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Theme Session S

Distribution of blue whiting (*Micromesistius poutassou* Risso 1826) larvae along the western Iberian coast. Results from a joint research cruise to Spanish and Portuguese waters.

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ABSTRACT

Within the framework of the EU Shelf Edge Fisheries and Oceanography Study (SEFOS), a joint research cruise was conducted with the German RV „Heincke“ from 5 February to 15 March 1996 in the waters west of the Iberian Peninsula. Our objective was to examine the horizontal and vertical distribution of larval blue whiting in relation to the hydrography west of Iberia. This paper presents results from sampling a large scale grid (standard grid) west of Portugal and Spain from 38° 50' to 43° 00' N and from the repeated sampling of a subset of stations (additional grid) along the shelf break Sea-surface water temperatures were about 2 °C higher than the long term means. Strong north-easterly winds apparently caused upwelling at the shelf break. During the standard grid sampling few larvae of blue whiting were found. In comparison, higher abundances of larvae were found during sampling in the additional grid effort. In the additional grid larvae were distributed in three distinct patches along the shelf break and peak abundance occurred in the most southerly area sampled The occurrence of small larvae (< 3.0 mm) suggested that spawning had just taken place. Larvae from off northern Spain showed different vertical distributions and occurrences with certain temperatures and salinities than those off Portugal. These preliminary results indicate that larvae off the coast of Portugal may belong to a separate population of blue whiting which show adaptations in their reproductive behaviour to the specific oceanographic regime in this area.

INTRODUCTION

Along the western European shelf edge blue whiting occur from the southern tip of Portugal up to northern Norway (SVETOVIDOV, 1986). The stock is one of the most important fishery resources in the area (BAILEY, 1982). Most of the knowledge on the reproductive biology of blue whiting is restricted to the northern parts of its distribution range north of 43° N and the knowledge on the distribution of blue whiting eggs and larvae west of the Iberian peninsula is very limited. In particular, there is much discussion as to time and area of spawning and suggestions for its onset range from January to March. The goal of our investigation was to determine the abundance and distribution of blue whiting eggs and larvae along the Iberian Peninsula. This research was carried out within the framework of the EU Shelf Edge Fisheries and Oceanography Study (SEFOS) and represents a joint effort among German, Spanish, and Portuguese biologists.

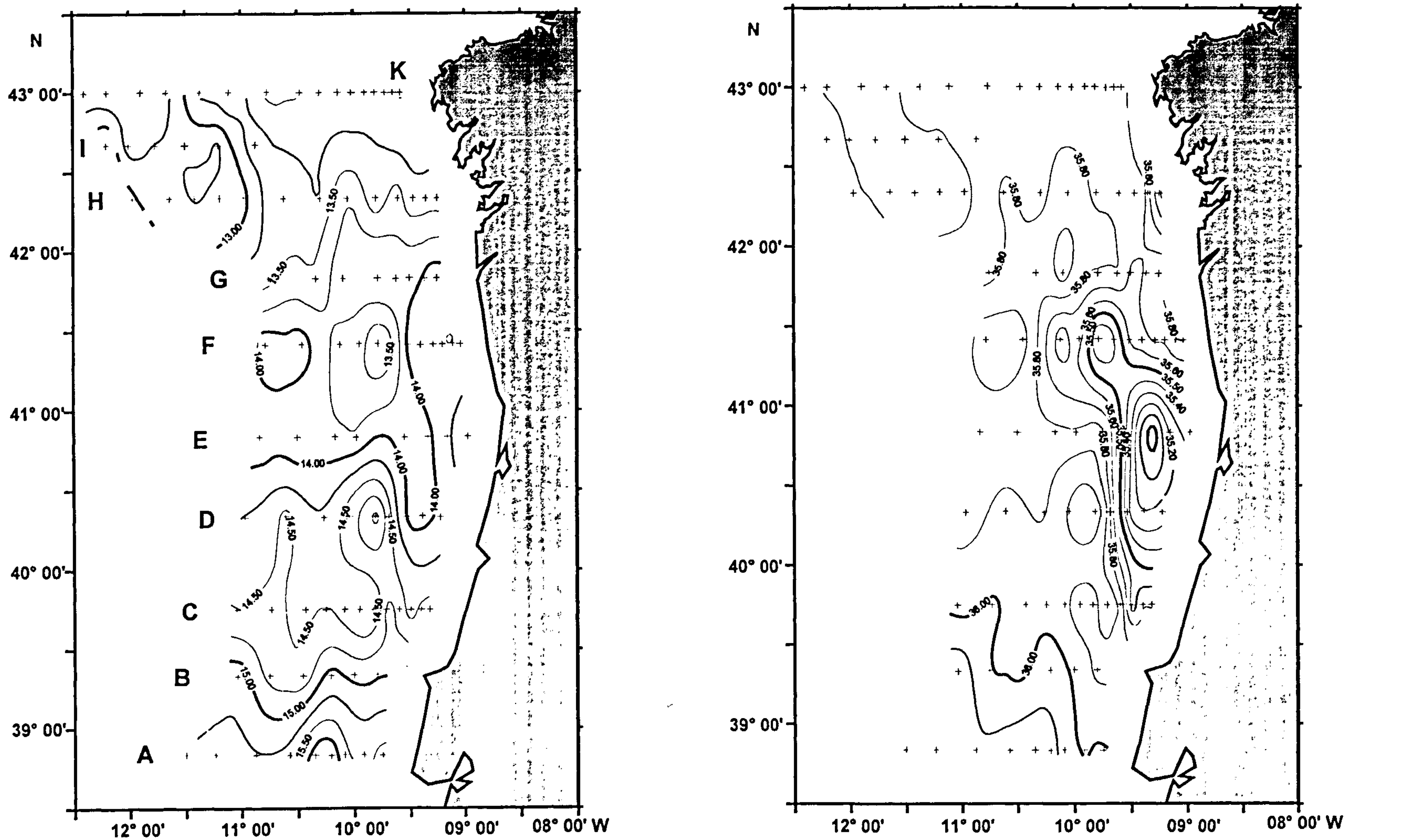

Figure 1: Horizontal distribution of surface temperatures (°C, left) and salinities (right) during the standard of Heincke cruise to Portugal and Spain from 5 February to 15 March 1996. The sampling stations are represented by crosses.

