

RESULTS OF HYDROBIOLOGICAL INVESTIGATIONS ON A BRACKISH WATER BAY
(SACCA DEGLI SCARDOVARI) OF THE PO RIVER DELTA

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ABSTRACT: Hydrobiological investigations were carried out in "Sacca degli Scardovari", a bay in the southern part of the Po River Delta, on the following subjects: hydrology, physical and chemical characteristics of the sediments, plankton chlorophyll-a contents, distribution and structure of zooplankton and zoobenthos, mussel production, inwards migrations and feeding habits of fish fry, fishable stock.

RESUME: Des recherches hydrobiologiques ont été menées sur la "Sacca degli Scardovari", une baie dans la partie méridionale du Delta du Po; on a considéré les sujets suivants: hydrologie, caractéristiques physiques et chimiques des sédiments, concentrations de chlorophylle-a planctonique, distribution et structure du zooplancton et du zoobenthos, production des moules, montée et régime alimentaire des alevins, analyse des stocks des poissons exploités.

The Sacca degli Scardovari is a large bay located between two terminal branches of the Po River, in the southern part of its Delta. The bay is about two centuries old and in the last decades it was bordered by high dikes in order to protect the land from the sea floods; its area is 32 km² and its average depth is 1.5 m. This report mainly deals with the results of investigations carried out in this bay from 1976 to 1979.

During June 1976 in a forty station-grid, the upper sediments were sampled for granulometric and chemical analyses and for investigations on structure of macro and meiobenthos communities. A 0.1 m² Van Veen grab and a hand-lowered 28 cm² corer were respectively used for sampling macro and meiobenthos. From April 1978 to May 1979 water samples were collected nearly fortnightly at eight stations for analyses of the main physical and chemical parameters and of the chlorophyll-a contents and zooplankton samples were gathered at four stations by means of a pump fitted out with an 80 µm mesh net. Fry samples were collected during 1978 and 1979 with a large trowled net. A not exploited bed of *Mytilus galloprovincialis* was sixmonthly sampled by SCUBA diver from November 1977 to November 1979. Lastly, a series of monthly catches of commer-

cial fish from 1960 to 1977 was analyzed to assess the fishable stock in the bay.

The main results of the investigations can be summarized as follows.

Hydrology - The physical and chemical data were statistically processed. Distances of Mahalanobis (D^2) between stations were calculated (Poole, 1974) and the UPGMA method of clustering according to Sneath and Sokal (1973) was applied to the D^2 matrix. Analysis showed a zonation of the bay into two different areas. The southern zone is characterized by short-term and irregular variations of almost all the water parameters, due to tide and coastal currents. In the northern zone these variations are smoother owing to a slower water renewal and a seasonal pattern of some parameters as nutrients can be seen. During summer, in the water layer close to the bottom, a pronounced peak of PO_4 -P content ($10.6 \mu\text{g-at P/l}$) was recorded in concomitance with a complete depletion of dissolved oxygen.

Sediments - Three main bottom areas with a different sediment composition can be distinguished: a northern zone with a well-sorted sediment and a clay content ranging from 31% to over 40%, a southern zone which has a lower clay content (between 21% and 30%) in the poorly-sorted sediment and a fine sand zone lying even more southwards, near the sand banks facing the sea. The per cent contents of both organic carbon and organic nitrogen in sediments is generally related to the particle size composition: the highest carbon and nitrogen percentages are found in the clayey sediments of the inner zone. Both granulometric characteristics and organic matter contents of the sediment are clearly influenced by the tidal currents flowing in the bay approximatively along a clockwise pathway.

Phytoplankton and zooplankton - Plankton chlorophyll-a concentration is at its maximum ($154 \mu\text{g/l}$) in the northern zone during summer. Mean concentration values are clearly decreasing from the northern zone to the southern one. Distribution of the zooplankton densities follows the same space pattern; the mean density is about 190 ind./l in the northern sampling station while it is ranging from 68 to 84 ind./l in the central and southern stations. The major zooplankton components are meroplankton groups (larvae of Polychaeta, Gastropoda, Bivalvia, and Cirripedia) which show the highest densities in the inner zone of the bay; holoplankton groups, represented by neritic Copepoda, Cladocera and Tunicata, are particularly abundant in the southern zone. The seasonal density trend is characterized by spring and summer peaks in the northern sampling station; in all the other stations density maximum occurs in October.

Zoobenthos - Macrobenthos is mainly represented by 14 Polychaeta, 16 Mollusca and 7 Amphipoda species, among which *Polydora ciliata*, *Cerastoderma glaucum* and *Corophium insidiosum* are respectively the most widespread and abundant species. Meiobenthos is mainly represented by 32 Nematoda and 25 Harpacticoida species, among which *Sabatieria pulchra* and *Canuella perplexa* are respectively dominant. By means of a cluster analysis carried out on the matrices of Bray & Curtis similarity indexes (1957) it was possible to identify a northern and a southern zone of the bay characterized by different macro and meiobenthic sub-communities. Macrobenthos structure seems to be mainly affected by water movements and salinity, while meiobenthos structure is related to the granulometric and chemical composition of the upper sediments.

Mussel production - By means of a computer resolution of the length frequency distribution of mussels, four size/age classes were detected and for each of them it was possible to calculate survivorship, length and weight growth and production. Mussels in the bay are fast-growing, but affected by strong mortality. The yearly production is similar to that of *M. edulis* in the northern Europe coastal areas.

Fish fry - The inwards migrations of fry display an abundance trend showing two seasonal peaks. The higher peak occurs in spring and is mainly supported by *Liza ramada*, *L. aurata*, *L. saliens*, *Sparus aurata*, *Dicentrarchus labrax* and flatfishes, such as *Solea solea* and *Platyichthys flesus*; the autumn peak by *L. saliens*, *L. aurata*, *L. ramada* and *Mugil cephalus*. Among the fry of grey mullets, *L. saliens* is constantly present in the bay, while *L. ramada* is the dominant species in March and *L. aurata* in April. *M. cephalus* and *Chelon labrosus* account for less than 1% of the total catches. Fry catches were maximal in March and April (over 1300 specimens per standard unit effort) and minimal from July to September and in January (only 1 specimen per standard unit effort). The stomach contents of juveniles of five species (*L. ramada*, *L. aurata*, *L. saliens*, *S. aurata* and *D. labrax*) were analyzed: the feeding habits show noticeable variations according to size for each species (Ceccherelli et al., 1980).

Fishable stock - The sequence of monthly catches of commercial fish from 1960 to 1977 shows two maximum points, one in spring (mainly formed by sand smelts, young grey mullets, especially *L. saliens*, young flounders and yellow eels) and the other in autumn (sand smelts, grey mullets and flounders in reproductive phase and silver eels). Catch per unit effort is high from December to April (about 10 kg/boat/day) owing to the lower number of employed persons and even higher in October and November (12 kg/boat/day) because of the plenty of fishes; in the other

months it is about 8 kg/boat/day. The mean catch for the whole period is about 100 kg/ha/year.

To sum up, it can be said that the inner part of the bay has hydrological and trophic characteristics of a sheltered lagoon; the outer one shows many peculiarities of an estuarine embayment largely influenced by the sea.

The high biomass of planktonic and benthic populations supports a rich stock of fry of euryhaline fish species which are exploited by a specialized fishery and sold to be sown in brackish water fish ponds. Euryhaline fish species of market size and mussels are fished too. These exploitations give economically important yields: this suggests the opportunity to maintain the embayment in the present state avoiding further interferences which could compromise its own evolution.

References

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