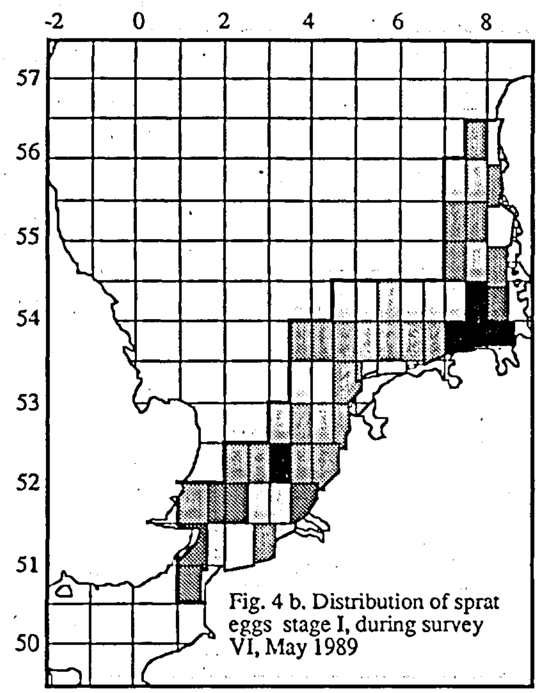


Fig. 4 b. Distribution of sprat eggs stage I, during survey VI, May 1989

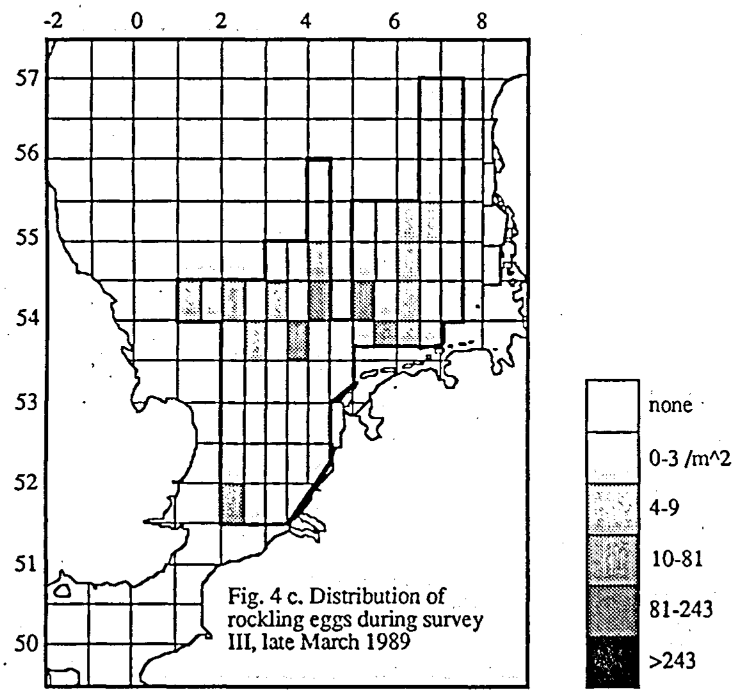


Fig. 4 c. Distribution of rockling eggs during survey III, late March 1989

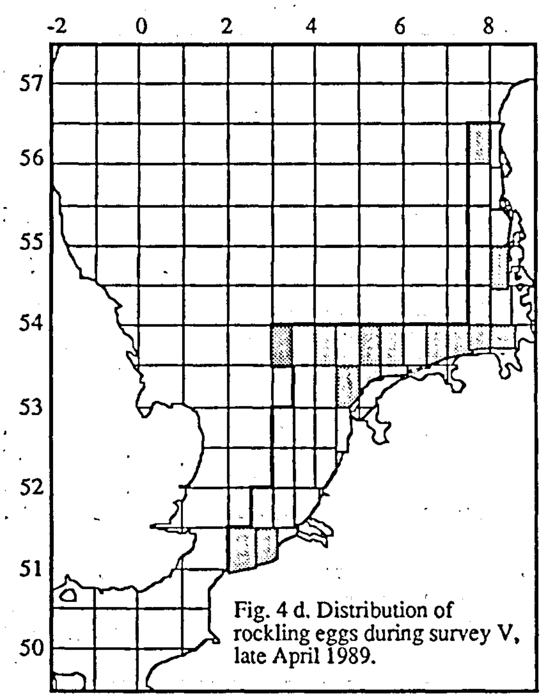


Fig. 4 d. Distribution of rockling eggs during survey V, late April 1989.

