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The Shelf Edge Current and Its Effects on Fish Stocks

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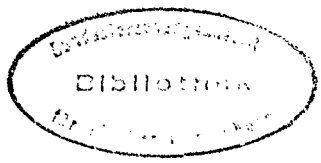

INCIDENCE OF THE POLEWARD CURRENT AND VERTICAL MOTION IN HAKE RECRUITMENT

by

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ABSTRACT

The historical series of bottom trawl surveys carried out in autumn in the waters of Galicia and the Cantabrian sea show that the processes of hake recruitment lead to well-defined aggregations of juveniles which are found in certain areas of the continental shelf. These concentrations vary in density according to the strength of the year class, although they remain generally stable in size and spatial location. The size of these aggregations, estimated using geostatistical techniques, is found to be between 30 and 50 km. The mesoscale dynamic and vertical motion of water masses associated with it seem to have clear consequences with respect to the distribution and size of hake recruit concentrations. The areas of greatest spatial coincidence are found where there is vertical forcing (obtained from the formulation of the vector Q in the Omega equation), which may be caused by hake feeding behaviour. This species makes nocturnal vertical migrations to prey on organisms living in upper layers.

INTRODUCTION

The area covered by this study (Fig.1) is the waters of Galicia and Cantabrian sea (ICES Division VIIIc and the northern part of IXa). In this area, european hake (Merluccius merluccius L.) spawns during the early months of the year and adults gather in the deep waters of the shelf break (Fig. 2). The larvae of this species are usually found over the slope at depths between 100 and 250 m. The process of recruitment of juveniles to the bottom originates in the shelf break and they move towards shallower areas to concentrate in autumn in bottoms between 90 and 150 m (Sánchez, 1995). These juveniles make vertical migrations at night to feed on species which live in upper layers, mainly anchovy and silvery pout (Olaso, 1990).

The historical series of bottom trawl surveys carried out in autumn show that the processes of hake recruitment lead to well-defined aggregations of juveniles which are found in certain areas of the continental shelf (Fig.3). These concentrations vary in density according to the strength of the year class, although they remain generally stable in size and spatial location. The size of these aggregations, estimated using geostatistical techniques, is found to be between 30 and 50 km. The distributions of juveniles in the area studied over the last decade (Sánchez, 1995) show the highest concentrations in three defined areas which are repeated every year, and which are those denominated as La Coruña, Ribadeo and Peñas. In some years another two smaller concentrations appear, that of Rías Bajas and that of Guetaria. These areas of high concentration, situated between 90 and 180 m and with predominantly muddy bottoms, must provide the appropriate habitat and the availability of the necessary food for recruits.

The strength of annual hake recruitment has been continually observed in these waters since 1983 by means of a series of autumn bottom trawl surveys carried out by the R/V CORNIDE DE SAAVEDRA. The analysis of the recruitment indices obtained since 1990 (Fig. 4), together with the fact that the biomass of spawners has been at a historical low (Anon., 1995) shows four years of very poor recruitment (1990, 1992, 1993 and 1995) and two years of good recruitment (1991 and 1994). This implies, a certain level of independence between the strength of recruitment and the spawner biomass, and the existence of other factors greatly affecting the recruitment processes. To study which abiotic parameters may influence the survival of recruits, the environmental variables from 1993 were studied under two main working hypothesis:

1. The current pattern in the slope area conditions larval drift towards recruitment areas. An intense geostophic flow towards the western part of the Bay of Biscay carries eggs and larvae towards the oceanic area, thus increasing mortality during the later process of recruitment to the bottom of the continental shelf.

2. Once the juveniles are recruited to the bottom and are able to move, their later development is affected by the availability of food. Enriching processes of the surface layers which strengthen the food chain may favour the presence of recruits over the bottom.

INFLUENCE OF THE SHELF EDGE CURRENT ON THE STRENGTH OF RECRUITMENT

A flow begins to appear towards the interior of the Bay of Biscay in autumn in the study area. This flow grows notably in the winter months due to the poleward current. This phenomenon can be appreciated in the results obtained in the central area of the Cantabrian Sea in 1995 (Fig. 5). If the intensity of this flow, which transports warm and salty waters, is intense enough to last until the spring, the salinity of the

surface layers is observed to be abnormally high, as happened in April in 1992 and 1993 (Fig. 6). According to hypothesis 1, this is reflected in very low recruitment indices in these years (Fig. 4).

IMPORTANCE OF MESOSCALE ACTIVITY IN THE LOCATION OF AGGREGATIONS OF RECRUITS

The salinity observed at 20 m in the autumn surveys shows 1993 as being radically different to 1994 and 1995 with respect to circulation over the continental shelf-slope area (Fig. 7). The high values of salinity observed in 1993 are a consequence of a current pattern towards the easternmost part of the Bay of Biscay. To the contrary, the low salinity found in 1994 and 1995 is due to the absence of the supply of salty waters from the west. In the easternmost area, it is seen how waters of very low salinity appear in these last two years, originating from flows coming from the French continental shelf. In 1994 these areas were particularly conspicuous with nuclei of very low salinity (34.6) with clearly mesoscale characteristics.

The temperature distributions at 90 m clearly show the different origins of the water masses of 1994 and 1995 with respect to1993 (Fig. 8). In the three years studied, the important degree of mesoscale activity in the form of anticyclonic eddies is clear, notably the repetition of gyres over the continental shelf with negative vorticity off La Coruña, Estaca-Ribadeo and Cape Peñas. This is due to the fact that the entrance of the relatively warm waters of the poleward current is introduced between the cold coastal upwelling waters and the cold stratified waters outside the continental shelf in a geostrophic balance with negative vorticity (anticyclonic). The fact that the presence of these eddies is repeated in the same areas in the three years studied may be down to topographic factors which induce negative vorticity in the water masses previously described.

