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Interranual variability in horizontal patterns of larval fish assemblages in the northeastern Aegean Sea (eastern Mediterranean) during early summer

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ABSTRACT

Larval fish community structure was studied in the northeastern Aegean Sea (NEA) over an area influenced by the advection of Black Sea water (BSW). Sampling was carried out in early summer during a period of 4 years (2003–2006). Taxonomic composition and abundance presented high variability in space that remained relatively constant among years. Tow depth and indicators of trophic conditions in the upper water column (i.e., zooplankton displacement volume, fluorescence) explained significantly the structure of larval assemblages during all surveys. The northern continental shelf (Thracian and Strymonikos shelf), where a large amount of enriched, low salinity BSW is retained, was dominated by larvae of epipelagic species, mainly anchovy (*Engraulis encrasicolus*). Interannual changes in horizontal extension of the BSW seemed to match closely observed changes in the distribution of anchovy larvae. Mesopelagic fish larvae were particularly abundant beyond the continental shelf (over the North Aegean Trough) where a strong frontal structure is created between the low salinity waters of BSW origin and the high salinity waters of the Aegean Sea. Larvae of certain mesopelagic species (e.g., *Ceratoscopelus maderensis*) may occasionally be transported inshore when the prevailing current meanders towards the coast or feeds anticyclonic gyres over the continental shelf.

1. Introduction

Spatiotemporal patterns of ichthyoplankton communities, with respect to abundance, distribution and species composition, have been traditionally a basic topic of scientific research in fisheries oceanography (Govoni, 2005). Ichthyoplankton surveys provide useful data for the assessment of important parameters of commercially important fish populations (i.e. spawning stock biomass, recruitment), but can also improve our knowledge on the agents structuring larval assemblages. Looking beyond the single species level may facilitate our understanding on fundamental ecological and evolutionary aspects of fish faunas (Moser and Smith, 1993).

A large number of biological and physical factors contribute to the formation, maintenance and disruption of larval fish assemblages as has been pointed out for several coastal systems around the world's oceans since the early 90's (e.g. Boehlert and Mundy, 1993; Doyle et al., 1993). The biotic and abiotic environment controls the mesoscale distribution patterns of fish larvae either indirectly, by affecting the timing and location of adult egg production, or, directly, by influencing larval advection, mortality and behavior (Moser et al., 1993). Regarding the Mediterranean waters, research on the structure of larval fish communities has been progressively developed in the last two decades. A large amount of information has been published concerning the western part of the Mediterranean Sea (Catalan Sea, Balearic Archipelago), which has recently been reviewed by Sabatés et al. (2007a). Latitudinal and vertical distributions of fish larvae in relation to short-term mesoscale variability have also been examined in the western Alboran Sea (Vargas-Yánez and Sabatés, 2007). In the central and eastern Mediterranean information on ichthyoplankton assemblage structure and distribution is scant (straits of Sicily: Cuttitta et al., 2004; northern Aegean Sea: Somarakis et al., 2000, 2002).

The present study was directed towards an improvement of our understanding of the factors that determine distribution patterns of fish larvae in the northeastern Aegean Sea (NEA). NEA is a topographically and hydrologically complex Sea, consisting of a set of three relatively broad continental shelf areas (Thracian shelf, Strymonikos shelf and Lemnos plateau) separated by the deep North Aegean Trough (Fig. 1). Enriched, low salinity Black Sea water (BSW) enters into the NEA and largely affects water column structure and circulation in the region (Zervakis and Georgopoulos, 2002; Isari et al., 2006). NEA is characterized by relatively high levels of productivity (e.g., Siokou-Frangou et al., 2002; Isari et al., 2006, 2007), abundant fish stocks (especially small pelagic species) (Stergiou

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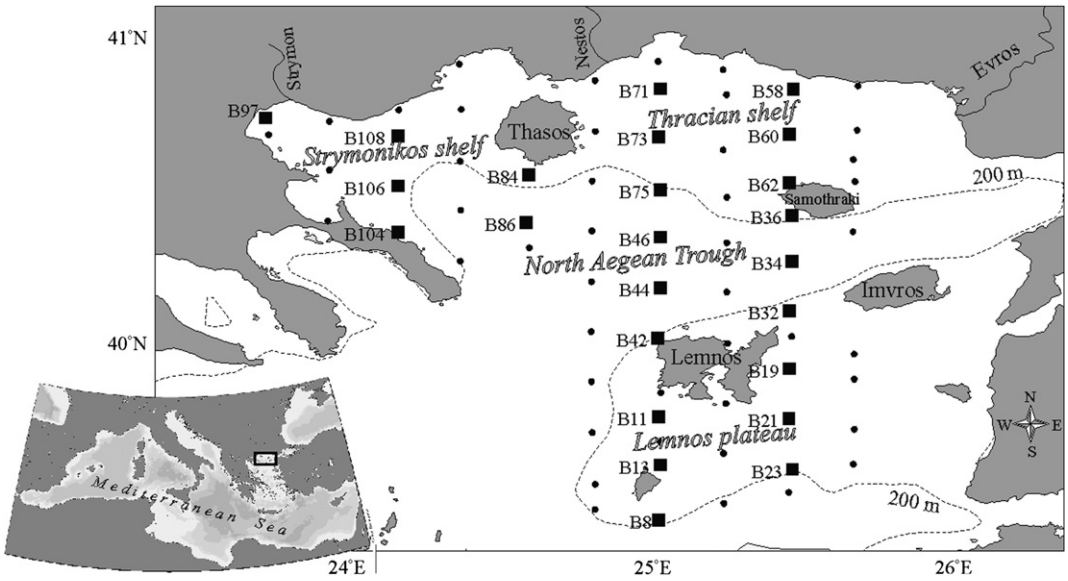