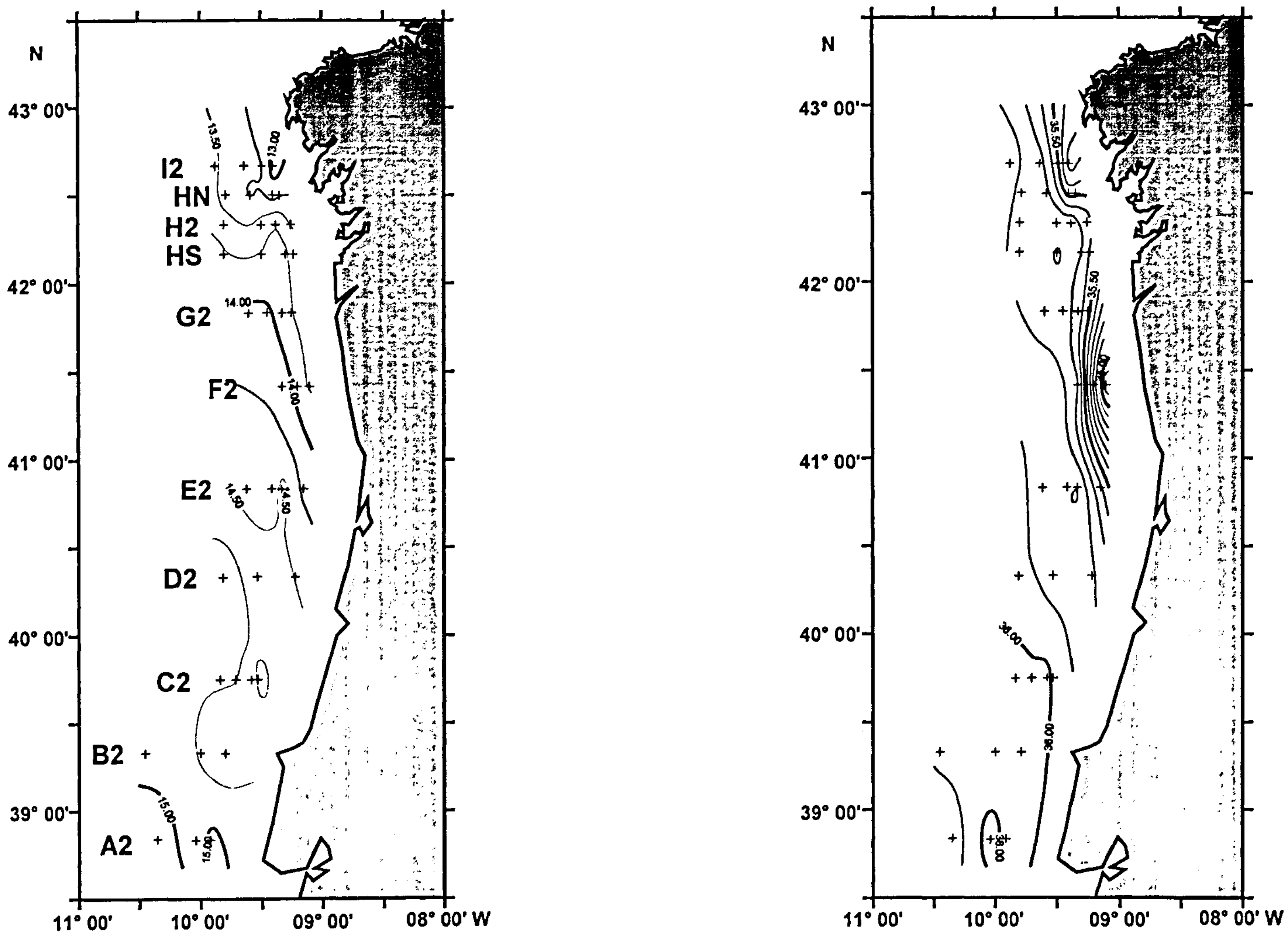

Figure 2: Horizontal distribution of surface temperature (° C, left) and salinities(right) of the additional grid of Heincke cruise to Portugal and Spain from 5 February to 15 March 1996. The sampling stations are represented by crosses.

Material and Methods

A station grid (standard grid) was worked from the South to the North (figure 1, left) of which the stations off the Portuguese coast were sampled from 13 to 24 February and the stations off the Spanish coast from 27 February to 8 March 1996. An additional grid mainly consisting of selected stations from the standard grid along the shelf break (figure 2, left) was sampled from the North to the South from 8 to 13 March 1996.

At each station sampling procedure consisted of one CTD cast down to 1000 m or 5 - 10 m above the seabed and one or two multiple-opening-closing-net (MCN, see e. g. KLOPPMANN 1994) hauls (depending on the bottom depth) according to the following table:

NET NO.	SAMPLED DEPTHS - SHALLOW -	SAMPLED DEPTHS - DEEP -
1	200 - 150 m	500 - 400 m
2	150 - 100 m	400 - 300 m
3	100 - 50 m	300 - 250 m
4	50 - 25 m	250 - 200 m
5	25 - 0 m	200 - 0 m

Thus, up to 9 discrete depth strata were sampled at each station. In addition a double oblique Bongo (60 cm diameter) haul was made at each station to a maximum depth of 100 m. Both MCN and Bongo had 200 µm mesh nets, depth recording devices and flowmeters to measure the amount of water filtered. Samples were stored in 4 % formalin-seawater-solution which was buffered to pH > 8.5 with borax. The contents of one bongo net were sorted immediately after recovery for fish larvae only.

In the laboratory samples from the MCN were sorted for blue whiting eggs and larvae (samples from the Spanish coast by IEO, Madrid, samples from the Portuguese coast by IPIMAR, Lisbon). Total length of blue whiting larvae was measured to the nearest 0.5 mm below. For the presentation of the horizontal distribution larvae were grouped into two length classes: larvae < 5 mm TL and larvae ≥ 5 mm TL. Three length classes (< 3 mm, 3 - < 5 mm and ≥ 5 mm) were assembled for the presentation of the vertical distribution. Numbers of blue whiting eggs and larvae were standardised to numbers per 100 m^3 of water filtered for the presentation of the vertical distribution. For the horizontal distribution values are given in numbers of larvae per 1 m^2 sea-surface.

We present only the results from the shallow MCN sampling (0 - 200 m, transects G - K and I2 - A2) supplemented by the results from the bongo samples where MCN data are not yet available (transects A - F and egg and length data of transects F2 - A2).

Results

Hydrography and weather

During the whole cruise rough weather conditions with mainly northerly to north-easterly winds up to 8 Bft. prevailed. Moderate weather with low wind velocities was only observed