The dynamic associated to the eddies with important variations in vorticity causes an outstanding ageostrophic vertical motion. The Q vector formulation of the Omega equation (Hoskins et al., 1978) is used to study the relationship between mesoscale structures and the induced ageostrophic vertical forcing. The convergence of this vector indicates the regions where upward forcing exists (Hoskins and Pedder, 1980). The vertical motions are repeated to a greater or lesser extent in the areas of La Coruña, Ribadeo and Peñas in the three years studied. In 1994 there was an intense vertical mesoscale activity throughout the area of the Cantabrian Sea (Fig. 10).

In accordance with the hypothesis 1 and 2, the years of weak eastward flows and intense vertical mesoscale activity, regenerating the photic layer, may be favourable to hake recruitment. In 1993 the flows were clearly eastward and mesoscale activity was reduced to the three areas of La Coruña, Ribadeo and Peñas (Fig. 9), which as a consequence gave rise to low recruitment indices and the presence of hake juveniles only in these three areas. 1994 was favourable in the two hypotheses mentioned, with weak flows over the slope and great mesoscale activity throughout the Cantabrian Sea, which led to high recruitment indices and high density of recruits in the concentrations in this sea (Ribadeo, Peñas and Guetaria). Thus, the origin of the concentration of Guetaria lies in the supply of larvae from spawners in the French continental shelf. In 1995, although the eastward flows in spring were not very intense, leading to a favourable larval drift, the areas of vertical motion were very scarce in the Cantabrian Sea (Fig. 11), which caused the fall in recruitment indices and low density of concentrations.

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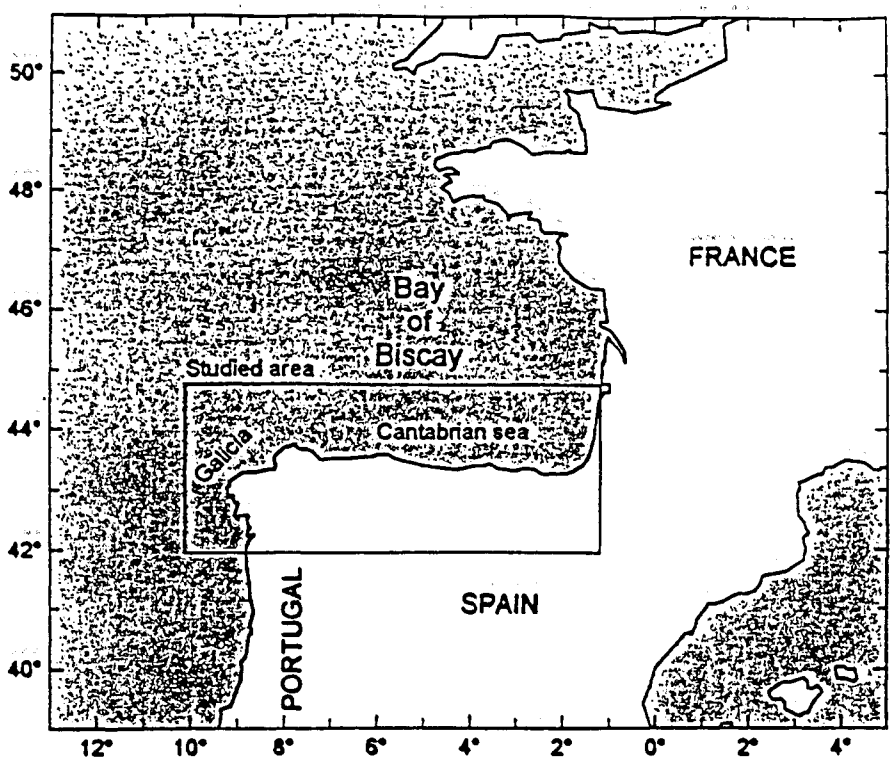

Figure 1. Studied area.

