Ambienti acquatici di transizione: aspetti ecologici e problemi semantici

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Dati e risultati dai progetti europei: CLEAN, ROBUST, NICE & DITTY
e dal progetto MURST: NITIDA

Il termine **acque di transizione** (transitional waters) viene introdotto con la direttiva 2000/60/EC con lo scopo di una semplice classificazione delle acque superficiali in dolci, intermedie, marino costiere (McLusky & Elliot, 2007). La definizione è : **corpi idrici superficiali in prossimità della foce di un fiume, che sono parzialmente di natura salina a causa della loro vicinanza alle acque costiere, ma sostanzialmente influenzati dai flussi di acqua dolce**

La definizione è però ambigua ed esclude la maggior parte delle lagune mediterranee che non ricevono acque dolci (Tagliapietra & Volpi Ghirardini, 2006), mentre è applicabile alle lagune del Baltico. Viene proposto il termine: **ambienti di transizione**

Una definizione operativa "**aquatic areas which are neither fully open coastal nor enclosed or flowing freshwater areas**" è proposta da McLusky & Elliot (2007).

McLusky & Elliott, 2007. Transitional waters: A new approach, semantics or just muddying the waters? Estuarine, Coastal and Shelf Science 71: 359-363

Tagliapietra, D., Ghirardini, A.V., 2006. Notes on the coastal lagoon typology in the light of the EU Water Framework Directive: Italy as a case study. Aquatic Conservation: Marine & Freshwater Ecosystems 16, 457e467.

… the term transitional waters … reflects the evolution of language in this subject area, encompassing tidal estuaries and non-tidal brackish water lagoons.

La discussione è ancora aperta - conclusione dell’editorial di McLusky & Elliot (2007)

Non solo una questione semantica : nell’applicazione della WFD alcuni stati membri non considerano le transitional waters.

McLusky & Elliott, 2007. Transitional waters: A new approach, semantics or just muddying the waters? Estuarine, Coastal and Shelf Science 71: 359-363

LAND-OCEAN INTERACTIONS IN THE COASTAL ZONE (LOICZ)
Core Project of the
International Geosphere-Biosphere Programme: A Study of Global Change (IGBP)

Nutrient fluxes in transitional zones of the Italian coast

Compiled and edited by G. Giordani, P. Viaroli, D.P. Swaney, C.N. Murray, J.M. Zaldivar and J.I. Marshall Crossland

LOICZ REPORTS & STUDIES NO. 28

Giordani G., P. Viaroli, D. P. Swaney, C. N. Murray, J. M. Zaldivar and J. J. Marshall Crossland (eds), 2005. Nutrient fluxes in transition zones of the Italian Coast. LOICZ REPORTS & STUDIES No. 28.

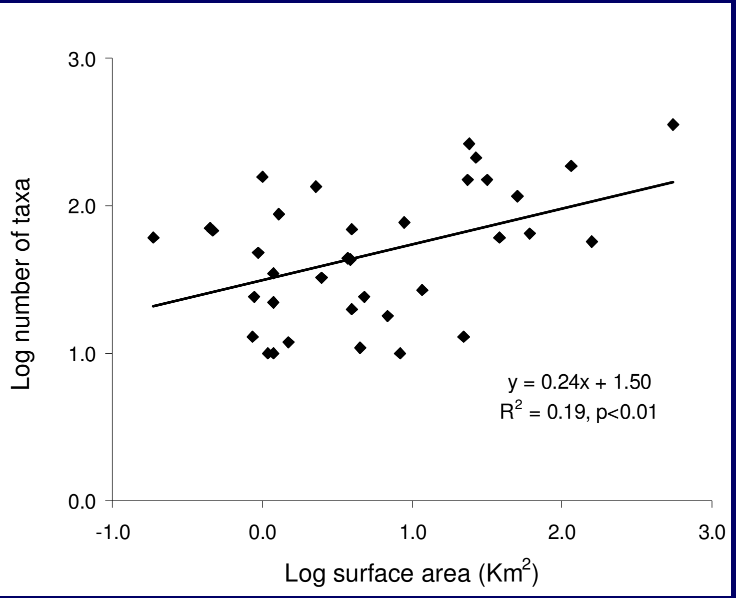
http://www.dsa.unipr.it/lagunet

Coastal lagoon typology

Basset, A., Sabetta, L., Fonnesu, A., Mouillot, D., Do Chi, T., Viaroli, P., Giordani, G., Reizopoulou, S., Abbiati, M., Carrada, G.C., 2006. Typology in Mediterranean transitional waters: new challenges and perspectives. Aquatic Conservation: Marine and Freshwater Ecosystems 16, 441-455.

Tagliapietra, D., Ghirardini, A.V., 2006. Notes on the coastal lagoon typology in the light of the EU Water Framework Directive: Italy as a case study. Aquatic Conservation: Marine & Freshwater Ecosystems 16, 457-467.

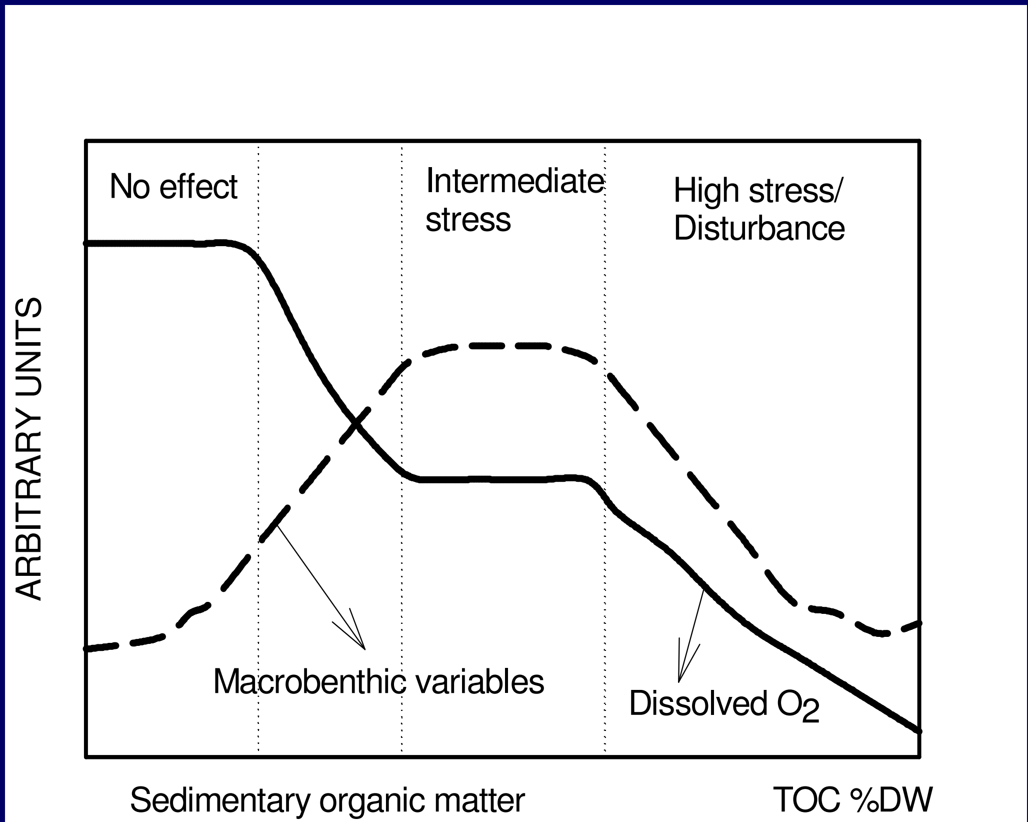
- Climate
- Morphometry
- Tidal range
- Freshwater influence
- Geology
- Biogeochemistry



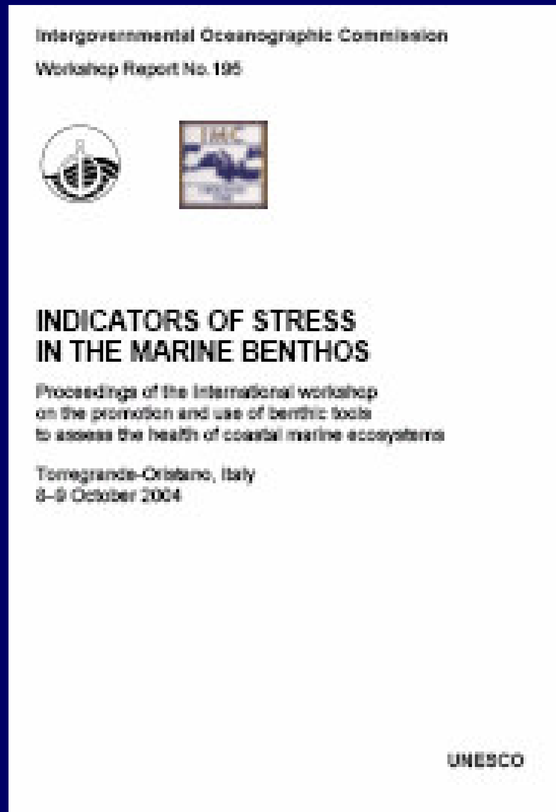
BenthOC

Investigation of relationships between macrobenthos communities and sedimentary organic matter content in transitional waters soft sediments along the Italian coast to develop benthic indicators of environmental quality

(leaders P. Magni & D. Tagliapietra)



modified from Pearson & Rosemberg (1978), Hyland et al. (2000), de Wit et al. (2001); Viaroli et al. (2004)



Intergovernmental Oceanographic Commission

Workshop Report No. 195

INDICATORS OF STRESS
IN THE MARINE BENTHOS

Proceedings of the international workshop on the promotion and use of benthic tools to assess the health of coastal marine ecosystems

Torregrande-Oristano, Italy
8–9 October 2004

UNESCO

Nel Mediterraneo gli ambienti di transizione sono soprattutto lagune costiere

Caratteristiche unificanti e tratti distintivi

Bassa profondità	**Prevalenza delle comunità bentoniche** **Risospensione**
Gradienti di salinità	**Zonazione**
Variabilità morfologica	**Zonazione**

