The spatial variability of trace element bioaccumulation processes: Tools to environmental management

5th Annual World Congress of Marine Biotechnology-2015

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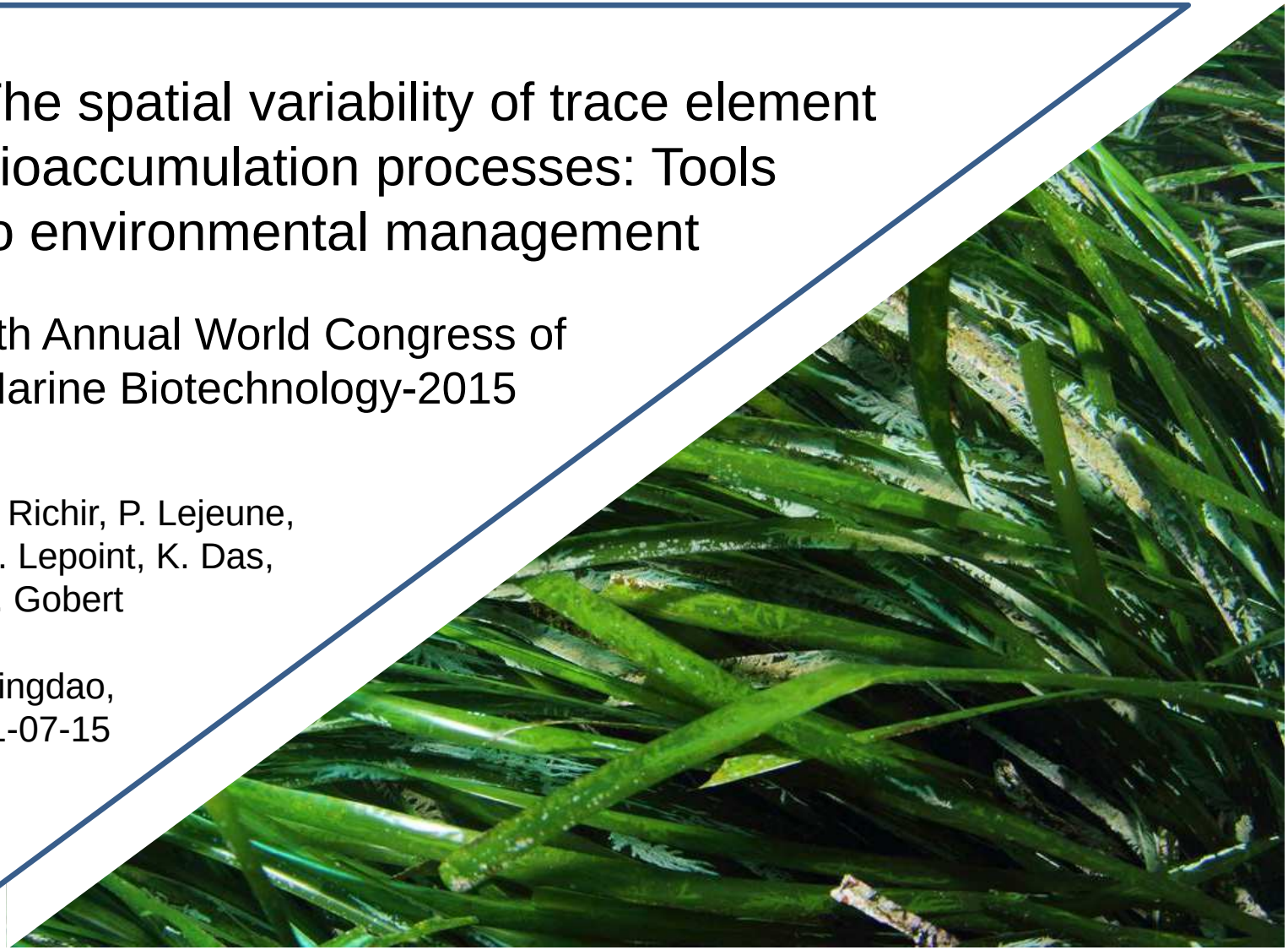
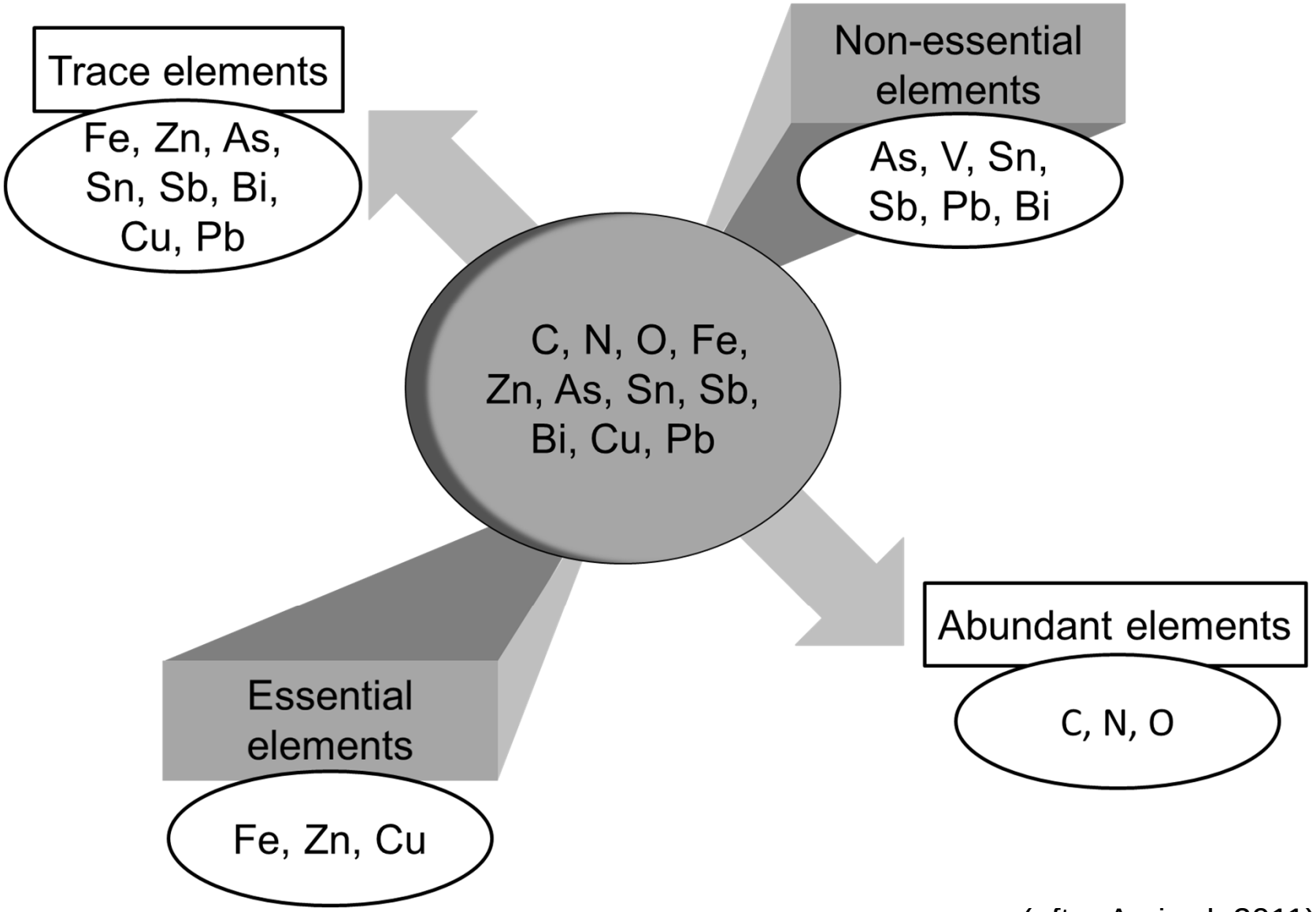
S. Gobert

Qingdao,
11-07-15



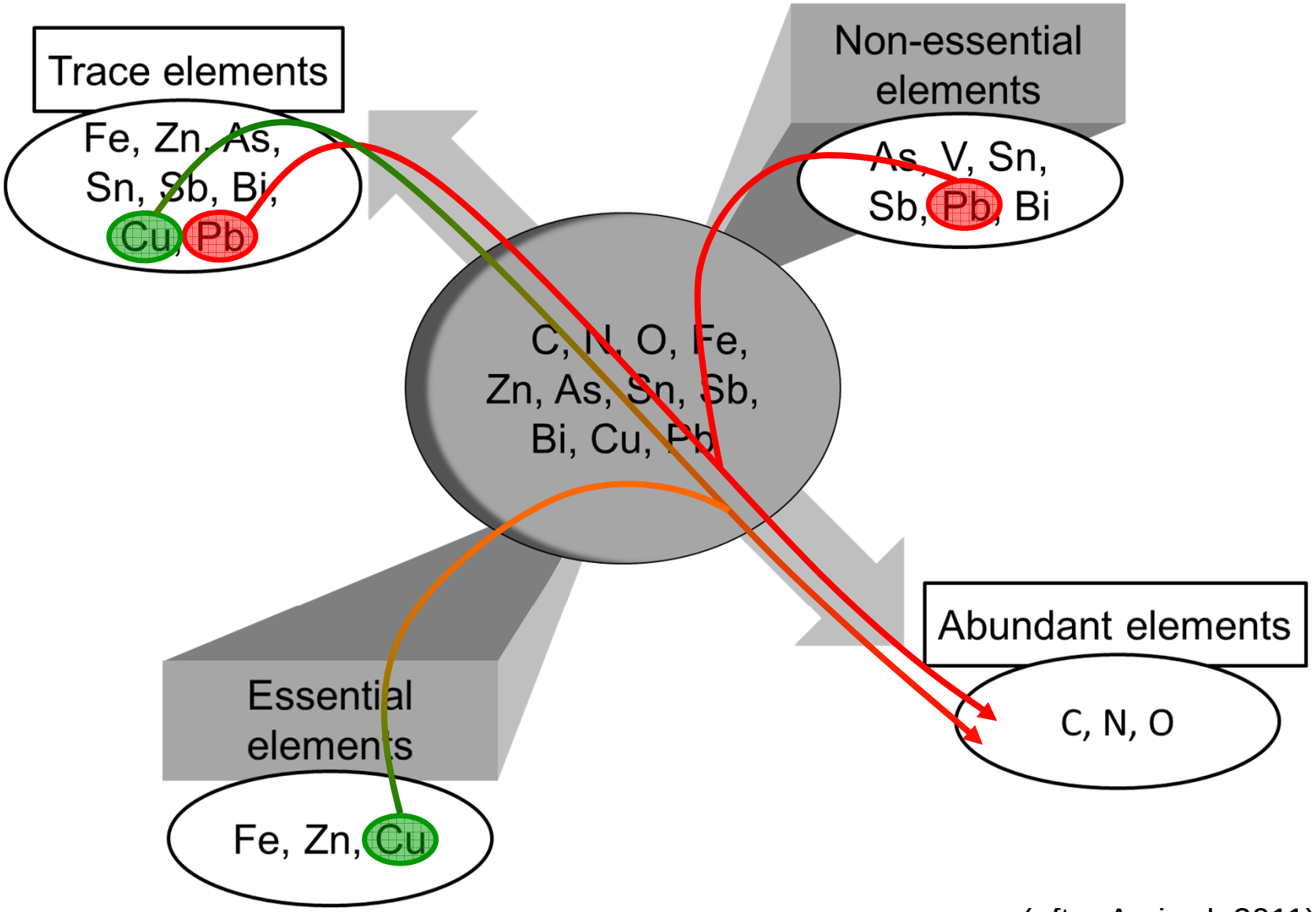
Trace elements

INTRODUCTION



(after Amiard ,2011)

