Study of the Biomass and Spatial Distribution of Deep Pelagic Fish Larvae of the Sicilian Channel in Relationships to the Physical and Chemical Parameters of the Water Column

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Abstract

Mesopelagic fish represent one of the most important links in the food chain of the marine ecosystem. Their abundance in the Mediterranean sea makes them the most important members of the deep water fauna and a potential resource for future fisheries. The aim of this work is the study of the spatial distribution, composition and biomass of mesopelagic fish larvae species in relationship with the oceanographic parameters of the Sicilian Channel. This area is characterized by different water masses associated with the typical hydro graphic structures of the Channel (Atlantic Ionian Stream-AIS), influencing the presence and distribution of fish species larval stages. Samples were collected during oceanographic surveys, on board of URANIA O/V in years 2005, 2006 and 2007. Distribution maps of the hauls, grouped in clusters, showed similar patterns during all analyzed years. The most common spots we found were located under Pozzallo, Cape Passero and Siracusa, though there were small spots along the central shelf of the western coast. These results would be influenced by the existence of different water masses on the surface, associated with the AIS path and with the hydrographic structures. The occurrence of these species in shelf areas would be associated with the coastal upwelling characterizing the northern part of the study area. In addition, the accumulation of larvae on the south-eastern edge could be related to the strong salinity front off Cape Passero.

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 [1]. 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 [2]. A large number of biological and physical factors contribute to the formation, maintenance and disruption of larval fish assemblages as it has been pointed out for several coastal

Families	**Species**	**2005**	**2006**	**2007**
Gonostomatidae	*Cyclothone braueri*	100%	100%	100%
Sternoptychidae	*Maurolicus muelleri*	100%	-	100%
Phosichthyidae	*Vinciguerria attenuata*	22%	12%	19%
	Vinciguerria nimbaria	3%	8%	5%
	Vinciguerria poweriae	39%	37%	29%
	Vinciguerria spp	36%	43%	47%
Paralepididae	*Lestidiops jayakari*	7%	10%	18%
	Pseudosphyraenoides sp			
	Paralepis affinis	45%	38%	42%
	Paralepis coregonoides	19%	12%	12%
	Arctonozenus risso	2%	-	-
	Sudis hyalina	-	-	3%
	Paralepide spp	27%	50%	25%
Myctophidae	*Ceratoscopelus maderensis*	22%	25%	16%
	Lobianchia spp	4%	5%	4%
	Diaphus holti	-	-	0,4%
	Electrona risso	8%	4%	12%
	Hygophum spp	15%	2%	22%
	Lampanyctus crocodilus	11%	19%	25%
	Lampanyctus pusillus	2%	-	0,6%
	Myctophum punctatum	4%	5%	11%
	Myctophum humbolditi	-	-	-
	Myctophum spp	34%	40%	9%
Stomiatidae	*Stomias boa*	100%	-	100%

Table 1: List of mesopelagic species larvae detected during July 2005, 2006, 2007 and the percentage of each species among the belonging families.

systems around the world's oceans since the early 90's [3, 4].

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) [5]. Latitudinal and vertical distributions of fish larvae in relation to short-term mesoscale variability have been also examined in the western Alboran Sea [6]. In the central and eastern Mediterranean information on ichthyoplankton assemblage structure and distribution is scant (straits of Sicily: [7]; northern Aegean Sea: [8]; [9]).

