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Results of the spring 2004 North Sea ichthyoplankton surveys

The distribution of fish eggs and larvae from the international ichthyoplankton survey

N. Taylor, C. J. Fox, L. Bolle, M. Dickey-Collas, P. Fossum, G. Kraus, P. Munk, N. Rolf, C. van Damme, and M. Vorbach

ICES CIEM
International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer
H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

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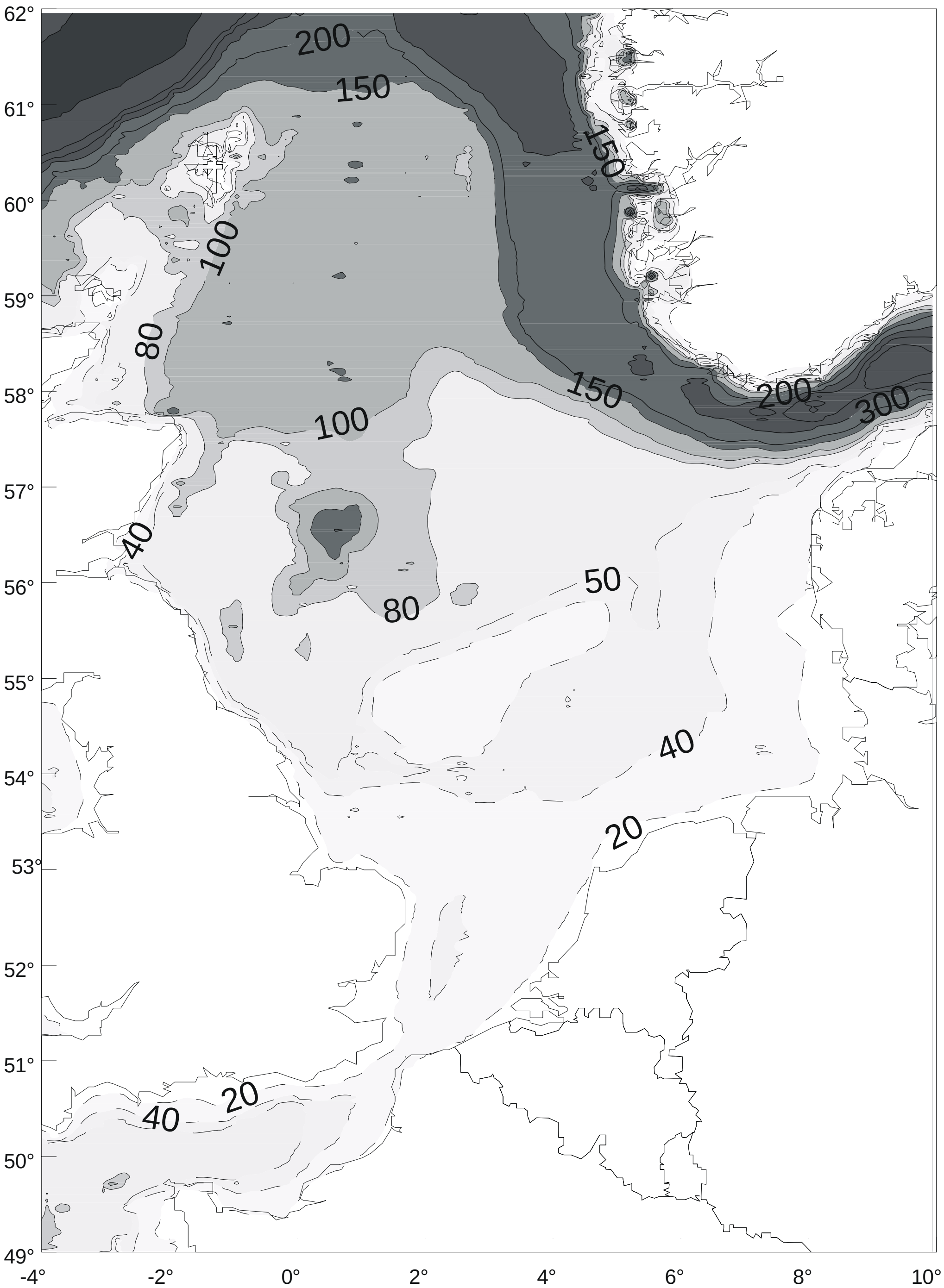

Bathymetry of the North Sea (contours in metres).

1 Introduction

A key recommendation of the meeting of scientific experts, which accompanied the Fifth International Conference on the Protection of the North Sea, 20-21 March 2002, Bergen, Norway, was that there should be regular monitoring of the spawning grounds of important commercial fish species. Up to this point there had never been a comprehensive survey of spawning grounds covering the whole North Sea. The problem was seen as particularly pressing in relation to cod, where a lack of up-to-date information hampered the design of suitable protection measures. In response, ICES set up a planning group (PGEGGS) to review whether a complete North Sea survey targeting eggs and larvae would be feasible. Planning took several years owing to the complex international nature of the problem, but in late 2003 and early 2004, ichthyoplankton surveys covering the whole North Sea were conducted to comprehensively assess the spawning areas of cod and plaice. The survey itself was titled PLACES (Plaice and Cod Egg Survey) to distinguish it from the work of the planning group (PGEGGS). A group of international research institutes took part from England, the Netherlands, Germany, Denmark, and Norway. Subsamples of eggs that were "cod-like" in appearance were presorted from samples at sea and preserved in ethanol for analysis using species-specific genetic probes. The remainder of each sample was preserved in formalin, and the ichthyoplankton were identified later, using traditional visual methods. A full account of the material and methods used, plus initial results of the distributions of cod and plaice spawning, can be found in Fox *et al.* (2005a). Details of the molecular methods used to identify cod-like eggs are reported in Taylor *et al.* (2002). For the cod-like eggs, proportions were assigned, based on the genetic results at each station, but these results are not presented here. This report presents the distributions and abundances of eggs and larvae of the other species identified from the survey series.

2 Survey coverage

Sampling took place between 49 to 62 degrees of latitude north, and 9 degrees of longitude east to 4 degrees west. Because of the size of the area, the North Sea was divided into sectors that were surveyed at varying intervals by individual cruises (Figure 2.1). In all, 927 hauls were made over a period of nearly four months from late December 2003 to early April 2004. The details of each cruise including its primary objective are summarized in Table 2.1. Cruises wholly dedicated to surveying plaice and cod eggs (PLACES cruises) were planned to coincide with the spawning activity of these species, based on historical information. Additional sampling was undertaken opportunistically on a number of cruises in order to improve temporal and spatial coverage.

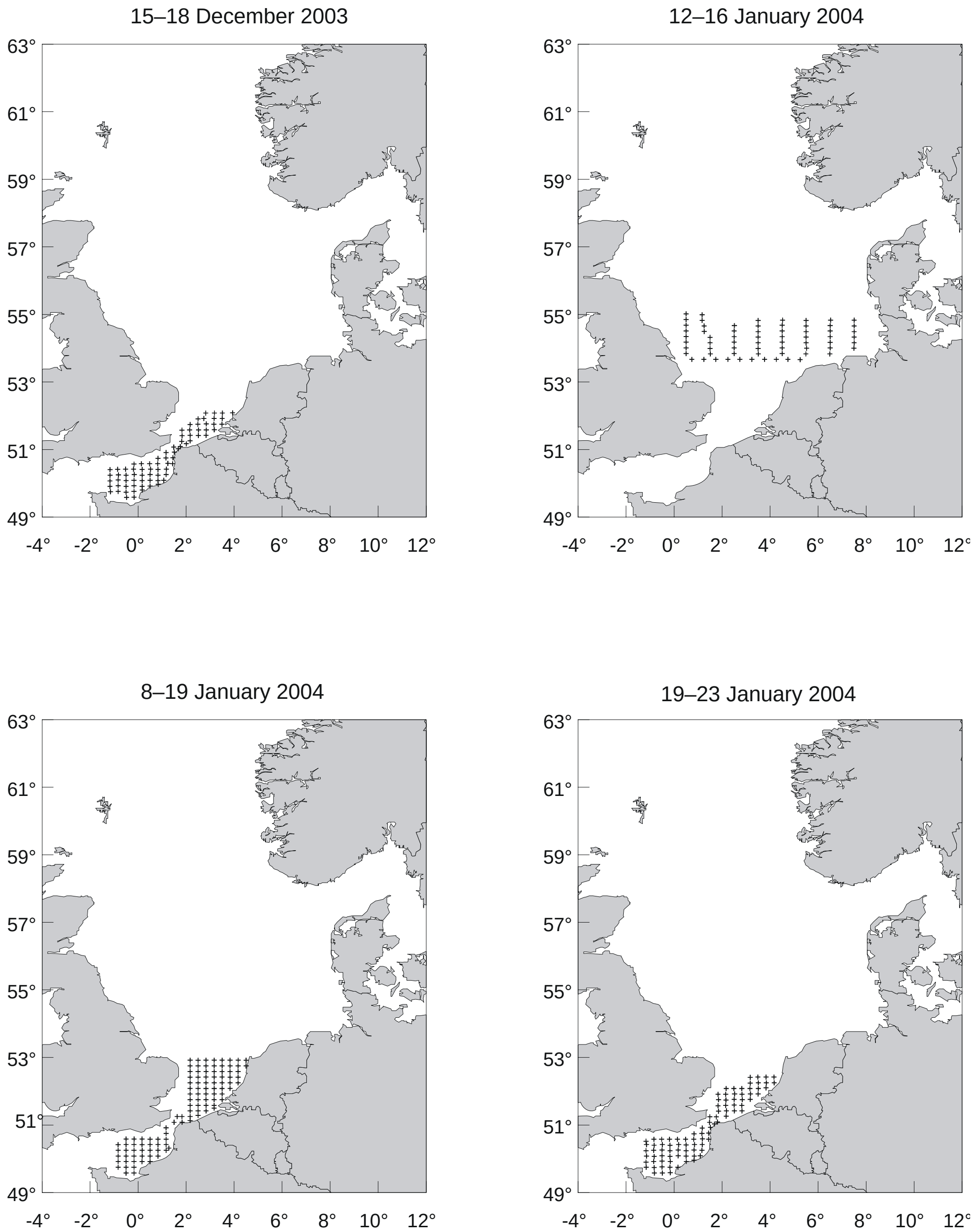

Figure 2.1. Individual survey grids for the 2003 and 2004 ichthyoplankton surveys (continued on the next page).

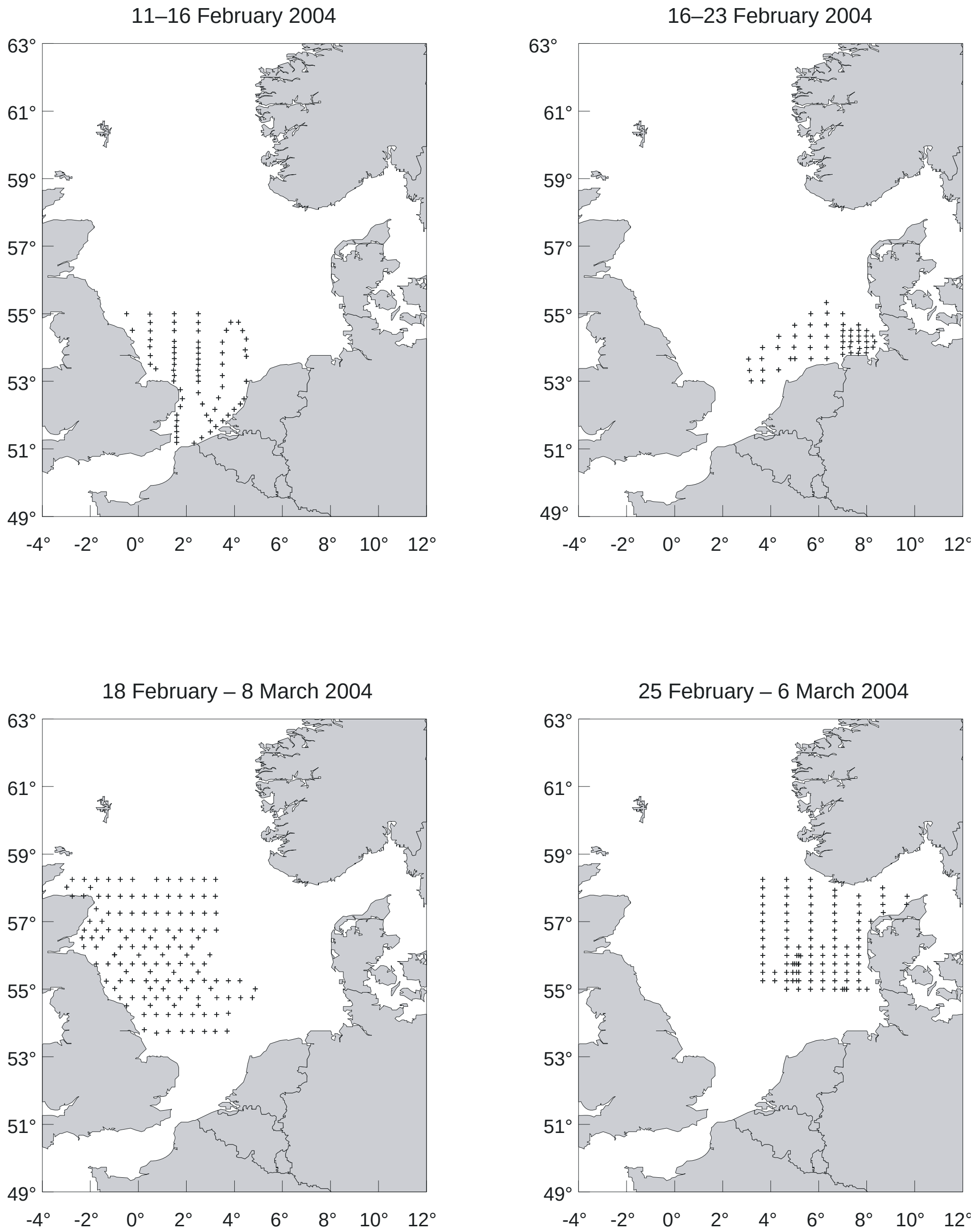

Figure 2.1 continued. Individual survey grids for the 2003 and 2004 ichthyoplankton surveys (continued on the next page).

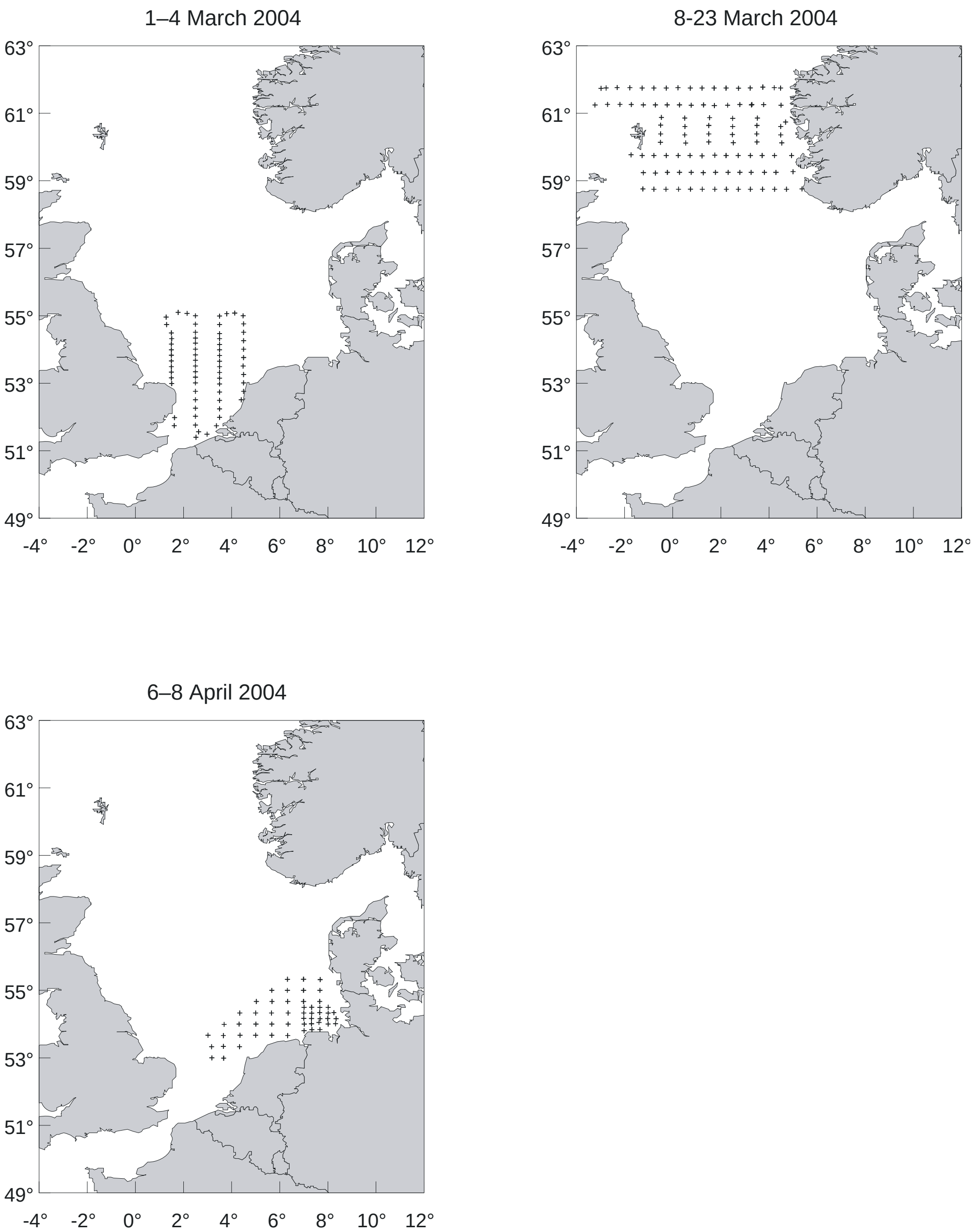

Figure 2.1 continued. Individual survey grids for the 2003 and 2004 ichthyoplankton surveys.

Table 2.1. Details of ichthyoplankton surveys carried out in the North Sea in 2003 and 2004.

Country	Ship	Cruise type	Start	End	Hauls made	Gear	Plankton analysed	Cod-like eggs presorted for geneprobes
Netherlands	Tridens II	Herring larval	15/12/03	18/12/03	77	Gulf III, 20-cm opening*, 270 µm mesh	All eggs, herring larvae	No
Netherlands	Tridens II	PLACES	12/01/04	16/01/04	66	53 cm Gulf VII, 28-cm opening, 270 µm mesh	All eggs	Yes
Germany	Alkor	GLOBEC	08/01/04	19/01/04	108	53 cm Gulf VII, 28-cm opening*, 270 µm mesh	Plaice and cod-like eggs only	None found
Netherlands	Tridens II	Herring larval	19/01/04	23/01/04	92	Gulf III, 20-cm opening*, 270 µm mesh	All eggs, herring larvae	No
Netherlands	Tridens I	PLACES	11/02/04	16/02/04	69	53 cm Gulf VII, 28-cm opening*, 270 µm mesh	All eggs	Yes
Germany	Heinke	PLACES	16/02/04	23/02/04	52	bongo, 60-cm opening*, 500 µm mesh	Cod-like eggs, Pleuronectidae and Clupeidae eggs only. All larvae	Yes
England	Corystes	PLACES	18/02/04	08/03/04	137	76 cm Gulf VII, 40-cm opening*, 270 µm mesh	All eggs and larvae	Yes
Denmark	Dana	PLACES	25/02/04	06/03/04	107	bongo, 60-cm opening*, 330 µm mesh	All eggs. Cod, Pleuronectidae and sandeel larvae	Yes
Netherlands	Tridens II	PLACES	01/03/04	04/03/04	66	53 cm Gulf VII, 28-cm opening*, 270 µm mesh	All eggs, sandeel larvae	Yes
Norway	Haakon Mosby	PLACES	08/03/04	23/03/04	99	Gulf III, 20-cm opening*, 330 µm mesh, Seabird CTD	All eggs and larvae	Yes
Germany	Alkor	PLACES	06/04/04	08/04/04	54	bongo, 60-cm opening*, 500 µm mesh	Cod-like eggs, plaice and Clupeidae eggs only; all larvae	None found

***Opening size indicates diameter of the sampler mouth.**

3 Sampling methods and equipment

3.1 Shipboard plankton sampling

A recommendation was made during planning to standardize sampling gear based on the Gulf VII high-speed plankton sampler (see Nash *et al*. (1998) for specifications). However, owing to different sampling aims and logistical restraints, this proved impracticable, and so a wider variety of gear designs was employed (Table 2.1). In general, the Gulf samplers consisted of an unencased frame fitted with a nose cone of between 20 to 40 cm in aperture diameter. For herring larval cruises (Table 2.1), the standard sampler design was a Gulf III and was encased. Mesh sizes for the main body of the nets ranged from 270 to 330 µm. Plankton was collected in a codend bag constructed using the same mesh size as the main net. Samplers were fitted with CTD sensor units to collect environmental data. On three of the surveys, sampling was carried out using bongo nets with a 60-cm opening and with mesh sizes ranging from 330 to 500 µm.

At each of the station positions, the samplers were deployed in an oblique mode from the surface to within two metres of the seabed (or as close as bottom topography would allow) and returned to the surface. Towing speed was between 3 and 4.5 knots. At shallower stations, multiple oblique tows were undertaken to enable a sufficient volume of water to be filtered. At deeper stations, the samplers were deployed down to a maximum depth of between 100 and 150 metres. It was aimed to produce smooth dive profiles with a minimum duration of 15 minutes to ensure that the same volume of water per unit depth was filtered. Each type of sampler was fitted with one or more flowmeters whose output was subsequently used to calculate the volume of water filtered during each deployment. Details of the volumes filtered by cruise and gear type are shown in Table 3.1.1.

Table 3.1.1. Water volumes filtered.

Country	Ship	Gear	Water volume filtered per station (m^3)				
			n	Min	Max	Mean	Std. dev.
Netherlands	Tridens II	Gulf III, 20-cm opening*, 270 µm mesh	77	14.5	87.0	47.5	17.9
Netherlands	Tridens II	53 cm Gulf VII, 28-cm opening, 270 µm mesh	66	39.9	255.7	137.6	44.9
Germany	Alkor	53 cm Gulf VII, 28-cm opening*, 270 µm mesh	108	6.3	67.8	30.1	14.4
Netherlands	Tridens II	Gulf III, 20-cm opening*, 270 µm mesh	92	21.3	112.1	53.8	17.8
Netherlands	Tridens I	53 cm Gulf VII, 28-cm opening*, 270 µm mesh	69	21.7	233.7	70.8	43.1
Germany	Heinke	bongo, 60-cm opening*, 500 µm mesh	52	24.2	195.0	113.6	40.7
England	Corystes	76 cm Gulf VII, 40-cm opening*, 270 µm mesh	138	211.8	848.7	420.5	94.5
Netherlands	Tridens II	53 cm Gulf VII, 28-cm opening*, 270 µm mesh	66	55.0	188.5	87.4	22.9
Denmark	Dana	bongo, 60-cm opening*, 330 µm mesh	239	306.4	917.7	561.3	124.9
Norway	Haakon Mosby	Gulf III, 20-cm opening*, 330 µm mesh, Seabird CTD	99	31.4	146.3	72.3	24.3
Germany	Alkor	bongo, 60-cm opening*, 500 µm mesh	54	35.8	265.2	125.5	55.7

***Opening size indicates diameter of the sampler mouth.**

3.2 Shipboard sample analysis and preservation

On dedicated PLACES surveys, it was planned to use a genetic method to distinguish the early stage cod eggs from those of haddock, whiting, and some other species whose eggs are visually identical. Full details of this protocol can be found in Fox *et al.* (2005a). In summary, eggs classified as cod-like, that is measuring 1.1 to 1.75 mm in diameter and not possessing oil globules or other characteristic features, were preselected from the fresh plankton samples and assigned a developmental stage according to Thompson and Riley (1981). Note that eggs of all developmental stages were selected during these surveys. The eggs were then transferred to individual tubes containing ethanol in order to preserve high quality DNA. Shipboard sorting continued until up to 100 eggs had been removed from each sample.

This protocol was followed on each survey, with the exception of the Danish cruise on which bongo nets were deployed and two plankton samples retrieved per station. For these samples, all material in one codend was fixed in 4% formalin (4% formaldehyde in distilled water buffered with 2.5% sodium acetate trihydrate (w/v)) for subsequent laboratory sorting, while cod-like eggs were subsampled into ethanol from the other codend. For all other samples, the remainder of the plankton sample was fixed in 4% acetate-buffered formalin and returned to the participating institute for sorting and identification of the ichthyoplankton.

On non-PLACES dedicated cruises, the whole plankton sample was fixed in 4% acetate-buffered formalin for subsequent laboratory sorting. At present, genetic-based identification of fish eggs cannot be reliably undertaken on formaldehyde fixed material, so these cruises were used to provide data on the distribution of plaice eggs (Fox *et al.,* 2005a) and some other species, but not of species producing cod-like eggs.

3.3 Laboratory identification of fish eggs and larvae

Plankton samples were sorted and identified by in-house staff, except for material collected by Denmark; this was analysed by the Institute of Oceanology, Sopot, Poland. Fish eggs were picked out of the preserved samples using low-power microscopy. These were then identified and enumerated, based on size and appearance according to Russell (1976). For eggs to which a developmental stage was assigned, this was done using descriptions given by Simpson (1959) and Thompson and Riley (1981). All eggs lacking oil globules and measuring between 1.1 and 1.75 mm in diameter were classified as cod-like and assigned a developmental stage. Plaice eggs were identified based on their size (>1.75 mm diameter) and thick chorion and were also measured and staged. All participants analysed cod-like and plaice eggs. With the exception of the German samples, eggs lacking oil globules and smaller than 1.1 mm diameter, plus eggs of all sizes with oil globules, were also picked out. These were identified to species level where possible and counted, but not staged. A summary of the analyses undertaken from each survey is given in Table 2.1.

Figure 3.3.1 shows the size frequencies of all eggs lacking oil globules that were measured (i.e. *not* total numbers) and includes those already preselected for genetic analysis. Eggs measuring from approximately 0.8 to 1.2 mm are likely to consist of eggs mainly from species such as dab (*Limanda limanda*) and to a lesser extent flounder (*Platichthys flesus*). Eggs in the range of approximately 1.0 to 1.25 mm in diameter cover a larger range of species including whiting (*Merlangius merlangus*), witch (*Glytocephalus cynoglossus*), *Trisopterus* spp. (Norway pout, poor cod, and bib), and others. Eggs of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) also overlap with the upper end of this range.

