

# MODELLING ANTROPOGENIC IMPACT ON PRIMARY PRODUCTION OF SADO ESTUARY

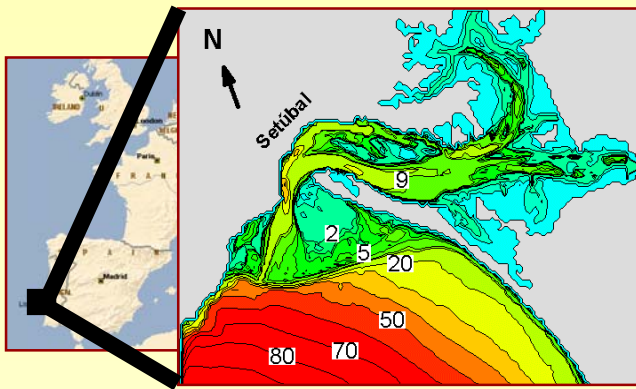


Martins, F.<sup>‡</sup> ; Pina, P.<sup>‡‡</sup> ; Neves, R. <sup>‡‡</sup>

<sup>‡</sup> E.S.T. – Univ. Algarve, Portugal. [fmartins@ualg.pt](mailto:fmartins@ualg.pt)

<sup>‡‡</sup> I.S.T. – Technical University of Lisbon, Portugal.

**ABSTRACT:** Sado estuary, the second largest estuary of Portugal, is considered a sensitive region from the ecological point of view. Most of its area is classified as natural reserve and, at the same time, it is intensively used for industrial and agricultural activities. The current state of the estuary can be considered as good. In the near future the nutrient load reaching the estuary is expected to increase due to the use of large quantities of irrigation water diverted from Guadiana River into Sado catchment basin. The MOHID2000 modeling system is used to assess the current state of the estuary in terms of nutrient concentrations and primary production. Various scenarios of nutrient loads are used to evaluate the sensibility of the system to this variable and to predict future trends of the estuary.

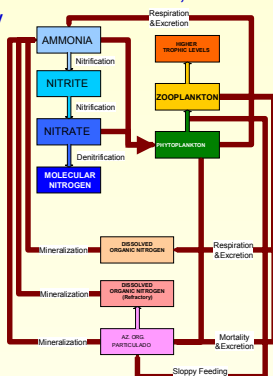
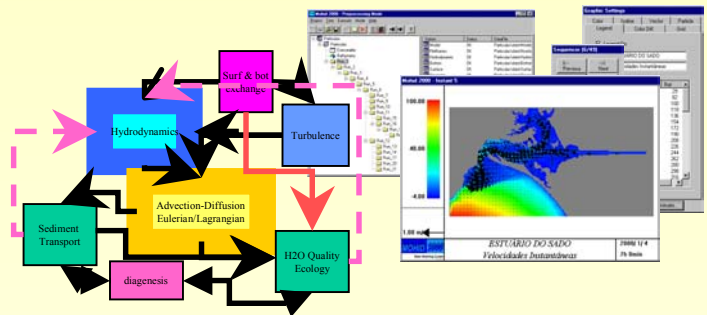


## Sado Estuary

- Area: 160 Km<sup>2</sup>; Av. Depth: 8 m;  $V_{\text{tide}}: 12 \times 10^3 \text{ m}^3/\text{s}$
- Semi-diurnal tide: 0.6 m to 1.6 m amplitude
- Highly variable river flow. Average: 60 m<sup>3</sup>/s
- East Side: Mudflats ; West Side: Sand banks
- East Side: Natural Reserve ; West side: Industry
- Despite some local problems still good "ecological quality" in average: low eutrophication, low Ecoli, low heavy metals, dolphins!

## MOHID2000 Modeling System

- Object Oriented, Fortran 95, Finite Volume, Generic vertical coordinate (Miranda et. Al., 2000); (Martins et. Al., 2001)
- User-Friendly Interface (pre- and post-processing)
- Hydrodynamic and Advection-Diffusion are common to all models
- Different hydrodynamic models for different processes: Shallow waters, Wind Waves, Hydrology

