

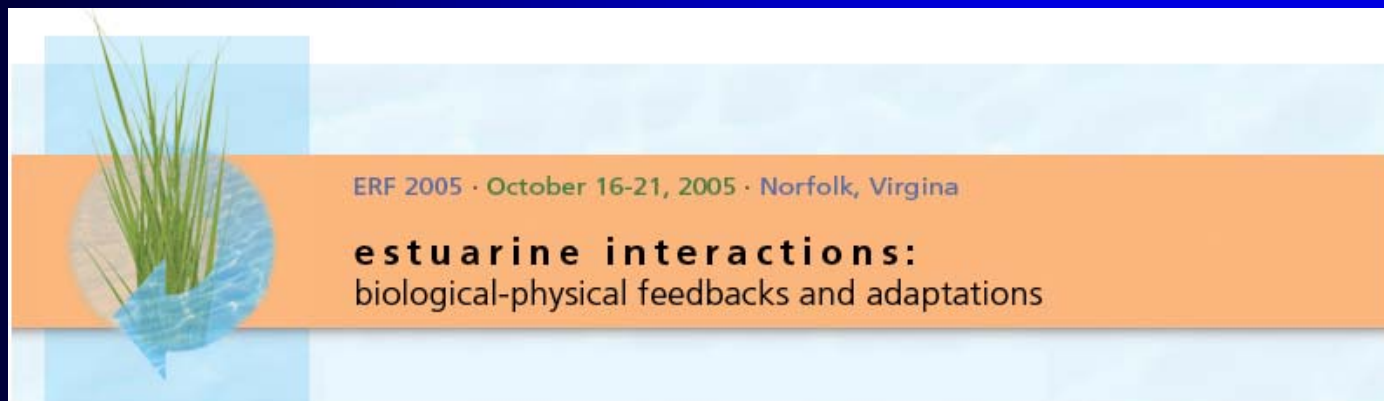
A methodology for defining homogeneous water bodies in transitional and coastal waters under the EU Water Framework Directive

A. Newton, J.G. Ferreira, A.M. Nobre, M.T. Simas,
M.C. Silva, A. Meirinho, S.B. Bricker, W.J. Wolff



www.imar.pt

www.noaa.gov



Topics

slides

Water Bodies and the WFD

2

Problem definition and objectives

1

Methodology

1

Case studies

1

Methodology application

Natural criteria

3

Human criteria

3

Final definition of water bodies

1

Final comments and acknowledgments

2

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:

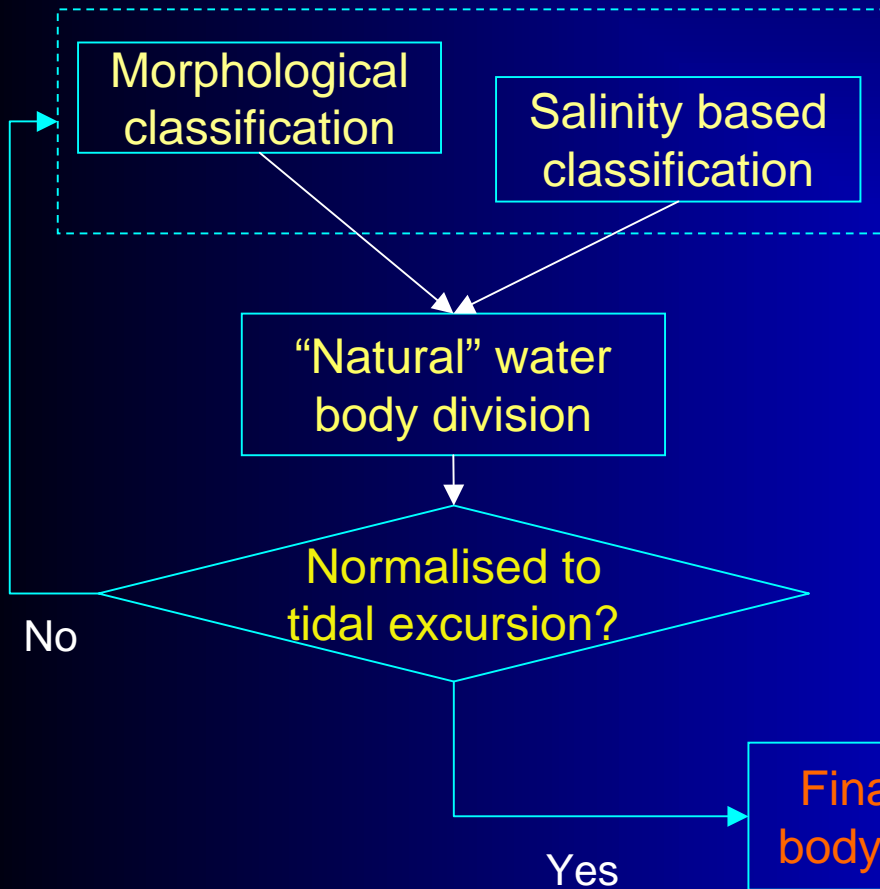
- ✓ Required by Water Framework Directive and useful for fulfilment of other legislation such as US Clean Water Act
- ✓ Methodology should be based on sound scientific grounding and also meaningful for managers
- ✓ Must bring together both natural and human dimension

