The use of multiple lines of evidences to conduct risk assessment in sediments affected by CO_2 acidification

Manoela R. de Orte, Ángel DelValls, Augusto Cesar and Inmaculada Riba

PICES

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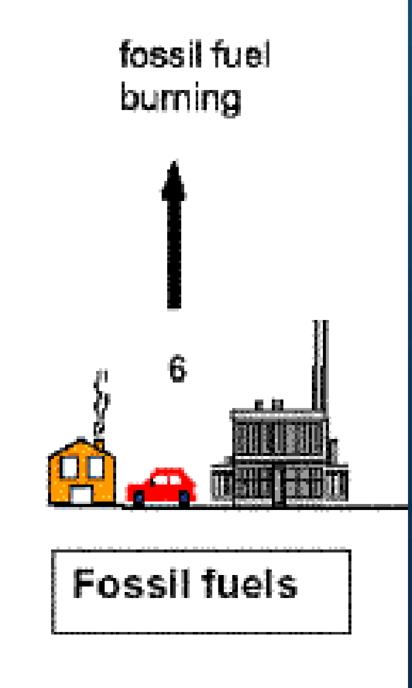
CAPES

Concentration of atmospheric CO_2: 402.68 ppm (Mauna Loa, July 2014)

"Unprecedented concentration in the recent planet history (human)"

Related to fossil fuel use



Urgent need to reduce emissions

Options to reduce emissions

- Change of combustibles (other than fuels)
- Improve energy efficiency
- Use of renewable and nuclear energy
- Increase of biological sinks of CO_2
- **Capture and storage of CO_2**

Until 2100, it can contribute among 15 and 55 % of the world mitigative effort (IPCC 2005).

CO_2 Capture and storage (CCS)

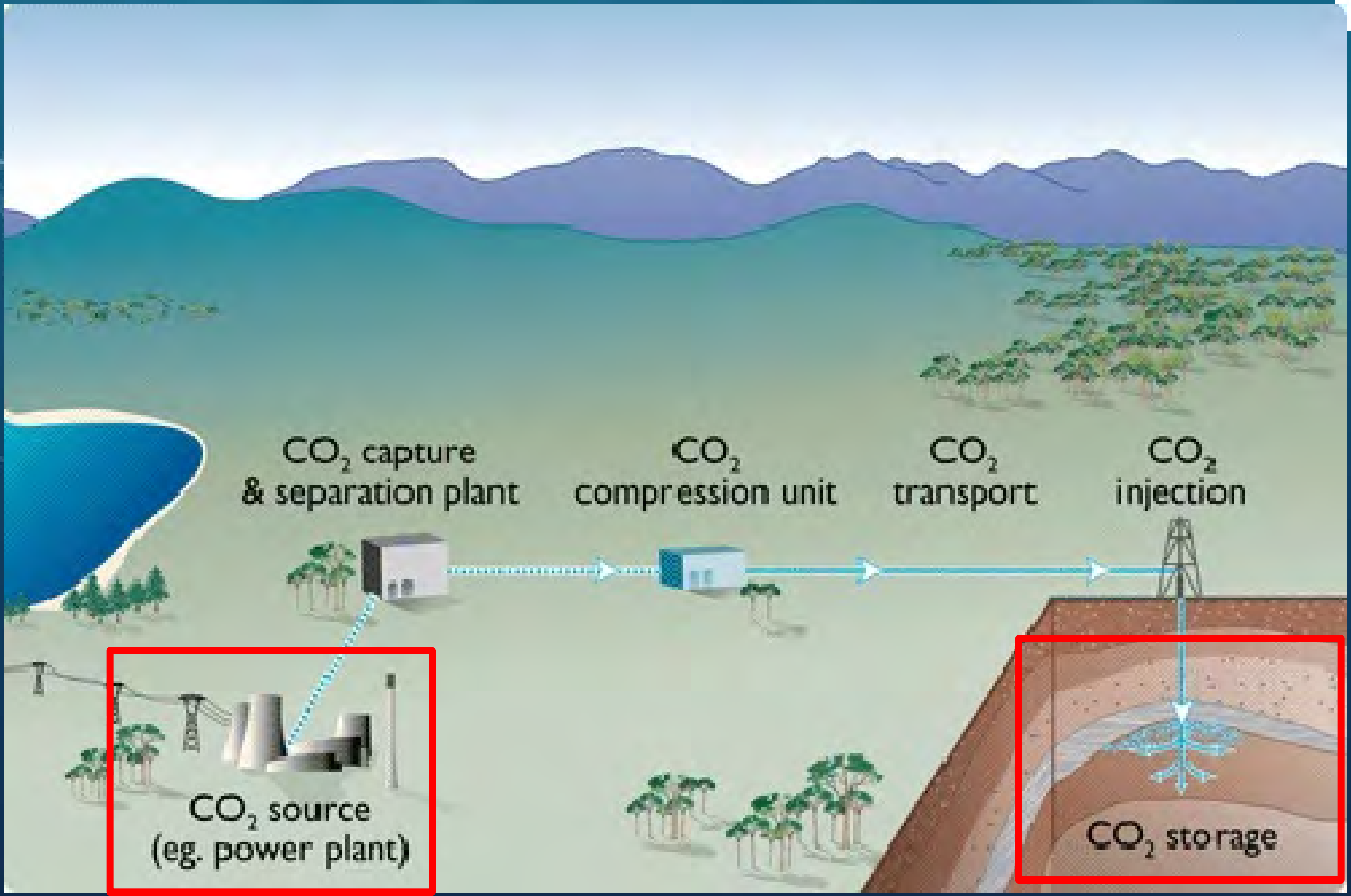
-**Ocean storage:** direct dumping of CO2 in the water column or on the deep sediment

-**Mineral carbonation:** industrial fixation of CO_2 to inorganic carbonates

-**Industrial uses:** instead of fuel use of CO_2 in chemical processes

-**Biological sequestration:** by primary production using microalgae

-**Geological storage:** e.g. deplete oil and gas reservoirs, deep saline formations, etc.



- **Deplete oil and gas reservoirs**
- **Deep Saline formations**

CO_2 geological storage

Several ongoing projects → Need to be regulated

The worldwide capacity of potential CO2 storage reservoirs

Ocean and land-based sites together contain an enormous capacity for storage of CO_2[a]. The world's oceans have by far the largest capacity for carbon storage.

Sequestration option	Worldwide capacity[b]
Ocean	1000s GtC
Deep saline formations	100s–1000s GtC
Depleted oil and gas reservoirs	100s GtC
Coal seams	10s–100s GtC
Terrestrial	10s GtC
Utilization	<1 GtC/yr

[a] Worldwide total anthropogenic carbon emissions are ~7 GtC per year (1 GtC = 1 billion metric tons of carbon equivalent).

[b] Orders of magnitude estimates.

Herzog, 2001

Global CCS MAP, October 2014
http://www.sccs.org.uk/expertise/global-ccs-map

Conventions for the Protection of the Marine Environment

Consistency agreement among conv.

- **LONDON CONVENTION AND PROTOCOL**

  In November 2006 the text of the convention was amended to allow the storage of CO_2 in marine geological structures

  Framework and waste assessment guideliness for CO_2 sequestration developed

- **OSPAR CONVENTION**

  In June 2007, the text of the convention was amended to allow the storage of CO_2 in marine geological structures, **and <u>oblies the contract countries to apply the risk assessment and management guidelines formulated by the convention.</u>**

- **EUROPEAN COMISSION**

  A new EU Directive on CCS has been adopted in Dec. 2008.