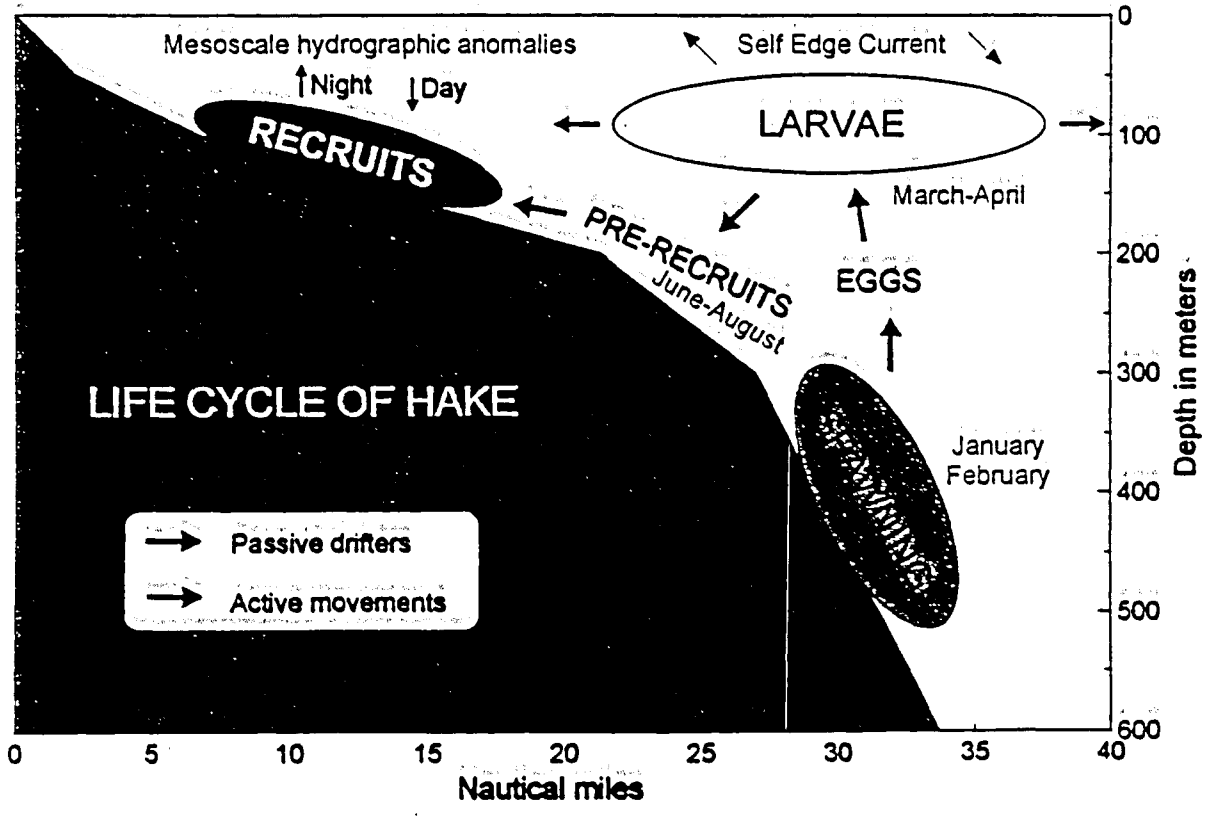

Figure 2. Life cycle of european hake.

