A methodology for defining homogeneous water bodies in transitional and coastal waters under the EU Water Framework Directive

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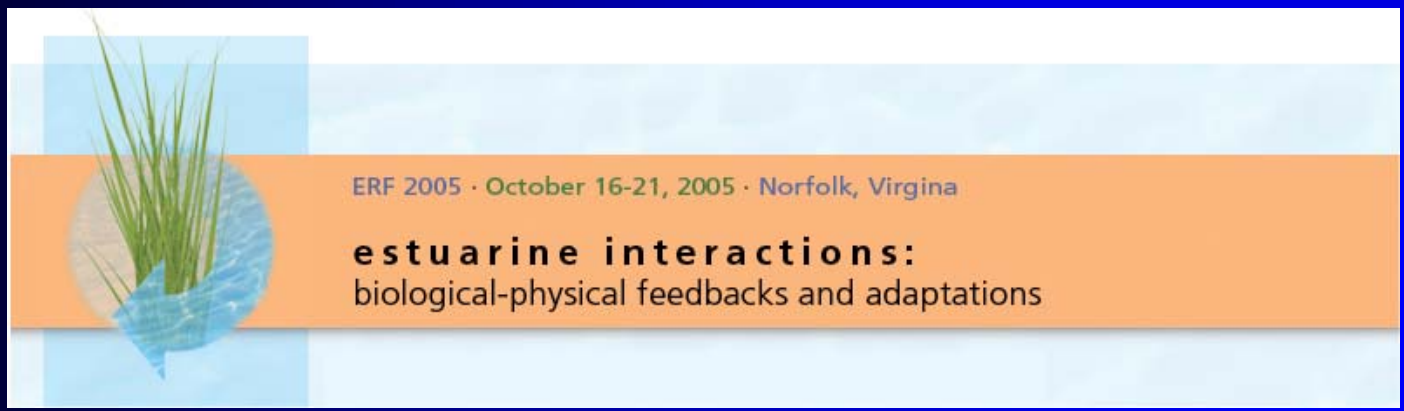

Topics

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Article 2.10 of the WFD

☑ *"Body of surface water"* means a discrete and significant element of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal, a transitional water or a stretch of coastal water.

☆ One water body can belong only to one quality class

☆ Small elements of surface water belonging to the same type may be grouped for assessment and reporting purposes

Characterisation of surface waters

- 1st step in the assessment of the WFD ecological status
- Identification of surface water bodies
- Grouping WB into types
- Definition of biological and chemical reference conditions (RCs) (natural baseline) for those types
- Due December 22, 2004