Unitwin: Wicop

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CO_2 geological storage

LEAKAGE FROM THE STORAGE

- Short term: mainly during operation

  Risk of leakage of what fills the pore space in the formation: natural gas (mainly methane) and formation waters (mainly seawater) (Wallman, 2008)

- Long term: mainly post operation

  Risk of leakage of CO_2 and associated substances

CO_2 geological storage

MAIN IMPACTS IN THE ENVIRONMENT

$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow CO_3^{2-} + 2H^+$
$CO_2 + H_2O + CO_3^{2-} \leftrightarrow 2HCO_3^-$

OCEAN ACIDIFICATION

CO2 LEAKAGE: ≈ 5.1
(EL Hierro- CANARY ISLAND)

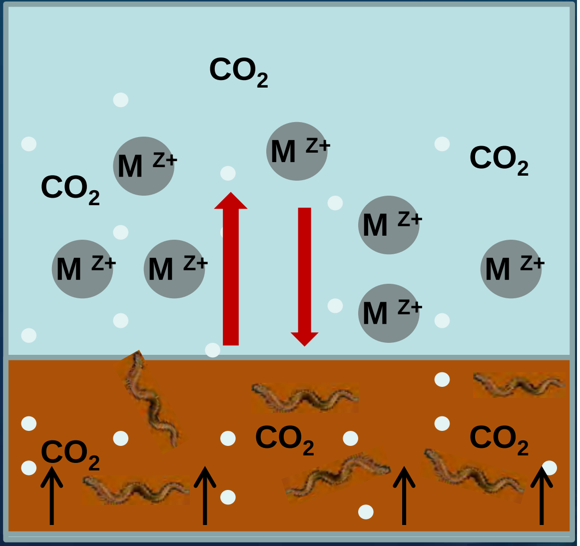
CO_2 geological storage

MAIN IMPACTS IN THE ENVIRONMENT

DIRECT EFFECTS → Acidosis
Hypercapnia
Asphyxiation

INDIRECT EFFECTS → MOBILITY OF METALS

- BIOAVAILABILITY
- TOXICITY



Basic steps for Risk Assessment for geological storage

1. PROBLEM FORMULATION

2. SITE SELECTION AND CHARACTERISATION

3. EXPOSURE ASSESSMENT

4. EFFECTS ASSESSMENT

5. RISK CHARACTERISATION

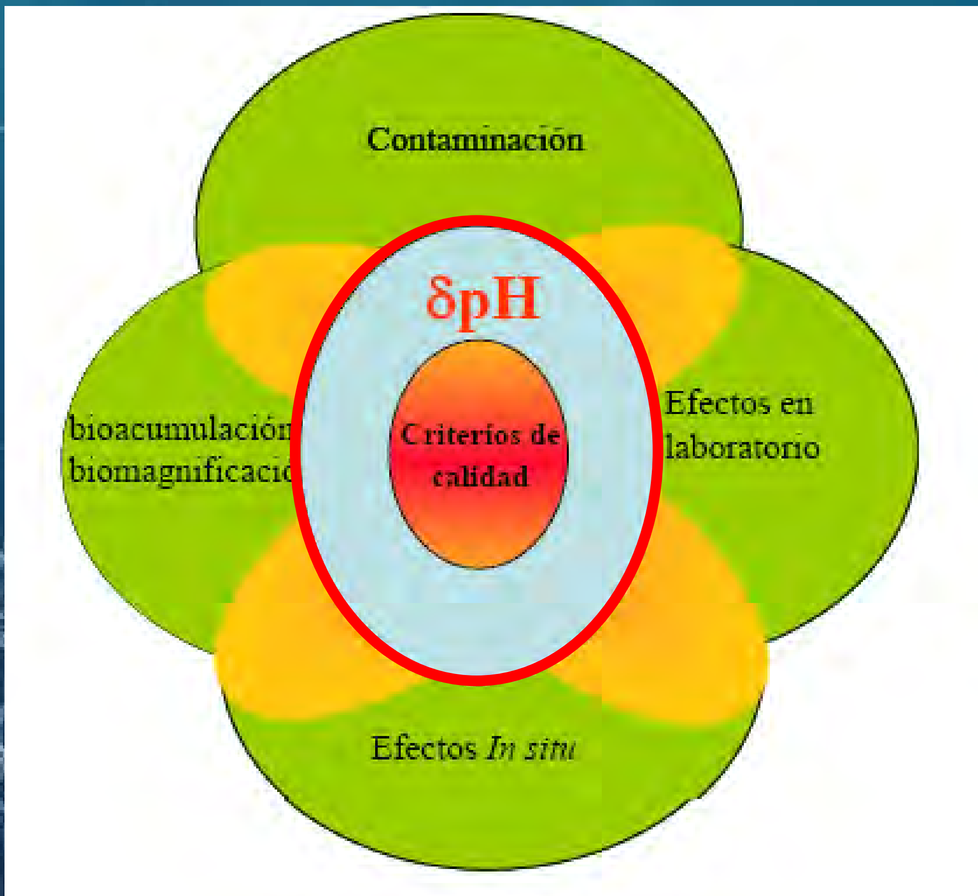
6. RISK MANAGEMENT

Determine the sensibility of species and communities

Determine the scale of exposure

Significant adverse consequences in the marine environment and human health

WEIGHT OF EVIDENCE APPROACH



What contaminants?

What levels?

What biological effects?

ECOSYTEM HEALTH

Quantification of pollution

Quality values

Bioaccumulation/Biomagnification of contaminants?

HUMAN HEALTH

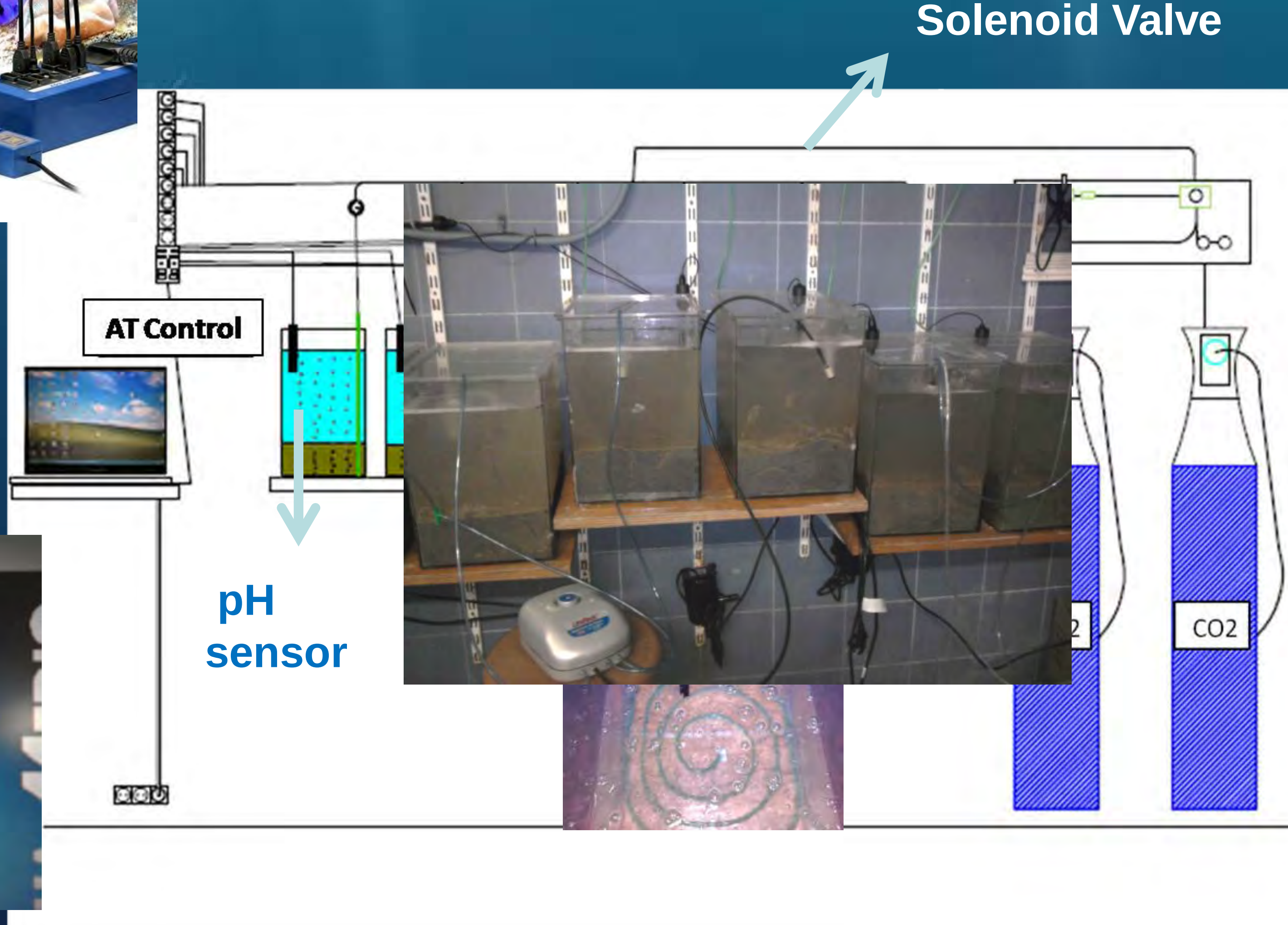
-Tissue quality values

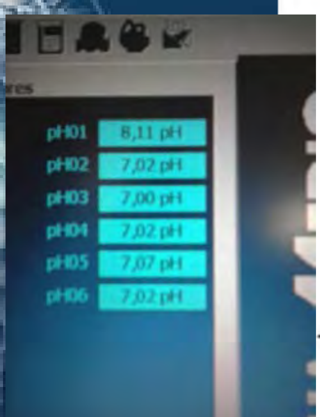
Acidification of the environment

↓

pH variation in LOEs

Designed CO_2 injection system: patented #201200753 (9/2013)





