RESEARCH IN PROGRESS ON *POSIDONIA OCEANICA* IN THE LIGURIAN SEA, WESTERN MEDITERRANEAN

G. MATRICARDI

"Development models of aquatic organisms research" group. Istituto di Anatomia Comparata dell'Università di Genova, Viale Benedetto XV, 5, 16132 Genova, Italia

In recent years, *Posidonia oceanica* (L.) Delile has been extensively studied by many authors in several coastal regions of the Mediterranean (BOUDOURESQUE *et al.*, 1984; BOUDOURESQUE *et al.*, 1989). However, data on the distribution and phenology of the *posidonia* meadows are still fragmentary and little informing for large areas of this sea. Excluding some little meadows in the Gulf of Trieste and the not well investigated eastern coast of the Adriatic Sea, the Ligurian Sea is the northern distribution area of the seagrass. It is characterized by surface climatic conditions (temperature and salinity) which differ from the neighbouring Gulf of Lions (generally colder and more aline) and Tyrrhenian Sea (warmer during winter) (PICCO, 1990). Few and localized information on *Posidonia* meadows in the Ligurian Sea is available from litterature : BIANCHI and PEIRANO (1990) supplied a complete and discussed bibliography; unfortunately this work, which is followed by a detailed mapping (scale 1:25.000) of the meadows of the whole Liguria province, has not been published. Other available mappings mainly refer to Portofino Promontory and Cinque Terre area on the east coast of Liguria, and to the region between Cogoleto and Loano on the west coast (BIANCHI *et al.*, 1987). Furthermore, most of the existing bibliography provide faunistic information, omitting data on phenology, morphology, upper and lower limit features, etc.

The research group "Development models of aquatic organisms" of the Comparative Anatomy Institute of the University of Genova, working from 1986 on growth strategies in marine invertebrates, engaged in investigations on *P. oceanica* as a support information on the ecosystem in which the selected target species lived. Given the lack of data, the first aim was to obtain detailed maps of the investigated meadows. A simple and fast acoustic technique has been developed to provide information also on the density of the prairie (WURTZ *et al.*, 1988). By this technique, density maps of Spotorno (8°26'E, 44°14' N), Cogoleto (8°39' E, 44°24' N), and Nervi (9°2' E, 44°23' N) meadows have been obtained (scale 1:10.000); in the same areas, permanent transects have been localized and described to set up an historical data base on the evolution of the meadows. While investigations on the morphology and the growth strategy of *Electra posidoniae* Gautier (Bryozoa, Cheilostomata) on *posidonia* leaves were carried on (MATRICARDI *et al.*, 1991), data on shoot density (40x40 cm quadrats), leaf number and measures (by age classes; GIRAUD, 1979), leaf base measure, apex condition, brown tissue extension and the index of epiphytism (MORRI, 1991) were collected on a seasonal sampling design and at different depths (0-30 m). According to GIRAUD (1977), preliminary data suggest to classify Nervi meadow as "Stade IV: herbier très clairsemé" (mean density : 216.7 shoots/m^2, 15 m depth), Prelo meadow (Portofino Promontory) as "Stade II : herbier dense" (mean density : 427 shoot/m^2, 5 m depth) and Spotorno meadow as "Stade II" (mean density: 181.5 shoots/m^2, 10 m depth); detailed data are still necessary to describe better shoot densities in the meadows. Statistical comparisons with similar data coming from other mediterranean regions will provide information on morphological differences related to environmental conditions. In the Spotorno and Nervi meadows, monthly investigations have been planned from 1994 to describe the leaf cycle of the plant, performing, by multivariate statistics, a better estimate of the mean dimensions of each leaf in the bundle during the year. More general information on the *Posidonia* ecosystem interactions are collected in the Spotorno meadow.

Some peculiar topics about *P. oceanica* biology have also been investigated. Flowerings have been observed at Cala dell'Oro (Portofino Promontory - 9°10' E, 44°19' N - 22 m depth, 1992) and Sori (9°7' E, 44°23' N - 4 m depth, 1993) (unpublished data). The phenology of a recent *Posidonia* settlement on hard substrate is monitored from 1992 at Cogoleto, in order to obtain information about the development of a prairie (DAVICO and MATRICARDI, 1995).

Field operations have been supported by the Sezione di Quinto of the Lega Navale Italiana, the Noli Diving College and the Gruppo Subacqueo Sori, to which our best thanks are addressed for the pretious collaboration. The main results of the researches listed above will be the subject of detailed works in the future.