COASTAL LAGOONS IN EUROPE

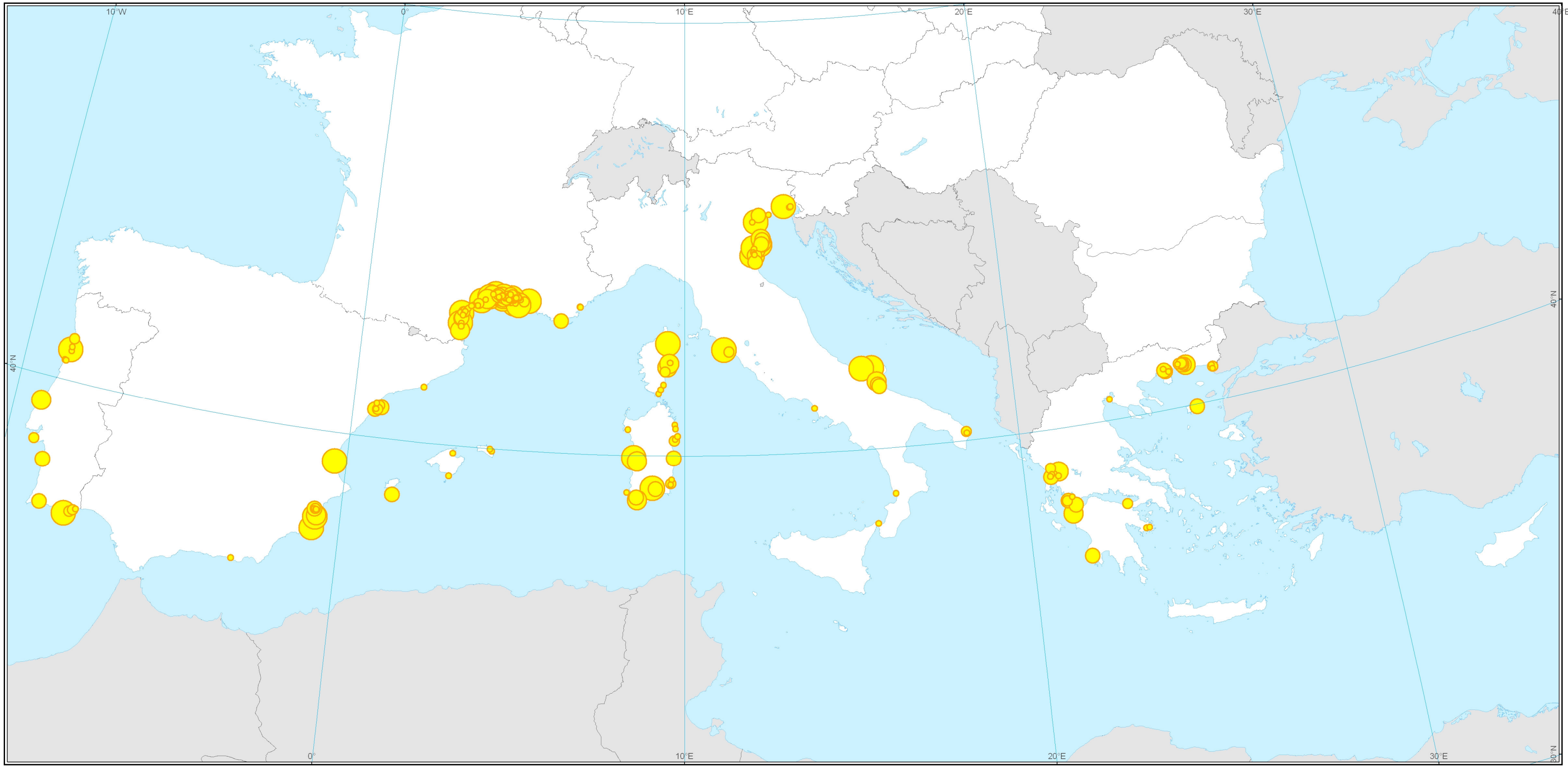
Legend

Coastal lagoons in Ha

- < 100 Ha
- 100 - 200
- 200 - 500
- 500 - 1000
- > 1000 Ha

0 162.5 325 650 Kilometers

Sources : EEA Corine Land Cover 2000
Coordinate Reference System: ETRS89 Lambert Azimutal Equal Area
Cartography : JRC, 04/2007



EEA – Corine Land Cover 2000

Lagune mediterranee

Intervallo di superficie (km^2)	lagune		Area		
	No.	%	km^2		%
0.25-0.50	65	31.1	23.3	0.4	1.1
0.51-1.00	33	15.8	25.2	0.8	1.2
1.0-5.0	68	32.5	160.8	2.4	7.9
5.0-10.0	16	7.7	106.2	6.6	5.2
10.0-50.0	15	7.2	338.4	22.6	16.5
50.0-100.0	6	2.9	365.0	60.8	17.9
100.0-200.0	5	2.4	661.6	132.3	32.4
> 200.0	1	0.5	364.7	364.7	17.8
Total	209	100.0	2045.2		100.0