Trace elements



(after Amiard ,2011)

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PERIODIC TABLE *of the* ELEMENTS

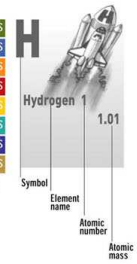
DEPARTMENT OF SCIENCE AND TECHNOLOGY

	IA 1	IIA 2											IIIA 13	IVA 14	VA 15	VIA 16	VIIA 17	VIII A 18
1	H Hydrogen 1 1.01																	He Helium 2 4.00
2	Li lithium 3 6.94	Be Beryllium 4 9.01											B Boron 5 10.81	C Carbon 6 12.01	N Nitrogen 7 14.01	O Oxygen 8 16.00	F Fluorine 9 19.00	Ne Neon 10 20.18
3	Na Sodium 11 22.99	Mg Magnesium 12 24.31											Al Aluminium 13 26.98	Si Silicon 14 28.09	P Phosphorus 15 30.97	S Sulphur 16 32.06	Cl Chlorine 17 35.45	Ar Argon 18 39.95
4	K Potassium 19 39.10	Ca Calcium 20 40.08	III B 3 Scandium 21 44.96 Sc	IV B 4 Ti Titanium 22 47.88	V B 5 V Vanadium 23 50.94	VI B 6 Cr Chromium 24 52.00	VII B 7 Mn Manganese 25 54.94	VIII 8 Fe Iron 26 55.85	VIII 9 Co Cobalt 27 58.93	VIII 10 Ni Nickel 28 58.69	I B 11 Cu Copper 29 63.55	II B 12 Zn Zinc 30 65.39	Ga Gallium 31 69.72	Ge Germanium 32 72.61	As Arsenic 33 74.92	Se Selenium 34 78.96	Br Bromine 35 79.90	Kr Krypton 36 83.80
5	Rb Rubidium 37 85.47	Sr Strontium 38 87.62	Y Yttrium 39 88.91	Zr Zirconium 40 91.22	Nb Niobium 41 92.91	Mo Molybdenum 42 95.94	Tc Technetium 43 (98)	Ru Ruthenium 44 101.07	Rh Rhodium 45 102.91	Pd Palladium 46 106.42	Ag Silver 47 107.87	Cd Cadmium 48 112.41	In Indium 49 114.82	Sn Tin 50 118.71	Sb Antimony 51 121.76	Te Tellurium 52 127.60	I Iodine 53 126.90	Xe Xenon 54 131.29
6	Cs Caesium 55 132.91	Ba Barium 56 137.33	Lanthanide Series	Hf Hafnium 72 178.49	Ta Tantalum 73 180.95	W Tungsten 74 183.85	Re Rhenium 75 186.21	Os Osmium 76 190.23	Ir Iridium 77 192.22	Pt Platinum 78 195.08	Au Gold 79 196.97	Hg Mercury 80 200.59	Tl Thallium 81 204.38	Pb Lead 82 207.20	Bi Bismuth 83 208.98	Po Polonium 84 (209)	At Astatine 85 (210)	Rn Radon 86 (222)
7	Fr Francium 87 (223)	Ra Radium 88 (226)	Actinide Series	Rf Rutherfordium 104 (261)	Db Dubnium 105 (262)	Sg Seaborgium 106 (263)	Bh Bohrium 107 (262)	Hs Hassium 108 (265)	Mt Meitnerium 109 (266)									

La Lanthanum 57 138.91	Ce Cerium 58 140.12	Pr Praseodymium 59 140.90	Nd Neodymium 60 144.24	Pm Promethium 61 (145)	Sm Samarium 62 150.36	Eu Europium 63 151.96	Gd Gadolinium 64 157.25	Tb Terbium 65 158.92	Dy Dysprosium 66 162.50	Ho Holmium 67 164.93	Er Erbium 68 167.26	Tm Thulium 69 168.93	Yb Ytterbium 70 173.04	Lu Lutetium 71 174.96
Ac Actinium 89 227.02	Th Thorium 90 232.03	Pa Protactinium 91 231.03	U Uranium 92 238.02	Np Neptunium 93 (237)	Pu Plutonium 94 (244)	Am Americium 95 (243)	Cm Curium 96 (247)	Bk Berkelium 97 (247)	Cf Californium 98 (251)	Es Einsteinium 99 (254)	Fm Fermium 100 (257)	Md Mendelevium 101 (258)	No Nobelium 102 (259)	Lr Lawrencium 103 (260)

ALKALI METALS
ALKALI EARTH METALS
TRANSITION METALS
OTHER METALS
OTHER NONMETALS
HALOGENS
NOBLE GASSES
RARE EARTH METALS

At room temperature the element is:
- Gas
- Liquid
- Natural solid
- Man-made solid [synthetic]

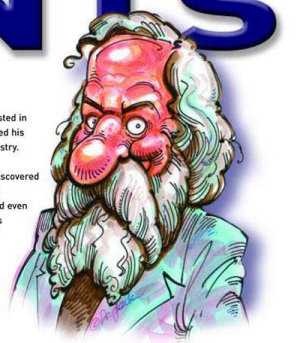


DMITRI MENDELEYEV (1834 – 1907)

The Russian chemist, Dmitri Mendeleyev, was the first to observe that if elements were listed in order of atomic mass, they showed regular (periodical) repeating properties. He formulated his discovery in a periodic table of elements, now regarded as the backbone of modern chemistry.

The crowning achievement of Mendeleyev's periodic table lay in his prophecy of then, undiscovered elements. In 1869, the year he published his periodic classification, the elements gallium, germanium and scandium were unknown. Mendeleyev left spaces for them in his table and even predicted their atomic masses and other chemical properties. Six years later, gallium was discovered and his predictions were found to be accurate. Other discoveries followed and their chemical behaviour matched that predicted by Mendeleyev.

This remarkable man, the youngest in a family of 17 children, has left the scientific community with a classification system so powerful that it became the cornerstone in chemistry teaching and the prediction of new elements ever since.
In 1955, element 101 was named after him: Md, Mendelevium.



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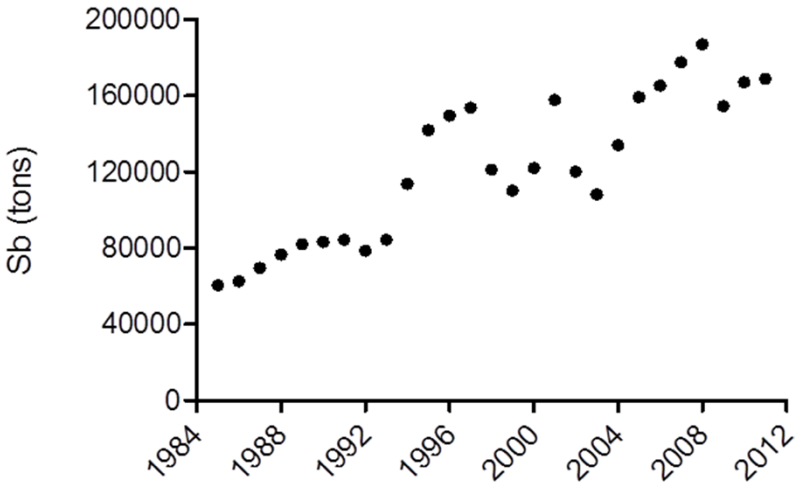
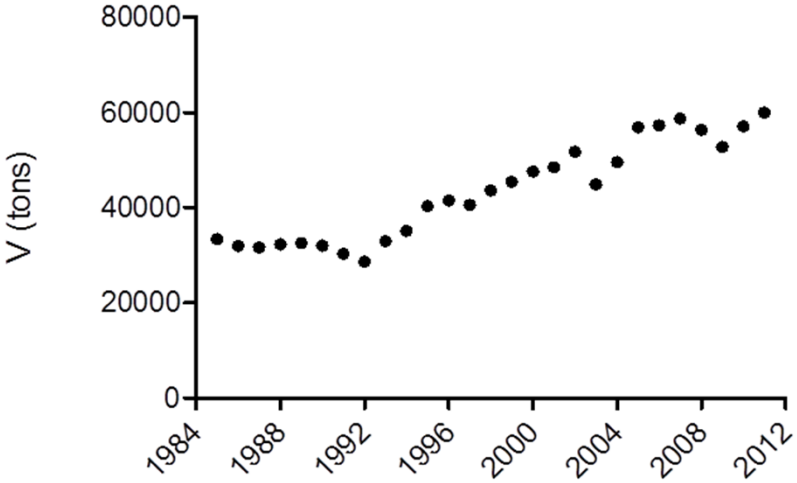
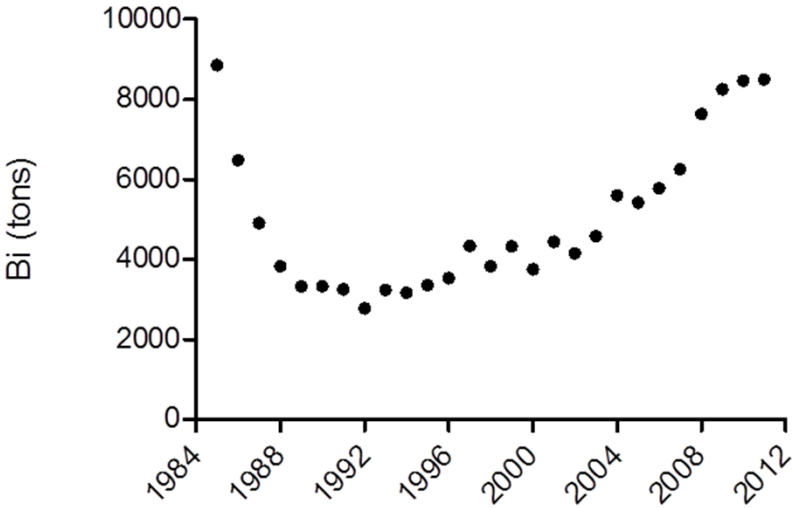
World production of trace elements