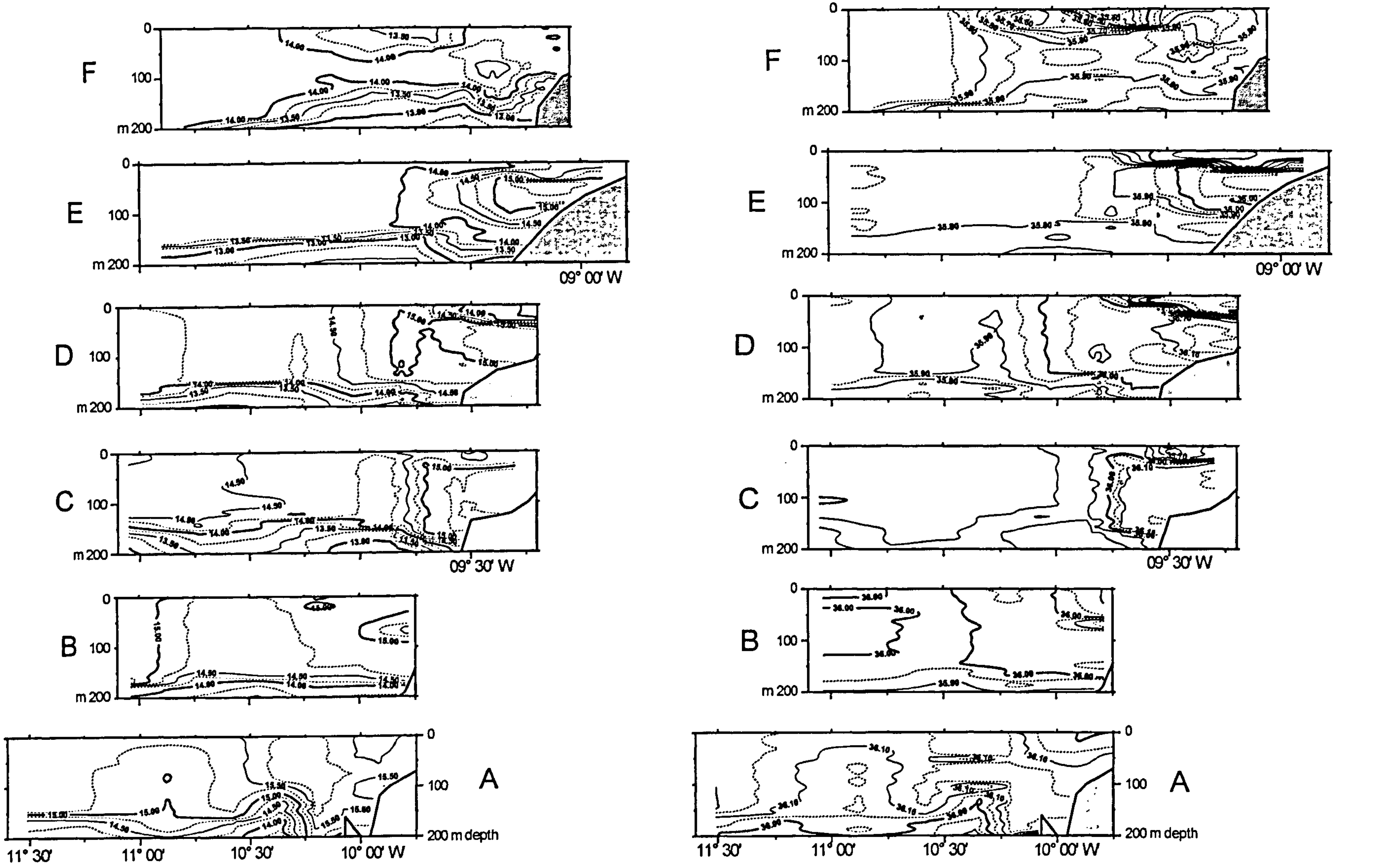

Figure 3: The vertical distribution of temperature (°C, left) and salinity (right) off Portugal during sampling the standard grid.

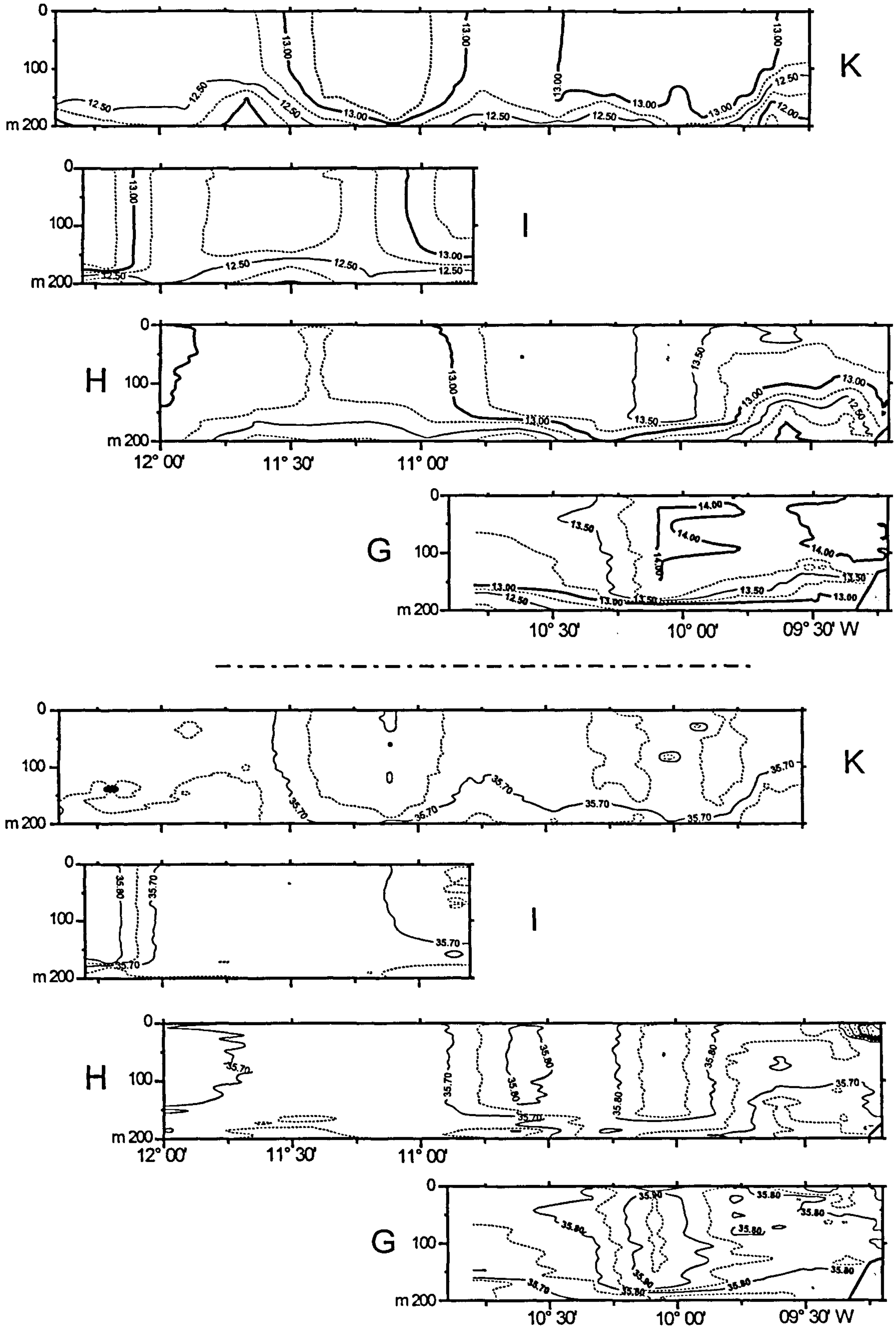

Figure 4: The vertical distribution of temperature (°C, top) and salinity (bottom) off Spain during sampling the standard grid.