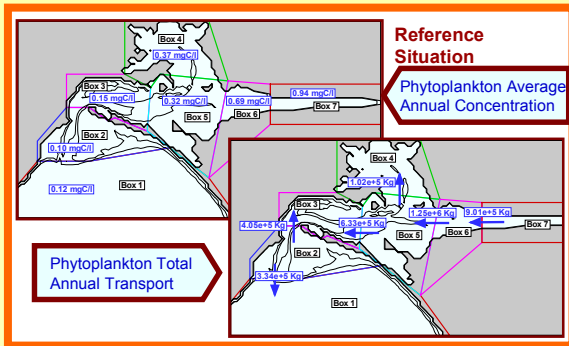
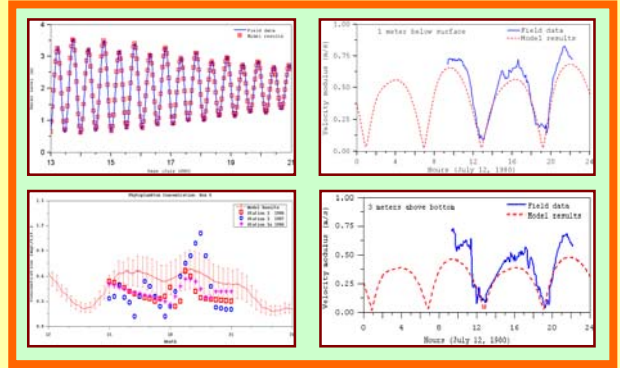


## Water Quality & Ecological Model

- WASP based. Generic Zero-D approach (EPA, 1985)
- Model solved for each 400mx400m cell and integrated over boxes.
- Nitrogen Cycle, Dissolved Oxygen, BOD, Zoo- and Phytoplankton
- Lagrangian or Eulerian Approach. Same mesh of the Hydrodynamic model

## Calibration and validation

- Forcing: Tide + River flow. Mesh: 60x79 points.
- Hydrodynamic calibration: Water levels and velocities.
- Hydrodynamic validation: Water levels.
- Sediment and chemical species: Comparison with literature values.
- Ecological model: Comparison with literature values (Cabeçadas, 1993) enables only qualitative and trend analysis.



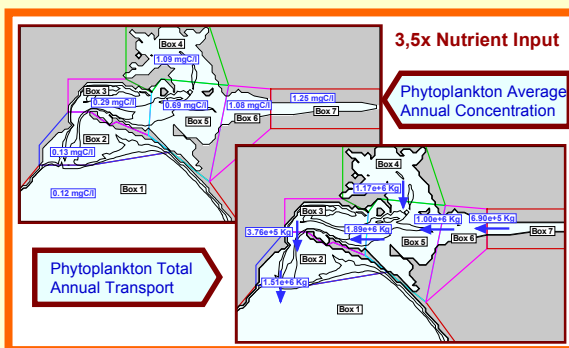
## Estuary Reference Situation

- High nutrient concentrations, high productivity and reasonable good trophic conditions agree with observations
- Boxes 4 and 5 (Marateca flats) are high productivity areas.
- Fluxes between boxes 2 and 3 and between boxes 4 and 5 do not agree with concentration gradient highlighting the non-conservative nature of Phytoplankton and heterotrophic activity

## Phytoplankton dynamics

- Box 4 (marateca) more productive than box 5 but the higher grazing makes it a sink of phytoplankton.
- Same reasoning for boxes 2 and 3: The production from the flat regions of box 2 (cambalhão) supply box3 overcoming the larger grazing.
- The concentration gradients inside each box and the transport variations along each box border could not be simulated with a simple "box model"

Box	Zoograzing Annual KgC/m3 Converted	Ammonia to Phytoplankton Annual KgC/m3 Converted	Nitrate to Phytoplankton Annual KgN/m3 Converted
Box1	4.75E+05	-2.32E+05	1.96E+05
Box2	2.09E+06	1.64E+06	1.21E+06
Box3	1.26E+07	1.22E+06	1.14E+06
Box4	5.69E+07	6.56E+06	7.19E+06
Box5	4.12E+07	4.11E+06	5.46E+06
Box6	7.07E+07	1.13E+07	1.88E+07
Box7	7.60E+07	1.74E+07	2.09E+07



## Sensibility to nutrient increase

- Large increases in nutrient input produce only moderate increase in Phytoplankton concentration.
- Abovementioned results denotes good resilience of the estuary
- Phytoplankton fluxes change directions in boxes 4-5 and 2-3 highlighting an increase in productivity.

## Conclusions

- Methodology prove to be adequate for the proposed work.
- Lack of measurements enable only qualitative and trend analysis.
- The observed good trophic condition of the estuary was reproduced.
- The impact of nutrient increase is expected to be moderate.

## REFERENCES

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- EPA, 1985. *Rates, constants, and kinetics formulations in surface water quality modeling* (2nd. ed.). United States Environmental Protection Agency, Report EPA/600/3-85/040. Martins, F., R.
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