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

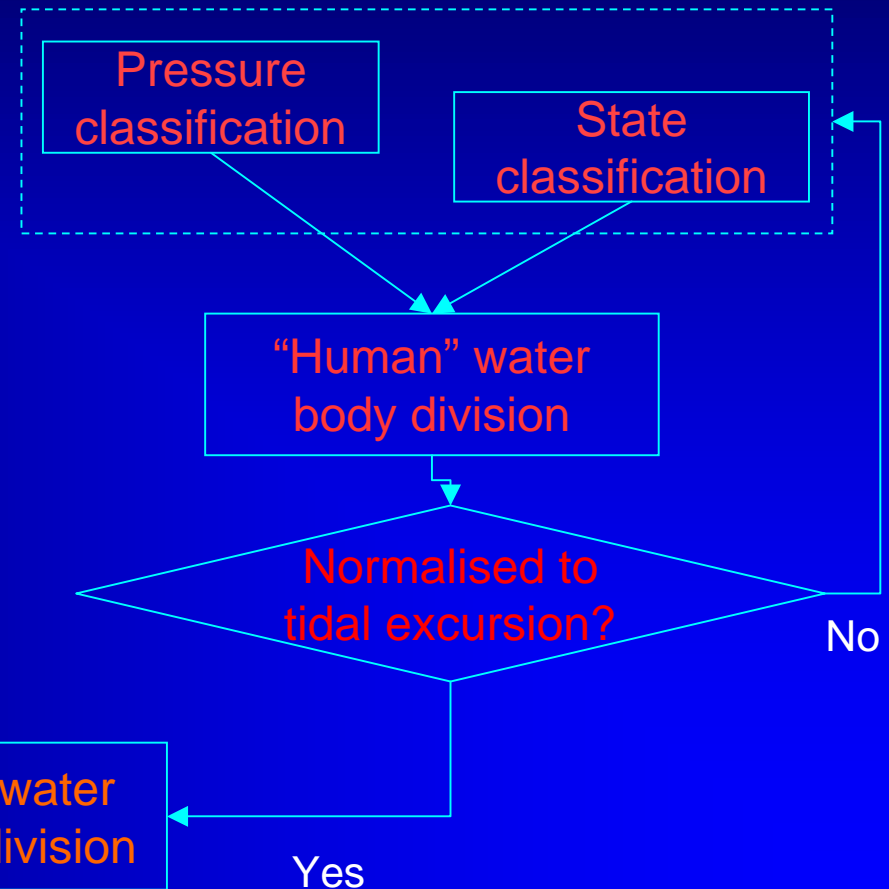
Methodology

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

Natural characteristics

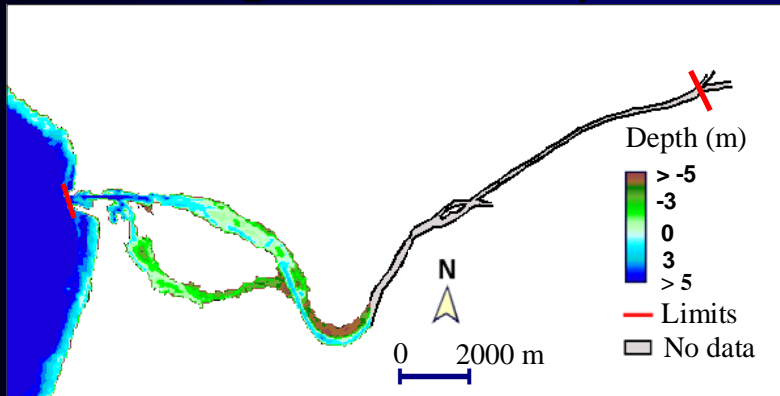


Human dimension

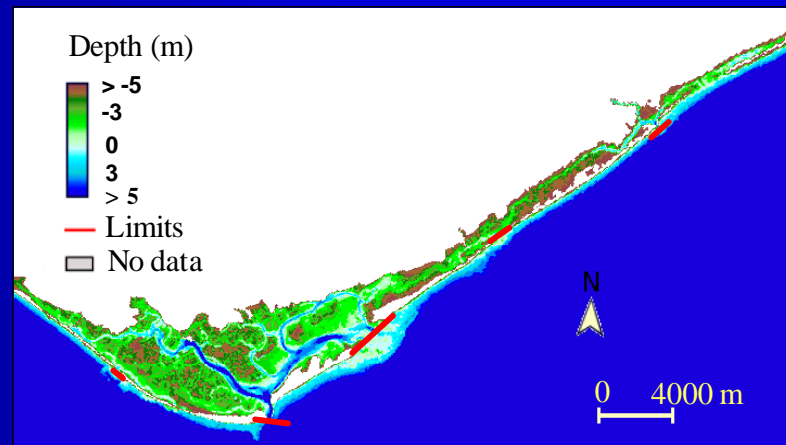


Case studies

Mondego Estuary - a tubular ecosystem

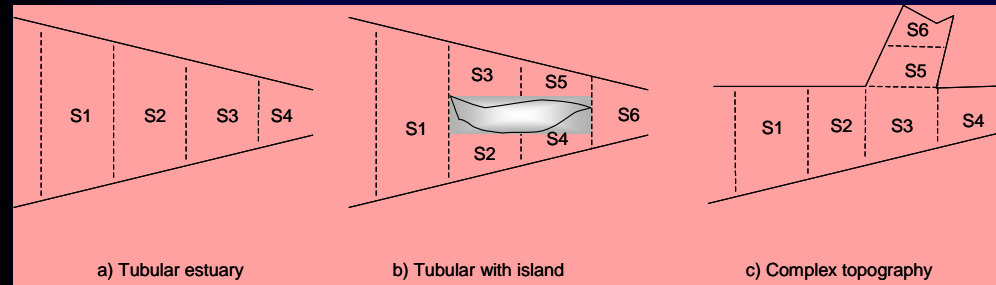