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MODELLING THE SPATIAL DISTRIBUTION AND ASSESSMENT OF *NEPHROPS NORVEGICUS* (L.) BY GEOSTATISTICS

F. MAYNOU[1], G. Y. CONAN[1] AND F. SARDÀ[2]

[1] Gulf Fisheries Centre, Dept. Fisheries & Oceans, Moncton, N.B., E1C 9B6 Canada
2 Institut de Ciències del Mar, Pg. Joan de Borbo, s/n. 08039 Barcelona, Spain

An extenisve survey was carried out in order to accurately map the distribution and assess the harvestable biomass of *Nephrops norvegicus* by geostatistics. The survey site is located off Tarragona (NE Spain), at shelf and slope depths (84.5 to 713 m) on commercial fishing grounds. The area surveyed was 939.5 km^2. Sampling was carried out from 6 to 16 May 1994 over 72 stations, using a specially designed otter trawl (Maireta System, SARDÀ *et al.*, 1995). In order to retain small individuals, a 12 mm cod-end stretched mesh was fitted to the trawl. Opening of the trawl was measured by a SCANMAR acoustic system, stabilizing at 16 m width and 2 m height. Tows were made parallel to the depth contours and lasted 15-30 min. Start and end locations were measured by G.P.S., and area swept by the trawl was computed exactly. The survey was carried out over 24 h periods, but only preliminary results for day-time samples are presented here.

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In order to accurately map and further estimate the density of Norway lobster individuals, the geostatistical technique was applied (MATHERON, 1971; JOURNEL and HUIJBREGTS, 1978, CONAN *et al.*, 1992). The linear geostatistical method is a two stage optimal interpolation method. First, the spatial structure of dependence is examined by computing experimental semivariograms. A semivariogram is a form of autocovariance function which analyzes the spatial dependence among samples. In the case of spatial independence among samples, the mathematical expectation of the semivariogram function is the variance of the population. The existence of spatial astructuration in the population is revealed by a monotonously increasing semivariogram up to the distance (called range) in which the effects of spatial dependence are negligible, the stabilizing around the sample variance (called sill). Experimental semivariograms computed for Norway lobster samples in the study area showed a structure of variability stabilizing around 5-7 km, for all biological categories selected (adult males and females, juvenile males and females), in accordance with previous results from nearby areas (CONAN *et al.*, 1992). 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). A spherical model was fitted (sill = 3.742, range = 7.2 km, figure 1). The fit was very similar for all biological categories considered, thus only results for total density of *Nephropss* are presented.

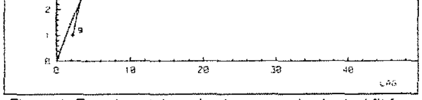
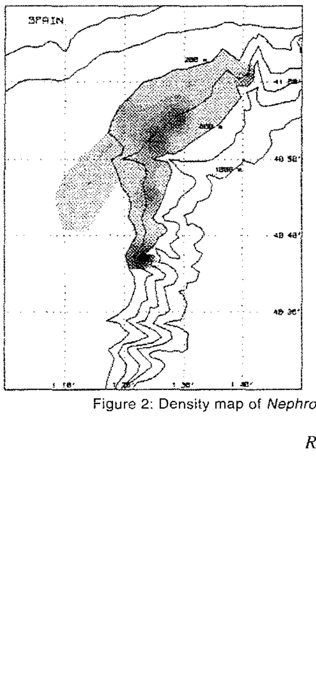


Figure 1: Experimental semivariogram and spherical fit for total number of Norway lobster:

The mapping was conducted by estimating the density of individuals over an arbitrarily fine grid on the polygon defined by presence of positive samples (200 to 600 m depth, except for a shallower zone on the shelf of the Ebro delta). The (linearly) optimal interpolator is obtained is obtained solving the point kriging system of linear equations at each point of the grid. The resulting map is presented in figure 2. The geostatistical technique of block kriging (MATHERON, 1971) was implemented over the mapped area to obtain estimates of the density of *Nephropss* individuals and total biomass. The kriging or estimation variance obtained when solving the system of equations was used to set confidence limits to our estiamtes. Average density computed by kriging was 341.5 ± 218.3 ind/km^2 and total number of individuals was 320,905.8 ± 205,065.2 or 6,420 ± 4,010 kg.

Geostatistics, as a tool for mapping the distribution of a species and assessing the potential of the resource, proves adequate for benthic resources presenting a complex pattern of spatial structuration, such as *Nephrops norvegicus*. Confirming previous results (CONAN *et al.*, 1992), Norway lobster populations are structured in patches of high density of around 7 km in diameter. A preliminary analysis of the night-time samples reaveals the same pattern and location of high-density patches, although at much lower density (due to the light-dependent catchability of the species). Adult and immature (< 26 mm CL) individuals show the same pattern of spatial distribution and high-density patches overlap extensively for biological categories, which could be of importance in the management of the resource. Due to the complex biological cycle of the species (seasonal variability of catchability, especially of berried females) and its burrowing habits, the application of geostatistics is limited by other factors than those properly pertaining to the spatial modelling stage and should be utilized within a concepyual biological model for the species.



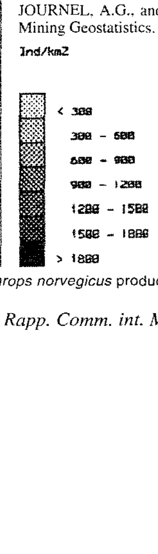


Figure 2: Density map of *Nephrops norvegicus* produced by kriging

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