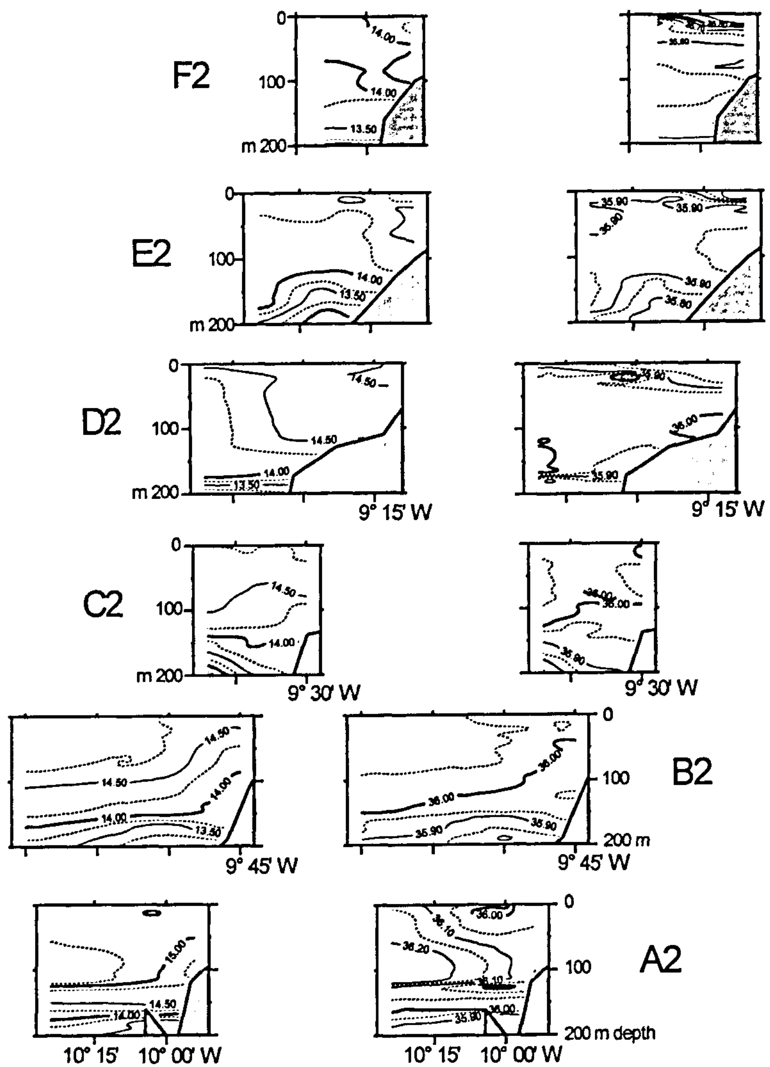

Figure 5: The vertical distribution of temperature (°C, left) and salinity (right) off Portugal during sampling the additional grid.

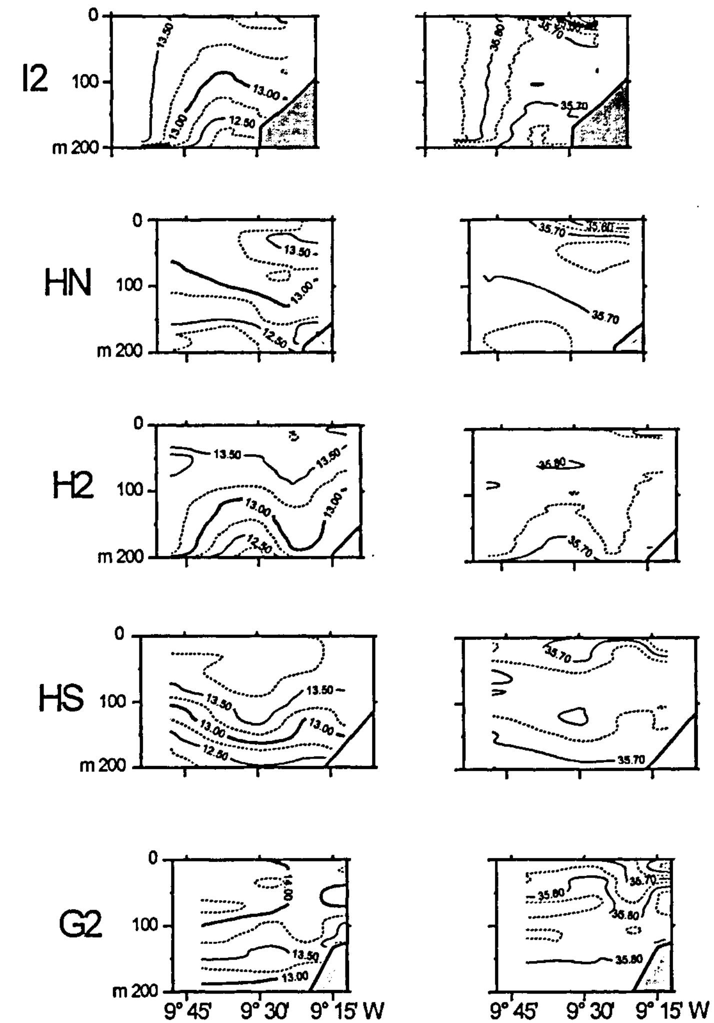

Figure 6: The vertical distribution of temperature (° C, left) and salinity (right) off Spain during sampling the additional grid.

during relatively short periods in-between and at the end of the cruise while sampling the additional grid.

During the first part of the cruise, sea-surface temperatures (SST) off Portugal were approximately 2 °C higher than the long term monthly means of February (DHI, 1967). Offshore the 14 °C isothermal was shifted some 90 nm to the North. Its extension was even further north in the near shore areas (figure 1, left) indicating an advection of warm waters to the North. The same picture was true for SST off Spain but anomalies were not as high as observed off Portugal. Surface salinity values ranged from S = 35.0 to above 36.0. The horizontal distributions of salinity for both the standard grid and the additional grid resemble the long term monthly means (DHI, 1967; figures 1, right and 2, right). During both sampling exercises lenses of less saline water were observed near the greater river runoffs.

Strong northerly and north-easterly winds appeared to have caused some upwelling as evidenced by the decreasing depth of the isothermals and isohalines at the shelf break of transect F (figure 3). There was also a core of relatively warm (> 15 °C) saline waters along the shelf break between 30 and 100 (150) m depth which could be traced up to transect G (F). In the additional grid, similar SST values were observed (figure 2, left). Although the vertical temperature and salinity structure was not as well developed within the additional grid, there was some indication of upwelling along transects I2, B2 and possibly H2 (figures 5 and 6). Lenses of low saline coastal water seemed to protrude in the upper 30 to 50 m across the shelf on transects C to F of the standard grid and on transects I2, HN and F2 of the additional grid.