INTRODUCTION



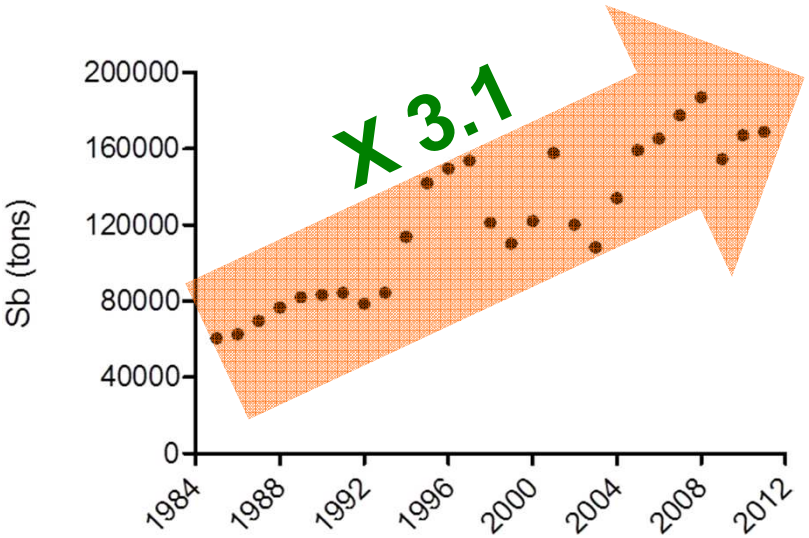


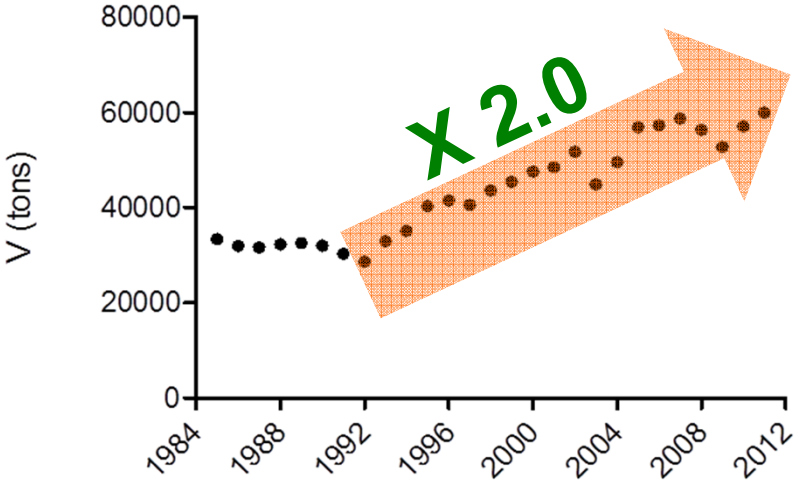


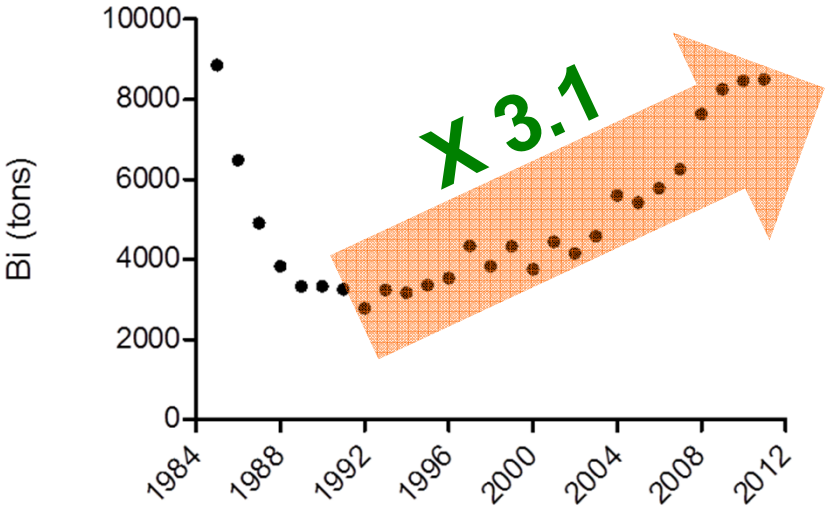
data compiled from the Mineral Yearbooks published by the US Geological Survey on www.usgs.gov

World production of trace elements

INTRODUCTION







data compiled from the Mineral Yearbooks published by the US Geological Survey on www.usgs.gov

Bio-monitoring

INTRODUCTION

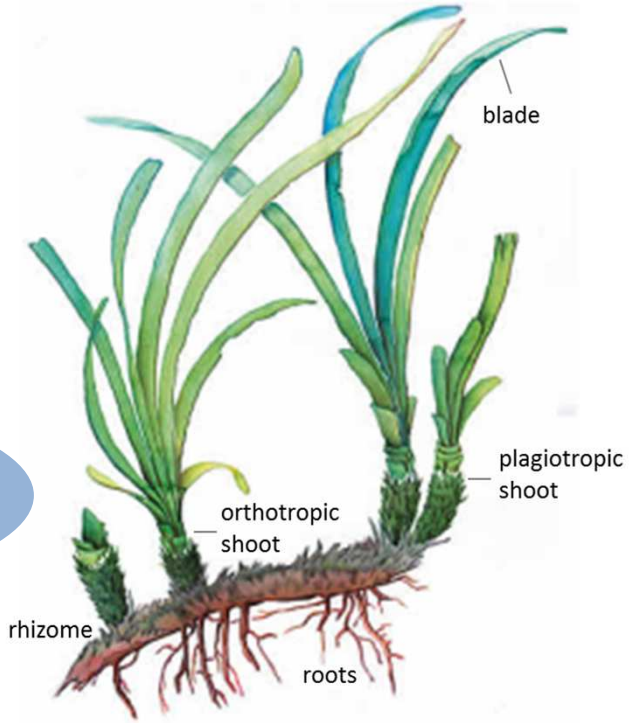
Mytilus galloprovincialis

Contamination

↓

trace elements

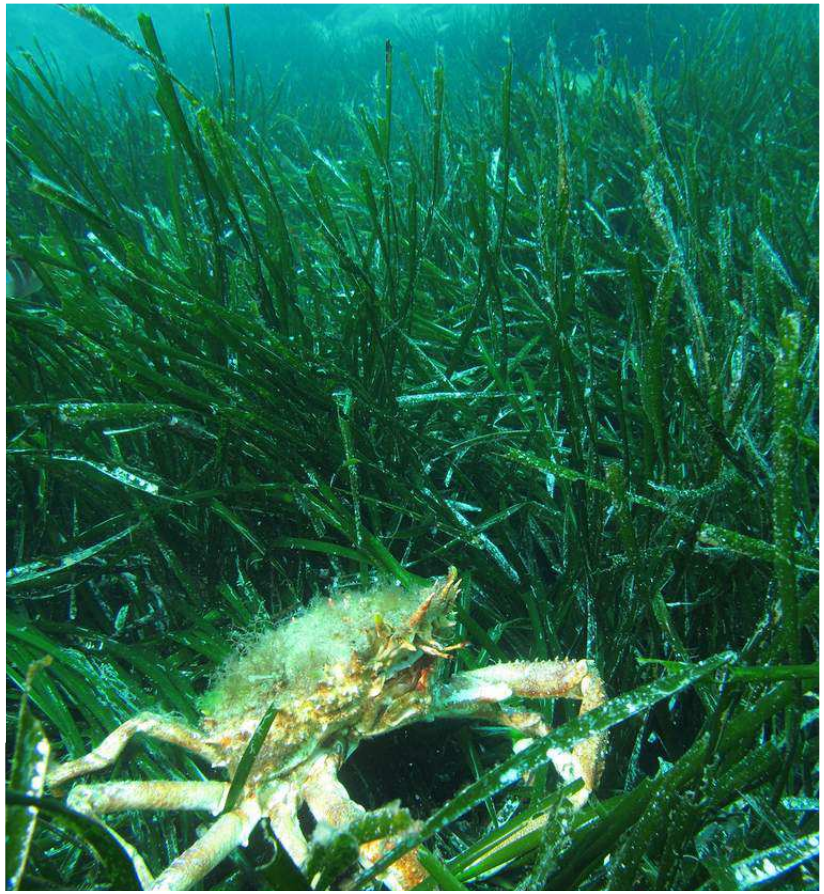
↙ ↘

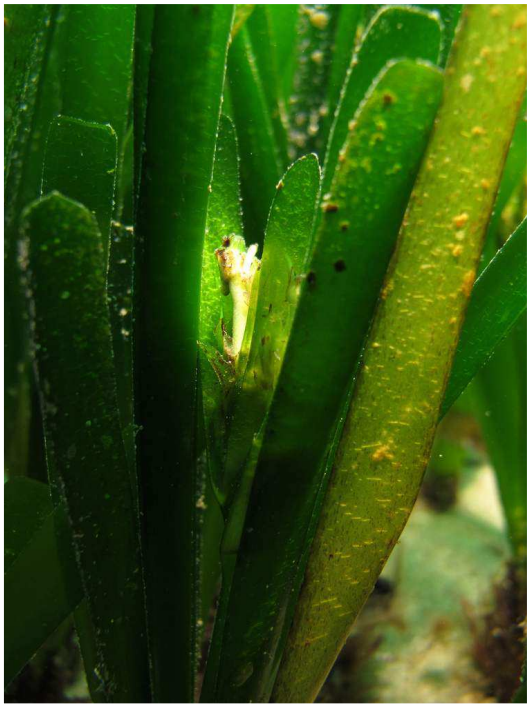


Posidonia oceanica

direct measurements in the environment: water, suspended matter, sediments.

