# North Sea spawning grounds of the sole *(Solea solea)* located from the 1984 Belgian plankton survey

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*Borremans, C. 1987.* North Sea spawning grounds of the sole *(Solea solea)* located from the 1984 Belgian plankton survey. *Proc. V Congr. europ. Ichthyol., Stockholm 1985, pp. 187–191.* During spring 1984 large ichthyoplankton surveys were performed to determine the spawning period and the spawning places of the sole in the Southern Bight of the North Sea. In March and April most eggs were found close to the Belgian coast and the coast of Brittany, which agrees with results of previous plankton surveys. In the second of the surveys, however, high densities were also found at stations about 50 km from the coast – in the open sea. An attempt is made to explain whether these early stage eggs were laid in the locality, contrary to what is normally accepted, or drifted there from the Belgian or the English coast.
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In 1984, the International Council for the Exploration of the Sea organized a plankton survey covering the whole Southern Bight of the North Sea and the Eastern part of the English Channel. Four countries (the Netherlands, Great Britain, Germany and Belgium) contributed to this project. The main objective of the survey was to estimate for the fisheries management purpose the spawning stock biomass of sole *(Solea solea* Linnaeus) in the North Sea by sampling the planktonic eggs. This estimation will be compared with the classical Virtual Population Analysis estimation. By counting planktonic eggs errors due to catch limitations will be omited (Saville 1981). From previous observations soles are known to spawn in inshore waters within the 30 m depth-line (Ehrenbaum 1910, Russel 1976). In view of the possible existence of offshore spawning grounds, the sampling area was extended to the whole Southern Bight.

In the North Sea the sole spawns from early April to August, with a main period in May (Van de Velde 1973, Russel 1976). To cover the major part of the spawning season, four successive surveys were carried out, the first one beginning end of March, and the last one ending end of June. The sampling scheme was adapted to take account of earlier spawning in the South, with a wave of reproductive activity progressively spreading to the North (Russel 1976).

Looking at the Belgian contribution to the project we noticed during the second survey a higher concentration of sole eggs at certain stations in the middle of the Southern Bight, more than 55 km away from the nearest coast. At most of these stations the echo sounder indicated depths exceeding 30 m. In this paper I will examine the question whether this region should be considered spawning area, or if the eggs may have drifted there from the coastal zones.

I want to acknowledge the Fisheries Research Station at Ostend, Belgium, for chartering the fishing-vessel and performing the practical work at sea and the Institute for Scientific Research in Industry and Agriculture, Brussels, Belgium, for subsidizing the research. Special thanks are extended to Ms. Bogaert for technical assistance in the laboratory and to M. Bergmans for reading through this text.

## Materials and Methods

The most substantial Belgian contributions to the international survey were made during the first two surveys (26 March to 5 April and 24 to 28 April) when the area shown in Fig. 1 was sampled. The fishing vessel 'Nieuwpoort 736' was chartered to scan the Southern Bight and the English channel. During the first survey, the stations closest to the Belgian coast were sampled by a vessel of the Belgian navy. Samples were taken by a double-oblique haul to 5 m above the seabottom with a Torpedo/DG III High Speed Plankton Sampler (mesh size 420 $\mu$m) (Beverton & Tungate 1967). During the haul the cable of the Torpedo was slackened and hauled in at a speed of 1 $ms^{-1}$. The towing speed was 5 kn. During the sampling the surface temperature of the water was recorded to allow estimation of the development time of the eggs. The plankton was fixed on deck with a 40% formaldehyde solution, diluting the total sample to a concentration beneath 4%, and transferred to the laboratory. There the samples were sorted and the entire ichthyoplankton was identified to spe-

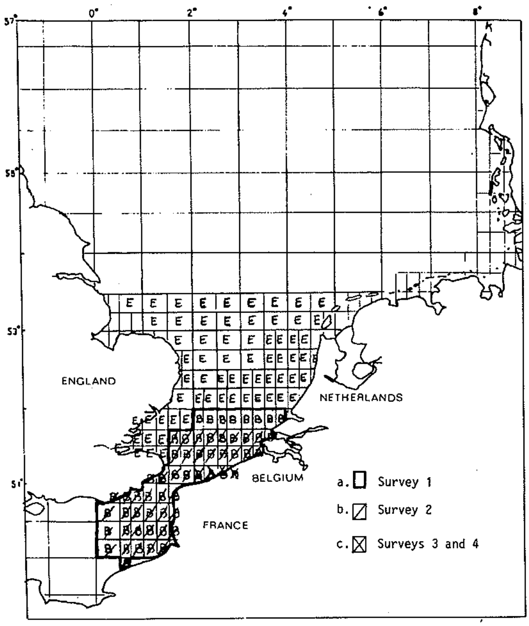


Figure 1. Indication of the Belgian sampling area in the North Sea during the 4 plankton surveys.

cies level on the basis of Russel (1976). Riley (1974) was used to stage the sole eggs.