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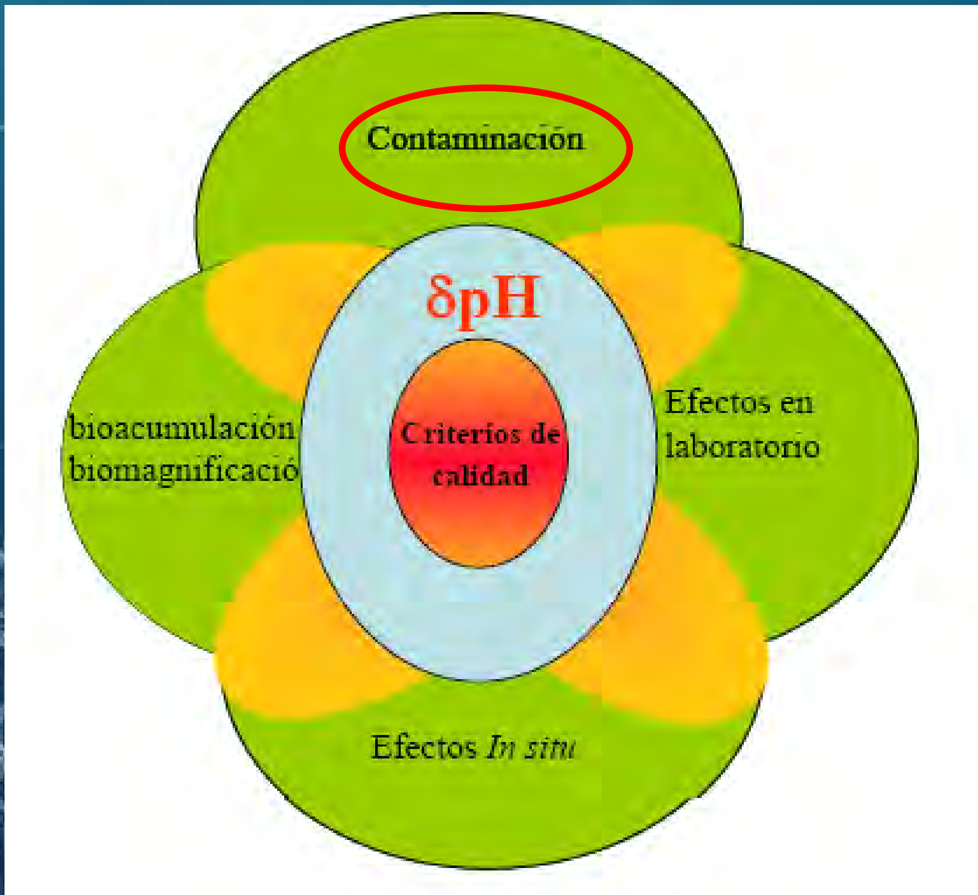

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Marine Pollution Bulletin 86 (2014) 59–67
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Marine Pollution Bulletin
journal homepage: www.elsevier.com/locate/marpolbul
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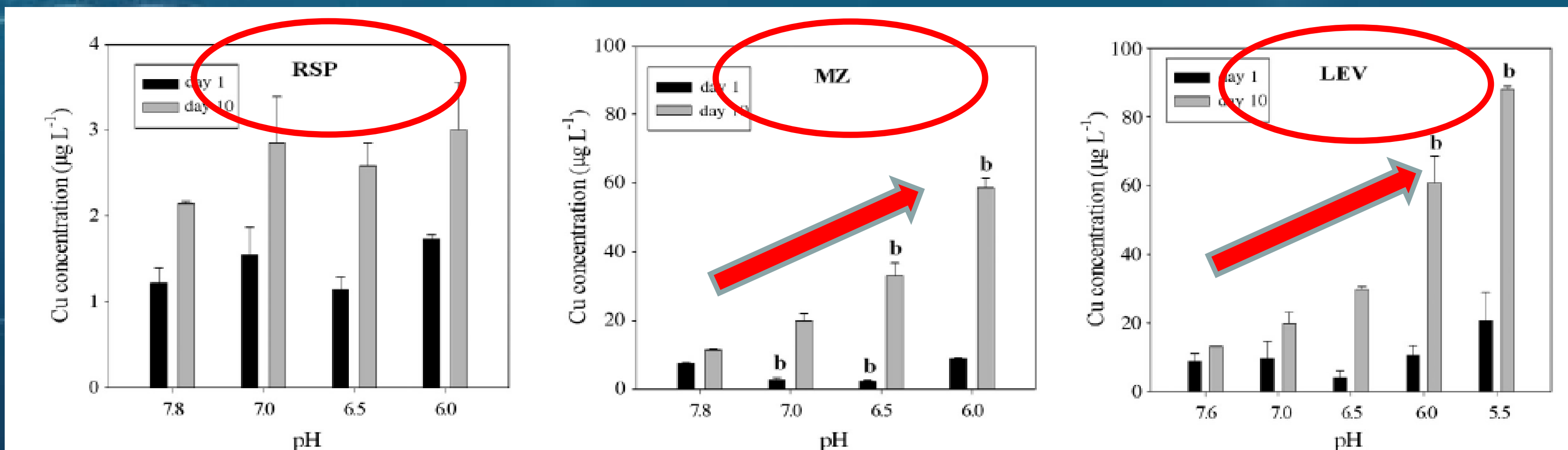
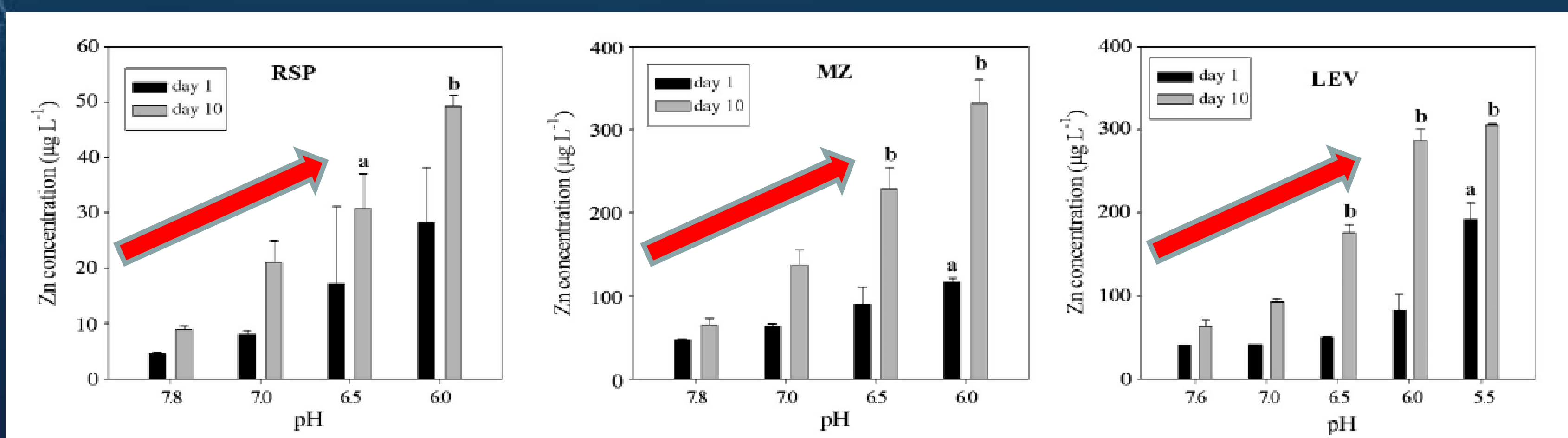
Simulation of the potential effects of CO_2 leakage from carbon capture and storage activities on the mobilization and speciation of metals

