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BIOLOGICAL CONSEQUENCES OF THE CABO FRIO UPWELLING*

by

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A very original oceanographical experience based on the upwelling of deep, rich water, and with a scientific, educational and economic aim, is presently in progress in Brazil. The Cabo Frio Project has already been described by its author, Admiral P. Moreira da Silva, in several communications. This contribution deals specifically with the biological aspects of the programme.

The Cabo Frio region is favoured by the existence of an upwelling whose greatest benefit seems to be derived by sardinellas. The project is concerned with a close examination of the phenomena involved, and with trying to obtain useful results for Man.

The biological programme follows two main lines: (1) a better knowledge of the natural phenomenon and the directly increased organic production, and (2) research and development of its direct utilization based on available deepwater nutrients.

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(1) The first objective will be reached through a carefully organized study of the plankton, qualitative and quantitative, correlated with physical and chemical parameters. Three different approaches have been planned:

- static routine observations at a characteristic station, at four depths, conducted on alternate days during a year;
- dynamic observations accompanying the surface drift of upwelled deep water identified by use of a buoy;
- experimental observations on primary production.

The following planktonic parameters are considered:

- seston (counting of particles with Coulter counter);
- phytoplankton (counting and systematic classification of cells);
- zooplankton (counting and systematic classification of organisms, biomass);
- pigments and C_{14} assimilation.

The zooplankton is collected by the simultaneous use of a pump and a vertical closing net. A temperature-pressure sensor allows direct control of the sampling level from the deck; the light intensity versus depth is also graphically recorded.

(2) The second objective could be the natural fertilization of a small bay through the pumping of deep water from the open ocean. Because of the uncertainties in determining the consequences of this process, we decided to experiment under controlled conditions, in volumes great enough to obtain representative results. This will be achieved by means of a simplified food chain with three trophic levels using selected species. At each level the energy transformation rates will be evaluated.

The expected production, from the nutrients available in deep water, may be estimated by theoretical calculation; for example, a nitrate concentration of $7.5 \mu\text{gAt}/1 \text{ NO}_3\text{-N}$ might give 8.5 g/m^3 of phytoplankton (fresh weight).

Experimental research in this field will be conducted by means of three units:

- an algal culture laboratory for studies on fertilization mechanisms and the cultivation of inocula for outdoor mass production;
- an aquarium working with juveniles;
- an outdoor experimental plant for tests on the food chain.

The three trophic levels will be investigated in tanks of different capacities, whose terrace-like layout allows water distribution by gravity. The production of the phytoplankton cultures is based on a sequential method. These tanks (15 000 litres) are supplied with deep water from two storage tanks (30 000 litres each) and connected to the tanks for herbivorous species (1 000 litres). The tertiary level (30 000-litre tanks) is planned to be autonomous and supplied only by surface water.

At the same time, direct production experiments will be conducted, according to classical aquaculture techniques (floating rafts and lines for molluscs, floating cages for fish, and tanks for crustaceans). The first step emphasizes the cultivation of locally available species, even those not directly related to the upwelling, the choice of these being motivated by the search of a global yield. In a first approach the following species were selected: the mussel (*Perna perna*), the mangrove oyster (*Crassostrea rhizophorae*), the Japanese oyster (*C. gigas*) and the French oyster (*Ostrea edulis*) - in this instance the seed was imported for experimental purposes - the shrimps, *Penaeus brasiliensis* and *P. paulensis*, and the fish, *Mugil* spp, *Trachinotus* spp, *Diplodus argenteus*, *Centropomus undecimalis* and *C. parallelus*.