Mesopelagic fish are scotophil species living from 100 m to 1000 m of depth. They have typical larval stages of photic zone. Their abundance in the Mediterranean sea [10, 9] makes them the best represented members of the deep water fauna and they are very likely to be preys of other fish species. They represent one of the most important link in the food chain of the marine ecosystem [11]; in fact, 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

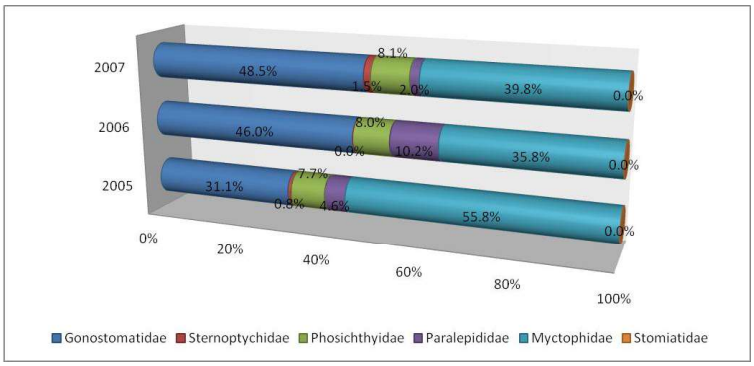

Figure 1: Percentage of abundance of each larval families in years 2005, 2006 and 2007.

their potential use as a resources for features fisheries, it is important to collect data on their distribution, abundance and life cycle. The aim of this study is focused on the improvement of mesopelagic species spatial distribution, on their composition and abundance through the knowledge of their larval stages in relation to Sicilian Channel's oceanographic parameters.

This area is characterized by different water masses associated with the typical hydro graphic structures of the Channel influencing the presence and distribution of fish species larval stages. Specifically, the surface circulation in this area is controlled by Atlantic-Ionian Stream (AIS, [12]) flowing from west to east in the surface layer of the Mediterranean basin. Below this layer corresponding to the mesopelagic environment, the Levantine Intermediate Water (LIW) flows in opposite direction: it is a colder and more saline water compared to the surface layers. The AIS has a cyclonic pattern: it enters the Channel by its west boundary and follows a large cyclonic meander, which embraces the Adventure Bank. Then, it moves close to the shore, in the middle of the southern coast of Sicily. In fact, the AIS pattern makes a cyclonic meander out of Cape Passero, separating again when it encounters the shelf of Malta. This surface circulation pattern supports the upwelling of water derived by LIW and thus determines the enrichment of surface layers.

2 Materials and Methods

Biological data were collected in the south of Strait of Sicily during the BANSIC hydrographic and icthyoplanktonic surveys carried in July 2005, 2006 and 2007 years on board of O/V URANIA. The sampling was made on a station grid of 4×4 nautical miles in sea zones closer to the coasts; a grid of 12×12 nautical miles was adopted for the off-shore areas. In each station ichthyoplankton samples have been collected by means of a Bongo40 net, which is composed by two coupled nets with the inlet mouth diameter of 40 cm and mesh size 200 µm. The plankton oblique tows were carried out to a depth of 100 m, wherever possible, with a constant speed of 2 knots. The filtered water volume of each mouth

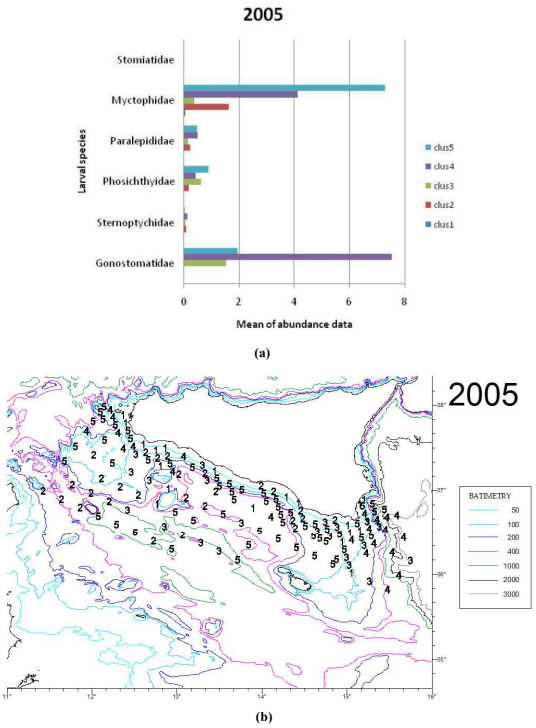

Figure 2: (a) Mean of abundance of larval species belonging each family among hauls, grouped through cluster analysis in year 2005. (b) Distribution of hauls of BANSIC 05, grouped through cluster.

