



# An index of environmental quality for Italian transitional waters

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# Water Framework Directive 2000/60/EC



The WFD was published in 2000



Member States had to acknowledge the WFD by 2003

Italy began in 2006....



The WFD aims at achieving GOOD ecological status for all European water bodies by the year 2015!!

## Tasks needed for the implementation of the WFD:

- (a) classification of the water bodies into different types (Annex II)
- (b) definition of reference conditions for each of the types (Annex II)
- (c) assessment of the ecological quality status of the water bodies (Annex V)

## Problems related to the implementation of the WFD:

- (a) water bodies are not homogeneous and their classification into a large number of types can lead to an unmanageable situation
- (b) definition of reference conditions could be very difficult, e.g. in estuaries where the water is a continuum with a strong salinity gradient
- (c) the WFD does not propose clear methodologies for use in determining the physico-chemical status of TW and coastal waters, based upon the defined typologies and references...

## Problems...

Following WFD implementation, a cool **five typologies** of water bodies have been established just along a stretch of 100 km in the Basque Country coastline\*:

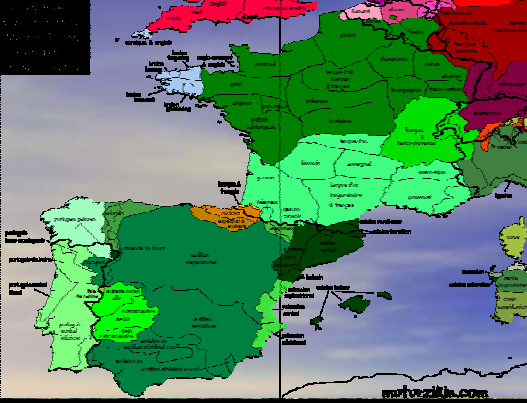
Type I – small river-dominated estuaries

Type II - estuaries with extensive inter-tidal flats

Type III – estuaries with extensive sub-tidal areas

Type IV – full marine semi-exposed coast

Type V – full marine exposed coast



\* Borja et al (2004). Mar Poll Bull 48, 209-218

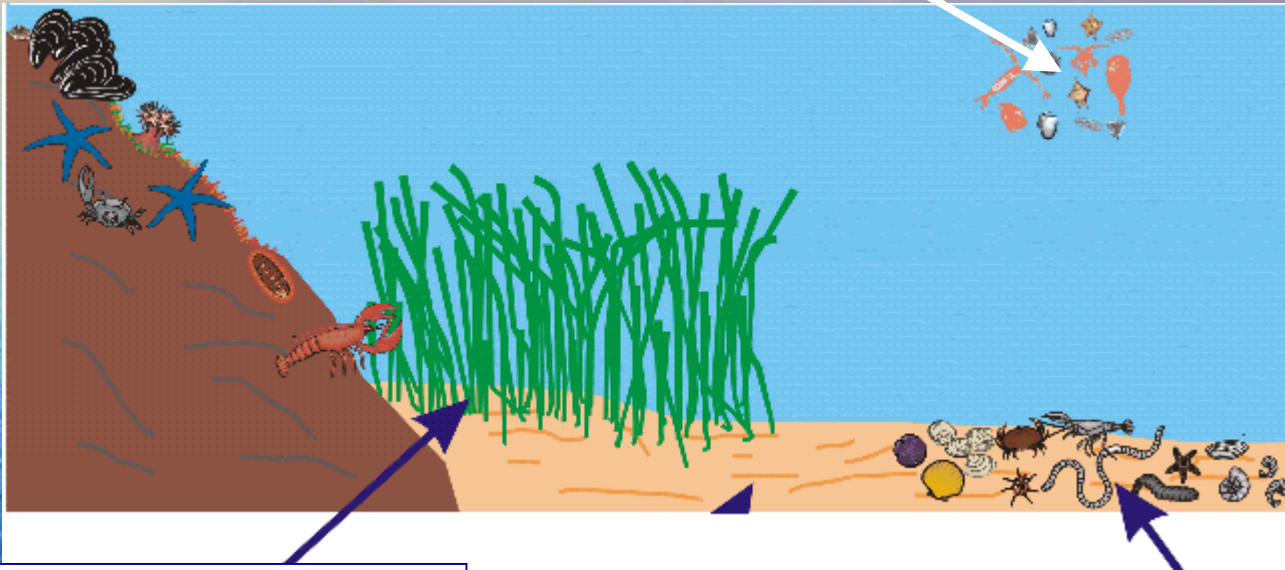
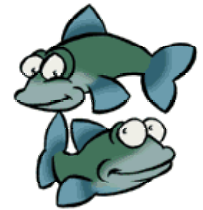
# Biological Quality Elements (BQEs)

Coastal waters

Phytoplankton

Transitional waters

+



Aquatic flora:  
seagrass, seaweeds

Benthic invertebrates

# CLASSIFICATION



A 5 class-system to define the ecological status

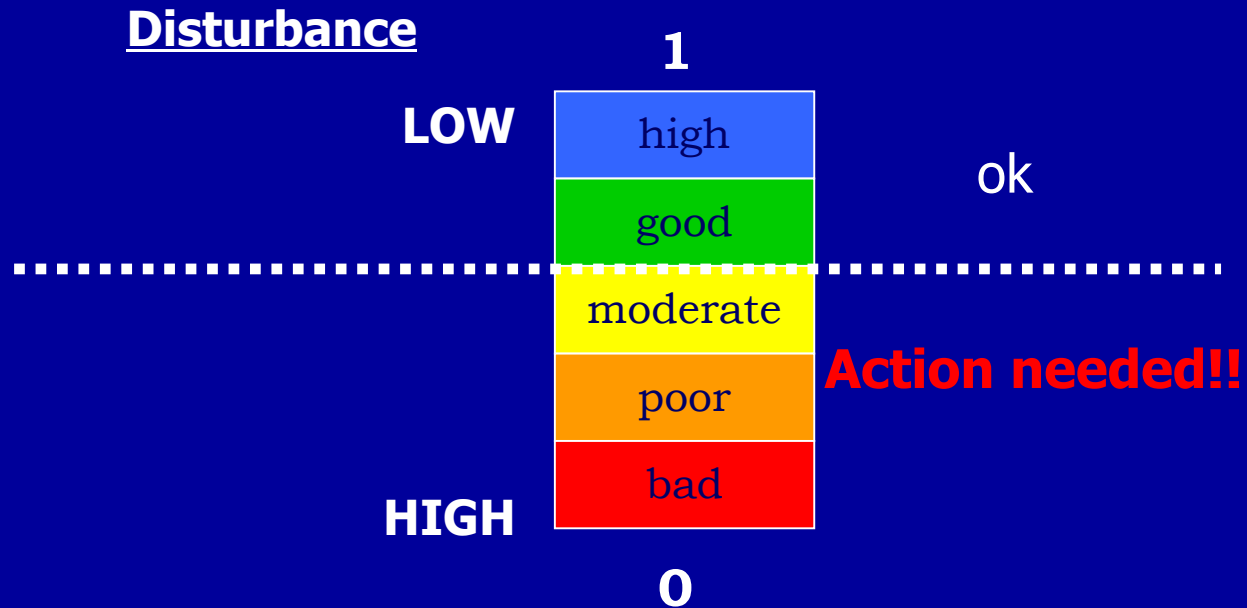
**Deviation of BQEs from  
reference conditions**