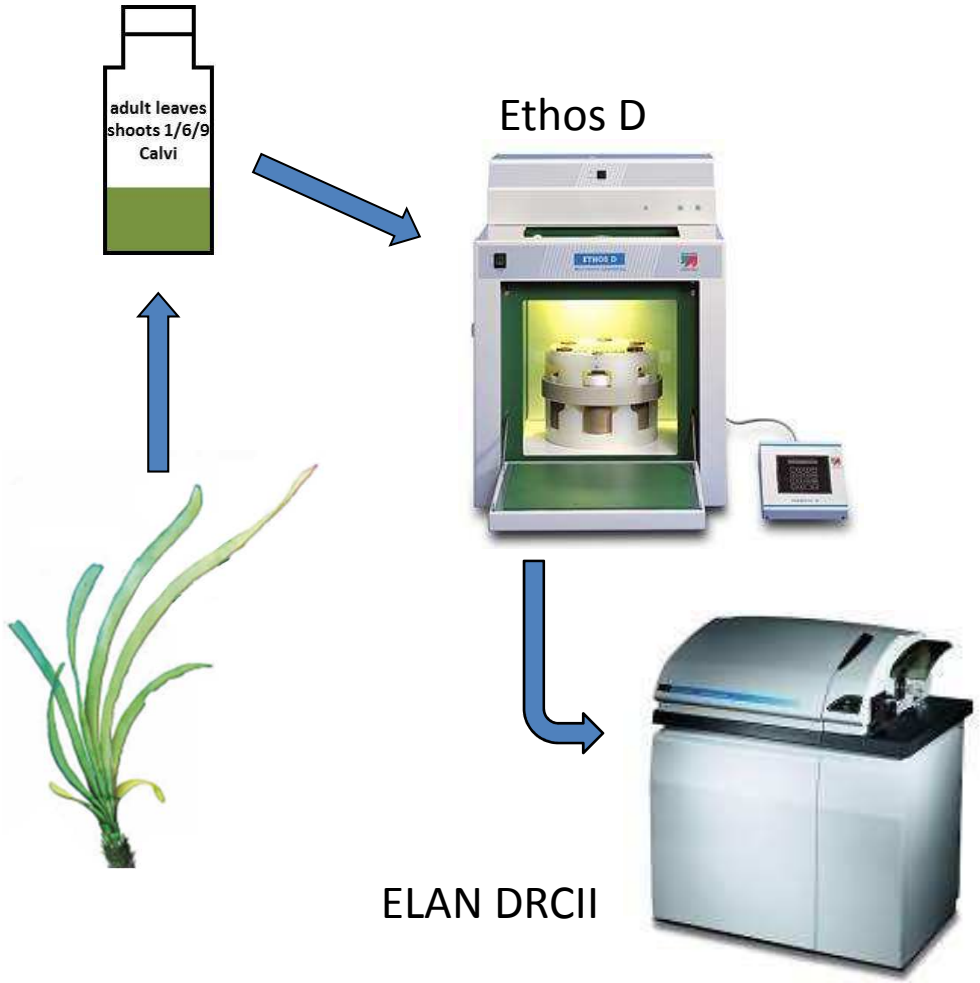
bioindicators = organisms accumulating pollutants to levels representative of their habitat contamination status.





Laboratory analyses

METHODS

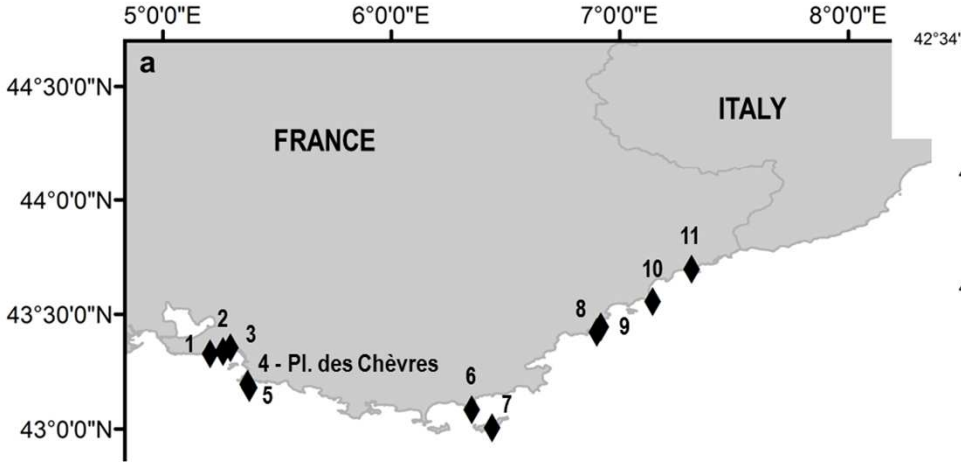


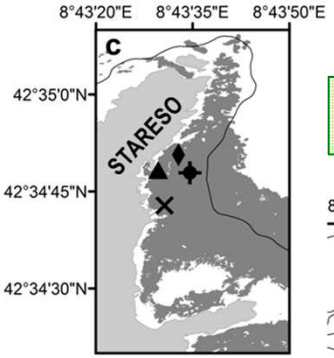
Analytical steps:

- homogeneous sample
- acidic digestion in a microwave oven
- measures :
  - inductively coupled plasma mass spectrometer

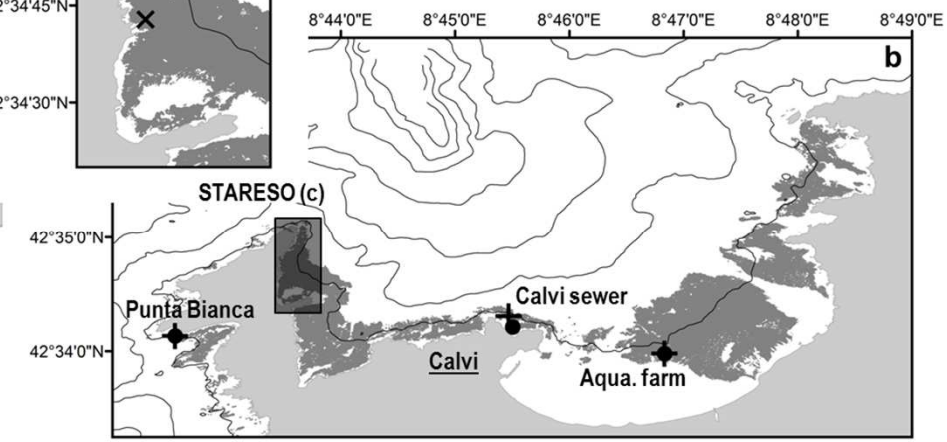
Scale ? Sampling effort ?

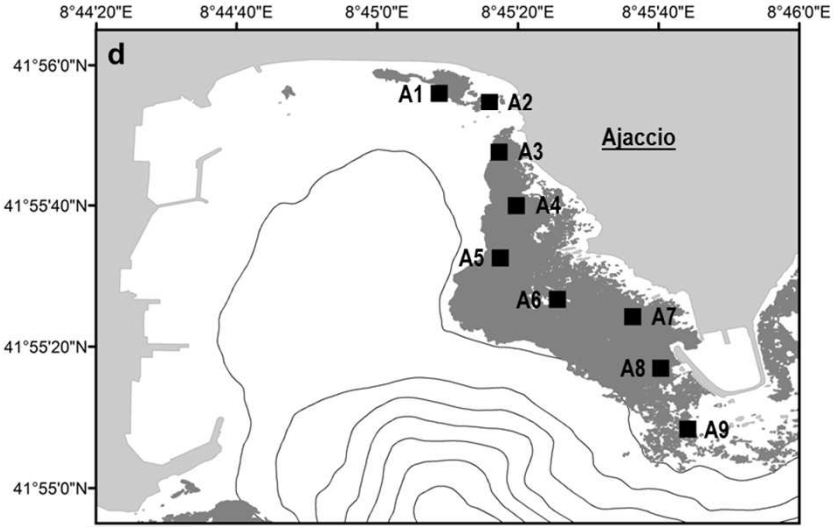
TE accumulation in *P. oceanica* studied at different scales :

