ECOLOGICAL MODELING: THE GENERAL METHODOLOGICAL APPROACH AND ITS APPLICATION TO THE EMILIA-ROMAGNA COASTAL ECOSYSTEM

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A general methodological approach is discussed which rationalizes the interdisciplinary effort necessary to the understanding of any marine ecosystem. The approach is based on modeling, divided into several successive phases, of all the basic parameters which are needed to the comprehension of the ecosystem, namely: physical processes (hydrography, circulation, in general the dynamics of the considered basin); chemical processes (the basic nutrients considered as passive scalar in the circulation field); biological and biochemical processes (the non conservative interactions acting as sources and sinks for nutrients and biomass). The methodological approach is thereafter applied to the Emilia-Romagna coastal ecosystem and the properties of this last one are discuseed in detail.

The most modern approach to rationalize and understand the complex behavior of a sea basin from a general, comprehensive point of view is based upon the concept of modeling. Modeling is the only conceptual methodology which allows to include into a unified structure the different, multivaried aspects characterizing a water mass, in particular a water mass at sea. These aspects being of such a different nature, namely physical, chemical, biological, geological, require as a necessity an interdisciplinary study and only the modeling approach is capable of unifying them into a rational structure which is not only phenomenological and descriptive, but also quantified, explicative, and previsional. Such a structure can be thought of as constituted by different successive phases. The first one is necessarily the phenomenological phase; based upon an experimental knowledge of the considered basin in its different aspects. The second phase is the modeling of the physical properties of the water mass, specifically the quantitative prediction of the space time evolution of its circulation. This explains the dynamical behavior of the basin, and is consequently the frame in which one can study the space-time evolution of the water mass properties. The third phase is that in which these properties are considered as passive scalars, namely influenced only by diffusion and advection by sea currents. In the fourth phase the non-conservative interactions are introduced affecting the different biological, chemical and geological parameters. The last phase is that in which hypothetical interventions upon the system can be simulated and their effects predicted. This methodological approach is being used in

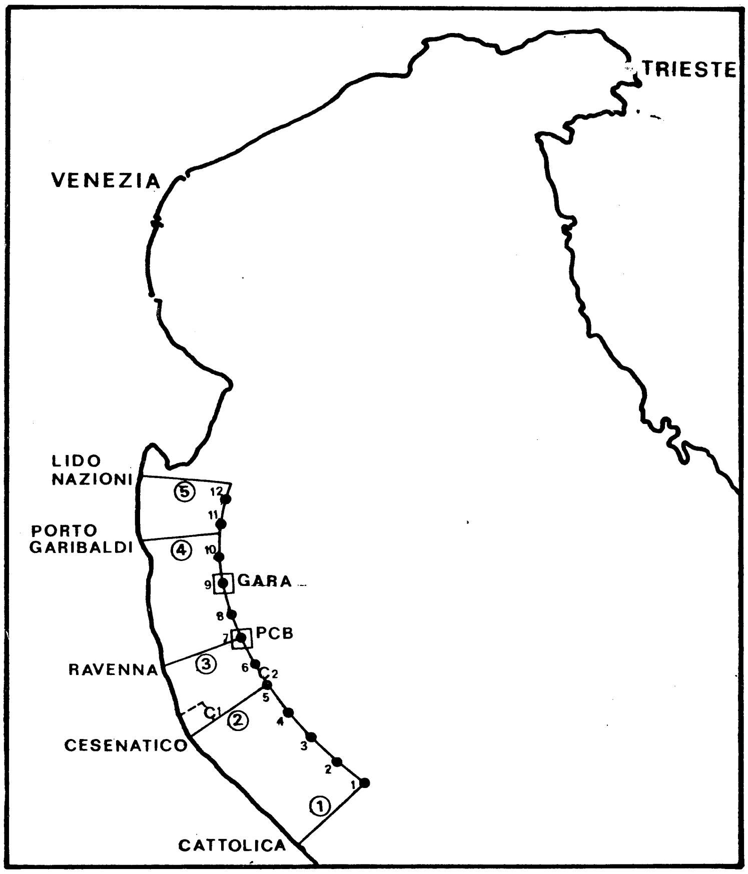

Fig. 1. – Emilia-Romagna littoral.

an interdisciplinary study of the coastal ecosystem of the Emilia-Romagna littoral (Fig. 1). The basic phenomenology is illustrated in Figs. 2,3,4,5. In Figs. 2,3, the horizontal distributions, respectively for summer and winter seasons, are shown for salinity, silica, nitrates, and biomass.