**Reference conditions**

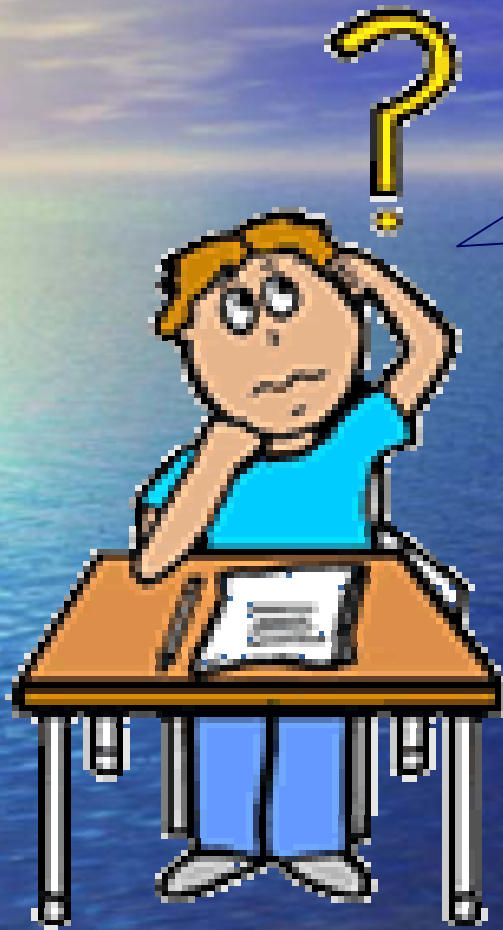


# Classification of ecological status: Environmental Quality Ratio (EQR)

$$\text{EQR} = \frac{\text{Measured BQE}}{\text{Reference BQE}}$$



## Other problems...



How to define the deviation  
from reference conditions ?

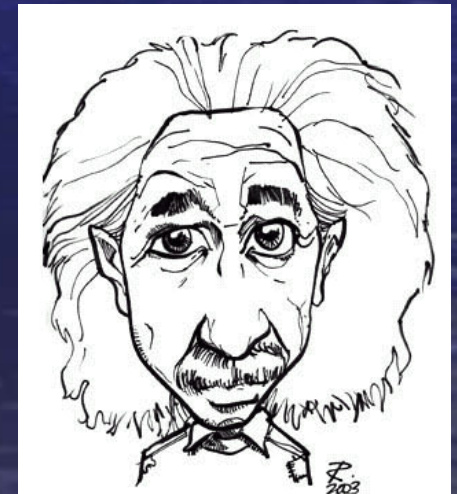
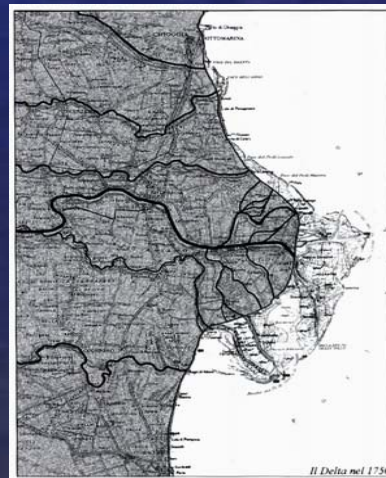


(but, perhaps more important,  
how to define reference conditions???)

“The reference condition for a water body type is a description of the physico-chemical elements which corresponds totally or nearly totally to undisturbed conditions i.e. with no, or with only minor impact, from human activities” (WFD, 2000/60/EC)

WFD identifies options for deriving reference conditions:

- (i) Comparison with an existing undisturbed site
- (ii) Historical data and information
- (iii) Expert judgement

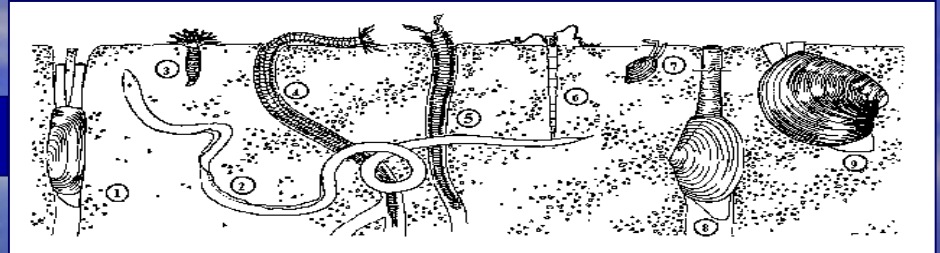


Problems in deriving reference conditions arise from the absence, in most European Regions, of **unimpacted areas and pre-industrial historical data...**



Hence the use of “virtual” reference locations as an expert judgement approach must be considered...

e.g: benthic macroinvertebrates



High status	Good status	Moderate status
Livello di diversità e di abbondanza dei taxa di invertebrati entro il “range” associato alle condizioni inalterate	Livello di diversità e di abbondanza dei taxa di invertebrati <b>leggermente al di fuori del “range”</b> associato alle condizioni tipiche specifiche	Livello di diversità e di abbondanza dei taxa di invertebrati <b>moderatamente al di fuori del “range”</b> associato alle condizioni tipiche specifiche
Presenza di tutti i taxa sensibili alle alterazioni associati alle condizioni inalterate	Presenza delle maggior parte dei taxa sensibili delle comunità tipiche specifiche	Presenza di taxa indicativi di inquinamento Assenza di numerosi taxa sensibili delle comunità tipiche specifiche

Three methods proposed as classification systems for benthic fauna are under testing within the MED-GIG

