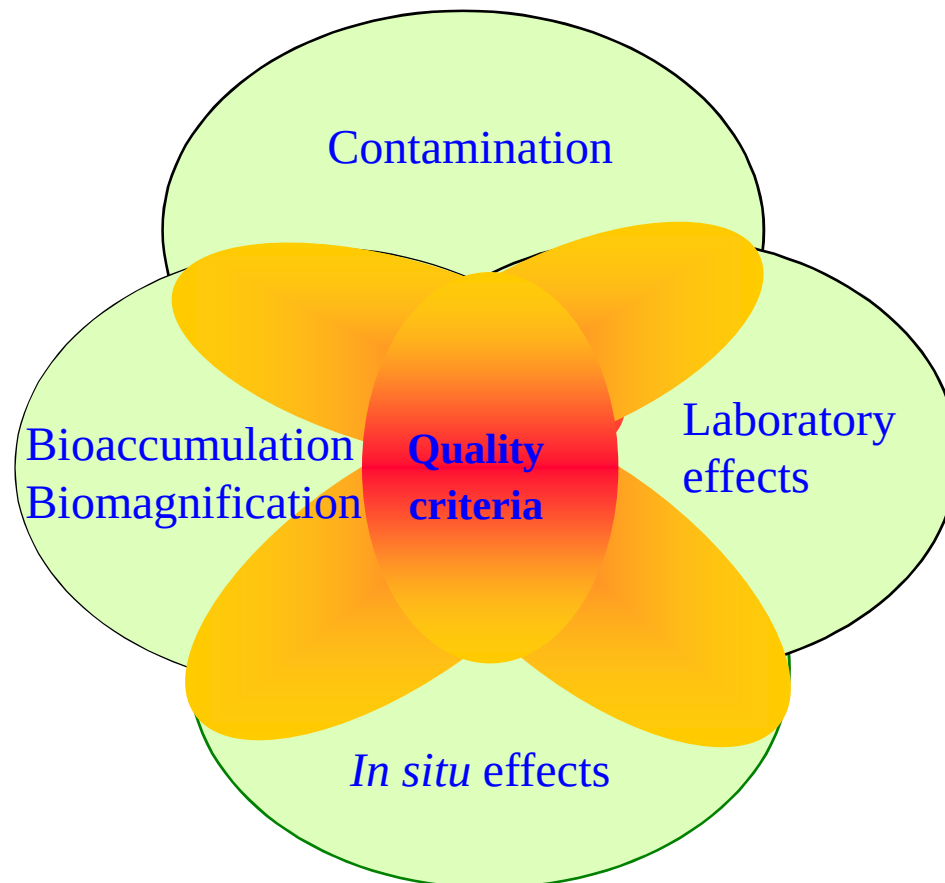


Indicators and indices of vulnerability of coastal areas: The use of WOE for risk assessment

DeValls (angel.valls@uca.es)

- Definition of WOE
- Description of LOEs and Index
- Application to Case studies
 - Mining spill
 - Dredged material
 - Carbon Capture & Storage

The treatment of the data obtained synoptically (figure) gives a global and realistic view of the state of the environment and allow to identify degraded zones and zones free of anthropogenic influence, and to determine environmental quality criteria (contaminant concentrations associated and not associated to biological damage). This is done using **multivariate statistics**.



What contaminants?

What levels?

What biological effects?

ECOSYSTEM HEALTH

-Quantification of pollution

- Quality values

Bioaccumulation/Biomagnification
of contaminants?

HUMAN HEALTH

-Tissue quality values

Sediment contaminant concentration and its availability are related to its physico-chemical parameters. For the correct evaluation of the potential environmental risk of these substances this information is necessary:

- Granulometry
- Total Organic Carbon (TOC)
- Acid volatile sulphide (AVS)
- Total content of metals: Fe, Mn, As, V, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Sn, Co and Zn.
- Metal speciation
- Organic compounds: PCBs, PAHs and others (TBTs etc.)

Toxicity bioassays developed in laboratory

Organism	Exposition route	T (°)	Duration	Enspoint
<i>Corophium volutator</i> <i>Ampelisca brevicornis</i> <i>Gammarus locusta</i> (adult amphipod)	Solid Phase	20	10 -28 days	Survival (%) Reproduction (%)
<i>Vibro fischeri</i> (bacteria population)	Solid Phase Liquid Phase	15	15 min-1h	Inhibition of the luminescence
<i>Echinocardium cordatum</i> (adult sea urchin)	Solid Phase	15	14 days	Survival (%)
<i>Arenicola marina</i> (adult polichaete)	Solid Phase	15	10 day 28 days	Survival (%) Bioaccumualtion
<i>Ruditapes philippinarum</i> (juvenile clams) Larvae calms	Solid Phase Liquid Phase	15	48h-15 days	Survival (%) Burrowing activity(TE50) Biomarkers Bioaccumulation Histological damage
<i>Brachionus plicatilis</i> (rotifer population)	Liquid Phase	25	7 days	Population decrease (TL50)
<i>Paracentrotus lividus</i> <i>Arbacia lixula</i> <i>Spharequinus granularis</i> (sea urchin embryos)	Liquid Phase (elutriate)	20	48 h	Embryo development (EC50)
<i>Sparus aurata</i> (Juvenile pelagic fish)	Solid Phase	20	1-3 months	Survival (%) Bioaccumulation Histological damage ELISA
<i>Solea senegalensis</i> (juvenile flat fish)	Solid Phase	20	1-3 months	Survival (%) Burrowing activity (TE50) Bioaccumulation Histological damage
<i>Carcinus maenas</i> (adult crab)	Solid Phase	15	21 days-3 months	Survival (%) Histological damage biomarkers

Bioassay using amphipods



Different species:

- *Ampelisca brevicornis*
- *Corophium volutator*
- *Gammarus locusta*



**12h settle
+
12h aerate**



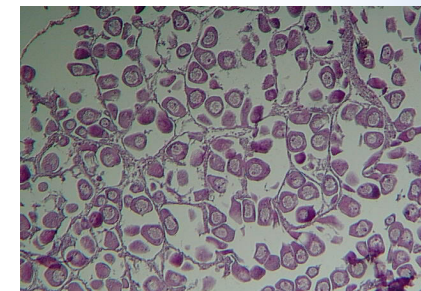
**Sediment sample + clean
sea water**

**20 organisms each replicate
and minimum 3 replicates
each sample**

**10 days: survival
28 days: reproduction and
survival**

Measured biomarkers

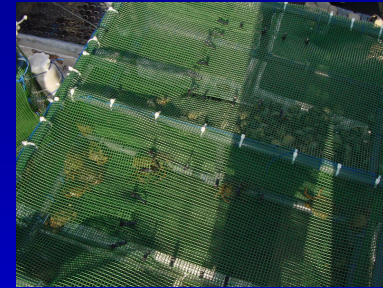
BIOMARKER	DESCRIPTION
Metallothioneins	Its induction indicates exposition to metals
GSH	It determines the total concentration of glutathione, a natural antioxidant
DNA damage	It detects breaks in single chain DNA
EROD	It determines Ethoxiresorufin-O-deethylase, enzyme present in phase I of the detoxification.
CAT	It detects the antioxidant enzyme catalase.
SOD	It detects dismutase superoxidase, antioxidant enzyme.
GR	It detects the glutathione reductase, antioxidant enzyme.
GPX	It detects the glutathione peroxidase, antioxidant enzyme
GST	It detects glutathione transferase, enzyme present in phase II of detoxification
LPO	It determines the level of determined substances produced during lipidic peroxide breaks that react with thiobarbituric
Vitellogenine/vitelline	Its induction indicates the exposition to endocrine disruptors.



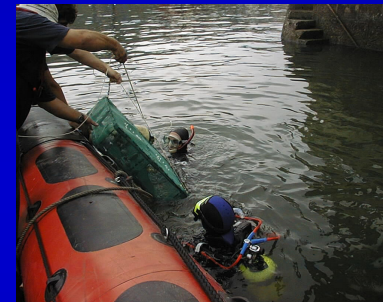
in situ EFFECTS

- Toxicity bioassays using caged organisms
 - Biomarkers
 - Histopathology
- Studies of benthic macrofauna

Toxicity bioassay using *Carcinus maenas* and *Ruditapes philippinarum* in situ



Organisms are shipped from the laboratory to the field in coolers.



Cages are divided in two different zones to maintain the crabs, *Carcinus maenas* (24 each cage) in one side and the clams, *Ruditapes philippinarum* (50 each cage) in the other side. Cages are fixed to the bottom in duplicate each sampling zone.



BIOACCUMULATION / BIOMAGNIFICATION

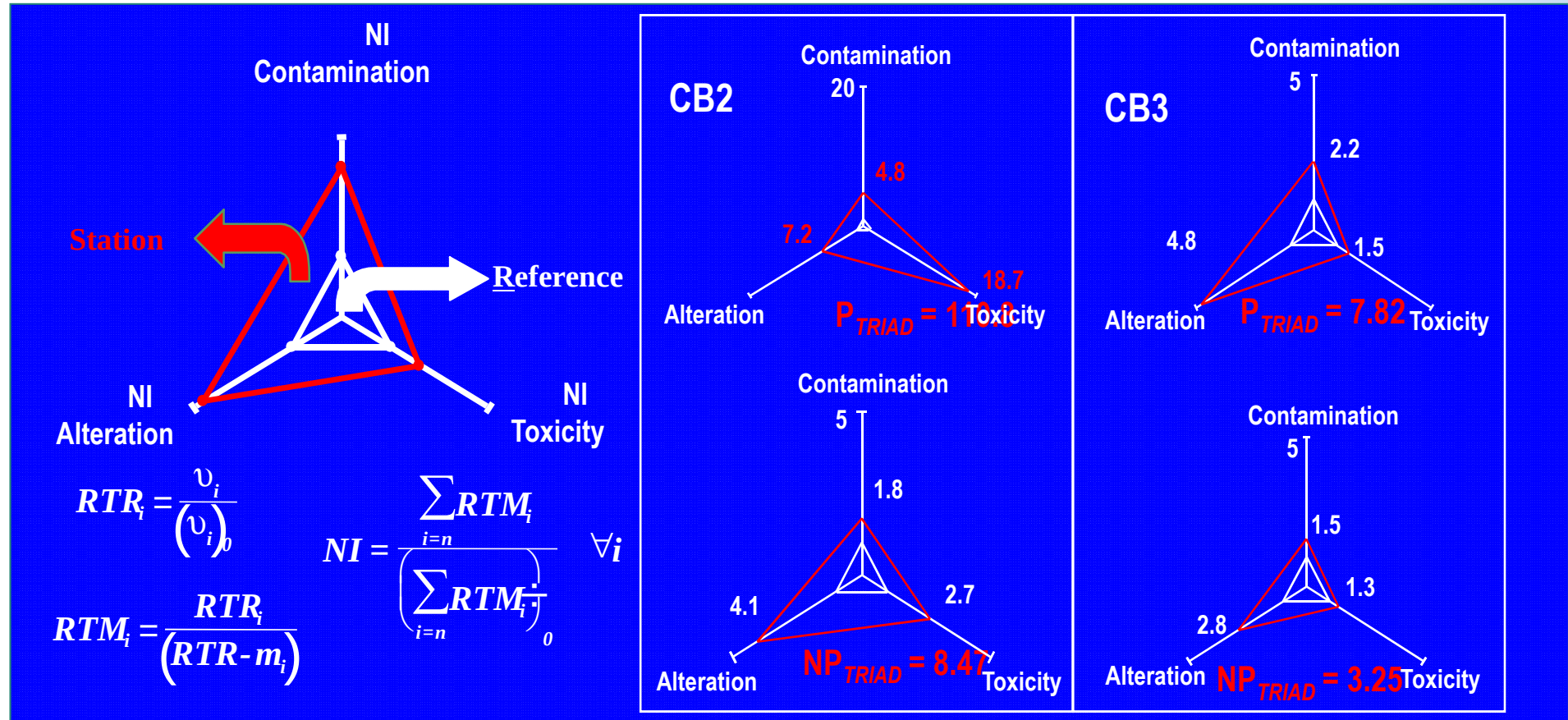
The relationship between concentration of contaminants in tissues and toxic effects measured in organisms is receiving increased attention during the last decades.