Fish eggs were the primary target of most samples analysed (with the exception of the herring larval cruises). Fish larvae were also identified from some surveys, but this varied between institutes, depending on resources available. As a result, all larvae were analysed from only four of the 11 surveys (Table 2.1), and therefore distribution patterns are relatively incomplete. Identification of larvae was carried out following Russell (1976).

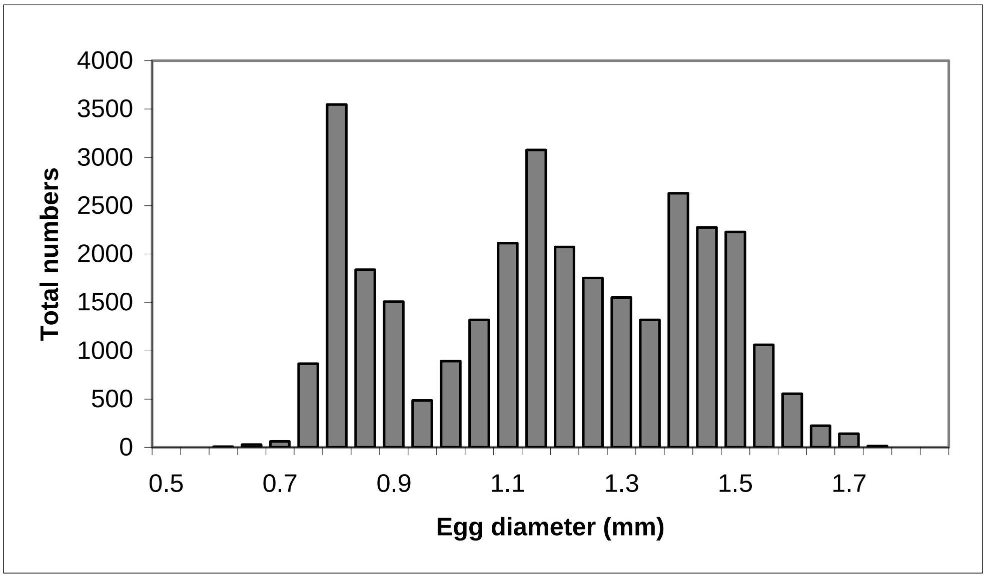

Figure 3.3.1. Size frequencies of all measured, unidentified eggs without oil globules (numbers not raised by sampling volume).

3.4 Application of TaqMan probes to presorted eggs

Eggs for genetic typing were transferred to the University of East Anglia, Norwich, UK, where TaqMan analyses were performed against known standards. Technical details of the TaqMan method for distinguishing eggs of cod, haddock, and whiting are described in Taylor *et al.* (2002) and results of previous applications in the Irish Sea in Fox *et al.* (2005b). Results from the application of the method to the eggs preselected during these 2004 North Sea ichthyoplankton surveys are not presented in this report. However, results of some preliminary modelling and data analysis are described in Fox *et al*. (2005a).

3.5 Data analysis and data storage

Ichthyoplankton data were expressed as numbers of organisms per cubic metre of seawater using estimates of the volume of water filtered at each station derived from the flowmeters. Numbers m^{-3} were then converted to numbers per metre squared of sea surface by multiplying by the depth sampled. The resulting abundance data were plotted as composite bubble distributions (using Surfer version 8, Golden Software Inc., Colorado, USA) on a square root scale, and these are presented here. Bubble diameter is related to the square root of numbers m^{-2} above a non-zero baseline of 0.1 m^{-2}.

4 Results

4.1 The ichthyoplankton

Over the period surveyed, fish eggs from 13 species and larvae from 28 species were identified. For practical reasons, a further three groups of eggs and six groups of larvae were identified to the family or genus level only (e.g. Rocklings, Triglidae spp., Ammodytidae, Gobiidae). All of the species or taxonomic groups found are listed in Tables 4.1.1a–d. These tables also show the maximum densities of eggs and larvae recorded from each survey and their occurrence as a percentage of the stations where a positive record was obtained. Figures 4.1.1 to 4.1.38 map the egg and/or larval distributions for many of the species identified. For ease of presentation, these have been plotted on a combined map of the North Sea covering the full survey period. A + symbol denotes stations where a plankton tow was carried out, but no eggs or larvae of the indicated species were caught.

An important note about coverage

It is important to emphasize that the distribution maps of eggs and larvae are an amalgamation of all the stations sampled over an extended period from mid-December to early April. The timing and duration of these surveys were planned to provide the best coverage of the spawning activity of cod and plaice, and therefore, many species that might occur in the North Sea but spawn only partially within or outside of this period will not be fully described. In addition, depending on the amount of analysis undertaken by each participating institute, not all eggs and particularly larvae were identified from each cruise (Table 3.1.1). Hence, these maps are not intended to represent the total spawning products in either number or total distribution for any given species, and interpretation must be made with reference to Figure 2.1 and Tables 4.1.1a–d.

4.1.1 Unidentifiable (cod-like) eggs without oil globules, egg diameter 1.1 to 1.75 mm (Figure 4.1.1)

Cod (*G. morhua*) and haddock (*M. aeglefinus*) produce eggs that are identical in appearance until embryonic pigmentation develops during development stages IV and V. Therefore, they cannot be positively distinguished using visual means. It has been shown using genetic typing that whiting eggs also overlap significantly in size with these two species (Fox *et al.,* 2005b), further adding to difficulties in identification. In 2004, one of the main aims of the ichthyoplankton surveys was to separate early stage cod eggs from those of haddock, whiting, and other species with similar eggs. All eggs measuring between 1.1 and 1.75 mm in diameter inclusive and lacking an oil globule were classified as cod-like and a subsample of these used for genetic analysis. The occurrence and distribution of all such eggs are shown in Figure 4.1.1. The size frequencies of measured and staged eggs (i.e. a subsample) are included in Figure 3.3.1. Cod-like eggs were found at a large proportion of the stations sampled on most cruises (Table 4.1.1b). However, none were identified from one of the January surveys or the final cruise in April. Highest densities occurred in February and March in the central and southern parts of the North Sea and off the coast of Scotland. Peak abundance was 525.7 eggs m^{-2}. Subsequent application of the TaqMan method revealed that the greatest proportion of the eggs, 48%, were from haddock, 22% from whiting, 18% from cod, and the remaining 12% from other unidentified species (Fox *et al.,* 2005a).

4.1.2 *Clupea harengus* – herring (Figure 4.1.2)

Herring are demersal spawners that deposit their eggs in clusters on the bottom substrate. As a result, the eggs are not caught in ichthyoplankton surveys. The larvae of herring are difficult to distinguish from other Clupeid species, such as sprat (*Sprattus sprattus*) and pilchard (*Sardina pilchardus*). Separation, however, is possible from differences in the number of muscle blocks running the length of the larvae. For this survey series, herring larvae were positively separated by each of the institutes that identified any Clupeid larvae. However, sprat and pilchard larvae were not always separated (see below). In the North Sea, the herring stock comprises several substocks that spawn at different times of the year. Generally, spawning starts in September in the northern North Sea, with a southerly drift of the developing larvae, and ends in January of the following year in the southern North Sea (see references in Nash and Dickey-Collas, 2005). The distribution of herring larvae identified from the 2004 surveys appears to reflect this pattern, and nearly all of the larvae were recorded in the southern North Sea and eastern English Channel in December and January. However, this distribution is heavily biased by the use of data from two surveys that were carried out as part of the International Herring Larvae Surveys coordinated by ICES and thus are entirely dedicated to the sampling of larval herring. On the first of these surveys in December 2003, the highest abundance at a significant 17 108.7 larvae m^{-2} was reached. Relatively fewer herring larvae were identified in the remaining surveys, but this is probably because they missed by some months the peak of spawning in the areas concerned.

4.1.3 *Sprattus sprattus* – sprat (Figures 4.1.3 and 4.1.4)

Sprat eggs are pelagic, 0.8–1.3 mm in diameter, do not possess any oil globules, and are characterized by segmented yolk. Sprat are abundant in northern European waters, particularly in coastal and inshore areas. Spawning takes place in the North Sea from January to July, although sprat are also thought to spawn until September (Torstensen, IMR, Norway, pers. comm.), mainly in the southeastern sector and in the Skagerrak (Munk and Nielsen, 2005). Sprat eggs were recorded on three of the ten surveys that sought to identify them. Highest densities, up to the maximum of 44 eggs m^{-2}, were found off the Dutch and German coasts during early April. Significant numbers were also caught in late February/early March in northwestern and central regions. Figure 4.1.4 shows the abundance of sprat larvae on surveys where they were positively distinguished from other Clupeid larvae, such as herring and pilchard. Sprat larvae were found in low densities in areas similar to the eggs on these surveys. On surveys where sprat larvae were not separated from those of pilchard (i.e. the German cruises in February and March), such larvae were grouped together under the classification of Clupeid (see below).

4.1.4 *Sardina pilchardus* – pilchard and Clupeidae (Figures 4.1.5 and 4.1.6)

The eggs of pilchard measure 1.3–1.9 mm in diameter and are easily recognized by their segmented yolk, single oil globule, and large perivitelline space. Spawning is reported to take place in spring and summer in the southern North Sea. Relatively dense numbers of pilchard eggs were found in central areas of the North Sea during the April survey. Smaller abundances were also recorded as early as mid-February in the south. Pilchard larvae were identified from two surveys in March and April. Maximum densities were 0.4 and 4.7 m^{-2} respectively, and occurrence was restricted to only a few stations. However, as previously mentioned, Clupeid larvae were not always separated and, for presentation purposes, pilchard larvae have been plotted together with the unidentified Clupeid specimens (Figure 4.1.6). Maximum density of Clupeid larvae was 8.6 m^{-2}.

4.1.5 *Argentina sphyraena* – lesser silver smelt (Figure 4.1.7)

Eggs of the lesser silver smelt are relatively large (1.7–1.85 mm) with segmented yolk and a single oil globule. A few eggs of this species were caught during the survey series. Occurrence was confined to the northeast of Scotland in February and March and maximum abundance was 4.1 eggs m^{-2}. No larvae were recorded, although they would be expected to occur throughout most of the year from April onwards.

4.1.6 *Argentina silus* – greater silver smelt (Figure 4.1.8)

The greater silver smelt is essentially a deepwater species that lives close to the seabed. Spawning also takes place in deep water at depths of between 400 and 500 m, and hence it is unlikely that the eggs would be caught during most ichthyoplankton surveys. A small number of the larvae, however, were identified in samples collected from deeper stations in the northern North Sea. The maximum concentration was 2.2 larvae m^{-2}.

4.1.7 *Maurolicus muelleri* – pearlside (Figure 4.1.9)

Pearlside eggs are highly characteristic because they possess a hexagonally sculpted shell, segmented yolk, and a single oil globule. Size ranges from 1.32 to 1.65 mm in diameter. Spawning is reported to take place from March to September in the North Sea. In this survey, series of eggs were found on one cruise in February in the very north. The maximum concentration reached 4.2 eggs m^{-2}. No larvae were reported.

4.1.8 *Gadus morhua* – cod (Figure 4.1.10)

Cod eggs are included in the group of measured eggs with no oil globules (Figures 3.3.1 and 4.1.1). Subsequently, data were worked up to produce maps of cod egg distribution using genetic probe results, but these are not included in this report. Cod larvae were found on each of the surveys that analysed all larvae. Highest abundances (up to 56.9 larvae m^{-2}) occurred in the waters off the German Bight and coast of Denmark in February and March. Relatively high numbers were also caught in the northern North Sea in March, but only few were recorded in the central North Sea.

4.1.9 *Melanogrammus aeglefinus* – haddock (Figure 4.1.11)

Like cod, the eggs of haddock were not identified visually. Instead they were grouped together with eggs of a similar size that lack oil globules (Figures 3.3.1 and 4.1.1) and submitted for genetic typing. The resulting analyses and distributions are not included in this report. Haddock larvae were found mostly in waters off the Scottish coast and in the northern North Sea. Sampling in these areas took place during February and March, and maximum density was 85.3 larvae m^{-2}.

4.1.10 *Merlangius merlangus* – whiting (Figure 4.1.12)

Whiting eggs are presented along with those of cod, haddock, and others that are not identified separately (Figures 3.3.1 and 4.1.1). Russell (1976) stated that whiting eggs range in diameter from 0.97 to 1.32 mm, and thus, larger whiting eggs overlap the lower limit of the cod-like egg grouping. Whiting larvae, although relatively abundant in terms of number, were largely confined to areas to the northeast of Scotland and off the coasts of the Netherlands and Germany. Highest densities were caught in late February to early March. The maximum number recorded was 138 larvae m^{-2}.

4.1.11 *Micromesistius poutassou* – blue whiting (Figure 4.1.13)

Blue whiting eggs are not routinely identified in plankton samples. Adults spawn at depths of between 300 and 400 m, and so eggs are likely to occur beyond depths usually sampled on most ichthyoplankton surveys. In addition, they have no oil globule and range in diameter from 1.04 to 1.28 mm, i.e. similar to many other species, and are thus indistinct. In the 2004 surveys, larvae of blue whiting were found in low numbers in the northern North Sea in March. The pattern of distribution is consistent with spawning in deep water near the edge of the continental shelf. The maximum concentration was 8.7 larvae m^{-2}.

4.1.12 *Trisopterus esmarkii* – Norway pout – and *Trisopterus minutus* – Poor cod (Figure 4.1.14)

The eggs of this species are similar to those of *Trisopterus minutus* (poor cod), *M. merlangus* (whiting), and others, and so are not individually identified in plankton samples. Similarly, the larvae of *T. esmarkii* and *T. minutus* are difficult to distinguish between and are often classified together under the nomenclature Gadidae. In 2004, a mixture of analyses was used, depending on the institute. Larvae were positively identified as Norway pout from the Norwegian survey in March, while for two other surveys in February/March, larvae were recorded as Gadidae. For ease of presentation, these have been plotted together. The vast majority of the larvae consisted of those recorded as Norway pout. Concentrations of between 30 and 145.5 larvae m^{-2} occurred over a large area in the northern North Sea in March. Gadidae were recorded in smaller numbers (maximum 10.7 larvae m^{-2}), mainly off the Scottish coast, but no larvae were positively identified as *T. minutus* during this period.

4.1.13 *Trisopterus luscus* – bib, pout

The eggs of this species lack an oil globule and range in diameter from 0.9 to 1.23 mm. They cannot be readily separated from those of a similar size and appearance, and so are recorded along with the other unidentifiable eggs without an oil globule and measuring less than 1.1 mm in diameter (Figure 3.3.1). A single bib larva (not plotted) was caught off the Scottish coast in February.

4.1.14 *Pollachius pollachius* – pollack (Figure 4.1.15)

Pollack is another species that produces eggs of a size range and appearance similar to many others lacking an oil globule. Their eggs range in diameter from 1.1 to 1.22 mm and, because this overlaps with others such as *M. merlangus* and *T. luscus*, they were not identified separately (Figures 3.3.1 and 4.1.1). In 2004, of the samples that were analysed for larvae, pollack were recorded only from the last survey in April. They were caught in low numbers mainly in the German Bight. Maximum abundance was 3.0 larvae m^{-2}.

4.1.15 *Pollachius virens* – saithe (Figure 4.1.16)

Saithe eggs are similar to those of *P. pollachius* and thus have few distinguishing features. The adults may occur throughout the North Sea, but spawning takes place in the deeper waters of the northern North Sea from January to April. In 2004, large numbers of saithe larvae were recorded in this area in March, and peak abundance was 650 m^{-2}.

4.1.16 *Brosme brosme* – torsk (Figure 4.1.17)

The eggs of *B. brosme* measure 1.29–1.51 mm in diameter, and have a single oil globule, which appears pinkish in colour, and an unsegmented yolk. In the North Sea, this species is restricted to northern waters, and spawning starts in April through to July. Eggs were caught to the east of the Shetland Isles and off the coast of Norway in the April survey. No larvae were recorded.

4.1.17 Rocklings – Gadidae (Figures 4.1.18 and 4.1.19)

Four species of rockling are found in the North Sea: *Ciliata mustela* (five-bearded rockling), *Ciliata septentrionalis* (northern rockling), *Enchelyopus cimbrius* (four-bearded rockling), and *Gaidropsarus vulgaris* (three-bearded rockling). All are members of the family Gadidae. Rockling eggs are small in diameter (0.5–0.99 mm) with a single oil globule, but were not identified to species level in these plankton samples. The adults of *E. cimbrius* and *G. vulgaris* are distributed throughout the North Sea, while *C. mustela* and *C. septentrionalis* are confined to shallow coastal waters. In the 2004 surveys, rockling eggs were found to be relatively abundant and were caught over a wide area, including inshore and in open water. The spawning times of each species, although varied, overlap at least in part with the period sampled, and so eggs of any of these species might have been captured. Highest concentrations were recorded during the later surveys that took place from mid-February onwards. Rockling larvae occurred in low numbers and were found in two main areas, in the northern North Sea in March and in the German Bight in April.

4.1.18 *Molva molva* – ling (Figure 4.1.20)

Ling is generally a deepwater fish and, in the North Sea, its distribution is mainly confined to northern areas. Females spawn between March and July on grounds predominantly to the north of the British Isles, and therefore the eggs are uncommon in the North Sea. A few eggs were observed, however, at a small proportion of the stations in February/March. No larvae were identified from the samples analysed.

4.1.19 Triglidae – gurnards (Figure 4.1.21)

Neither the eggs nor larvae of this group were identified to genus or species. However, of the four species occurring in the North Sea, *Eutrigla gurnardus* (grey gurnard) is the most common, and spawning takes place in spring and summer. *Aspitrigla cuculus* (red gurnard) and the less common *Trigloporus lastoviza* (streaked gurnard) have a more restricted distribution and both spawn in summer. *Trigla lucerna* (tub gurnard) spawn from March to October. As a group, gurnard eggs were relatively widespread in the 2004 surveys. Maximum abundances occurred in January in the southern North Sea, earlier than previously reported, and a few eggs were even identified from the surveys in December and January. The larvae rarely feature strongly in plankton samples, and in 2004, none were reported. Triglidae exhibit a bottom-feeding habit, and it is suggested that the developing larvae quickly drop out of the water column and so are not caught in plankton surveys.

4.1.20 Cottidae – bullheads and sculpins (Figure 4.1.22)

Bullheads and sculpins are a shallow-water family that deposit benthic eggs on rocky or weedy substrate. The younger larval stages are not easily identified to species and have therefore been grouped together as Cottidae. However, based on larger individuals, two species were identified in these surveys, *Myoxocephalus scorpius* (bull-rout) and *Taurulus bubalis* (sea scorpion). For presentation, their numbers have been combined with unidentified specimens, but details for each species can be found in Tables 4.1.1c and d. Cottidae larvae were found in low numbers, mostly in inshore areas, in February and March surveys.

4.1.21 *Agonus cataphractus* – pogge (Figure 4.1.23)

The eggs of this species are benthic. Pogge larvae occurred from February onwards in low concentrations. Most were distributed in the German Bight, and the maximum density recorded was 1.7 larvae m^{-2}.

4.1.22 *Liparis* spp. – sea snail (Figure 4.1.24)

Sea snails are another shallow-water group laying benthic eggs. In the 2004 surveys, they most commonly occurred in shallower water, particularly in the German Bight area. Numbers were low (less than 1.6 larvae m^{-2}), and highest incidence was from the sixth survey of the series, which took place in February.

4.1.23 Ammodytidae – sandeel (Figure 4.1.25)

The eggs of the whole of this group are benthic and are not caught in the plankton. Five species of Ammodytidae occur in the North Sea. *Gymnammodytes semisquamatus* (smooth sandeel) and *Hyperoplus lanceolatus* (greater sandeel) both spawn from late spring to summer and are therefore unlikely to feature as larvae in spring surveys. Of the remaining three species, *Ammodytes marinus* (Raitts sandeel) spawns from November to February, *Hyperoplus immaculatus* (Corbins sandeel) spawns from December to April, while *Ammodytes tobianus* (lesser sandeel) can spawn both in spring and autumn (Munk and Nielsen, 2005). In the North Sea, *A. marinus* is the dominant species. For this survey series, sandeel larvae have not been identified to species, although this is possible using descriptions by Macer (1967) and Russell (1976). The larvae were analysed from half of the surveys in 2004, thus sampling coverage was good compared with most other larval groups/species (Tables 3.1.1 and 4.1.1c–d). Sandeel larvae were relatively abundant on each of these surveys and widely distributed. Peak numbers were found in February and early March, particularly off the coasts of Scotland and in the German Bight. Maximum concentration was 1912.4 larvae m^{-2}.

4.1.24 Callionymidae – dragonets (Figures 4.1.26 and 4.1.27)

The eggs of Callionymidae have a sculpted case and are therefore very distinct. Eggs and larvae of the two most common species occurring in the North Sea have not been separately identified from these surveys. *Callionymus lyra* (common dragonet) is the most abundant and widely distributed dragonet in the North Sea and spawns in spring and summer. *Callionymus maculatus* (spotted dragonet), spawns from April to August, and the eggs and larvae are found over deeper water than *C. lyra* (Wheeler, 1978). A third species, *Callionymus reticulatus* (reticulated dragonet), spawns in the English Channel between April and September and is therefore unlikely to be represented in the 2004 samples. Eggs of the Callionymidae were found in highest abundances during March. Peak numbers (up to 27 eggs m^{-2}) occurred off the northeast coast of Scotland and near the northern limits of the North Sea. The larvae were rare, probably because sampling occurred too early in most areas, and low numbers were caught at isolated positions.

4.1.25 Gobiidae – gobies (Figure 4.1.28)

Gobiidae are a large group of fish common in inshore waters and producing benthic eggs. Up to 13 species are found in the North Sea. Their larvae are not well described, and though easy to identify as a group because of their prominent swimbladder and characteristic pigmentation, they are not routinely identified to species level. In 2004, larvae were relatively widespread and reached their highest abundances off the coasts of England and Scotland in February and March. Maximum concentration was 19.5 larvae m^{-2}.

4.1.26 *Phrynorhombus norvegicus* – Norwegian topknot (Figure 4.1.29)

Norwegian topknot spawn in late spring and summer, so peak spawning is likely to occur later than the period covered by these surveys. Nevertheless, eggs were found in early spring in central parts of the North Sea. Maximum concentration was 10.8 eggs m^{-2}. No larvae were identified.

4.1.27 *Pleuronectes platessa* – plaice (Figures 4.1.30 and 4.1.31)

Preliminary analysis of the distributions of stage I plaice eggs identified by these surveys is presented in Fox *et al.* (2005a). The composite map shown here represents the numbers of all stages of plaice eggs added together. Plaice spawn from late December to May and, because it was one of the target species of the cruise series, most of the surveys were planned over this period to provide suitable temporal coverage. Eggs were caught on every survey from mid-December to April. During the earliest cruise in the southern North Sea and eastern English Channel, eggs were caught at nearly half of the stations sampled, and maximum concentration was 15.6 eggs m^{-2}, indicating that spawning was already underway here. By the end of January in the same areas, maximum numbers reached 117.8 eggs m^{-2}. Similar abundances were found in and to the north of the German Bight in February and March. For the more northerly cruises, peak numbers were comparatively low. Overall, the patterns of plaice spawning were similar to historical results, such as Simpson (1959). From the samples analysed, plaice larvae were most abundant in the same areas as the eggs. Highest concentrations occurred in February and March. The maximum number caught was 19.0 larvae m^{-2}. Plaice larvae were also identified from samples taken off the British coast, but none were found in the northern areas.

4.1.28 *Platichthys flesus* – flounder (Figure 4.1.32)

The eggs of this species have no oil globule and range in diameter from 0.8 to 1.13 mm. They are indistinguishable from eggs of a similar size such as *Limanda limanda* (dab) and *Trisopterus luscus* (bib). The adults inhabit coastal, estuarine, and brackish waters, but spawning is known to occur offshore. Of the samples analysed for larvae, flounder were identified exclusively in those from an area off the coasts of Germany and the Netherlands. Peak numbers in February were 16.6 larvae m^{-2}. This increased to 38.9 larvae m^{-2} during the final survey in April (Table 4.1.1c).

4.1.29 *Limanda limanda* – dab (Figure 4.1.33)

Dab are another species that produce small eggs with no oil globule, making them indistinguishable from similar sized eggs produced by other fish (Figure 3.3.1). Dab larvae were recorded from February, but highest numbers were found in April in the southeastern North Sea. Here, maximum concentrations were 288.2 larvae m^{-2}. Patches of dab larvae were also found in the northern North Sea and off the British coast.

4.1.30 *Microstomus kitt* – lemon sole (Figure 4.1.34)

Lemon sole is reported to spawn in spring and summer at depths of about 100 m. Proportionally few stations in 2004 occurred in water deeper than 100 m, or were only sampled to a maximum of this depth; therefore, the eggs, if present, were liable to be undersampled or missed altogether. In addition, lemon sole eggs can only be positively identified at a late stage of development when a characteristic pigmentation of the embryo is visible, but no late-stage eggs were recorded. A few larvae, however, were recorded on two out of four surveys from which larvae were analysed (Tables 4.1.1c and d).

4.1.31 *Glyptocephalus cynoglossus* – witch (Figure 4.1.35)

Like those of *M. kitt*, witch eggs can only be identified in the late embryonic stages. However, no late-stage witch eggs were recorded in the 2004 surveys. Larvae were found in low densities in isolated patches. The highest concentration (6.8 larvae m^{-2}) occurred in March.

4.1.32 *Hippoglossoides platessoides* – long rough dab (Figures 4.1.36 and 4.1.37)

The eggs of long rough dab range from 1.38 to 3.5 mm in diameter (Munk and Nielsen, 2005), having a characteristic large perivitelline space and no oil globule. The adults occur throughout the North Sea, and spawning takes place from January to May. In 2004, the highest abundances of long rough dab eggs were caught from mid-February on the more northerly cruises. Peak numbers occurred to the northwest of the German Bight and in the waters between the Shetland Isles and Norway (79.6 eggs m^{-2} and 93.9 eggs m^{-2}, respectively). In comparison, few were identified in the southern North Sea and English Channel during the period sampled. The larvae were also distributed mainly in the northern North Sea, where they occurred in relatively high numbers at several stations.

4.1.33 *Solea solea* – sole (Figure 4.1.38)

Spawning of sole in the North Sea occurs mainly in southern areas and takes place from spring to early summer. Previous egg distribution studies reported first spawning in March in the Southern Bight, developing northwards along coastal areas as the season progressed (van

Beek, 1989). In 2004, similar spatial patterns were found. In the 2004 surveys, sole eggs were identified in their highest abundance (up to 9.1 eggs m^{-2}) from the samples collected in January. Because peak spawning has been shown to occur in April or May (van Beek, 1989; van der Land, 1991), these surveys would have missed the real maximum of egg production. A single sole larva was identified in the April survey (Tables 4.1.1c and d) near the Dutch coast (not plotted).