**Table. 6** Details on the macroinvertebrates indexes under study.

Index	Formula	GI	GII	GIII	GIV	GV
<b>AMBI</b>	$\{(0 \times \%GI) + (1.5 \times \%GII) + (3 \times \%GIII) + (4.5 \times \%GIV) + \{(6 \times \%GV)\} / 100$	Sensitive	Indifferent	Tollerant	2 <sup>nd</sup> order opport.	1 <sup>st</sup> order oppört.
<b>BENTIX</b>	$[(6 \times GI) + 2 \times (\%GII + \%GIII) / 100]$	Sensitive	Tollerant (2 <sup>nd</sup> order opportunists)	Tollerant (1 <sup>st</sup> order opportunists)		

Index	Formula	ES50 <sub>0.05</sub>
<b>BQI</b>	$BQI = \left( \sum_{i=1}^n \left( \frac{A_i}{\text{tot}A} \times ES50_{0.05i} \right) \right) \times {}^{10}\log(S + 1)$	species tolerance value

A= abundance S= number of species G= taxa group

The main difference between AMBI and BENTIX is the number of degrees proposed:

AMBI – 5 different degrees of sensitivity or tolerance to disturbance factors

BENTIX – 3 ecological groups

Major debate concerns the ecological characteristics of individual species and therefore their assignment to different categories...

# The paradox of TWs quality...

Recently developed indices (e.g. AMBI\* and BENTIX\*\*) are based on dividing soft benthic species into previously defined ecological groups (Pearson & Rosenberg 1978; Grall & Glemarec 1997)

They provide information about the relative abundances of the sensitive species faced with increased organic matter in the sediment and abundance of species that are resistant or indifferent or favoured by such conditions

They aim to determine anthropogenic stress (relate to abundance of stress tolerant species) which may also be tolerant of natural stressors such as in TWs..

**but TWs are naturally organic rich systems...!**

\* Borja et al (2000), Mar Poll Bull 40, 1100-1114

\*\* Simboura & Zenetos (2002), Med Mar Sci 3, 77-111

## ...perhaps needs another index

The *Fuzzy INdex of Ecosystem integrity* (FINE) is specifically developed for transitional environments. The idea is that structural and functional attributes at the community level are expected to provide more general indications on overall ecosystem health and alterations.

The rationale of FINE is that certain attributes, selected on the basis of established principles of benthic ecology, are fundamental for lagoon functioning.



# Transitional waters in Italy



**Italy: ~170 TWs**

**but**

140 having a surface  $< 10 \text{ km}^2$

57  $< 0.5 \text{ km}^2$

28  $< 1 \text{ km}^2$

# Proposed typology of Italian TWs



(factorial classification scheme)

Geomorfologia	Range di marea	*Superficie	#Salinità
Estuari			
Delta			
Lagune	> 50 cm		
	< 50 cm	> 2.5 km <sup>2</sup>	
		< 2.5 km <sup>2</sup>	Oligohaline < 5
			Mesohaline 5-20
			Polyhalina 20-30
			Euhaline 30-40
			Hyperhaline > 40
* per entrambe le classi di Range di marea			
# per tutte le combinazioni fattoriali di classi di Range di marea e Superficie			

(22 typologies...)

# Proposed habitat types for Italian TWs



Type of bottom substrate	Dominant vegetation	Legend
<b>Gravel /rock</b> (particle size > 2 mm)	Without vegetation	
	Macroalgae	
	Submerged macrophytes	
	Emerging macrophytes	
<b>Sand</b> (0.05 mm < particle size < 2 mm)	Without vegetation	
	Macroalgae	
	Submerged macrophytes	
	Emerging macrophytes	
<b>Mud</b> (particle size < 0.05 mm)	Without vegetation	
	Macroalgae	
	Submerged macrophytes	
	Emerging macrophytes	

# **Proposta di scheda tecnica per il campionamento degli “elementi biologici di qualità” ai fini del monitoraggio negli ecosistemi acquatici di transizione in recepimento della Direttiva Comunitaria Acqua (CE 2000/60)**

Il nuovo programma di Monitoraggio delle Acque di Transizione in Italia si basa sulla classificazione di Tipologie di ecosistemi acquatici di transizione definita dal MATTM in sintonia con le linee adottate dal Gruppo Mediterraneo di Intercalibrazione Geografica (MED-GIG) e si propone di essere operativo dal 2007.

Alla elaborazione e realizzazione delle schede partecipano:

Alberto Basset, Sebastiano Calvo, Gian Carlo Carrada, Alberto Castelli, Angelo Cau, Ester Cecere, Anita Franco, Piero Franzoi, Nicola Galuppo, Franco Giovanardi, Roberta Girardi, Mariella Grieco, Giulio Izzo, Claudio Lardicci, Giovanna Marino, Giulia Massini, Antonio Mazzola, **Michele Mistri**, **Cristina Munari**, Gianni Fulvio Russo, Letizia Sabetta, Enzo Saggiomo, Nicola Sechi, Adriano Sfriso, Antonella Signorini, Davide Tagliapietra, Patrizia Torricelli, Giuseppe Trinchera, Pierluigi Viaroli, Salvatrice Vizzini

## **Scheda tecnica per il campionamento del "FITOPLANCTON"**

### **COSTO TOTALE CAMPIONAMENTO**

1. Campionamento stagionale: 1,179M€ - 1,958M€
2. Campionamento estivo: 0,8M€

## **Scheda tecnica per il campionamento del "FITOBENTHOS"**

(not estimated)

## **Scheda tecnica per "MACROINVERTEBRATI BENTONICI"**

### **COSTO TOTALE CAMPIONAMENTO**

1. Campionamento pluriennale: 1,156M€ - 2,081M€
2. Campionamento semestrale: 0,609 M€ - per campionamento 1,218 M€ per anno

## **Scheda tecnica per il campionamento della "FAUNA ITTICA"**

### **COSTO TOTALE CAMPIONAMENTO**

1. Campionamento semestrale: 0,333 – 0,600 M€ - per campionamento;
2. 0,666 - 1,200 M€ per anno

1° problem: money

First year of sampling: 6 M€..!!

2° problem: expertise

Taxonomic experts are an endangered species..!!