These relationships MAY have as a final aim to derive tissue quality guidelines (TQGs) defined as the concentrations of the chemicals measured in the different tissues that are associated or not with the biological effect measured in a parallelism with the sediment quality guidelines (SQGs) widely used around the world.

To identify possible toxic agent(s), requires body burden data collected from the same organisms exhibiting toxicity in a weight of evidence evaluation, which is deeply explained then.

INTEGRATED METHODS: Triaxial method

POLLUTION INDEX are calculated using contamination, alteration and toxicity data.

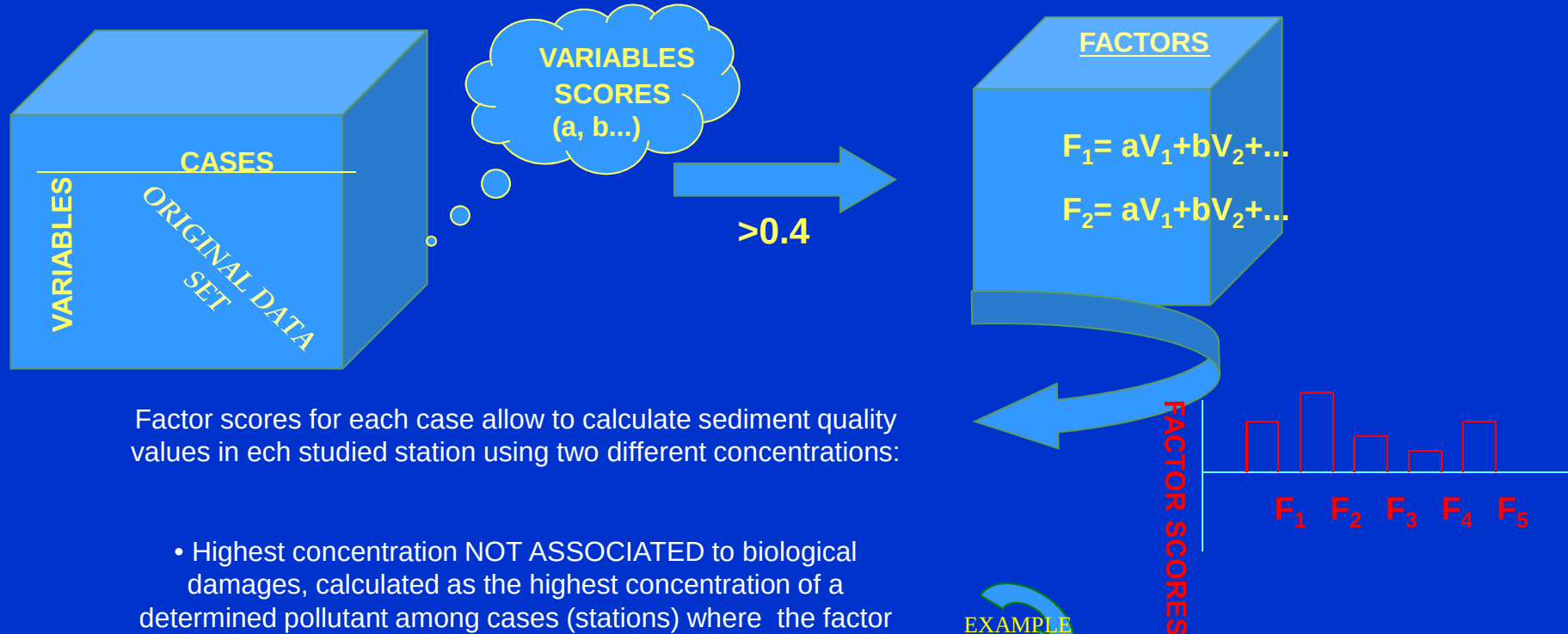


Del Valls TA, JM Forja & A Gómez-Parra. An integrative assessment of sediment quality in two littoral ecosystems from the Gulf of Cádiz. *Environmental Toxicology and Chemistry*, 17, 1073-1084, 1998.

Del Valls TA & PM Chapman. Advances in marine ecotoxicology: The use of integrative assessments (SQT) to evaluate environmental quality. *Okeanologiya*, en prensa.

MULTIVARIATE ANALYSIS

PRINCIPAL COMPONENT EXTRACTION PROCEDURE



Factor scores for each case allow to calculate sediment quality values in each studied station using two different concentrations:

- Highest concentration NOT ASSOCIATED to biological damages, calculated as the highest concentration of a determined pollutant among cases (stations) where the factor scores associated with biological effect are ≤ 0 .
- Lowest concentration ASSOCIATED to biological damage, calculated as the lowest concentration of a determined pollutant among cases (stations) where the factor scores associated with biological effect are ≤ 0 .

EXAMPLE

	Absence or minimum biological effect	Proved biological effect	Uncertainty area
Cr	< 86.2	> 90.2	> 86.2 < 90.2
Cd	< 0.94	> 1.24	> 0.94 < 1.24
Pb	< 51.2	> 52.5	> 51.2 < 52.5
Ag	< 0.64	> 0.68	> 0.64 < 0.68
Cu	< 49.4	> 71.2	> 49.4 < 71.2

The Guadalquivir estuary and the Aznalcóllar mining spill



- On 25th April 1998 the Park and the estuary were impacted by the release of 7 10⁶ m³ of acid water and mud.
- from the processing of pyrite ore, and was rich in toxic metals.