was measured by a calibrated flow-meters (type G.O. 2030).
The zooplanktonic samples were stored in alcohol at 70% and then observed in the laboratory by stereomicroscopy for the taxonomic analysis of the ichthyoplanktonic species. In order to identify the distribution of different species in relation of AIS trajectory the hauls were grouped through the cluster analysis, based on $\log_{10}$ (X+1) transformed species abundance data. Bray-Curtis distance [13] was used and Ward's method[14], as grouping method.

3 Results

155 stations were sampled during the year 2005. Among mesopelagic larval species the most abundance ones were Gonostomatidae and Myctophidae, which represented 31.13% and 55.82% respectively. Other families as Sternoptychidae, Phosichthyidae and Paralepididae were detected in very low proportions (Figure 1). Among species belonging to Gonomastidae family only one species was founded (Cyclothone braueri) [15], while among species belonging to Mycthophidae family the more abundant founded species

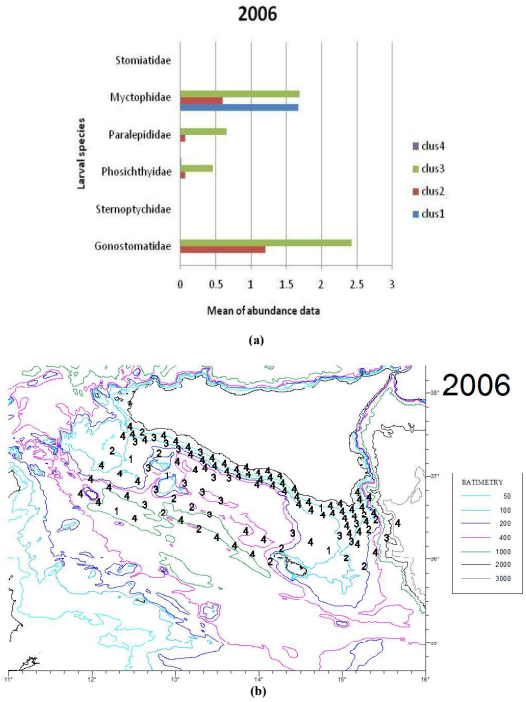

Figure 3: (a) Mean of abundance of larval species belonging each family among hauls, grouped through cluster analysis in year 2006. (b) Distribution of hauls of BANSIC 06, grouped through cluster.

were *Myctophum* spp and *Ceratoscopelus maderensis*[16], with 34% and 22% of the total respectively (Table 1).

123 stations were sampled during the BANSIC 2006 and the 13% of the total larval fish were mesopelagic species. The most abundance mesopelagic larval species were Myctophidae and Gonostomatidae, which respectively represented 46.02% and 35.80% of the total. Other families as Phosichthyidae and Paralepididae were detected in very low proportions (Figure 1). In the Myctophidae family 7 species were detected, *Myctophum* spp and *Ceratoscopelus maderensis*[16] were the most abundant species, accounting for 40% and 25% of the Myctophidae. Among species belonging Gonostomatidae family, *Cyclothone braueri* [15] was the only species we found (Table 1). This year, the weight of the zooplankton samples has been 315.95 g.