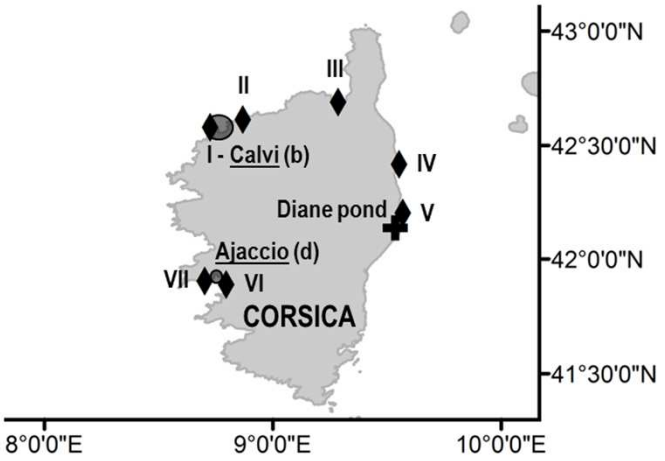




2. In a bay (1 km scale)





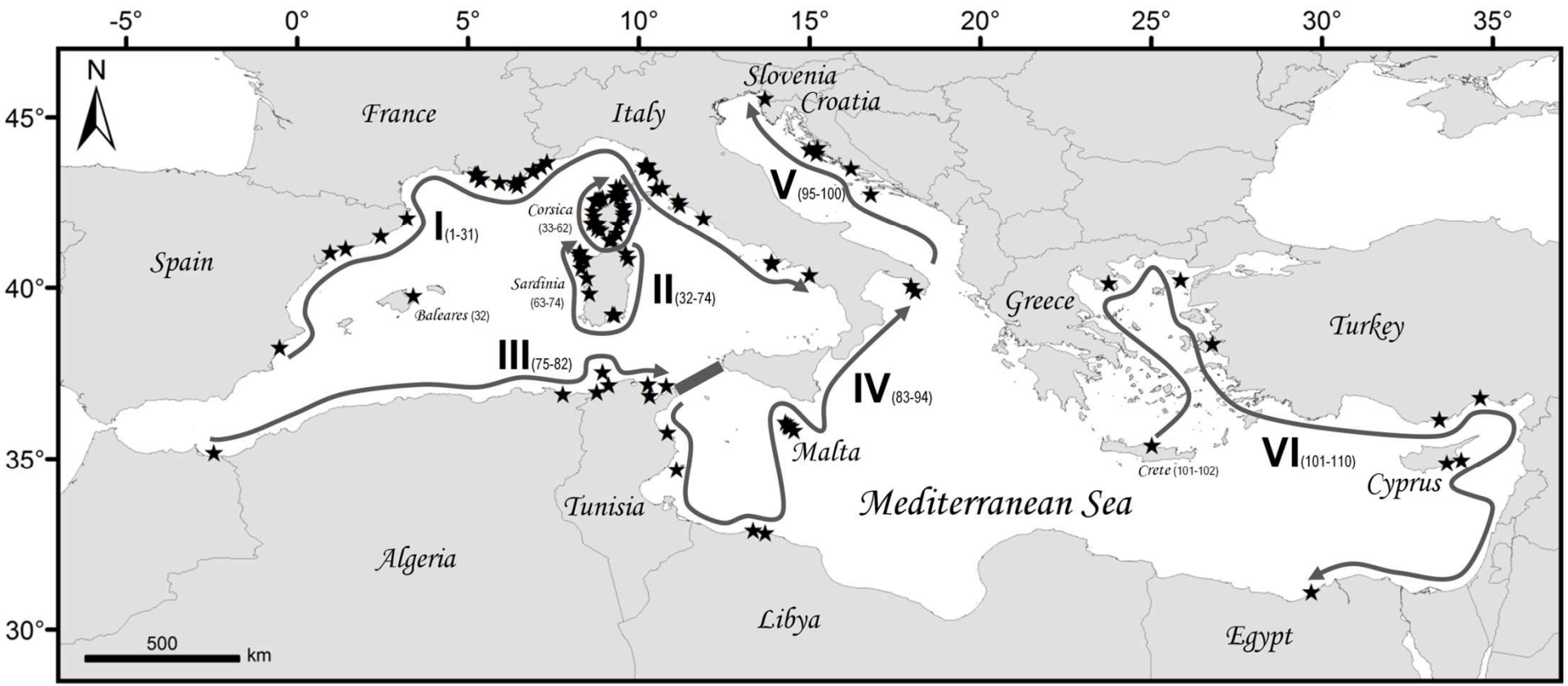


3. Along the French Mediterranean littoral (10-100 km scale)

1. Along a radial (100 m scale)

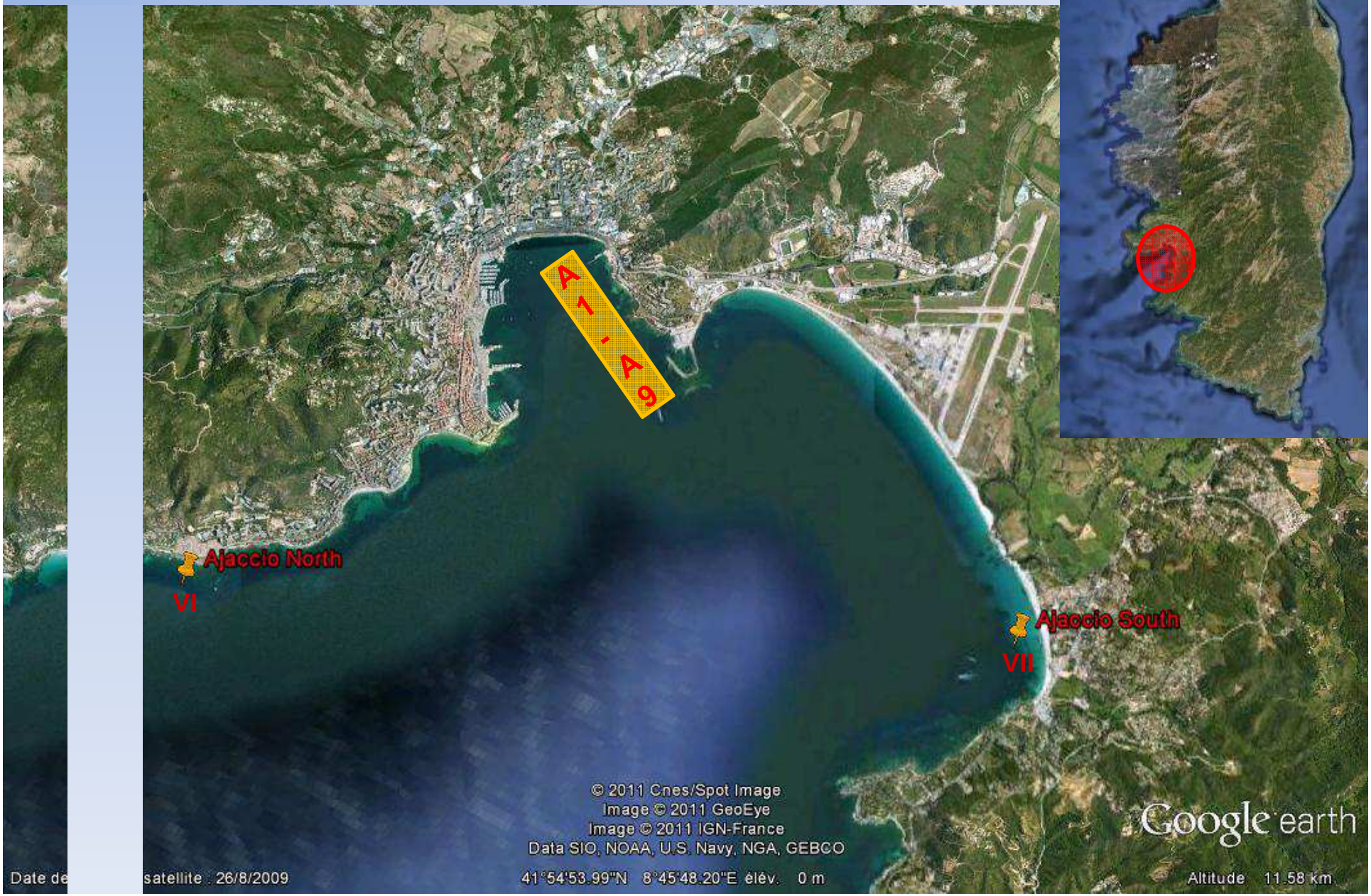
Scale ? Sampling effort ?

TE accumulation in *P. oceanica* studied at different scales :