Table 4.1.1a. List of identified species occurring as eggs and the maximum density on each of the surveys in the North Sea in 2003 and 2004. Species marked * have been plotted.

	Maximum concentrations (nos. m^{-2})										
	2003	2004									
Species	15–18 Dec	12–16 Jan	8–19 Jan	19–23 Jan	11–16 Feb	16–23 Feb	18 Feb–8 Mar	25 Feb–6 Mar	1–4 Mar	8–23 Mar	6–8 Apr
*Sprattus sprattus**	0	0	–	0	0	0	35.2	0	0	5.0	43.5
*Sardina pilchardus**	0	0	–	0	4.6	0	0	0	0	0	21.9
*Argentina sphyraena**	0	0	–	0	0	–	1.7	0	0	4.1	–
*Maurolicus muelleri**	0	0	–	0	0	–	0	0	0	4.2	–
*Brosme brosme**	0	0	–	0	0	–	0	0	0	11.2	–
Rocklings (Gadidae)*	0	2.0	–	0	7.1	–	44.8	110.3	20.4	29.6	–
*Molva molva**	0	0	–	0	0	–	0.2	0	0	0	–
Triglidae*	0.7	0.5	–	109.4	1.1	–	3.3	0	0.8	7.6	–
Callionymiidae*	0	0	–	2.8	0	–	26.9	0	0	10.6	–
Scophthalmus maximus	0	0	–	0	0	–	0	0	0	3.8	–
*Phrynorhombus norvegicus**	0	0	–	0	0	–	10.8	0	0	3.8	–
Zeugopterus punctatus	0	0	–	0	0	–	4.5	0	0	0	–
*Pleuronectes platessa**	15.6	18.6	113.9	117.8	59.5	120.1	81.9	46.2	42.4	4.5	1.0
*Hippoglossoides platessoides**	0	0	–	0	1.7	0	67.0	79.6	9.9	93.9	–
*Solea solea**	0	0	–	9.1	1.7	–	0	0	0.4	1.3	–
Buglossidium luteum	0	0	–	0	0	–	0.5	0	0	1.2	–
Cod-like eggs 1.1–1.75 mm*	53.0	22.5	0	279.5	166.8	121.3	525.7	91.0	295.6	252.8	0
Unidentified eggs <1.1 mm	11.3	152.7	–	709.2	974.6	–	1261.7	2385.9	1591.3	255.6	–
Number of stations worked	77	66	108	92	69	52	137	107	66	99	54

– indicates data not available.

Table 4.1.1b. List of identified species occurring as eggs and their frequency (as percentage of stations where at least one egg was found) on each of the surveys in the North Sea in 2003 and 2004.

	% Positive stations										
	2003	2004									
Species	15–18 Dec	12–16 Jan	8–19 Jan	19–23 Jan	11–16 Feb	16–23 Feb	18 Feb–8 Mar	25 Feb–6 Mar	1–4 Mar	8–23 Mar	6–8 Apr
Sprattus sprattus	0	0	–	0	0	0	29.9	0	0	1.0	68.5
Sardina pilchardus	0	0	–	0	2.9	0	0	0	0	0	42.6
Argentina sphyraena	0	0	–	0	0	–	3.6	0	0	1.0	–
Maurolicus muelleri	0	0	–	0	0	–	0	0	0	5.1	–
Brosme brosme	0	0	–	0	0	–	0	0	0	5.1	–
Rocklings (Gadidae)	0	1.5	–	0	24.6	–	31.4	21.5	13.6	11.1	–
Molva molva	0	0	–	0	0	–	2.2	0	0	0	–
Triglidae	1.3	4.5	–	15.2	2.9	–	50.4	0	3.0	16.2	–
Callionymiidae	0	0	–	3.3	0	–	40.1	0	0	28.3	–
Scophthalmus maximus	0	0	–	0	0	–	0	0	0	2.0	–
Phrynorhombus norvegicus	0	0	–	0	0	–	10.9	0	0	2.0	–
Zeugopterus punctatus	0	0	–	0	0	–	0.7	0	0	0	–
Pleuronectes platessa	46.7	83.3	61.1	77.2	60.9	71.2	73.0	75.7	80.3	18.2	13.0
Hippoglossoides platessoides	0	0	–	0	4.3	0	73.7	54.2	43.9	51.5	–
Solea solea	0	0	–	4.3	5.8	–	0	0	4.5	1.0	–
Buglossidium luteum	0	0	–	0	0	–	1.5	0	0	1.0	–
Cod-like eggs 1.1–1.75 mm	48.0	66.7	0	93.5	81.2	80.8	95.6	90.6	98.5	76.8	0
Unidentified eggs <1.1 mm	36.4	50.0	–	81.5	72.5	–	95.9	84.1	98.5	70.7	–
Number of stations worked	77	66	108	92	69	52	137	107	66	99	54

– indicates data not available.

Table 4.1.1c. List of identified species occurring as larvae and the maximum density on each of the surveys in the North Sea in 2003 and 2004. Species marked * have been plotted.

	Maximum concentrations (nos. m^{-2})										
	2003	2004									
Species	15–18 Dec	12–16 Jan	8–19 Jan	19–23 Jan	11–16 Feb	16–23 Feb	18 Feb–8 Mar	25 Feb–6 Mar	1–4 Mar	8–23 Mar	6–8 Apr
Clupeidae*	–	–	–	–	–	0	1.6	–	–	0	8.6
*Clupea harengus**	17108.7	–	–	934.3	–	9.9	0.4	–	–	1.2	1.8
*Sprattus sprattus**	–	–	–	–	–	0	5.1	–	–	0	0
*Sardina pilchardus**	–	–	–	–	–	0	0.4	–	–	0	4.7
*Argentina silus**	–	–	–	–	–	0	0	–	–	2.2	0
*Gadus morhua**	–	–	–	–	–	6.9	1.6	56.9	–	13.6	0.4
*Melanogrammus aeglefinus**	–	–	–	–	–	0	85.3	–	–	70.4	0
*Merlangius merlangus**	–	–	–	–	–	20.0	138.2	–	–	9.1	11.4
*Micromesistius poutassou**	–	–	–	–	–	0	0	–	–	8.7	0
Gadidae*†	–	–	–	–	–	0.5	10.7	–	–	0	0
*Trisopterus esmarkii**†	–	–	–	–	–	0	0	–	–	145.5	0
Trisopterus luscus	–	–	–	–	–	0	0.5	–	–	0	0
*Pollachius pollachius**	–	–	–	–	–	0	0	–	–	0	3.0
*Pollachius virens**	–	–	–	–	–	0	0.2	–	–	650.0	0
Rocklings (Gadidae)*	–	–	–	–	–	0.4	0.8	–	–	2.4	3.8
Cottidae*‡	–	–	–	–	–	0	0.2	–	–	0	0
*Myoxocephalus scorpius**‡	–	–	–	–	–	0.4	0	–	–	1.9	0
*Taurulus bubalis**‡	–	–	–	–	–	0.7	0	–	–	0	0
*Agonus cataphractus**	–	–	–	–	–	1.7	0.1	–	–	0	0.1
Cyclopterus lumpus	–	–	–	–	–	0	0	–	–	0	0.1
Liparis spp.*	–	–	–	–	–	1.5	0.5	–	–	0	0.5
Anarhichas lupus	–	–	–	–	–	0	0	–	–	2.0	0
Chirolophis ascanii	–	–	–	–	–	0	0.9	–	–	0	0
Pholis gunnellus	–	–	–	–	–	0.2	0	–	–	0	0
Ammodytidae*	–	–	–	–	–	664.4	1912.4	946.1	303.8	123.6	69.7
Callionymiidae*	–	–	–	–	–	0	0.2	–	–	2.7	0
Gobiidae*	–	–	–	–	–	0.2	19.5	–	–	6.3	0
Scophthalmus rhombus	–	–	–	–	–	0	0	–	–	4.5	0
Scophthalmus maximus	–	–	–	–	–	0	0	–	–	3.8	0
Right-eyed flatfish	–	–	–	–	–	0	0	303.4	–	0	0
*Pleuronectes platessa**	–	–	–	–	–	10.6	8.0	19.0	–	0	0
*Platichthys flesus**	–	–	–	–	–	16.6	0	–	–	0	38.9
*Limanda limanda**	–	–	–	–	–	29.6	24.0	–	–	23.1	288.2
*Microstomus kitt**	–	–	–	–	–	0	1.4	–	–	0	0.4
*Glyptocephalus cynoglossus**	–	–	–	–	–	0	0.5	–	–	6.8	0
*Hippoglossoides platessoides**	–	–	–	–	–	0	1.9	–	–	54.5	0
Solea solea	–	–	–	–	–	0	0	–	–	0	0.2
Unidentified larvae	–	–	–	–	–	0	13.4	–	68.6	30.3	0
Number of stations worked	77	66	108	92	69	52	137	107	66	99	54

† plotted together.

‡ plotted together as Cottidae.

– indicates data not available.

Table 4.1.1d. List of identified species occurring as larvae and their frequency (as percentage of stations where at least one larva was found) on each of the surveys in the North Sea in 2003 and 2004.

	% Positive stations										
	2003	2004									
Species	15–18 Dec	12–16 Jan	8–19 Jan	19–23 Jan	11–17 Feb	16–23 Feb	18 Feb–8 Mar	25 Feb–6 Mar	1–4 Mar	8–23 Mar	6–8 Apr
Clupeidae	–	–	–	–	–	0	2.9	–	–	0	24.1
Clupea harengus	59.7	–	–	88.0	–	21.2	10.9	–	–	1.0	25.9
Sprattus sprattus	–	–	–	–	–	0	10.2	–	–	0	0
Sardina pilchardus	–	–	–	–	–	0	4.4	–	–	0	1.9
Argentina silus	–	–	–	–	–	0	0	–	–	4.0	0
Gadus morhua	–	–	–	–	–	44.2	12.4	24.3	–	23.2	9.3
Melanogrammus aeglefinus	–	–	–	–	–	0	28.5	–	–	37.4	0
Merlangius merlangus	–	–	–	–	–	36.5	8.0	–	–	4.0	53.7
Micromesistius poutassou	–	–	–	–	–	0	0	–	–	4.0	0
Gadidae	–	–	–	–	–	1.9	10.2	–	–	0	0
Trisopterus esmarkii	–	–	–	–	–	0	0	–	–	53.5	0
Trisopterus luscus	–	–	–	–	–	0	0.7	–	–	0	0
Pollachius pollachius	–	–	–	–	–	0	0	–	–	0	11.1
Pollachius virens	–	–	–	–	–	0	0.7	–	–	55.6	0
Rocklings (Gadidae)	–	–	–	–	–	1.9	2.2	–	–	3.0	18.5
Cottidae	–	–	–	–	–	0	1.5	–	–	0	0
Myoxocephalus scorpius	–	–	–	–	–	7.7	0	–	–	2.0	0
Taurulus bubalis	–	–	–	–	–	1.9	0	–	–	0	0
Agonus cataphractus	–	–	–	–	–	9.6	1.5	–	–	0	1.9
Cyclopterus lumpus	–	–	–	–	–	0	0	–	–	0	1.9
Liparis spp.	–	–	–	–	–	17.3	1.5	–	–	0	7.4
Anarhichas lupus	–	–	–	–	–	0	0	–	–	1.0	0
Chirolophis ascanii	–	–	–	–	–	0	2.9	–	–	0	0
Pholis gunnellus	–	–	–	–	–	1.9	0	–	–	0	0
Ammodytidae	–	–	–	–	–	61.5	51.1	41.1	72.7	13.1	64.8
Callionymiidae	–	–	–	–	–	0	1.5	–	–	2.0	0
Gobiidae	–	–	–	–	–	1.9	83.2	–	–	6.1	0
Scophthalmus rhombus	–	–	–	–	–	0	0	–	–	3.0	0
Scophthalmus maximus	–	–	–	–	–	0	0	–	–	2.0	0
Right-eyed flatfish	–	–	–	–	–	0	0	21.5	–	0	0
Pleuronectes platessa	–	–	–	–	–	11.5	14.6	23.4	–	0	0
Platichthys flesus	–	–	–	–	–	32.7	0	–	–	0	50.0
Limanda limanda	–	–	–	–	–	67.3	25.5	–	–	5.1	59.3
Microstomus kitt	–	–	–	–	–	0	2.9	–	–	0	1.9
Glyptocephalus cynoglossus	–	–	–	–	–	0	5.1	–	–	1.0	0
Hippoglossoides platessoides	–	–	–	–	–	0	16.1	–	–	24.2	0
Solea solea	–	–	–	–	–	0	0	–	–	0	1.9
Unidentified larvae	–	–	–	–	–	0	39.4	–	12.1	31.3	0
Number of stations worked	77	66	108	92	69	52	137	107	66	99	54

– indicates data not available.

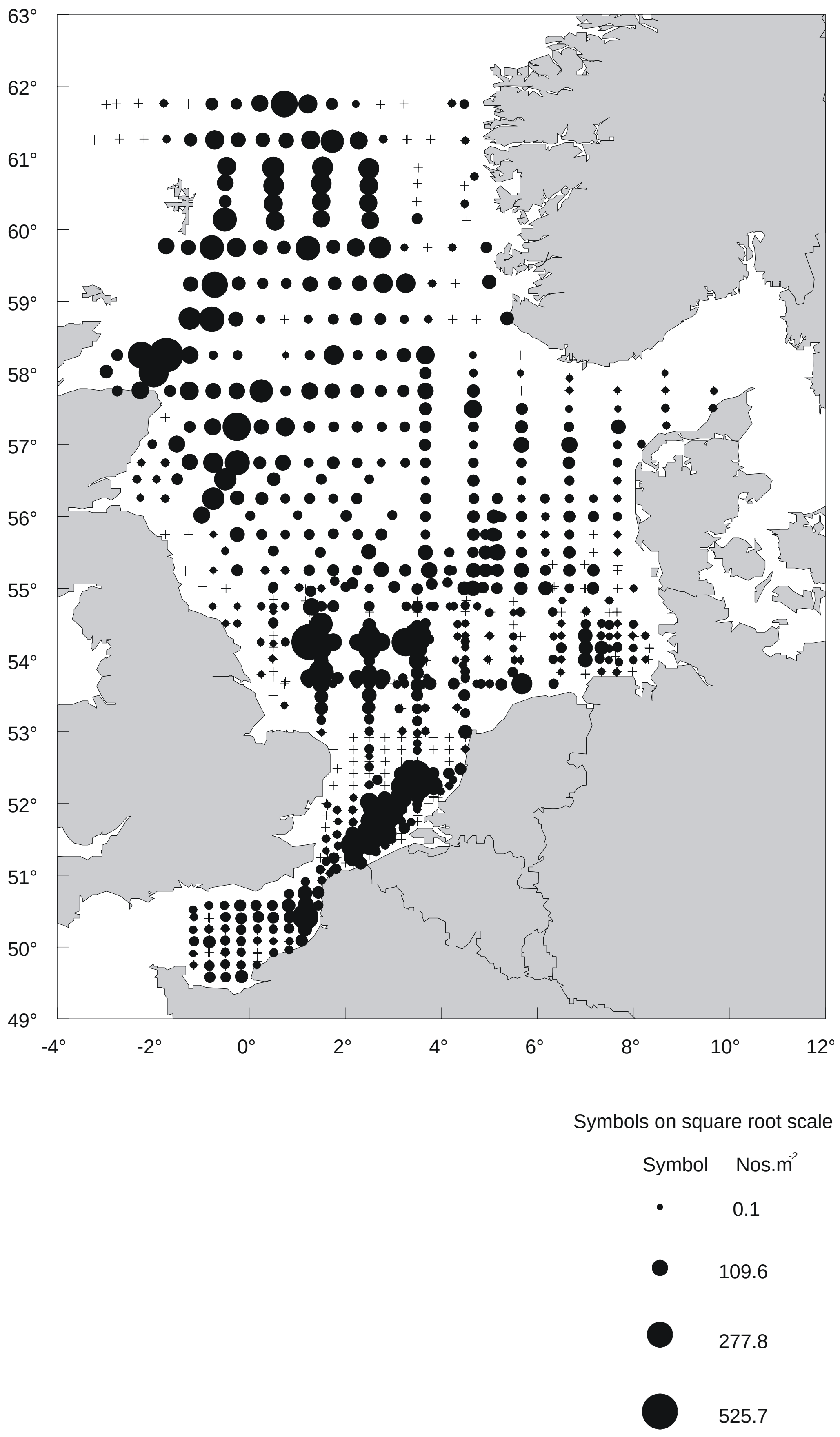

Figure 4.1.1. Composite map of abundance (nos. m^{-2}) of unidentified (cod-like) eggs, 1.1–1.75 mm in diameter, lacking oil globules.

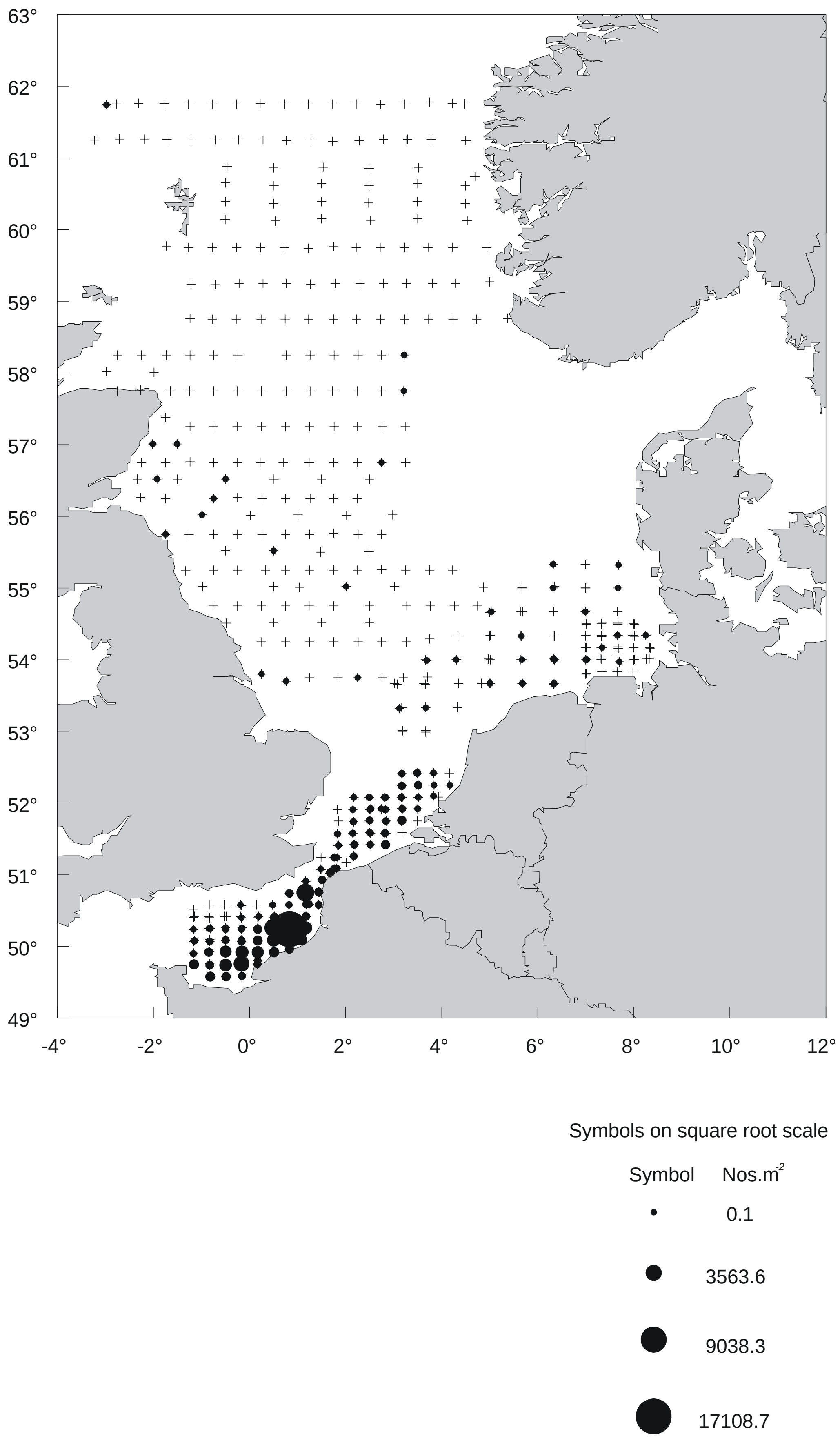

Figure 4.1.2. Composite map of herring (*Clupea harengus*) larval abundance (nos. m^{-2}) in 2004.

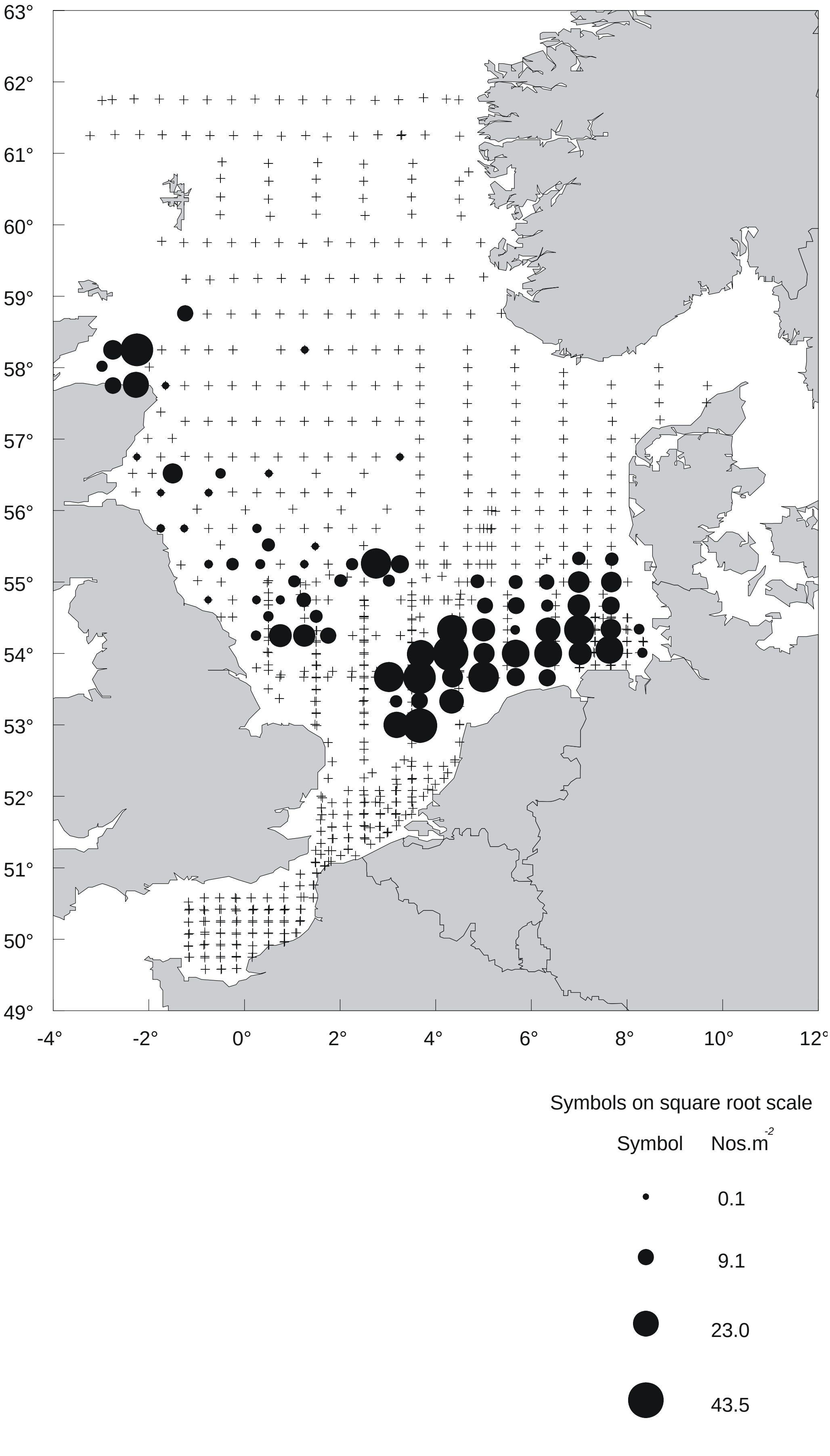

Figure 4.1.3. Composite map of sprat (*Sprattus sprattus*) egg abundance (nos. m^{-2}) in 2004.

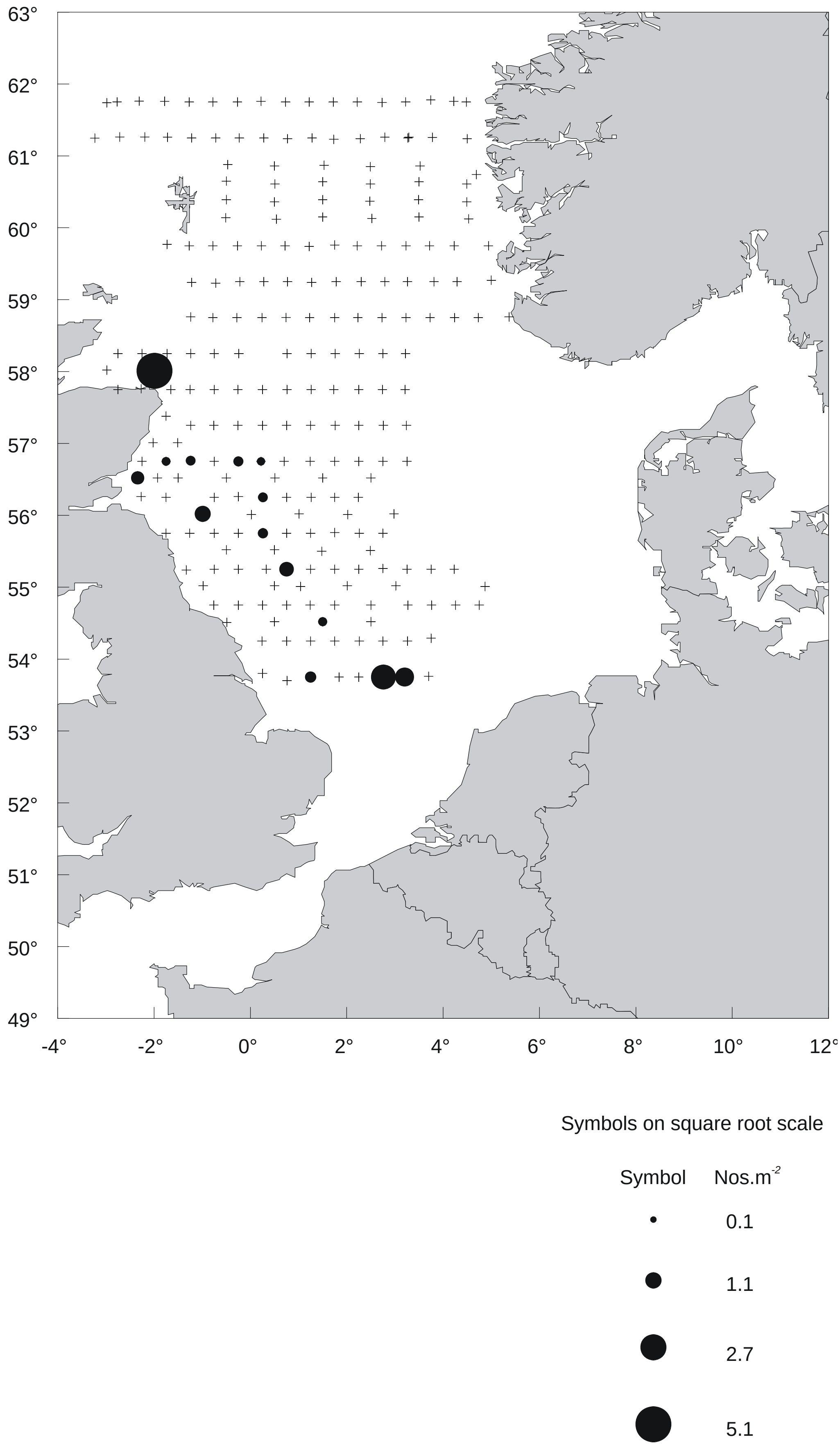

Figure 4.1.4. Composite map of sprat (*Sprattus sprattus*) larval abundance (nos. m^{-2}) in 2004.

