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Mesopelagic fish larvae species in the Strait of Sicily and their relationships to main oceanographic events

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Abstract

This work investigates the spatial distribution and species composition of mesopelagic fish larvae and their relationship with the main oceanographic events in the area studied. Samples were collected during a hydrographic and ichthyoplanktonic survey carried out in the Strait of Sicily in July 2000. Sorting revealed that 1258 out of the 4098 fish larvae identified belonged to mesopelagic species; *Cyclothone braueri* (67.6% of the total), *Electrona Risso* (7.8%) and *Myctophum punctatum* (7.7%) were the most prevalent species, with 850, 97, and 98 individuals, respectively. The surface density patterns of mesopelagic fish larvae appear to be related to the hydrographic characteristics and structures determined by the surface circulation path.

Introduction

Though they represent one of the most important links in the food chain in the marine ecosystem (Tortonese, 1970), mesopelagic fish are not commonly caught and they also have a very low economic value. Nevertheless, their abundance in the Mediterranean sea (Olivar et al., 1998; Somarakis et al., 2002) makes them the best-represented member of the deep water fauna and they are the most common prey to other fish species. In this sense, mesopelagic fish are highly relevant in the diet of economically important species and can be considered as a 'link' in the energy transfer between the deeper environment and the higher layers of the water column. Taking into account the important function of these species in the trophic marine chains, and particularly their potential use as a resource for future fisheries, it is important to collect data on their distribution, abundance and life cycle. Moreover, the literature is scarce on the biology and distribution of mesopelagic species, especially in the southern part of the Mediterranean sea, and in particular in the Strait of Sicily this work represented the first approach in this direction.

The study area is characterized by the existence of different water masses associated with the typical hydrographic structures caused by surface circulation phenomena; knowledge of circulation patterns may help us to interpret the distribution of the larval stages of these species (Olivar et al., 1998; Hare et al., 2001; Doyle et al., 2002). Specifically, the surface circulation in the Strait of

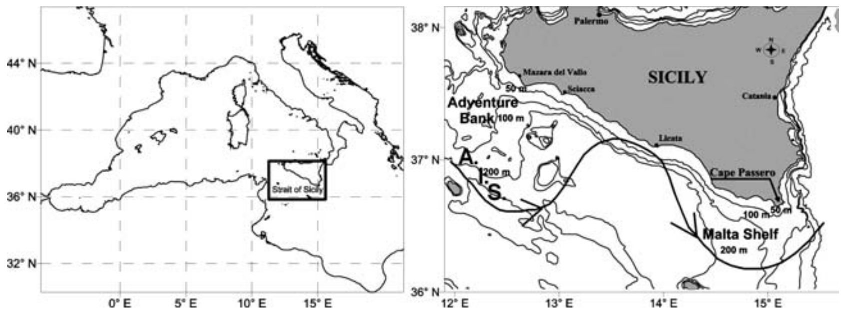

Figure 1. Western and Central Mediterranean, with the study area shown in the box (left panel), and a detailed map of the study area with the average path of the Atlantic Ionian Stream (A.I.S.) superimposed (right panel).

Sicily is controlled by Modified Atlantic Water (MAW) motion, or the so-called Atlantic-Ionian Stream (AIS, Robinson et al., 1999). According to these authors, it enters the Strait by its west boundary and follows a large cyclonic meander, which embraces the Adventure Bank (Fig. 1). Then it moves close to the shore, approximately in the middle of the southern coast of Sicily, separating again when it encounters the shelf of Malta. However, AIS path presents year-to-year variability that has consequences on the other predominant hydrological phenomena occurring in the region, such as the extent of upwelling and the formation of frontal structures (Lermusiaux & Robinson, 2001).

Material and methods

Biological data were collected in the Strait of Sicily, off the southern Sicilian coast, during the BANSIC2000 hydrographic and ichthyoplanktonic survey carried out from 23rd June to 13th July 2000 onboard the R/V URANIA. This survey was originally designed to study the anchovy larvae distribution in the Strait of Sicily and the correlation between said larval distribution and the main oceanographic events in this area.

