



Different key roles of mesoscale oceanographic structures and ocean bathymetry in shaping larval fish distribution pattern: A case study in Sicilian waters in summer 2009



Angela Cuttitta ^a, Enza Maria Quinci ^{a,*}, Bernardo Patti ^a, Sergio Bonomo ^b, Angelo Bonanno ^a, Marianna Musco ^a, Marco Torri ^{a,c}, Francesco Placenti ^a, Gualtiero Basilone ^a, Simona Genovese ^a, Grazia Maria Armeri ^a, Antonina Spanò ^a, Marco Arculeo ^c, Antonio Mazzola ^d, Salvatore Mazzola ^a

^a National Research Council, Institute for Marine and Coastal Environment (IAMC-CNR), Detached Unit of Capo Granitola, via del Mare 3, Torretta Granitola, 91021 Trapani, Italy

^b National Research Council, Institute for Marine and Coastal Environment (IAMC-CNR), Calata Porta Di Massa, Napoli 80133, Italy

^c University of Palermo, Department of Biological Chemical Pharmaceutical Science and Technology, viale delle Scienze 16, Palermo 90128, Italy

^d University of Palermo, Department of Earth and Marine Sciences, via Archirafi 36, Palermo 90123, Italy

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ABSTRACT

Fish larvae data collected in year 2009 were used to examine the effects of particular environmental conditions on the structure of larval assemblages in two oligotrophic Mediterranean areas (the Southern Tyrrhenian Sea and the Strait of Sicily). For this purpose, relationships with environmental variables (temperature, salinity and fluorescence), zooplankton biomass, water circulation and bathymetry are discussed. Hydrodynamic conditions resulted very differently between two study areas. The Southern Tyrrhenian Sea was characterized by moderate shallow circulation compared to the Strait of Sicily. In this framework, distribution pattern of larval density in the Tyrrhenian Sea was mainly driven by bathymetry, due to spawning behavior of adult fish. There, results defined four assemblages: two coastal assemblages dominated by pelagic and demersal families and two oceanic assemblages dominated by mesopelagic species more abundant in western offshore and less abundant in eastern offshore. The assemblage variations in the western side was related to the presence of an anti-cyclonic gyre in the northern side of the Gulf of Palermo, while in the eastern side the effect of circulation was not very strong and the environmental conditions rather than the dispersal of species determined the larval fish communities structure. Otherwise in the Strait of Sicily the currents were the main factor governing the concentration and the assemblage structure. In fact, the distribution of larvae was largely consistent with the branch of the Atlantic Ionian Stream (AIS). Moreover, very complex oceanographic structures (two cyclonic circulations in the western part of the study area and one anti-cyclonic circulation in the eastern part) caused the formation of uncommon spatial distribution of larval fish assemblages, only partially linked to bathymetry of the study area. Typically coastal larvae (pelagic families: Engraulidae and Clupeidae) were mostly concentrated in the offshore areas and off Capo Passero, where the presence of a thermo-haline front maintained their position in an area with favourable conditions for larval fish feeding and growth.

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1. Introduction

The studies on ichthyoplankton distribution, mainly of commercially important species, play an important role in ecology and evolution of fish populations (Moser and Smith, 1993; Neilson and Perry, 1990), because the spatial distribution of early life stages can be the major determinant of recruitment success and consequently of the adult population sizes (Boehlert and Mundy, 1993; Govoni, 2005; Moser and Watson, 2006; Sinclair, 1988). The early life history of the fish populations

depends on several factors that affect mainly the spawning biomass of fish adults (Basilone et al., 2013; Giannoulaki et al., 2013; Somarakis et al., 2004) and the larval fish conditions (Riveiro et al., 2011), mainly due to feeding success (Pepin et al., 2014), to optimal habitat (Sabatés et al., 2006, 2007; Valavanis et al., 2008) and to predation (Litvak and Leggett, 1992; Steele and Forrester, 2002; Yin and Blaxter, 1987). Moreover, mesoscale oceanographic structures including geostrophic and wind influenced current regimes (wind-induced mixing of the surface layer, upwelling) play an important role in determining the patterns of abundance and distribution of larval fish populations. This is because they act as mechanisms of retention and concentration of fish larvae in recruiting areas creating oceanic conditions favorable for the growth and survival (Alemany et al., 2006; Falcini et al., 2015; Paris et al., 2007).