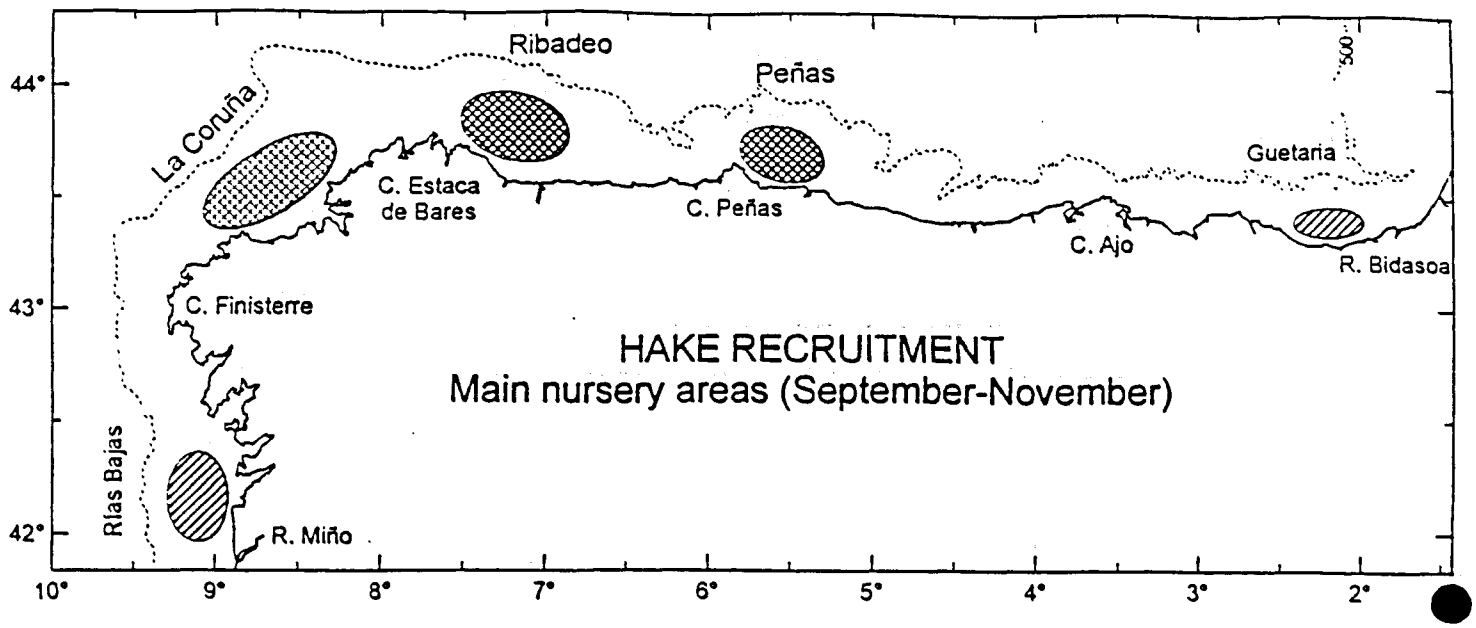

Figure 3. Main nursery areas

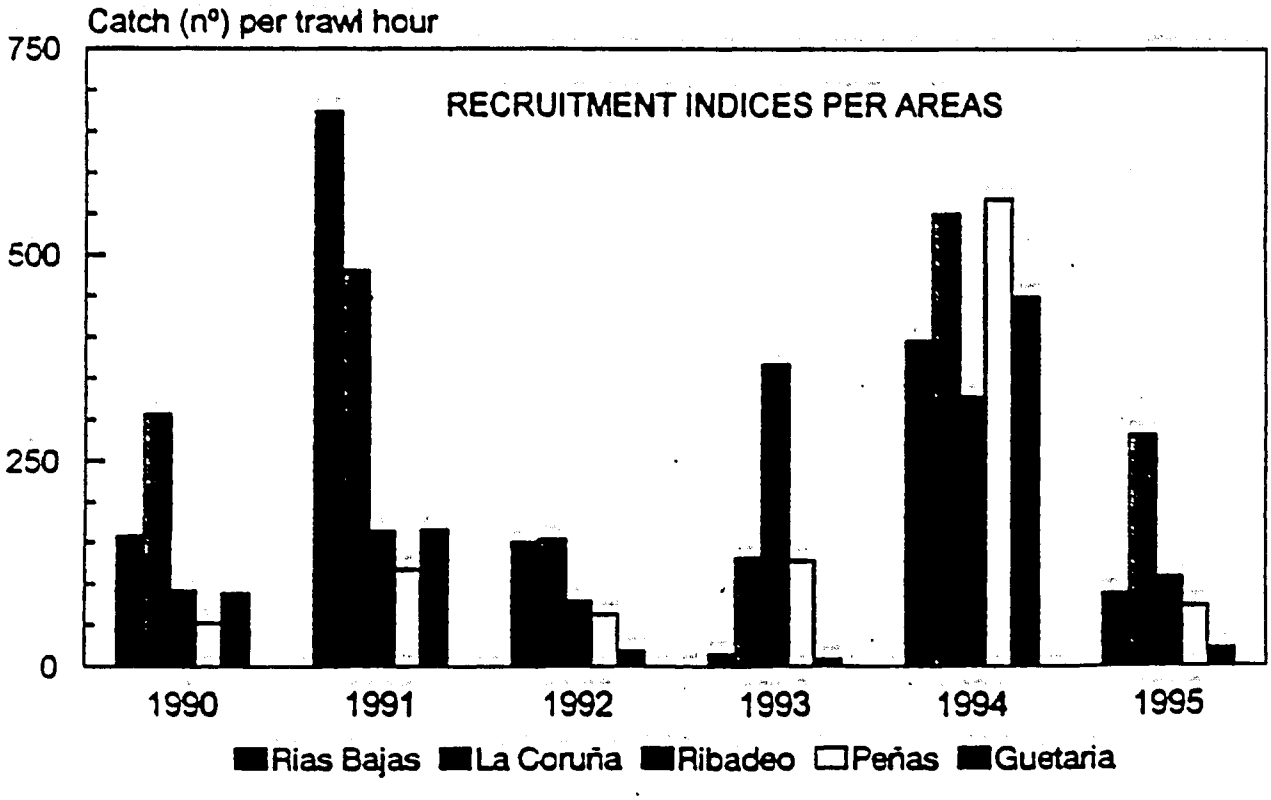

Figure 4. Recruitment indices per areas

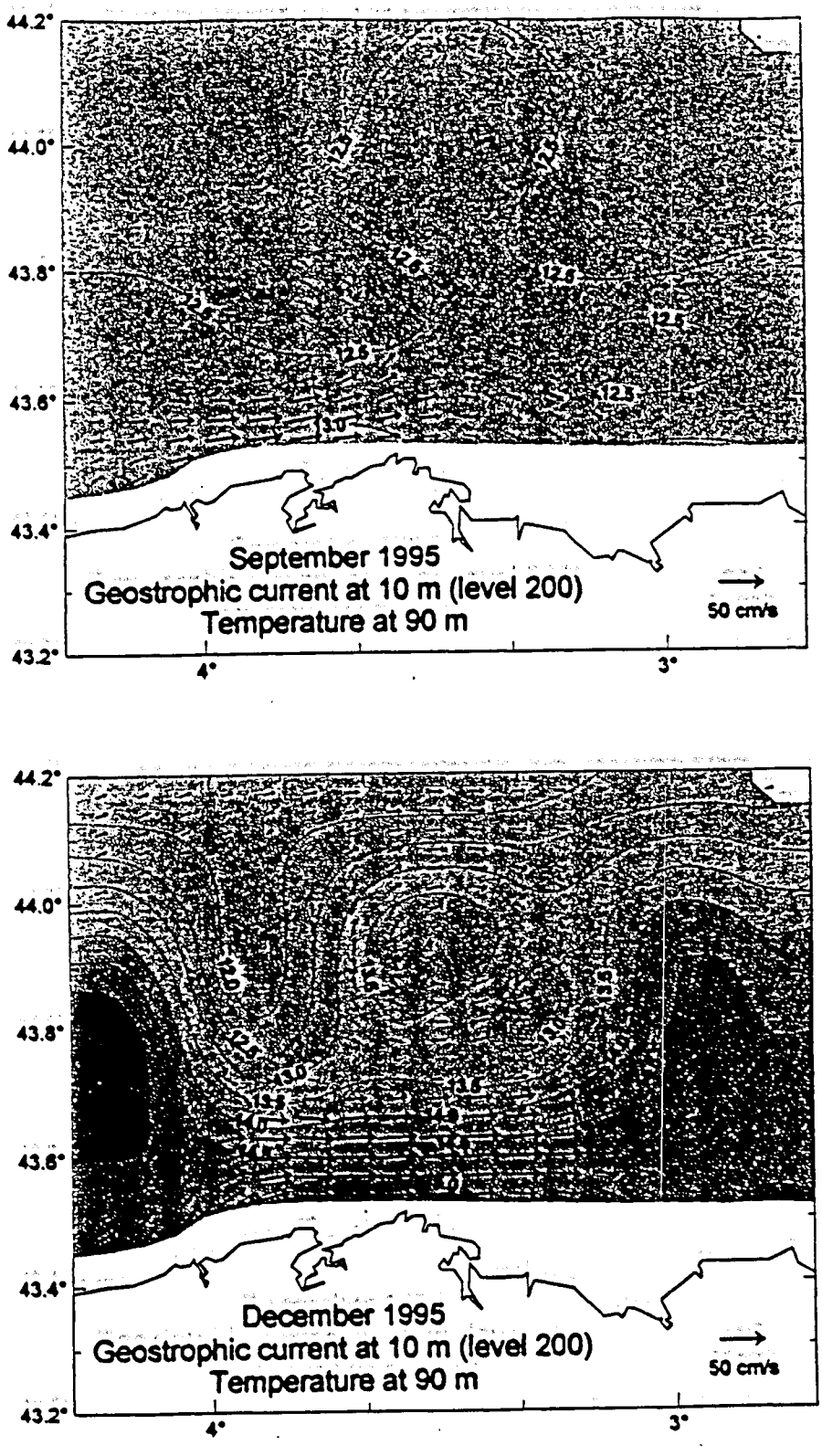

Figure 5. Geostrophic current and temperature during September and December of 1995.