46.9% con A< 0.50 km^2

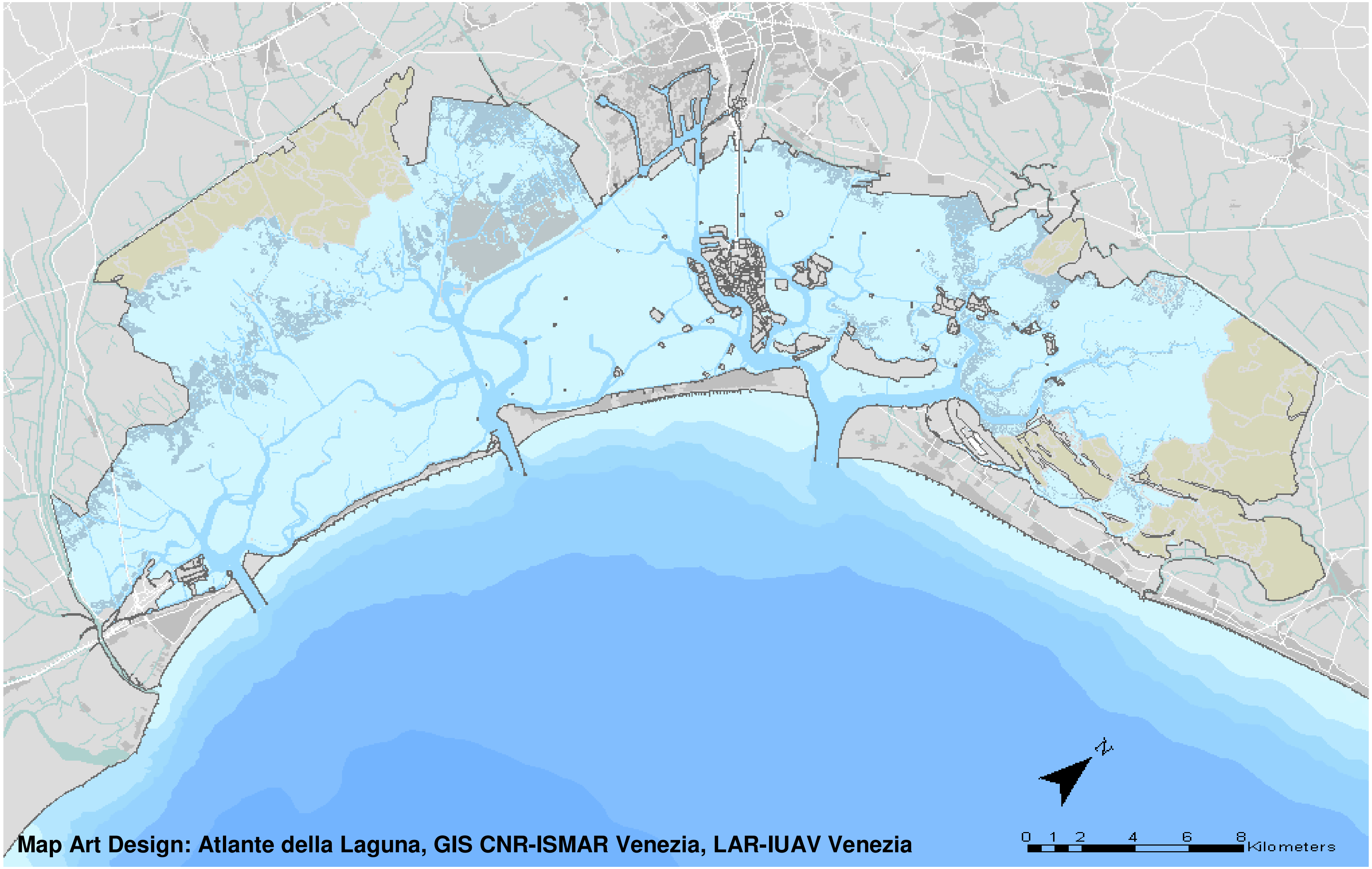
79.4% con A< 5.0 km^2

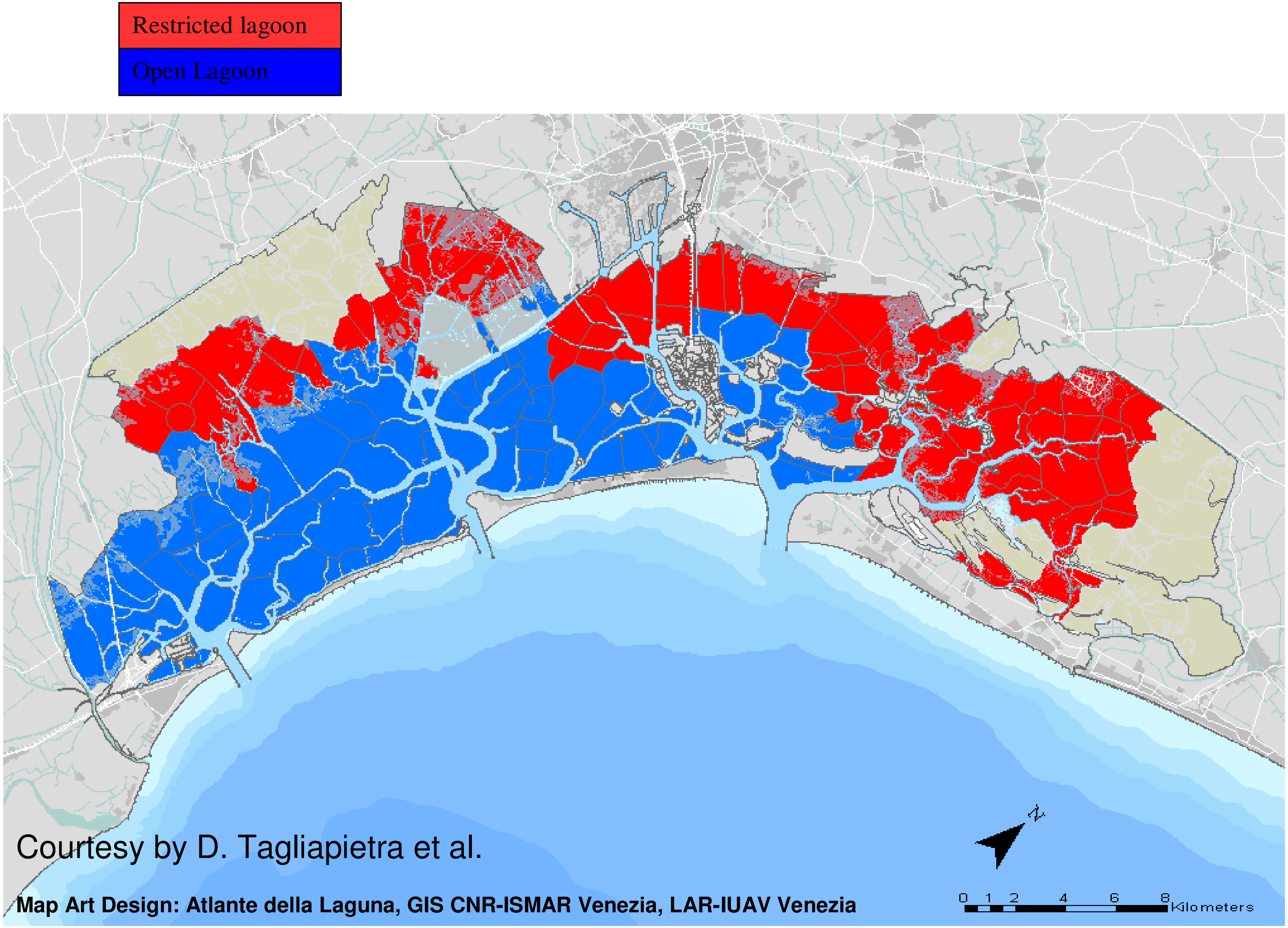
Lagune italiane

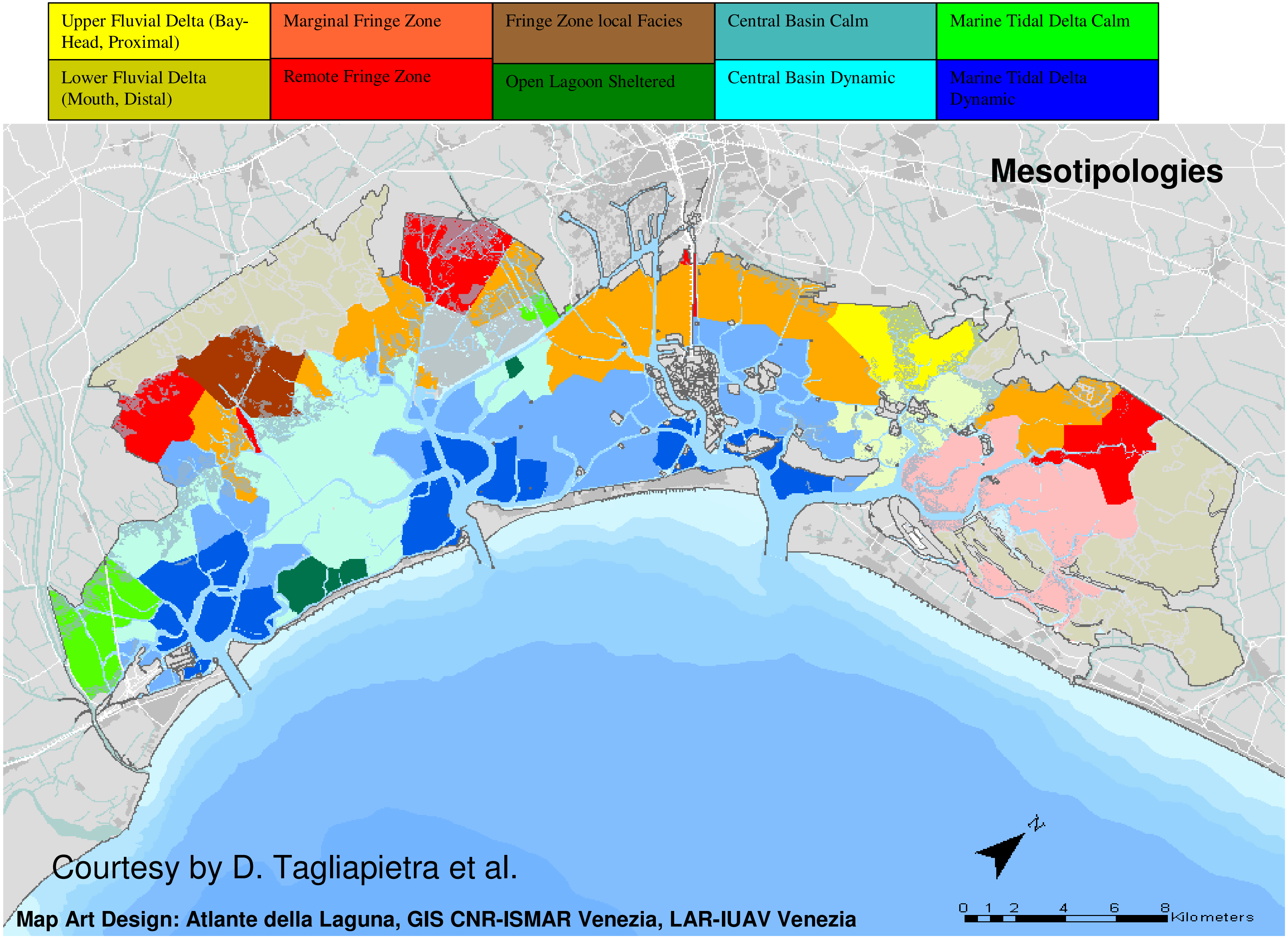
Intervallo di superficie (km^2)	Nord Adriatico	Sud Adriatico	Tirreno	Sicilia	Sardegna
0.51-1.00	3	0	3	2	18
1.0-5.0	4	3	5	1	15
5.0-10.0	4	0	0	0	3
10.0-50.0	7	0	1	1	4
50.0-100.0	1	2	0	0	0
100.0-200.0	1	0	0	0	0
> 200.0	1	0	0	0	0
Numero totale	21	5	9	4	40
Superficie totale	1068.0	120.2	43.9	22.4	143.7

Il 76% delle aree lagunari si trova nell'alto adriatico

A multiscalar approach (Tagliapietra and Co-workers)




Restricted lagoon
Open Lagoon
N
Courtesy by D. Tagliapietra et al.
Map Art Design: Atlante della Laguna, GIS CNR-ISMAR Venezia, LAR-IUAV Venezia
0 1 2 4 6 8
Kilometers



Upper Fluvial Delta (Bay-Head, Proximal)
Marginal Fringe Zone
Fringe Zone local Facies
Central Basin Calm
Marine Tidal Delta Calm
Lower Fluvial Delta (Mouth, Distal)
Remote Fringe Zone
Open Lagoon Sheltered
Central Basin Dynamic
Marine Tidal Delta Dynamic
Mesotipologies
Courtesy by D. Tagliapietra et al.
Map Art Design: Atlante della Laguna, GIS CNR-ISMAR Venezia, LAR-IUAV Venezia
N
0 1 2 4 6 8 Kilometers

Numero minimo di repliche che garantisce una descrizione adeguata dell’eterogeneità spaziale (Bartoli et al., 2003. Aquatic ecology 37: 341-349)

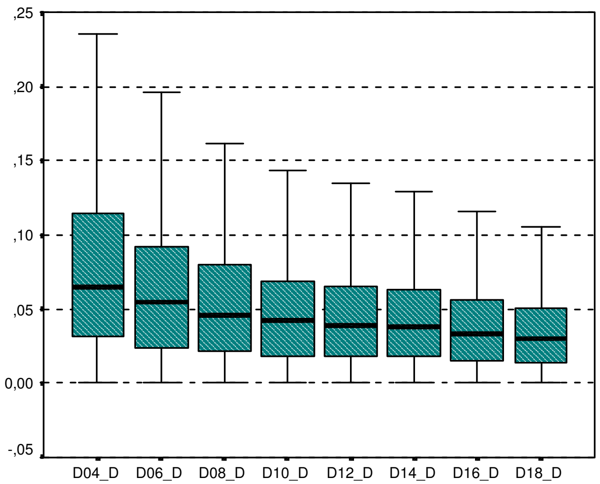
$$d = \left| \frac{BEA - An}{BEA} \right|$$

Where:

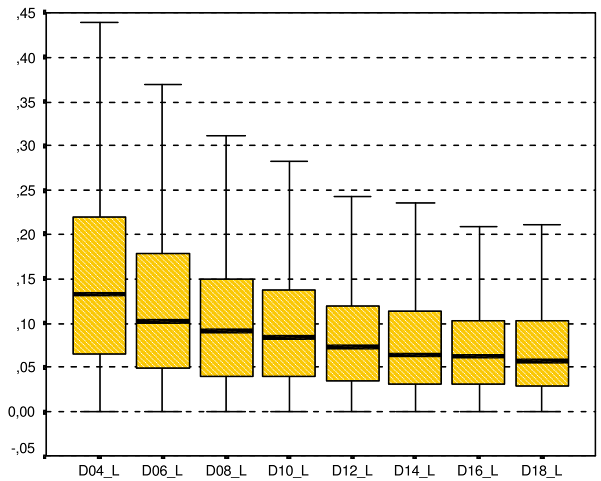
$BEA = Best\ Estimate\ of\ the\ true\ Average\ (assumed\ as\ the\ average\ of\ 18\ replicates)$