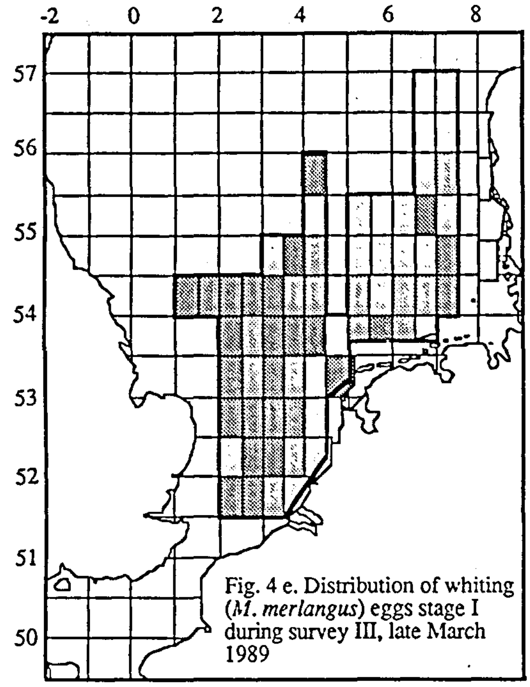
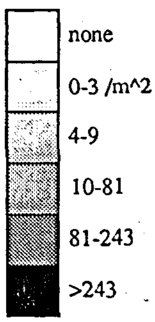


Fig. 4 e. Distribution of whiting (*M. merlangus*) eggs stage I during survey III, late March 1989



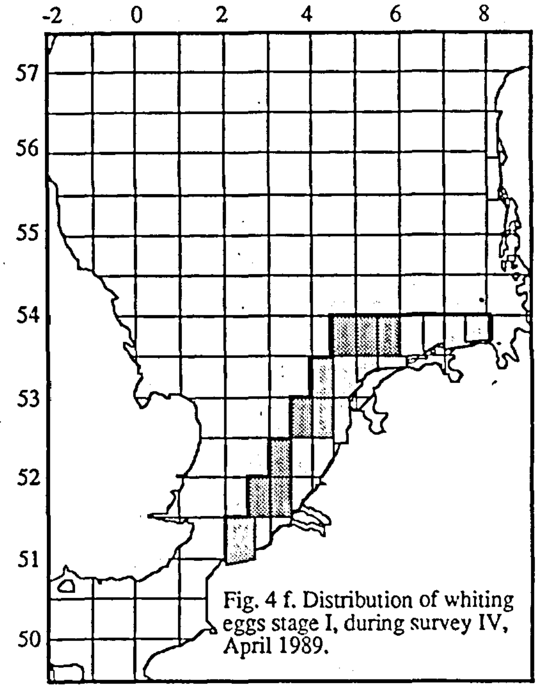


Fig. 4 f. Distribution of whiting eggs stage I, during survey IV, April 1989.