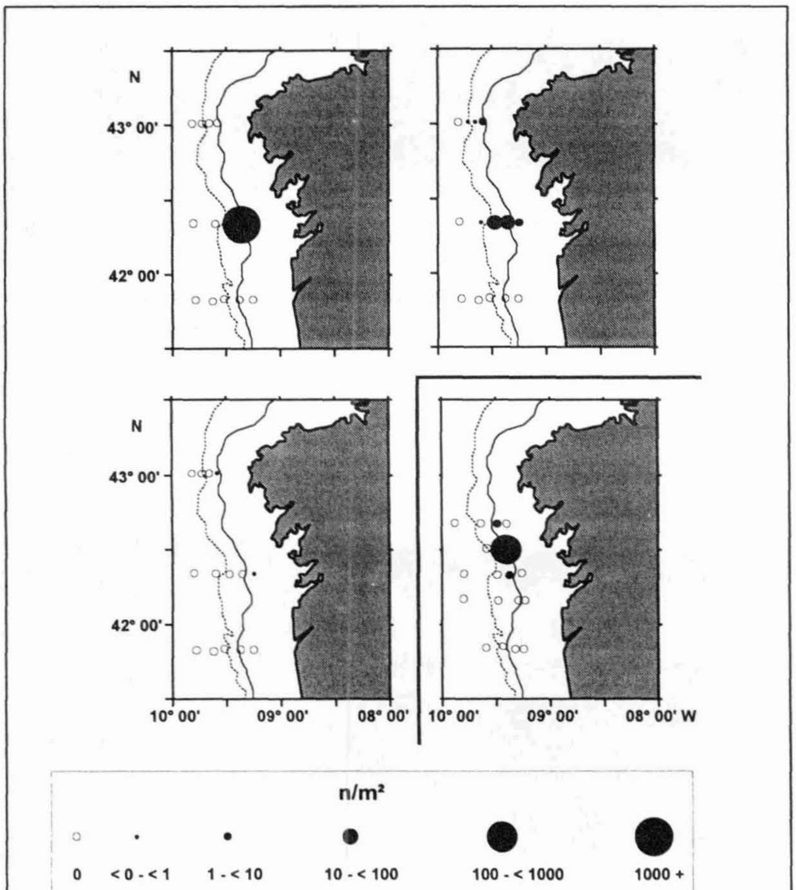

Figure 7:
Horizontal distribution of blue whiting eggs (top left), larvae < 5 mm (top right) and of larvae ≥ 5 mm (bottom left) off Spain during the standard grid. The picture on the bottom right shows the horizontal distribution of blue whiting eggs off Spain during the additional grid 1 to 2 days later.

Blue whiting egg and larvae distribution

Horizontal distribution

Eggs

To date only samples collected from off the Spanish coast have been analysed. Within the standard grid, blue whiting eggs were found at only one station (2831.20 eggs/m²; figure 7). In the additional grid only 1 to 2 days later eggs were found at three stations with relatively low abundances (maximum abundance of 127.50 eggs/m²), also centred above the 200 m depth contour (figure 7). In both the standard and the additional grids, eggs were found above 200 m depth.

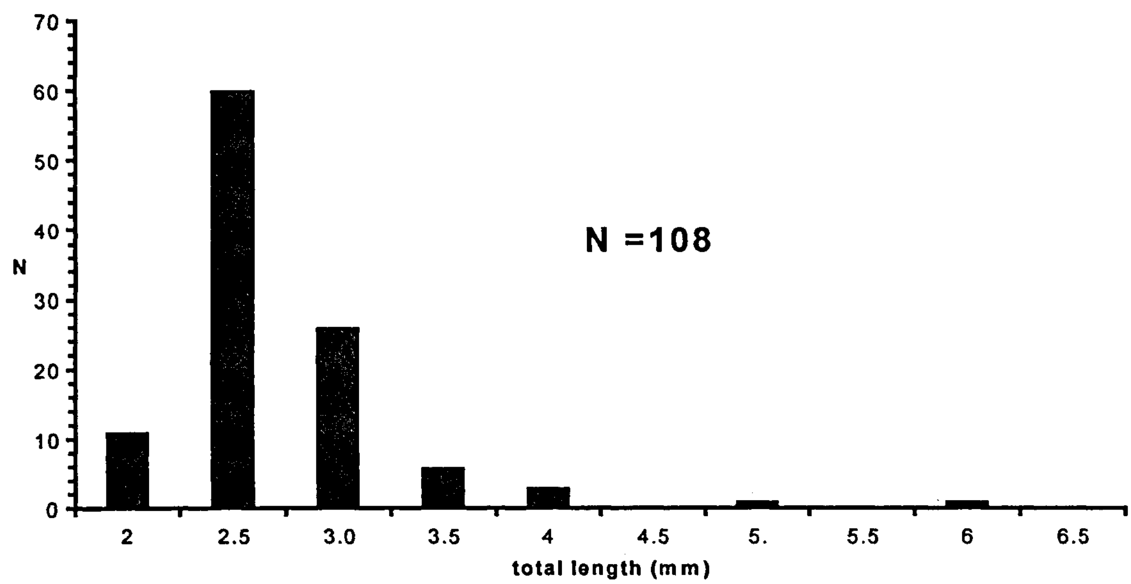

Figure 8: The lengths frequency distribution of blue whiting larvae from the standard grid off Spain.

Larvae

Except for two single records from the bongo there were no blue whiting larvae caught off the Portuguese coast during the first part of the cruise. Off Spain on transects H and K blue whiting larvae appeared in relatively low abundances between 0.5 and 15.5 individuals per 1 m². Their occurrence was centred around the 200 m depth contour with growing larvae becoming more abundant towards the coast (figure 7). Larvae measured between 2.0 and 6.0 mm with most larvae being smaller than 3.0 mm (figure 8) suggesting that we mainly caught recently hatched larvae (see e. g. SEATON AND BAILEY 1971; COOMBS AND HIBY 1979).

Larvae of blue whiting became more abundant during sampling the additional grid (figure 9 left). Now on almost every station records of blue whiting larvae were made. The mean abundance (25.46 larvae/m²; $s = 47.14$; median = 2.92/m²) was relatively low when compared with the northern spawning areas. However, there were three centres of high abundance with maximum values above 100 larvae per every 1 m². These centres, situated on transects I2, F2 and C2 were well separated by stations with low or zero abundance.

