Morphological and hydraulic-sedimentological features of the Lignano tidal inlet (Northern Adriatic Sea)

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In the framework of a scientific program aimed at a systematic hydraulic sedimentological study of all the lagoon tidal inlets in the Northern Adriatic Sea, this paper presents the results of research carried out at the Lignano inlet, the largest of the six mouths of the Marano and Grado lagoons.

The Lignano channel provides the opportunity for an accurate analysis of the natural reaction of a lagoon mouth to the dynamic factors that determine the mobility and deposition of sediments in tidal environments characterized by practically unidirectional two-way current flows. Moreover, no dredging has ever been done because the inlet retains its shape in a natural way.

Morphological-bathymetrical and current measurements were carried out, coupled with a series of samplings within the channel.

The sea bottom configuration shows a clear asymmetry of the inlet with the axis oriented towards the east. This feature is a direct consequence of the stabilisation of the western side of the mouth (construction of the seawall in 1937-1940) as well as of the natural response to the changing equilibrium conditions (erosion of the eastern side), as partially observed by DORIGO (1965).

The local mean tidal range is approx. 65 cm; during spring tides, the excursion can reach 105 cm. Owing to exchanges between the lagoon and the sea through the Lignano mouth, up to 40-50 million m^3 water, both during flood and ebb-tide, can flow through a 4000 m^2 wide liquid section. Tidal currents are therefore considerable, with recorded peaks of 170 cm/s (DORIGO, 1965). The series of launchings of drift crosses that were done both during flood and ebb-tide highlighted that during ebb-tide currents move faster along the eastern part of the channel, while during flood-tide currents flow more towards the centre and more symmetrically about the axis of the channel. The sedimentological results confirm the morphological and current data : the median is perfectly correlated with the bathymetrical pattern of the inlet and with ebb-tide lines. Coarser sediments are located along the strip where maximum speeds was observed, which corresponds to the axis of the channel (greater depths).

This strip has well sorted, symmetric sediment while sorting and skewness tend to worsen near the edges of the channel, which are characterised by a sharp reduction of energy.

There are two main grain-size classes which account for over 90% of the analysed samples : the 150-210 µm class which prevails in the central section of the channel, and the 105-150 µm class which is predominantly at the sides of the channel.

The distribution of frequence percentages of the two main modes has led to a definition of the structure of the sediment masses by varying grain-size, thereby defining the transit axes.

The coarser sediments (150-210 µm) are almost entirely located at greater depth, along the axis of the channel. Here the sediment masses present modal values of 50-60% lined up along the flood lines, as highlighted by current-meter observations, which proves the greater strength of the currents rising along the axis of the channel. On the other hand, the finer sediments (105-150 µm) with modal values greater than 60% line up along the sides of the channel: on the eastern side of the channel, the lining-up corresponds to the ebb-tide linest while on the western sidet finer sand masses seem to be linked to the slower floodtide currents which characterize the lesser depth.

There is therefore a direct correlation between speed/direction of the currents and the distribution of sand masses with different grain-sizes: flood currents are more effective along the axis of the channel, where coarser sands than those located along the sides can be found; the latter are associated with the lower speeds which are characteristic of ebbtide currents on the eastern side and of flood tide currents on the western one.

From the point of view of applications, all types of investigations (bathymetry, current field and sedimentology) have clearly- shown that maximum sediment transport occurs mainly towards the western side of the channel, particularly during ebb- tide. This proves that the axis of the channel tends to shift eastwards and hence that erosion phenomena continue on this side of the channel, thereby highlighting the instability of the eastern side as compared to the western side.

REFERENCES

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An experimental approach to multidisciplinary studies on sediment-water interaction processes South of the Po Delta, N. Adriatic Sea, Italy

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In order to develop a descriptive model of the ecosystem of the Northern Adriatic Sea, it is important the uderstanding of biogeochemical cycles of nutrients at the sediment-water interface, within the water columns and in the uppermost sedimentary column. This requires the study of the contribution of bottom and suspended sediment and particulate organic matter to nutrient mass balance. In addition, it is also important the quantification of the exchange potential and its link to early diagenetic processes.

To do this one should study: a) seasonal variations in sediment and water properties, b) response of the sediment and water columns to local and regional hydrodynamics (wave and current regimes), c) source inputs and distributions, d) fluxes quantifications, e) role of the bioturbation processes.