Manoela Romanó de Orte[a,*], Aguasanta M. Sarmiento[b], T. Ángel DelValls[a], Inmaculada Riba[a]





Science of the Total Environment 470–471 (2014) 356–363

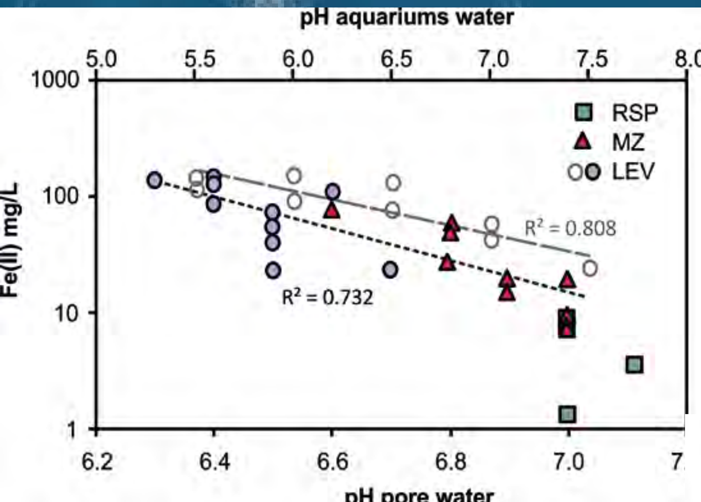
Contents lists available at ScienceDirect

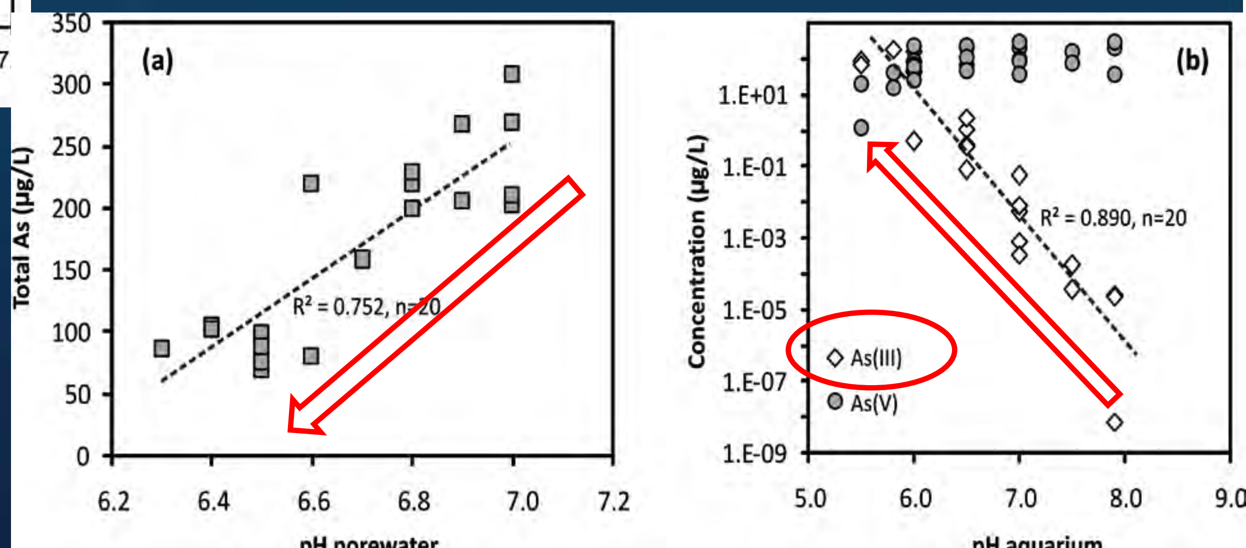
Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Effects on the mobility of metals from acidification caused by possible CO_2 leakage from sub-seabed geological formations

Manoela Romanó de Orte [a], Aguasanta M. Sarmiento [b,*], Maria Dolores Basallote [a], Araceli Rodríguez-Romero [a], Inmaculada Riba [a], Angel delValls [a]





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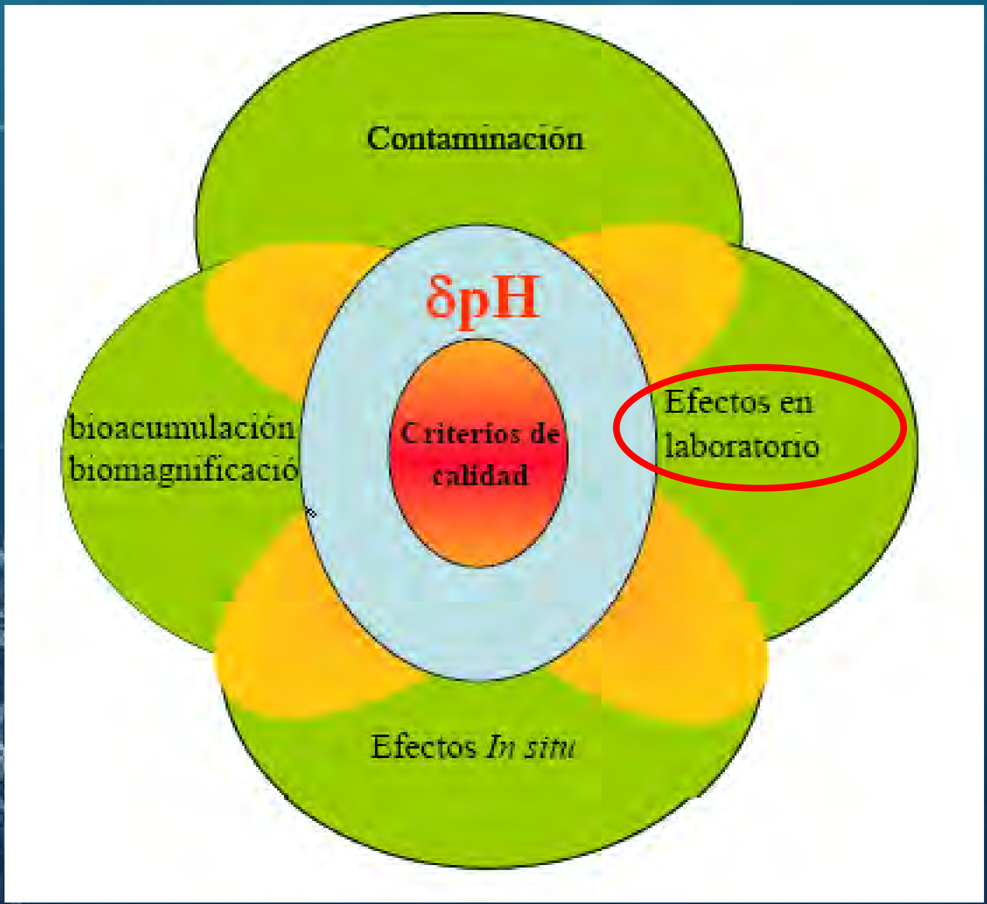

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Environmental Science & Technology