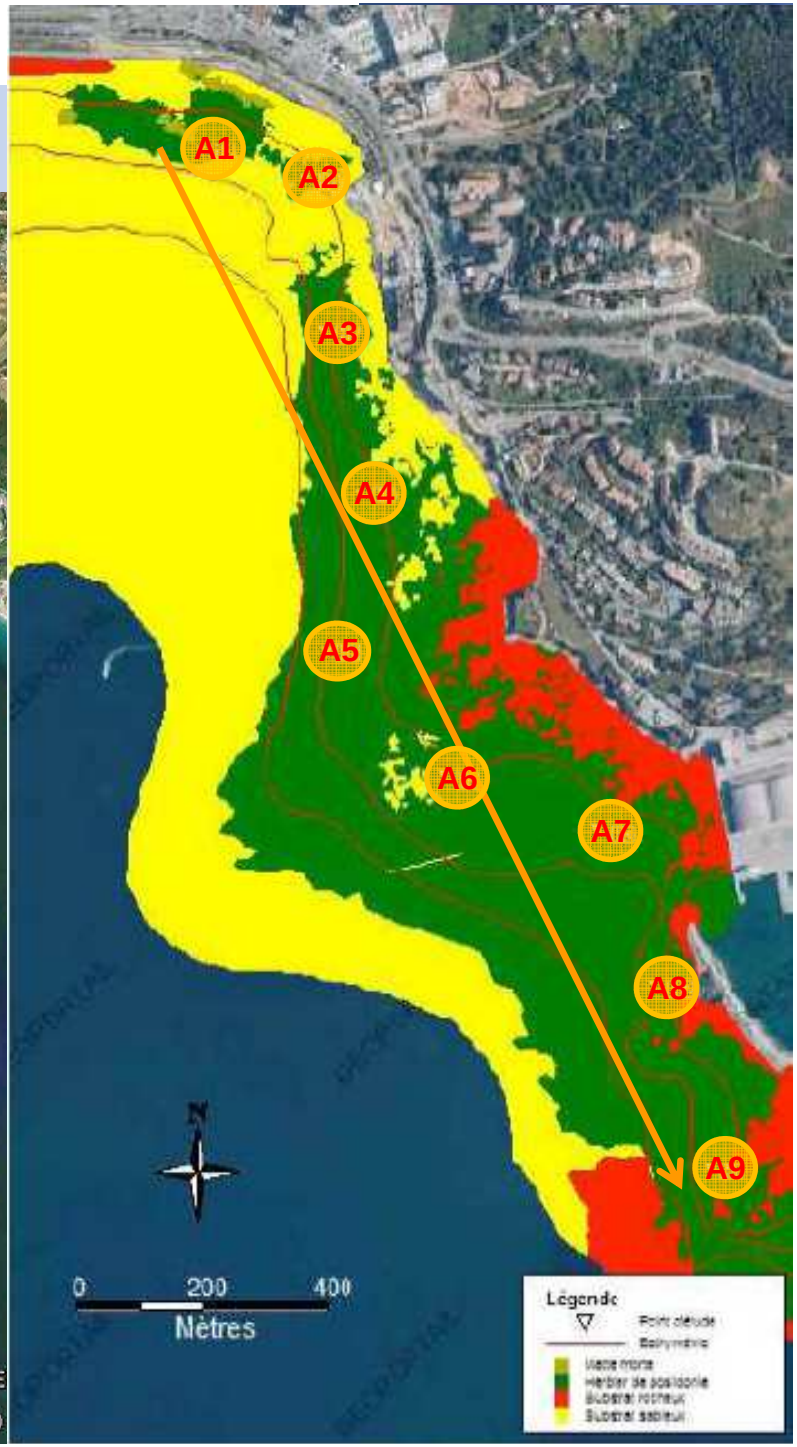


4. Along the whole Mediterranean coastline (100-1000 km scale)

Radial monitoring: Ajaccio Bay

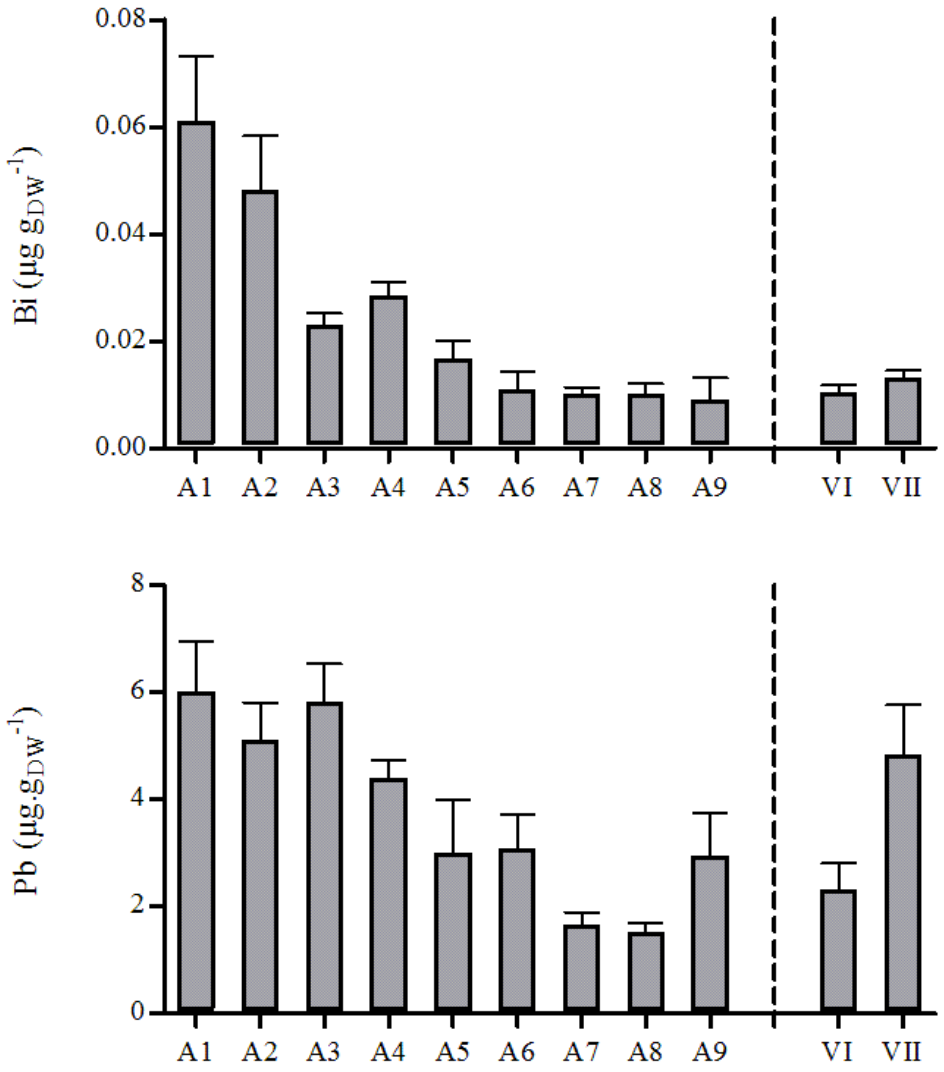


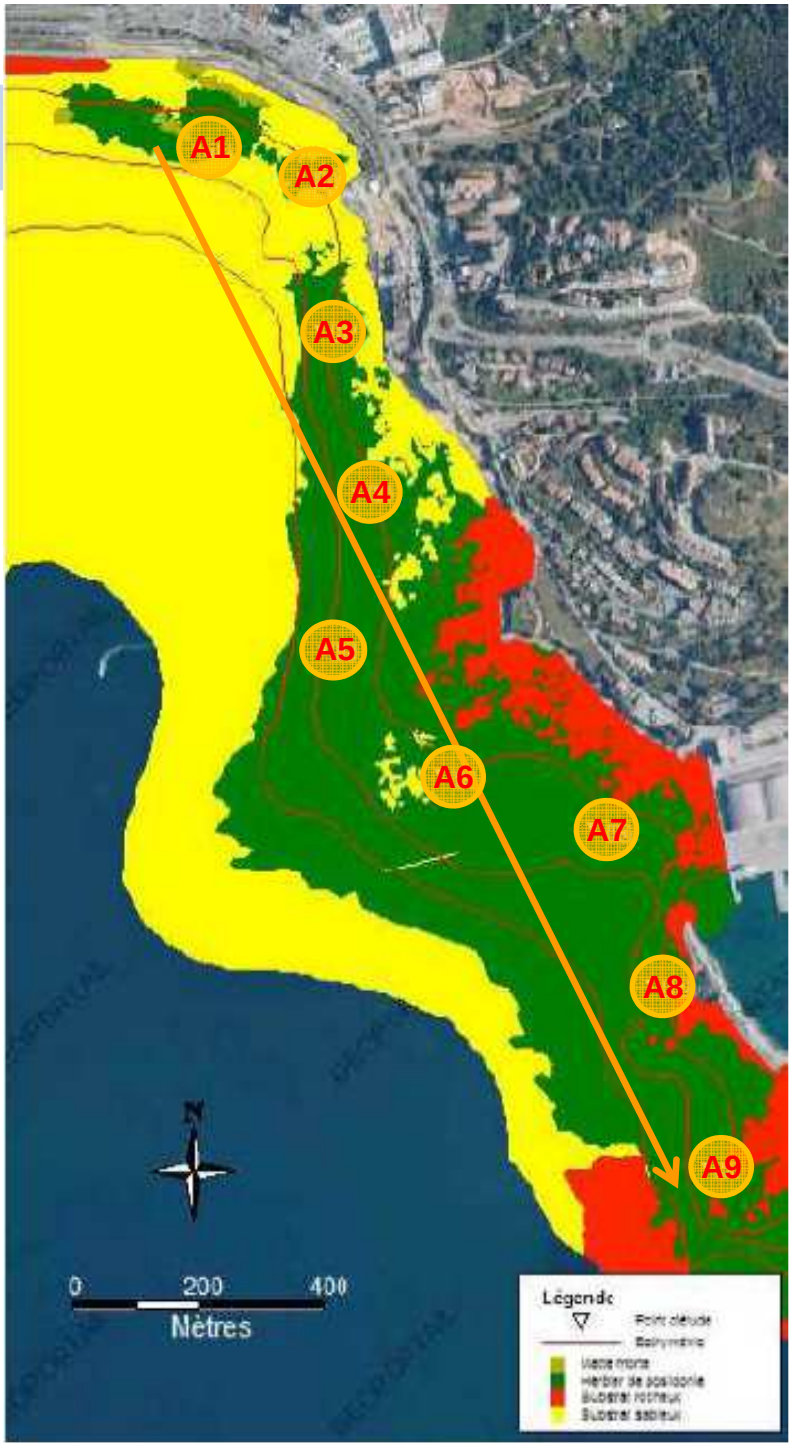
Radial monitoring: Ajaccio Bay



Radial monitoring: Ajaccio Bay

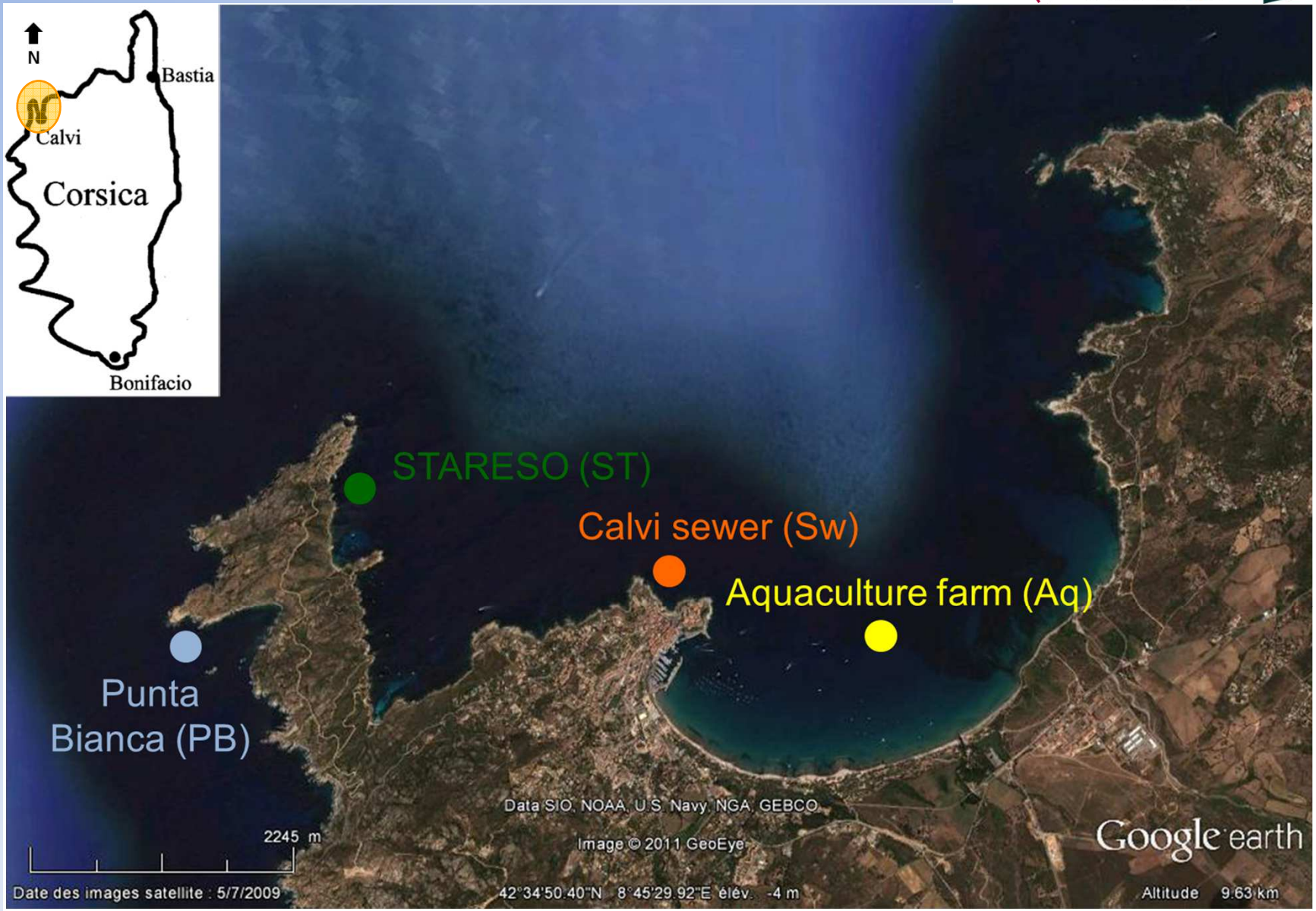
CASE STUDY





Local monitoring: Calvi Bay

CASE STUDY



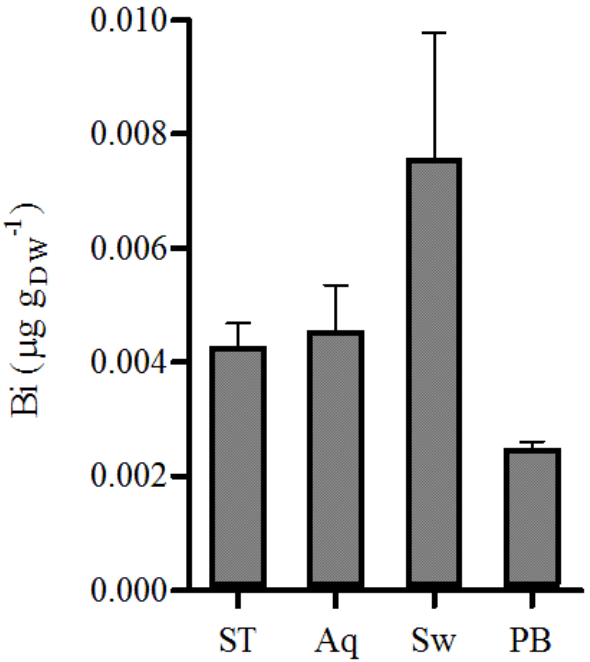
Local monitoring: Calvi Bay

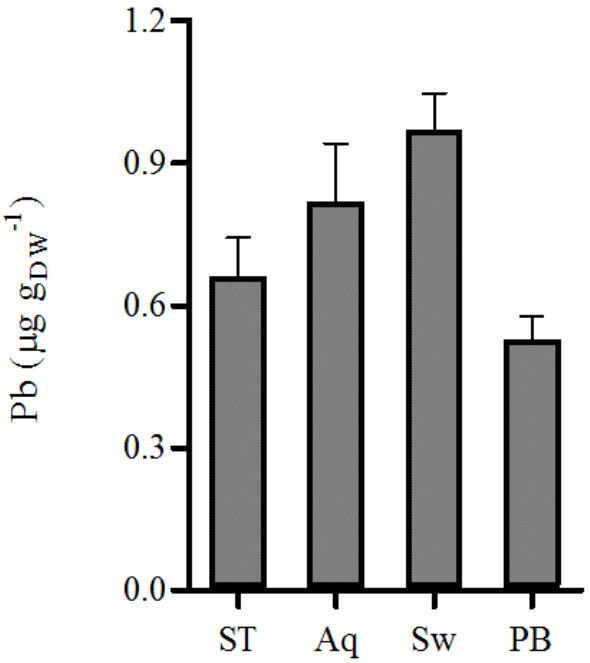
CASE STUDY

Lifestyle of organisms

- *P. oceanica* = rooted primary producer

→ weak point sources of long-term accumulations of pollutants in sediments.