Quite evident is the fundamental role payed by the Po River outflow in driving the dynamics of the coastal region and in determining the horizontal distributions of these properties. Figs. 4 and 5a show the characteristic stratification present in the coastal region also in wintertime when the interior of the basin is vertically homogeneous. This vertical stratification in the density anomaly field seems to indicate that the system has basically a two-layer structure. This hypothesis is however contradicted by Fig. 5b, in which a 3-layer structure is easily recognizable. This crude and schematic phenomenological description gives however the fundamental criteria to design the basic hydrodynamical model of the modeling approach, criteria summarized as:
- horizontal flexibility to describe closed basins as well as coastal, open boundary regions, in shallow or deep water.
- vertical flexibility, for which an arbitrary number of layers can be superimposed to simulate the vertical stratification, different for different properties.

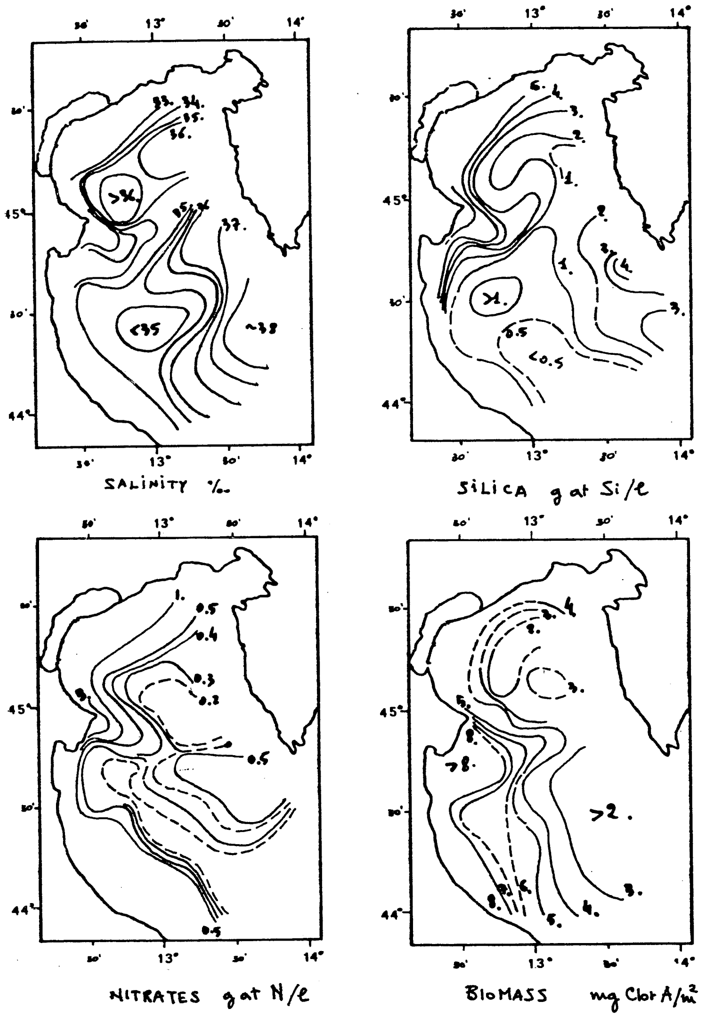

Fig. 2. – Summer horizontal distribution.