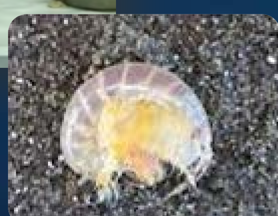
Article

pubs.acs.org/est

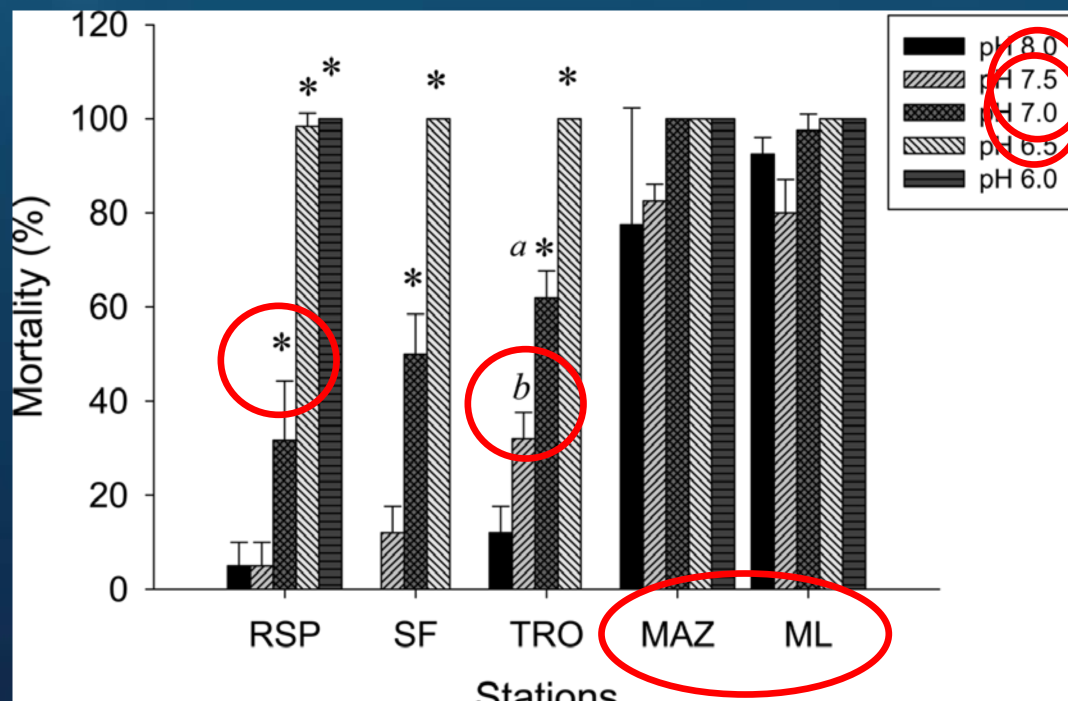
Studying the Effect of CO_2-Induced Acidification on Sediment Toxicity Using Acute Amphipod Toxicity Test

M. Dolores Basallote,*[,†] Manoela R. De Orte,[†,‡] T. Ángel DelValls,[†] and Inmaculada Riba[†]

[†]Cátedra UNESCO/UNITWIN WiCop. Departamento de Química-Física, Facultad de Ciencias del Mar y Ambientales, Universidad de Cádiz, Polígono Río San Pedro s/n, Puerto Real, Cádiz 11510, Spain



Ampelisca brevicornis



[ ] Metals in sediments

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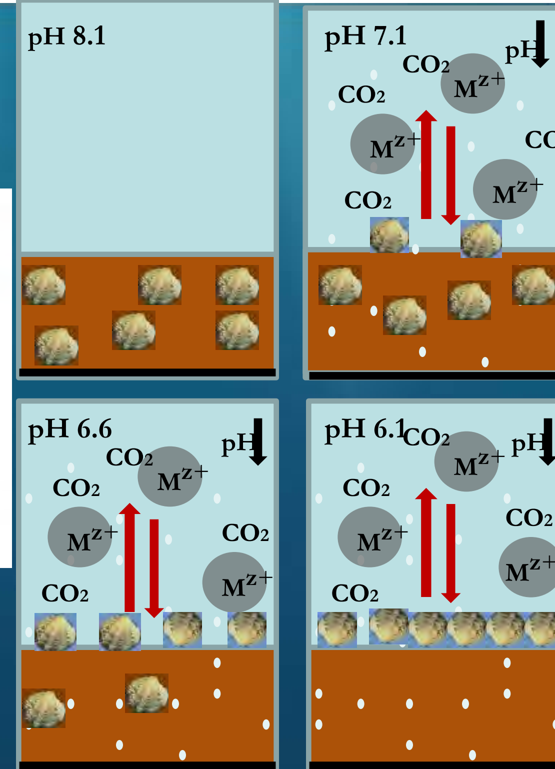
Environmental Science & Technology

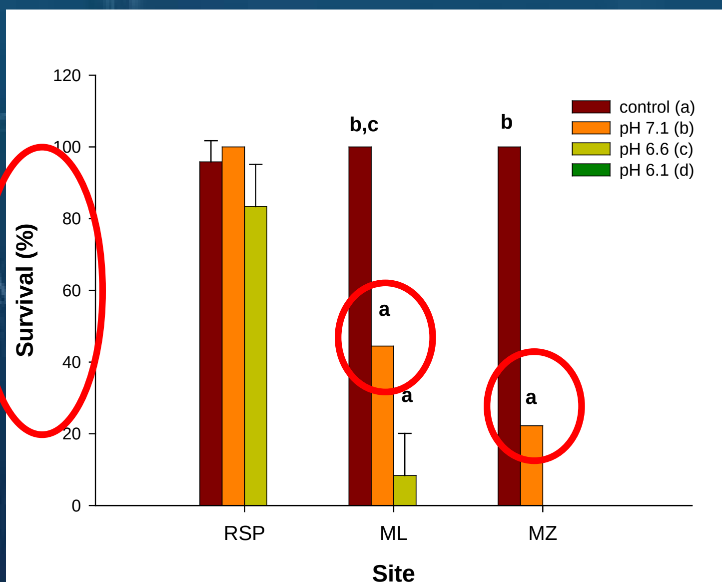
Article

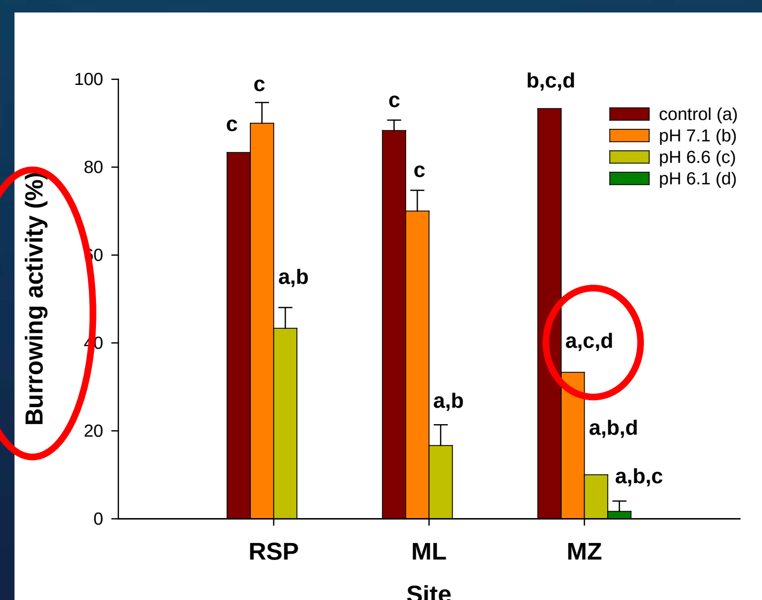
pubs.acs.org/est

Predicting the Impacts of CO_2 Leakage from Subseabed Storage: Effects of Metal Accumulation and Toxicity on the Model Benthic Organism *Ruditapes philippinarum*

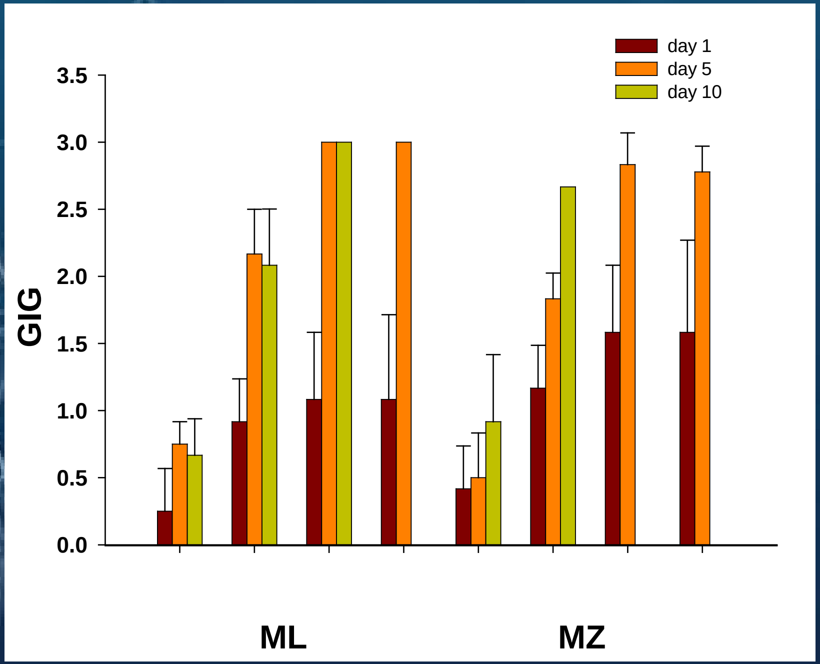
Araceli Rodríguez-Romero,*[,†] Natalia Jiménez-Tenorio,[‡] M. Dolores Basallote,[‡] Manoela R. De Orte,[‡,§] Julián Blasco,[†] and Inmaculada Riba[‡]