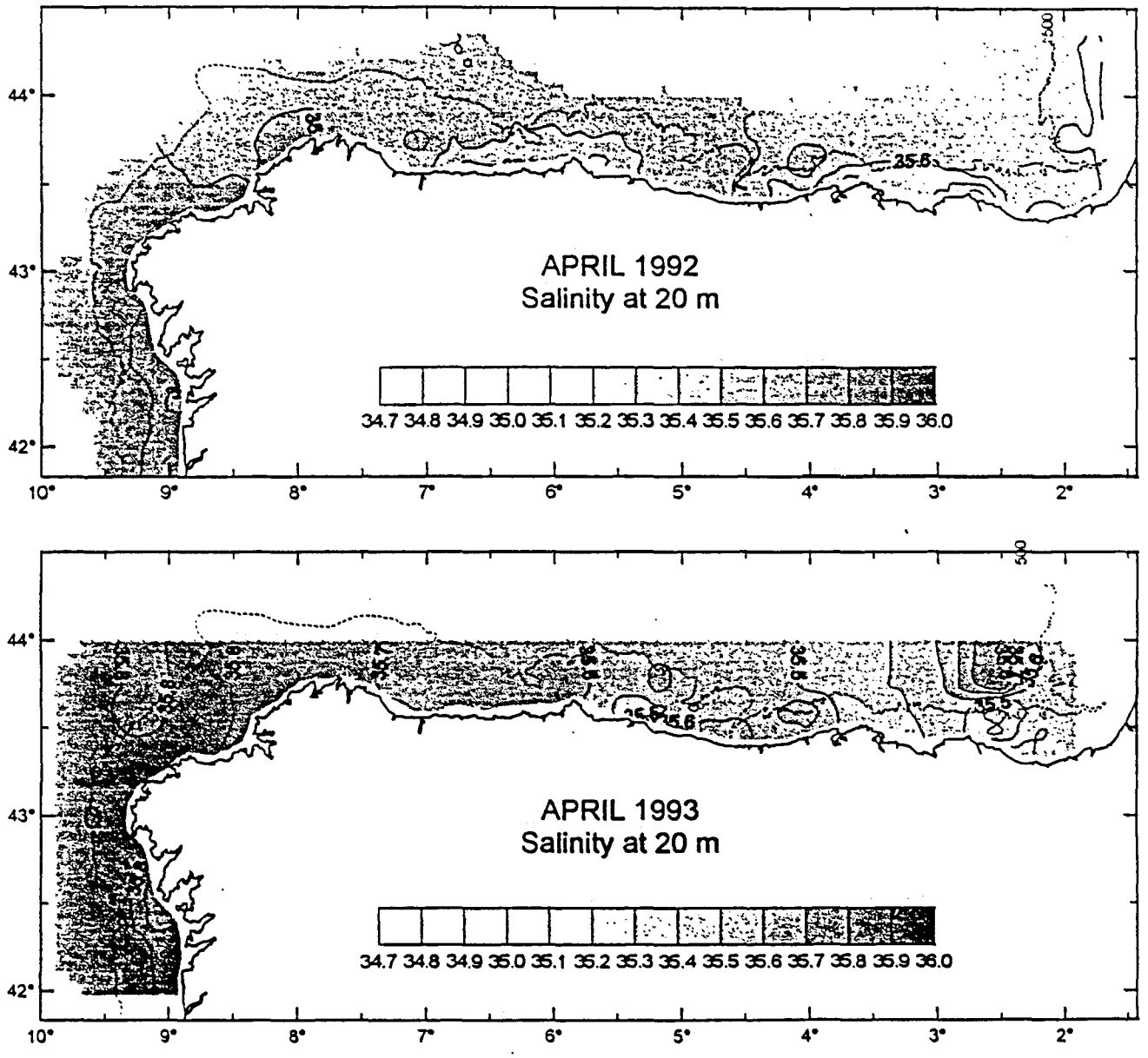

Figure 6. Salinity in April of 1992 and 1993.