Fig. 1. Geographic location of the study area and distribution of sampling sites. ■: Hydrographic and ichthyoplankton stations. ●: hydrographic stations.

et al., 1997; Somarakis et al., 2006), but also high biological and hydrological heterogeneity (Zervakis and Georgopoulos, 2002; Isari et al., 2006, 2007). The majority of ichthyoplankton studies in the area have focused on anchovy (*Engraulis encrasicolus*) egg production and early life history (Somarakis et al., 1997; Somarakis, 2005; Somarakis and Nikolioudakis, 2007). Information on multispecies larval fish associations is only presented in Somarakis et al. (2000, 2002) based on surveys covering the Thracian and Strymonikos shelves during June 1995 and 1996. The latter papers concluded that interannual and regional differences in relative abundance of larval species are largely determined by different spawning strategies and bathymetric distributions of adults. However, given that these surveys covered the Thracian and Strymonikos shelf, rather than the entire area affected by the advection of BSW in the NEA, the effect of hydrological and biological heterogeneity induced by the circulation of BSW remained unclear.

In the present study multispecies fish larvae data collected almost a decade later over a broad area of the NEA are analysed to assess the mesoscale distribution patterns, structure and composition of assemblages. Sampling was carried out in early summer (June) over a 4-year period allowing for an evaluation of interannual variability in the observed patterns.

2. Methods

2.1. Study area

NEA is an area of high productivity comparatively to the highly oligotrophic southern part of the Aegean Sea (Stergiou et al., 1997; Siokou-Frangou et al., 2002). This has been mainly attributed to local topography and the influence of the less saline Black Sea water (BSW). The studied area is characterized by strong bathymetric heterogeneity, with several extended continental shelf areas (up to 60 km wide) being separated by a nearly centrally located depression (down to 1550 m). Moreover the physicochemical characteristics of the water column are highly determined by the outflow and subsequent advection of the BSW in the area, which is known to induce mesoscale hydrological structures (fronts, gyres) (Zodiatis and Balopoulos, 1993; Zervakis and Georgopoulos, 2002) as well as high biological complexity (Isari et al., 2006, 2007). Low salinity BSW, outflowing from the Dardanelles straits, creates a pronounced salinity gradient along the eastern shelf of Lemnos island (Lemnos front) as it converges with the more saline Aegean Sea waters. This salinity front although temporally persistent, varies greatly in position (Zervakis and Georgopoulos, 2002). The general circulation pattern of BSW is subject to considerable, mainly wind-driven, seasonal variability that has been described in detail elsewhere (e.g. Somarakis et al., 2002; Isari et al., 2006). However, most of its northerly advected branch is entrapped in an almost permanent anticyclonic gyre over the Thracian shelf, around the island of Samothraki (the Samothraki gyre).

2.2. Sample collection and analysis

Four oceanographic surveys were carried out between 1/6 and 12/6 in 2003, 31/5 and 12/6 in 2004, 31/5 and 16/6 in 2005 as well as 17/6 and 1/7 in 2006. Sampling grid comprised 24 stations, located at five 20 NM-spaced transects, with an interval of approximately 10 NM between stations (Fig. 1). The majority of stations covered continental shelf areas (Thracian shelf, Strymonikos shelf, Lemnos plateau), while there were also sites located over the deep central basin of the NEA (Fig. 1).

Plankton sampling was performed using double oblique hauls of a 60 cm-bongo net with mesh sizes 250 and 500 μm. Bongo sampler was towed at 2–2.5 knots within 5 m from the bottom to the surface, or from 200 m depth to the surface at deep stations. The depth of the sampler could be monitored onboard at any time during the tow by means of a recording depth meter attached to the sampler. Volume of water filtered was calculated from a calibrated flowmeter in the mouth of each net. All samples were preserved immediately after collection in 10% borax-buffered formalin solution. In order to describe the thermohaline structure in the area CTD deployments were performed on a denser grid of 68 stations (Fig. 1), using a SEABIRD SBE 25 profiler equipped with a fluorometer. Salinity was measured using the Practical Salinity Scale.

Laboratory analysis involved only the samples collected with the 250 μm mesh. Fish larvae were sorted from the rest of the plankton, identified to the lowest possible taxonomic level, staged into yolk-sac, preflexion, flexion and postflexion larvae and enumerated. Taxonomic identification was based on an ichthyoplankton database created at the Hellenic Centre for Marine Research, including existing literature and more than 2000 drawings and photos of different developmental stages of more than 250 fish species inhabiting the Greek Seas (Siapatis and Somarakis, 2007). Fish