THE STUDY OF A RIVER PLUME BY MEANS OF NUMERICAL MODELS AND REMOTE SENSING

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A constant density, rotating bidimensional mathematical model free of lateral friction, for shallow water simulation, has been studied for the area 30 by 30 km (fig. 1) enclosing the zone of influence of the main plume of the Po River in the Adriatic Sea.

The Po is the largest Italian river 691 km long with flow rates ranging from 275 to 11000 cubic meters per second and velocities at the mouth up to 4 knots.

As the fresh waters enter the Adriatic Sea with sediment and pollution particles, transport and diffusion takes place in a variety of modes due to the main Adriatic termohaline and geostrophic currents, and to the wind and tide induced currents as well as to the river's rate of flow.

As a first approach, the model so far used does not take into account the diffusivity terms and density currents. Near the coast in fact the major role is played by the river jet and the tidal transport. These factors only have been taken in consideration at first.

Measurements, by means of current meters placed about 3 km from the shore in position C_1 to C_5 (fig. 2) show a good correlation between calculated and measured data. The plume meanders with sudden variations or steps, the shape of which

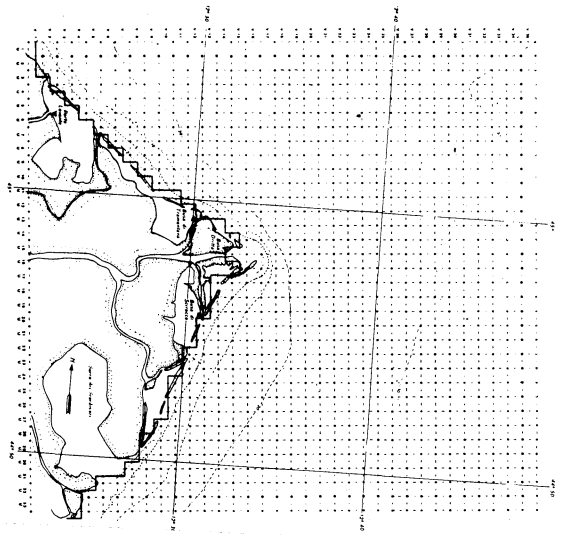


Fig. 1. Grid of the 30 X 30 km model (1 km mesh).

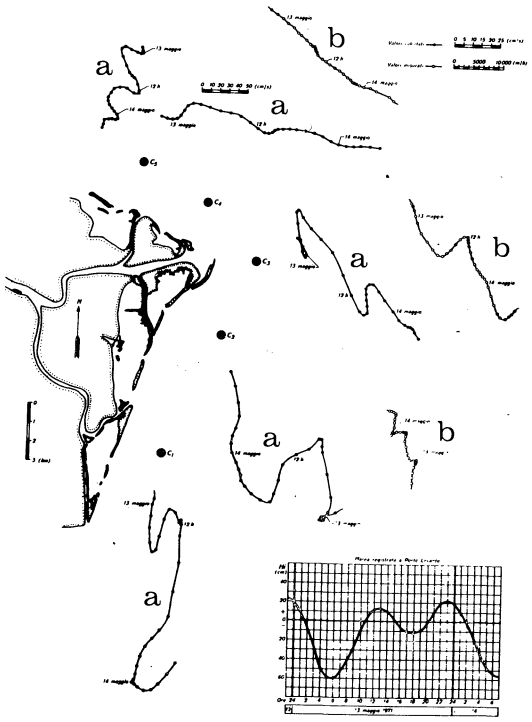


Fig. 2. Progressive current vector diagrams a) calculated, b) measured (13-14 May 1971).