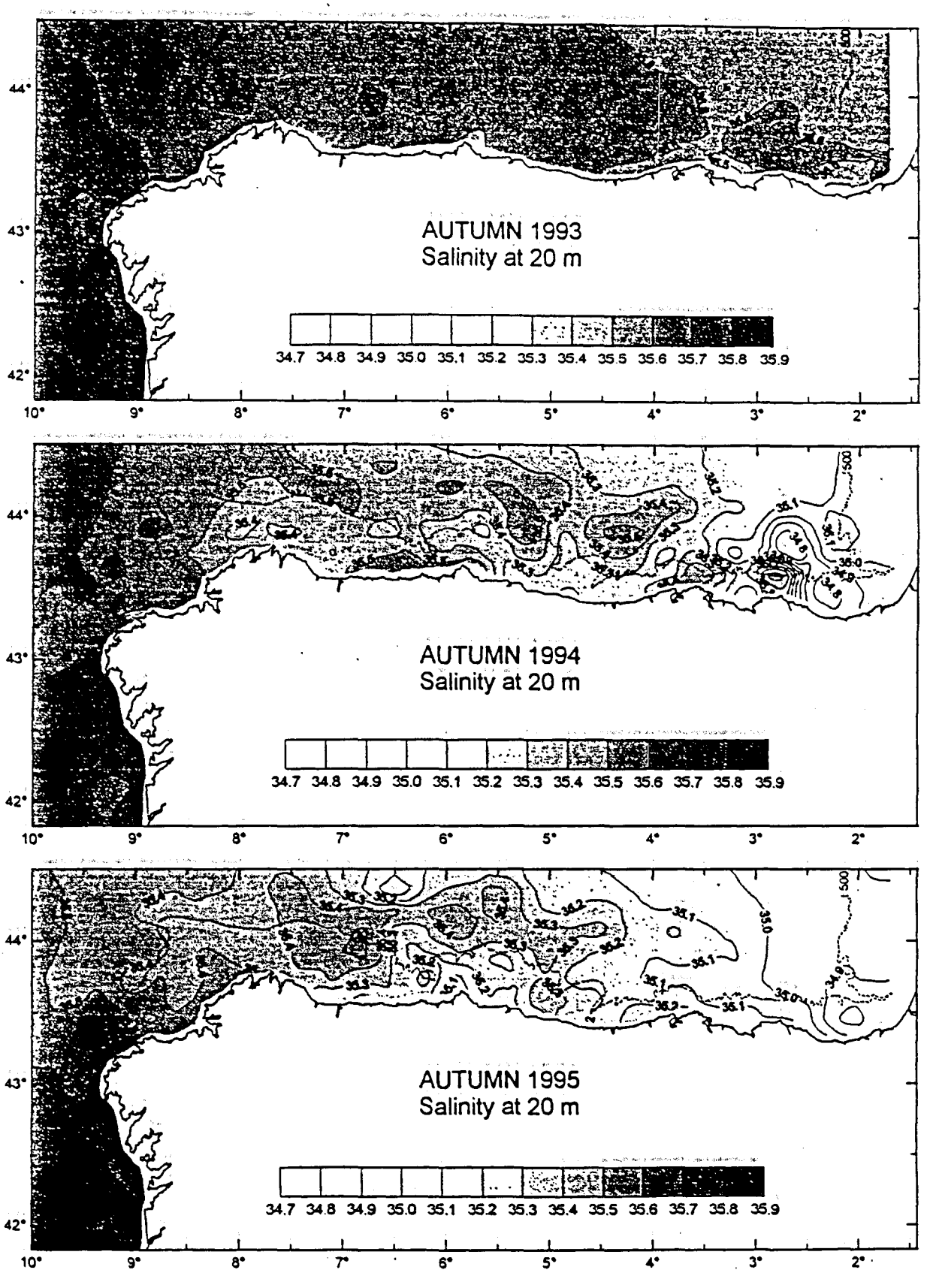

Figure 7. Salinity at 20 m during autumn of 1993, 1994 y 1995.

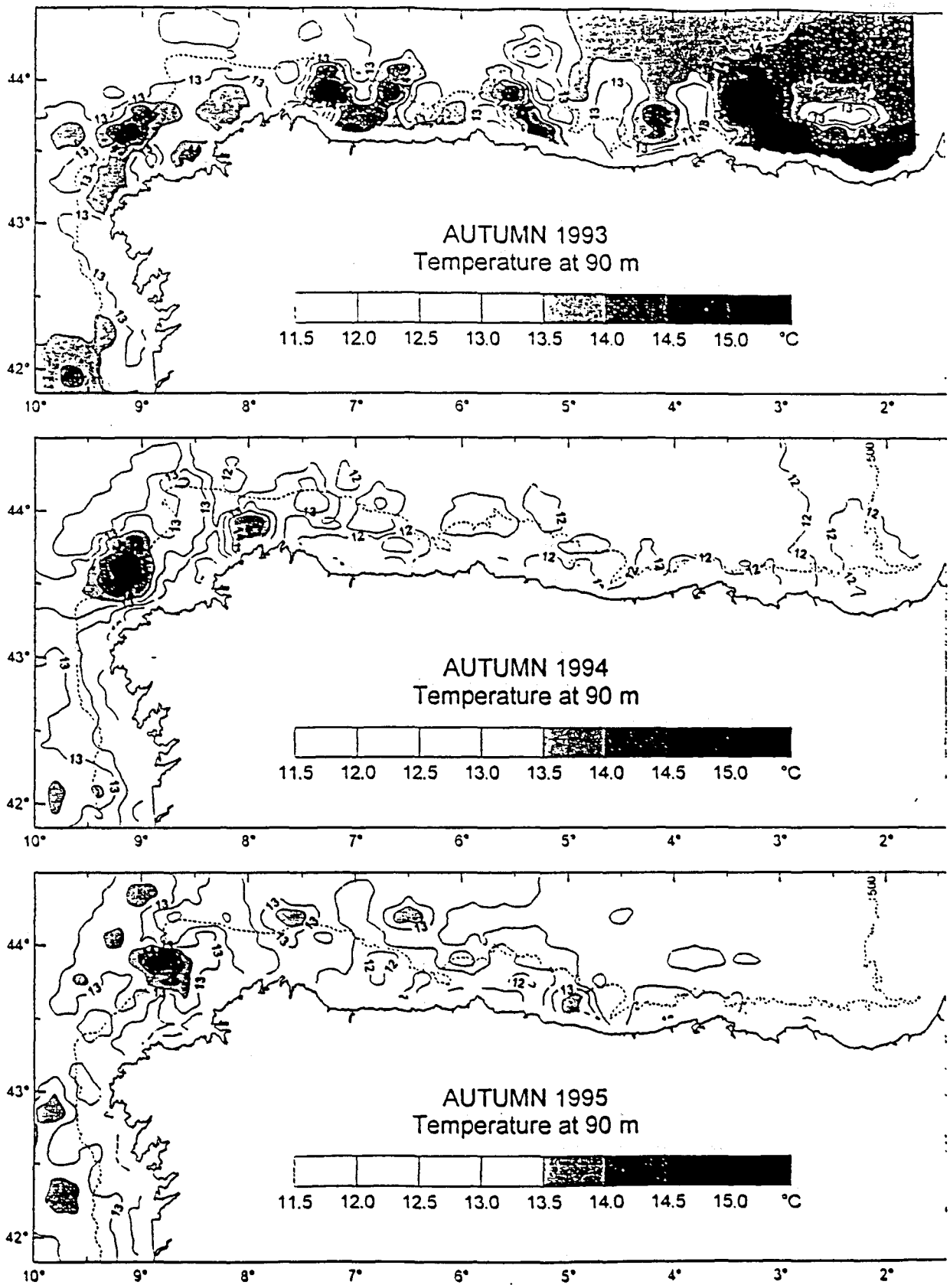

Figure 8. Temperature (°C) at 90 m during autumn of 1993, 1994 y 1995.