Ria Formosa - a dendritic ecosystem



Methodology - morphological criteria -

1. Draw cross-sectional profile



2. Calculate the adimensional shape factor σ for each section

$$\sigma_i = \log \left(\frac{w_i}{|z_i|} \right)$$

w_i : Mean width of section i (m)

z_i : Mean depth of section i (m)

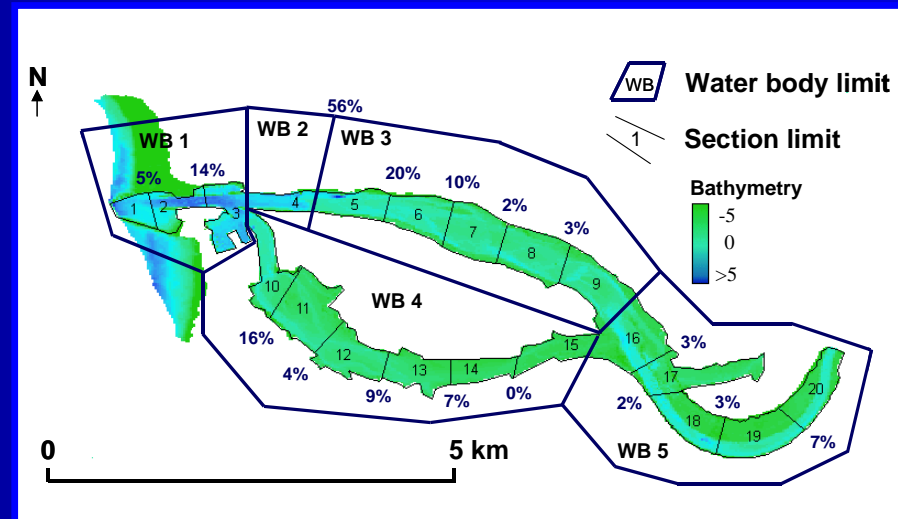
3. Aggregate longitudinally into water bodies using a threshold value of ϕ

