MAPPING AND ASSESSMENT OF ANCHOVY (*ENGRAULIS ENCRASICOLUS*) EGG PRODUCTION BY GEOSTATISTICS

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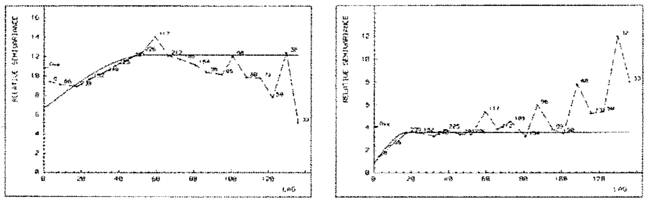
An anchovy egg sampling survey was carried out on the Catalan Sea shelf (Eastern Spain) from 27 to 31 May 1990. The experimental survey was planned within the Anchovy stock assessment project (PALOMERA and PERTIERRA, 1993). The survey comprehensively encompassed the spawning area and horizontal and vertical range known from previous work in the study area (PALOMERA, 1991, 1992). Details of the sampling scheme and sampling gear used can be found in PALOMERA and PERTIERRA (1993). Eggs were counted and assigned to a development stage according to the scales of REGNER (1985) and MOSER and AHLSTROM (1985).

In order to accurately map and further estimate the density of eggs at ages A and B (LO, 1985), geostatistical methods were applied (MATHERON, 1971; JOURNEL and HUIJBREGTS, 1978). The linear geostatistical method here employed is a two stage optimal interpolation technique. First, the spatial structure of dependence is determined by a spatial autocovariance function, in our case-study, the semivariogram. Experimental semivariograms were computed for eggs at ages A and B and revealed a structure of spatial dependence which increased progressively to 55 km for age A eggs and 19.5 km for age B eggs and then stabilized around the sample variance (figure 1). In order to proceed to the actual mapping or spatial prediction stage, the experimental semivariogram must be modeled by a theoretical semivariogram function which complies with certain mathematical conditions (MATHERON, 1971). Both for eggs at ages A and B, a spherical model was fitted, including a relatively high "nugget" term which represents micro-scale variability and white-noise or sampling error. The mapping was conducted by estimating the density of eggs at ages A and B over an arbitrarily fine grid on the polygon defined by presence of eggs. The (linearly) optimal interpolator is obtained solving the point kriging system of linear equations at each point of the grid. The results for eggs at ages A and B is presented in figure 2.

Figure 1: Experimental semivariograms and spherical fit.

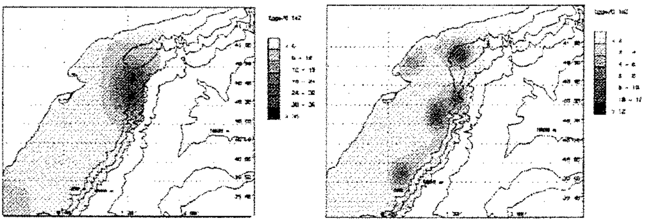
Age A Age B



The geostatistical technique further allows to estimate the global number of eggs over a polygon (regular or irregular) by block kriging (MATHERON, 1971; JOURNEL and HUIJBREGTS, 1978). The kriging variance obtained by solving the kriging system is used to give confidence limits to our estimates. The total number of eggs at ages A and B were $5.63*10^{11}$ $6.32*10^{11}$ and $1.41*10^{11}$ $0.74*10^{11}$, respectively. Linear geostatistics was successfully applied to describe the structure of spatial depence of anchovy eggs in the spawning area off the Catalan coast, as well as to map its distribution and to obtain global estimates which take into account the spatial autocorrelation among samples. Given the short duration of the survey (4 days) the maps give a punctual picture of the distribution of anchovy eggs -and therefore, of the parental stock- at a population level (SMITH and HEWITT, 1985.) Age A eggs are mainly centered in front of the Ebro river delta, near to the shelf break. Age B eggs show quite a different pattern "moving off" the main age A eggs center in 3-4 high-density patches some 20 km in diameter (of the same order of magnitude as the range of the fitted semivariogram function). This distribution pattern could be explained in terms of dispersal by the water masses.

Figure 2: Kriging maps for eggs age A and B.

Age A eggs Age B eggs



REFERENCES

JOURNEL, A.G. and HUIJBREGTS, C.J. 1978. *Mining Geostatistics*. Academic Press.
LO, N.C.H. 1985. A model for temperature-dependent Northern anchovy egg development and an automated procedure for the assignment of age to staged eggs. *In:* R. Lasker (ed.): An egg production method for estimating spawning biomass of pelagic fish: Application to the Northern anchovy, *Engraulis mordax*. U.S. Dep. Commerc., *NOAA Tech. Rep.* NMFS 36, pp. 43-50.
MATHERON, G. 1971. The theory of regionalized variables and its applications. *Cahiers du Centre de Morphologie Mathématique* de Fontainebleau. Fascicule 5.
MOSER, H.G. and AHLSTROM, E.H. 1985. Staging anchovy eggs. *In:* R. Lasker (ed.) : An egg production method for estimating spawning biomass of pelagic fish: Application to the Northern anchovy, *Engraulis mordax*. U.S. Dep. Commerc., *NOAA Tech. Rep.* NMFS 36, pp. 37-42.
PALOMERA, I. 1991. Vertical distribution of anchovy eggs and larvae in stratified waters of the Western Mediterranean. *Mar. Biol.*, 111: 37-44.
PALOMERA, I. 1992. Spawning of anchovy *Engraulis encrasicolus* in the Northwestern Mediterranean relative to hydrographic features in the region. *Mar. Ecol. Prog. Ser.*, 79: 215-223.
PALOMERA, I. and PERTIERRA, J.P. 1993. Anchovy biomass estimate by the daily egg production method in 1990 in the Western Mediterranean Sea. *Sci. Mar.* 57(2-3):243- 251.
REGNER, S. 1985. Ecology of planktonic stages of the anchovy, *Engraulis encrasicolus* (Linnaeus, 1758) in the central Adriatic. *Acta Adriatrica* 26(1):1-113.
SMITH, P.E. and HEWITT, R.P. 1985. Sea survey design and analysis for an Egg Production Method of Anchovy Biomass Assessment. *In:* R. Lasker (ed.): An egg production method for estimating spawning biomass of pelagic fish: Application to the Northern anchovy, *Engraulis mordax*, pp. 17-26. U.S. Dep. Commerc., *NOAA Tech. Rep.* NMFS 36.