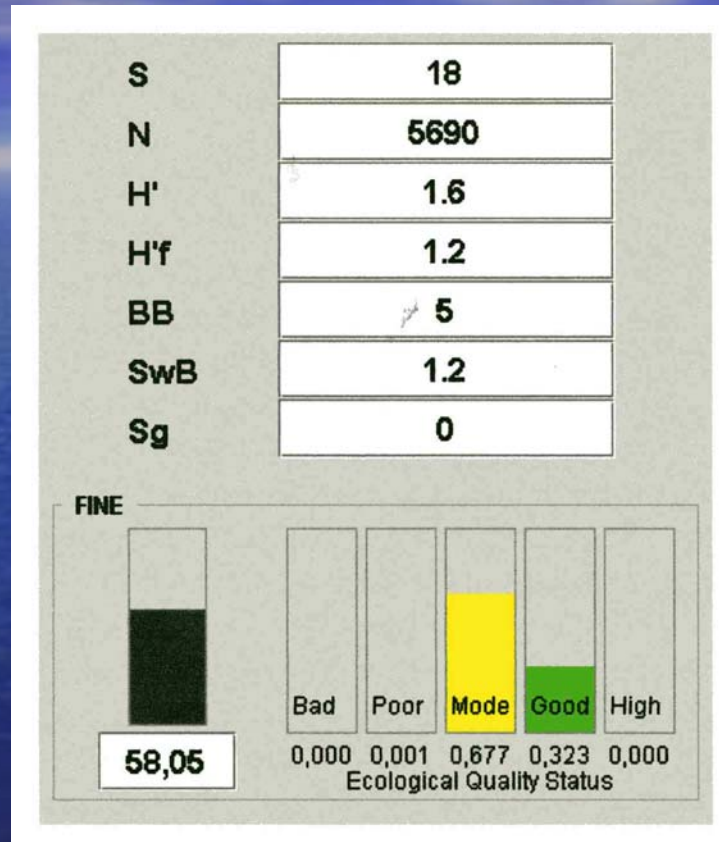


The WFD will require more but there are not enough being produced...

Stazione 13	Data di campionamento	13/03/2002	ottobre-02
taxa	NRGA	892	
Policheti	Spionidae	2	Non campionato
	Nereididae	3	
	Capitellidae	18	
N (n° tot.indiv. nel camp.)		<b>23</b>	
S (n° specie)		<b>3</b>	
D (indice di ricchezza specifica)		<b>1,5</b>	
H' (indice di Shannon-Weaver)		<b>1,0</b>	
J (indice di "evenness")		<b>0,6</b>	
c (indice di dominanza)		<b>0,6</b>	

	S	N	H'
SC3	20	8581	1,66
SC5	27	12823	1,53
SC8	34	5551	2,72
SC10	39	7361	2,64
SC15	35	5283	2,26
SC18	38	15385	2,30
SC20	36	8337	2,44
SC23	14	2665	1,78
SC27	15	5659	1,21
SC30	37	63889	1,99
SC33	5	523	0,92
SC38	6	3300	0,98

Stazione 14	Data di campionamento		13/03/2002	ottobre-02
taxa	NRGA		893	
Policheti	Spionidae		102	Non campionato
	Nereididae		10	
	Nephtyidae		2	
	Capitellidae		38	
Oligocheti	Tubificidae		4	
Bivalvi	Anadaridae	<i>Scapharca cfr. cornea</i> Réeve	1	
Crostacei	Gammaridae		1	
N (n° tot.indiv. nel camp.)			<b>158</b>	
S (n° specie)			<b>7</b>	
D (indice di ricchezza specifica)			<b>2,7</b>	
H' (indice di Shannon-Weaver)			<b>1,7</b>	
J (indice di "evenness")			<b>0,6</b>	
c (indice di dominanza)			<b>0,6</b>	



<http://web.unife.it/progetti/FINE/>

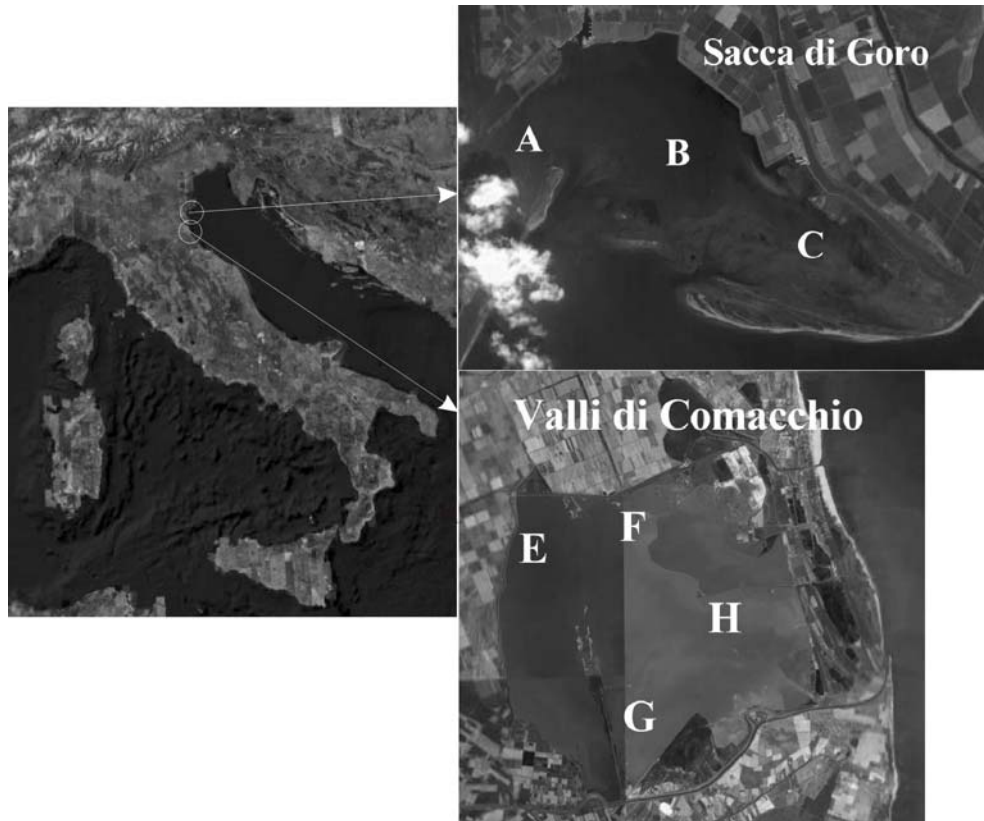
The creation of quality indices naturally involves the incorporation of a certain amount of subjective knowledge, that can be expressed, for example, in the assignment of species to ecological groups.

In the FINE index development we tried to restrict subjectivity to (a) choice of the input and output variables, and (b) design of the fuzzy functions relative to their modalities.

