ACOUSTIC-GEOSTATISTICAL ASSESSMENT AND HABITAT–ABUNDANCE RELATIONSHIPS OF SARDINE IN THE HELLENIC SEAS

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Abstract

Acoustic and environmental data from six research surveys (in summer and winter) in the Aegean and Ionian Seas were analysed to examine the spatial structure of sardine populations using geostatistical techniques, and study the spatial distribution of sardine in relation to environmental regimes using cumulative distribution function analysis. Geostatistical analysis showed that sardine formed meso- to large-scale patches. Generally, within the range of available measurements, sardine was significantly ($p<0.05$) associated to more productive inshore waters. This was more pronounced during the winter period.

Keywords: sardine, spatial distribution, geostatistics, environmental variable selection, Hellenic Seas

Introduction

In the Hellenic seas, sardine (*Sardina pilchardus* Walb.) forms the basis of commercially important fisheries comprising 11.4% of the mean total marine landings (1). The knowledge of the spatial organization of small pelagic fish stocks such as sardine is essential because it may affect both stock catchability and the results of assessment surveys and contributes to the understanding of fundamental ecological processes affecting the population (2). The present paper presents preliminary results on sardine's spatial structure in the coastal waters of Hellas, as well as its association with environmental parameters, based on the combination of data from concurrent hydroacoustic and hydrographic surveys.

Materials and methods

Acoustic data were collected during four research surveys (summer 1998, 1999 and winter 1999, 2000) onboard the R/V *Philia*, carried out along predetermined transects in the Central Aegean and Ionian Seas. The acoustic equipment used was a Biosonic Dual Beam 120 kHz V-Fin Echosounder. Acoustic echoes were registered continuously along transects and were integrated over one nm (Elementary Distance Sampling Unit). Sardine echoes were discriminated from those of other fishes by the characteristic echogram shape of the schools and back-scattered energy of single targets (3). Hydrographic sampling was performed over a grid of predetermined stations. At each station vertical profiles of fluorescence were obtained with a WetLabs fluorometer and zooplankton samples with a WP2-net. The study area was divided into seven sub-areas and geostatistical analysis was applied to study the spatial structure of sardine populations (4). In addition, we used cumulative distribution functions analysis (CDFs) to investigate the spatial distribution of sardine in relation to environmental regimes (5).

Results and discussion

The estimated autocorrelation range of omnidirectional variograms indicated that sardine formed meso- to large-scale patches (i.e. autocorrelation range varied from 2 nm to 15 nm). Specifically, sardine exhibited an autocorrelation range that generally agreed with the one observed for other sardine species and sub-species [*Sardinops sagax:* in the southern Benguella region ≈10 nm (6), *Sardina pilchardus pilchardus:* in the Catalan Sea and in the Bay of Biscay ≈ 8 nm (2 and references therein)]. The smallest ranges (2 to 6 nm) were observed in small gulfs (i.e. North Evoikos Gulf and Patraikos Gulf).

CDFs analysis (Table 1) revealed that sardine in the Central Aegean Sea was significantly ($p<0.05$) associated to the more productive inshore waters during summer, whereas the opposite was observed in the Ionian Sea. The latter could be attributed to differences in habitat selection between small (<100 mm) and large individuals (>100 mm) and respective differences in the length frequency distributions between the two areas (Fig. 1). In the winter, when sardine reproduction takes place in Hellenic waters, it was positively associated to areas of high productivity, in both regions.

Table 1. Indices of parameter selection by sardine. S: index of parameter selection; D: test statistic; p-value: probability of statistical significance of parameter selection based on randomization test. NS=Non significant.

		Central Aegean Sea			Ionian Sea		
Season	Parameters	S	D	p-value	S	D	p-value
Summer	Bottom depth (m)	-43.83	7.98	0.000	-3.94	4.62	0.039
	Zooplankton volume (ml/m^2)	176.60	9.22	0.000	-1965.82	6.74	0.000
	Mean Chl-a (µg/lt)	-38.75	2.96	NS	-15.02	2.66	NS
Winter	Bottom depth (m)	-59.16	4.17	0.003	-46.75	5.23	0.003
	Zooplankton volume (ml/m^2)	72.12	4.73	0.000	70.77	7.78	0.000
	Mean Chl-a (µg/lt)	29.91	3.59	0.001	-8.62	2.862	NS

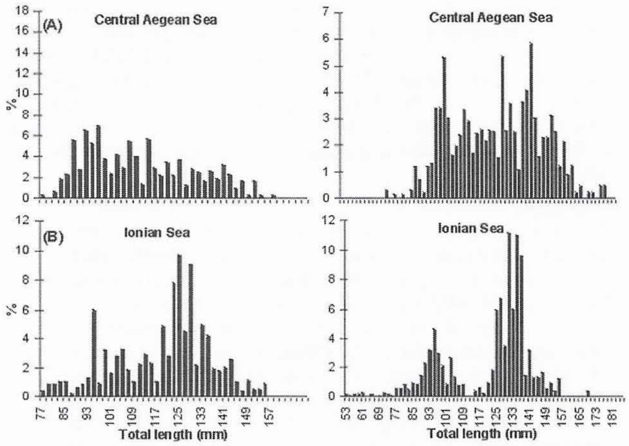

Fig. 1. Length frequency distribution of sardine (A) in July 1998 and (B) in June 1999.

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