$An = Average\ of\ n\ replicates\ with\ 4 \le n \le 18$

d<0,05 if n>6



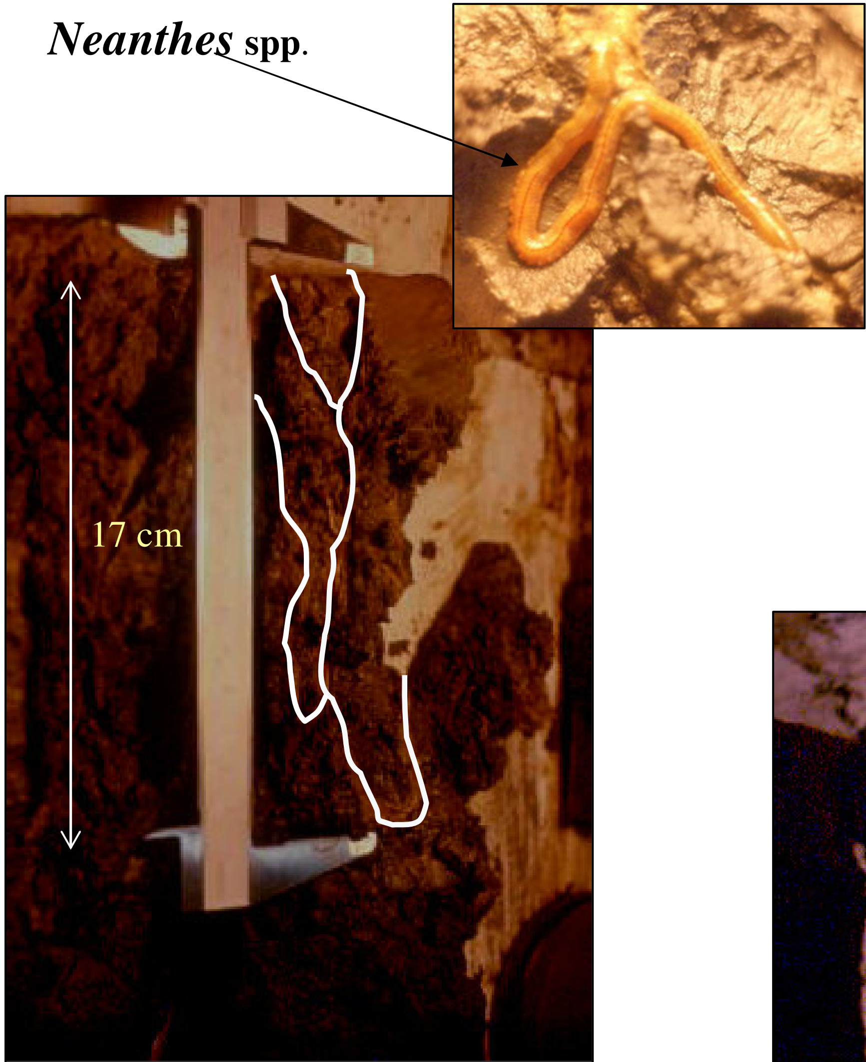
0,05<d<0,1 if n>6



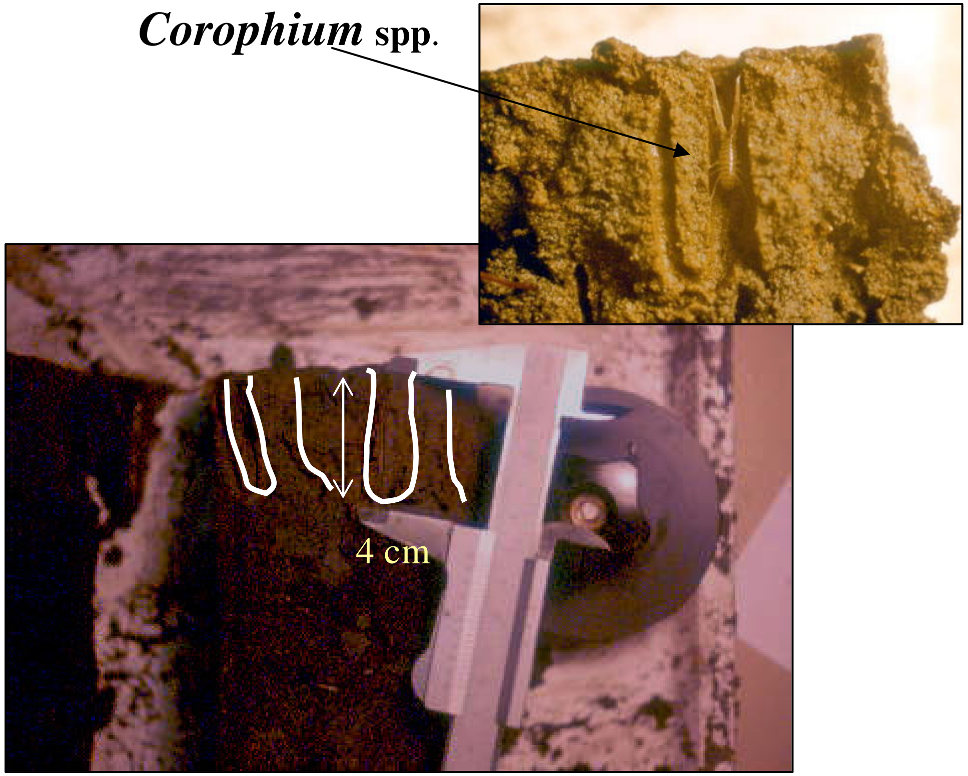
Deviation from BEA (Best Estimation from the true Average) in the dark (left) and light oxygen incubations

Profondità delle tane

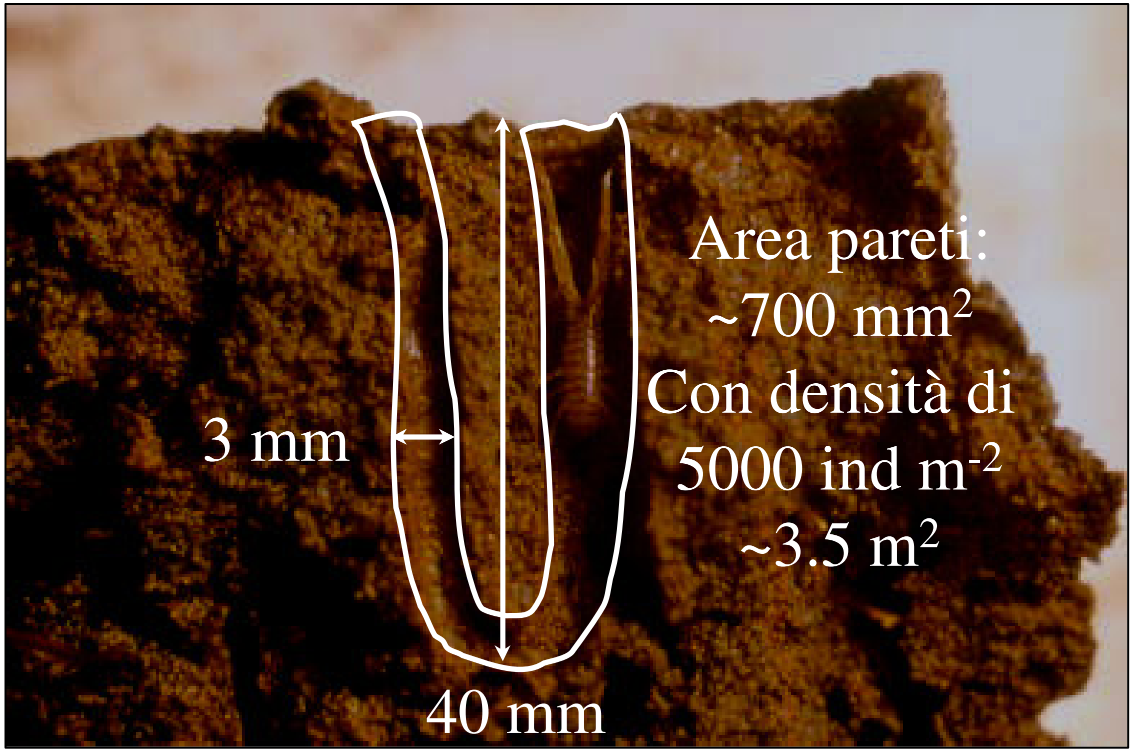
Neanthes spp.

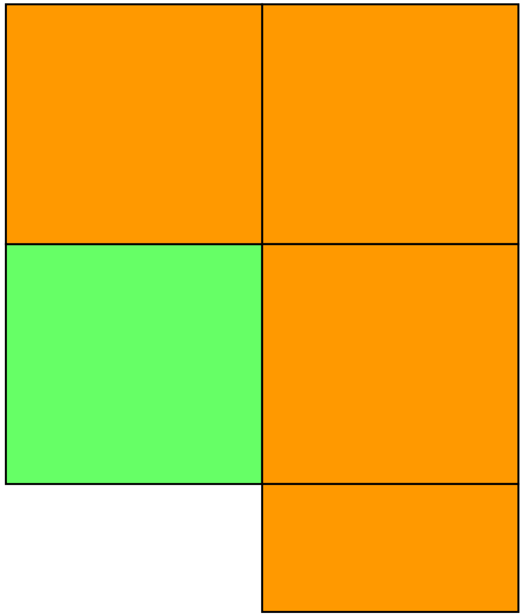


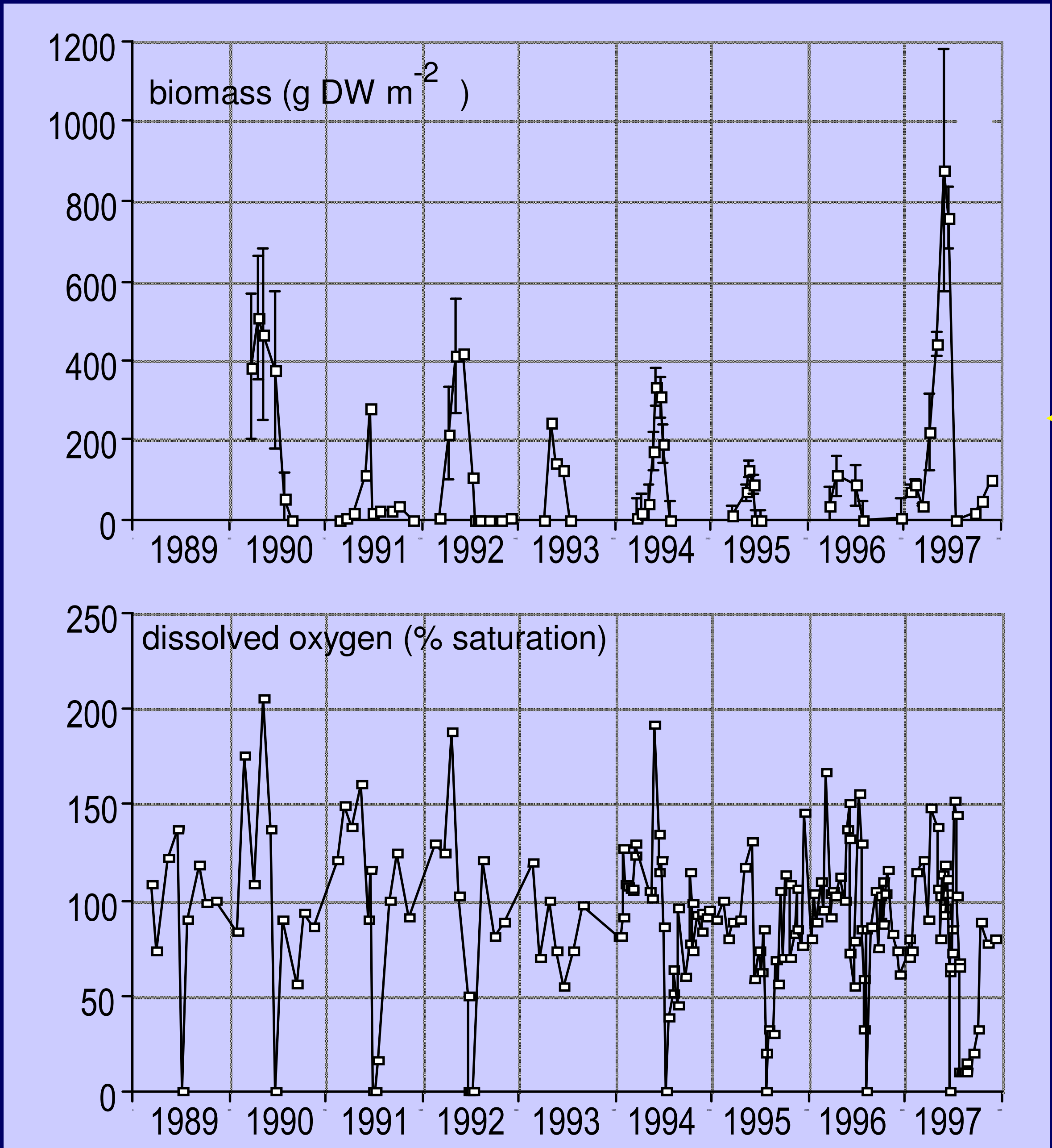
Corophium spp.