The association of each variable modality to an ecological status is then based on universally accepted ecological principles, like: "high diversity = high quality".

These general principles drive the 768 inference rules, which are automatically calculated from the fuzzy membership functions: external interventions are not required in this assessment, thus the total amount of subjectivity is reduced.

## Response of FINE to water and sediment data



Oxygen

Ntot

Ptot

Transparency

Ni

Cr

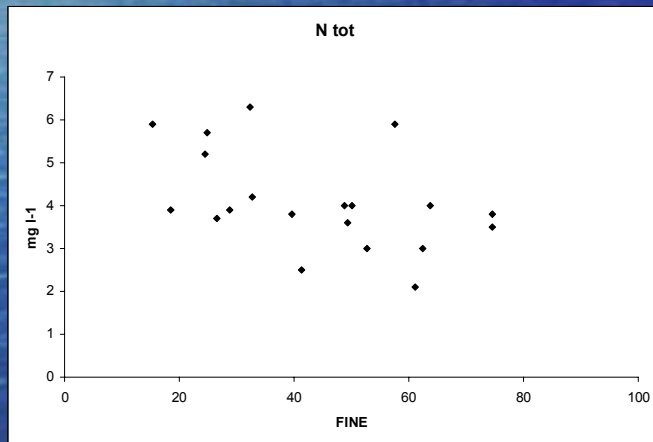
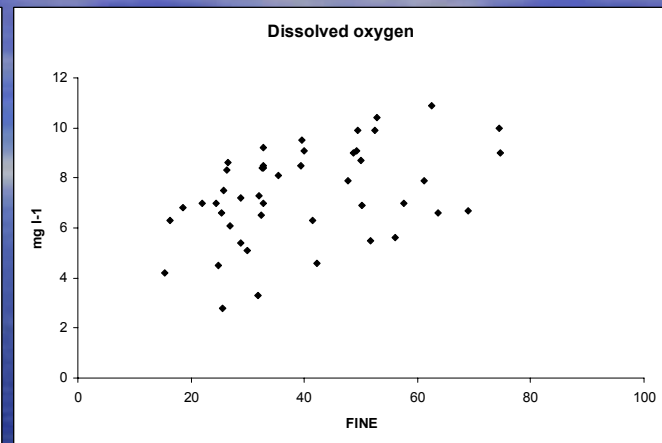
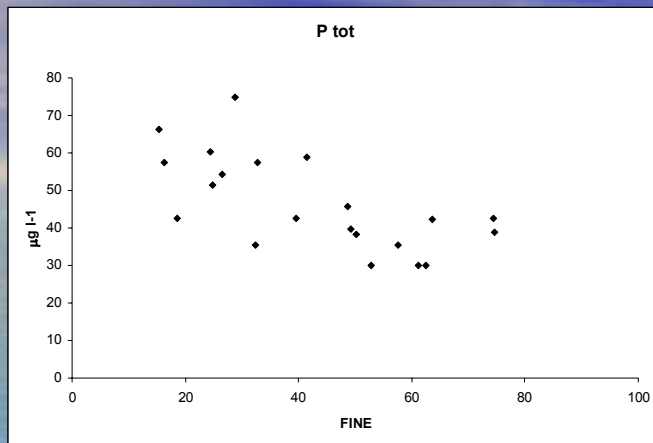
Pb

As

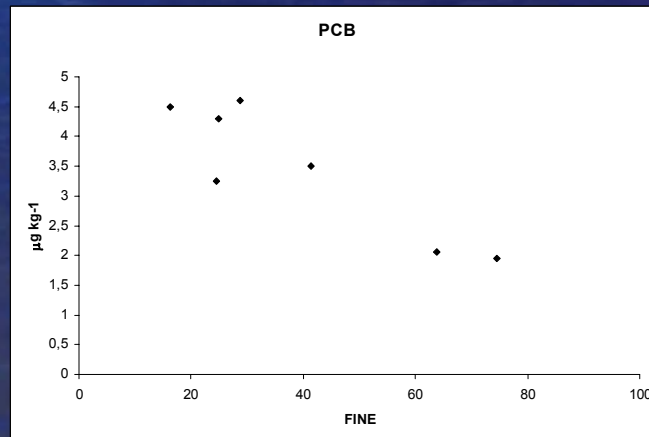
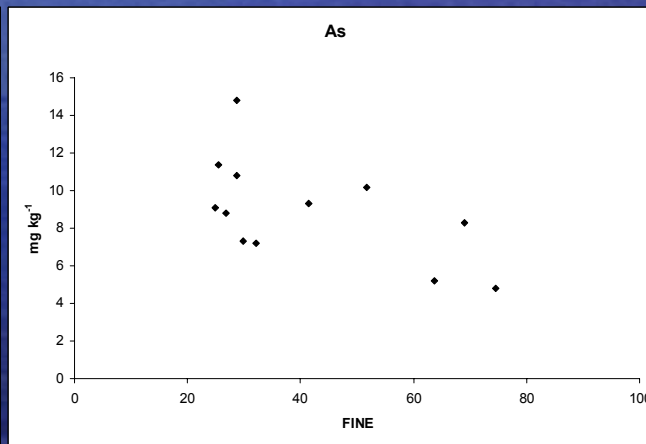
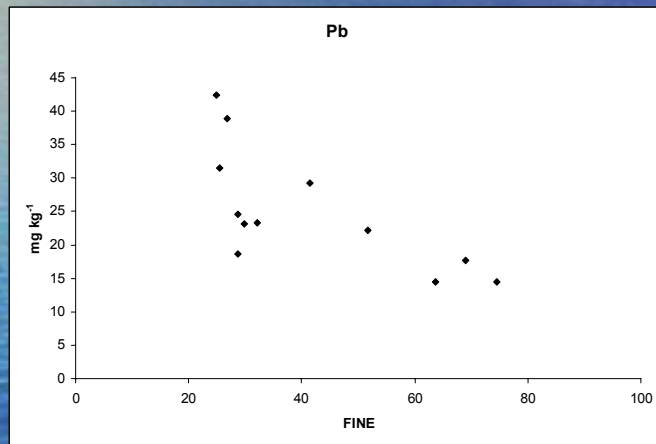
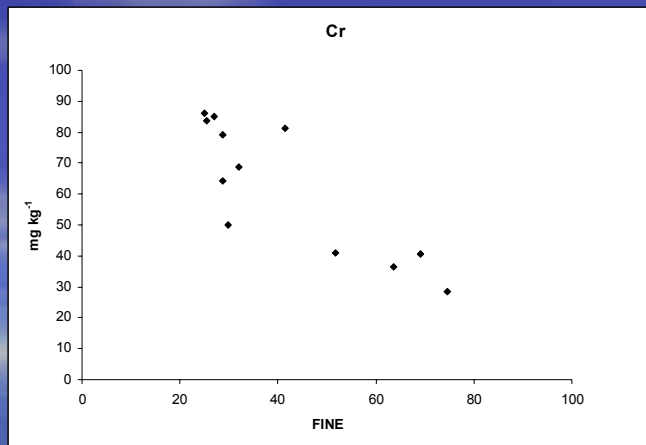
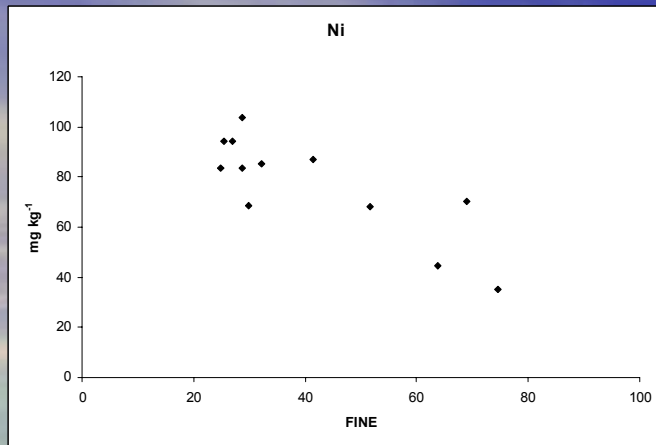
PCB