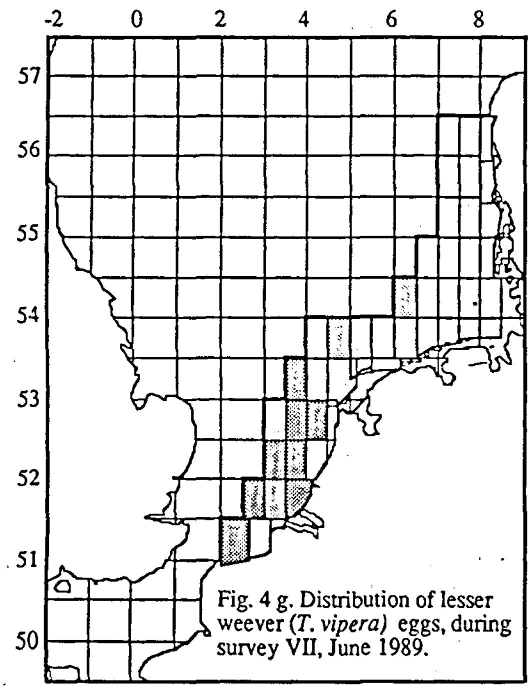
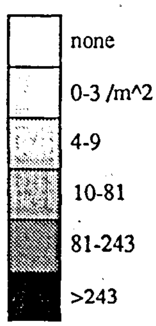


Fig. 4 g. Distribution of lesser weever (*T. vipera*) eggs, during survey VII, June 1989.



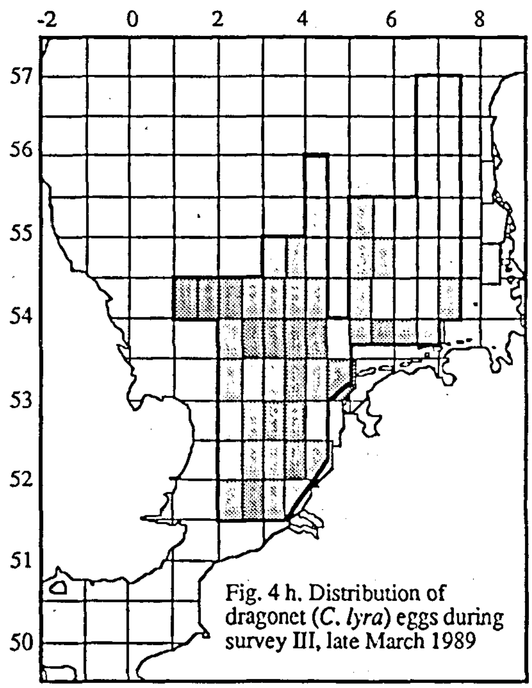


Fig. 4 h. Distribution of dragonet (*C. lyra*) eggs during survey III, late March 1989

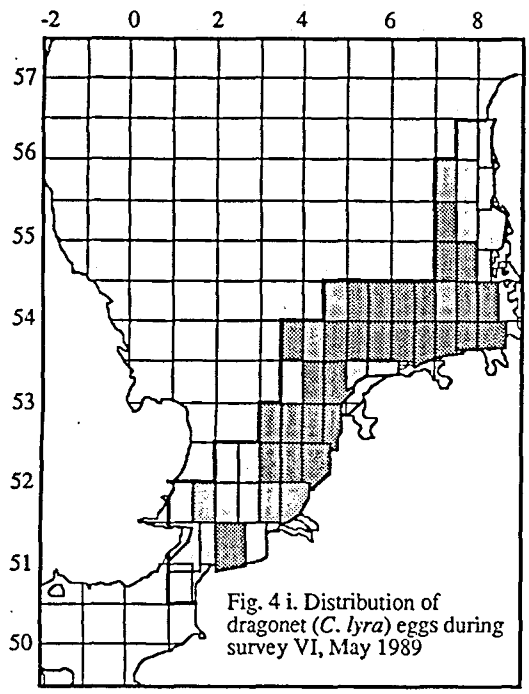
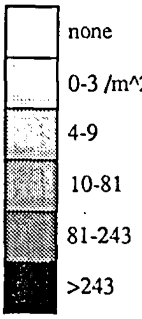