Estensione dell'interfaccia acqua-sedimento in relazione alla densità di Corophium





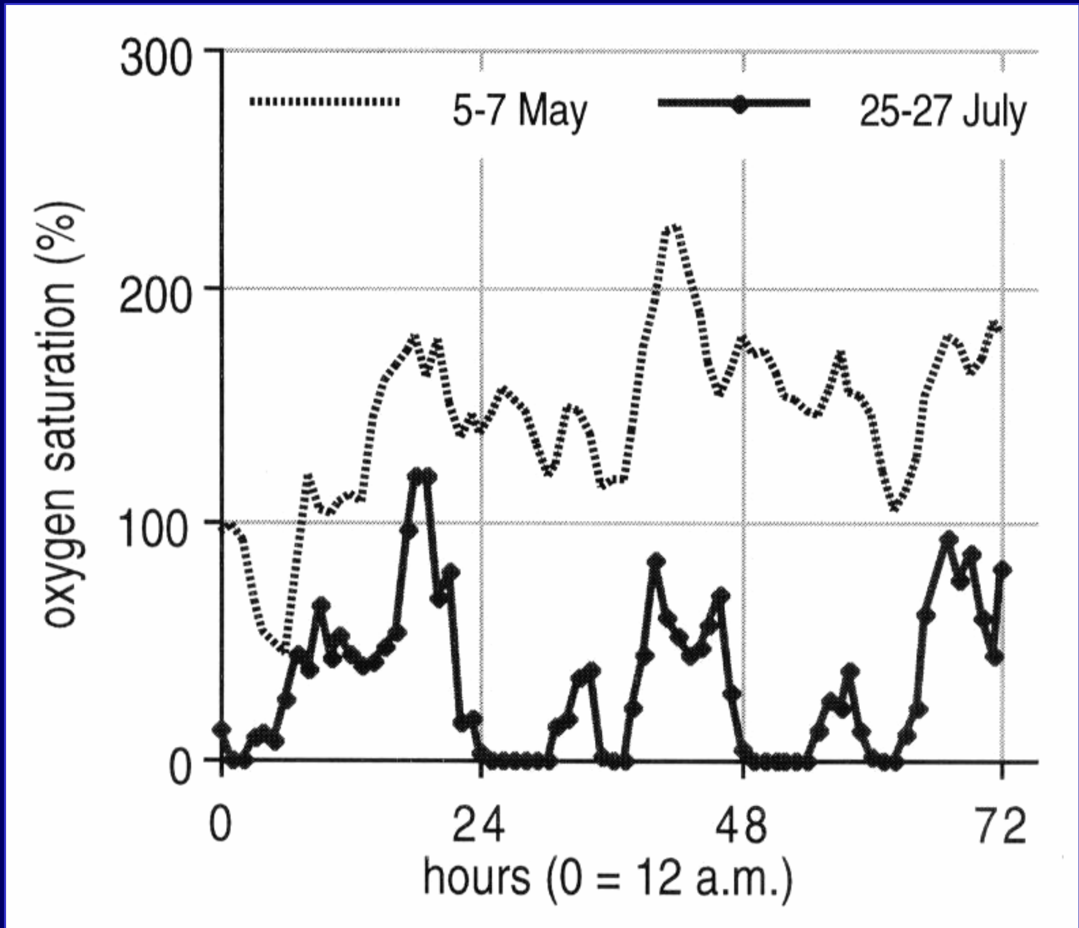


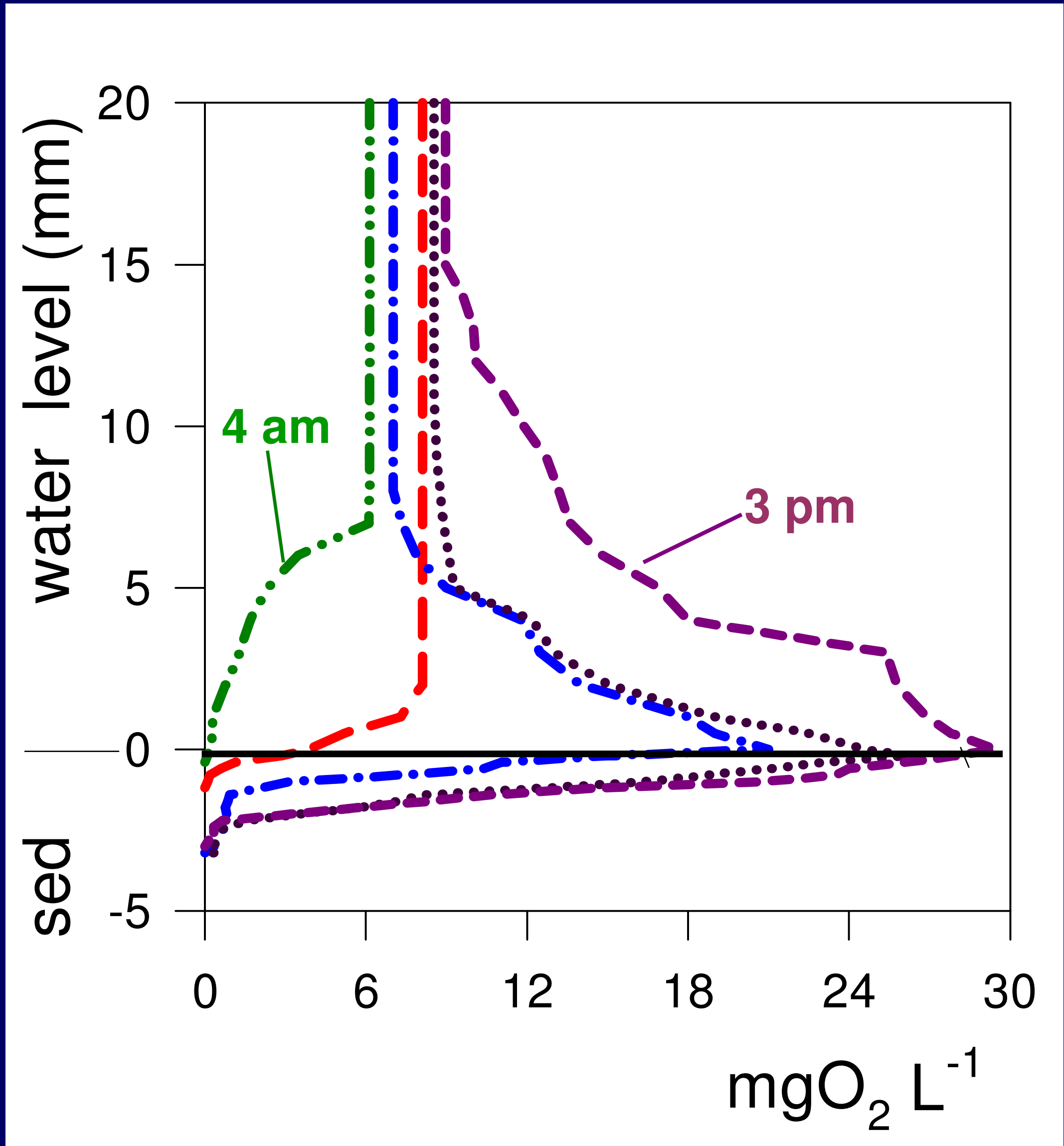
Sacca di Goro lagoon
(Po River Delta,
Northern Adriatic Sea)

biomass of the
seaweed *Ulva rigida*

and related dissolved
oxygen concentrations

Sacca di Goro Maggio-Luglio 1992 – variazioni delle concentrazioni dell'ossigeno nella colonna d'acqua