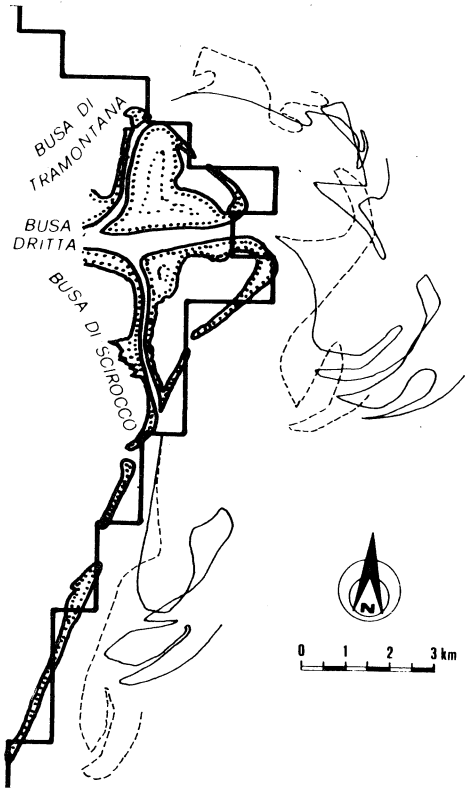
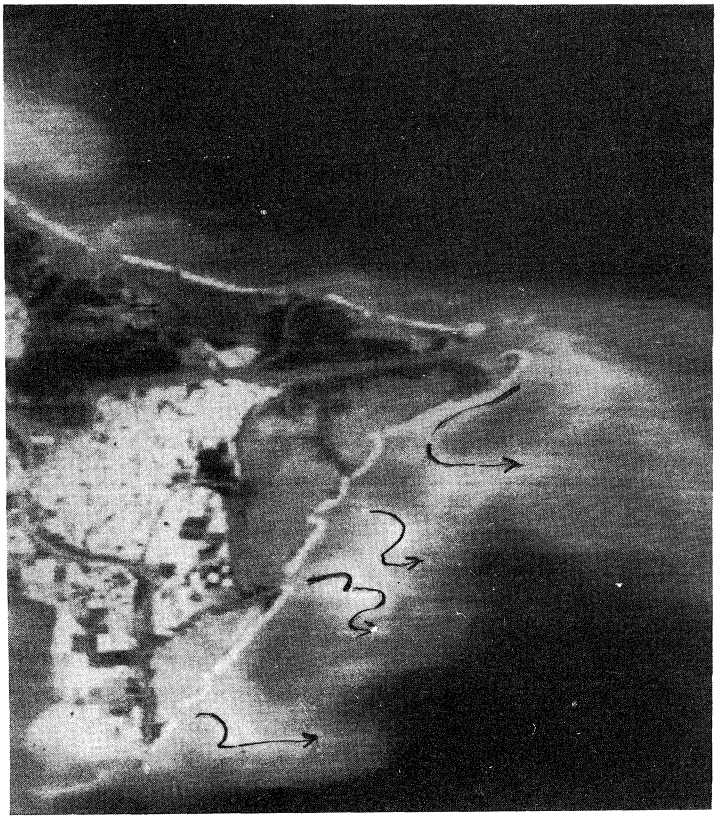


Fig. 3. Evolution of 3 plumes of the Po after 33 (dashed) and 49 (plane line) hours, calculated by model.



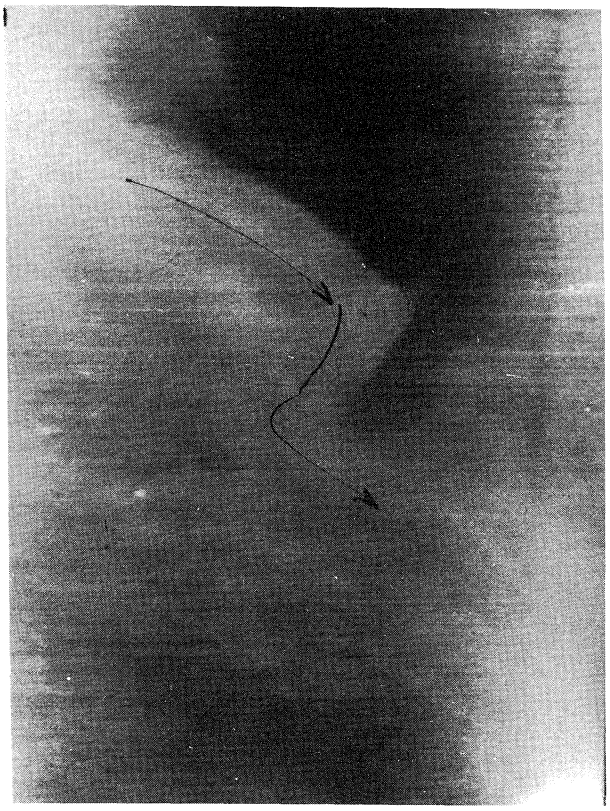


Fig. 4. OCS view of the various plumes of the Po Delta.

Fig. 6. Landsat picture of the meandering plumes from Venice Adige and the Po River, for tidal effects.

Fig. 5. OCS view from 11000 m altitude of the main plume off shore (~ 10 miles).

changes from spring to neap tide with the river water mass discharged and with wind strength and direction.

Running the model for events of 33 and 49 hours the outflowing water is seen to run first along the coast in a southward direction, then meander with the tidal currents from 2 to 6 km from the coast (fig. 3).

Further off-shore the model does not correspond as well to the measurements, made with eulerian and lagrangian methods (Drogues at 50 cm depth).

The first simple bidimensional model is therefore able to simulate the fresh water inflow within the 2 km where and when the stratification is not formed yet, in bottom depths shallower than 10 m.

Further off-shore the models,to simulate more realistically the plume, must include the diffusivity terms, and the water stratification. The grid must be finer near the coast and coarser off-shore and must geometrically follow the isobaths. Such bidimensional models constructed for more than one layer will then be able to simulate the plume up to 15 km off-shore, until the water jet of the plume is totally mixed with the sea water and its energy dissipated.

A tentative has been made to recognize the pattern of the plume in Landsat and OCS remote sensing images, assuming that in the process of transport and diffusion the meanders due to the tidal currents can be recognized and that the extension of the plume waters can be seen until they are completely mixed with Adriatic waters.

Results appear worth while and the possibility of improving the images interpretation with simultaneous sea truth measurements may permit a calibration of plume models.

The research program is entering now its second phase, in which models and remote sensing should describe more accurately this coastal process, and sea truth measurements over the entire area of 30 by 30 km will be made.