ELEMENT	CONCENTRATION(%)
Zinc	0.8
Lead	0.8
Copper	0.2
Cadmium	0.0025
Iron	34-37



Chemical		sediment quality guideline		
		"Not Polluted"	"Moderately polluted"	"Highly polluted"
Cu	A)	< 25	25-50	> 50
	B)	< 15	15-114	> 114
	C)	< 70	70-390	> 390
	D)	---	*	> 390
Pb	A)	< 40	40-60	> 60
	B)	< 23	31	> 250
	C)	< 35	35-110	> 110
	D)	---	*	> 450
Ag	C)	1.0	1.0-2.2	> 2.2
Cr	A)	< 25	25-75	> 75
	B)	< 22	22-111	> 111
	C)	< 80.0	80-145.0	> 145.0
Hg	A)	< 1.0	---	> 1.0
	B)	< 0.12	0.12-2.0	> 2.0
	C)	< 0.15	0.15-1.3	> 1.3
	D)	---	*	> 0.41
Ni	A)	< 1.0	< 1.0	< 1.0
	B)	< 0.1	< 0.1	< 0.1
	C)	< 0.15	<	< 0.15
Zn	A)	< 90	90-5	> 200
	B)	< 65	65-800	> 800
	C)	< 120	120-270	> 270
	D)	---	*	> 410
As	A)	< 3	3-8	> 8
	B)	< 4	4-33	> 33
	C)	< 33	33-85	> 85
	D)	---	*	> 57
PCB _T	B)	< 0.020	0.020-0.041	> 0.041
DDT _T	B)	< 5	5-9	> 9
	C)	< 1	1-7	> 7

A) United States Environmental Protection Agency (Army Corps., 1977)

B) Ontario Ministry of Environment (Persaud *et al.*, 1989)

C) National Oceanic and Atmospheric Administration (Long & Morgan, 1991);³

D) Washington State (WADOE, 1991).



Contaminants	Value descriptions		
	No or minimal adverse biological effects	Major adverse biological effects	Area of uncertainty
LAS	≈ 12.8	≈ 62.0	$12.8 < c < 62.0$
Pb	≈ 66.8	≈ 84.6	$66.8 < c < 84.6$
Ag	≈ 1.2	≈ 1.3	$1.2 < c < 1.3$
Cr	≈ 101.2	≈ 283.9	$101.2 < c < 283.9$
Hg	≈ 0.46	≈ 0.57	$0.46 < c < 0.57$

ESTACIONES

		1	2	4	5	6	7	8	gr1	gr4	gr6
Pb											
A	60	0,57	0,48	0,47	0,47	0,56	0,47	0,50	0,60	0,64	0,96
B	250	0,14	0,11	0,11	0,11	0,14	0,11	0,12	0,14	0,15	0,23
C	110	0,31	0,26	0,26	0,26	0,31	0,26	0,28	0,33	0,35	0,52
D	450	0,08	0,06	0,06	0,06	0,08	0,06	0,07	0,08	0,09	0,13
E	84,6	0,41	0,34	0,33	0,33	0,40	0,33	0,36	0,42	0,45	0,68
Zn											
A	200	0,72	0,83	1,47	1,69	1,98	1,26	1,68	3,72	0,89	1,39
B	800	0,18	0,21	0,37	0,42	0,49	0,31	0,42	0,93	0,22	0,35
C	270	0,53	0,62	1,09	1,25	1,47	0,93	1,24	2,75	0,66	1,03
D	410	0,35	0,41	0,72	0,83	0,96	0,61	0,82	1,81	0,43	0,68
E	225	0,64	0,74	1,31	1,51	1,76	1,12	1,49	3,30	0,79	1,23
Cu											
A	50	1,43	0,37	0,85	1,08	0,26	0,30	0,33	0,84	0,99	1,05
B	114	0,63	0,16	0,37	0,47	0,12	0,13	0,15	0,37	0,43	0,46
C	390	0,18	0,05	0,11	0,14	0,03	0,04	0,04	0,11	0,13	0,13
D	390	0,18	0,05	0,11	0,14	0,03	0,04	0,04	0,11	0,13	0,13
E	98	0,73	0,19	0,43	0,55	0,13	0,15	0,17	0,43	0,50	0,54
Cd											
A	6	0,13	0,10	0,14	0,10	0,23	0,13	0,14	0,51	0,21	0,15
B	9	0,08	0,06	0,09	0,07	0,15	0,09	0,10	0,34	0,14	0,10
C	10	0,08	0,06	0,08	0,06	0,14	0,08	0,09	0,31	0,13	0,09
D	5,1	0,15	0,11	0,16	0,12	0,27	0,15	0,17	0,60	0,25	0,18

A US Army Corps of Engineers, 1977; bioensayos específicos de toxicidad;