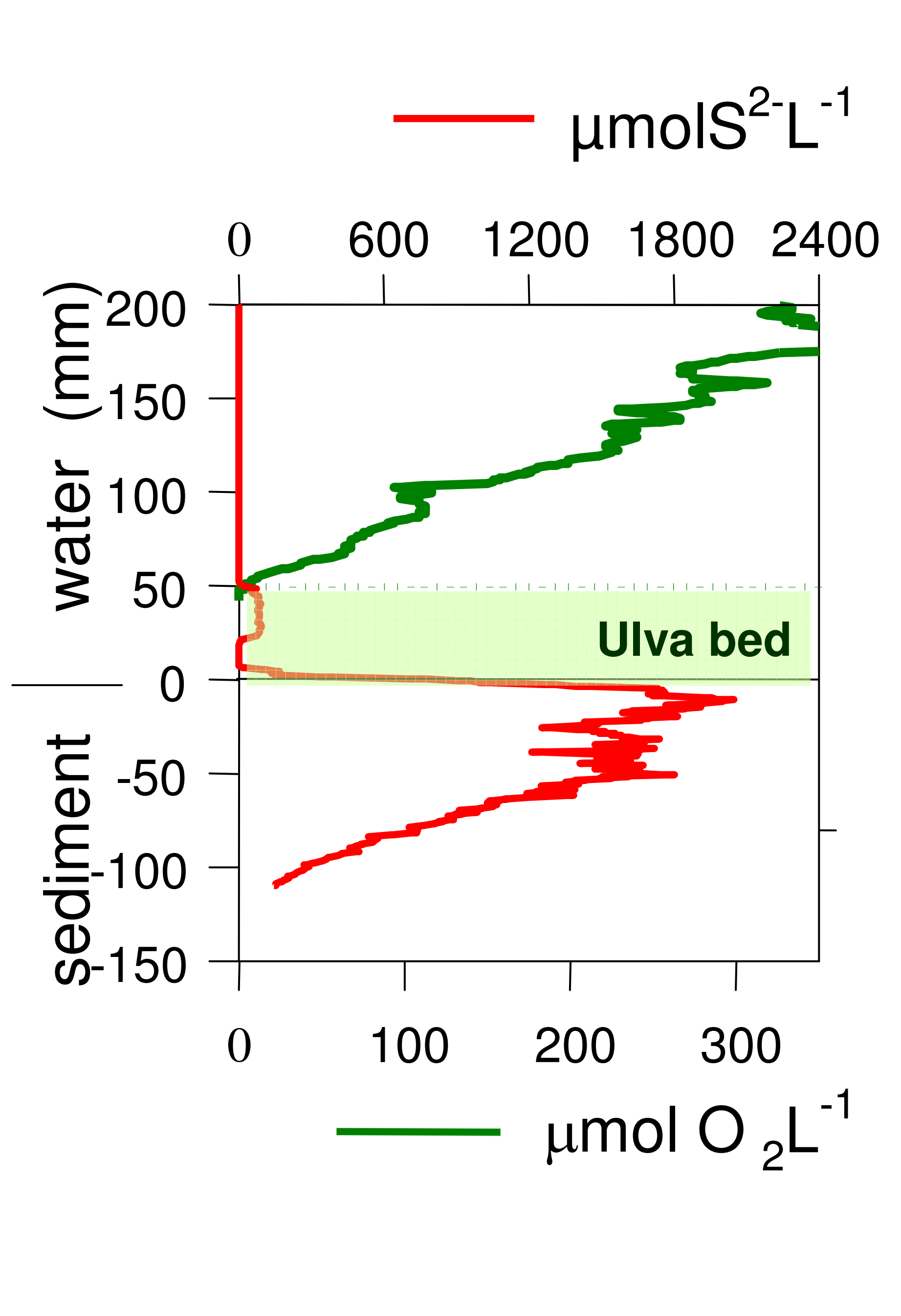




Sacca di Goro St G

Variazioni delle concentrazioni dell'ossigeno disciolto all'interfaccia acqua-sedimento in presenza di microfitobenthos

SWIMP: Sediment-Water Interface MicroProfiler, ISMES©, Italy. Modified from (Barbanti et al., 1996)



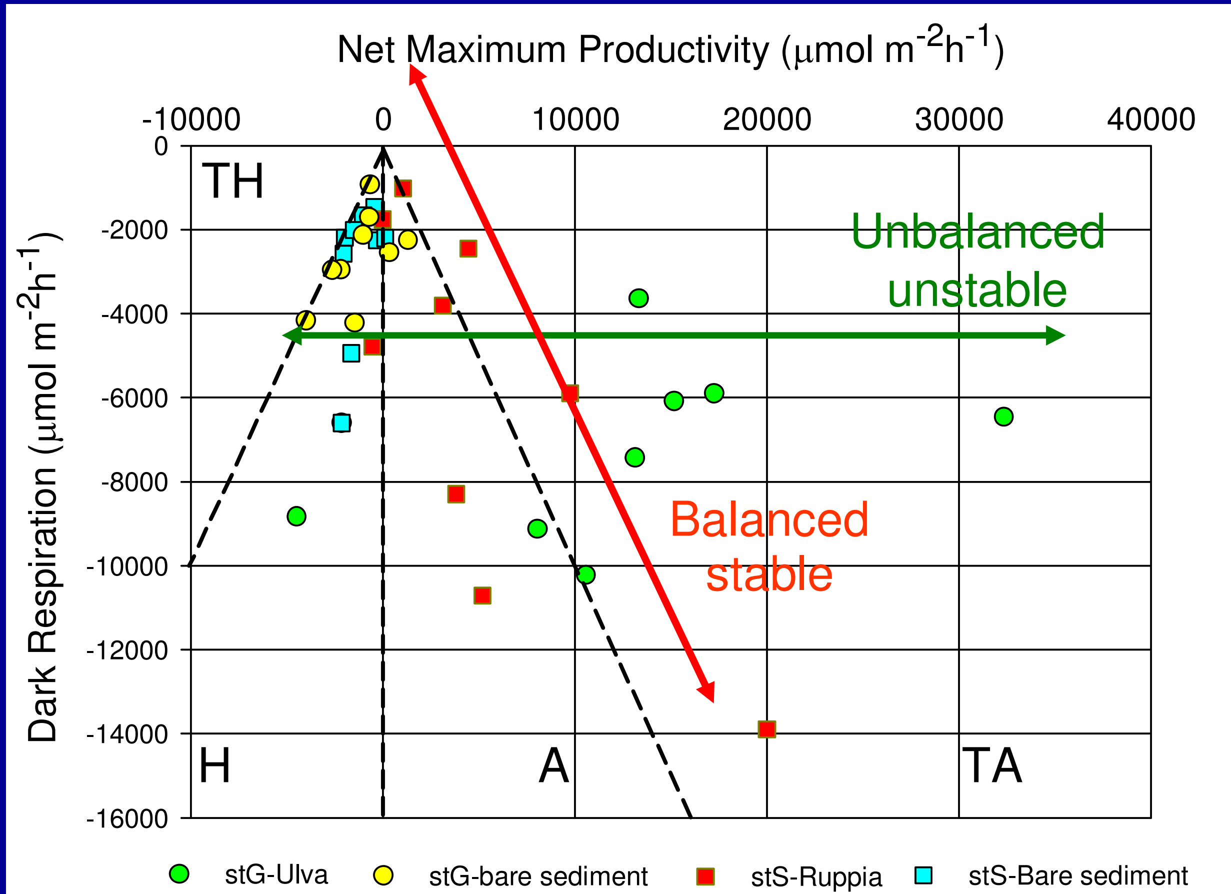
Sistemi a macroalghe

Sacca di Goro lagoon, st. 17 - Profili verticali di ossigeno e solfuri in uno strato di Ulva adagiato sul sedimento

SWIMP: Sediment-Water Interface MicroProfiler, ISMES©, Italy (Barbanti et al., 1996)

Concentrazioni dell'ossigeno o flussi di ossigeno?

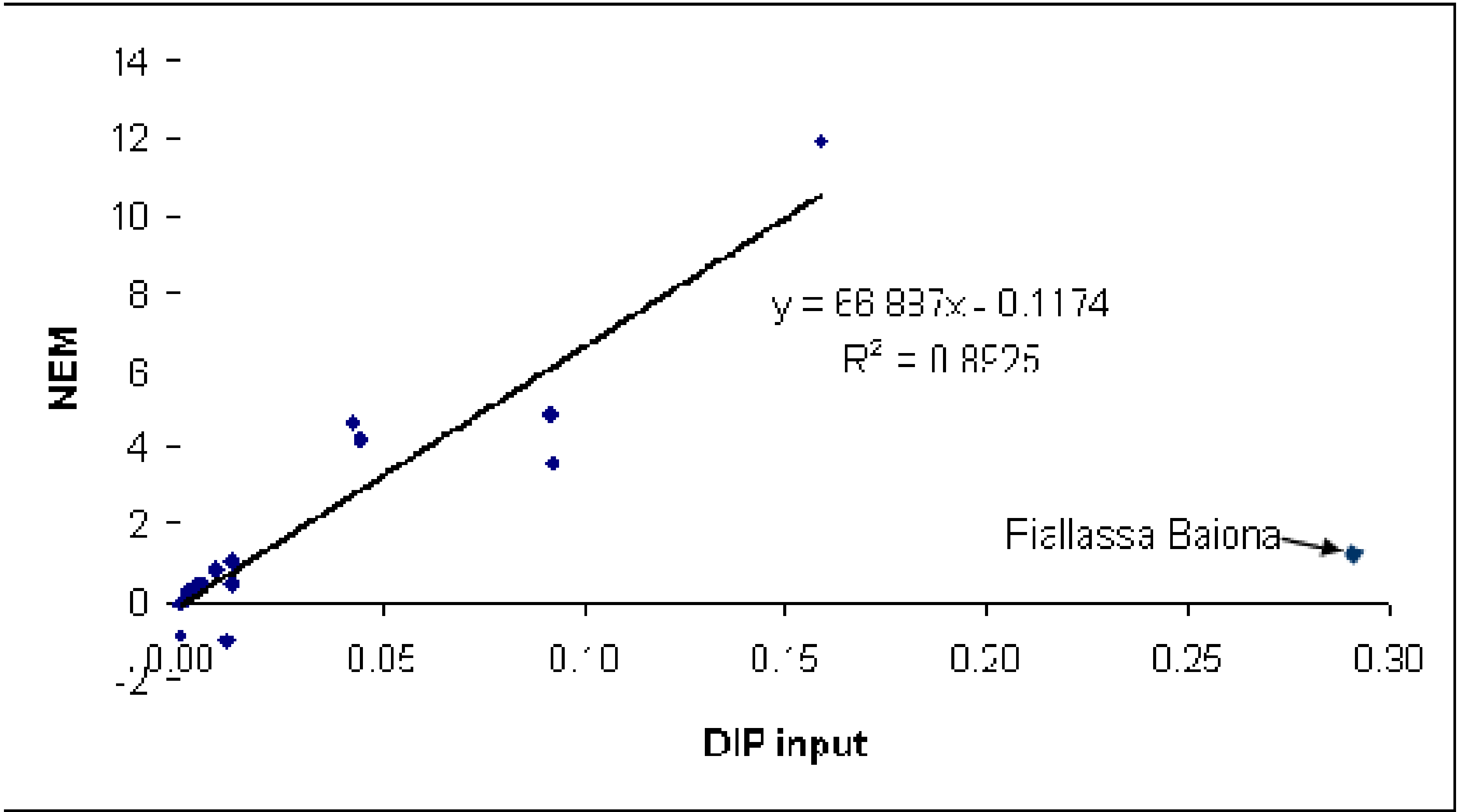
Ecosystem properties represented with NP and DR maximum potential: TH = total heterotrophy; H = net heterotrophy; A = net autotrophy; TA = total autotrophy (after Rizzo et al., 1996; and Viaroli and Christian, 2003)



Classification of ecosystem metabolism based on oxygen production (NP = net production at light saturation) and consumption (DR = dark respiration). BP = biomass peak (L: low, H:High), BD = biodegradability (R: refractory, La: labile) C= NP and DR peaks are coincident, S= DR peak follows the NP peak

(Rizzo et al., Estuaries, 1996; Viaroli & Christian, Ecological Indicators, 2003)

CATEGORIES	CONDITION	SYSTEM QUALIFICATIONS Rates	BP/BD	Timing
Dystrophy	DR=NP <0	1-10 $gO_2m^{-2}\ h^{-1}$	H/La	S
Total heterotrophy	DR=NP ≤0	< 1 $gO_2m^{-2}\ h^{-1}$	L/La	C
Net heterotrophy	DR < NP≤0	< 1 $gO_2m^{-2}\ h^{-1}$	L/R	C
Net autotrophy	0 < NP≤ |DR|	< 1 $gO_2m^{-2}\ h^{-1}$	L /R	C
Total autotrophy	0 < |DR| < NP	< 1 $gO_2m^{-2}\ h^{-1}$	L/R	C
Hyperautotrophy	0 < |DR| << NP	1-10 $gO_2m^{-2}\ h^{-1}$	H/La	S



Il metabolismo netto dell'ecosistema (NEM) può essere stimato con il modello biogeochimico LOICZ. Il NEM misura la produttività del sistema.