Fig. 4 i. Distribution of dragonet (*C. lyra*) eggs during survey VI, May 1989



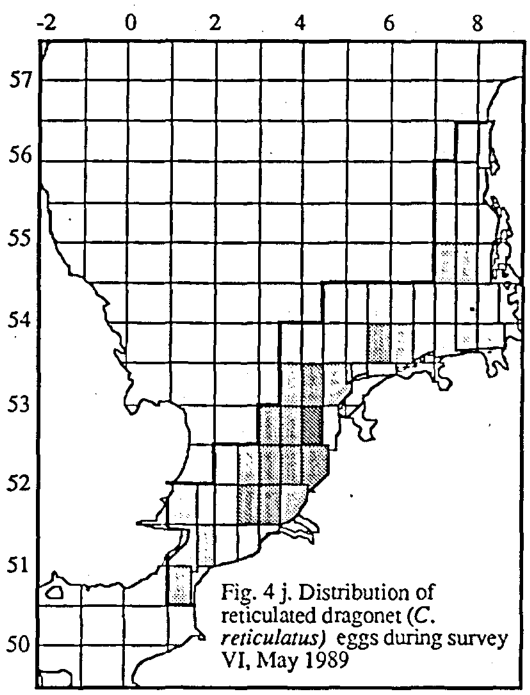


Fig. 4 j. Distribution of reticulated dragonet (*C. reticulatus)* eggs during survey VI, May 1989

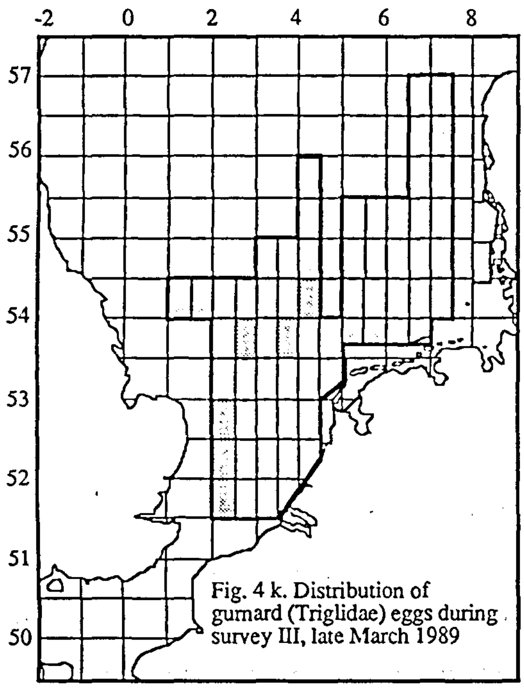
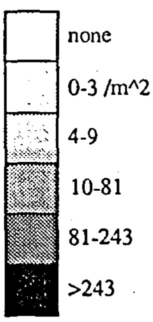


Fig. 4 k. Distribution of gurnard (Triglidae) eggs during survey III, late March 1989



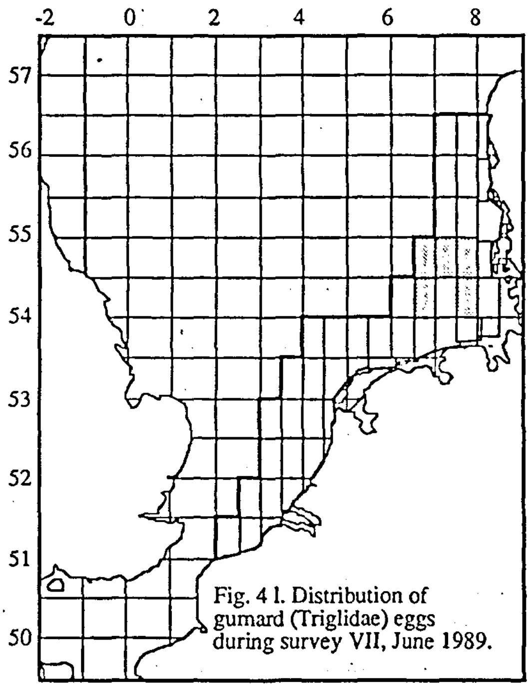


Fig. 4 l. Distribution of gurnard (Triglidae) eggs during survey VII, June 1989.