The northern Adriatic Sea, and in particular the region facing the Emilia-Romagna, suffers from coastal water eutrophication, and receives the polluted waters of the Po River, that drains the most industrialized regions of Italy.

To face the problem, an experiment was organized in an area south of the Po Delta, 8.5 Km offshore (Fig. 1), that involved oceanographic, sedimentological, biological, geochemical and radiometric investigations, by mean of extensive field and laboratory work. The work was performed jointly by IGM-CNR, U.S.G.S of Menlo Park and the Department of Animal Biology of University of Modena. The experiment aimed also at the calibration of marine technologies, under the sponsorship of "Progetto Finalizzato Biotecnologie e Strumentazione" (BTBS).

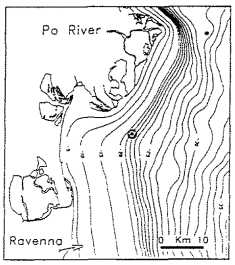


Fig. 1.- Permanent Station location

From late 1989 to mid 1990, the station was occupied by several automatic and semiautomatic collecting and measuring devices. Among them, a) short and long term sediment traps at 2 mt and 10 mt above the bottom, b) radio-buoy with measure of CTD, 02 and turbidity, c) U.S.G.S. tripod GEOPROBE, with 4 stacked EEM current meters, 2 LED optical transmissometers, 4 stacked OBS's, pressure and temperature sensors, d) VACM current meters at 2, 10, 15 mt above the bottom.

In addition to the occupation of the permanent station, two late summer and late winter sampling surveys was performed in order to obtain a more regional characterization.

The field and lab work in the permanent station included a) onboard description, subsampling and measure of chemical and physical parameters on box-corers, b) core sampling for pore waters and solid phase investigations. The laboratory work included: a) grain-size and texture analysis; b) measure of chemical parameter concentrations (nutrients, organic matter, toxics); c) extrusion of cores in inert atmosphere and measure of relevant parameters for diagenetic studies and flux calculations (BARBANTI *et al.*, this volume).

The results from the different approaches and studied items are under integration.

The permanent station's sea bottom is characterized by prevailing black highly hydrated at the surface and gradually compacting clays. Very few discontinuities are present in the sedimentary column, with decomposing shell fragments. The degree of colonization is low, mainly in late summer. At the surface the benthic fauna is dominated by *Corbula Gibba* and *Polichaetes*, where at 20-30 cm it is dominated by a different species of *Polichaetes* (BERGAMINI *et al.*, this volume).

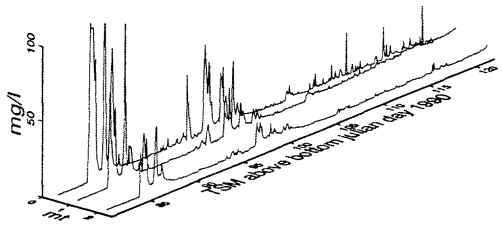
In general, the oxidation is poor. During late summer 1989 there were no evidence of the uppermost oxidized veneer, which is normally present. During summer 1989 there was the maximum of mucus ('marine snow') spreading in the area. This probably provoked abnormally anoxic conditions in the proximity of the bottom.

The GEOPROBE data have been used to determine the response of the sediment under wave stress. During the deployment, two moderate storms transited the area from NE and E, that provoked wave heigths of 2-3 mt, and a remarkable increases of water speed and turbidity at the bottom (Fig. 2) (CACCHIONE *et al.*, this volume). Otherwise, the normal sea-bed conditions were rather quiescent, with weak currents and wave energy, and low amounts of near-bottom suspended sediment. The results from the LED's have been converted to suspended load by re-calibrating the instrumentation with sediments of the site (DRAKE *et al.*, this volume).

The sediment traps collected remarkable quantities of suspended sediments, mainly during the transit of the storms. In general, the correlation between fluxes of sediments in the water column and storm periods is very good. In addition, the sampled materials were used for grain size and chemical analysis.

The water column is uniformely mixed during the winter seasons. In May a very sharp pycnocline is established. The 02 sensor revealed the presence of a very high peak of oxigen in the water column at the end of february. This peak can be probably adscribed to an algal blooming.

Fig. 2.- Total Suspended Matter measured by GEOPROBE's LED's at 3 levels above sea bottom. Storms from NE, E. Maximum wave height 2.5 mt.



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