* Corresponding author.

E-mail address: enzamaria.quinci@iamc.cnr.it (E.M. Quinci).

In the past, the influence of these factors on larval distribution was widely analyzed in the Mediterranean Sea, a semi-enclosed basin of which environmental characteristics are sensitive to both basin scale and local effects (e.g. winds, topography) and fluctuations of fish populations are not exclusively linked to fishing activity, but rather significantly affected by ocean conditions (Falcini et al., 2015; Lloret et al., 2000). Extensive work has mainly covered the coastal waters of the north-western part of the Mediterranean Sea (Alemany et al., 2006; Alvarez et al., 2012; García and Palomera, 1996; Olivar et al., 2012; Olivar and Sabatés, 1997; Palomera and Olivar, 1996; Palomera and Sabatés, 1990; Sabatés, 1990, 2004; Sabatés and Olivar, 1996; Sabatés et al., 2007) and to a lesser extent the central (Cuttitta et al., 2003, 2004) and the eastern parts (Aegean Sea: Isari et al., 2008; Somarakis et al., 2011; Tsikliras and Koutrakis, 2011; Tsikliras et al., 2014; eastern Ionian waters: Granata et al., 2011; Tunisian waters: Koched et al., 2013; Zarrad et al., 2013). These studies carried out in the Mediterranean Sea showed that there was a clear bathymetric separation of larval fish assemblages, due to different spawning behavior of adults: inshore assemblages have a different composition from offshore ones (Alemany et al., 2006; Giordano et al., 2014; Granata et al., 2011; Sabatés and Olivar, 1996). Generally, bathy and mesopelagic families were characteristic members of the oceanic group, while the inshore species consist of pelagic and demersal (Beldade et al., 2006; Sabatés et al., 2003; Tsikliras and Koutrakis, 2011). However, this trend can be disrupted by peculiar mesoscale oceanographic structures, because currents, fronts and gyre can reshape the distribution of fish larvae with advection and concentration (Agostini and Bakun, 2002; Falcini et al., 2015; Sabatés et al., 2013). On the other hand, the environmental parameters that can affect the distribution of fish larvae, such as temperature and food availability, are strictly dependent on local conditions and vary considerably at reduced spatial scale (García Lafuente et al., 2002).

This is the case of spatial distribution of larval fish assemblages in two oligotrophic areas in the Mediterranean Sea with different and peculiar environmental conditions: southern Tyrrhenian Sea and Strait of Sicily. The southern Tyrrhenian Sea has high relevance as a probable nursery area for many commercially important pelagic and coastal fishes such as *Seriola dumerili*, *Xiphias gladius* and *Thunnus thynnus* and it is a habitat for mesopelagic fishes and squids, and plays a key role in deeper ecosystem energy flux (Bruno et al., 2001; Giordano et al., 2014; Granata et al., 2011). The Strait of Sicily is one of the main fishing sites in the Mediterranean (García Lafuente et al., 2002). It is a region characterized by a dominant hydrographic feature (the Atlantic Ionian Stream (AIS)) that has clear influence on the spawning strategy and the recruitment success of many fish species (García Lafuente et al., 2002, 2005; Mazzola et al., 2000, 2002).

In this paper, the different roles of hydrographic, physical, chemical and biological conditions in these two study areas during summer 2009 were showed, with the aim of determining what are the conditions in which the dynamics of transport and the chemical–physical and biological properties can be decisive in affecting the spatial composition of fish larvae in Mediterranean Sea.