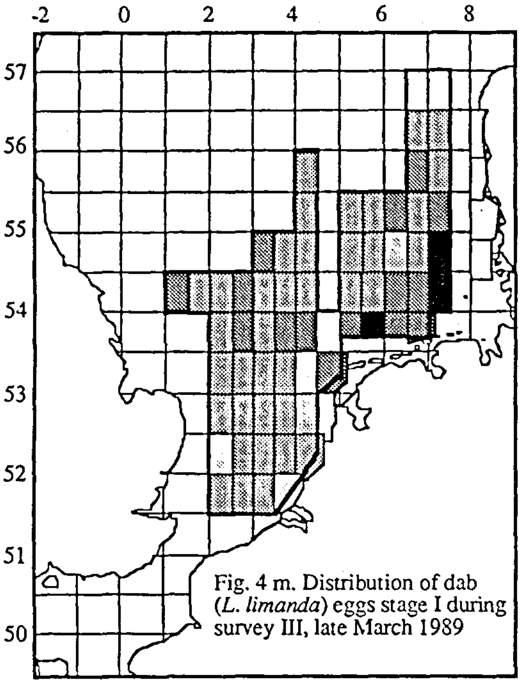
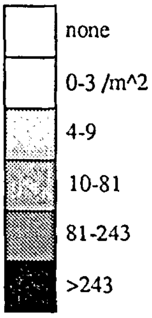


Fig. 4 m. Distribution of dab (*L. limanda*) eggs stage I during survey III, late March 1989



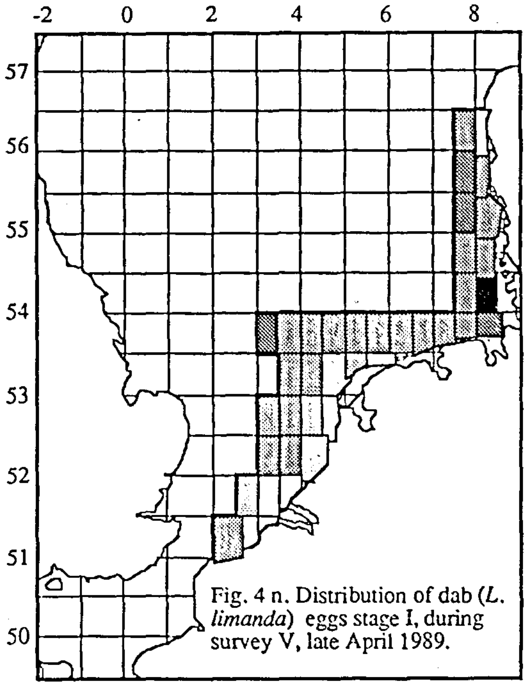


Fig. 4 n. Distribution of dab (*L. limanda*) eggs stage I, during survey V, late April 1989.

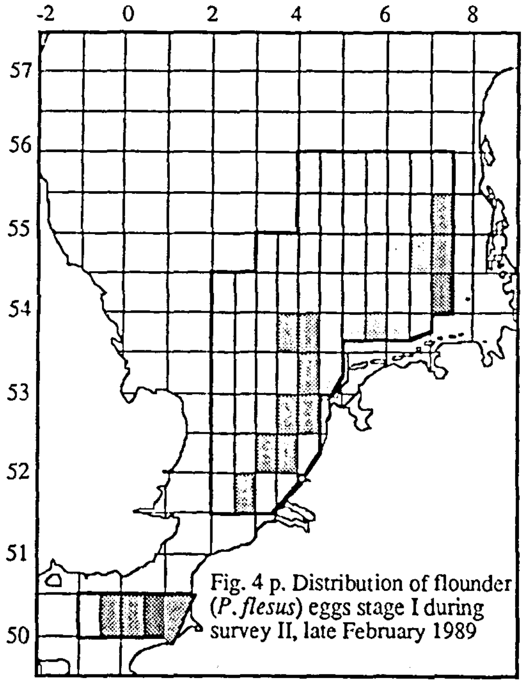
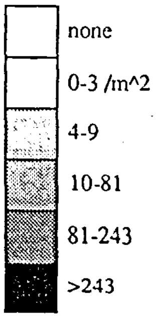