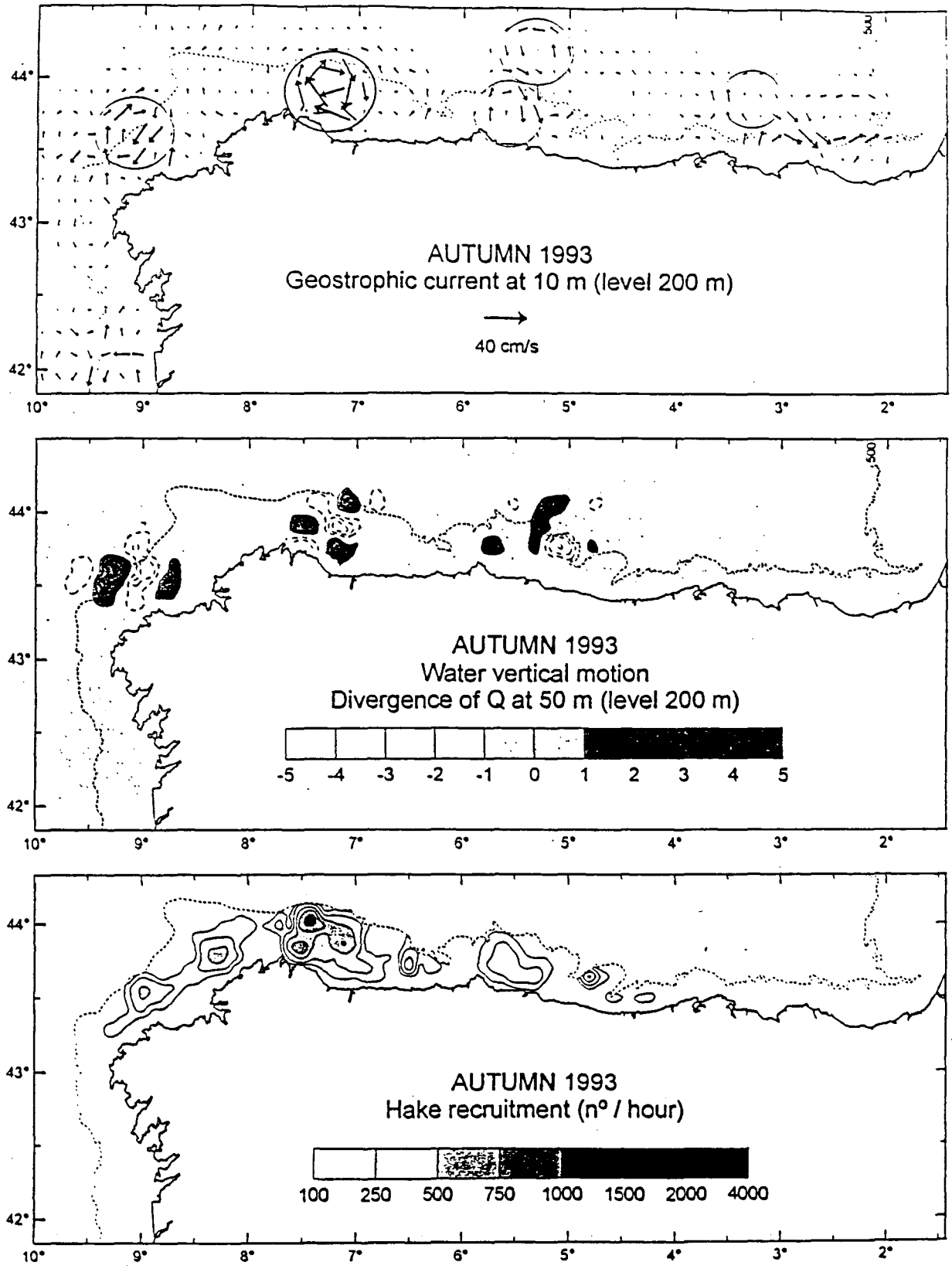

Figure 9. Geostrophic current, water vertical motion and hake recruitment during 1993.