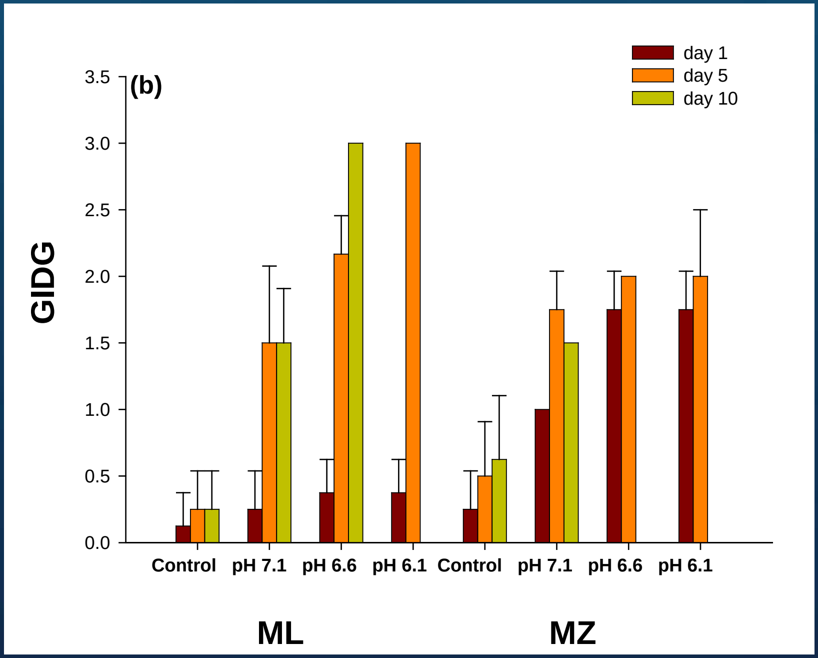




HISTOLOGICAL DAMAGE



Gills



Digestive gland

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Environment International 68 (2014) 105–117

Contents lists available at ScienceDirect

Environment International

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CrossMark

Simulation of CO_2 leakages during injection and storage in sub-seabed geological formations: Metal mobilization and biota effects

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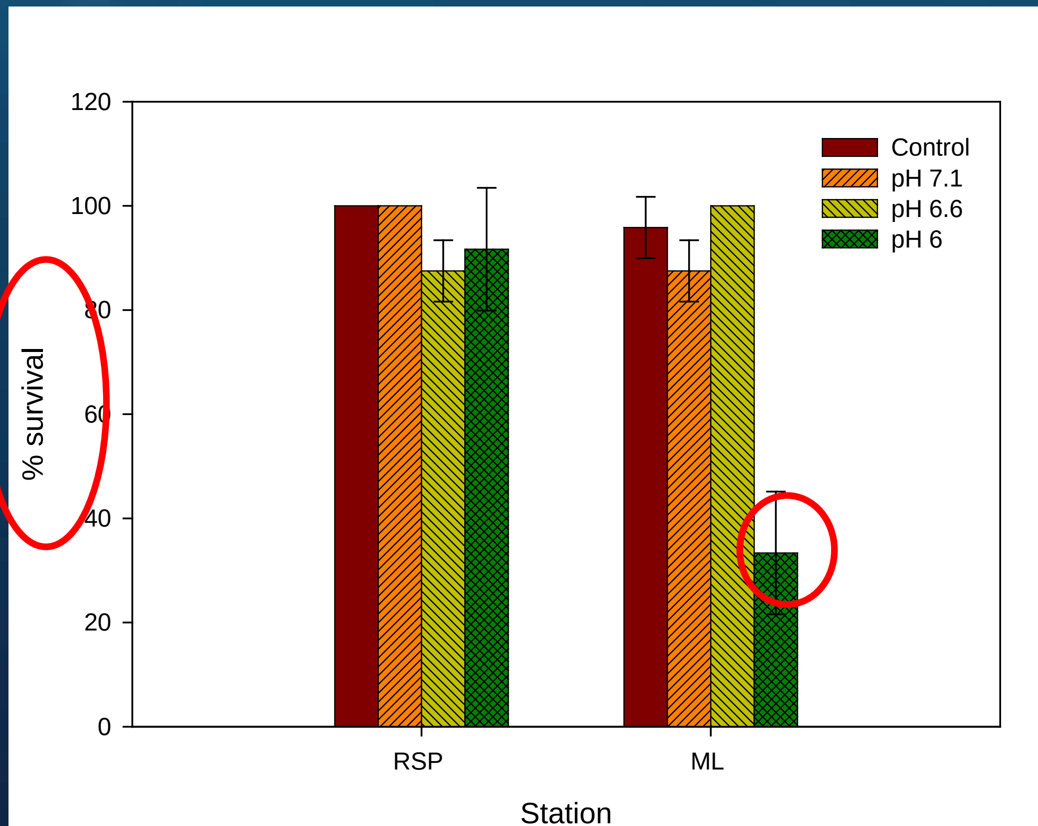
Polychaeta

H.Diversiculor



Unitwin: Wicop

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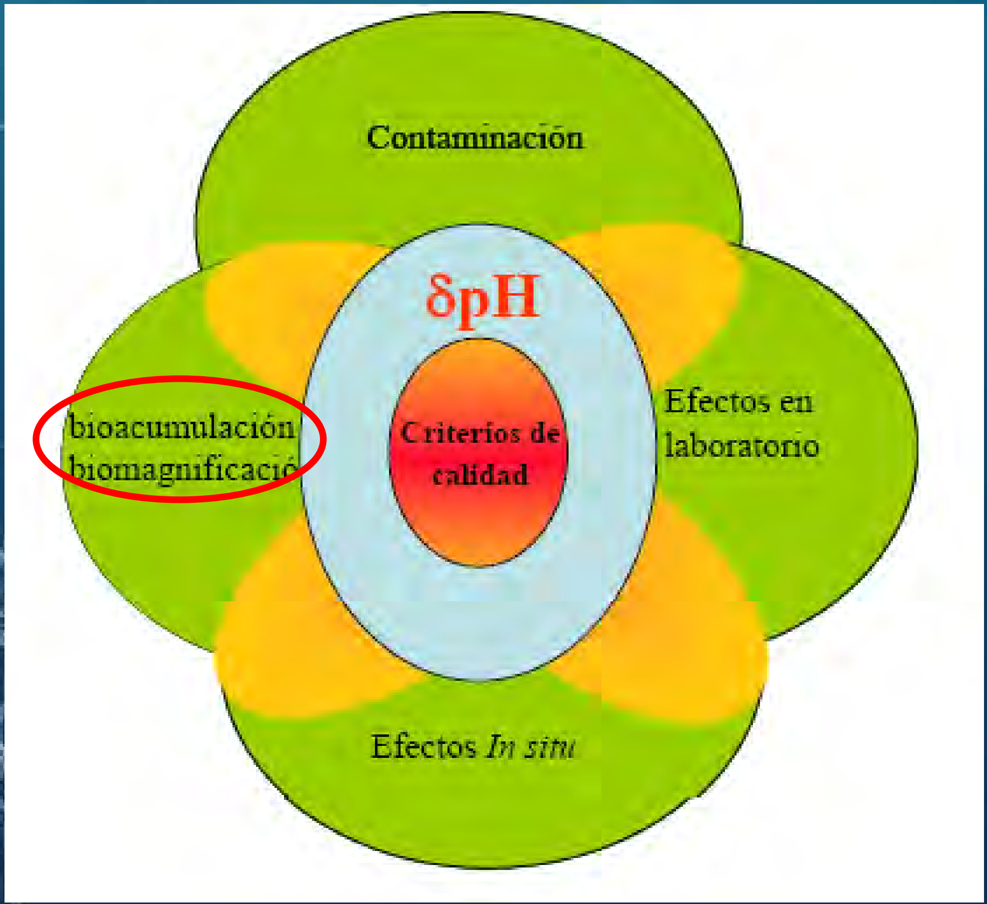