Fig. 4 p. Distribution of flounder (*P. flesus*) eggs stage I during survey II, late February 1989



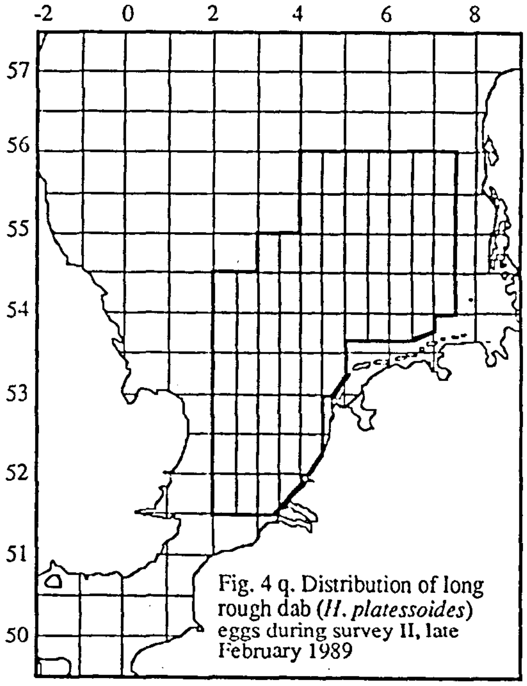


Fig. 4 q. Distribution of long rough dab (*H. platessoides*) eggs during survey II, late February 1989

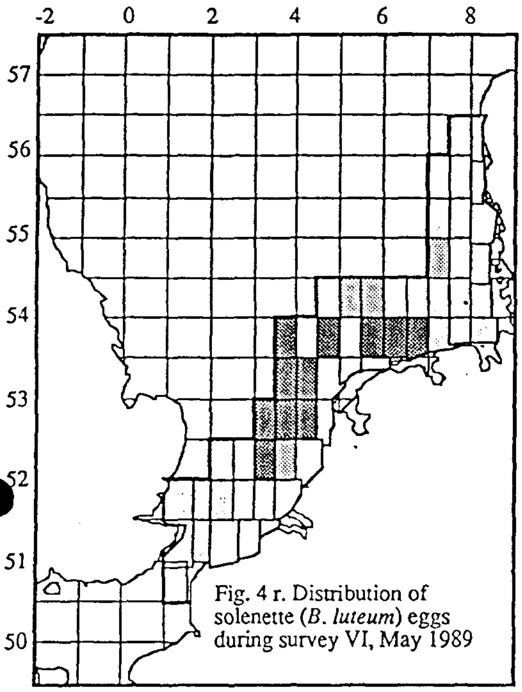
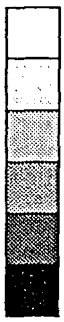


Fig. 4 r. Distribution of solenette (*B. luteum*) eggs during survey VI, May 1989



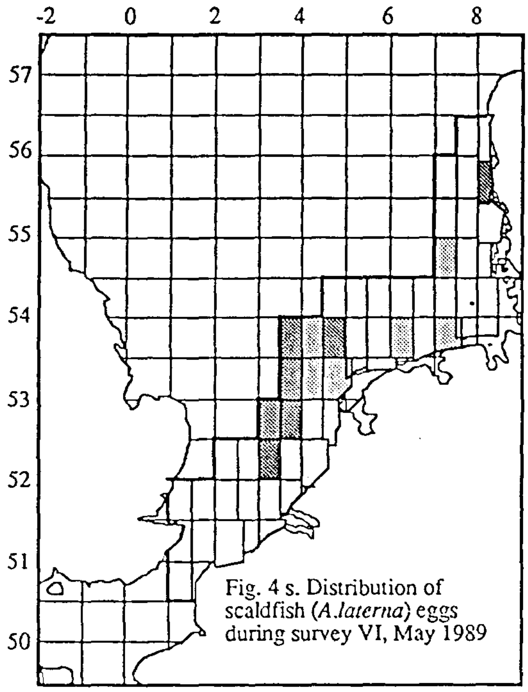


Fig. 4 s. Distribution of scaldfish (*A.laterna*) eggs during survey VI, May 1989