Problem definition and objectives

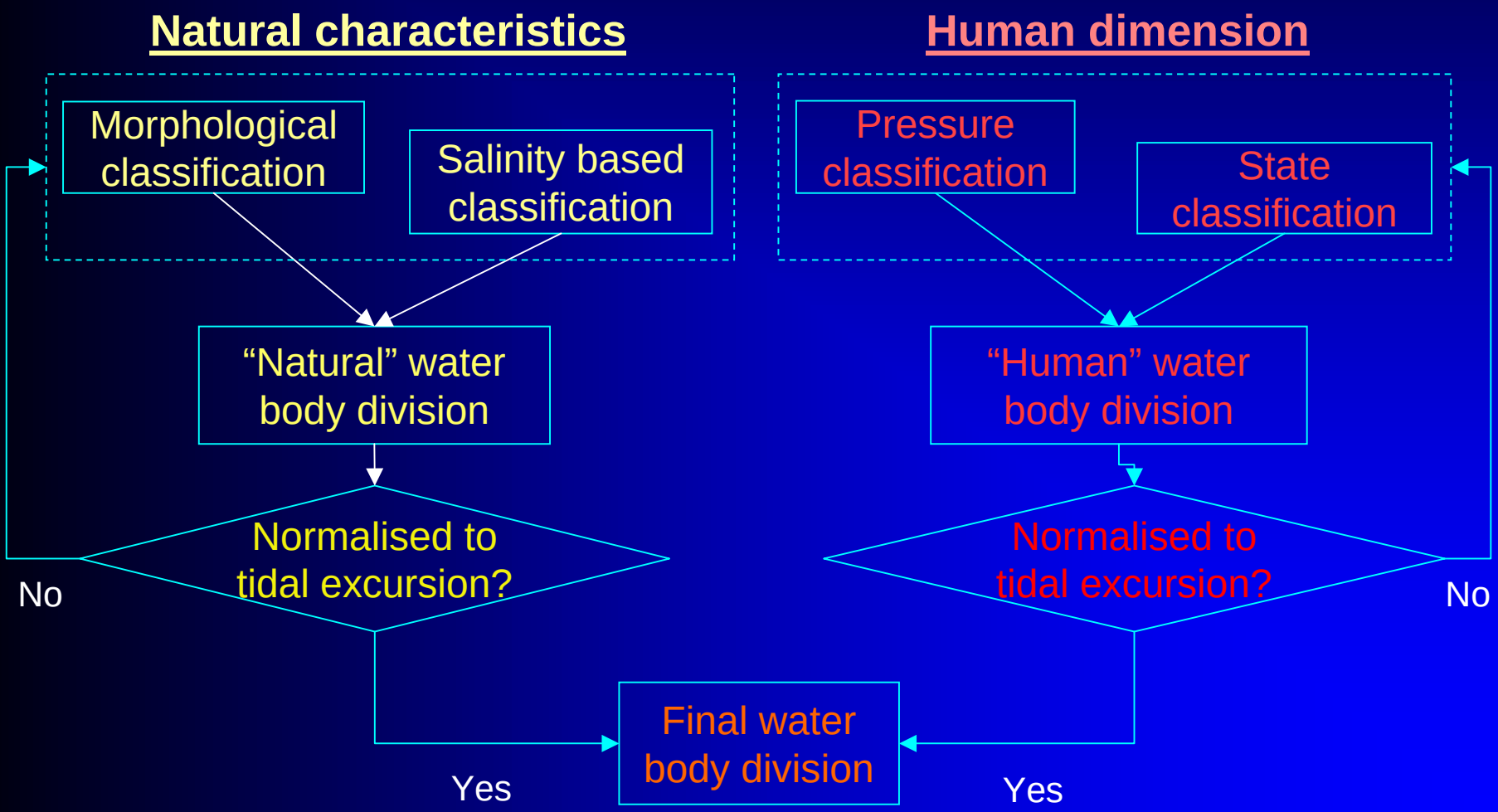
Ecosystem division into waterbodies for monitoring and management of coastal systems:

- ✓ **Required by Water Framework Directive and useful for fulfilment of other legislation such as US Clean Water Act**
- ✓ **Methodology should be based on sound scientific grounding and also meaningful for managers**
- ✓ **Must bring together both natural and human dimension**

Objectives: to develop and test a methodology for different types of transitional and restricted coastal systems.

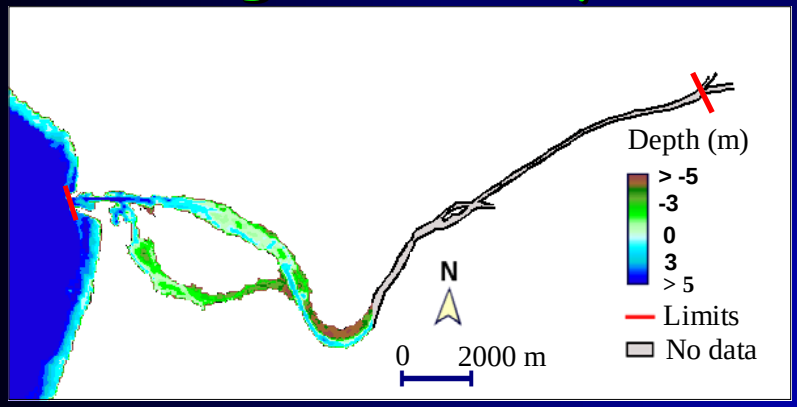
Methodology

Semi-quantitative methodology that divides the estuaries and inshore coastal waters into a meaningful set of water bodies, bringing together the following criteria:

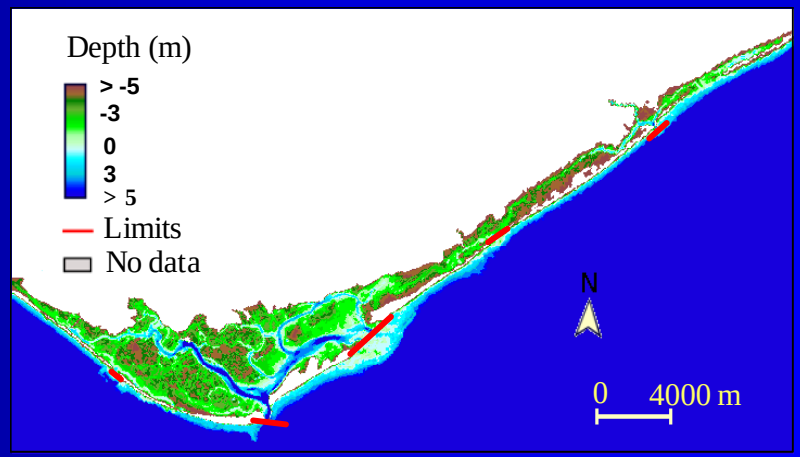


Case studies

Mondego Estuary - a tubular ecosystem

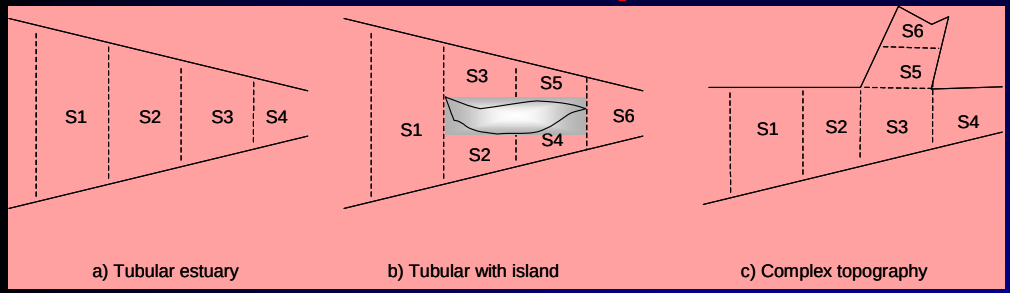


Ria Formosa - a dendritic ecosystem



Methodology - morphological criteria -

1. Draw cross-sectional profile



2. Calculate the adimensional shape factor σ for each section

$$\sigma_i = \log\left(\frac{w_i}{|\bar{z}_i|}\right)$$

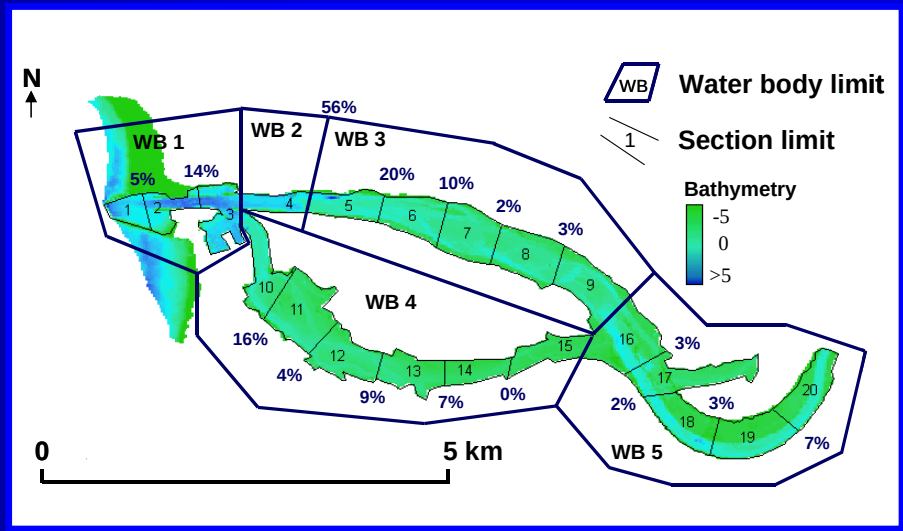
w_i: Mean width of section i (m)
z_i: Mean depth of section i (m)