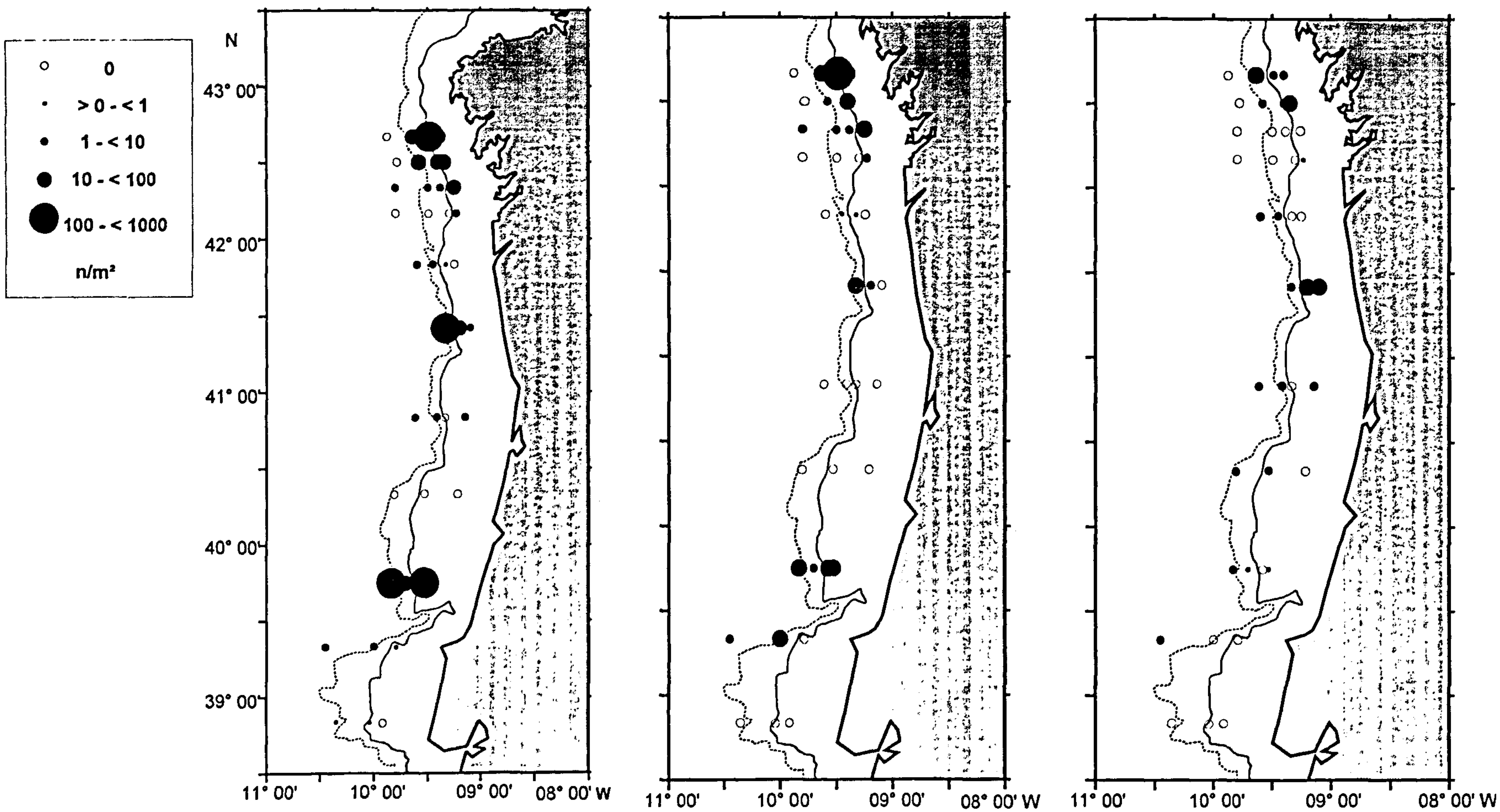

Figure 9: The horizontal distribution of all blue whiting larvae (left), of larvae < 5 mm (centre) and of larvae ≥ 5 mm (right) during the additional grid of Heincke cruise to Portugal and Spain. Except for the length distribution of transects A2 - F2 the figure is exclusively based on data from the MCN samples. Length distribution data from transects A2 - F2 are based on the bongo samples.

Total lengths of the larvae ranged from 2 mm to greater than 11.5 (figure 10). However, most larvae fell into the 3 mm length class. The lengths distribution showed a secondary mode at 6 mm.

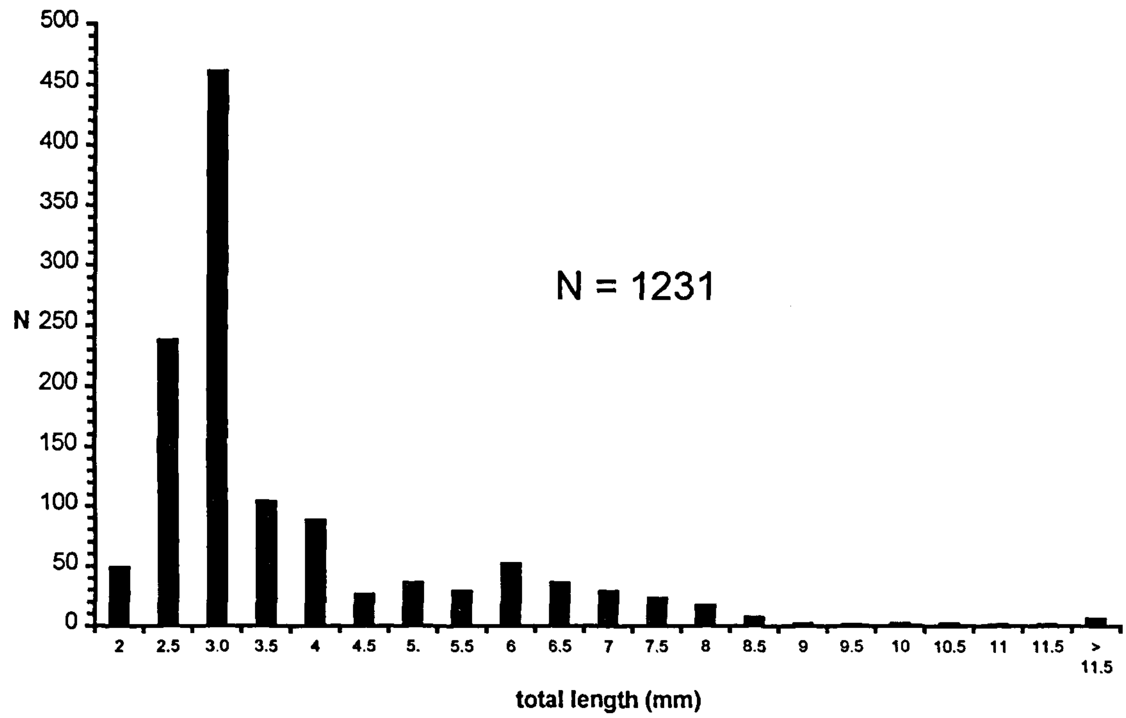

Figure 10: The length frequency distribution of blue whiting larvae from the additional grid.

The smaller larvae (TL < 5 mm) were found in three distinct patches along the western Iberian coast, separated by stations where no larvae were found (figure 9, centre). In Spanish waters larvae occurred primarily in inshore areas. Off the coast of Portugal larvae became more abundant in offshore deeper waters. In comparison to the patchy distribution of small larvae, older larvae (TL ≥ 5 mm) showed a more dispersed distribution (figure 9, right). However, there was one transect (transect H2) with zero values that seemed to separate two distinct areas of occurrence. In both sampling areas off Portugal and off Spain the core of abundance seemed to be more northward but remained close to the shelf edge.

Vertical distribution

Eggs

Only data from the shallow MCN hauls off Spain are available. Eggs of blue whiting occurred in all depths strata sampled (figure 11). However, within the few positive stations the bulk of eggs was caught in the deepest strata between 100 and 200 m where densities were always at least one order of magnitude higher than in the layers above.