2. Material and methods

2.1. Ichthyoplankton and oceanographic sampling

The two study areas are located in the southern side of the Tyrrhenian Sea and in the Strait of Sicily (Fig. 1).

Oceanographic data and ichthyoplanktonic samples were collected during two oceanographic surveys on board of the O/V Urania: Bansic 2009 carried out in the period 04–21 July 2009 in the Strait of Sicily and MedSudMed 2009 carried out from 26 July to 3 August 2009 in the Southern Tyrrhenian Sea. The sampling was made on a station

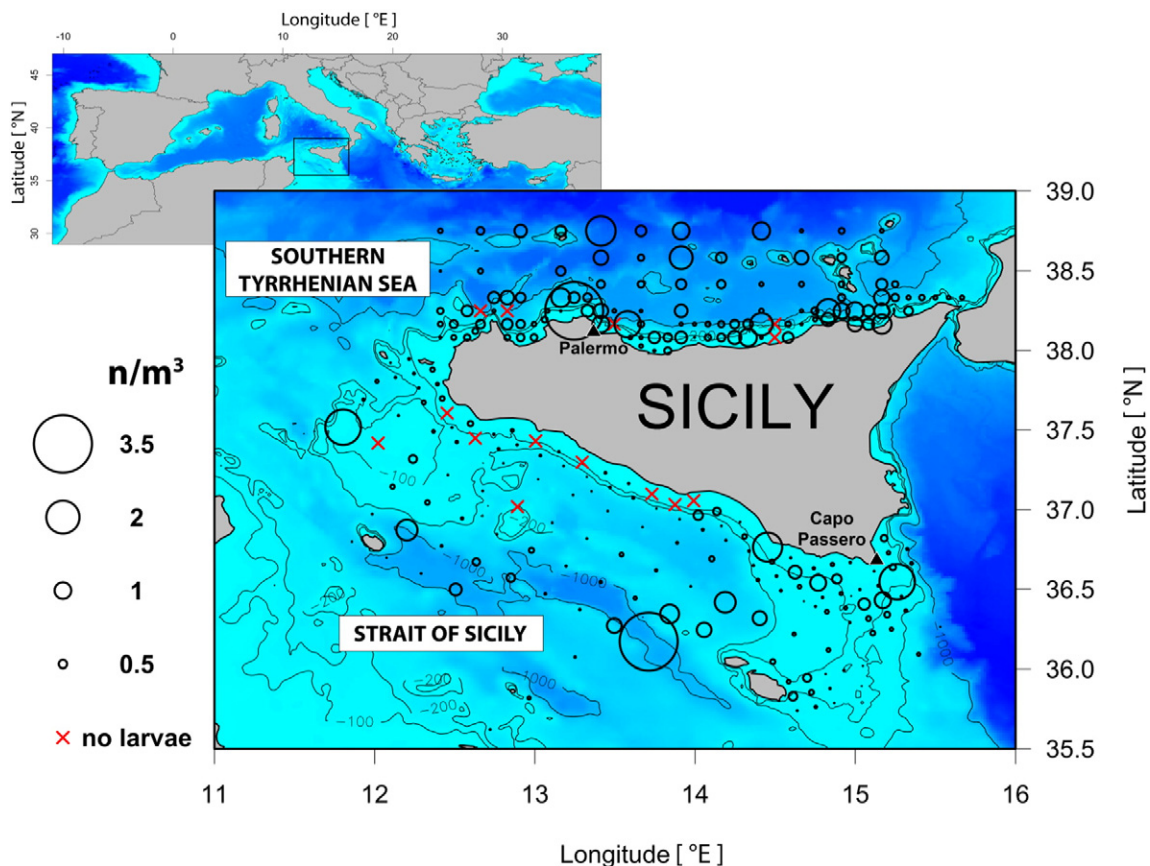


Fig. 1. Larval fish distribution in the study areas. The circle dimension is proportional to the total larval fish abundance.

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