3. Aggregate longitudinally into water bodies using a threshold value of ϕ

$$\phi_{i,i+1} = \frac{|\Delta\sigma_{i,i+1}|}{(\sigma_i + \sigma_{i+1})/2}$$

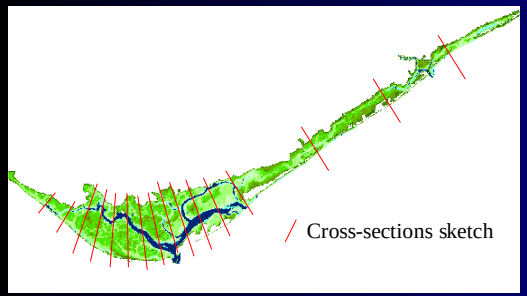
$\phi_{i,i+1}$: Aggregation factor (no units);
$\Delta\sigma$: Absolute difference between s_i and s_{i+1}(no units).

Mondego Estuary



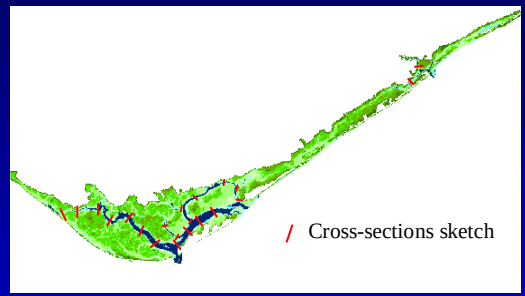
Methodology - morphological criteria -

In shallow systems with branched channels and large intertidal areas it is rather biased to define cross-sections:



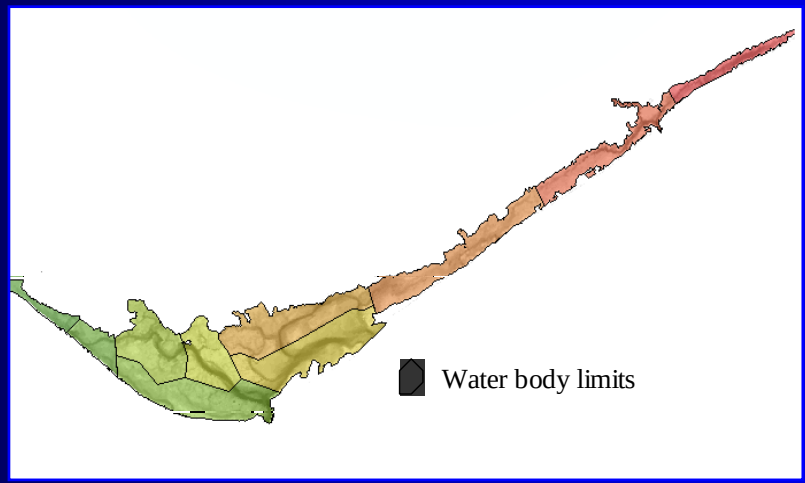
Two possibilities for drawing cross-sections:

- meaningless division of intertidal areas
- large set of small water bodies



Instead it is proposed that the division of dendritic systems is made using a heuristic criterion, e.g. drainage patterns evidenced by the bathymetry:

Ria Formosa



Methodology
- salinity criteria and *natural* harmonization-

Salinity zonation based on the NOAA National Estuarine Inventory:

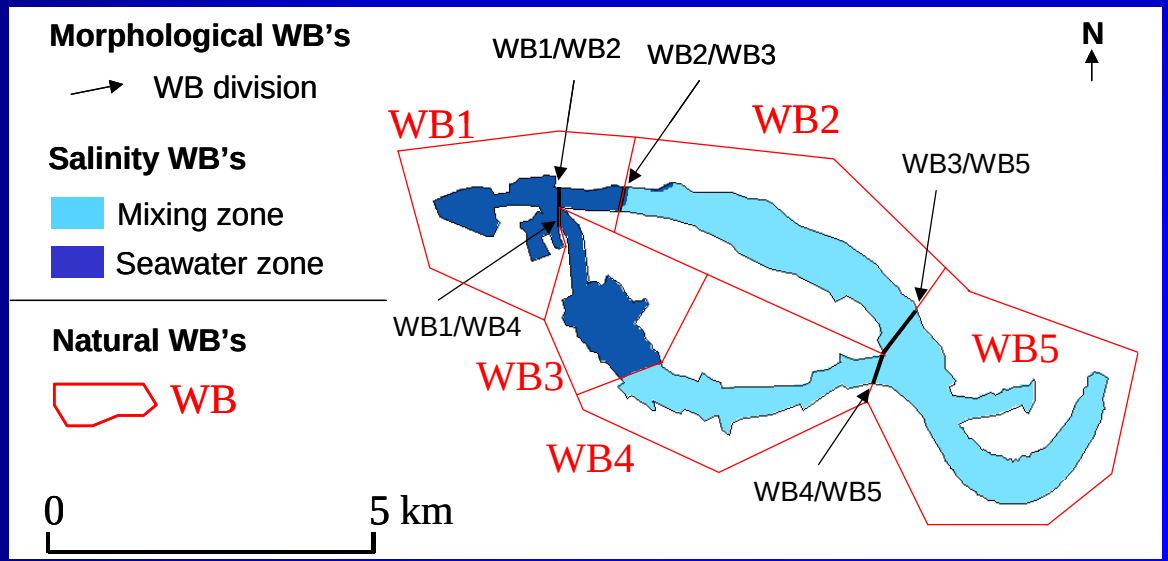
- **Tidal fresh zone (0 – 0.5)**
- **Mixing zone (0.5 – 25)**
- **Seawater zone (> 25)**

Salinity zones are interpolated using annual average values over the water column for each sampling stations.

Combination of the morphology and salinity dividers into a set of 'natural' water bodies:

- In cases where both limits are close together a centreline is defined between

- In other cases potentially lead to more water bodies

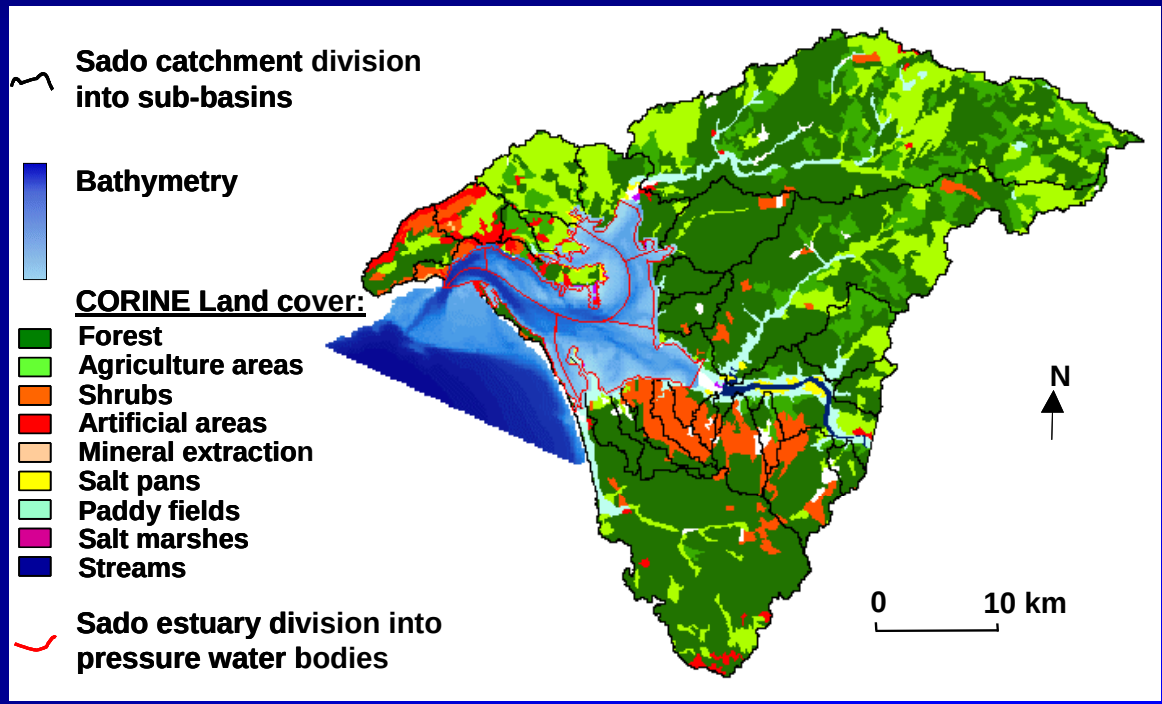


Methodology – human pressure criteria -

Steps for the definition of water bodies according with pressure criteria:

- Selection of the significant pressure (and representative variables)
- Assessment and partitioning of loads
- Normalization, analysis and aggregation:

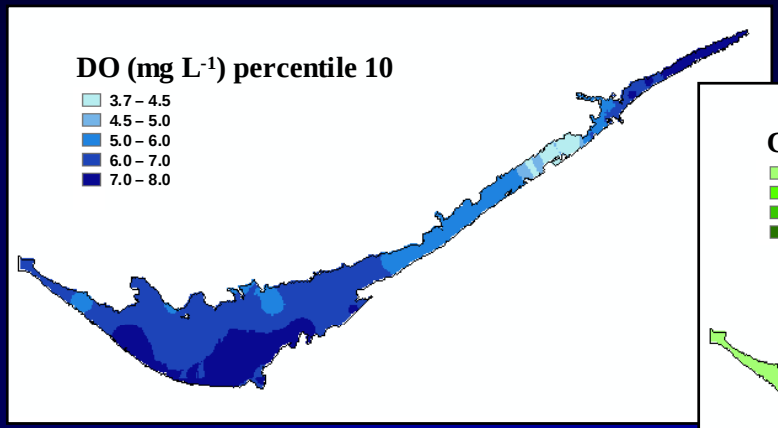
- Extend section of each sub-basin to the estuary
- Normalise N and P loading for each sub-basin
- Determine the limiting nutrient (using Redfield ratio)
- Use of a similarity index to aggregate contiguous lengths of the shoreline with similar pressure

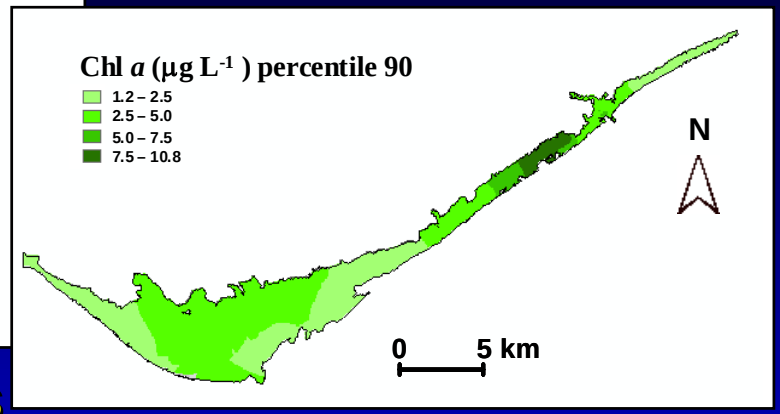


$$\tau_{i,i+1} = \frac{|\Delta\lambda_{i,i+1}|}{(\lambda_i + \lambda_{i+1})/2}$$

$\tau_{i,i+1}$: Aggregation factor (no units);
λ_i: N load normalised per length of shoreline (kg Nutrient y^{-1} m^{-1});
$\Delta\lambda$: Absolute difference between λ_i and λ_{i+1}(kg Nutrient y^{-1} m^{-1}).