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

$\phi_{i,i+1}$: Aggregation factor (no units);

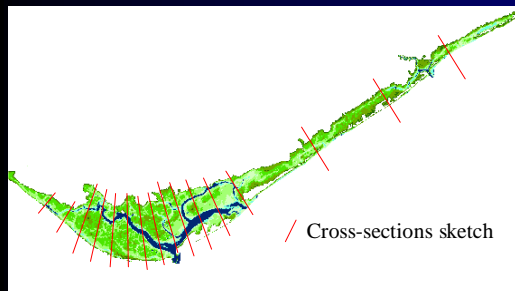
$\Delta\sigma$: Absolute difference between s_i and s_{i+1} (no units).

Mondego Estuary



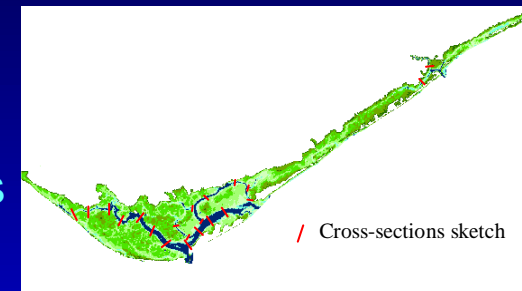
Methodology - morphological criteria -

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



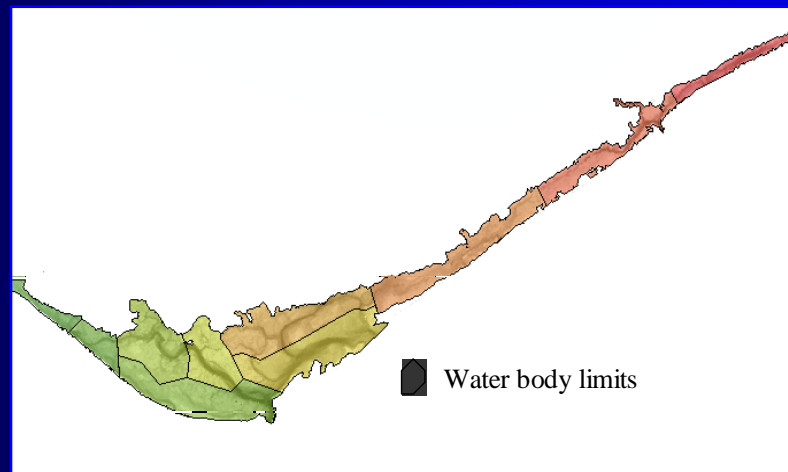
Two possibilities for drawing cross-sections:

- 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-

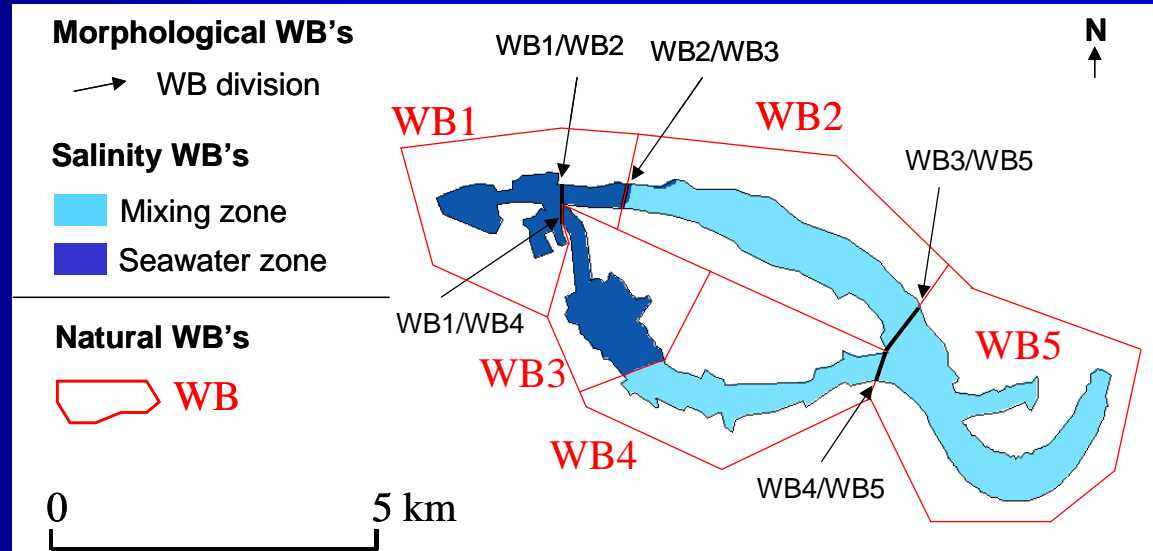
Salinity zonation based on the NOAA National Estuarine Inventory:

- 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)

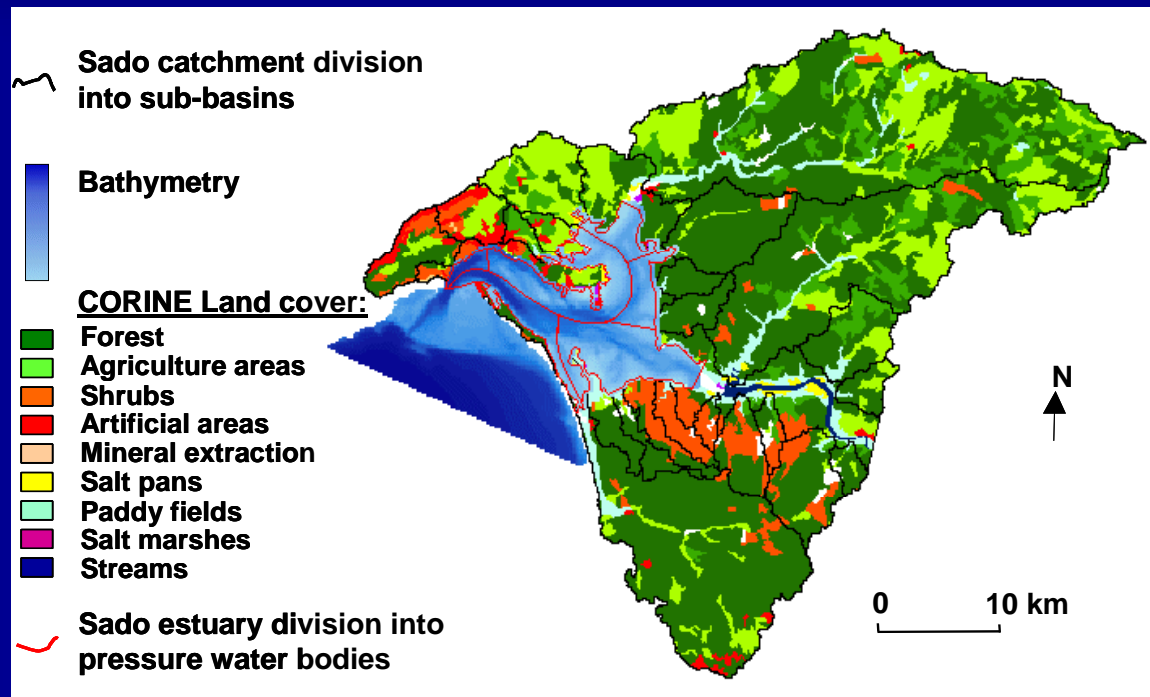
- Use of a similarity index to aggregate contiguous lengths of the shoreline with similar pressure