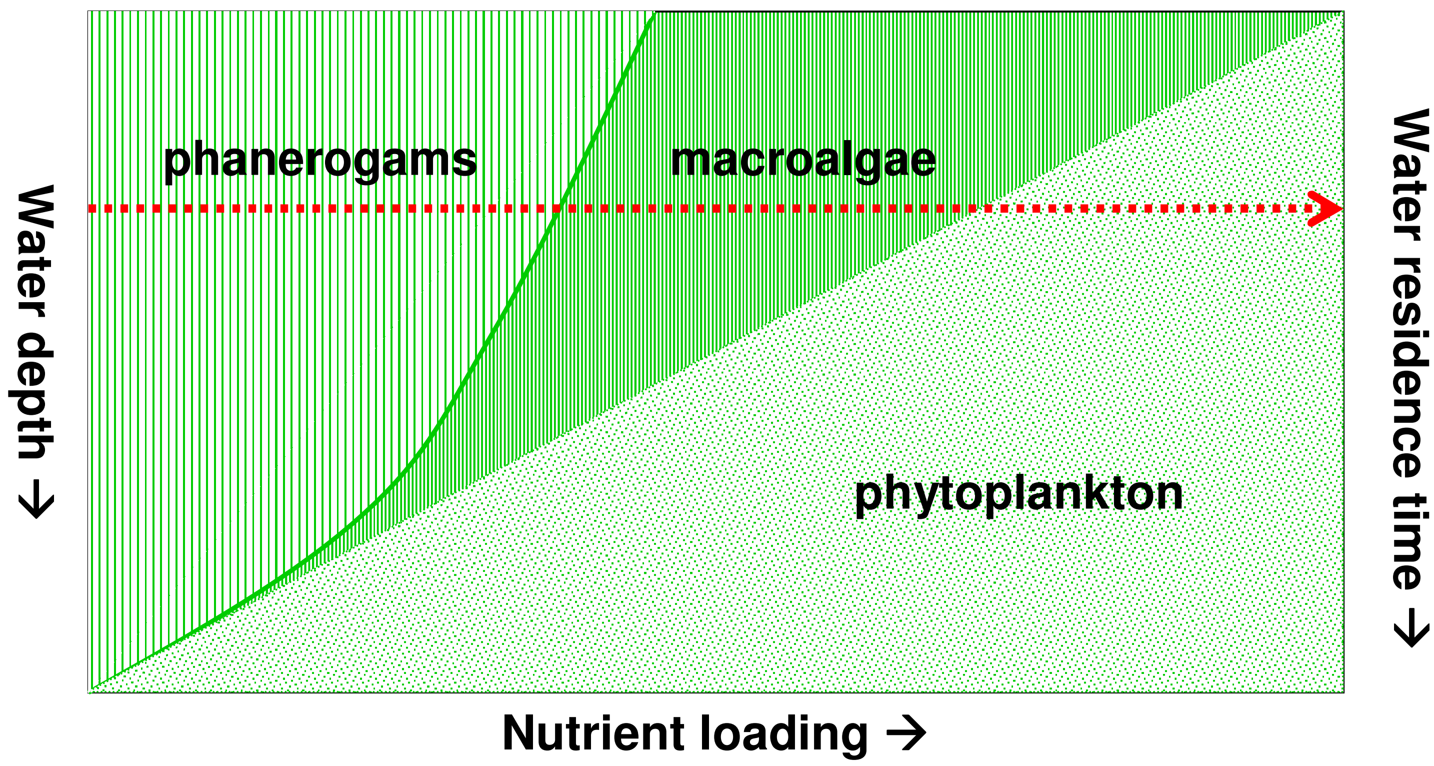
Relazione tra NEM (mol m^{-2} y^{-1}) e carico del fosforo inorganico (DIP, mol m^{-2} y^{-1}) in 17 lagune italiane (Giordani et al., 2005. LOICZ R&S 28)

- **Eutrofizzazione**
- **Bassa profondità → processi sedimentari**
- **Centralità del comparto bentonico**
- **Vegetazione bentonica come tracciante**

Conceptual representation of the succession of aquatic vegetation along an increasing eutrophication gradient according to 1: Nienhuis (1992), 2: Valiela et al. (1997) and Dahlgreen and Kautsky (2004); 3: Schramm (1999)

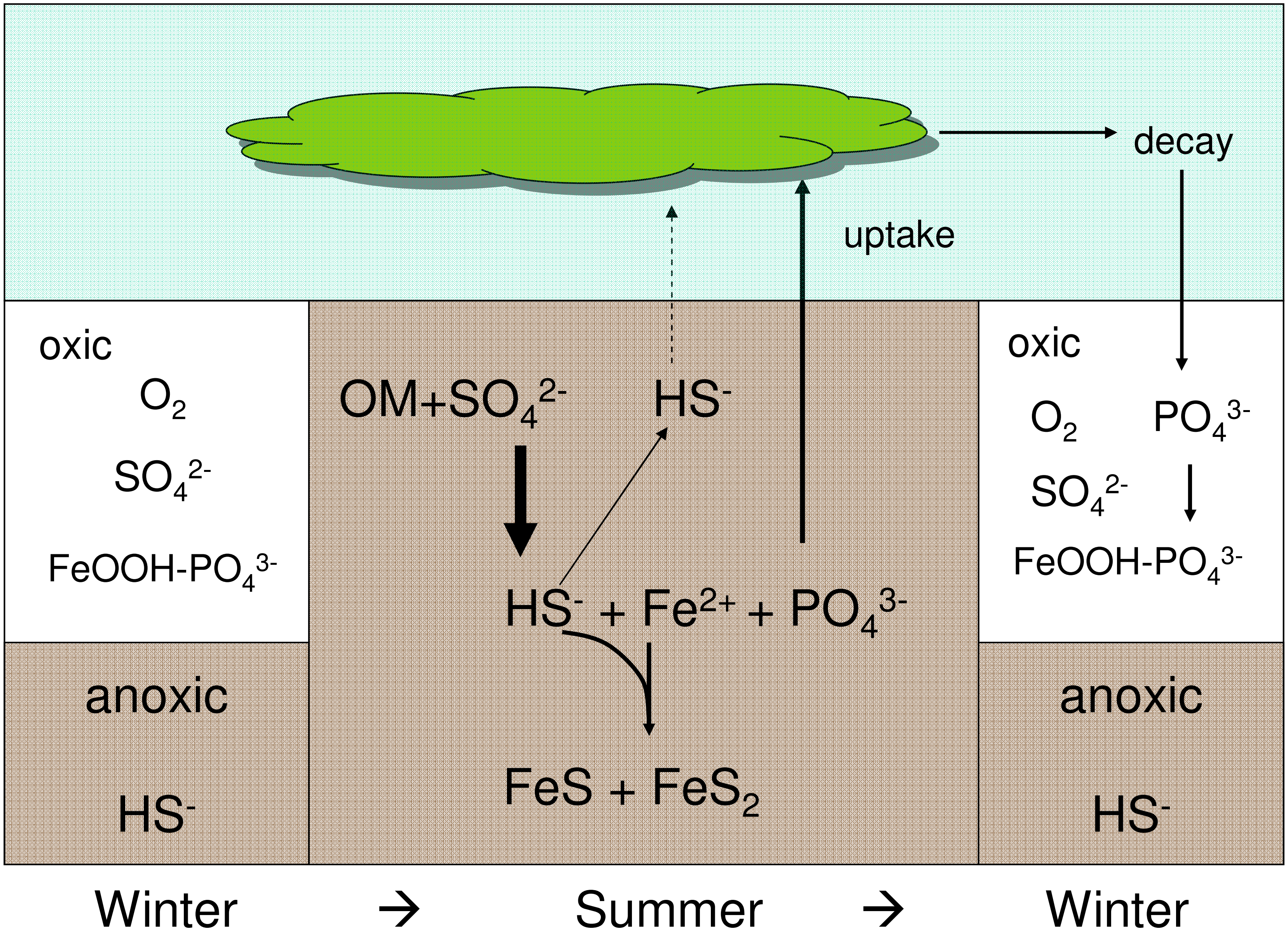
<table>
<tr><th colspan="4">Succession phases and conditions (pristine → altered)</th><th>Ref</th></tr>
<tr><td>phanerogams</td><td>phanerogams+epiphytes</td><td colspan="2">macroalgae+phytoplankton</td><td>1</td></tr>
<tr><td colspan="2">seagrasses</td><td>macroalgae</td><td>phytoplankton</td><td>2, 3</td></tr>
<tr><td>perennial benthic macrophytes</td><td>macrophytes+ fast growing epiphytes</td><td>free floating macroalgae+phytoplankton</td><td>phytoplankton picoplankton cyanobacteria</td><td>?</td></tr>
</table>

multivariate systems with non-liner behaviour

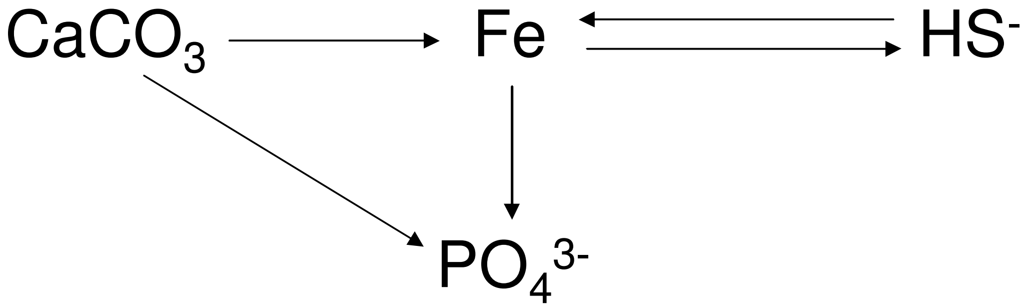


In nutrient poor, well-flushed and shallow waters phanerogams take advantage of nutrient supply from sediment. Long water residence times favour macroalgae and phytoplankton. Given a certain water residence time, the succession from perennial benthic species to macroalgae and phytoplankton seems mainly caused by nutrient loadings (Valiela et al., 1997, L&O 42: 1105-1118; Dahlgreen & Kautsky, 2004. Hydrobiologia 514: 249–258,).