Table 2  
Biotic and environmental data at the various sites. S: number of macrobenthic species; H': benthic diversity; H'f: benthic functional diversity; BB: biomass of benthic fauna; SwB: biomass of seaweeds; Sg: seagrass (al

Stn	S	Abundance (ind m <sup>-2</sup> )	H'	H'f	BB (gAFDW m <sup>-2</sup> )	SwB (gWW m <sup>-2</sup> )	Sg	FINE	Trasp (m)	O2 (mg l <sup>-1</sup> )	Ntot (mg l <sup>-1</sup> )	Ptot (µg l <sup>-1</sup> )	Ni (mg kg <sup>-1</sup> )	Cr (mg kg <sup>-1</sup> )
A1	13	9225	1.04	0.65	7.3	25.5	abs	39.6	0.7	9.5	3.8	42.7		
B1	16	6216	1.68	0.92	1.4	29.5	abs	52.8	1.5	10.4	3	30		
C1	18	15232	1.53	1.02	29.3	1352.8	abs	62.5	1.5	10.9	3	30		
E1	5	456	1.31	0.70	1.4	0	abs	26.5	0.8	8.6	3.7	54.4		
F1	19	122532	0.59	0.39	61.6	0	abs	48.7	0.7	9	4	45.6		
G1	11	6167	0.59	0.44	22.4	0	abs	49.3	1	9.1	3.6	39.7		
H1	4	604	0.89	0.27	0.6	0	abs	15.3	0.6	4.2	5.9	66.2		
A2	6	4477	0.58	0.52	5.8	0.0	abs	32.7	0.6	7	4.2	57.4		
B2	5	173	1.13	0.90	2.0	186.5	abs	18.5	0.6	6.8	3.9	42.7		
C2	11	3416	1.26	0.82	20.3	86.3	abs	61.1	1.1	7.9	2.1	30		
E2	9	2997	1.17	0.81	9.0	0	abs	50.1	0.4	6.9	4	38.2		
F2	14	11014	1.57	0.91	32.8	0	abs	57.5	0.6	7	5.9	35.3		
G2	16	5723	1.96	1.27	21.7	0	abs	74.6	0.8	9	3.8	38.8		
H2	6	136	1.67	1.12	0.8	0	abs	32.4	0.3	6.5	6.3	35.3		
A3	6	2306	0.49	0.27	0.2	0.0	abs	28.7	0.8	5.4	3.9	75	83.6	64.1
B3	11	1591	1.57	1.01	0.9	864.3	abs	41.4	0.9	6.3	2.5	58.8	87.1	81.3
C3	6	2047	0.67	0.55	1.6	58.7	abs	24.9	0.6	4.5	5.7	51.5	83.7	86.2
E3	6	1591	1.12	0.89	5.0	0	abs	24.5	0.3	7	5.2	60.3		
F3	13	5488	1.89	1.01	66.9	0	abs	63.7	0.7	6.6	4	42.4	44.5	36.3
G3	15	5784	1.73	1.24	55.0	0	abs	74.5	0.8	10	3.5	42.7	35.1	28.4
H3	3	1443	0.82	0.33	1.9	0	abs	16.3	0.3	6.3	5.9	57.4		
A4	13	55241	1.03	0.5	5.7	0	abs	31.8	0.5	3.3				
B4	11	5834	1.05	0.64	0.75	449	abs	42.2	0.7	4.6				
C4	18	4724	1.7	1.03	4.71	1759	abs	56.1	0.9	5.6				
E4	8	3392	1.42	0.93	4.9	0	abs	47.7	0.4	7.9				
F4	7	8485	1	0.67	1.74	0	abs	25.8	0.4	7.5				
G4	5	1961	0.89	0.45	0.23	0	abs	21.9	0.4	7				
H4	4	4366	0.42	0.26	0.63	0	abs	32.7	0.4	8.4				
A5	5	1085	1.17	1.07	0.52	60.1	abs	28.8	1	7.2			103.5	79.3
B5	4	74	1.33	1.01	59.6	1.85	abs	32.1	1	7.3			85.3	68.6
C5	6	8078	0.99	0.48	1.59	0	abs	26.9	1	6.1			94.2	85.2
E5	7	8313	0.88	0.6	0.96	0	abs	26.4	0.3	8.3				
F5	13	26948	1.29	0.7	2.13	0	abs	39.4	0.3	8.5				
G5	17	157201	1.24	0.39	7.91	0	abs	40	0.3	9.1				
H5	4	4724	0.72	0.69	0.45	0	abs	32.7	0.3	9.2				
A6	5	27972	0.13	0.1	0.84	0	abs	25.4	1.3	6.6				
B6	21	16218	1.71	1.01	2	0	abs	49.5	1.5	9.9				
C6	19	27750	1.15	0.88	45.6	773	abs	52.4	1.3	9.9				
E6	8	5414	1.45	0.82	9.1	0	abs	51.7	0.3	5.5			68.1	41.1
F6	7	12161	1.03	0.86	0.61	0	abs	29.9	0.3	5.1			68.6	50.1
G6	15	33645	1.75	1.26	36.41	0	abs	69	0.7	6.7			70.5	40.5
H6	6	9225	0.74	0.52	0.45	0	abs	25.5	0.4	2.8			94.3	83.6
E7	4	4884	0.7	0.45	1.44	0	abs	32.7	0.4	8.5				
F7	17	40318	1.59	0.62	11.62	0	abs	50	0.4	8.7				
G7	4	1344	1	0.94	35.74	0	abs	35.4	0.4	8.1				
H7	4	5673	0.72	0.47	2.81	0	abs	32.6	0.4	8.4				