A total of 133 stations were sampled using two distinct step grids, i.e. 4 n/mile for stations situated on the continental shelf and 12 n/mile for deeper stations. Samples were collected by means of Bongo 40 oblique tows at a constant speed of 2 knots using a 200 μm mesh size net for both sides of the frame and two separate General Oceanics flowmeters (mod. 2030R) for each net. Hauls were towed from the bottom to the surface or from 100 m to the surface, where the bottom was more than 100 m deep. No replicate tows were per-

Table 1. List of mesopelagic species larvae detected, their abundance and the proportion of each species according to their respective families

Family	Species	*N*	%
Gonostomatidae	*Cyclothone braueri*	850	91.30
	Cyclothone pygmaea	10	1.07
	Maurolicus muelleri	6	0.64
	Ichthyococcus ovatus	1	0.11
	Vinciguerria attenuata	18	1.93
	Vinciguerria poweriae	26	2.79
	Vinciguerria nimbaria	20	2.15
Myctophidae	*Electrona risso*	98	33.56
	Myctophum punctatum	97	33.22
	Myctophum humbolditi	1	0.34
	Hygophum benoiti	2	0.68
	Hygophum hygomi	8	2.74
	Diaphus rafinesqueii	21	7.19
	Diaphus holti	5	1.71
	Lobianchia gemellarii	8	2.74
	Lobianchia dofleini	7	2.40
	Lampanyctus pusillus	3	1.03
	Ceratoscopelus maderensis	41	14.04
	Notoscopelus elongatus	1	0.34
Paralepidae	*Lestidiops jayakari pseudosphyraenoides*	14	45.16
	Paralepis coregonoides	3	9.68
	Paralepis rissoi	11	35.48
	Paralepis affinis	3	9.68
Synodidae	*Synodus saurus*	3	100
Stomiatidae	*Stomias boa*	1	100

formed. Samples were stored in 4% buffered formaldehyde and then analyzed in the laboratory by stereomicroscopy. The spatial density (abundance) and size distribution patterns of the most abundant species of mesopelagic larvae in the study area were obtained using a surface analysis mapping software.

Hydrological data were collected during the same cruise with a CTD Sea-Bird 25 probe, from the sea surface to the bottom. The probe was descended at a constant velocity of 50 m/min. Only the downcast was selected for data processing. CTD casts (304 in total) were analyzed using Ocean Data View software and the path of the AIS was traced using the minimum salinity technique, which is applicable because the Atlantic water carried by the AIS is the only source of fresh water in this area (there is no river runoff). In fact, the AIS consists of modified Atlantic water that loses its identity as it moves further east. In the Strait of Sicily, the minimum salinity in the AIS is around 37.2.

Results and discussion

The biological data acquired during the summer of 2000 enabled us to obtain the first estimate of the distribution and abundance of mesopelagic species in the Strait of Sicily. The most recurrent families among mesopelagic larval species were Gonostomatidae and Myctophidae, which respectively represented 74.0% and 23.2% of the total (see Table 1). Other families (Paralepidae, Synodidae and Stomiatidae) were detected in very low proportions. In the Gonostomatidae family (7 species detected), *Cyclothone braueri* (Jespersen & Taaning, 1926) was the most abundant species, accounting for 91.3% of the Gonostomatidae and 67.6% of the total abundance. In the same family, *Vinciguerria poweriae* (Cocco, 1938), *Vinciguerria attenuata* (Cocco, 1938) and *Maurolicus muelleri* (Gmellin, 1789), accounted all together for less than 6%. In the Myctophidae family, a larger number of species (12) was identified. Among these species, the most abundant were *Electrona risso* (Cocco, 1938) (7.8% of the total), *Myctophum punctatum* (Rafinesque, 1810) (7.7%) and *Ceratoscopelus maderensis* (Bolin, 1959) (3.3%). In the Paralepidae family, five species were identified and the most abundant was *Lestidiops jayakari pseudosphyraenoides* (Ege, 1826), which accounted for 1.1% of the total. The size frequency distributions of the three most abundant species, as shown in Figure 2, indicates the same mode at 2 mm and similar size range, with more than 90% of the larvae between 0 and 4 mm.