161 stations were sampled during the BANSIC 2007 and the 24% of the total larval fish were mesopelagic species. The most abundance mesopelagic larval families were Gonostomatidae and Myctophidae, which represented 48.48% and 39.85% of the total respectively. Other families as Sternoptychidae, Phosichthyi-

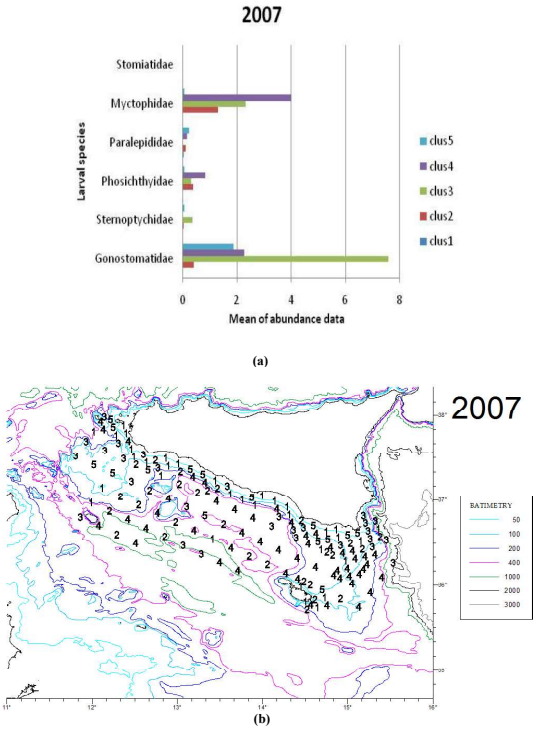

Figure 4: (a) Mean of abundance of larval species belonging each family among hauls, grouped through cluster analysis in year 2007. (b) Distribution of hauls of BANSIC 07, grouped through cluster.

dae, Paralepididae and Stomiatidae were detected in very low proportions (Figure 1). Among Gonostomatidae family, *Cyclothone braueri* [15] was the only species we detected, while among Myctophidae family 9 species were detected, *Lampanyctus crocodilus* and *Hygophum spp* were the most abundant species, accounting for 25% and 22% (Table 1). In 2007, the weight of the zooplankton samples was 795.61 g.

In year 2005, the hauls with absence of larvae (cluster 1) are located mostly inshore. Those of cluster 2 and 3, that have a minimal presence of Sternoptychidae and Myctophidae are in the north-west of the study area (Adventure Bank), while the hauls with major abundance of Gonostomatidae (cluster 4) are located in the east side (under Cape Passero) and the hauls of cluster 5 with major abundance of Myctophidae are located in the south-east (Figure 2).

In year 2006, the hauls with absence of larvae (cluster 1) and with minimal presence of Phosichthyidae (cluster 4) are mostly inshore. Hauls of cluster 2 have a minimum percentage of Gonostomatidae and Myctophidae, the same species but with a higher percentage characterize the cluster

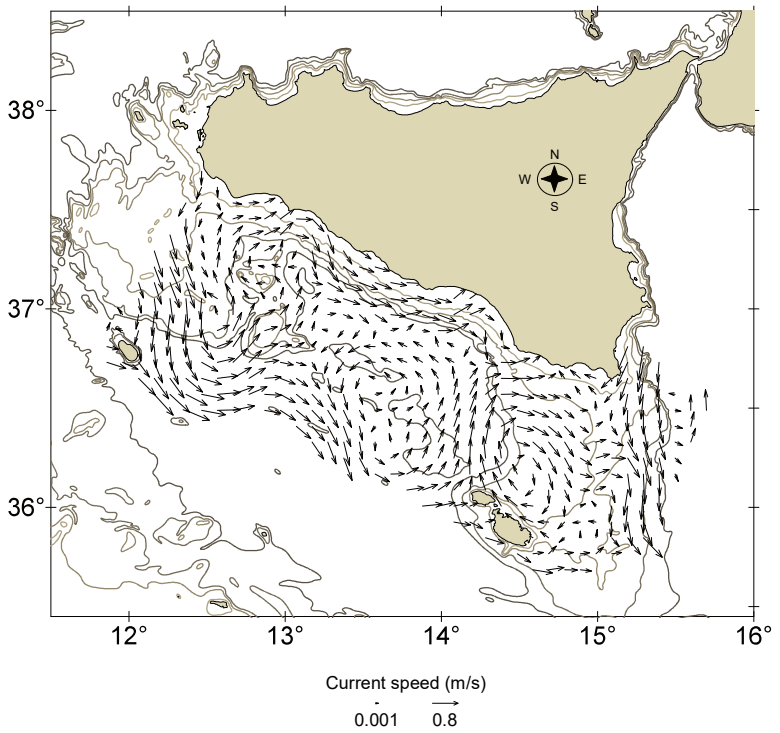

Figure 5: Surface geostrophic current pattern during July 2005.