Directions and strengths of residual currents in the North Sea and the English Channel as calculated by F. Ronday (University of Liége) for winter and summer time are shown in Figs. 2–3. Winter is taken to last 3 months from December to February and the summer months considered are June, July and August. The values of the current strengths are means of several years over the winter and summer period (Djenidi *et al.* 1985). In the straits of Dover and the central part of the Southern Bight the residual currents are directed northward. The velocity of these currents is 0.18 $kmh^{-1}$ on the average in the English Channel, accelerating to 0.48 $kmh^{-1}$ in the Straits of Dover, and slowing down to 0.24 $kmh^{-1}$ in the central part of the Southern Bight. The residual currents along the English and French coasts carry the ichthyoplankton towards the Straits of Dover. Eastwards of these narrows the strongest residual currents are found in the centre of the Southern Bight, though the currents decrease alongside the coasts. The velocity along the English coast is always low (about 0.06 $kmh^{-1}$) whereas that along the Belgian and Dutch coasts is much higher. In winter it goes up to 0.48 $kmh^{-1}$ off the Belgian coast, accelerating to 0.6 $kmh^{-1}$ off the Scheldt estuary, and returning to 0.51 $kmh^{-1}$ along the Dutch coast. The summer velocity off Belgium reaches only 0.2 $kmh^{-1}$ and is even less off Holland (0.03 $kmh^{-1}$).

Meteorological information obtained from the Royal Meteorological Institute (Table 1) shows that no extreme weather conditions such as storms occured which could alter the pattern of the current.

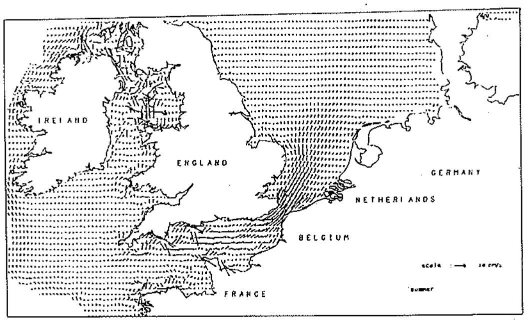


Figure 2. Average current strength and direction vectors in the North Sea and adjacent waters in summer.

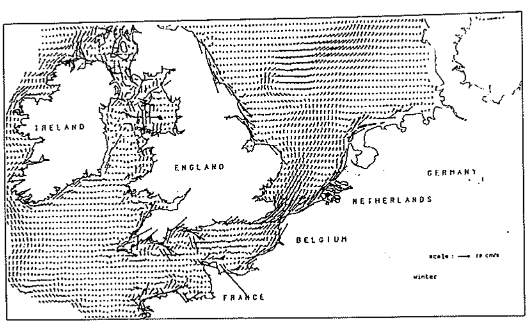


Figure 3. Average current strength and direction vectors in the North Sea and adjacent waters in winter.

# Results

The distribution pattern of sole eggs during the first survey (end of March) indicated two distinct spawning grounds, one along the coast of Normandy and another more important one off the French-Belgian border (Figs. 4 and 5). The patches spread out during the second survey (late April) when we found eggs all over the sampling area. The peak densities, however, again occurred at the same localities. The spawning ground in front of the French-Belgian border was especially

Table 1. *Weather conditions during the period 20 April to 5 May 1984. Information provided by the Royal Meteorological Institute.*