biogeochemical controls and switches (de Wit et al., 2001; Rozan et al., 2002)



key biogeochemical controls



$CaCO_3$	Fe	HS^-	PO_4^{3-}
-	+	-	+
+	-	+	-

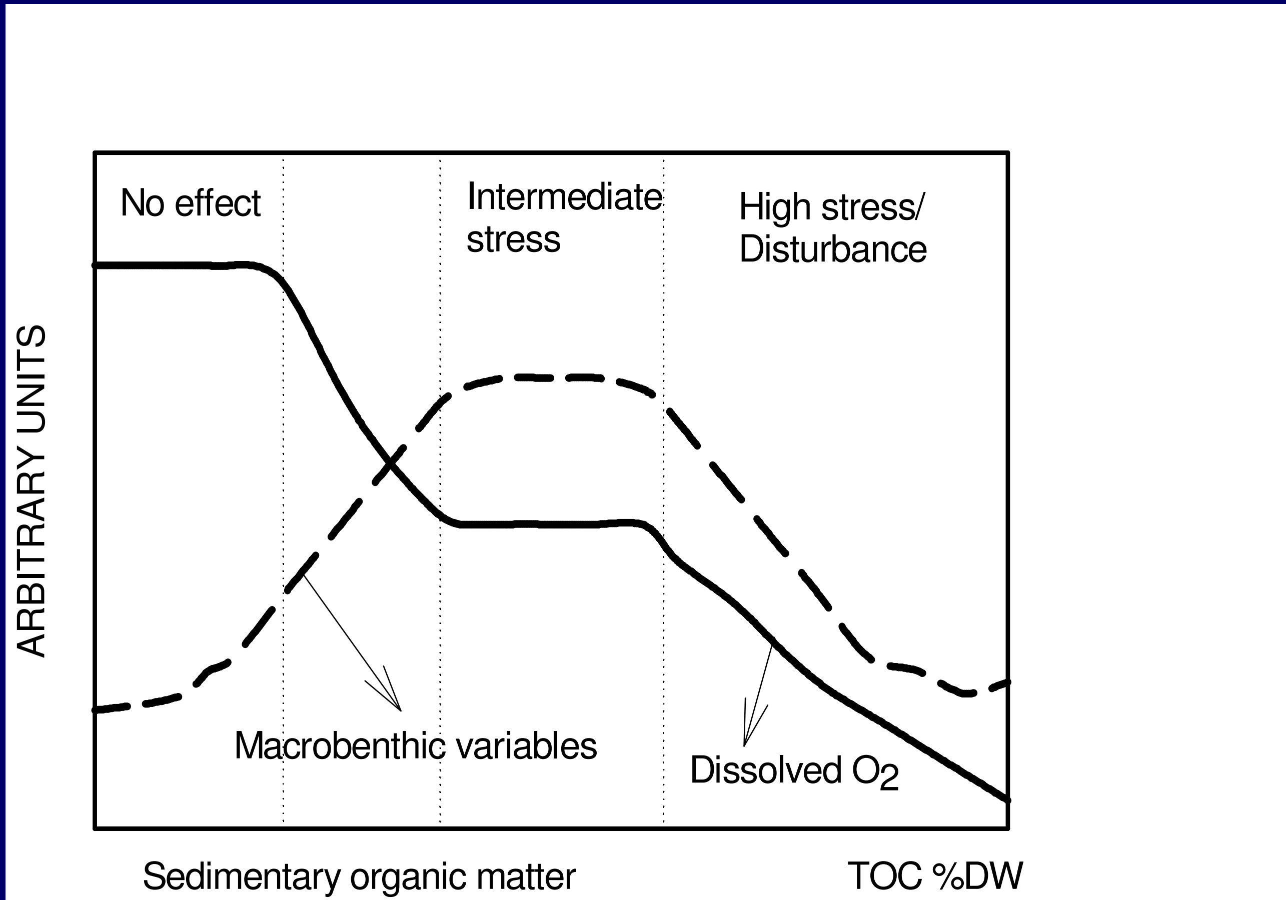
•Caumette P., Castel J, Herbert R., 1996. Coastal lagoon eutrophication and anaerobic processes (C.L.E.A.N.). Hydrobiologia 329

•Chambers RM, Fourquren JW, Macko SA, Hoppenot R, 2001. Biogeochemical effects of iron availability on primary producers in a shallow marine carbonate environment. Limnology and Oceanography 46: 1278-1286

•de Wit R et al., 2001. ROBUST: The ROle of BUffering capacities in STabilising coastal lagoon ecosystems. Continental Shelf Research 21: 2021-2041.

•Lapointe, B.E., M.M. Littler & D.S. Littler, 1992. Nutrient availability to marine macroalage in siliciclastic versus carbonate-rich coastal waters. Estuaries 15: 75-82

•Meysman FJR, Middleburg JJ, 2005. Acid-volatile sulphide (AVS) – A comment. Marine Chemistry 97: 206-212. Rickard D, Morse JW, 2005. Acid Volatile Sulphide (AVS). Marine Chemistry 97: 141-197.



Relationship between sedimentary organic matter, oxygen and macrobenthic variables. Modified from Pearson & Rosemberg (1978), De Wit et al. (2001), and Hyland et al. (2000)

Elemental and molecular composition (units: % dry weight) and decomposition of different macrophyte biomass under summer conditions (from De Wit et al., 1996; Viaroli et al., 1992 and 1996)

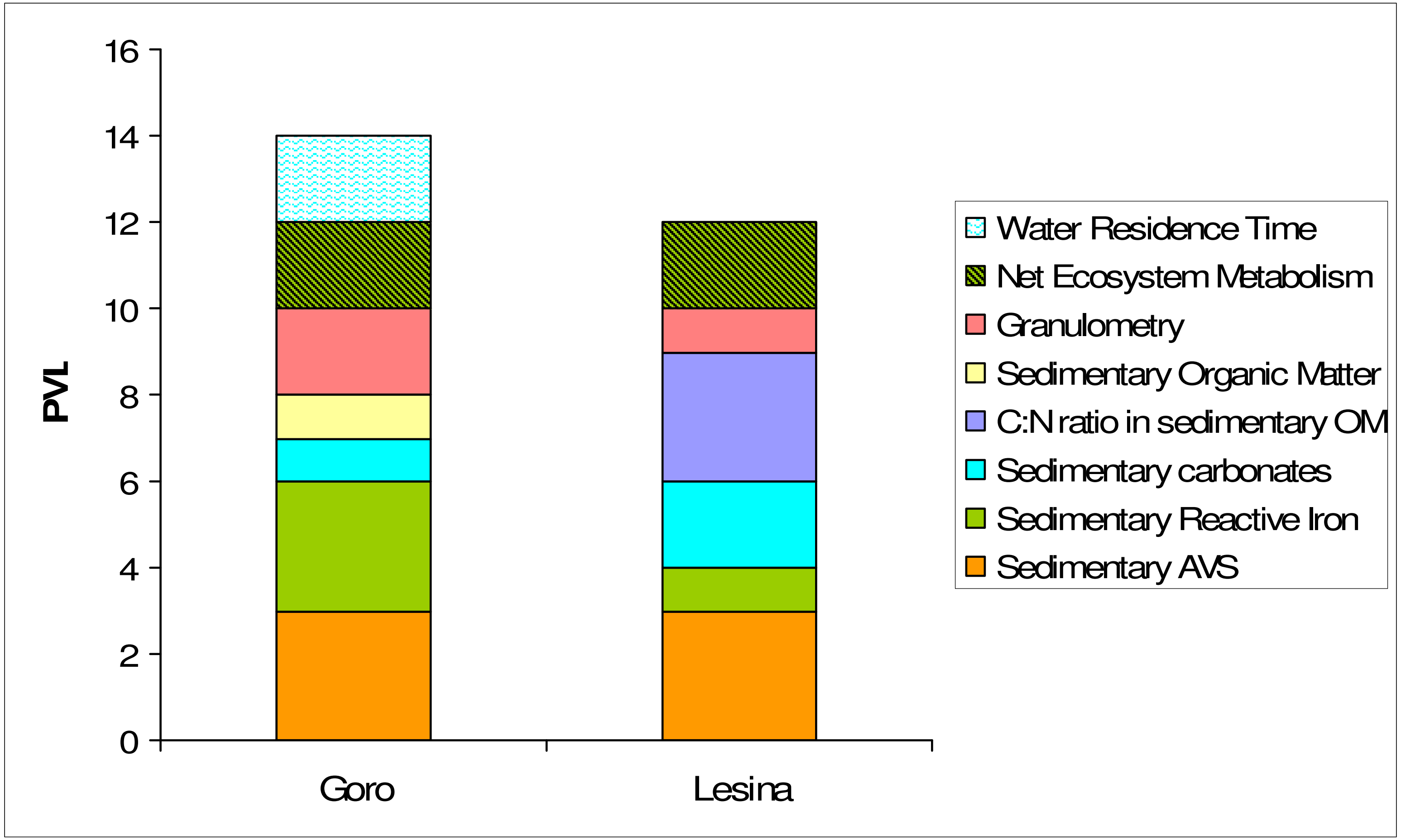
	Ulva	*Ruppia*	*Zostera*
C	20.5-38.9	34.9-37.7	40.1-45.5
N	2.2-5.1	2.2-3.4	2.4-3.1
P	0.11-0.68	0.14-0.38	0.24-0.29
AFDW	66-83	76-84	77-82
Hemicellulose	22.3-29.3	19.6-26.5	25.3-29.2
Cellulose	7.4-14.0	12.0-19.1	15.1-20.0
Lignin	-	2.0-3.4	3.1-7.2
Decomposition Half-time (d)	7-9	28	37

Variables and ranges for assessing the potential vulnerability level. Sedimentary variables are referred to the upper 5 cm sediment horizon

Potential Vulnerability Level	**Units**	**Low**	**Moderate**	**High**	**Very High**
Score		**3**	**2**	**1**	**0**
Water Residence Time (WRT)	days	<1	1-10	10-100	>100
Net Ecosystem Metabolism (NEM)*	mol $m^{-2}y^{-1}$	±1	±5	±10	<-10 or >10
Granulometry	-	sand	sand-silt	silt-clay	clay
Sedimentary Organic Matter (OM)	% dw	< 1	1-5	5-10	>10
C:N ratio in the sedimentary OM	-	>20	10-20	5-10	<5
Sedimentary carbonates	% dw	>40	20-40	5-20	<5
Sedimentary Reactive Iron	µmol cm^{-3}	>200	100-200	50-100	<50
Sedimentary Acid Volatile Sulphide (AVS)	µmol cm^{-3}	<50	50-100	100-150	>150

* NEM or NPmax vs DR

Potential Vulnerability level



vulnerability = impacts – effects of adaptation

(McFadden, Nicholls, Penning-Rowsell (eds), 2007. Managing Coastal Vulnerability. Elsevier, Oxford, 262 p.)

potential vulnerability = impacts – buffering capacity ?
(CLEAN and ROBUST projects)

Stressors?
Controlling factors?
Indicators of vulnerability?