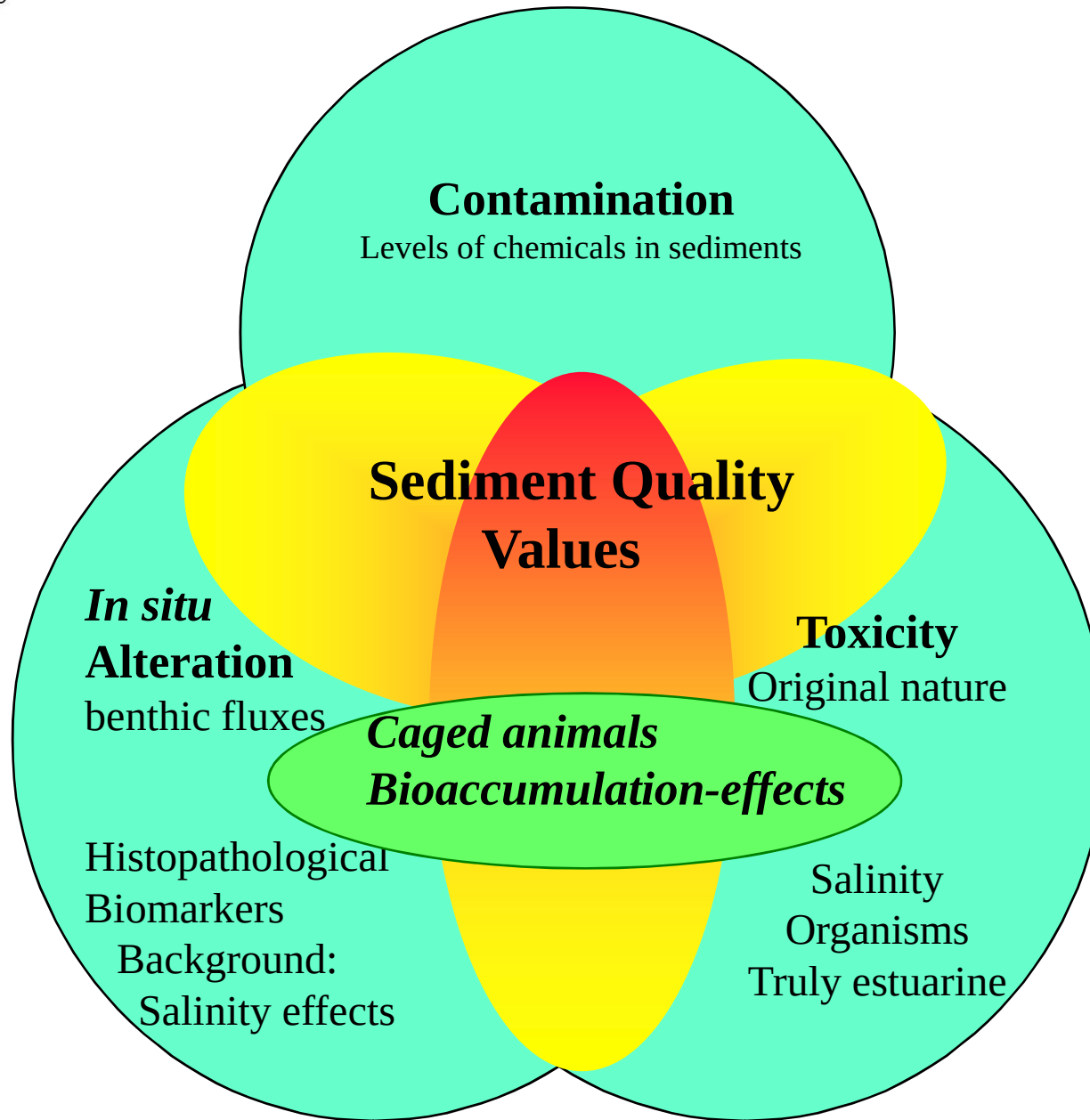
B USEPA (Persaud et al., 1989); bioensayos específicos de toxicidad

C Ministerio de Medio Ambiente (Ontario, Canada); Nivel de concentración Screening (SLC)

D Estado de Washington (WADOE, 1991); combinación AET y EqP

E Bahía de San Francisco y Golfo de Cádiz,

DeValls y Chapman (1998); Triad

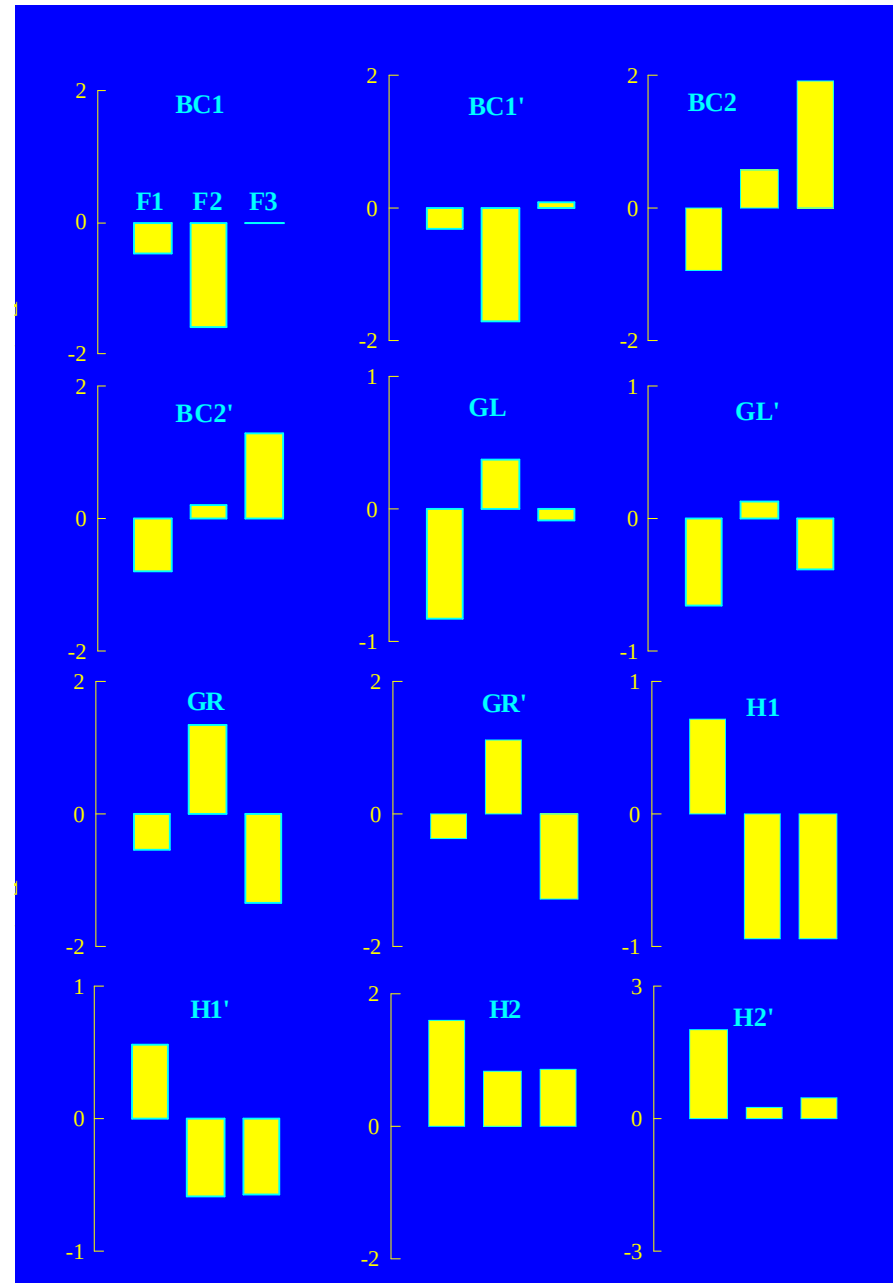


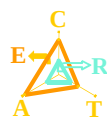
→ MAA

F1 (75%): Pollution.
 Contamination (metals, PAHs),
 toxicity, histological damage and
 bioaccumulation