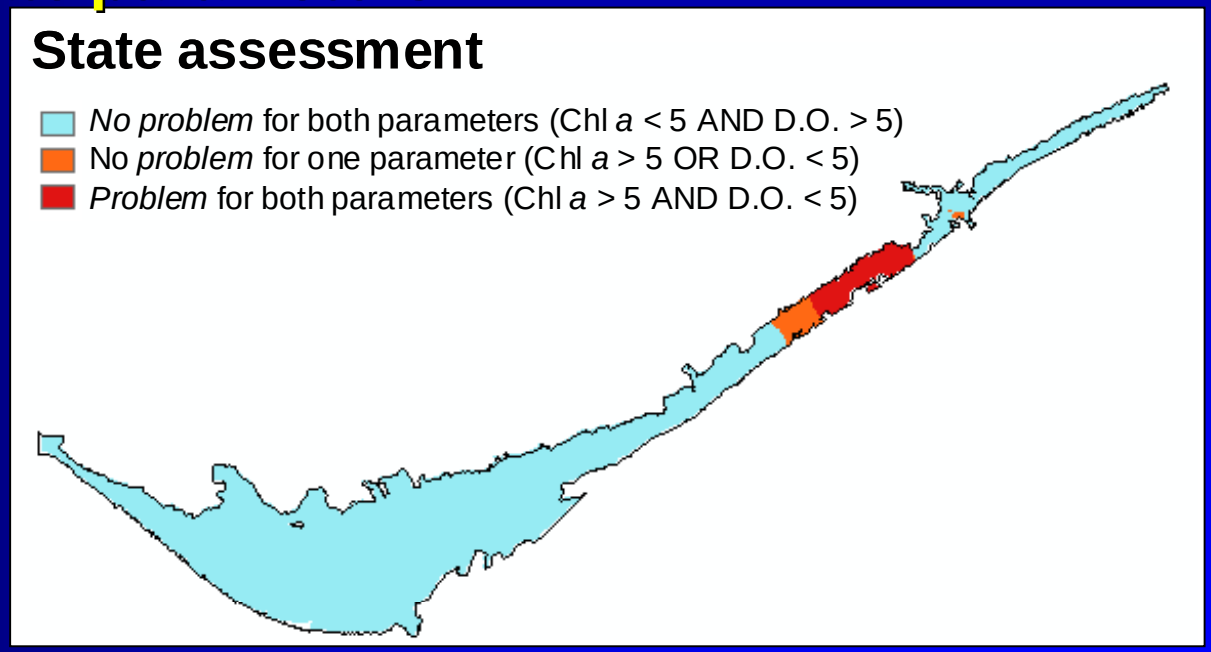
Methodology – state criteria -





- **Selection of appropriate parameters**
- **Data analysis**

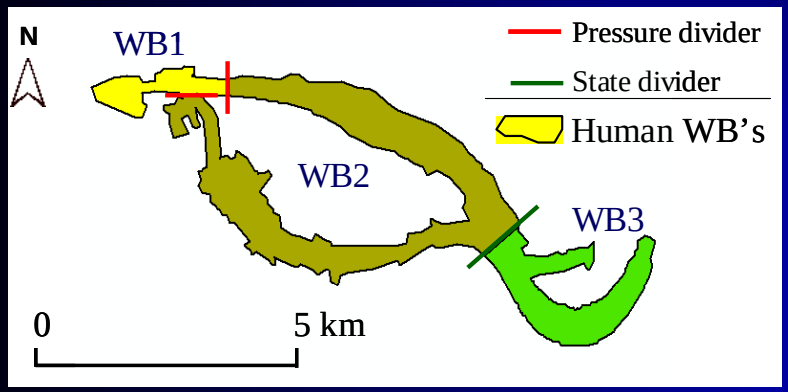
The 90th and 10th percentile cut-off points for chl *a* and D.O. were used as indicators of typically elevated (chl *a*) and low (D.O.) values *