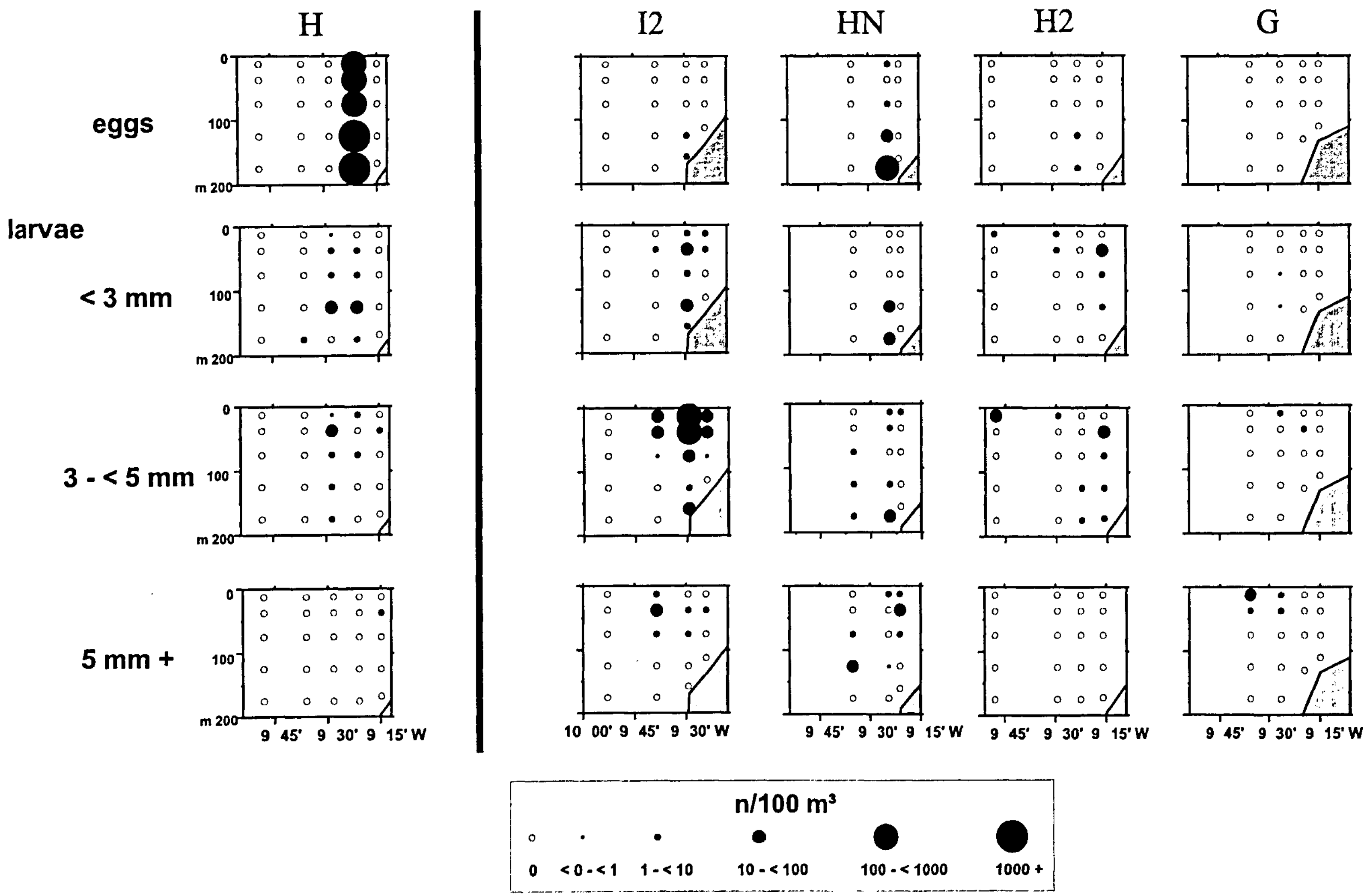

Figure 11: The vertical distribution of blue whiting eggs and larval lengths classes on transect H of the standard grid and on transects I2, HN, H2 and G2 of the additional grid.

Larvae

Data are only available from the shallow MCN hauls and only those from the additional grid and from the standard grid off Spain.

Larvae occurred in all depth strata sampled. Off Spain on the northernmost transects (H, I2, HN and H2, figure 12, right) the vertical distribution showed two distinct modes: one in the upper 50 m and one below 100 m. On all other transects larvae were only abundant in the upper 100 m (figure 12, left). These observed differences in depth distribution suggest somewhat contradictory preferences of the larvae for certain hydrographic conditions. While in the North larvae became abundant in relatively cool (about 13 °C) low salinity waters (about S = 35.8) on the southern transects high larval densities occurred in warm (above 14 °C) and high salininity waters (S > 35.9).

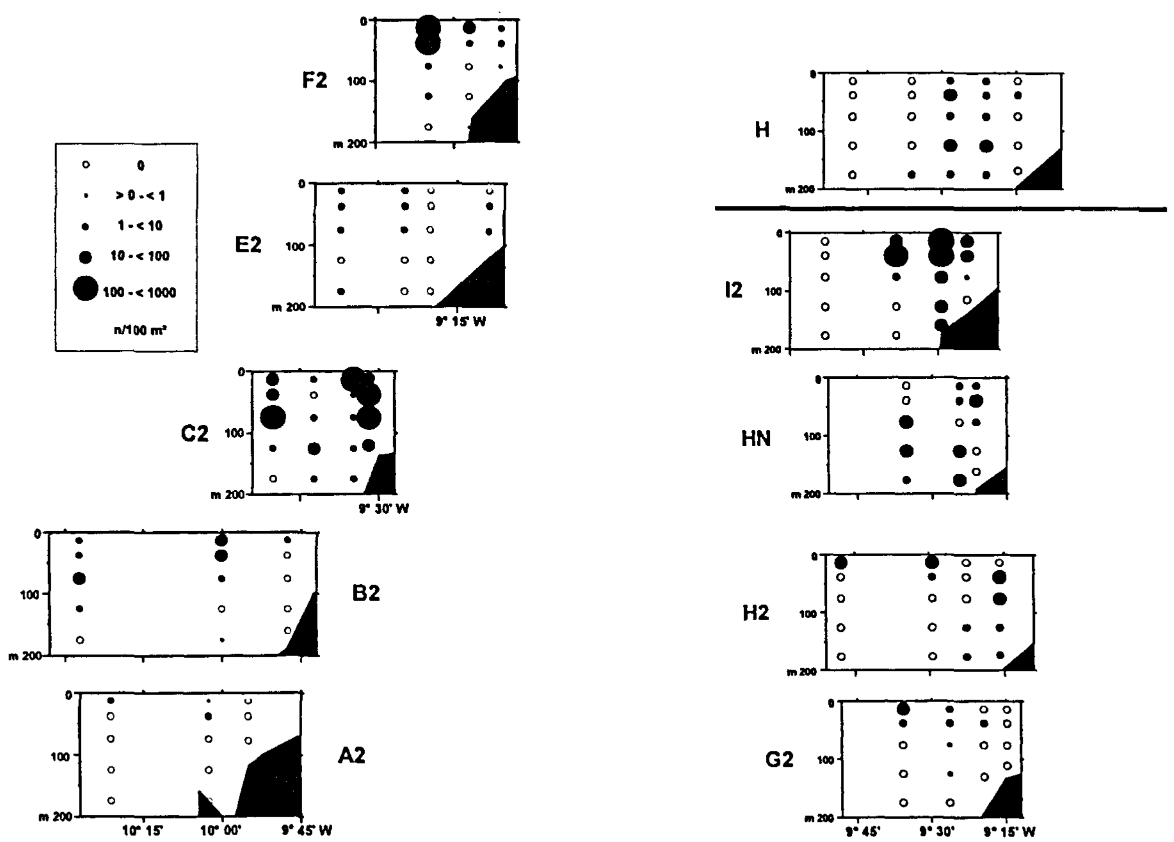

Figure 12: The vertical distribution of all blue whiting larvae off Portugal (left) and off Spain (right).

Vertical Distribution by Length

Only data from transects G - K and I2 - G2 are available (figure 11).

The smallest larvae (TL < 3 mm) mainly occurred in the deeper layers between 100 and 200 m. However, shallower occurrences were observed, especially in areas with slight indications of upwelling (e. g. transects H2 and I2). With growth blue whiting larvae seemed to ascend to shallower layers and most of the larger larvae became abundant in the upper 50 m. However, on transect HN the distribution seemed to be reversed, where higher densities of larger larvae occurred below 100 m.