Relationship between water chemical parameter values and FINE values for the selected stations during years 2004 and 2005



Relationship between  
sedimentary heavy metals  
concentration and FINE  
values in 2004 and 2005,  
and PCB concentration and  
FINE for year 2005 only

A positive correlation was found between FINE values and dissolved oxygen, and negative correlations between FINE and all the other chemical parameters

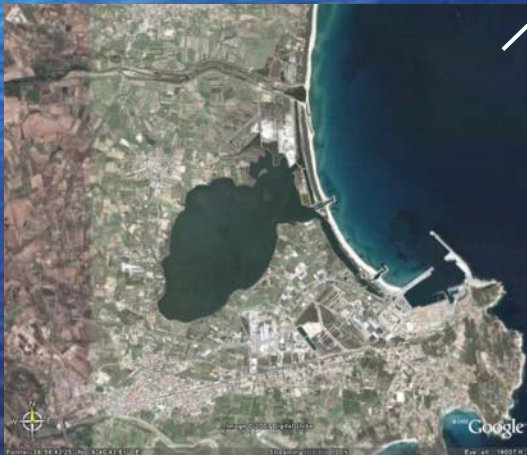
Table 4

Regression coefficients and regression ANOVAs between FINE scores and values of chemical parameters.

Chemical parameter	r	df	F	p
Ntot	-0.46	1, 18	4.8	0.041
Ptot	-0.66	1, 18	14.9	0.001
Trasp	-0.37	1, 44	6.9	0.012
O2	0.43	1, 44	9.9	0.003
Ni	-0.83	1, 10	21.8	0.001
Cr	-0.85	1, 10	26.9	0.001
Pb	-0.71	1, 10	9.9	0.010
As	-0.59	1, 10	5.3	0.044
PCB	-0.90	1, 5	22.2	0.005

# Tyrrhenian TWs

Padrongiano



Tortoli



Orbetello



## San Teodoro



20 kg m<sup>-2</sup>

Table 2






Biotic data. S: number of macrobenthic species; H': benthic alpha-diversity; H'f: benthic functional diversity; BB: biomass of benthic fauna; SwB: biomass of seaweeds; SgW: biomass of seagrass.

Station	S	Abundance (ind m <sup>-2</sup> )	H'	H'f	BB (gAFDW m <sup>-2</sup> )	SwB (gWW m <sup>-2</sup> )	SgB (gWW m <sup>-2</sup> )
ORBE-Cju	25	29563	2,53	1,07	173,3	0	0
ORBE-Fju	23	75134	1,41	0,88	113,8	0	0
ORBE-Nju	32	37592	2,25	1,29	134,1	1000	0
ORBE-Cma	34	29797	2,57	1,19	145	0	0
ORBE-Fma	17	13270	2,18	1,07	29,6	0	0
ORBE-Nma	25	48901	1,85	1,08	77,7	0	0
PADR-Lma	34	22107	0,65	0,39	158,3	0	0
PADR-Sma	44	6752	1,76	0,86	48,9	0	0
PADR-Cma	37	6410	2,2	1,12	4,1	0	0
PADR-Lju	34	23060	1,79	1,19	606,5	0	0
PADR-Sju	36	5966	2,61	1,33	110,9	0	0
PADR-Cju	36	15466	2,61	1,43	10,7	104	0
PADR-Loc	54	31218	2,31	1,42	205,1	200	0
PADR-Soc	62	26732	2,69	1,48	57,3	0	0
PADR-Coc	42	10767	2,44	1,46	23,9	50	0
TORT-1ju	29	10754	2,12	1,33	45,8	0	320
TORT-2ju	32	6925	2,77	1,49	247,9	0	0
TORT-3ju	13	5426	1,33	0,85	12	0	0
TORT-4ju	22	21188	1,33	1,02	243	0	570
TORT-5ju	19	27984	1,52	1,11	86,2	0	890
TORT-6ju	22	7868	2,27	1,46	56,8	290	0
TORT1ja	42	18056	2,53	1,31	345,3	0	325
TORT-2ja	34	8596	2,65	1,44	42,4	0	0
TORT-3ja	26	2503	2,63	1,25	25,3	0	0
TORT-4ja	14	5377	1,36	0,86	208,8	0	173
TORT-5ja	23	11901	1,99	1,4	97,5	0	127
TORT-6ja	23	2836	2,33	1,05	40,6	0	0
STEO-C	26	3774	2,14	0,98	3,27	50	0
STEO-BM	14	12444	1,48	1,19	3,77	15000	0
STEO-D	5	2002	0,52	0,42	0,8	25000	0

Table 3

FINE outputs with the different grades of membership associated to each ecological status class.

Station	Bad	Poor	Moderate	Good	High	FINE	EcoQ
ORBE-Cju	0	0	0,32	0,68	0	67	Good
ORBE-Fju	0	0	0,793	0,207	0	55	Moderate
ORBE-Nju	0	0	0,12	0,88	0	72	Good
ORBE-Cma	0	0	0,09	0,91	0	73	Good
ORBE-Fma	0	0	0,445	0,555	0	64	Good
ORBE-Nma	0	0	0,273	0,727	0	68	Good
PADR-Lma	0	0	1	0	0	50	Moderate
PADR-Sma	0	0	0,563	0,437	0	61	Good
PADR-Cma	0	0	0,709	0,291	0	57	Moderate
PADR-Lju	0	0	0,095	0,905	0	73	Good
PADR-Sju	0	0	0,005	0,995	0	75	Good
PADR-Cju	0	0	0,071	0,929	0	73	Good
PADR-Loc	0	0	0	1	0	75	Good
PADR-Soc	0	0	0,068	0,932	0	73	Good
PADR-Coc	0	0	0,053	0,947	0	74	Good
TORT-1ju	0	0	0	0	1	100	High
TORT-2ju	0	0	0,02	0,98	0	75	Good
TORT-3ju	0	0,004	0,819	0,177	0	54	Moderate
TORT-4ju	0	0	0	0,24	0,76	94	High
TORT-5ju	0	0	0	0,076	0,924	98	High
TORT-6ju	0	0	0,002	0,998	0	75	Good
TORT1ja	0	0	0	0	1	100	High
TORT-2ja	0	0	0,057	0,943	0	74	Good
TORT-3ja	0	0	0,075	0,925	0	73	Good
TORT-4ja	0	0	0	0,305	0,695	92	High
TORT-5ja	0	0	0	0	1	100	High
TORT-6ja	0	0	0,223	0,777	0	69	Good
STEO-C	0	0	0,792	0,208	0	55	Moderate
STEO-BM	0,001	0,371	0,628	0	0	41	Moderate
STEO-D	0,877	0,123	0	0	0	3	Bad