F2 (8%): Biological effects and
 bioaccumulation of Cd. Sequel of
 mining spill

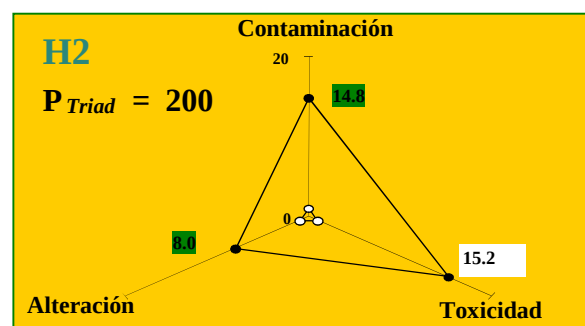
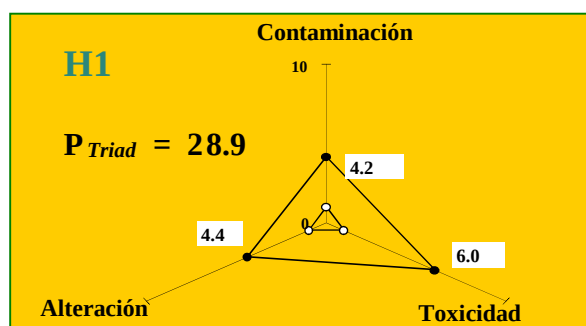
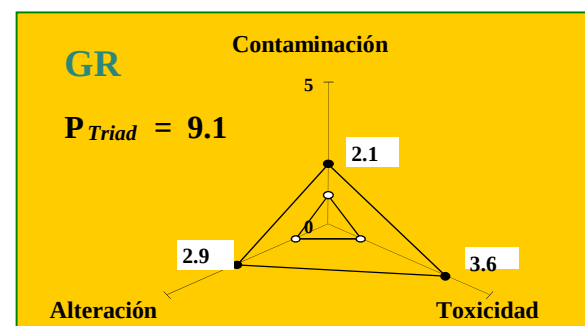
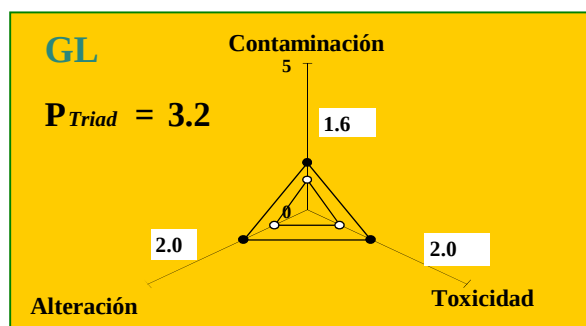
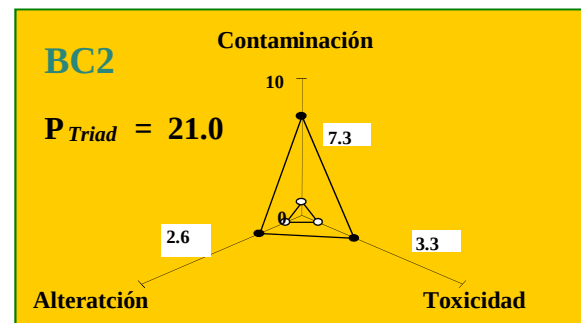
F3 (7.9%): Not pollution: Organic
 contamination. Not effects.