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

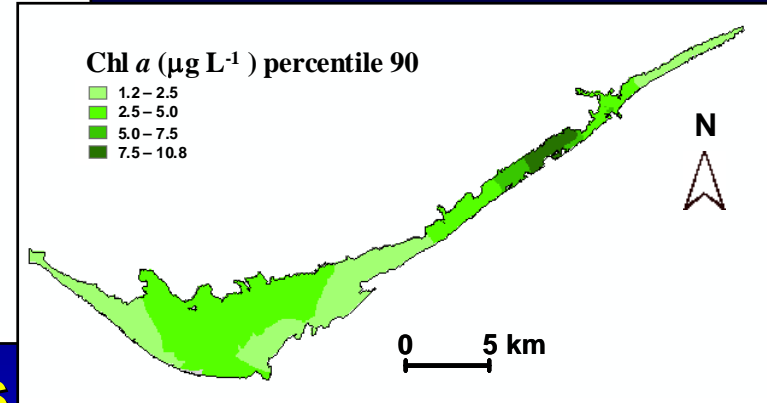
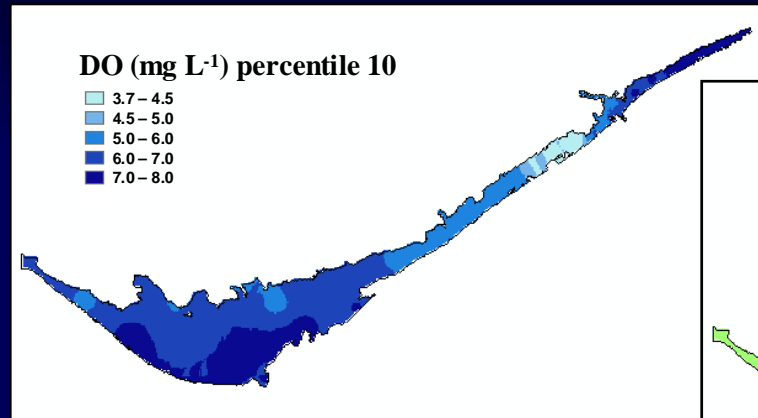
$\tau_{i,i+1}$: Aggregation factor (no units);

λ_i : N load normalised per length of shoreline ($\text{kg Nutrient y}^{-1} \text{m}^{-1}$);

$\Delta\lambda$: Absolute difference between λ_i and λ_{i+1} ($\text{kg Nutrient y}^{-1} \text{m}^{-1}$).