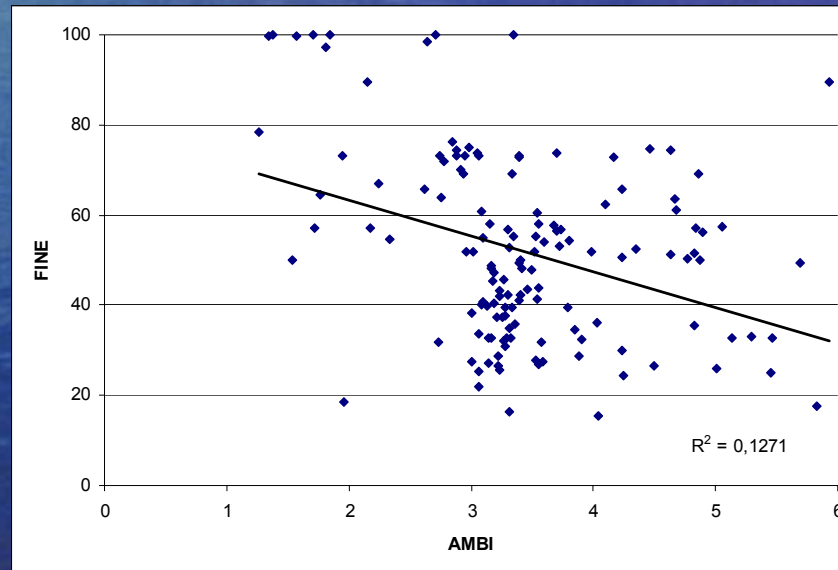
Undisturbed		<b>EcoQ</b> high	<b>AMBI</b> <1,2
Slightly disturbed		good	1,2-3,3
Moderately disturbed		moderate	3,3-4,3
Heavily disturbed		poor	4,3-5,5
Extremely disturbed		bad	>5,5

	<b>Mean AMBI</b>	<b>Disturbance Clasification</b>	<b>FINE</b>
ORBE-Cju	3,278	Slightly disturbed	67
ORBE-Fju	3,831	Moderately disturbed	55
ORBE-Nju	2,98	Slightly disturbed	72
ORBE-Cma	3,244	Slightly disturbed	73
ORBE-Fma	3,726	Moderately disturbed	64
ORBE-Nma	3,243	Slightly disturbed	68
PADR-Lma	2,094	Slightly disturbed	50
PADR-Cma	4,633	Moderately disturbed	61
PADR-Sma	1,275	Slightly disturbed	57
PADR-Cju	2,681	Slightly disturbed	73
PADR-Sju	1,36	Slightly disturbed	75
PADR-Lju	1,227	Slightly disturbed	73
PADR-Coc	4,393	Moderately disturbed	75
PADR-Soc	3,71	Moderately disturbed	73
PADR-Loc	3,137	Slightly disturbed	74
TORT-1ju	3,348	Moderately disturbed	100
TORT-2ju	2,876	Slightly disturbed	75
TORT-3ju	3,702	Moderately disturbed	54
TORT-4ju	2,753	Slightly disturbed	59
TORT-5ju	1,81	Slightly disturbed	65
TORT-6ju	1,942	Slightly disturbed	75
TORT1ja	2,707	Slightly disturbed	100
TORT-2ja	2,945	Slightly disturbed	74
TORT-3ja	2,746	Slightly disturbed	73
TORT-4ja	1,721	Slightly disturbed	55
TORT-5ja	1,373	Slightly disturbed	75
TORT-6ja	2,94	Slightly disturbed	69
STEO-C	4,579	Moderately disturbed	55
STEO-BM	1,405	Slightly disturbed	41
STEO-D	3	Slightly disturbed	3

As regard to estuarine and coastal waters, most indices proposed so far are based on the communities of benthic invertebrate fauna, which integrate environmental conditions and changes in a very effective way

The most used is AMBI (BENTIX and BQI)

Their application in brackish environments, however, appeared not always satisfactory, and the comparison amongst them showed controversial results



In order to minimize the problems due to misclassification, Borja recently recommended using AMBI as part of a multimetric approach in which AMBI is one of a set of measurements and indices (e.g. diversity and richness...)

# Concluding remarks

Is FINE a SMART\* index?

**NO**

\*(Simple, Measurable, Achievable, Realistic, Time limited)

The successful development of a system capable of assessing the quantity, quality and functional value of TW systems, irrespective of location, is not a trivial task

It will require a holistic ecosystem-based approach that at the same time focuses on individual species and habitats as well as accounting for those factors that affect these components at various temporal and spatial scales

The adopted framework for ecological assessment should:

- (i) Delineate regions (or habitats) that can be quantitatively defined (in time and space) according to their physical, chemical and biological characters
- (ii) identify clear relationships between anthropogenic disturbance and key ecological attributes of the target habitat and/or species
- (iii) assess and monitor the status of ecosystem performance relative to recent historical system states (and suitable reference sites)
- (iv) incorporate predictive models and other theoretical approaches
- (v) be of high relevance, robust from an analytical and statistical standpoint, and be able to meet environmental legislative criteria



The FINE index resulted in a ecologically and methodologically sound model structure that could have a wider validity and applicability in different TWs from different geographical areas, given that a pre-emptive calibration of the input and output fuzzy functions is made on the basis of site-specific information and historical knowledge.

The FINE model includes seaweeds, seagrass and benthos.

The WFD states the need to evaluate each element separately, in order to determine the impacts from different pressures over each of the elements, and this cannot be assessed when all of them are evaluated together, as in FINE...

...this could be one of the limitations of our model