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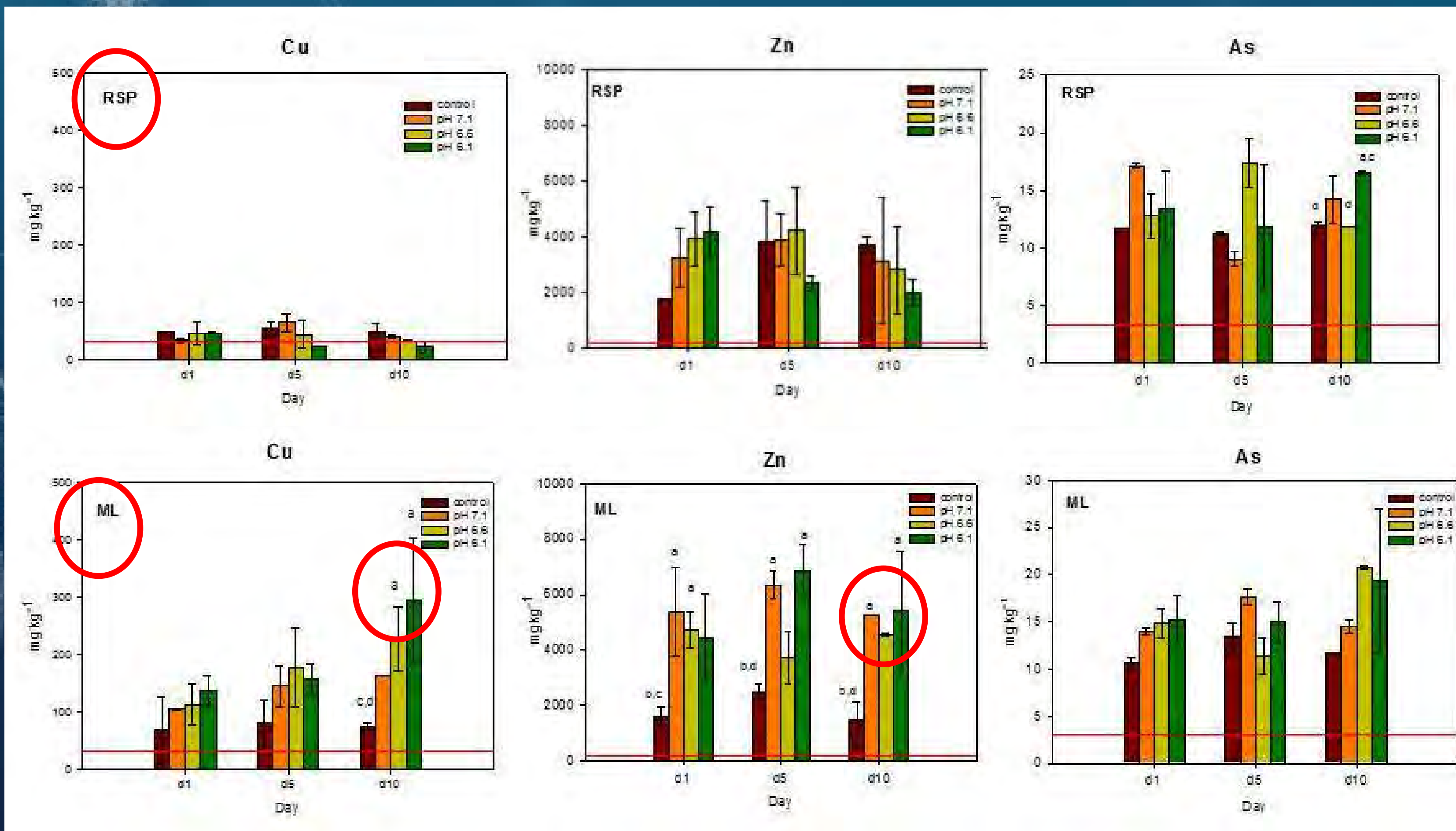

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Variables	Factor 1	Factor 2
pH		−0.74
Sand	−0.95	
Fines	0.95	
Organic carbon	0.95	
Organic matter	0.95	
Al in sediment	−0.74	
Fe in sediment	0.90	
Mn in sediment	0.63	
Cu in sediment	0.95	
Zn in sediment	0.96	
As in sediment	0.90	
Hg in sediment	0.92	
H. diversicolor mortality		0.78
Al bioaccumulation		0.91
Fe bioaccumulation		0.90
Mn bioaccumulation		0.87
Cu bioaccumulation	0.68	0.70
Zn bioaccumulation		0.70
As bioaccumulation		0.75
Hg bioaccumulation	0.53	
Al in seawater	0.80	
Fe in seawater		
Mn in seawater	−0.60	
Cu in seawater	0.79	0.51
Zn in seawater	0.53	0.83
As in seawater	0.75	0.63
Variance (%)	48.92	29.26
Cumulative %	48.92	78.18

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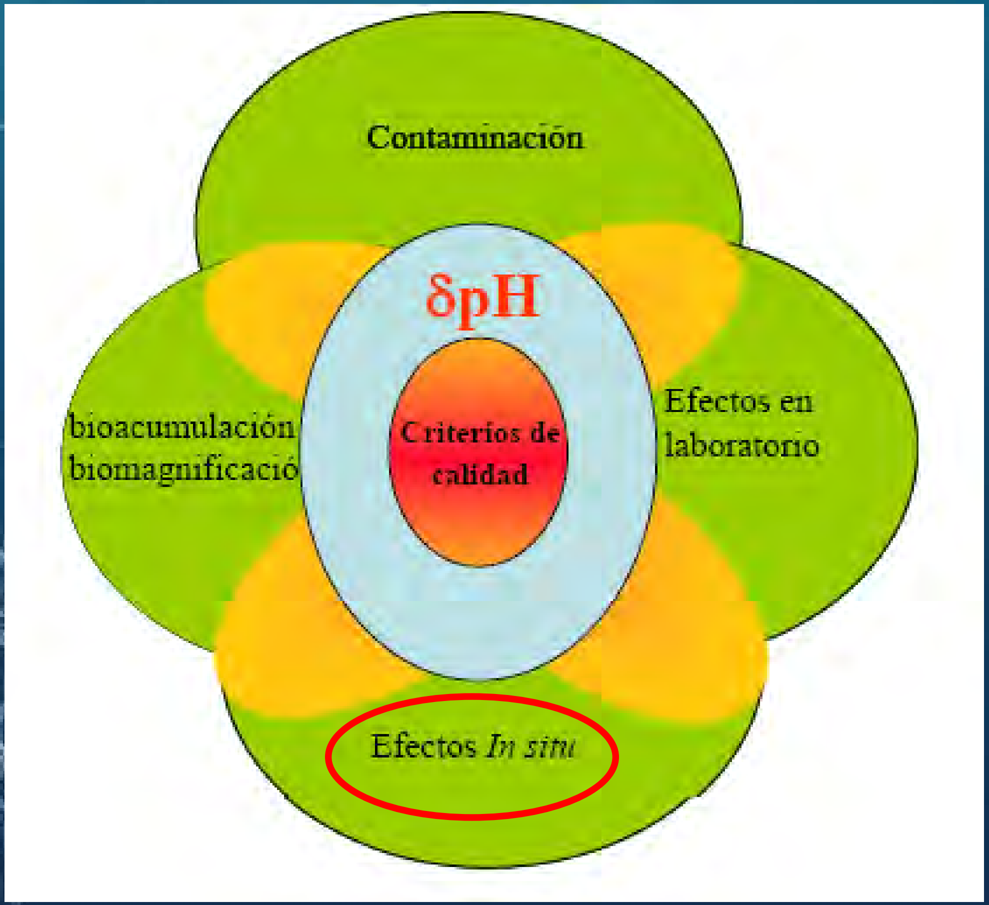