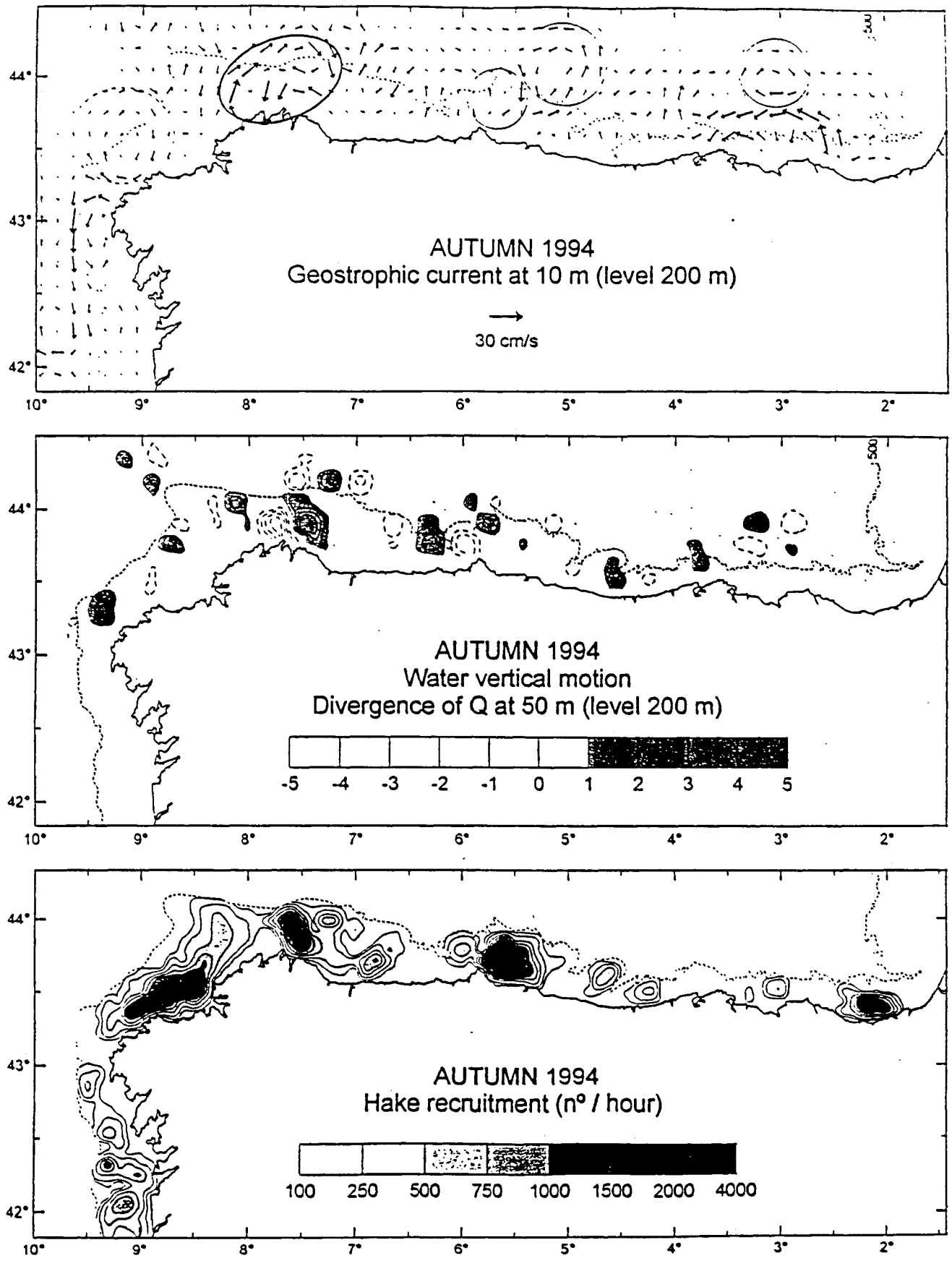

Figure 10. Geostrophic current, water vertical motion and hake recruitment during 1994.

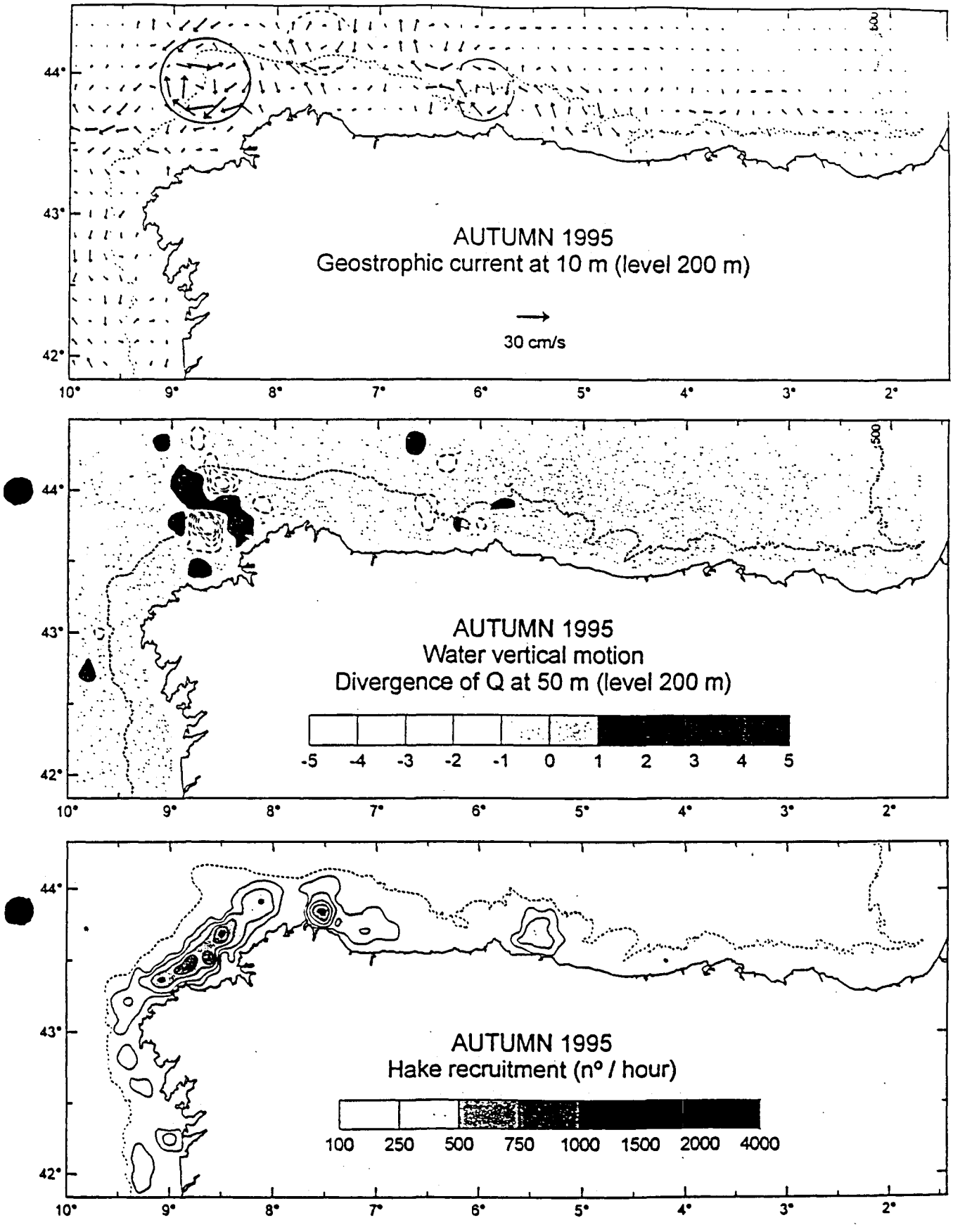

Figure 11. Geostrophic current, water vertical motion and hake recruitment during 1995.