EFFECT OF A TWO MONTHS CLOSED SEASON ON MONTHLY CATCHES OF HAKE (*MERLUCCIUS MERLUCCIUS*) AND RED MULLET (*MULLUS* SPP) IN A RESTRICTED AREA OFF THE CATALAN COAST (NW MEDITERRANEAN)

Paloma MARTIN

Instituto de Ciencias del Mar. CSIC. Barcelona, Spain

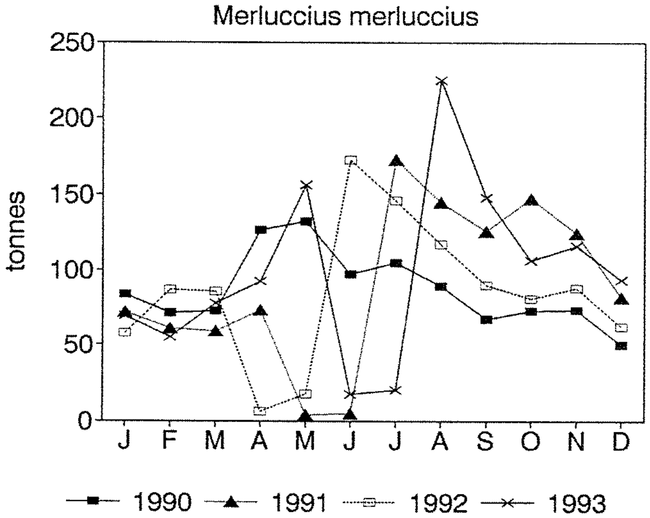
Hake (*Merluccius merluccius*) and red mullet (*Mullus* spp) are two of the most valuable fishing resources off the Catalan coast. Monthly catches of these two species undergo seasonal variations, specially marked in the case of the red mullet. During the year, highest hake catches are obtained by late spring and early summer, while highest red mullet catches correspond to late summer and autumn.

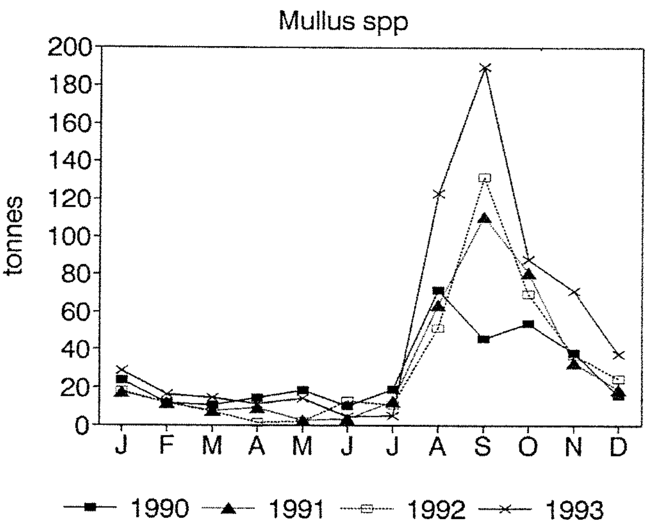
The trawling fleet operates five days a week, a maximum of 12 hours at sea per day. As an additional fishing regulation, from 1991 a closed season of a duration of two months was implemented in the southern third of the littoral. This closure affects about 200 vessels (57 000 hp) based in five fishing ports, which represents half of the trawl fleet. The period of closure is not the same every year : May and June in 199, April and May in 1992, June and July in 1993.

In the hake, highest catches were obtained during the three or four months from the opening of the activity of the trawling fleet after the closure. These months changed depending on the closed season period, the maximum monthly yield corresponding to the month following the end of the closure (July in 1991, June in 1992 and August in 1993). In the red mullet, the time of the year with highest catches was the same during 1990-1993, although the values of the maximum monthly catches were higher in the years with closure.

Both in the case of hake and in the red mullet, monthly catches after that time of the year when highest values are attained have remained at a level similar to that of 1990, year preceding the implementation of a closed season for trawling. In January 1994, hake and red mullet catches were similar to those of the four previous years. Also, it has not been observed a clear tendency of increasing hake and red mullet annual catches from 1990. Apparently, the result of the closure has been to concentrate the catches in a few months just after the closed season rather than bringing a sustained increase of catches during the whole year.

Part of the information used in this study was collected within a research project on trawling financed by the Generalitat de Catalunya (Contract Ref. PCC 300 12/90).





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

Francesco MAYNOU[1] and Isabel PALOMERA[2]

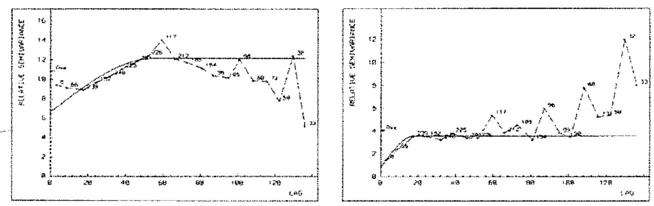
[1] Gulf Fisheries Centre, Dept.. Fisheries & Oceans, Moncton, Canada
[2] Institut de Ciències del Mar, Plaça del Mar, s/n. E-08039 Barcelona, Spain

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.

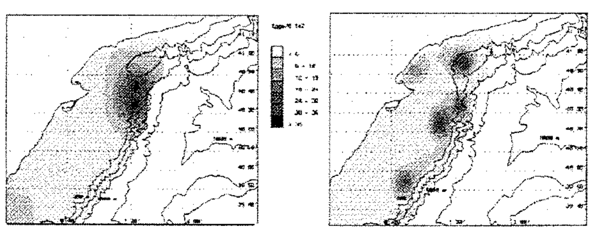
Age A Age B



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.

V