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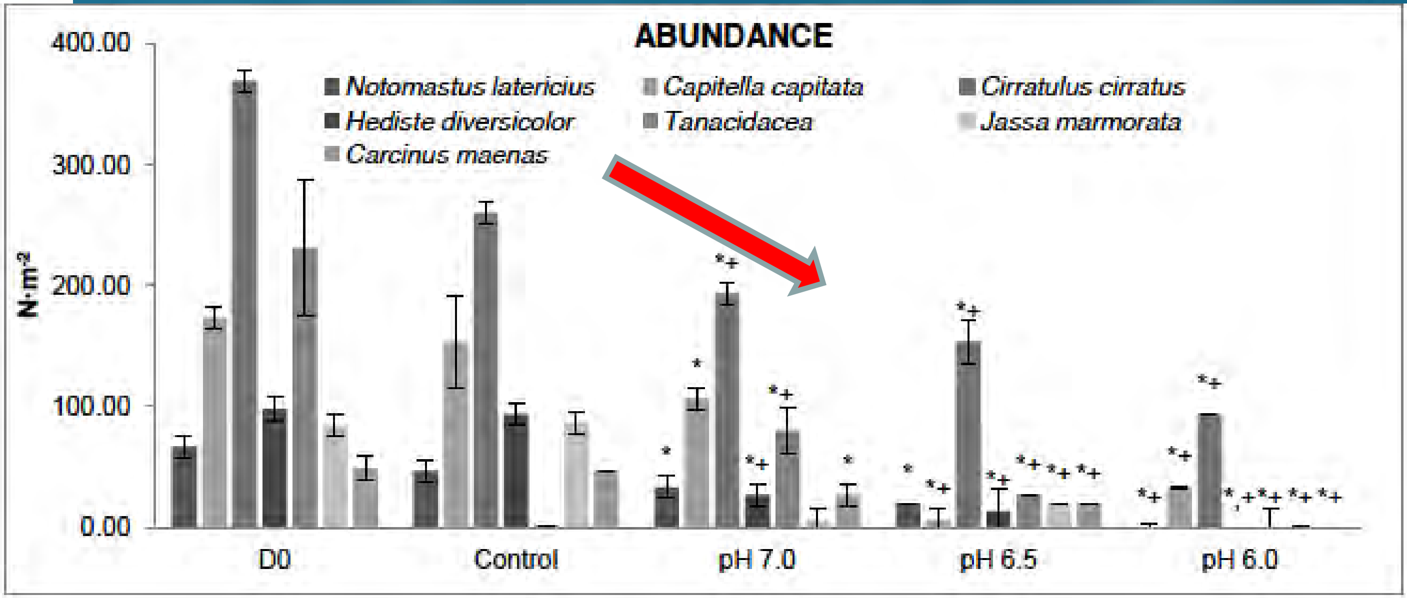
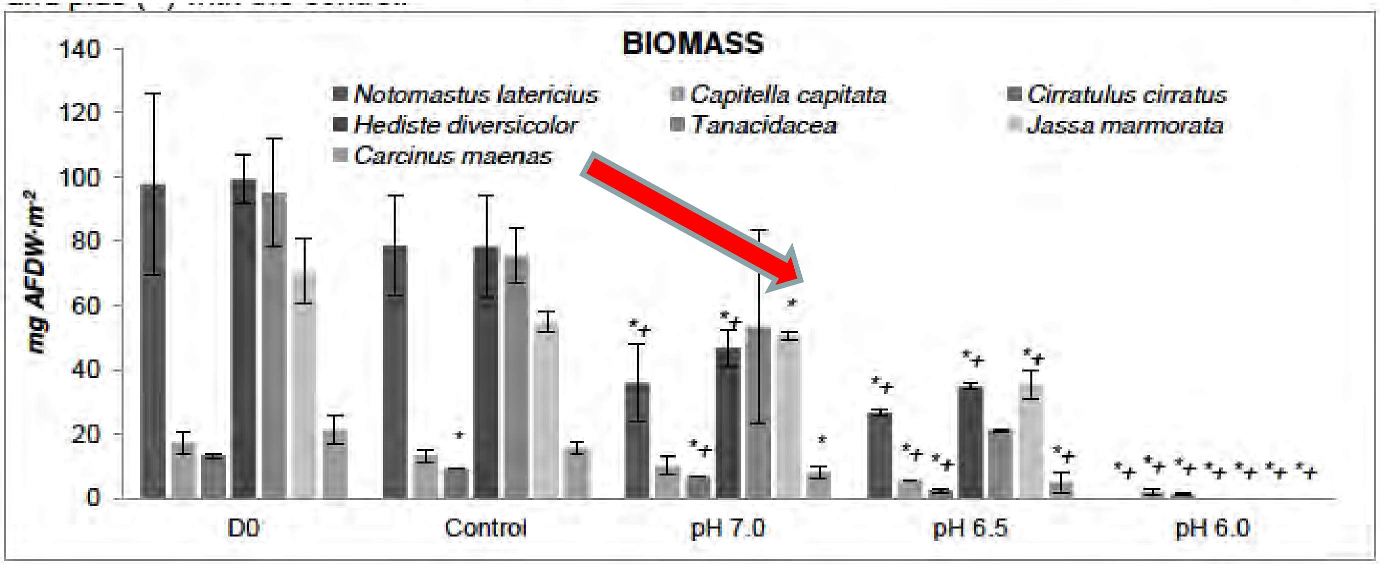
BENTHIC MACROFAUNA





PROJECT-BRAZIL

- " *The effects of CO_2 acidification on the bioavailability of contaminants in marine sediments associated with petroleum reservoirs leaks* **(ECO2Mar**)"

Study Area- Santos Estuarine System

Sediment sampling in contaminated areas

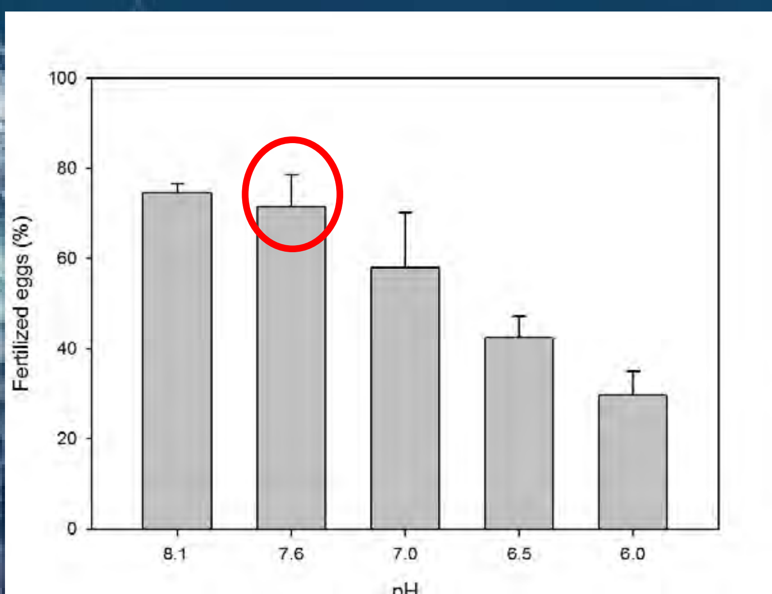
CCS

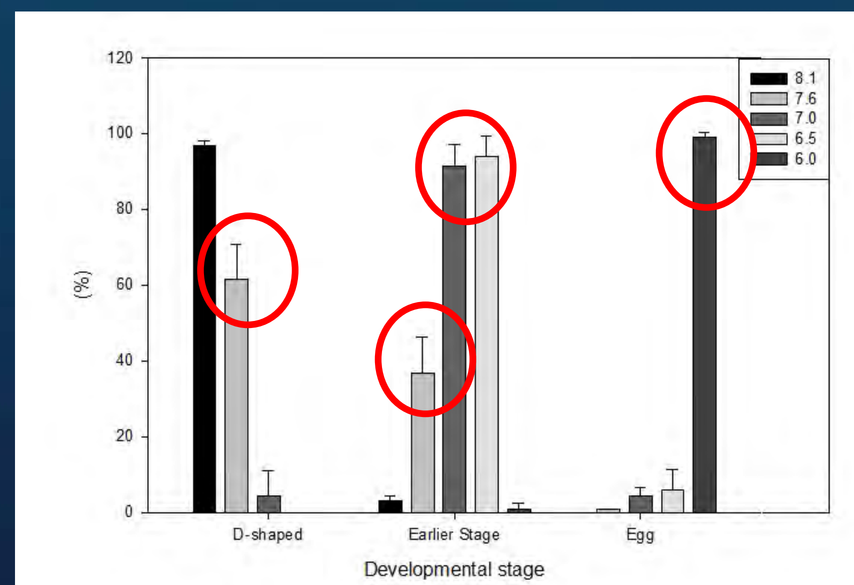
Ocean Acidification

MUSSELS

Perna perna

pHs (control) 7.6- 6.0





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Experiment with Amphipod: *Hyale yongi*

Sediment sampling in Santos Estuarine System

Acknowledgments

Project

➢" *The effects of CO_2 acidification on the bioavailability of contaminants in marine sediments associated with petroleum reservoirs leaks* **(ECO2Mar**)"

Ph.D. Scholarship

Postdoctoral Scholarship

Congress scholarship