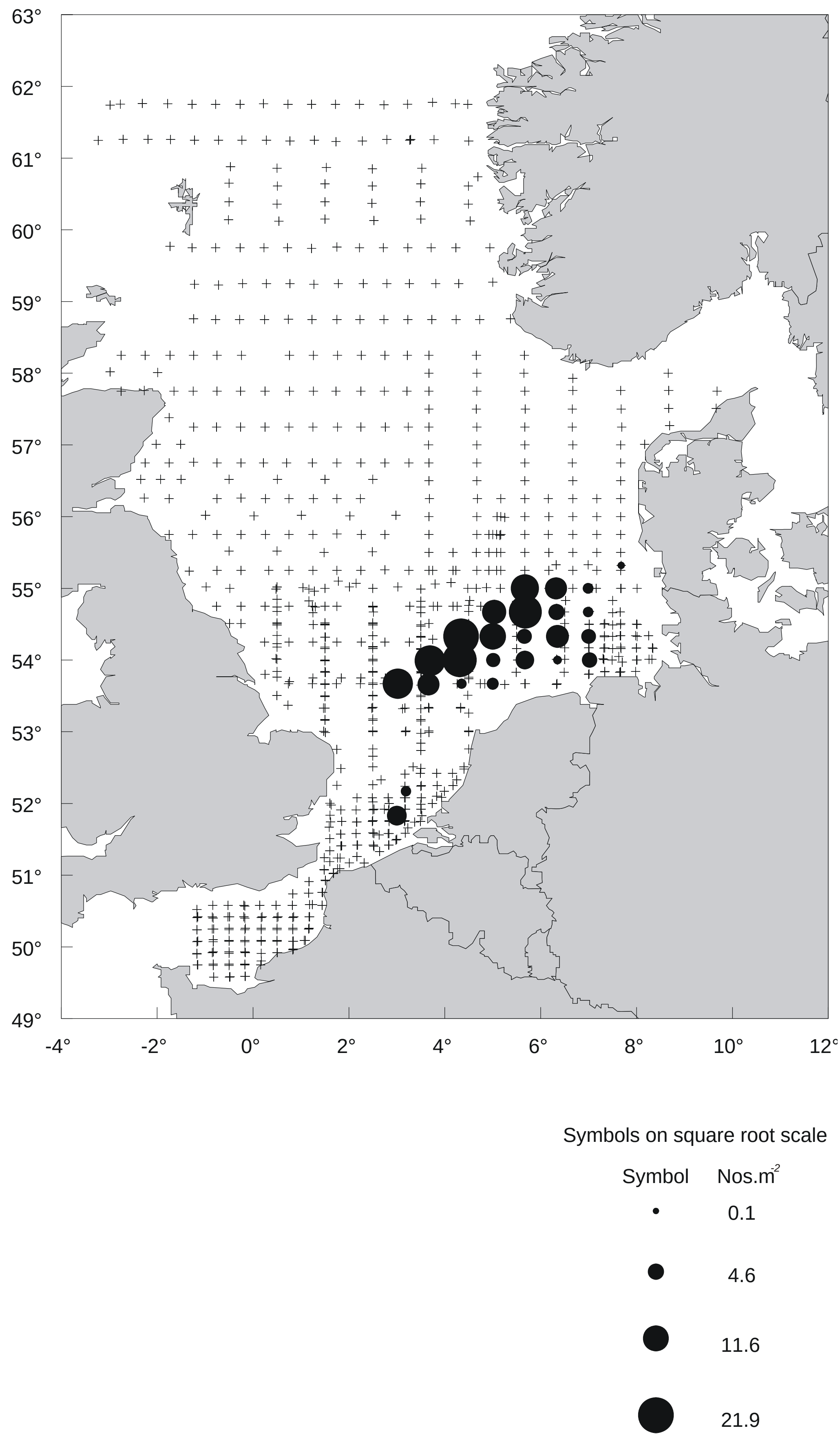

Figure 4.1.5. Composite map of pilchard (*Sardina pilchardus*) egg abundance (nos. m^{-2}) in 2004.

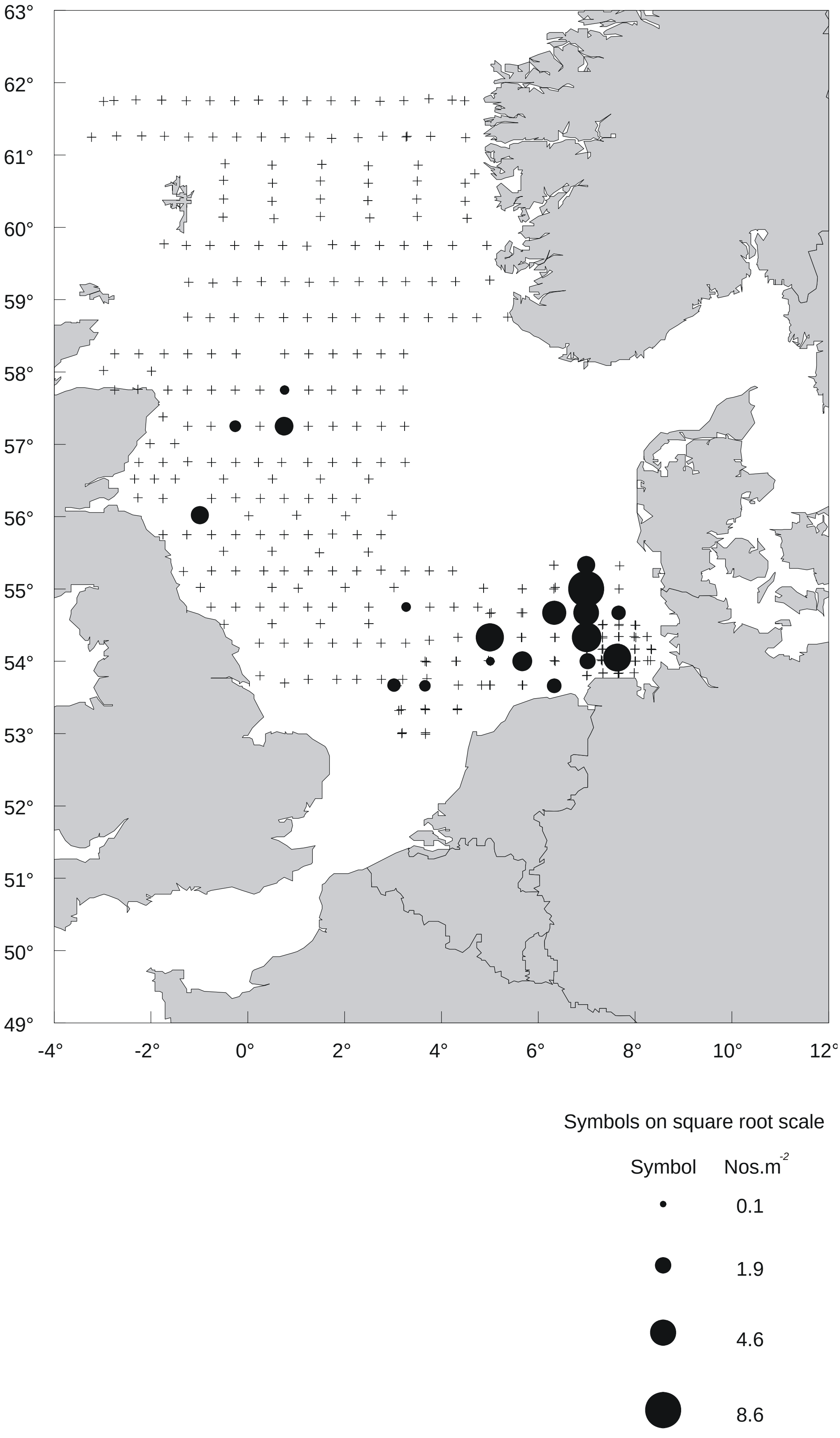

Figure 4.1.6. Composite map of pilchard (*Sardina pilchardus*) and Clupeidae larval abundance (nos. m^{-2}) in 2004.

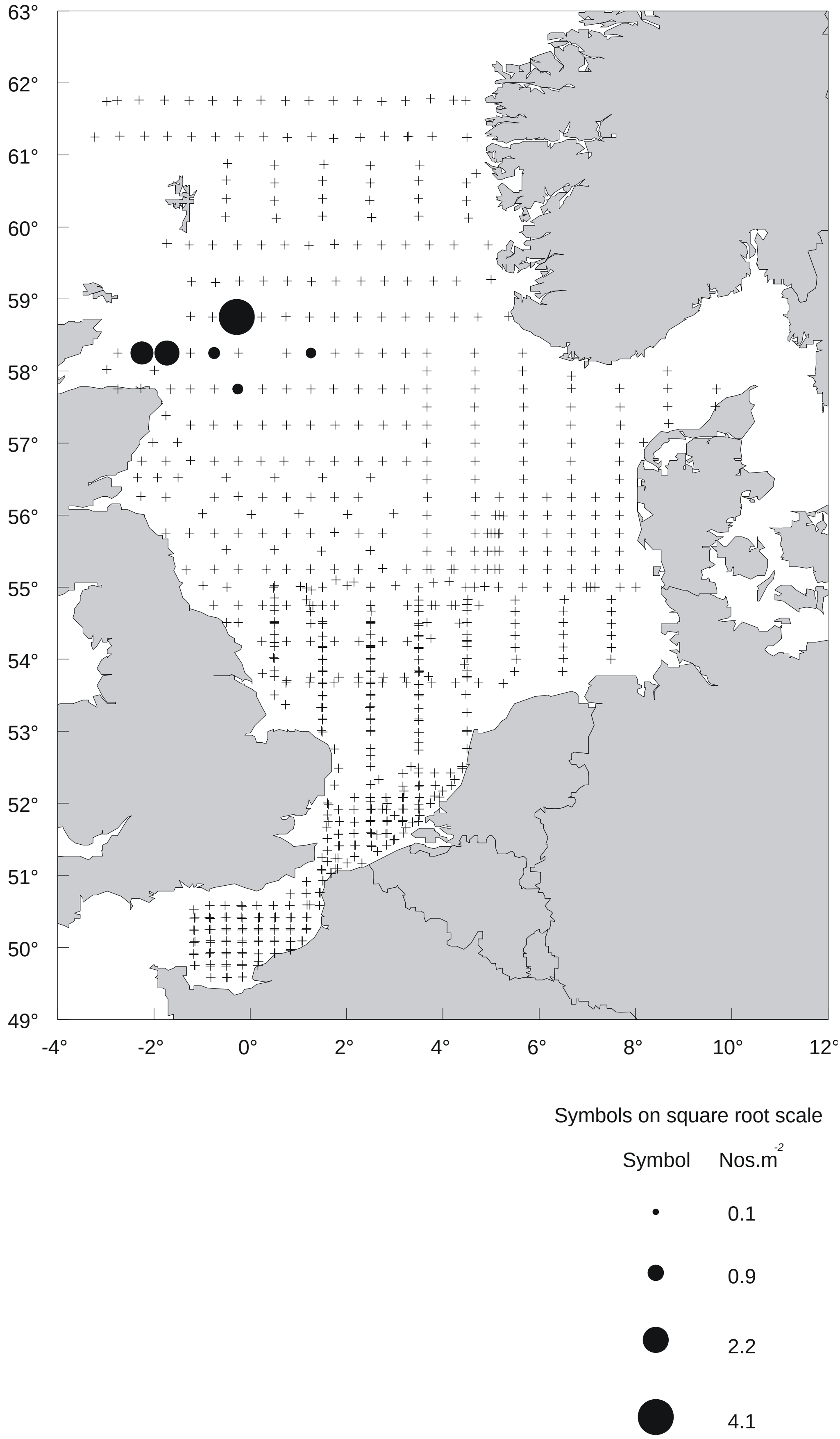

Figure 4.1.7. Composite map of lesser silver smelt (*Argentina sphyraena*) egg abundance (nos. m^{-2}) in 2004.

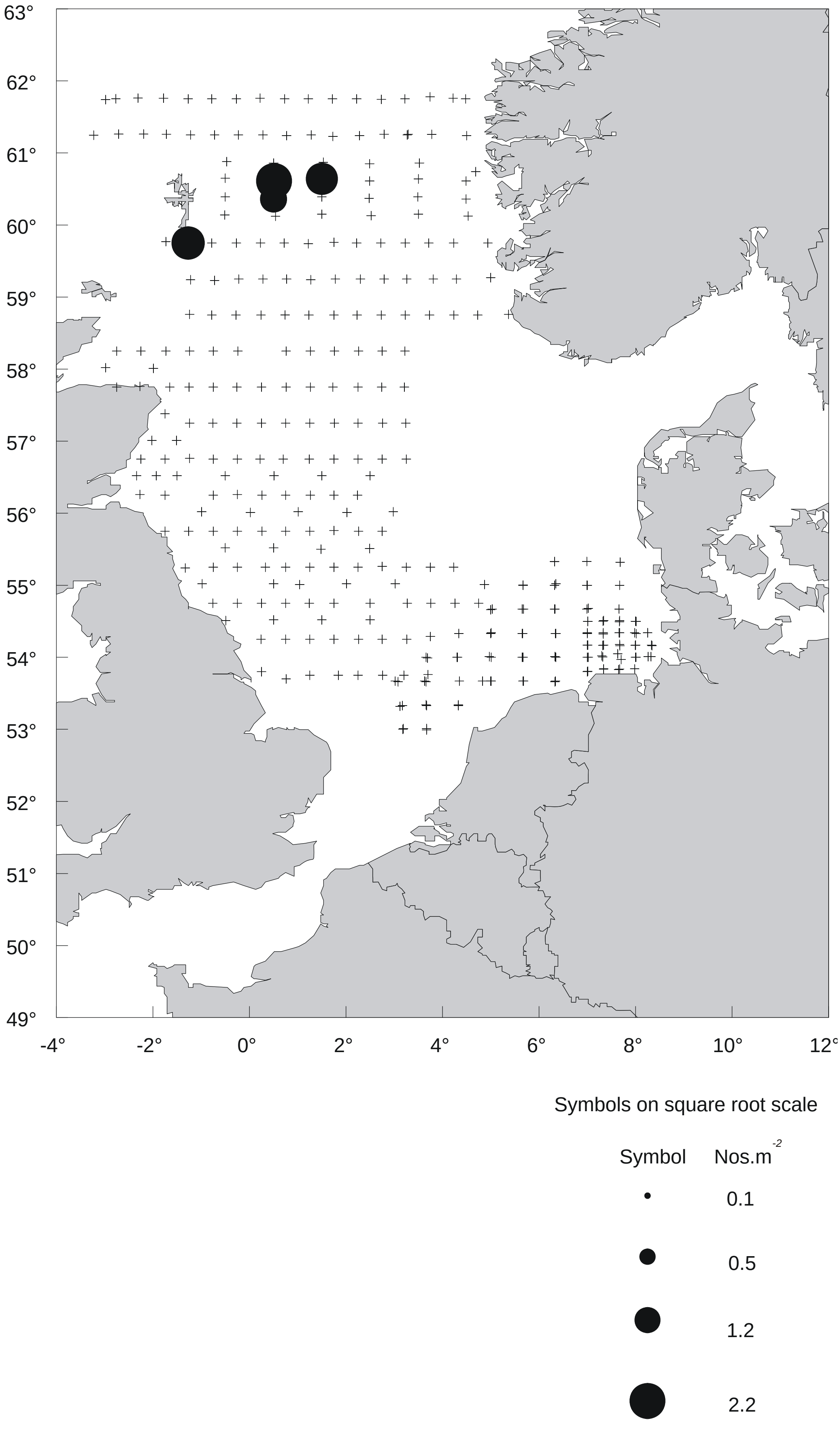

Figure 4.1.8. Composite map of greater silver smelt (*Argentina silus*) larval abundance (nos. m^{-2}) in 2004.

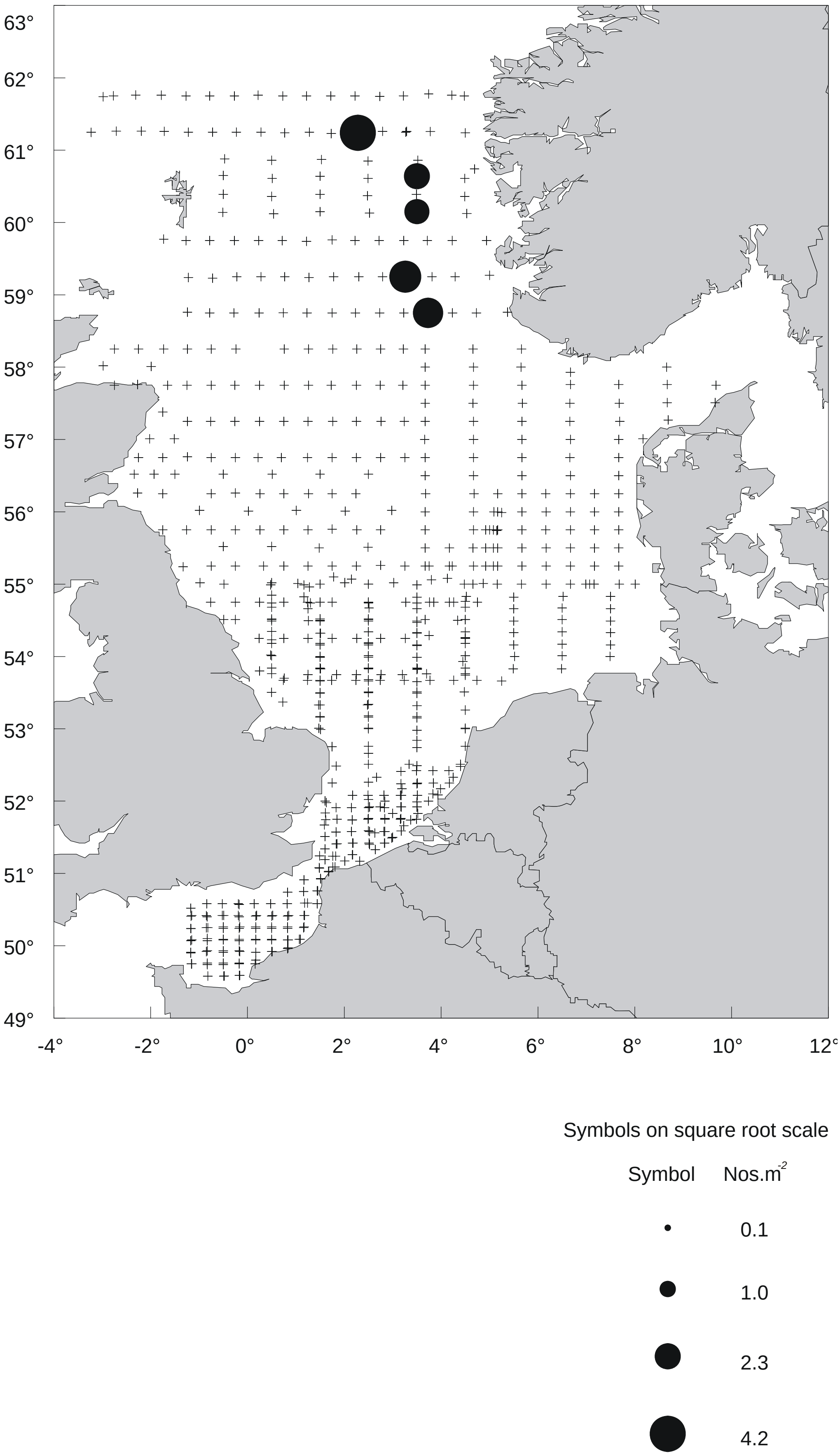

Figure 4.1.9. Composite map of pearlside (*Maurolicus muelleri*) egg abundance (nos. m^{-2}) in 2004.

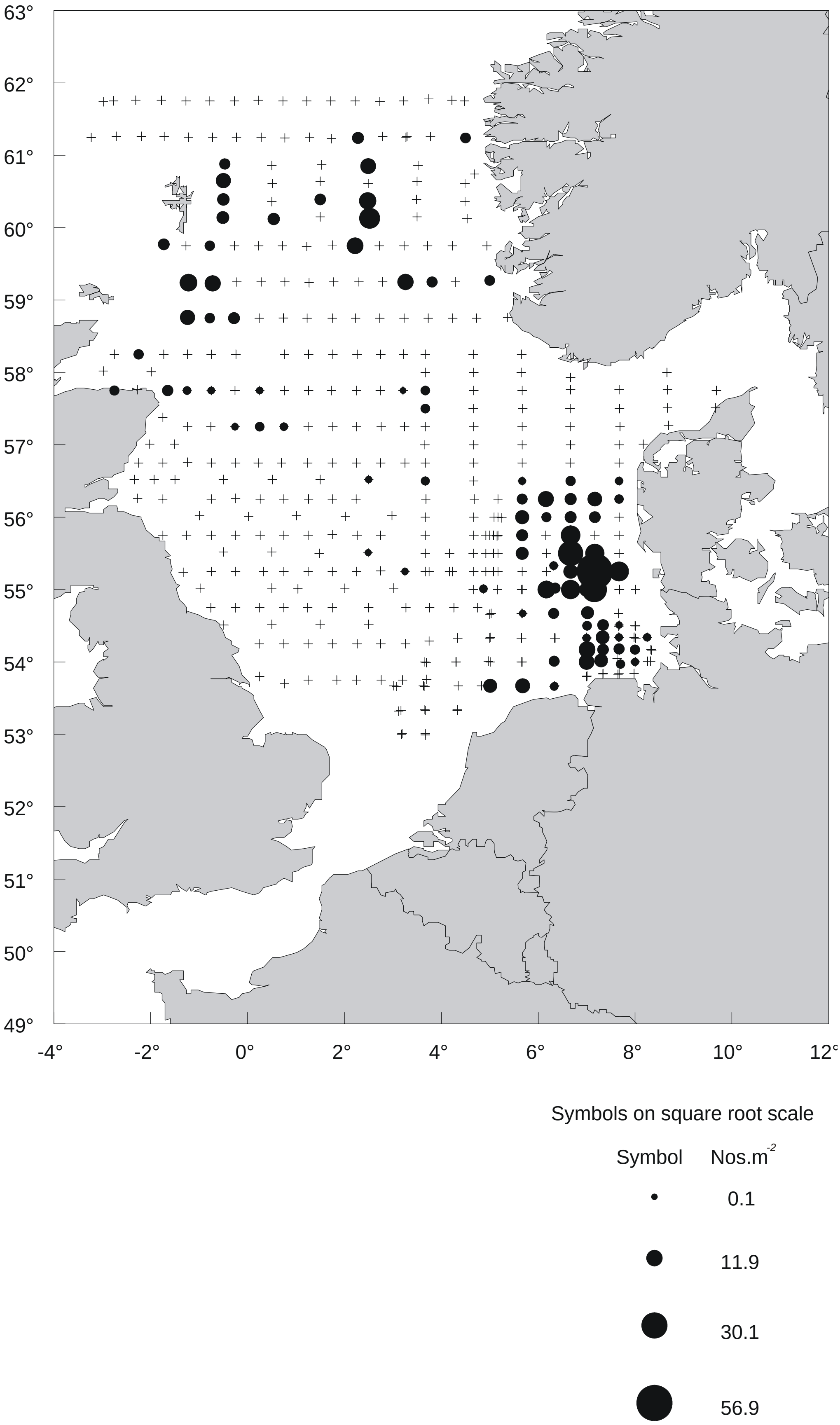

Figure 4.1.10. Composite map of cod (*Gadus morhua*) larval abundance (nos. m^{-2}) in 2004.