3. Both clusters are offshore (Figure 3). In year 2007, the hauls with absence of larvae (cluster 1) are inshore. The hauls of cluster 2 have a low percentage of Phosichthyidae and Myctophidae and are located in the western part of the study (Adventure Bank) and in the Maltese Bank. The hauls of cluster 3 and 5 show a low percentage of Gonostomatidae and are located mostly in the north-east, those of cluster 4 have a minimum presence of Myctophidae and are located in the south-east side (under Licata and Capo Passero) (Figure 4). Figures 5-7 show the path of the geostrophic currents estimated of CTD data collected in July 2005, 2006 and 2007. From such pattern it is possible to evaluate the AIS pattern in the study area.

In 2005, the AIS goes away from the Egadi Archipelago, moving southward.

Once it arrives at Pantelleria Island, it moves eastward, shifting into two arms: the first one goes to the cost and the second one flows parallel to the coast up to Malta, where it heads to the coast and then goes southward (Figure 5). In 2006, the AIS skims the coast of Marsala during its move to southward. After going over Pantelleria, the AIS moves eastward, flowing in the north of Malta and offshore Pozzallo (Figure 6).

In 2007, the AIS moves from Marsala to the east of Pantelleria, doing immediately a reverse close to the coast from Gela to

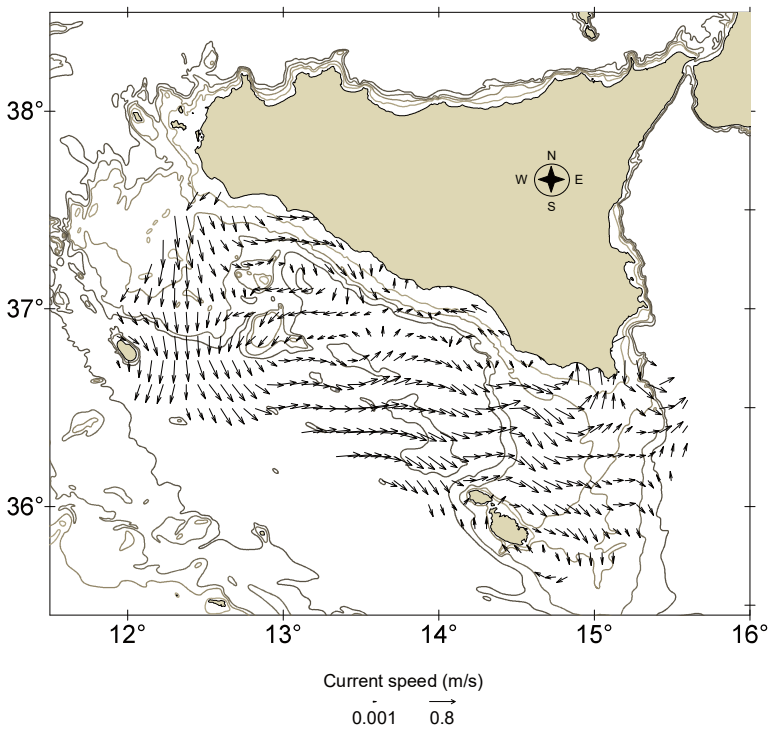

Figure 6: Surface geostrophic current pattern during July 2006.

Pozzallo, then heading southward (Figure 7).