Distribution maps obtained for the three most abundant species are shown in Figure 3a–c. *Cyclothone braueri* (Fig. 3a) is quite ubiquitous in the

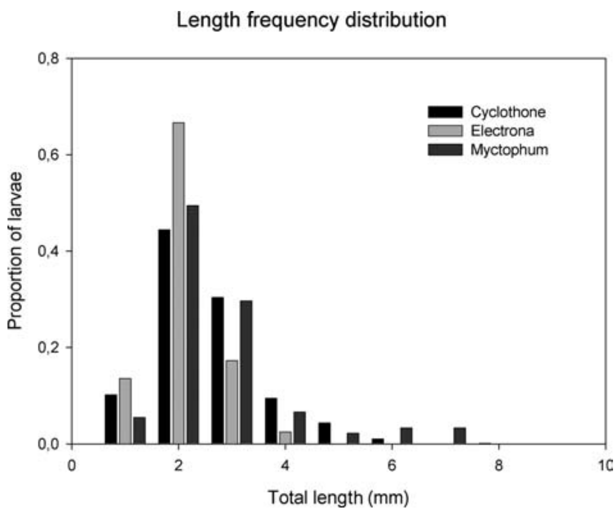

Figure 2. Length frequency distributions of the three main mesopelagic fish larvae detected during the BANSIC2000 survey (23rd June–13th July 2000).

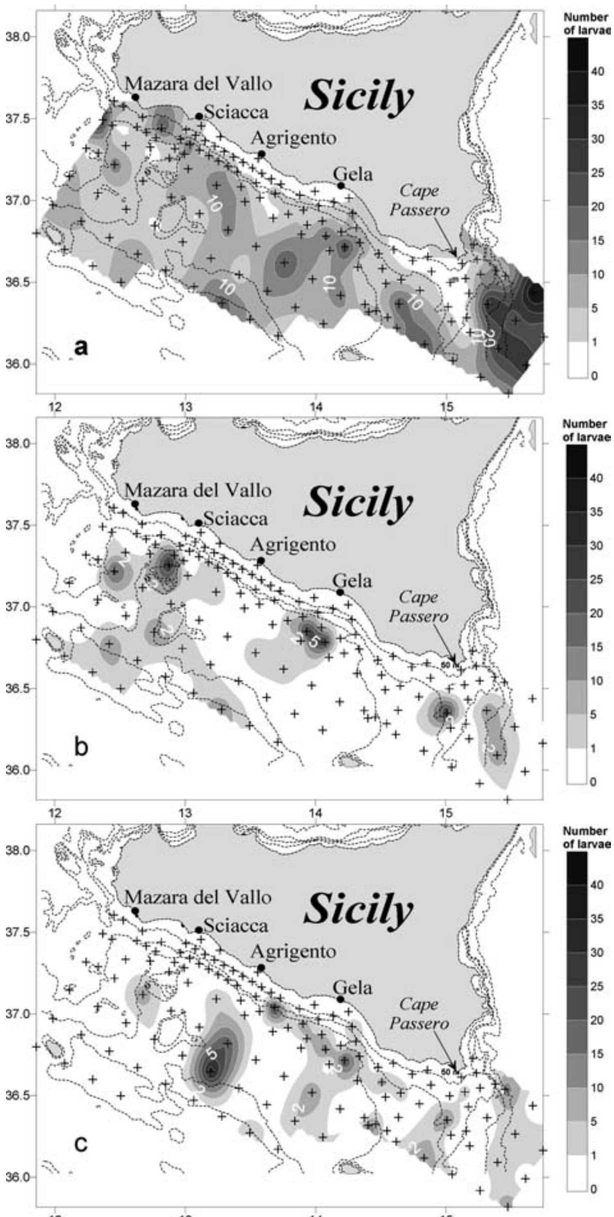

Figure 3. Larval distribution of the three most abundant mesopelagic fish species (numbers): *Cyclothone braueri* (a), *Myctophum punctatum* (b) and *Electrona risso* (c).

study area, concentrated mainly on the south-eastern edge of the region, off Cape Passero. Larvae are generally found offshore, though other concentrations were found in the shelf area between Mazara and Sciacca. *Myctophum punctatum* (Fig. 3b) shows a similar surface density distribution to Cyclothone, with its highest densities near Cape Passero and in slope regions off Licata and Sciacca. The third species, *Electrona risso* (Fig. 3c), exhibits a different surface pattern, as larvae were observed mainly in continental slope regions, south of parallel 37.