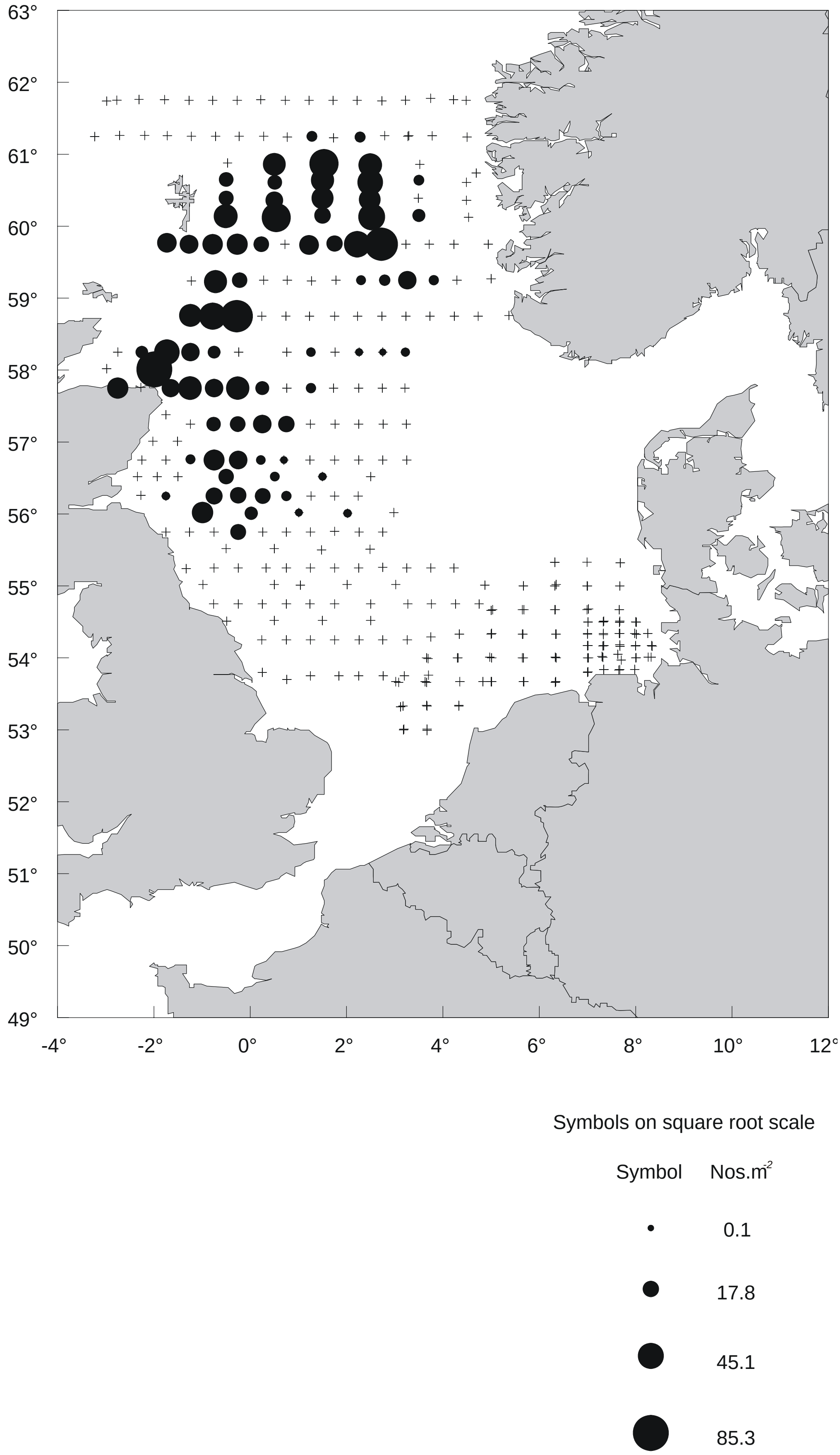

Figure 4.1.11. Composite map of haddock (*Melanogrammus aeglefinus*) larval abundance (nos. m^{-2}) in 2004.

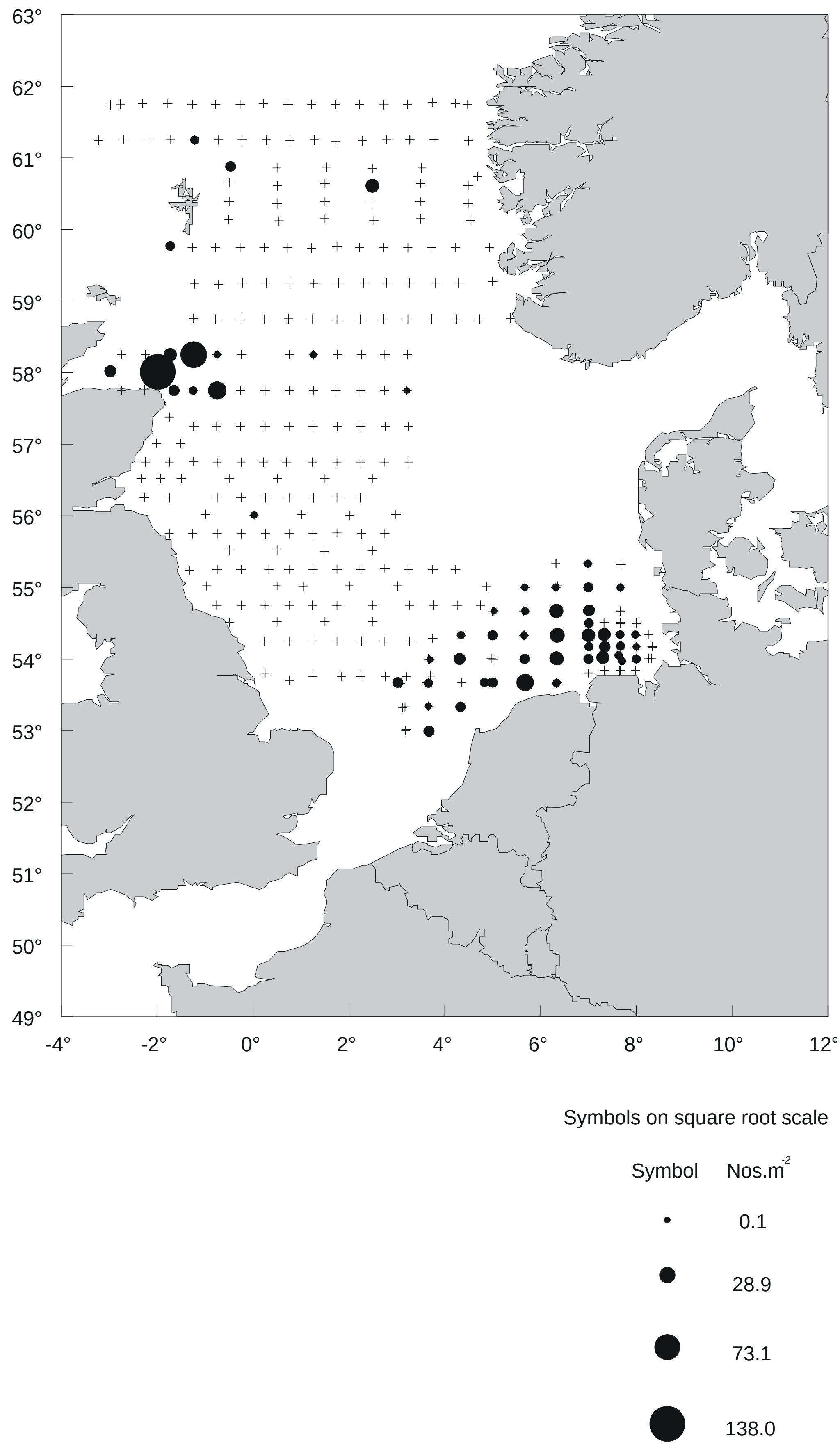

Figure 4.1.12. Composite map of whiting (*Merlangius merlangus*) larval abundance (nos. m^{-2}) in 2004.

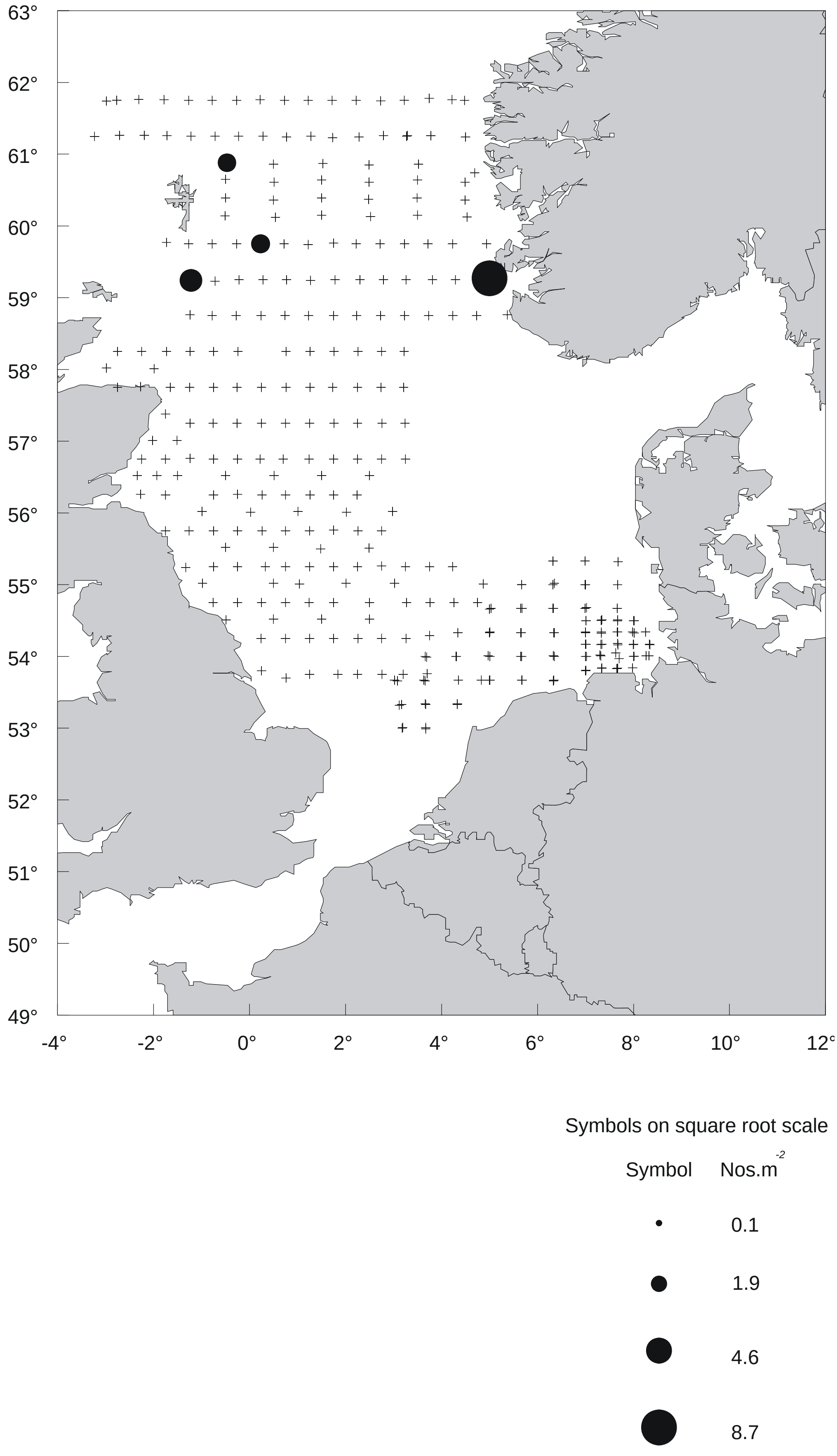

Figure 4.1.13. Composite map of blue whiting (*Micromesistius poutassou*) larval abundance (nos. m^{-2}) in 2004.

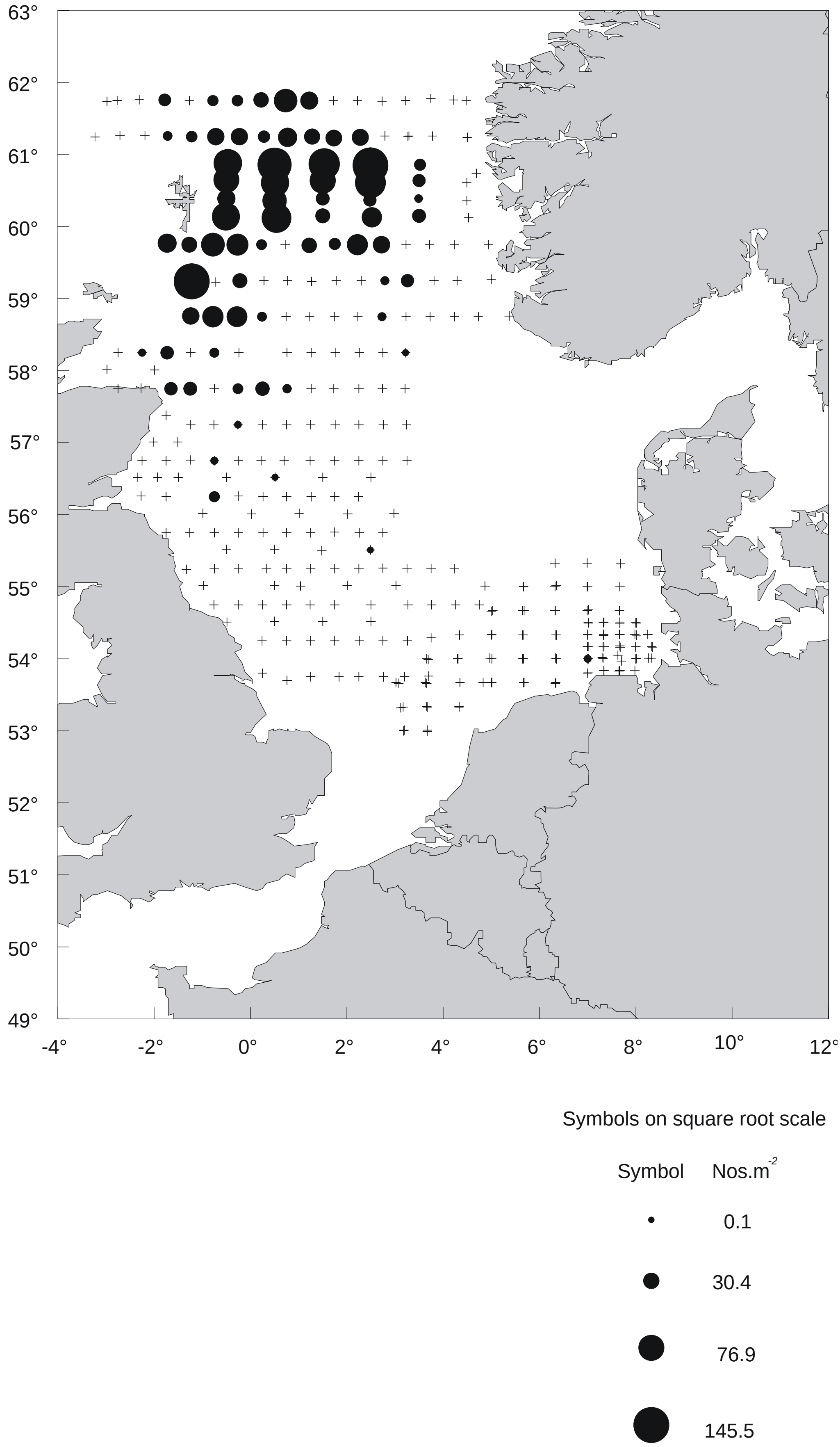

Figure 4.1.14. Composite map of Norway pout (*Trisopterus esmarkii*) and poor cod (*Trisopterus minutus*) larval abundance (nos. m^{-2}) in 2004.

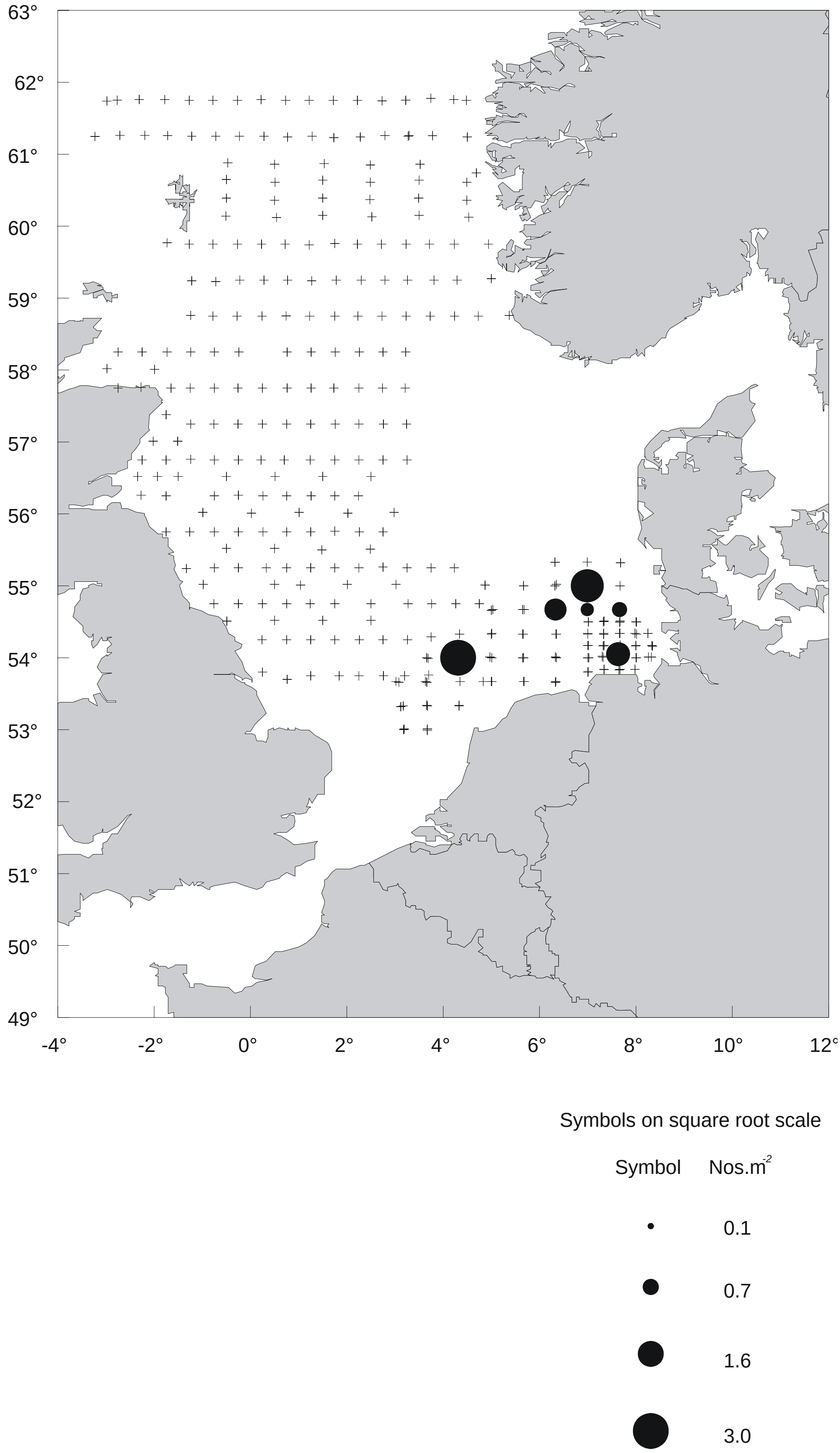

Figure 4.1.15. Composite map of pollack (*Pollachius pollachius*) larval abundance (nos. m^{-2}) in 2004.

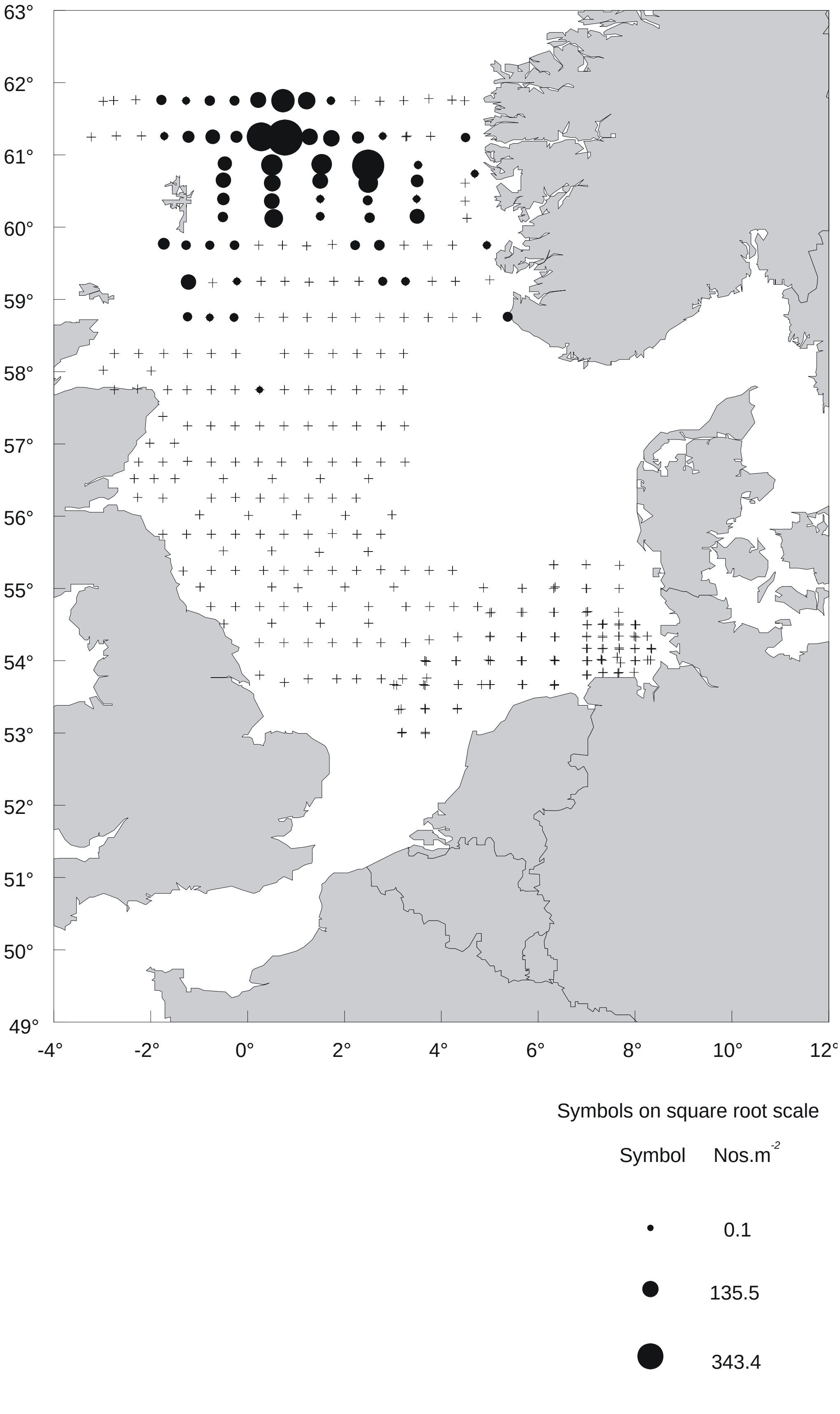

Figure 4.1.16. Composite map of saithe (*Pollachius virens*) larval abundance (nos. m^{-2}) in 2004.

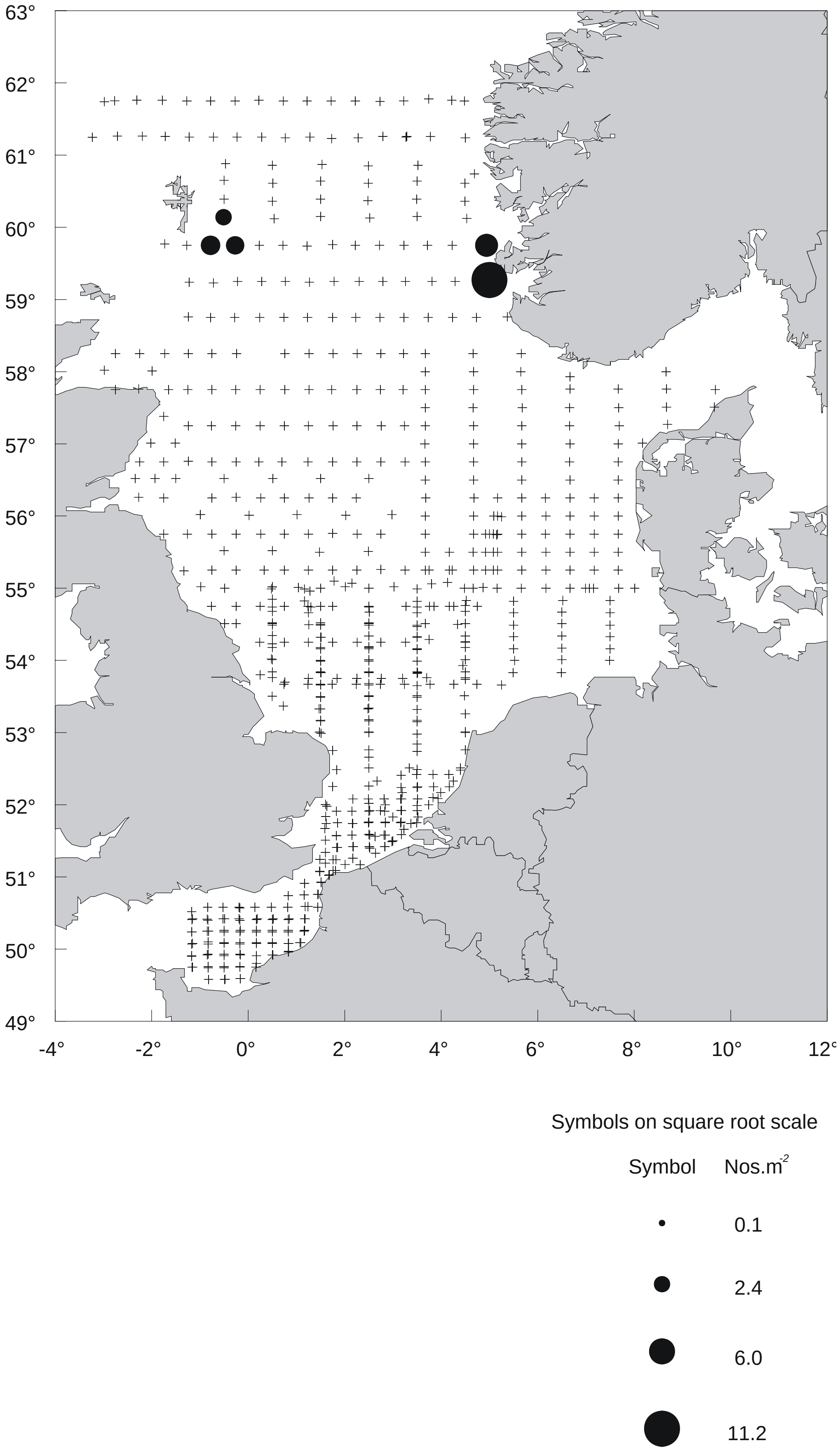

Figure 4.1.17. Composite map of torsk (*Brosme brosme*) egg abundance (nos. m^{-2}) in 2004.