Methodology – state criteria -

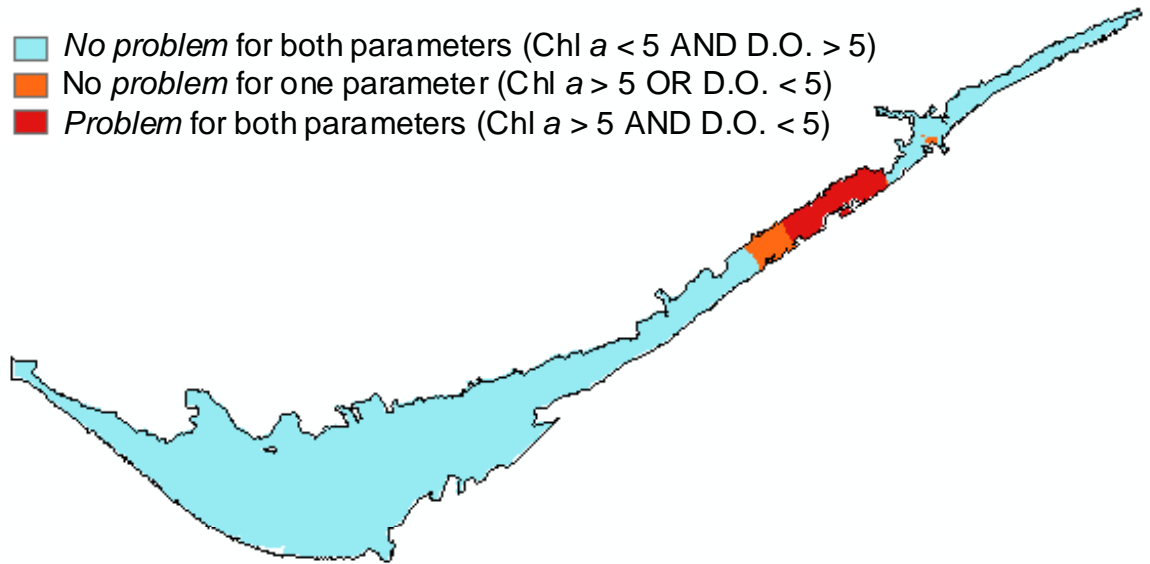


- Selection of appropriate parameters
- Data analysis

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 *

State assessment

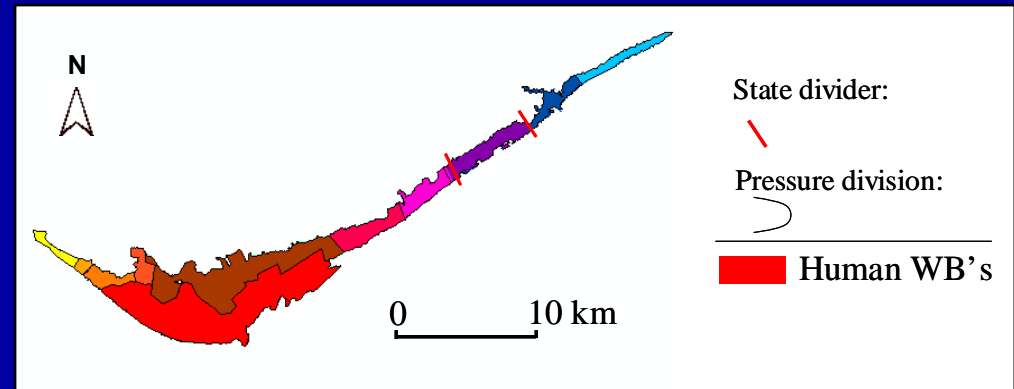
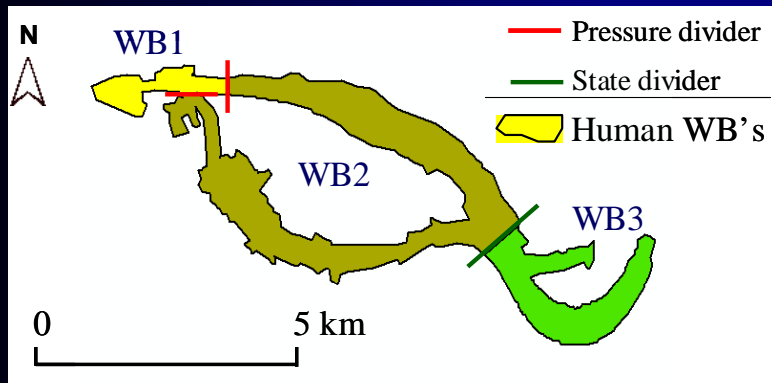
- No problem for both parameters (Chl *a* < 5 AND D.O. > 5)
- No problem for one parameter (Chl *a* > 5 OR D.O. < 5)
- Problem for both parameters (Chl *a* > 5 AND D.O. < 5)



* 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

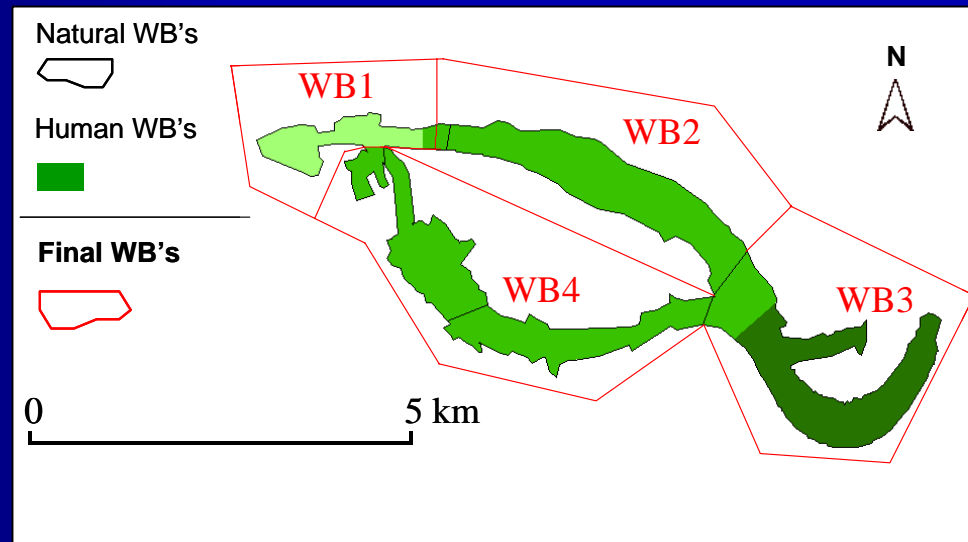
Combination of the pressure and state dividers into a set of 'human' water bodies:



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

- Co-authors
 - J.G. Ferreira,
 - A.M. Nobre,
 - M.T. Simas,
 - M.C. Silva,
 - A. Meirinho,
 - S.B. Bricker,
 - W.J. Wolff
- Ana Cristina Cardoso from JRC
- INAG-Portuguese water institute
- IMAR and CIMA