Hydrological data analysis showed that the AIS path differed from the 'normal' path of Figure 1. Figure 4 shows the path of the core of the AIS during June–July 2000, deduced using the mini-

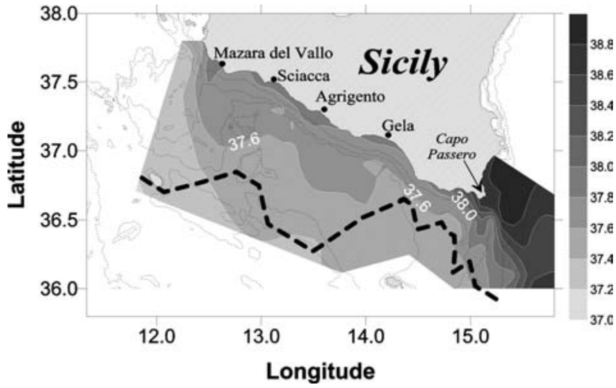

Figure 4. Salinity at a depth of 2 m during the BANSIC2000 survey and trajectory of the AIS (dashed line) deduced using the minimum salinity technique.

mum salinity technique and salinity at 2 m. The trajectory of the AIS core identified in this way suggests that the AIS was flowing far offshore and only approached the shore near the edge of Sicily, over the Maltese shelf. Path irregularities in the southern part of the Strait might be caused by the very small differences in the numerical value of the minimum salinity found in the different offshore legs, but also by interference with other small-scale oceanographic features that may be generated in the neighborhood with a strong salinity front off Cape Passero, visible in the lower right-hand corner of Figure 4. The higher salinity values along the south-eastern Sicilian coast reveal the presence of a well-developed coastal upwelling event. This is also confirmed by the temperature distribution, which exhibits a very large spatial variability. Surface temperature (2 m deep) ranges from 17 °C in coastal areas to 27 °C in the Ionian Sea off Cape Passero (see Fig. 5), with a mean value of 22.8 °C and a standard deviation of 2.1 °C. Finally, Figure 6 shows the average temperature below the thermocline, at depths ranging from 20 to 100 m (only stations with bottoms deeper than 100 m were included in the calculations).

Results showed the existence of different water masses on the surface, associated with the AIS path and with the hydrographic structures shown in Figures 4 and 5. These appear in turn to affect the distribution of mesopelagic species larvae observed. Specifically, the presence of Cyclothone and Myctophum offshore would testify to the bathypelagic environment of the adult fraction in their respective populations, whereas the occurrence of these species in shelf areas would be associated with the coastal upwelling characterizing the northern part of the study area, rather than being produced by onshore water intrusions, as

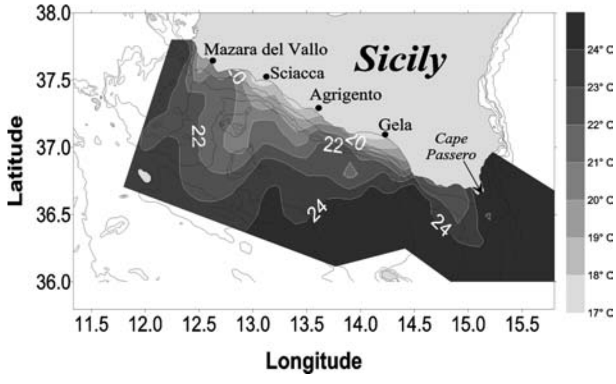

Figure 5. Temperature distribution at a depth of 2 m during the BANSIC2000 survey.

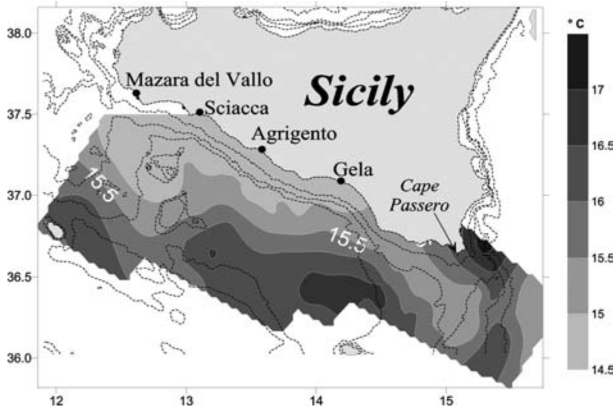

Figure 6. Average temperature distribution at depths ranging from 20 to 100 m (only stations with bottom depths beyond 100 m were considered).

observed by Olivar et al. (1998). The occurrence of both Cyclothone and Myctophum is associated with lower temperature values in the 20–100 m layer (see Fig. 6). In addition, the accumulation of larvae on the south-eastern edge could be related to the strong salinity front off Cape Passero. In contrast, Electrona larvae were only found offshore in waters affected by the AIS, characterized by higher temperature values below the thermocline (Fig. 6). Further developments would include collecting information on the age structure of the larval stages, as well as on their vertical distribution and their relationship with wind-induced upwelling events on a short temporal scale.

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