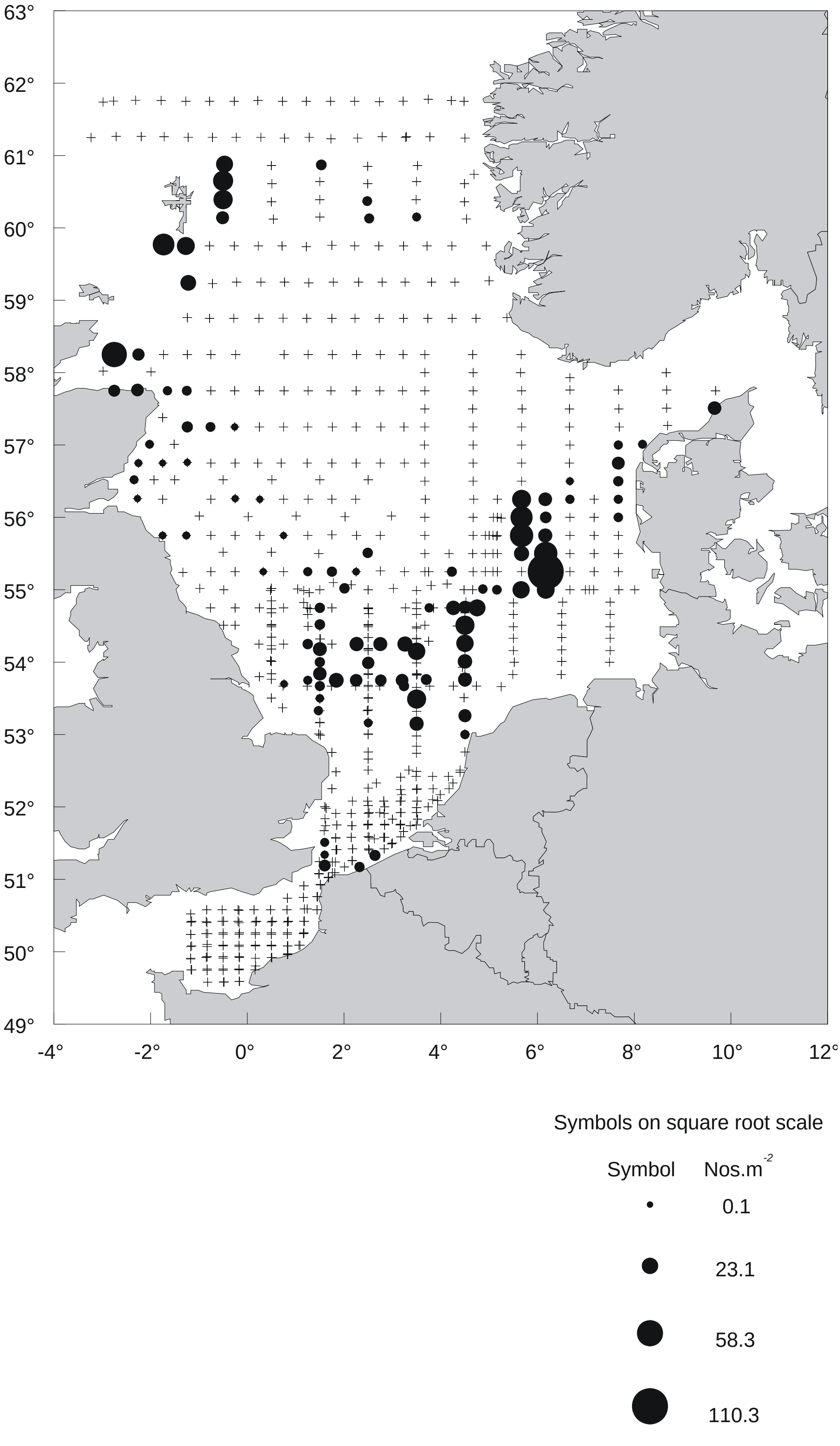

Figure 4.1.18. Composite map of rockling (Gadidae) egg abundance (nos. m^{-2}) in 2004.

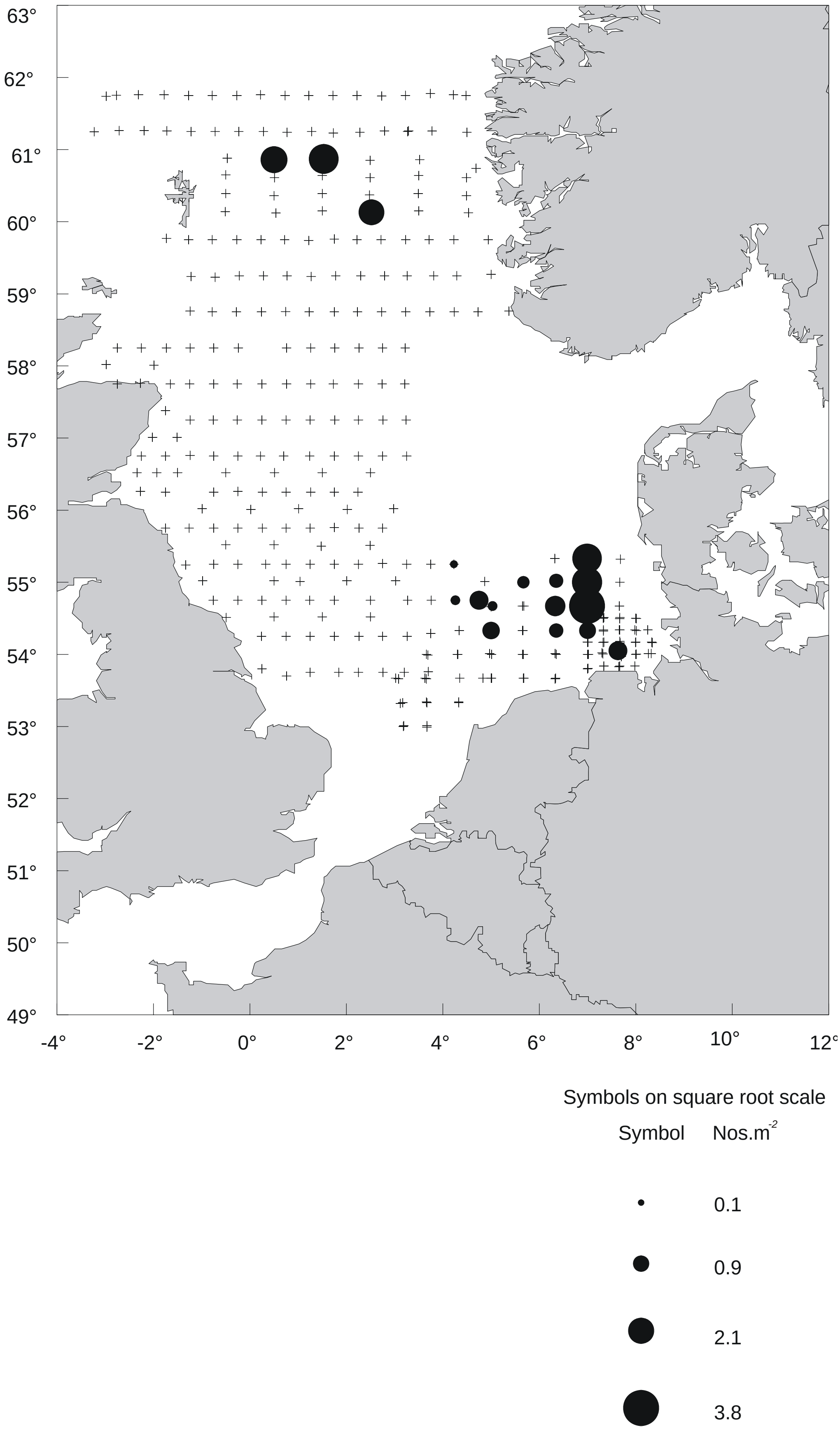

Figure 4.1.19. Composite map of rockling (Gadidae) larval abundance (nos. m^{-2}) in 2004.

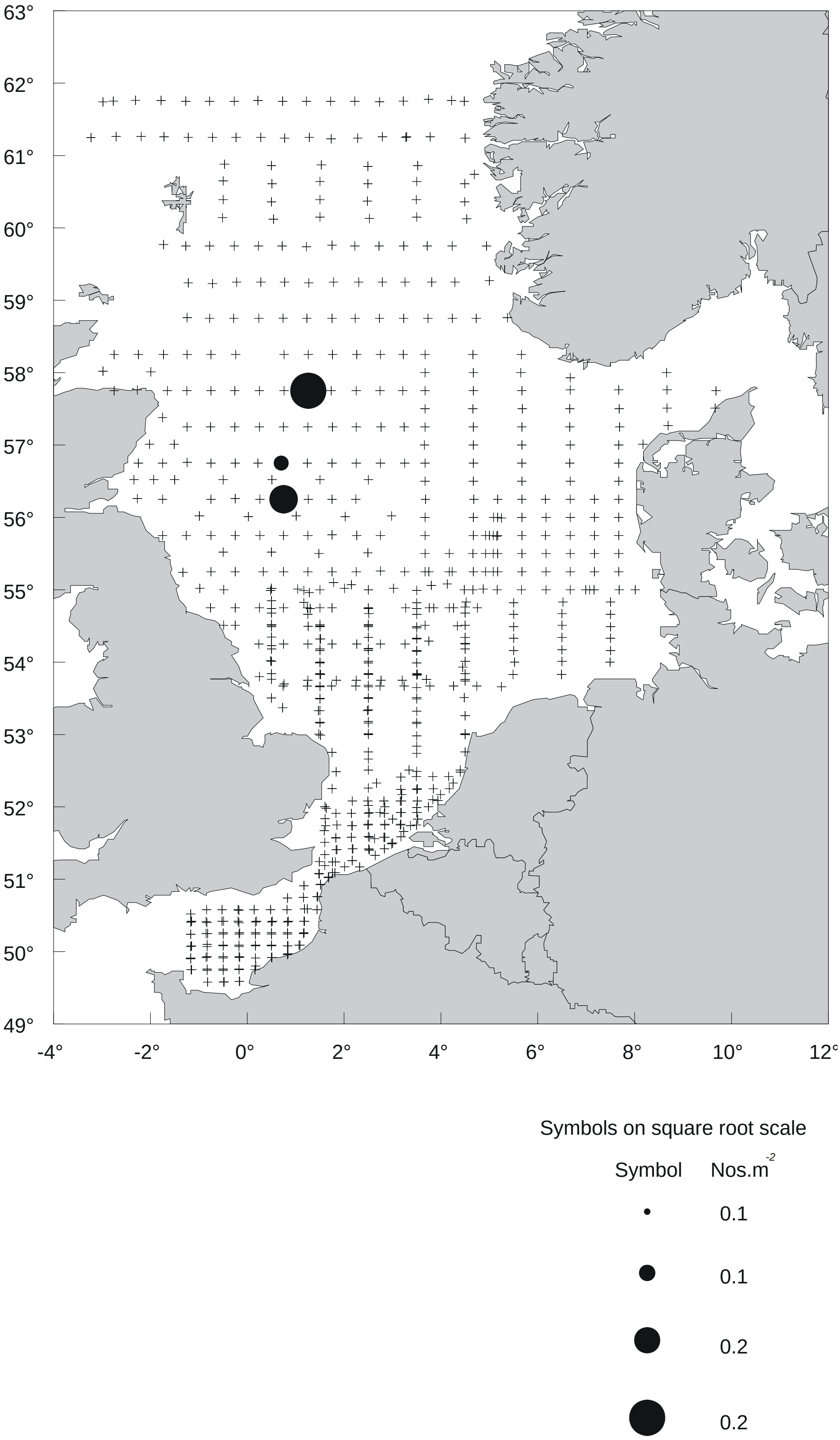

Figure 4.1.20. Composite map of ling (*Molva molva*) egg abundance (nos. m^{-2}) in 2004.

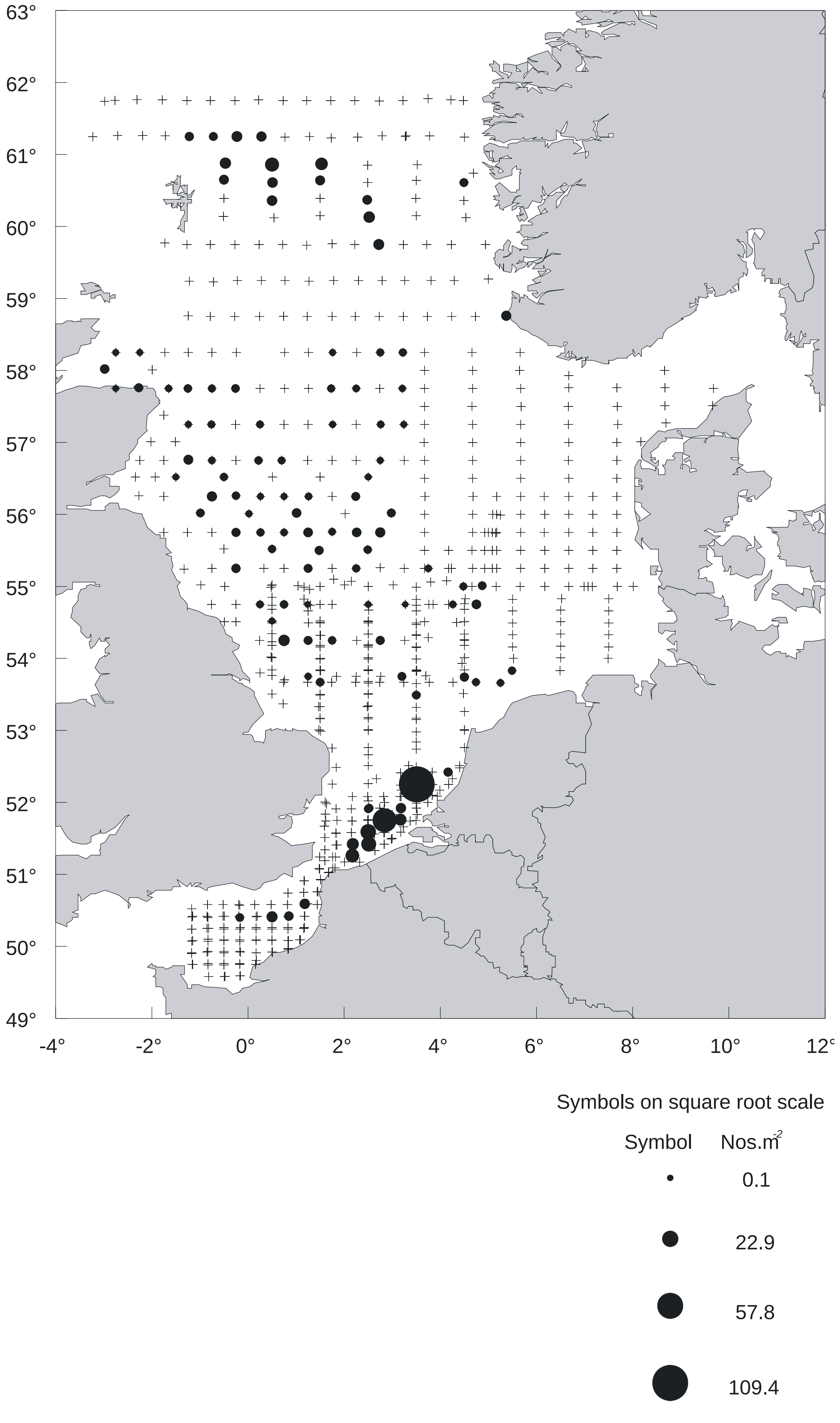

Figure 4.1.21. Composite map of gurnard (Triglidae) egg abundance (nos. m^{-2}) in 2004.

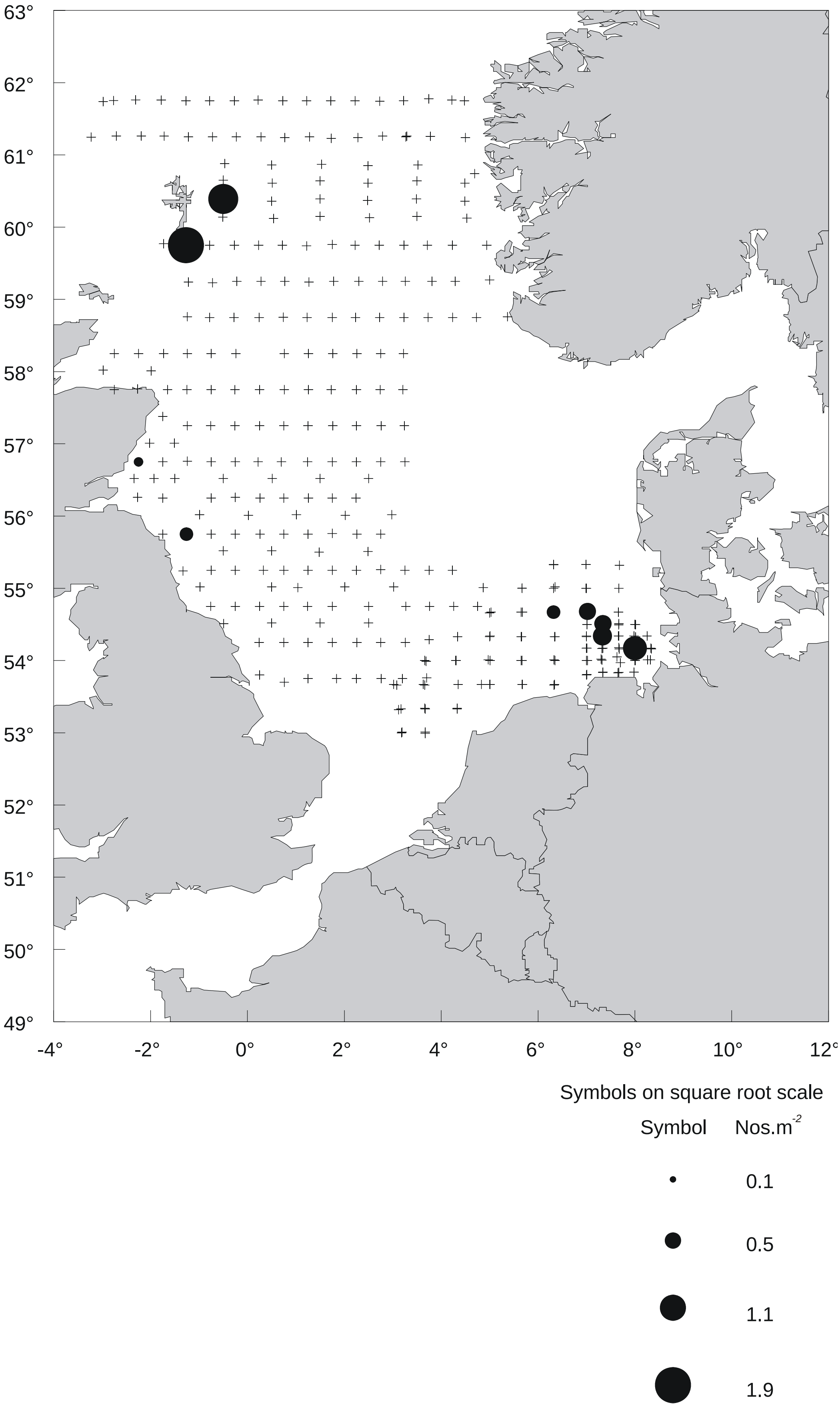

Figure 4.1.22. Composite map of Cottidae (bullheads and sculpins) larval abundance (nos. m^{-2}) in 2004.

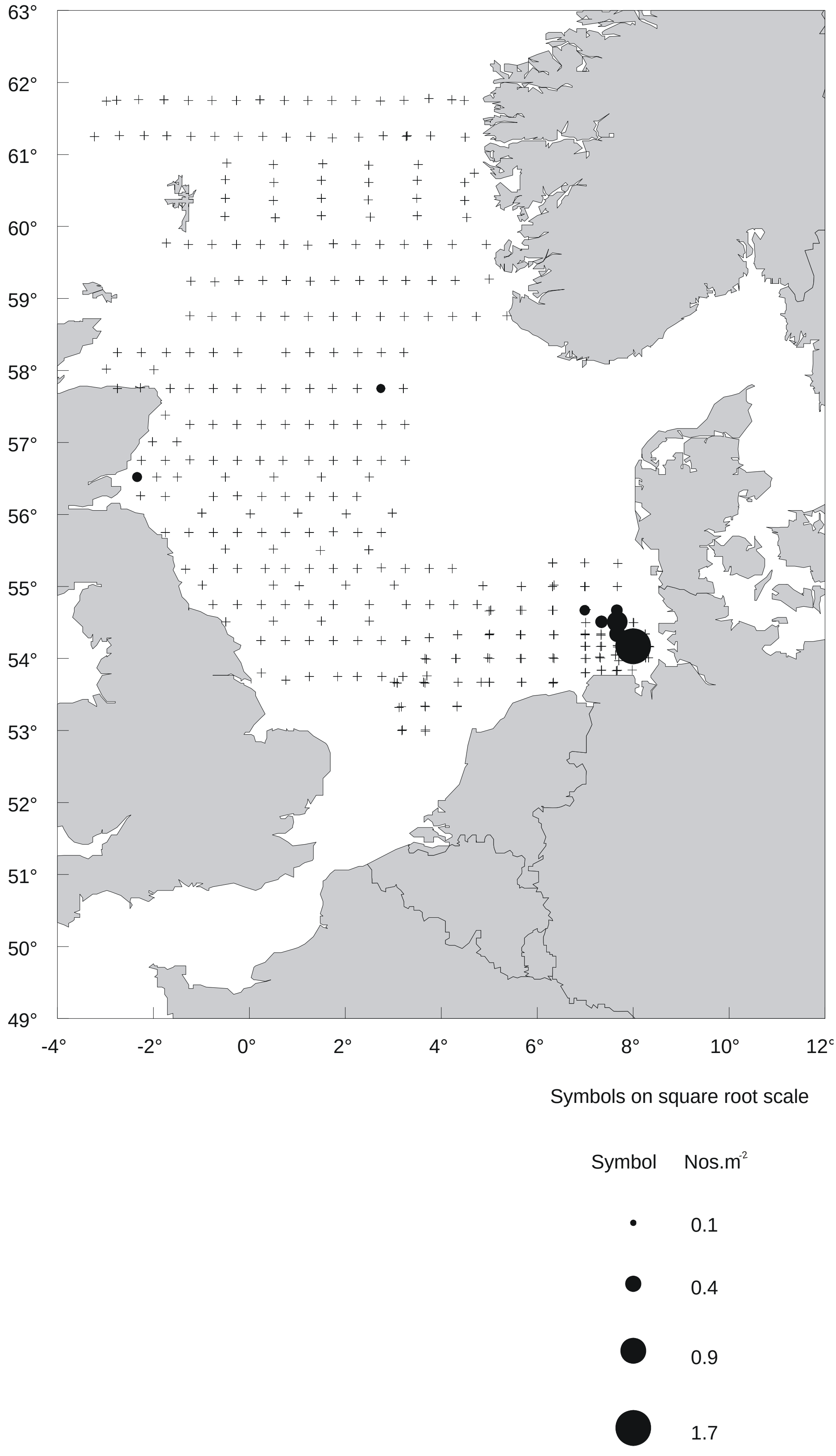

Figure 4.1.23. Composite map of pogge (*Agonus cataphractus*) larval abundance (nos. m^{-2}) in 2004.

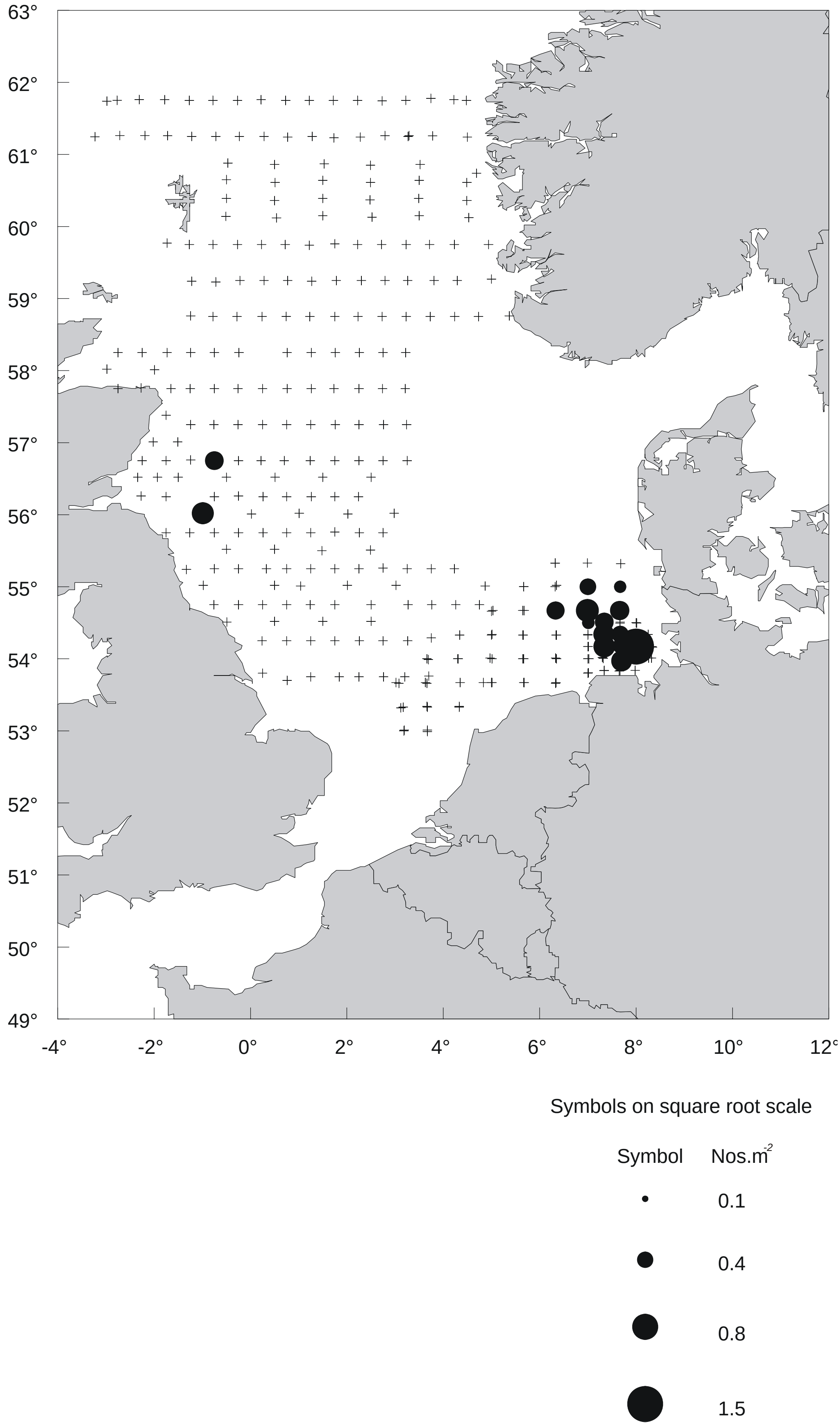

Figure 4.1.24. Composite map of sea snail (*Liparis* spp.) larval abundance (nos. m^{-2}) in 2004.