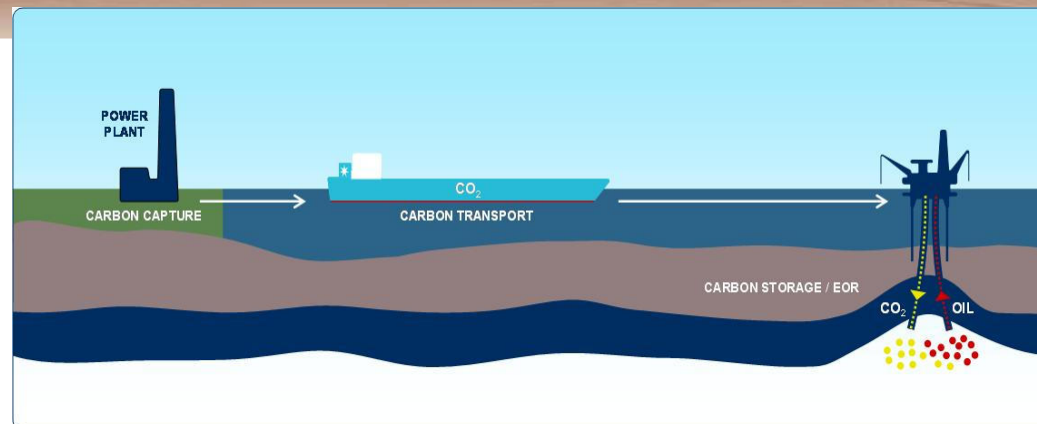
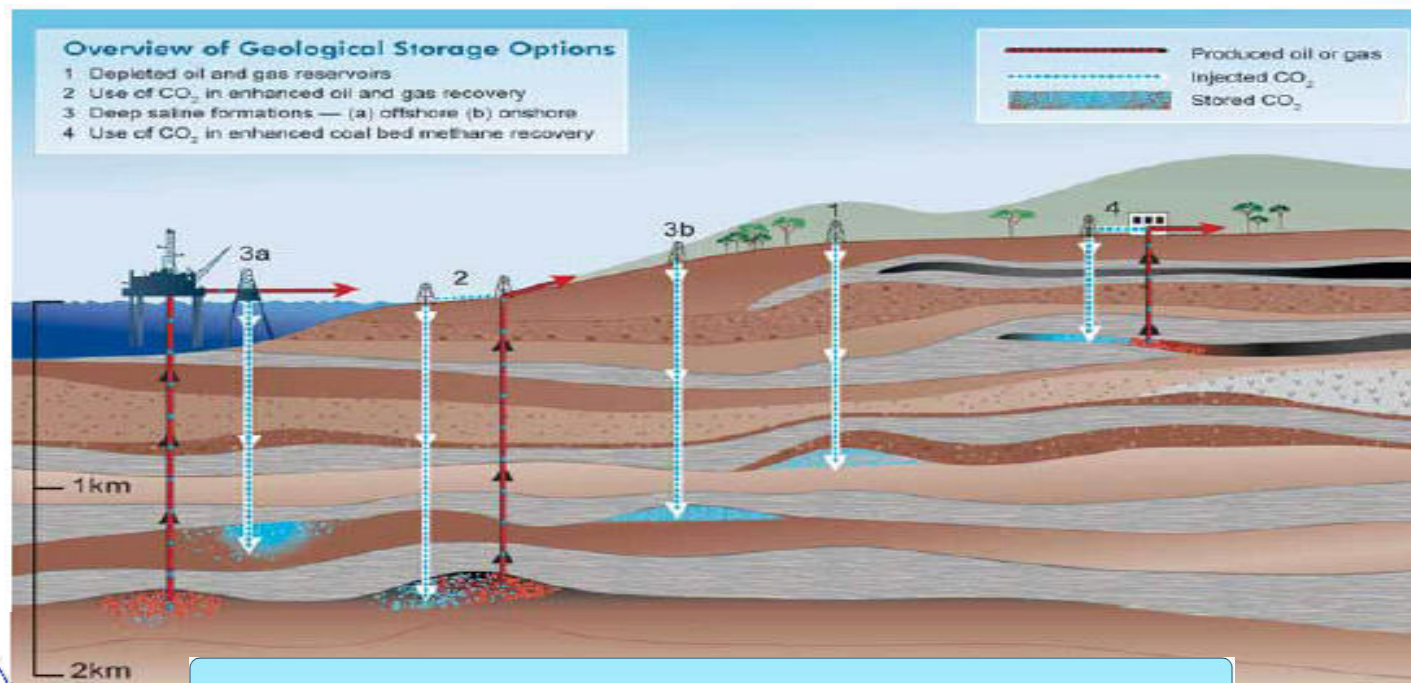