| Date | Windspeed and direction | Temperature of sea (°C) | Direction of waves | Wave-height |
|---|---|---|---|---|
| April 20 | Calm or weak variable wind: 4 to 8 kn. | 8° | variable or from NW | less than 0.25 m |
| 21 | Calm, later SSE to SW: 2 to 10 kn. | 7° to 8° | variable, later SSE | less than 0.25 m |
| 22 | Calm, later NNW to NE: 3 to 24 kn. | 8° | calm, later NNW and NE | less than 0.25 m, later 1m |
| 23 | N to NE: 17 to 25 kn. | 8° | N to NE | 1 m, temporarily 1.5 m |
| 24 | NE: 10 to 24 kn. | 8° | NE | 0.5 to 1 m |
| 25 | NE to E: 6 to 25 kn. | 7° to 9° | NE to ENE | 0.5 to 1 m |
| 26 | N to ENE: 14 to 20 kn. | 7° to 9° | NE | 1 m |
| 27 | N to NE: 16 to 28 kn. | 9° | NE | 1 m |
| 28 | ENE to N: 14 to 20 kn. | 9° | E to N | 1 m |
| 29 | E to SE: 15 to 24 kn. | 7° to 9° | E to SE | 1 to 1.5 m |
| 30 | N to E: 8 to 20 kn. | 9° | N to E | 0.5 to 1 m |
| May 1 | N to NE: 10 to 20 kn. | 9° | E to N | 0.5 to 1 m |
| 2 | N to NE: 10 to 20 kn. | 9° | N to NE | 1 m |
| 3 | Calm to 10 kn. from NE to NW | 9° | NE to NW | less than 0.25 m or 0.5 m |
| 4 | Calm to 16 kn. from NE at the end of the day | 9° | first SW, then calm, ending with NE to NNE | less than 0.25 m or 0.5 m |
| 5 | NE to N: 8 to 21 kn. | 9° | N to NE | 0.5 m or 1 m |

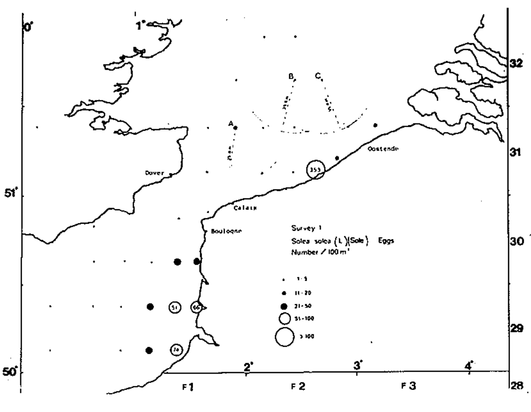


Figure 4. Distribution of sole eggs during the first survey.

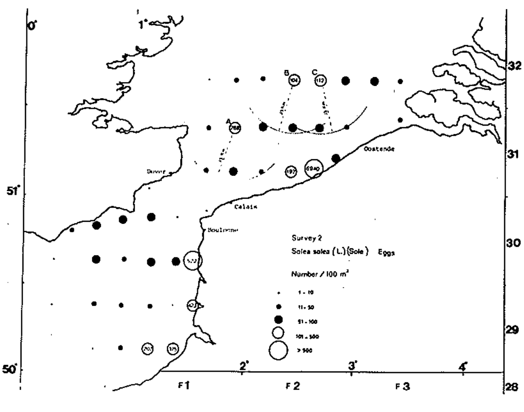


Figure 5. Distribution of sole eggs during the second survey.

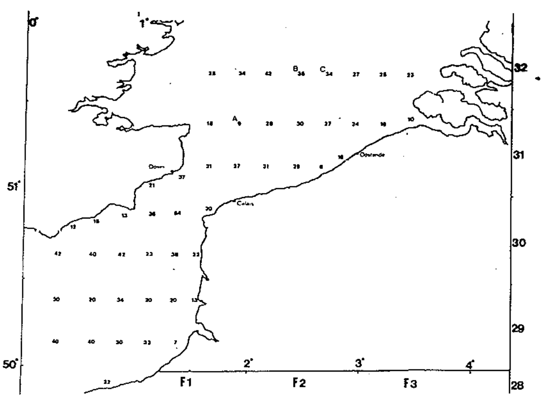

Figure 6. Recorded depth in meters on the sampling stations. Points A, B and C correspond to the stations with the highest sole egg densities in the second survey.

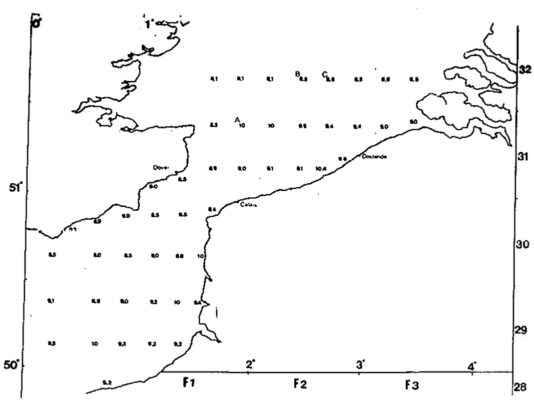

Figure 7. Temperature (°C) of the surface water on the sampling stations. Points A,B and C correspond to the stations with the highest sole egg densities in the second survey.

prominent. Fairly high densities were also observed in the central part of the Southern Bight at stations away from the coasts where the echosounder recorded depths between 20 and 42 m (Fig. 6).