4 Discussion

Distribution maps of the hauls, grouped in clusters showed similar patterns during all analyzed years. In fact, the most common spots we found were located under Pozzallo, Cape Passero and Siracusa, though there were small spots along the central shelf of the western coast. Distribution maps for the cluster with major abundance of Gonomastodae basically showed the presence of spots along the Egadi Islands and in the same sites where we found the Myctophidae. The distribution of cluster with presence of Phosichthyidae was along the central shelf of the western coast (from Porto Empedocle to Pozzallo) and under Cape Passero. During the sampling (July), the AIS skims along the Sicilian coasts only in the neighbours of Egadi Islands and Cape Passero, while there is a shift of the tide in the central part of the south-western coast. The trajectory of the identified AIS core suggests that the AIS was flowing offshore and only approached the shore near the edge of Sicily, over the Maltese Shelf. Path irregularities in the southern part of the Sicilian Channel might be caused by the very small differences in

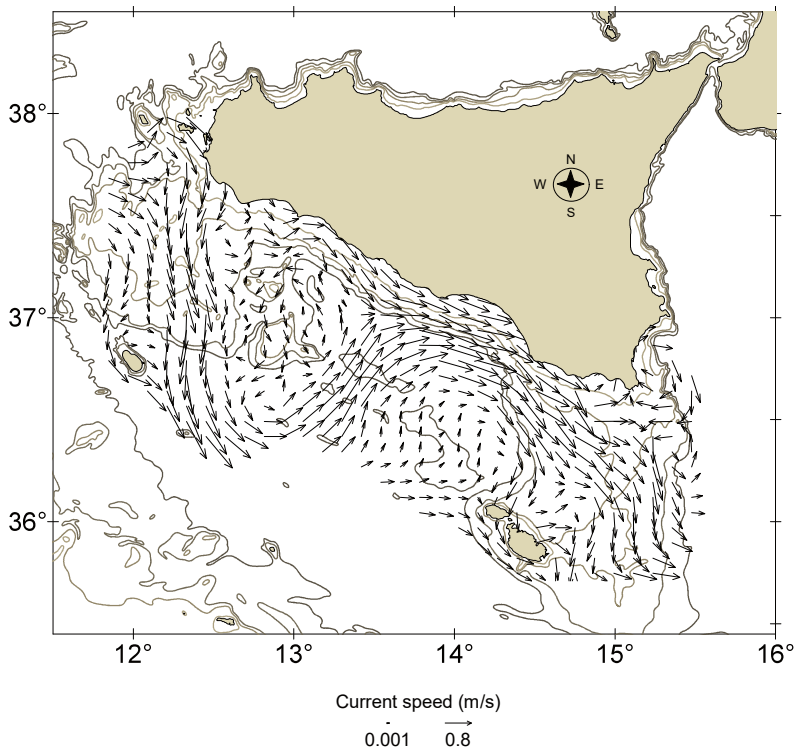

Figure 7: Surface geostrophic current pattern during July 2007.

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 neighbourhood with a strong salinity front of Cape Passero. 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.

5 Conclusions

Results showed the existence of different water masses on the surface, associated with the AIS path and with the hydrographic structures. AIS path presents year-to-year variability that has consequences on the predominant hydrological phenomena occurring in the region, such as the extent of upwelling and the formation of frontal structures [17].
These appear in turn to affect the distribution of mesopelagic species larvae observed. In fact, the presence of these families offshore would testify the bathy-

pelagic 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.
In addition, the accumulation of larvae on the south-eastern edge could be related to the strong salinity front of Cape Passero.
The higher larval concentration of Cape Passero raises the question of whether there are physical reasons for defining it as a retention area. There, the presence of a surface thermohaline front linked to the Ionian slope fronts (ISFs) [18] would be able to provide a suitable scenario of enrichment, concentration and retention (the fundamental triad; [19, 20]), thus forming a favourable nursery habitat for larvae [21].

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