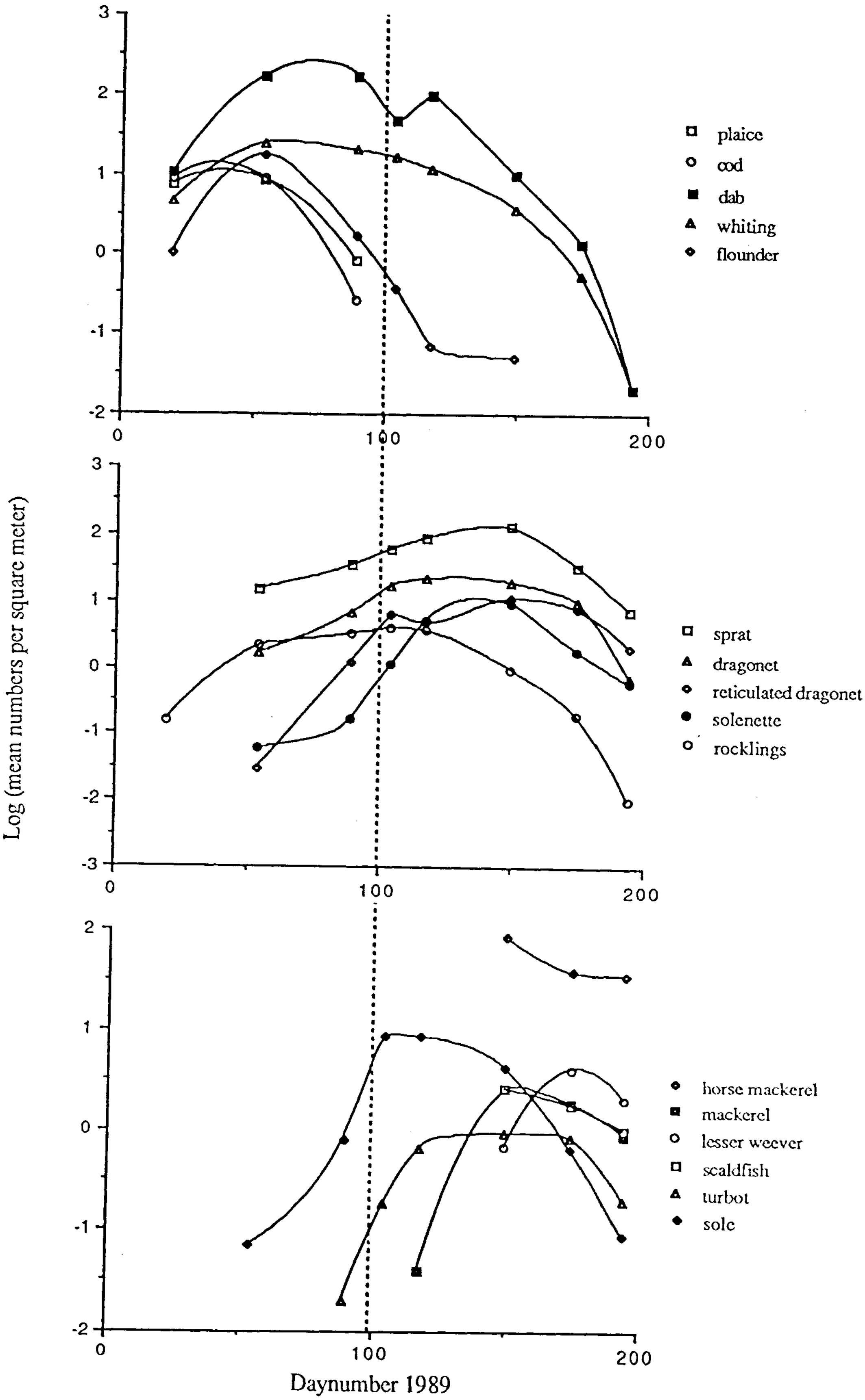


Fig. 5. Seasonal variation in abundance of fish eggs in 1989.
The vertical dotted line indicates a change in survey area.