Classic method

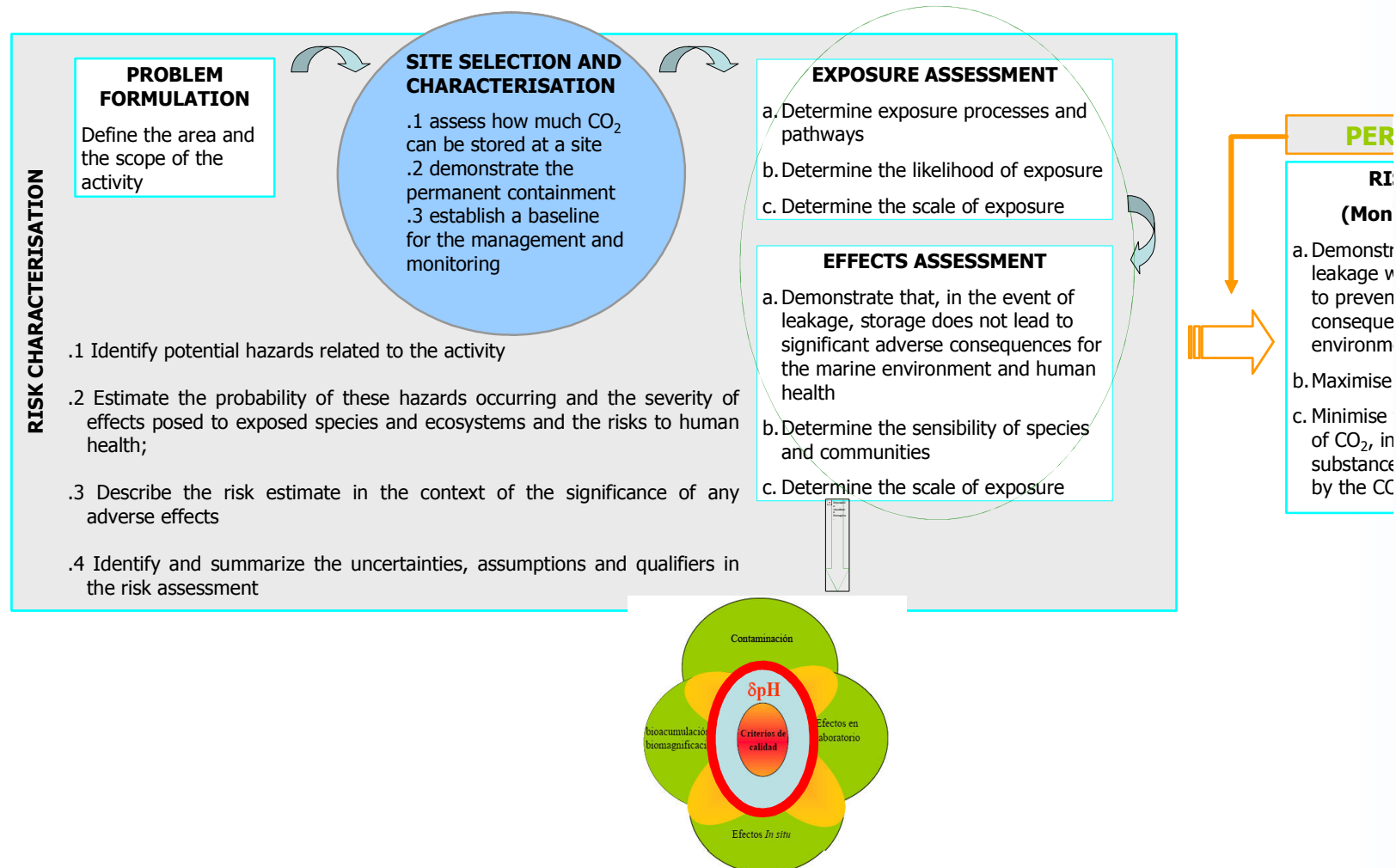
Index of pollution



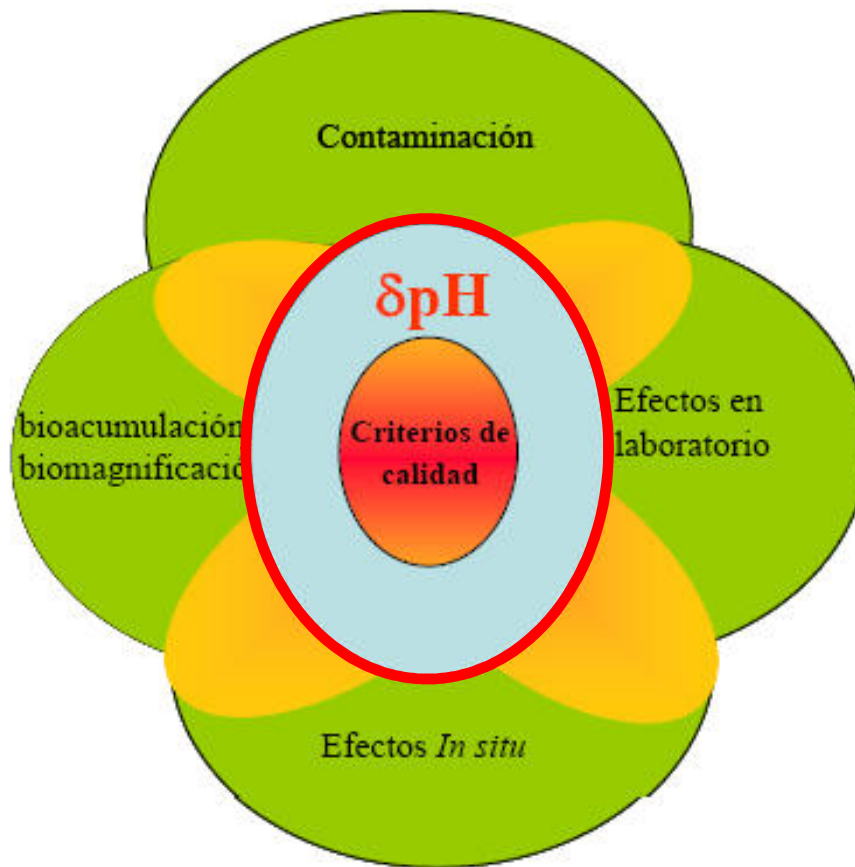
Environmental Effects associated with the storage and placement of CO₂ in marine geological structures. Ministry of Environment (Spain). London, OSPAR and Barcelona Conventions



Basic steps for Risk Assessment for geological storage



WEIGHT OF EVIDENCE APPROACH



Acidification of the environment



pH variation in LOEs

What contaminants?

What levels?

What biological effects?

ECOSYSTEM HEALTH

Quantification of pollution

Quality values

Bioaccumulation/Biomagnification of
contaminants?

HUMAN HEALTH

-Tissue quality values

Influence of sediment acidification on the bioaccumulation of metals in *Ruditapes philippinarum*

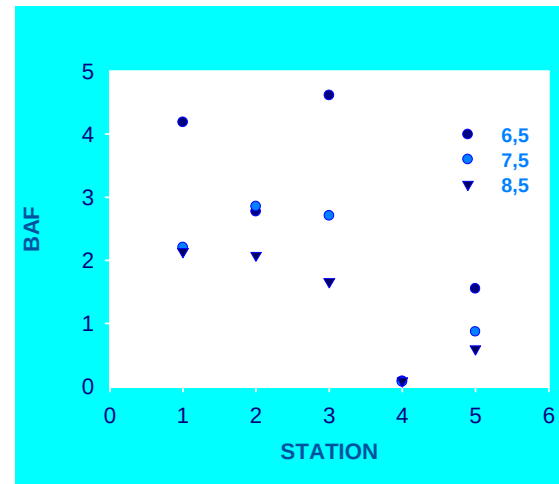
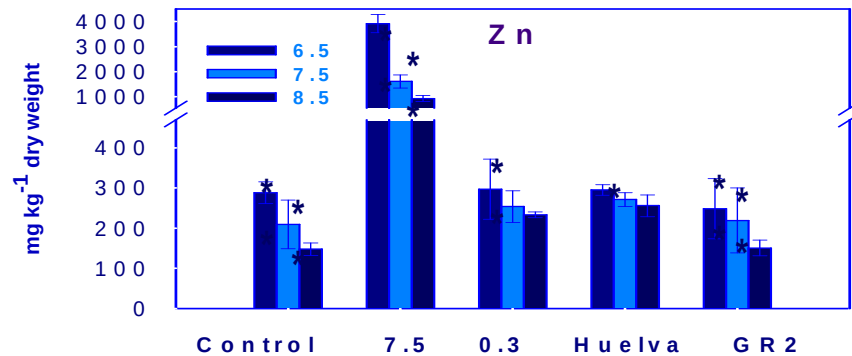
Inmaculada Riba · Judit Kalman · Carlos Vale ·
 Julián Blasco

Bioaccumulation, species at different pH (5.5,6.0,6.5,7.0,7.5,8.0-8.5)

SPECIES

- *Carcinus maenas*
- *Ruditapes philippinarum*
- *Arenicola marina*
- *Corophium volutator*
- *Ampelisca brevicornis*
- *Gammarus locusta*
- *Solea senegalensis*
- *Sparus aurata*

Ruditapes philippinarum



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http://www2.uca.es/facultad/ciencias_mar/menu_lateral/menu_lateral_paginas/revistaccmarinas.html

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