Results from selected stations and depth strata on transect F indicated that off Portugal larvae of all length classes occurred in the upper 50 m of the water column.

DISCUSSION

Most surprising were the - at first glance - contradictory results from the standard and additional grids of the cruise. With the exception of seven positive stations in the North, few blue whiting larvae were found during sampling the standard grid. In contrast, in the additional grid, between 1 and 29 days later, blue whiting larvae occurred on almost every station. The maximum size of larvae found within the additional grid was > 11.5 mm. Presuming an average growth rate of about 0.35 mm per day (M. BAILEY, SOAEFD, Aberdeen, pers. comm.) these larvae must have been in the area during our sampling of the standard grid. There may have been some constraints while sampling off Portugal which might have prevented these larvae from being caught with our plankton nets. As the samples from the additional grid have shown the distribution of blue whiting eggs and larvae is rather patchy in this particular area. Stations with high abundance lie very close to stations with low or zero abundance. Previous studies in the area (SOLÁ et al. 1994; FARINHA et al. 1996 and unpublished data from other BAH cruises) also show the same patchy distribution and that the average abundance is rather low when compared to the northern main spawning areas on Porcupine Bank (e. g. HILLGRUBER et al. 1995) and to the West of the Hebrides (COOMBS and PIPE, 1978). Thus it might be possible that due to the wide spacing of the transects we simply missed the larvae.

On the other hand growth studies on the larvae caught within this study show that off Portugal blue whiting larvae seem to grow faster than in the other more northern areas (MENESES, IPIMAR, Lisbon, pers. comm.). The average growth rate of about 0.45 mm per day is slightly higher than the rates estimated for the northern areas where during blue whiting spawning temperatures are about 5 °C lower than e. g. off Portugal (DHI, 1967 and see also KLOPPMANN et al. 1996 and MONSTAD et al. 1995 for comparison). The largest larvae (> 10 mm TL) were caught on 11 and 12 March on transects E2 and D2. Assuming a hatching length between 2.0 and 3.0 mm (SEATON AND BAILEY 1971; COOMBS AND HIBY, 1979) these larvae may have been in the area not before 22 February, a date when we already finished sampling on transect D. With most of the larvae being small (between 2.5 and 3.5 mm) it appears that in 1996 west of the Iberian Peninsula spawning of blue whiting did not commence before mid February reaching it's maximum in the beginning of March. Results from previous studies within the last 10 years are in concordance with this finding that off northern Spain eggs and larvae of blue whiting do not occur before February (unpublished data from IEO, Madrid).

As pointed out above there has been some discussion as to the time of spawning of blue whiting west of the Iberian Peninsula. Calculations of spawning time based on seasonal larval production further north (Bay of Biscay to Faeroes, BARTSCH and COOMBS, 1996) led to the assumption that off the Iberian peninsula blue whiting might spawn as early as January (see also BAILEY, 1982). However, this study and also studies on the gonadal ripening in blue whiting caught off Portugal (CUNHA, 1992) and off northern Spain (CENDRERO, 1967) point to a spawning time no earlier than February. This behaviour can only be understood in context with the special hydrography of the area.

The area off the Iberian Penisula is characterised by the seasonal occurrence of upwelling which reaches it's maximum in late summer (FIUZA et al. 1982; WOOSTER et al. 1976; CABANAS et al. 1992). Sporadic events of upwelling do also occur most probably in December and January. Under certain circumstances upwelling itself may be beneficial to the survival of fish larvae (CURY and ROY 1989) as it enhances production. However, upwelling is a result of an offshore Ekman-transport in the surface layer caused by coast-parallel equatorward directed wind-stress. Fish larvae entrained in this offshore transport may be driven into areas detrimental for survival (see BAKUN and PARRISH, 1991) or simply away from the normal habitat of their population (sensu SINCLAIR, 1988). In fish populations there exist adaptive strategies to avoid losses of offspring due to strong upwelling (PARRISH et al., 1983) in simply avoiding seasons and areas where strong upwelling occurs during reproduction. For blue whiting off the Iberian Peninsula this seems to be the case, as they obviously spawn in February and March when under normal conditions upwelling is at minimum (FIUZA et al. 1982) thus minimising the offshore losses of their offspring. The large growth rates estimated by MENESES (IPIMAR, Lisbon, pers. comm.) may in addition act as such an adaptive strategy in reducing the planktonic phase of the fishes. Moreover, in February the general wind direction is from the Southwest (DHI, 1967) resulting in an onshore drift in the surface layers. Secondly, fresher waters from the coast protrude to as far as the shelf edge. This mechanism enhances production and also retention above the shelf edge (see e. g. BAKUN and PARRISH 1991). Thus spawning in February would therefore enable the larvae to benefit from this mechanism, thus maximising survival.

However, in 1996 the special hydrography in the area may have delayed the time of spawning off Portugal for some days. During the standard grid unusually high temperatures above 15 ° C were measured in the layers between 25 and 200 m depth along the Portuguese shelf break. In their study on blue whiting eggs and larvae COOMBS and HIBY (1979) found that temperatures above 14.5 °C are detrimental for a successful development of the eggs. Thus it seems possible that due to the high temperatures no spawning took place in the area off Portugal.

The horizontal distribution pattern of the eggs and larvae resembles mainly those of other areas where these are mainly caught in the deeper waters above the shelf break (SCHMIDT, 1909; BAILEY, 1982; SOLÁ et al. 1994). However, in the North (north of 42° N) of the sampled area eggs and larvae appeared to become more abundant towards the coast while off Portugal the highest larval abundances were encountered more offshore. Moreover, in the North the vertical distribution of larvae differed from that off Portugal. Off northern Spain the vertical distribution of larvae was comparable to that of other areas with deep and shallow modes (COOMBS et al. 1981; HILLGRUBER et al. 1995). Their preference for relatively cool (around 13 °C) and low saline (< 35.7) waters also seemed to distinguish the larvae from the North from those off Portugal (south of 42° N). Here, larvae became only abundant in waters warmer than 14 °C of relatively high salinity (> 35.8) and they almost exclusively occurred in the shallower depths above 100 m - both young (i. e. recently hatched) and older larvae. Thus it may be possible that the different horizontal and vertical distribution patterns represent two blue whiting spawning populations with different spawning strategies: a deeper spawning population off northern Spain and a shallow spawning one off Portugal. This evidence is further supported by CUNHA (1992) who found that blue whiting caught off Portugal differ in many morphological aspects from those caught in the North.

However, blue whiting caught off the North-west of Spain and off Portugal chiefly consist of immature individuals and fishes spawning for the first time (ROBLES and PORTEIRO, 1978;

ROBLES et al. 1980, 1978; CUNHA, 1992). A fact that explains the relatively low abundance of eggs and larvae in the area and indicates that waters off the western Iberian Peninsula do not represent a major spawning area for blue whiting. Thus it seems unlikely that blue whiting caught off the Iberian Peninsula constitute own populations. It is more likely that the spawners of the eggs and larvae caught off northern Spain derive from a population from further north in the Bay of Biscay. The preferences for higher temperatures and salinities suggest that blue whiting larvae off Portugal derive from spawners that are possibly related to the blue whiting from the Mediterranean Sea.

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