During the four surveys the stage $I_a$ and $I_b$ eggs had always a great majority. The first two surveys their number amounted up to 75% with only a few II and III stage eggs. During the last two surveys the presence of $I_a$ and $I_b$ stage eggs declined to about 50% and the number of II and III stage eggs increased to about 40%. Stage IV eggs were only found sporadically. It is nevertheless not possible to say if this last observation is due to their development or to an increased predatory pressure on older eggs.

## Discussion

The existence of an important spawning ground of soles in Belgian coastal waters confirms previous observations (Van de Velde 1973, De Clerck & Van de Velde 1973, Van de Velde 1975). The spawning ground off the coast of Normandy is situated on the migration route of the soles to the northeast (Beillois *et al.* 1981).

From the current charts (Figs 2 and 3) we know that the eggs encountered in the central waters of the Southern Bight cannot originate from the spawning ground off the Belgian coasts, as the residual current there should carry them along the Dutch coast.

In order to know where these eggs were spawned, the age of the eggs and the velocity and direction of the currents must be known. With the prevailing temperature of about 9°C (Fig. 7), it would take 10 days for the eggs to pass through all its stages (Riley 1974, Russell 1976). This means that the youngest eggs (stage $I_a$ in Riley (1974)) cannot be older than 2 or 3 days. In our samples we encountered a majority of eggs actually belonging to stages $I_a$ and $I_b$.

By considering winter conditions of the current and the maximum possible age of the eggs, it is possible to calculate the maximum distance eggs could have drifted since spawning. Moreover we take a conservative approach by disregarding the fairly strong wind coming from the NE on the sampling day (Table 1, 27 April) which opposed the residual currents coming from the SW.

The currents arrive in the central part of the Southern Bight with an average velocity of 0.48 $kmh^{-1}$. Using this average velocity is justified because no extreme metereological conditions were recorded during the period of interest (Table 1). Planktonic eggs can therefore travel a distance of 35 km in 3 days. Tracing a radius of 35 km in the direction of the current shows that those eggs cannot originate from the English or French coasts. (Fig. 5).

The temperature of the water in the Southern Bight is rather uniform, with slightly lower values in the norternmost stations (Fig. 7) of our sampling area. No extreme values were recorded that could induce soles to spawn before attaining the coastal waters.

Spawning grounds of sole are thought to be limited by the 30 m depth line. A closer examination of the depth of the sampled stations in the central Southern Bight, showed a greather depth in the northernmost stations but a remarkable shallow depth at station A (Fig. 6). The existence of such big differences lead us to examine the seabottom

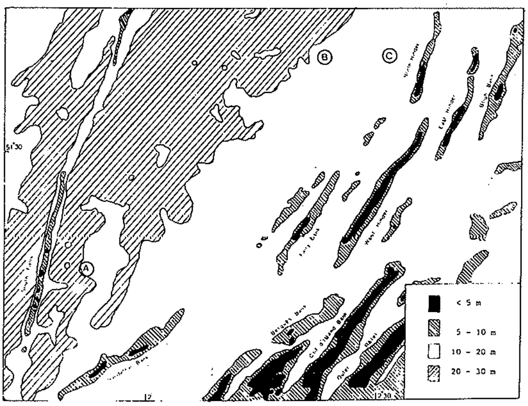


Figure 8. Chart of the bottom topography redrawn from Admirality Chart nr. 1406; points A,B and C as in Figs 4–7.

topography (Admirality Chart number 1406). Sandbanks occur in the studied area (Fig 8): station A is located near the 'South Falls' banks and stations B and C are situated slightly north of the 'Fairy Bank' and the 'West Hinder' and east of the 'Noord Hinder'. All of the stations are located in an area where the prevailing depth is less than 20 m.

The above considerations suggest that soles spawn in shallow water but not necessarily close to the coast. The presence of sole eggs in the middle of the Southern Bight could possibly be explained by adults spawning on or near the sandbanks.

A preliminary synthesis of all available results from the contributing countries indicates that the spawning peak of sole in our sampling area occurred late April – early May. In late May the highest densities off the English coast were found north of the mouth of the Thames. At the same time a very important spawning ground showed up in the German Bight. By late June considerable amounts of sole eggs were found along the English coast just south of 53° N and in the German Bight densities decreased charply in comparison with the previous survey. The definite integration of all results is to be expected by spring 1986.

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