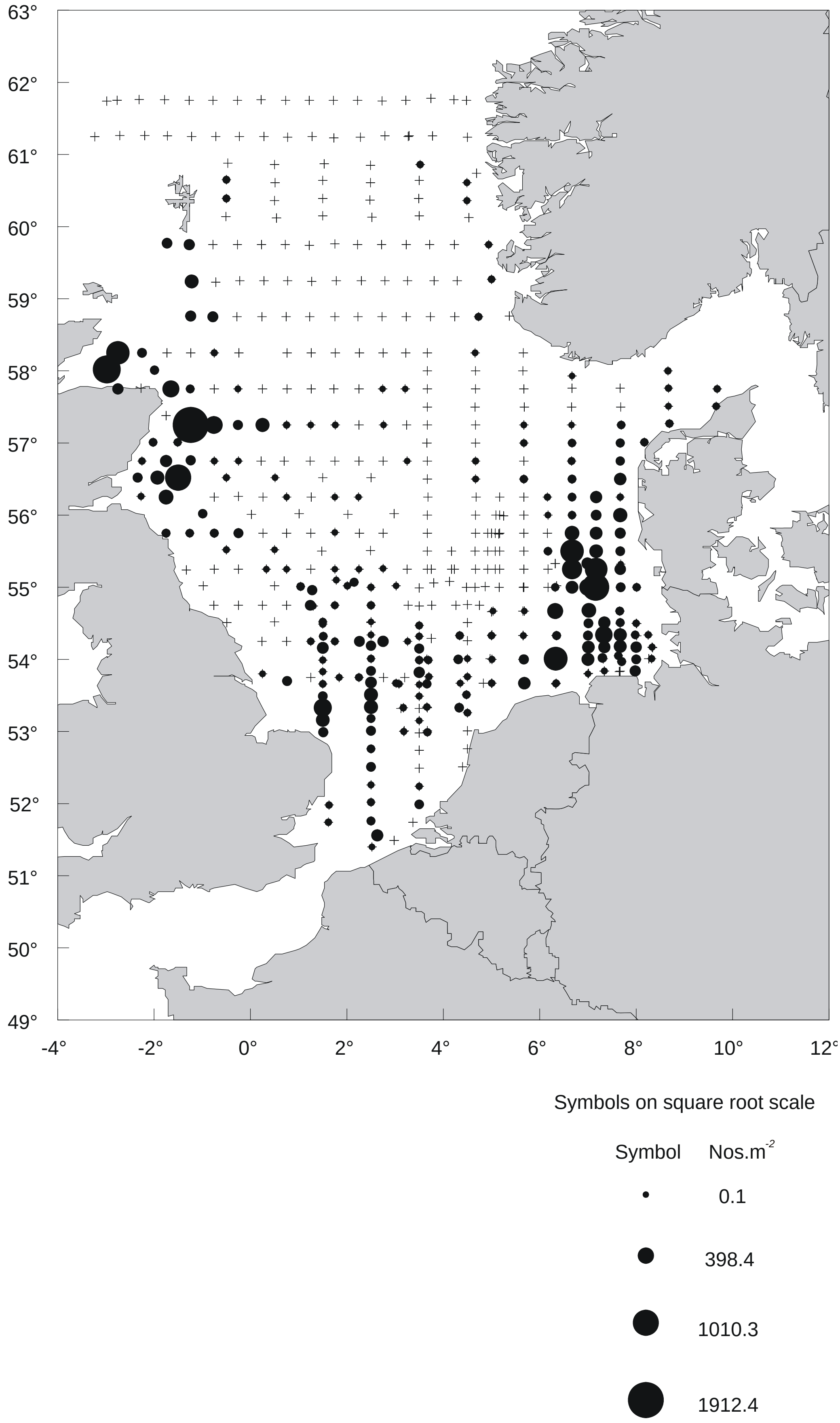

Figure 4.1.25. Composite map of sandeel (Ammodytidae) larval abundance (nos. m^{-2}) in 2004.

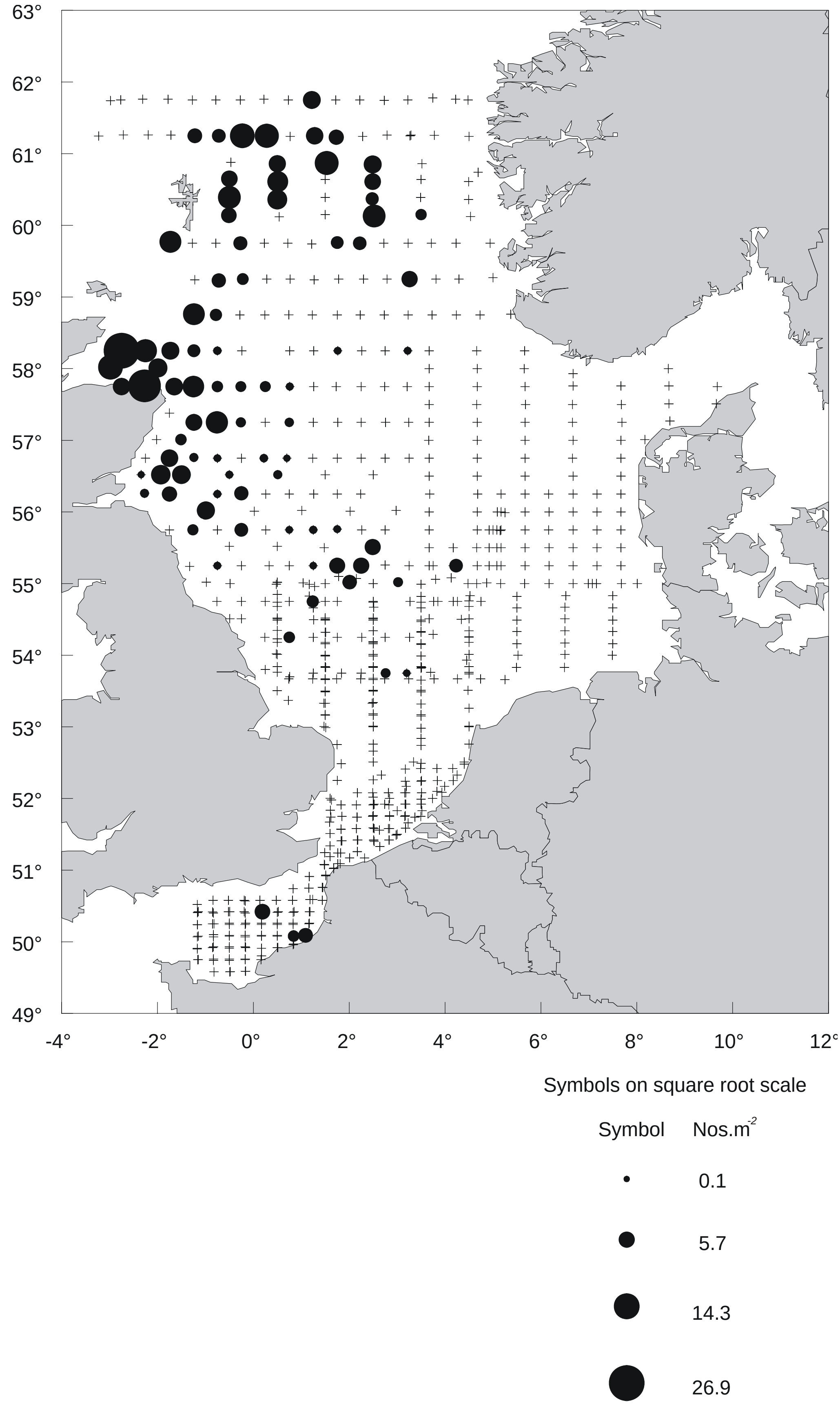

Figure 4.1.26. Composite map of dragonet (Callionymidae) egg abundance (nos. m^{-2}) in 2004.

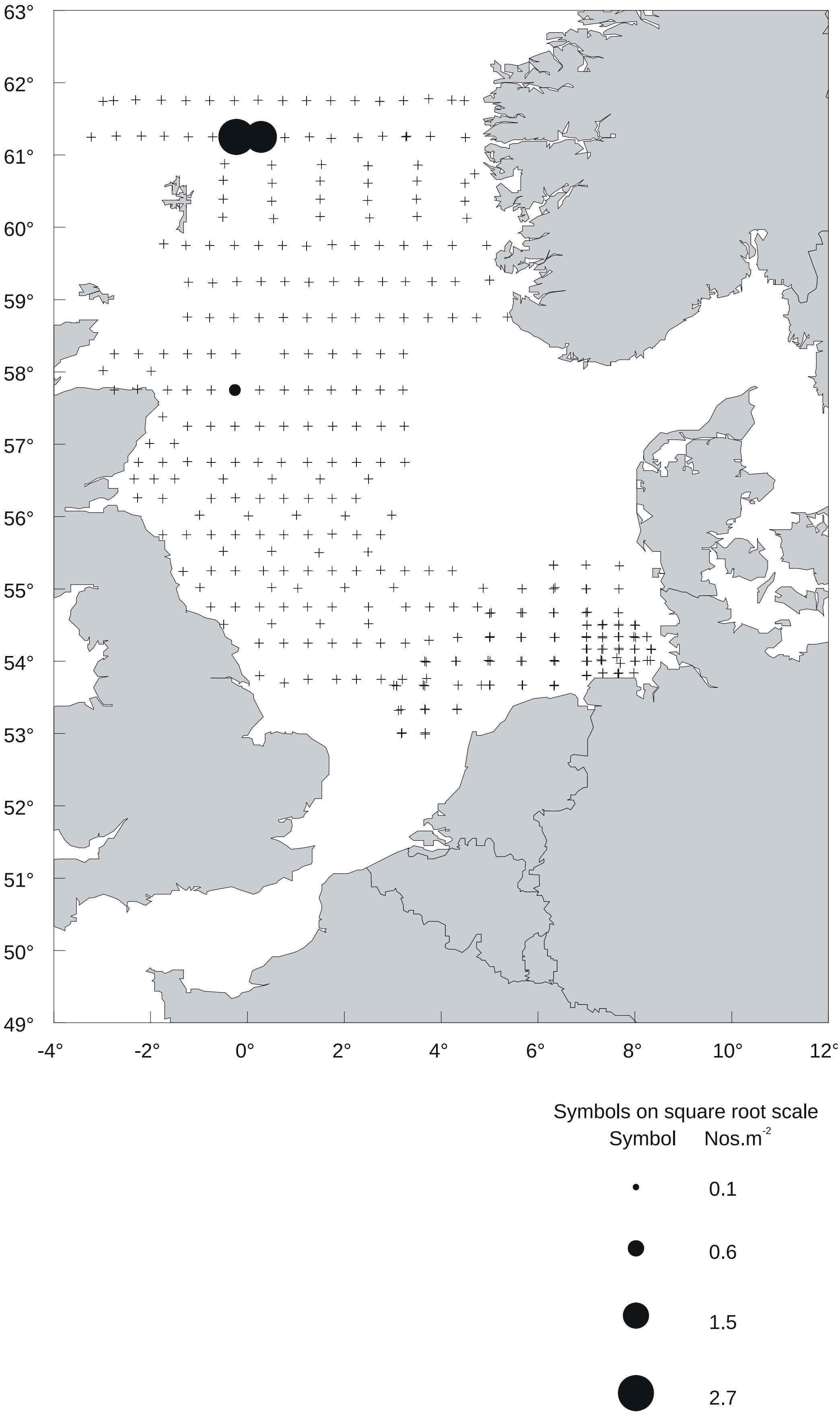

Figure 4.1.27. Composite map of dragonet (Callionymidae) larval abundance (nos. m^{-2}) in 2004.

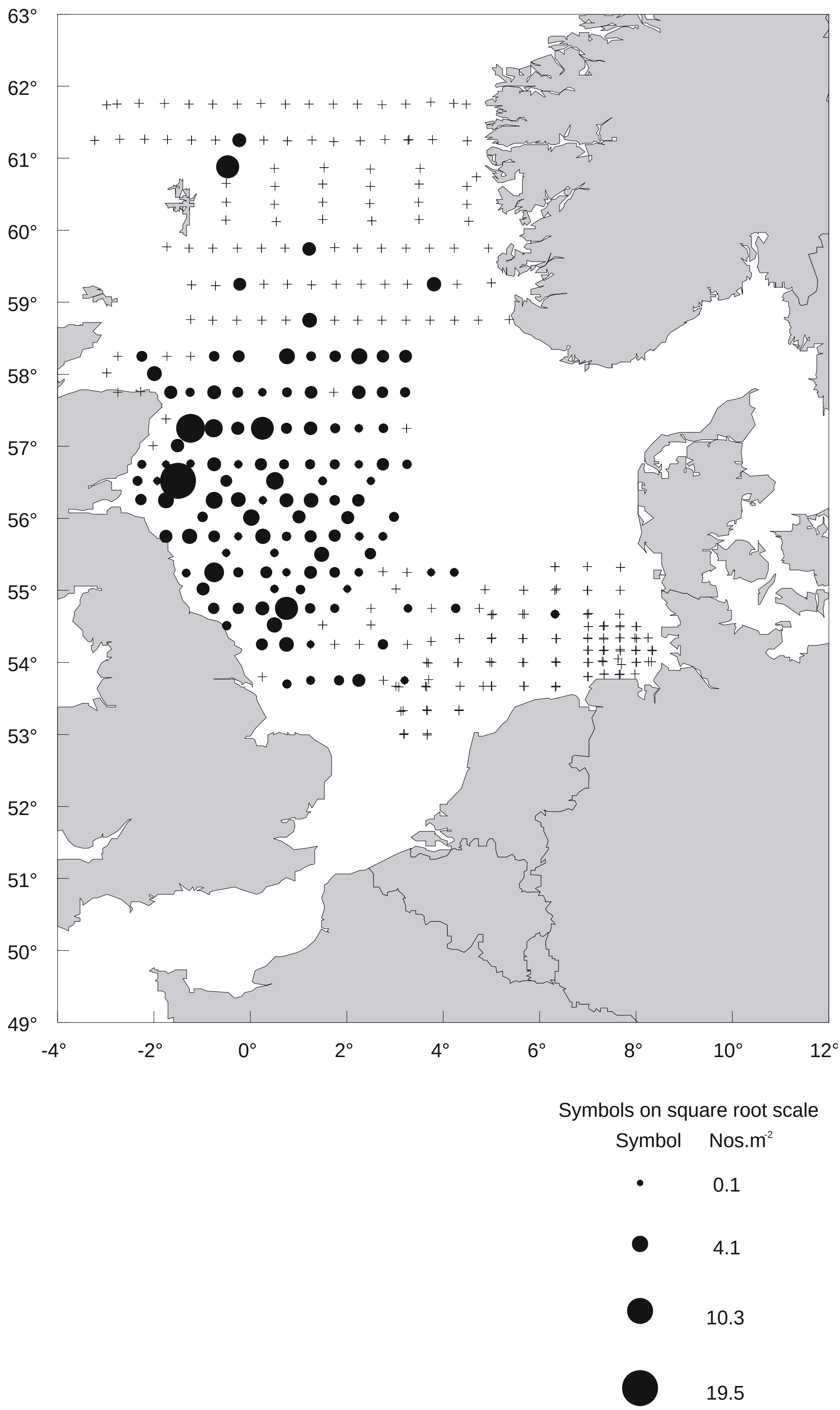

Figure 4.1.28. Composite map of goby (Gobiidae) larval abundance (nos. m^{-2}) in 2004.

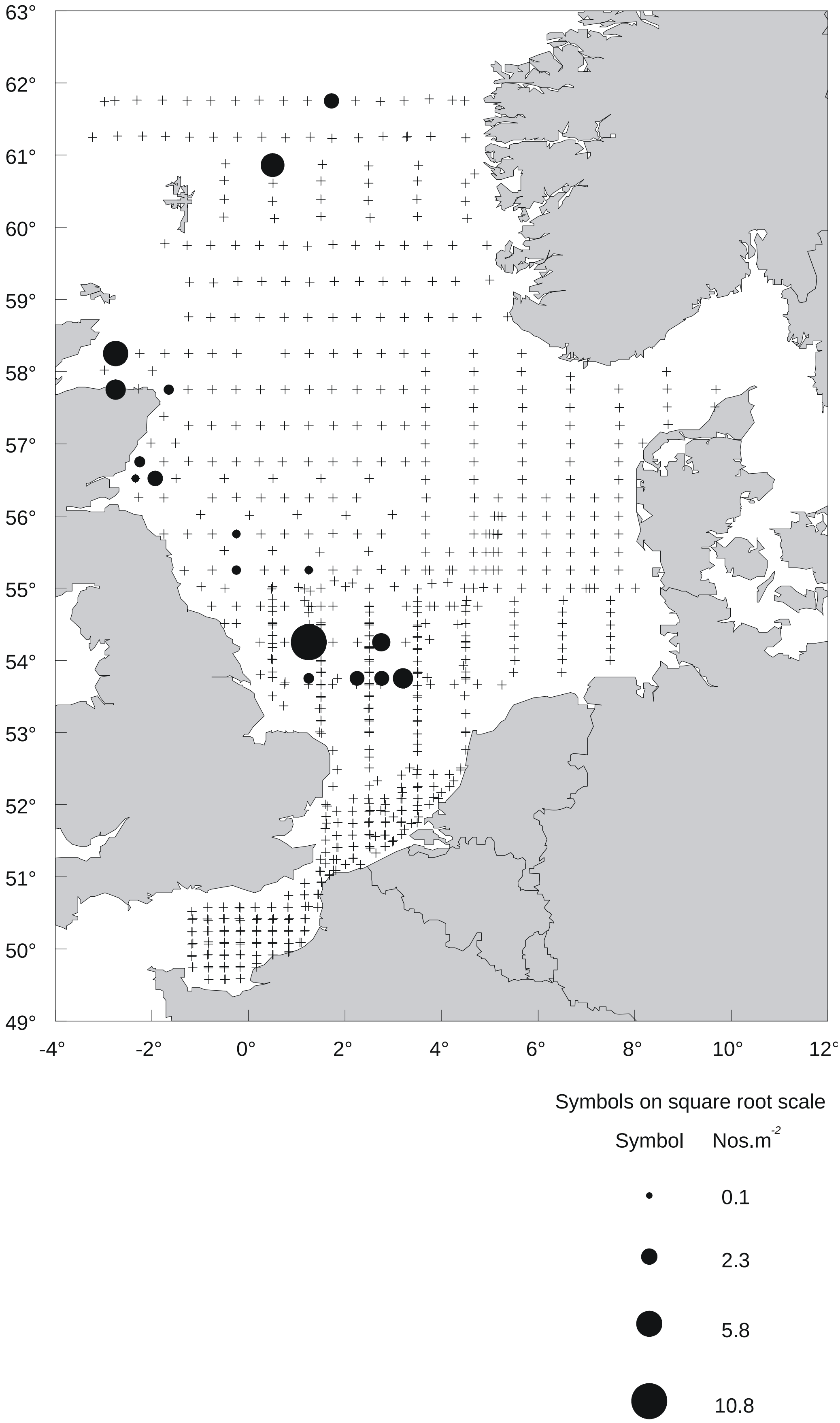

Figure 4.1.29. Composite map of Norwegian topknot (*Phrynorhombus norvegicus*) egg concentrations (nos. m^{-2}) in 2004.

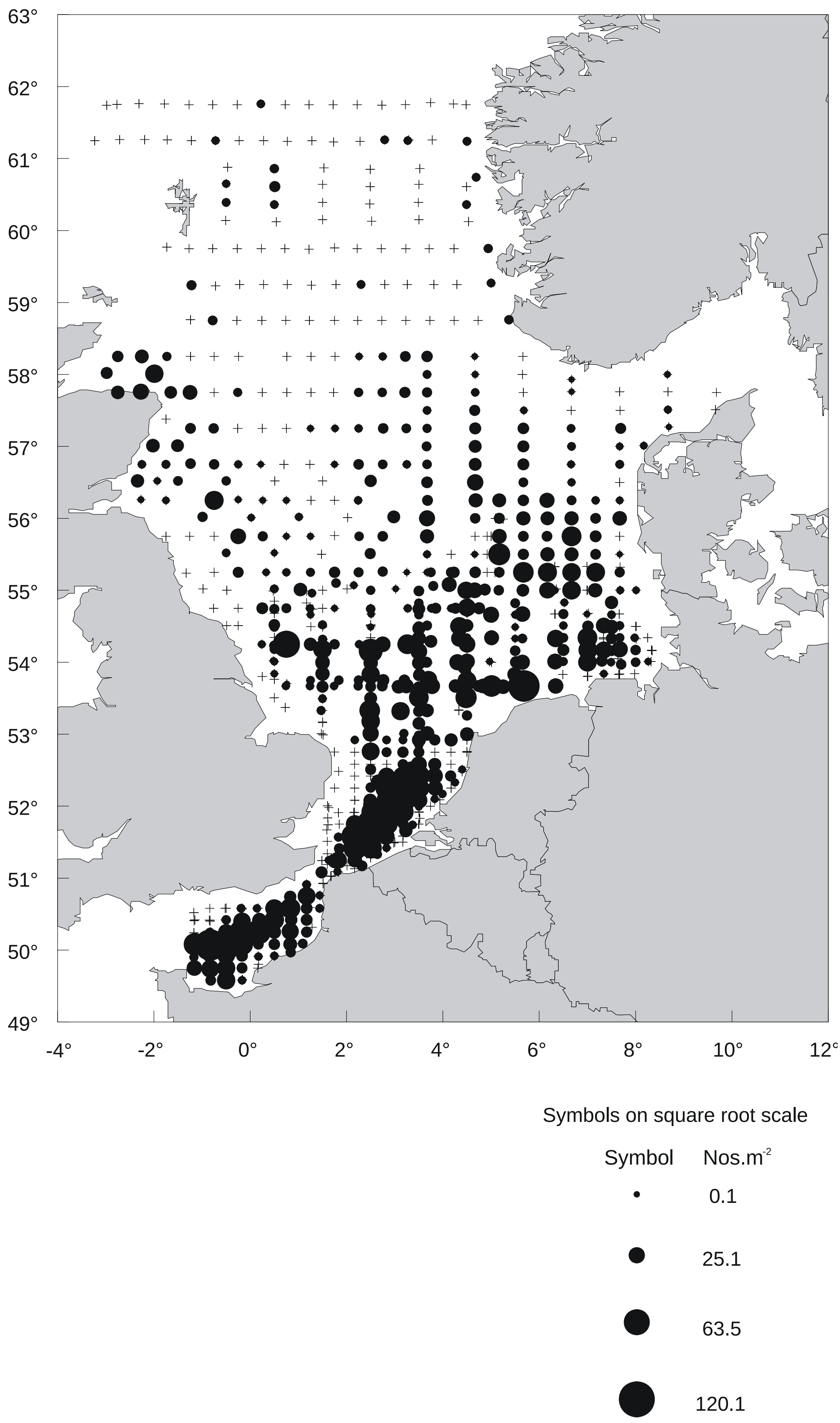

Figure 4.1.30. Composite map of plaice (*Pleuronectes platessa*) egg abundance (nos. m^{-2}) in 2004.

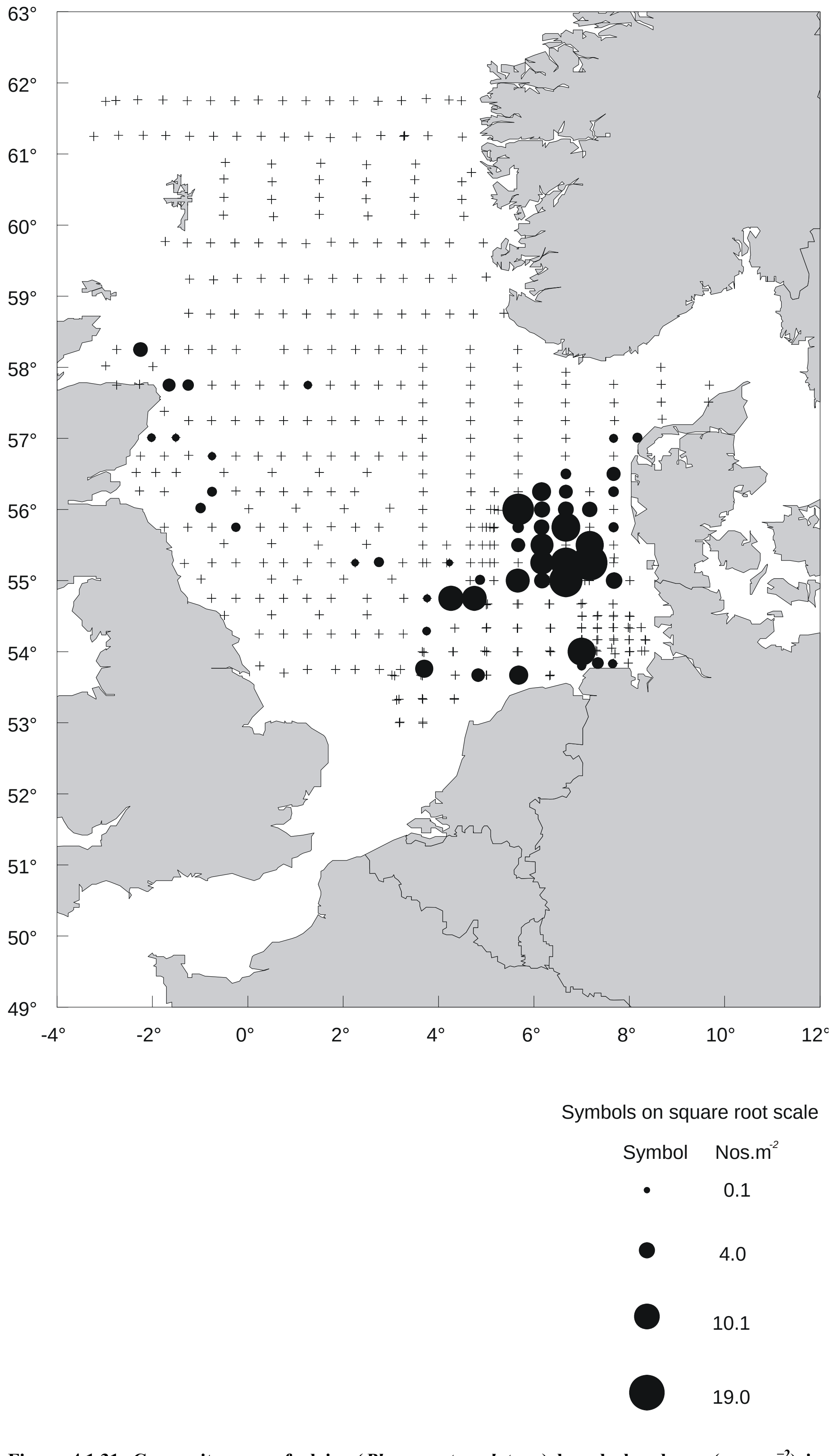

Figure 4.1.31. Composite map of plaice (*Pleuronectes platessa*) larval abundance (nos. m^{-2}) in 2004.