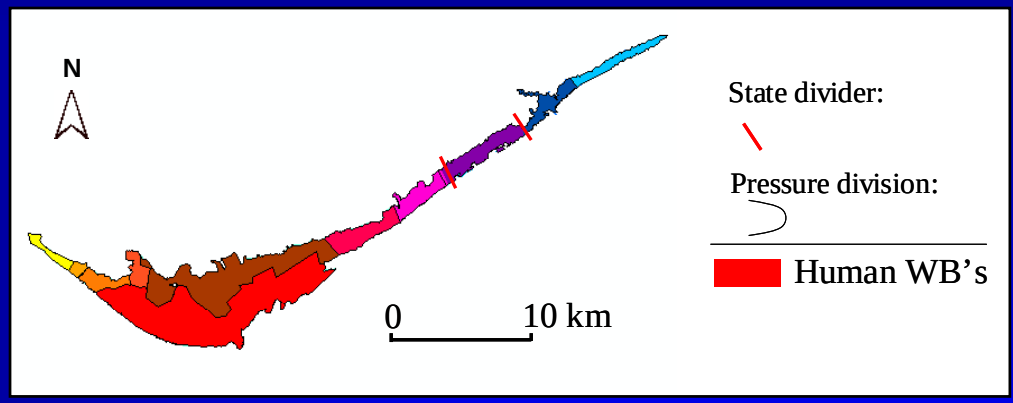


* Bricker, S.B., Ferreira, J.G. & Simas, T. 2003. An Integrated Methodology for Assessment of Estuarine Trophic Status. Ecological Modelling, 169: 39-60.

Methodology – *human* harmonization

Combination of the pressure and state dividers into a set of 'human' water bodies:

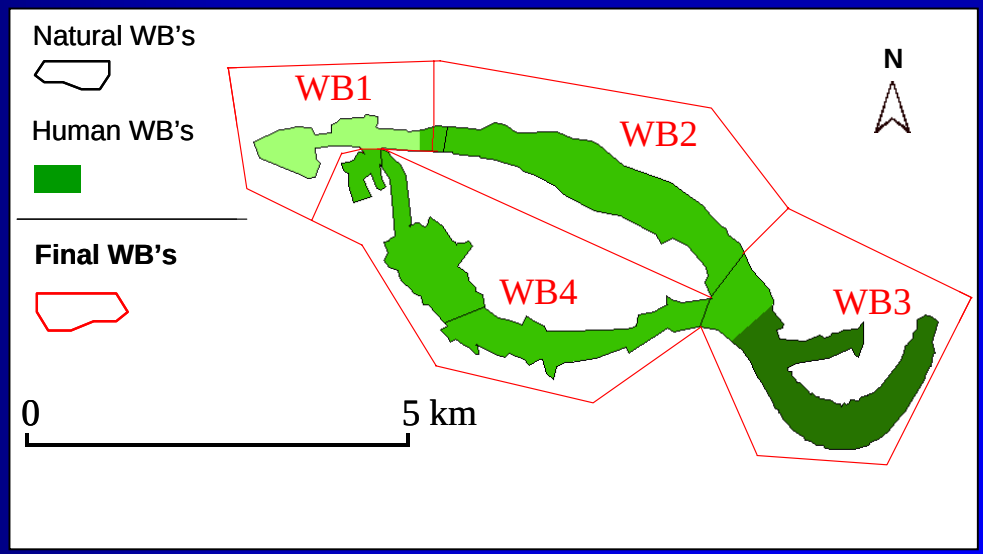




In both cases the straight forward combination of both criteria correspond to the human dimension water bodies

Methodology – final definition of water bodies -

The final definition of water bodies for an estuary is obtained by combining and harmonizing the natural and human components:



Final comments

☆ This semi-quantitative methodology provides a division of coastal systems into a meaningful set of water bodies integrating both natural characteristics and management criteria

☆ The final definition of water bodies will usually be a policy decision, this type of approach for the division of coastal systems into management units scientifically informs the decision-making process

☆ There are significant challenges in the definition of transitional water bodies to be used as “operational” units of the WFD, e.g. “natural” pressures such as harmful algal blooms.

☆Estuarine science must play a key role in informing decision-makers on what may be identified as human influence responsive to management measures.

☆ Since the WFD is currently undergoing a series of steps of technical definition, guidance and harmonisation, this is the appropriate time for scientific discussion of many of these issues, also important for US legislation

☆ The authors hope that this work will be a contribution to the increased information of coastal management by science

Acknowledgements

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