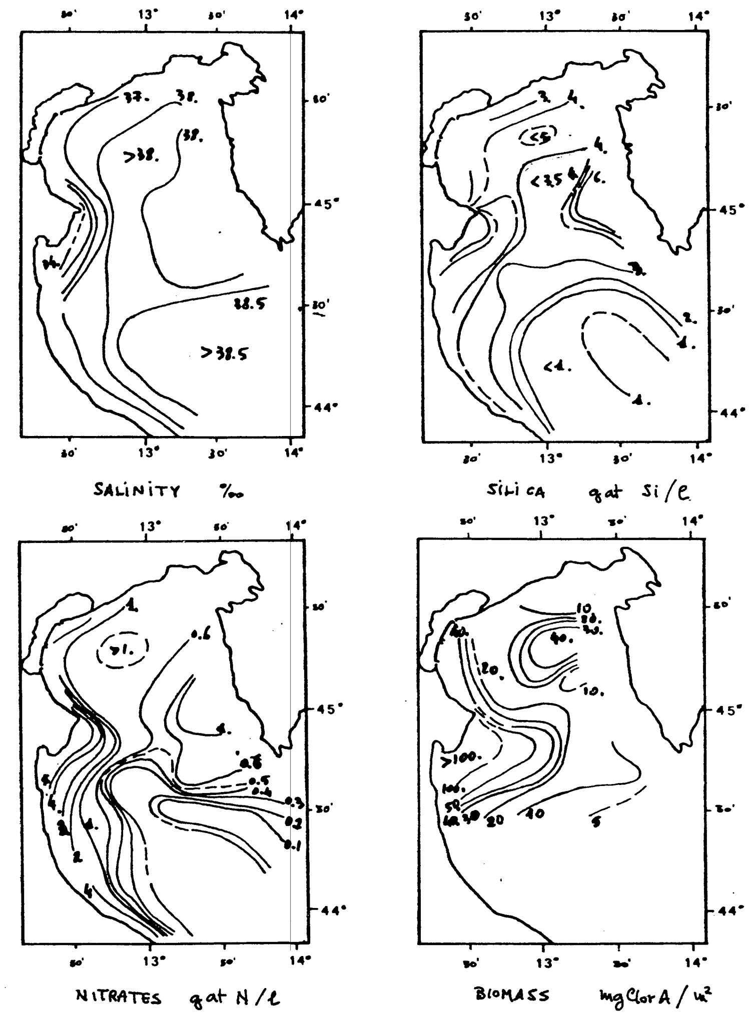

Fig. 3. – Winter horizontal distribution.

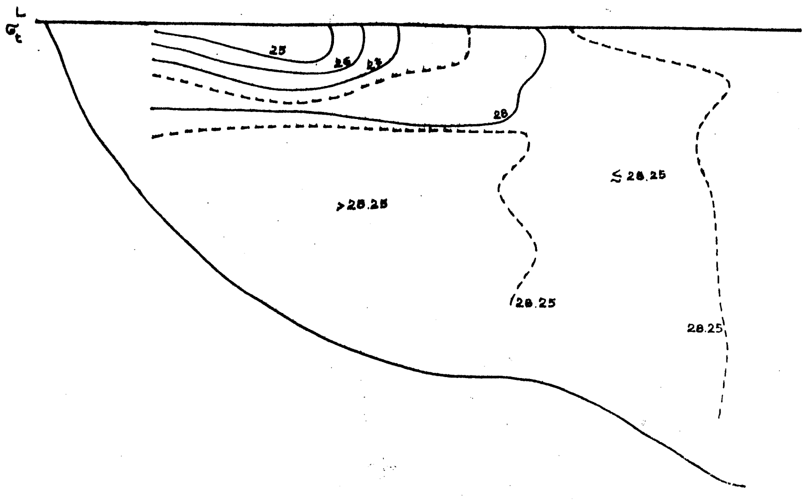

Fig. 4

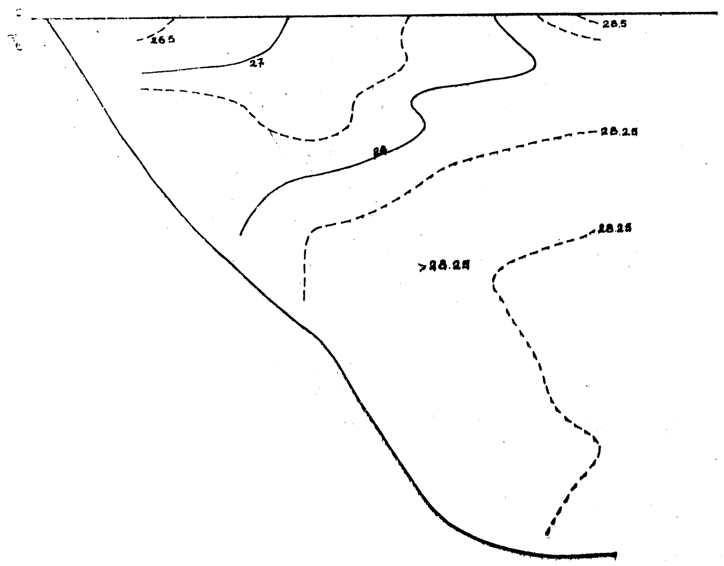

Fig. 5a

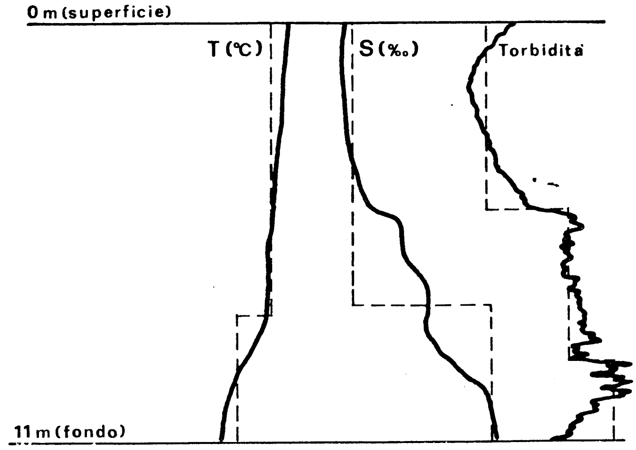

Fig. 6