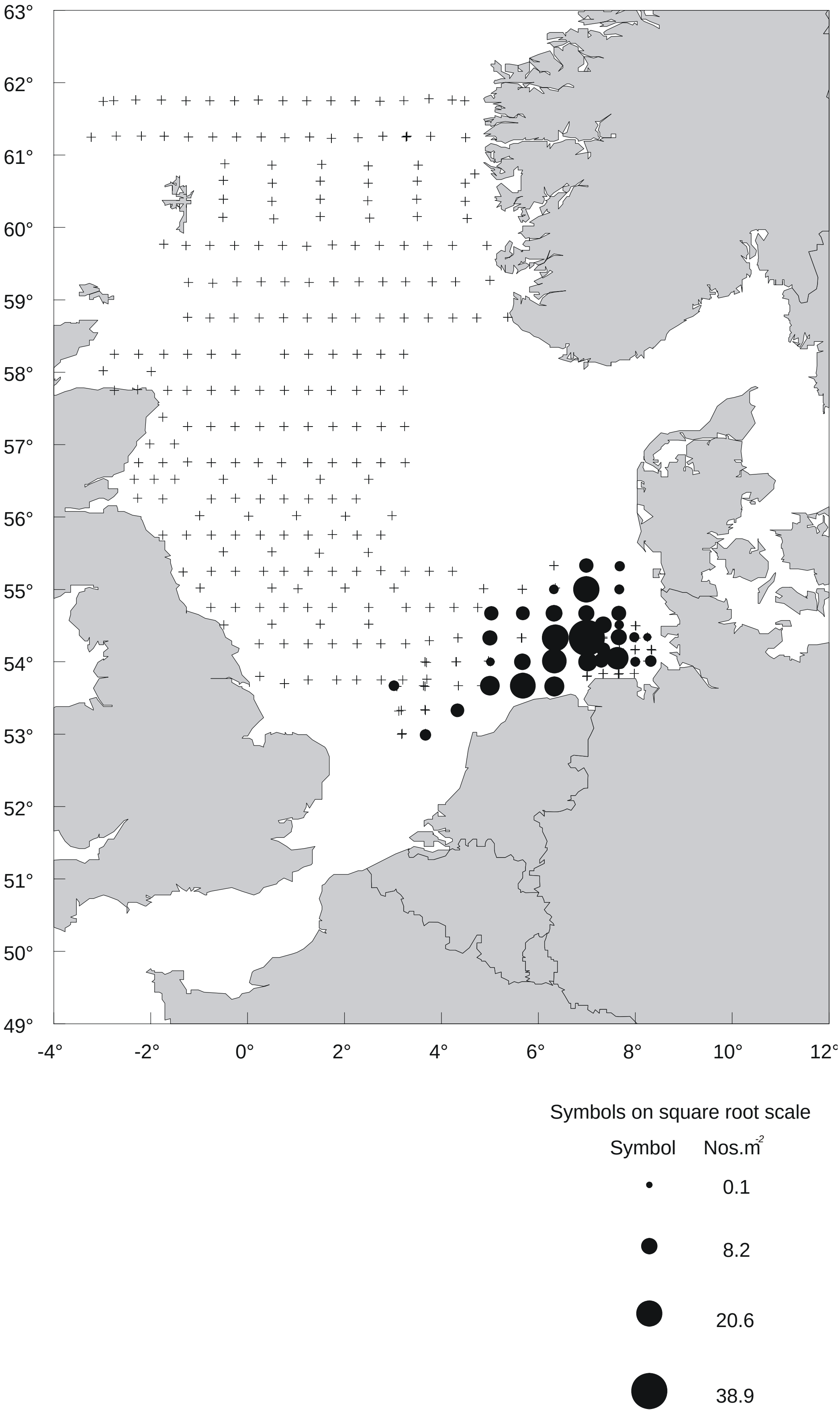

Figure 4.1.32. Composite map of flounder (*Platichthys flesus*) larval abundance (nos. m^{-2}) in 2004.

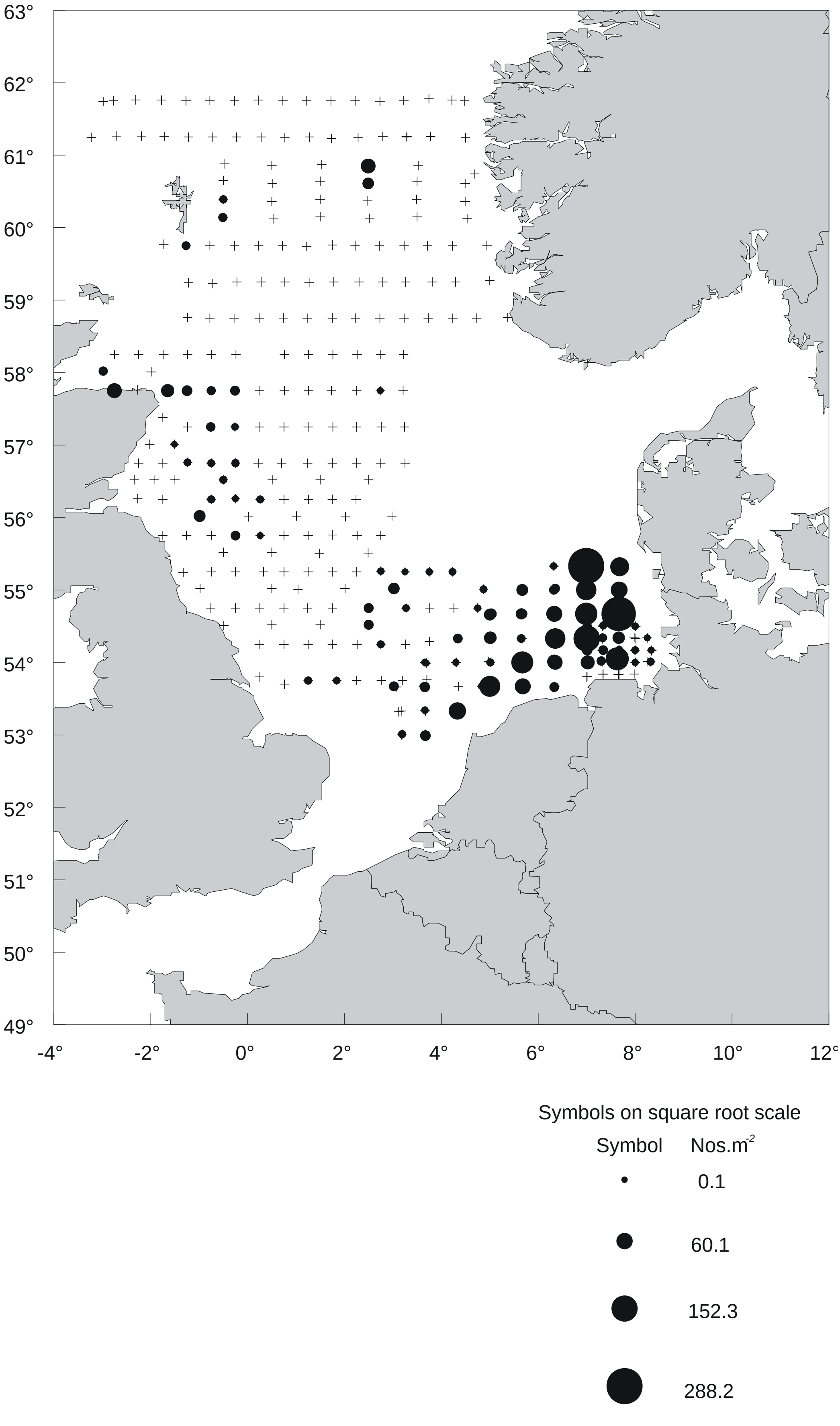

Figure 4.1.33. Composite map of dab (*Limanda limanda*) larval abundance (nos. m^{-2}) in 2004.

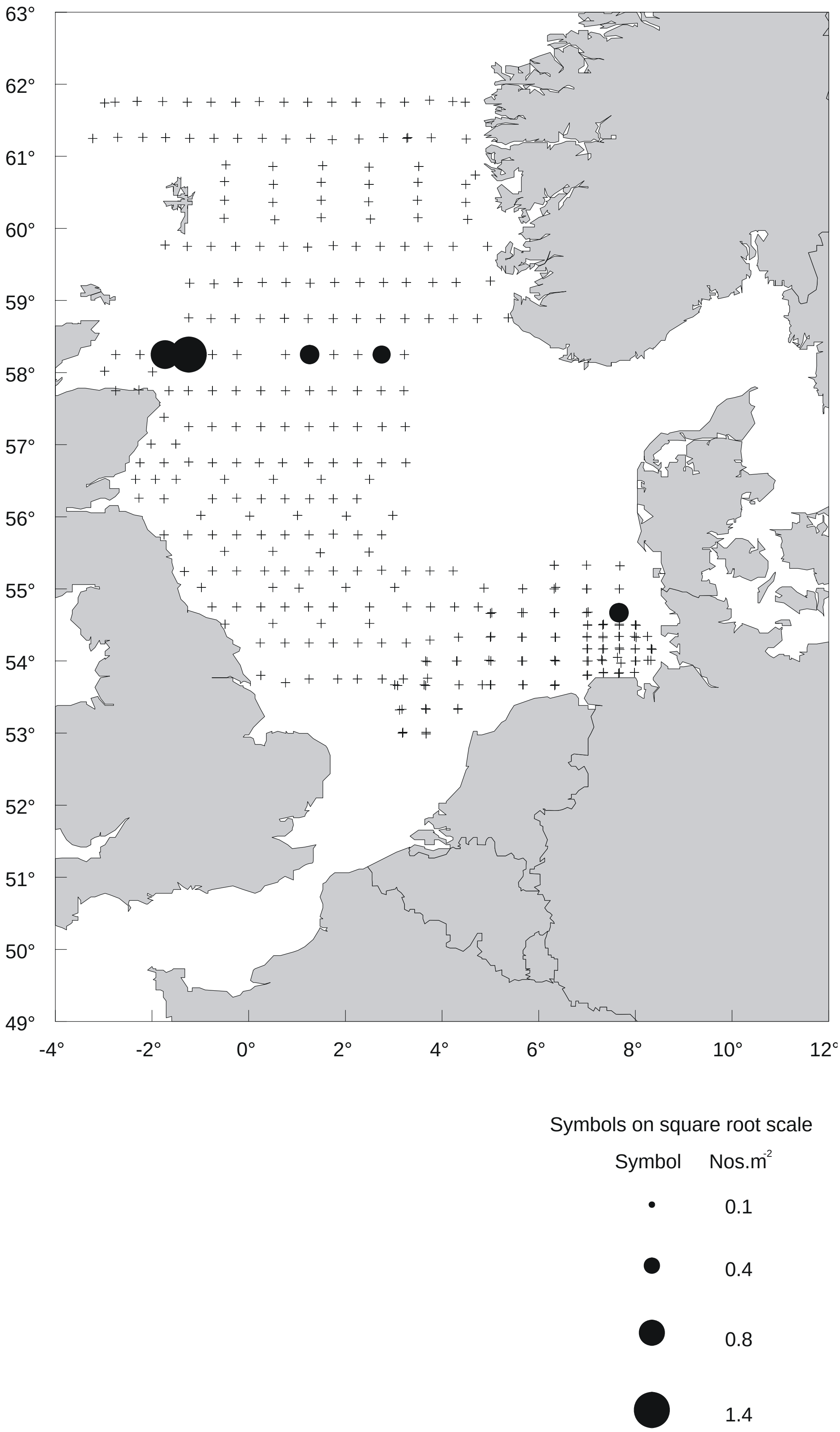

Figure 4.1.34. Composite map of lemon sole (*Microstomus kitt*) larval abundance (nos. m^{-2}) in 2004.

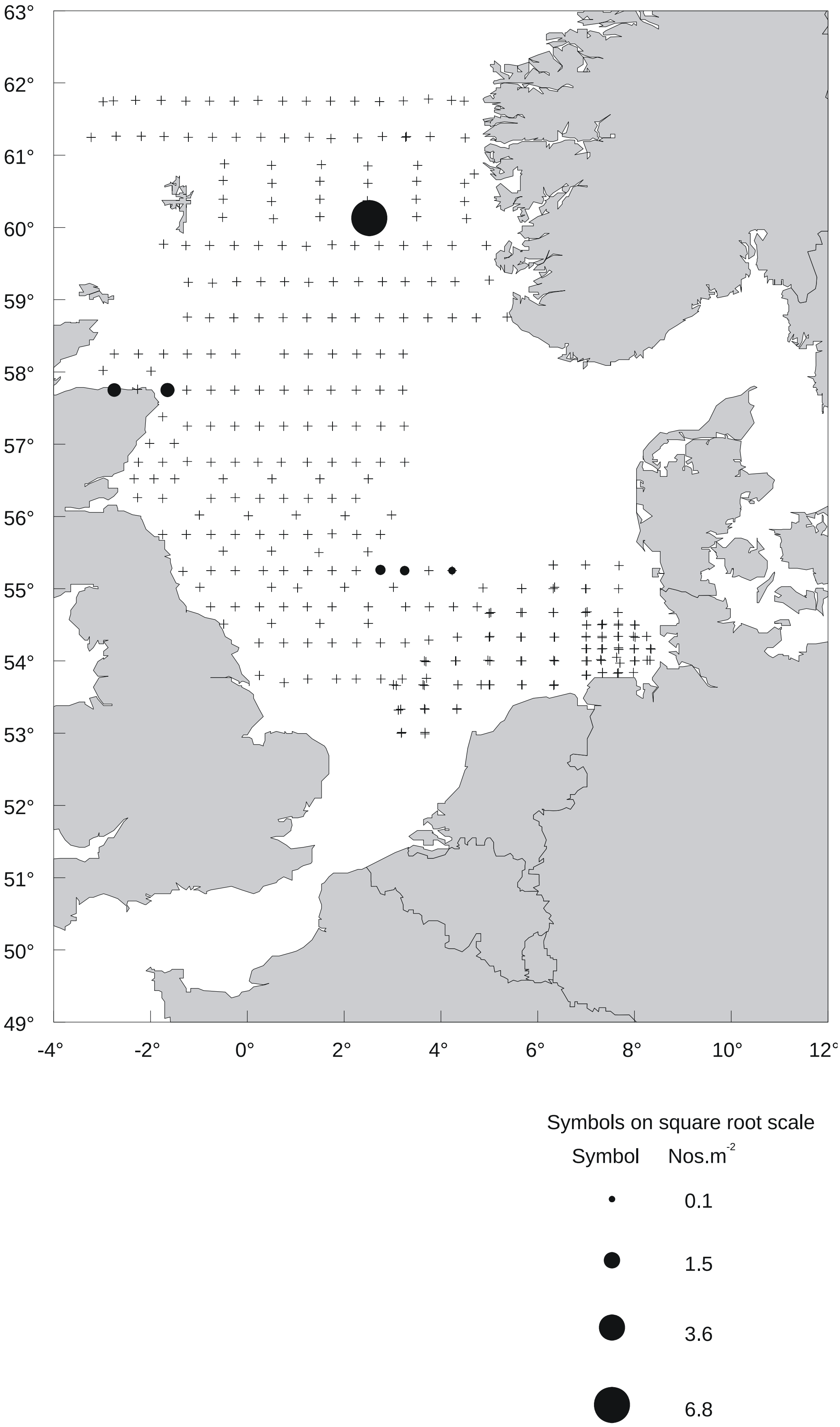

Figure 4.1.35. Composite map of witch (*Glyptocephalus cynoglossus*) larval abundance (nos. m^{-2}) in 2004.

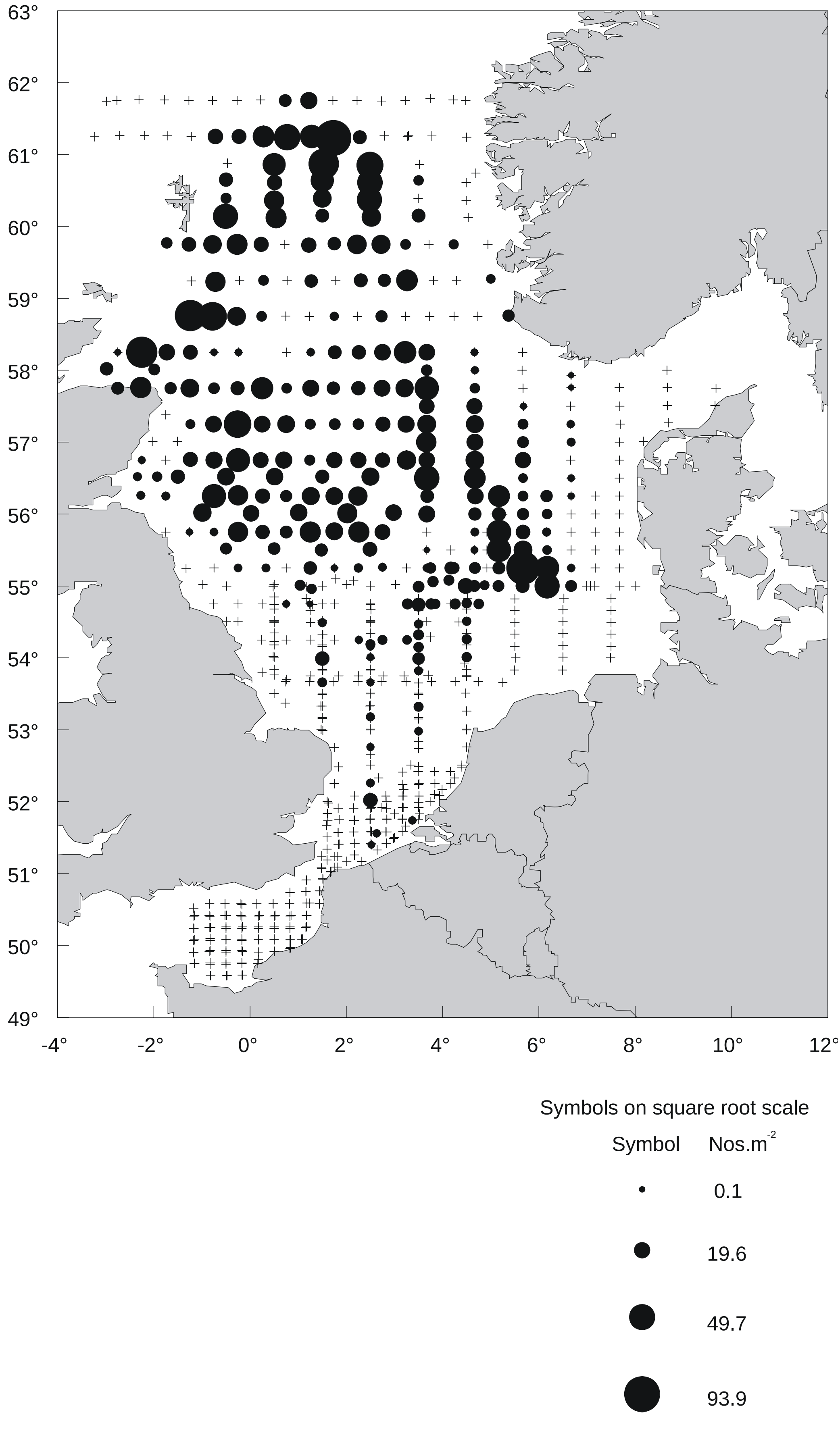

Figure 4.1.36. Composite map of long rough dab (*Hippoglossoides platessoides*) egg abundance (nos. m^{-2}) in 2004.

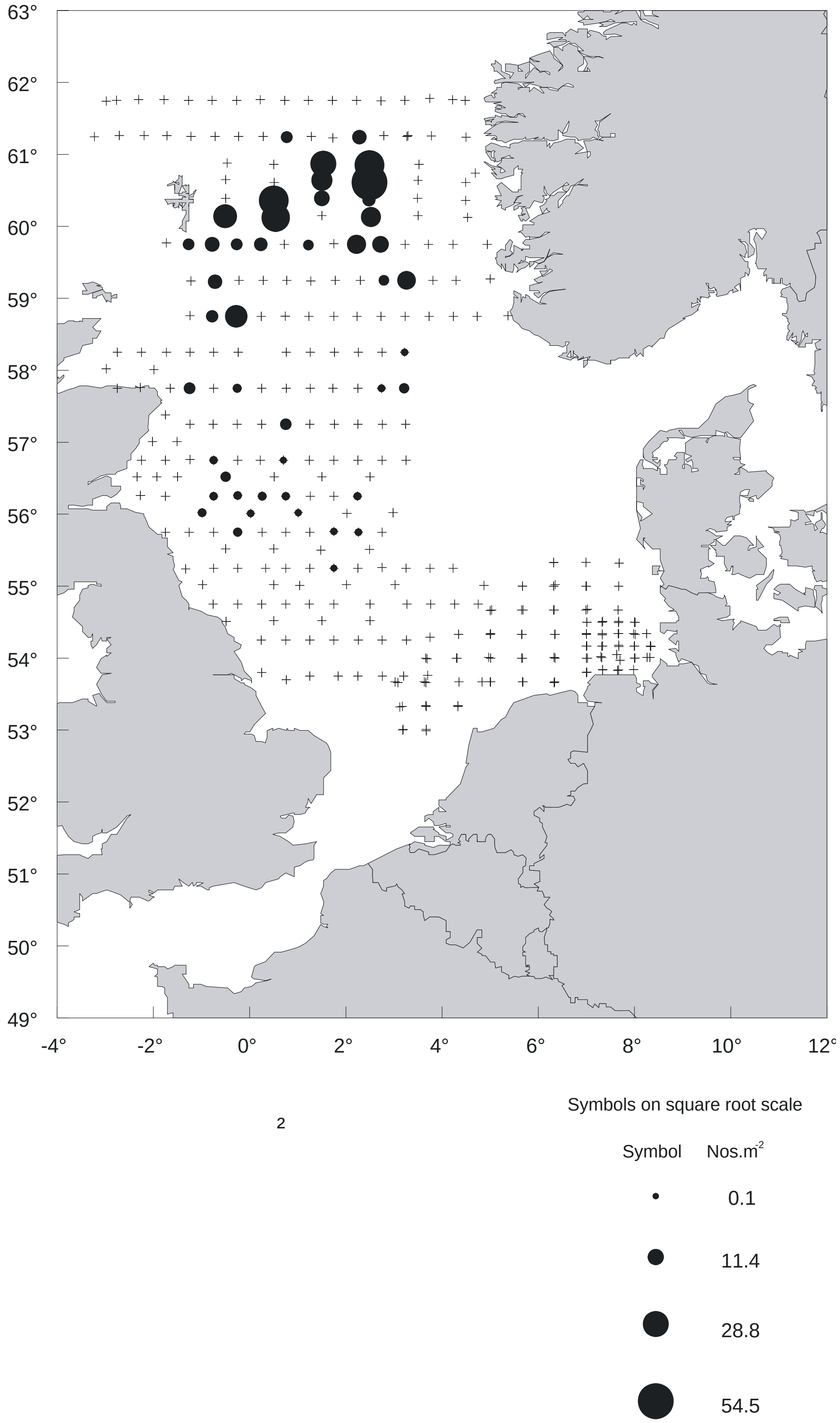

Figure 4.1.37. Composite map of long rough dab (*Hippoglossoides platessoides*) larval abundance (nos. m^{-2}) in 2004.

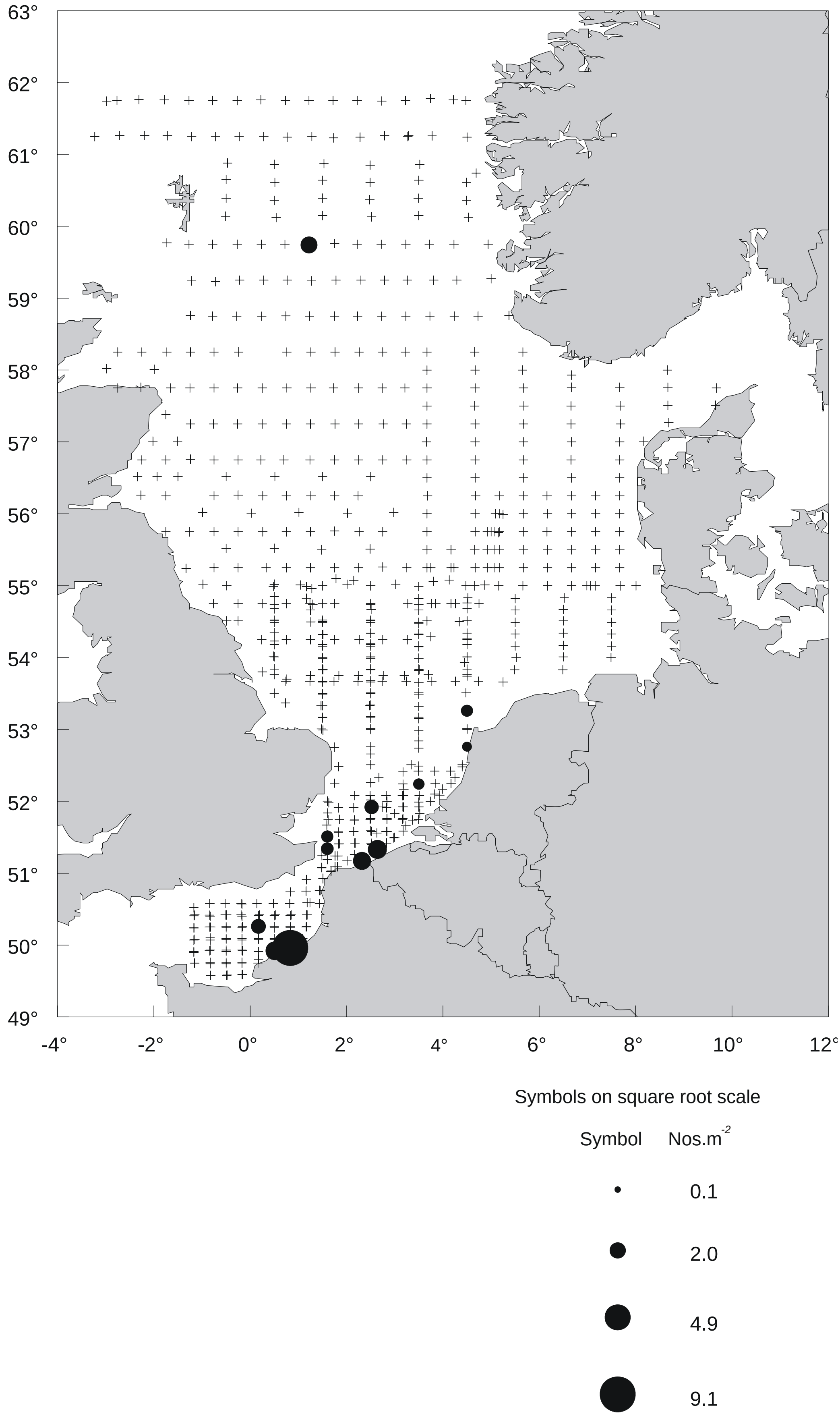

Figure 4.1.38. Composite map of sole (*Solea solea*) egg abundance (nos. m^{-2}) in 2004.

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