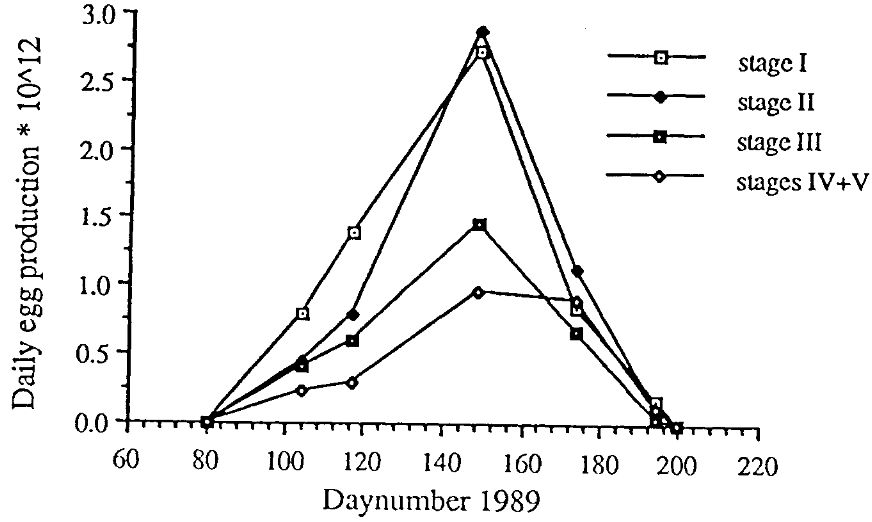


Fig. 6. Production curve sprat eggs.

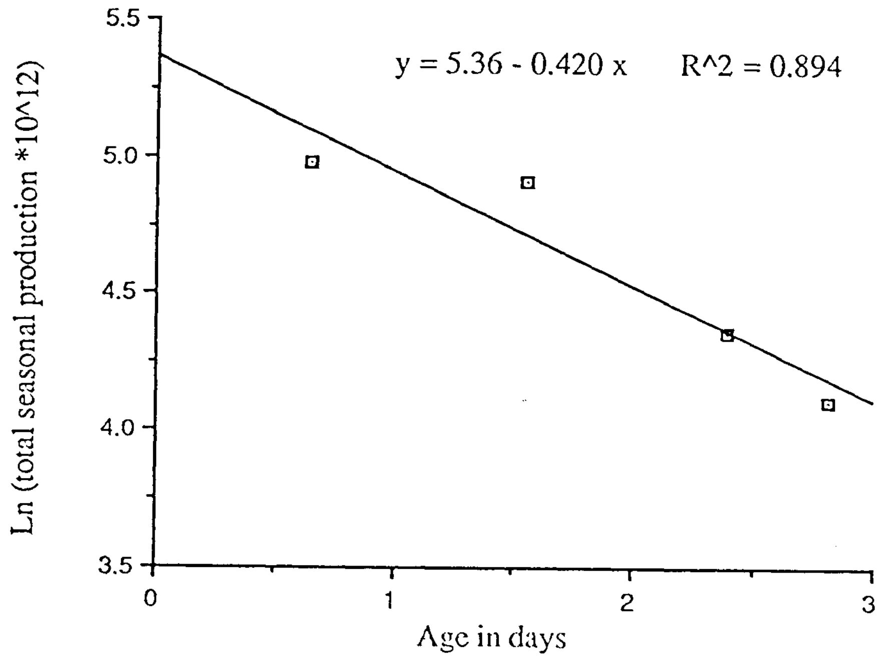


Fig. 7. Mortality curve sprat eggs. Calculated from the areas under the curves in fig. 6 and average ages per stage.