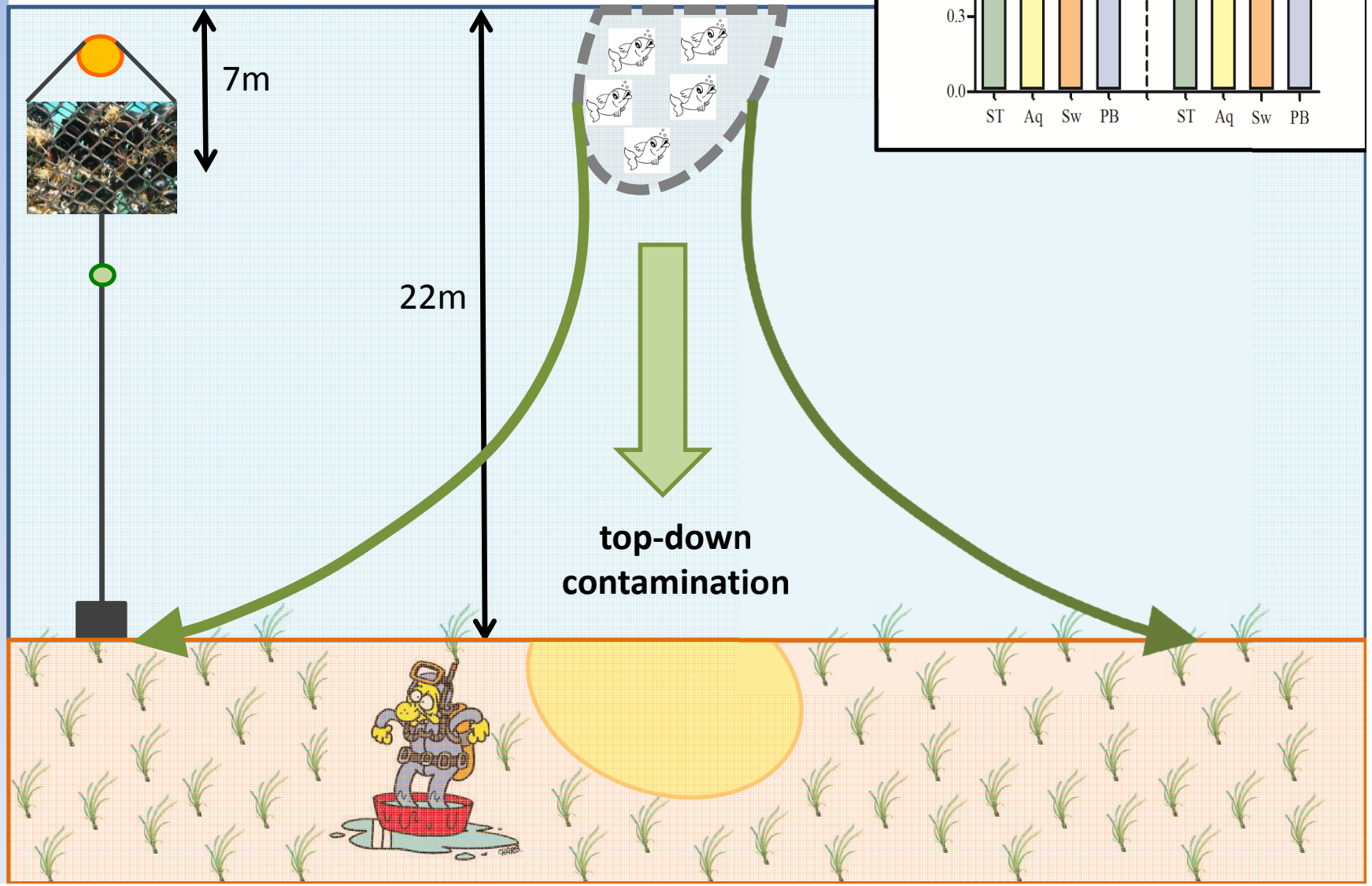


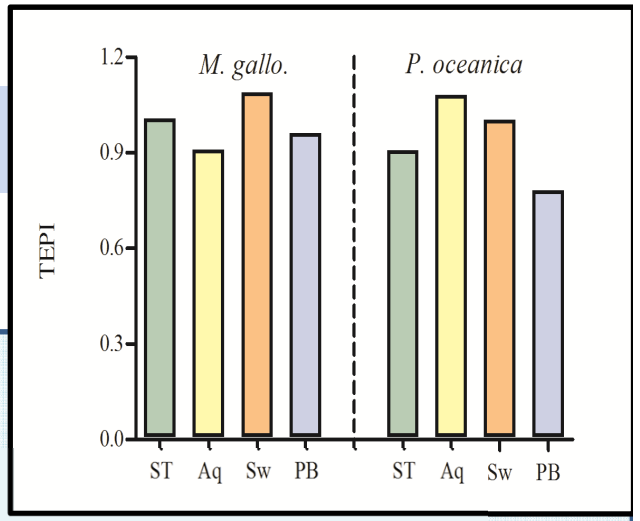


Local monitoring: Calvi Bay

CASE STUDY

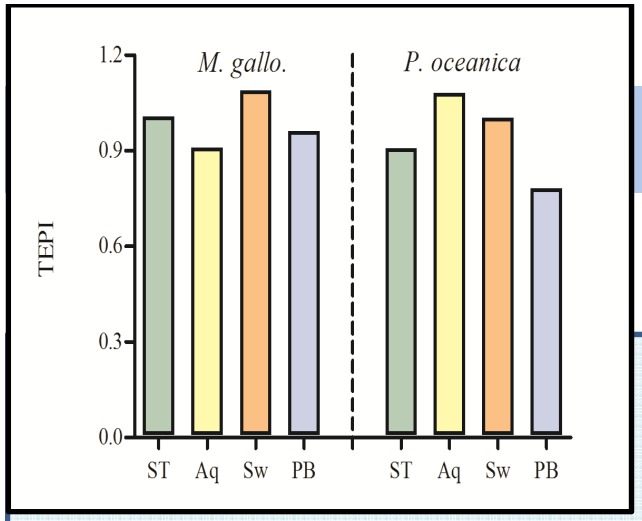
Calvi sewer vs Aquaculture farm:

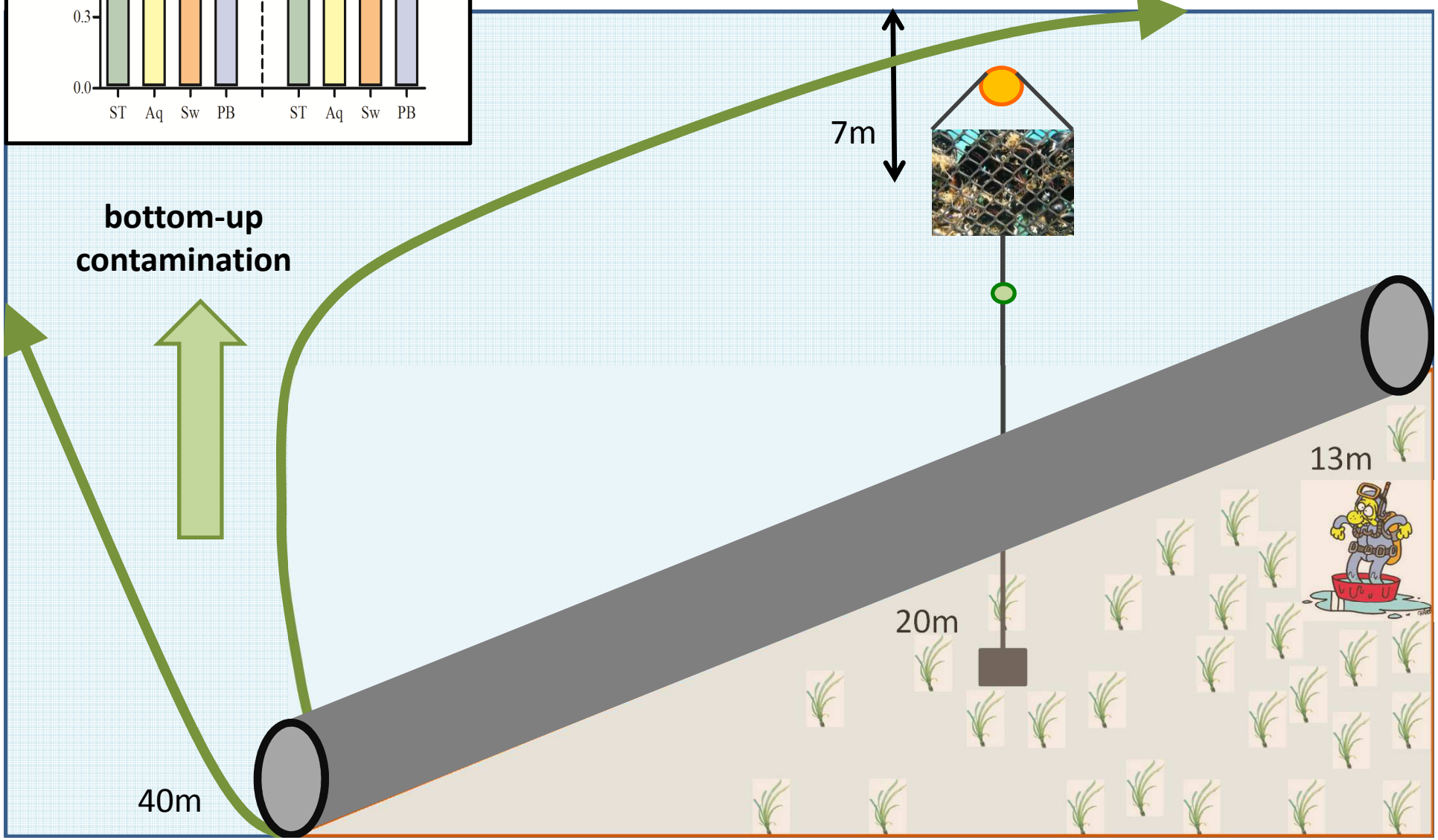


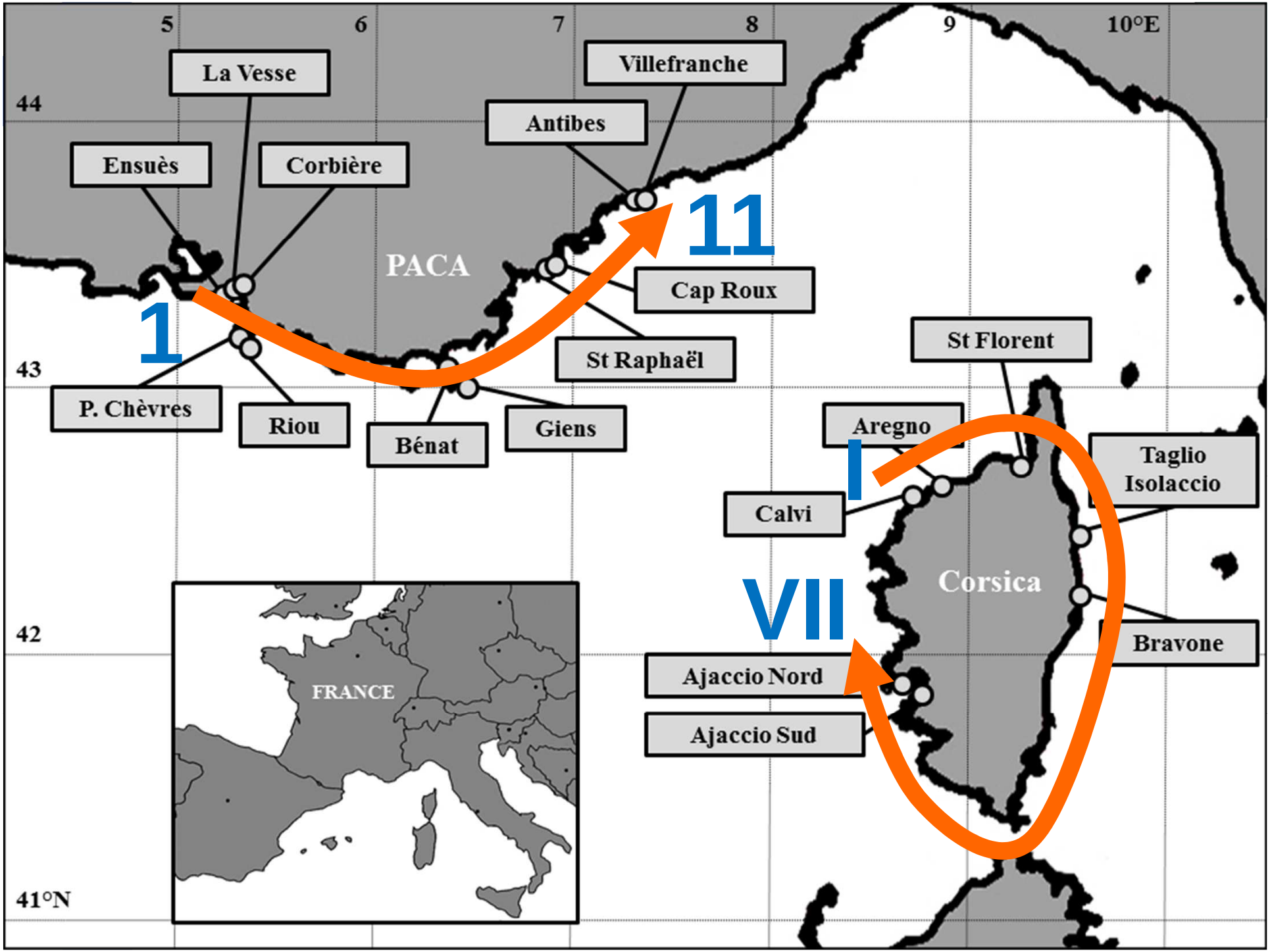


Local monitoring: Calvi Bay

Calvi sewer vs Aquaculture farm






5
6
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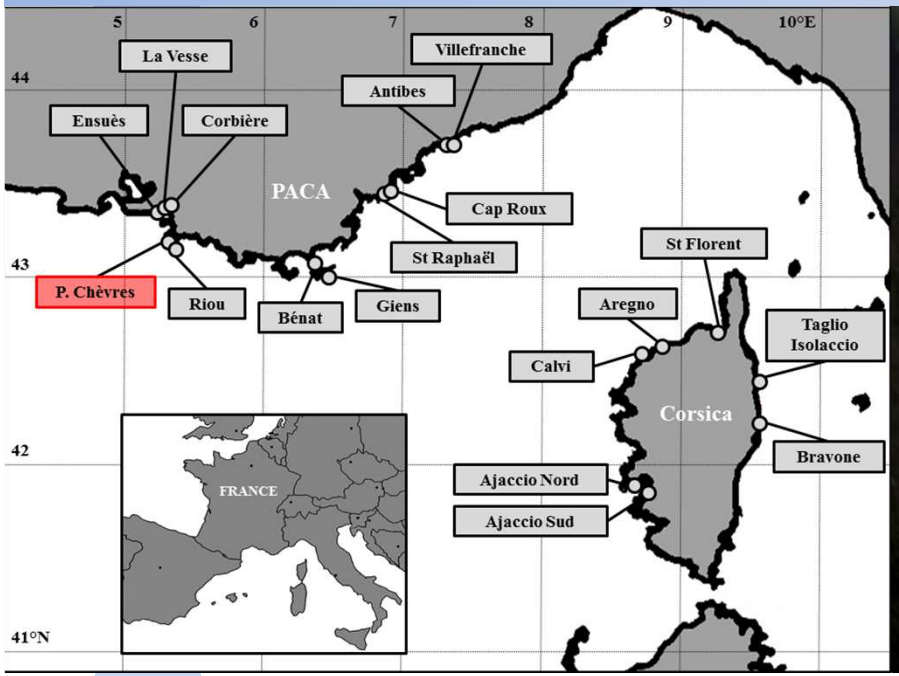
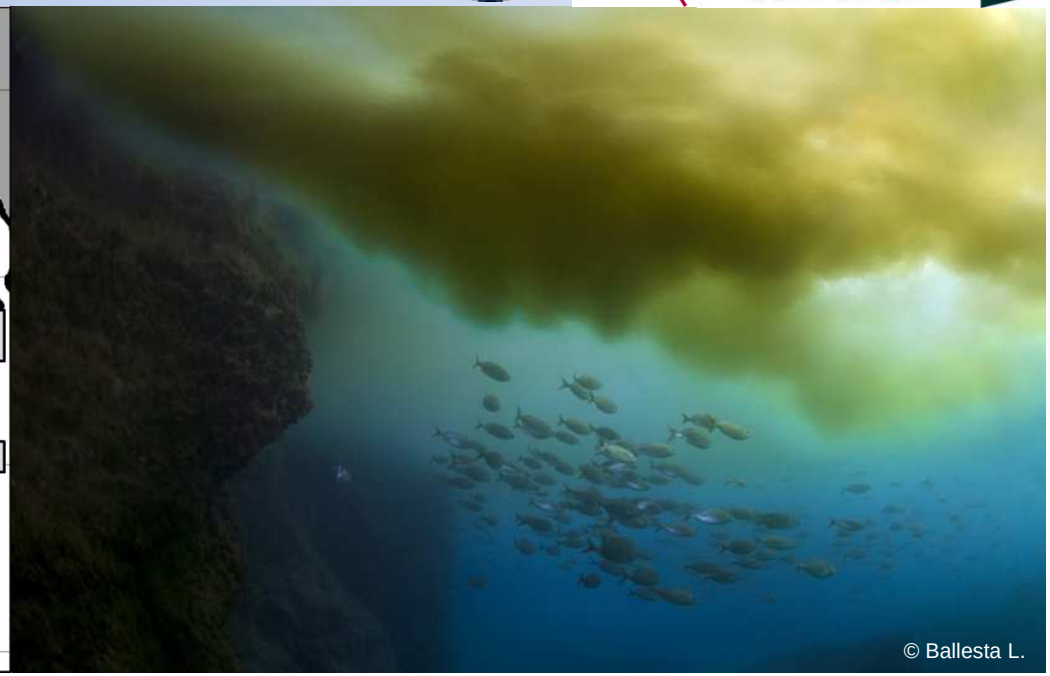
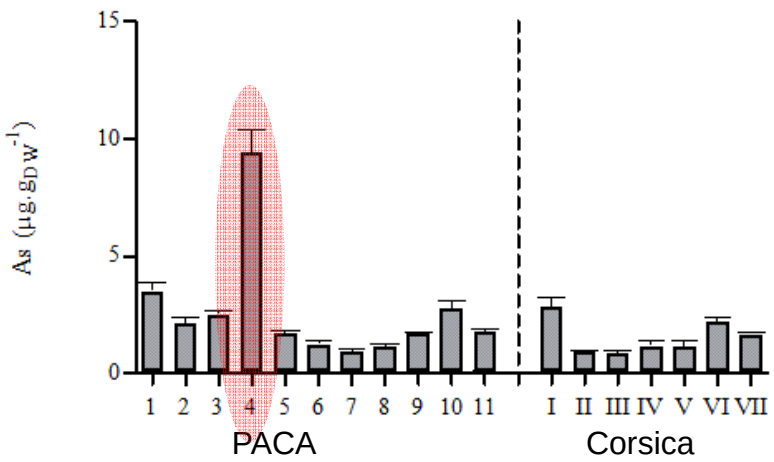
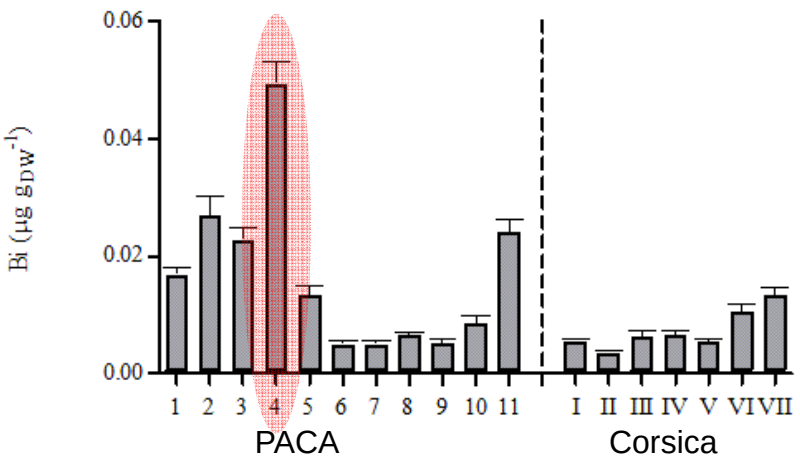
9
10°E
44
43
42
41°N
La Vesse
Villefranche
Antibes
Ensuès
Corbière
PACA
11
1
Cap Roux
St Raphaël
St Florent
P. Chèvres
Riou
Bénat
Giens
Aregno
I
Taglio Isolaccio
Calvi
Corsica
VII
Bravone
Ajaccio Nord
Ajaccio Sud
FRANCE

Regional monitoring: French littoral

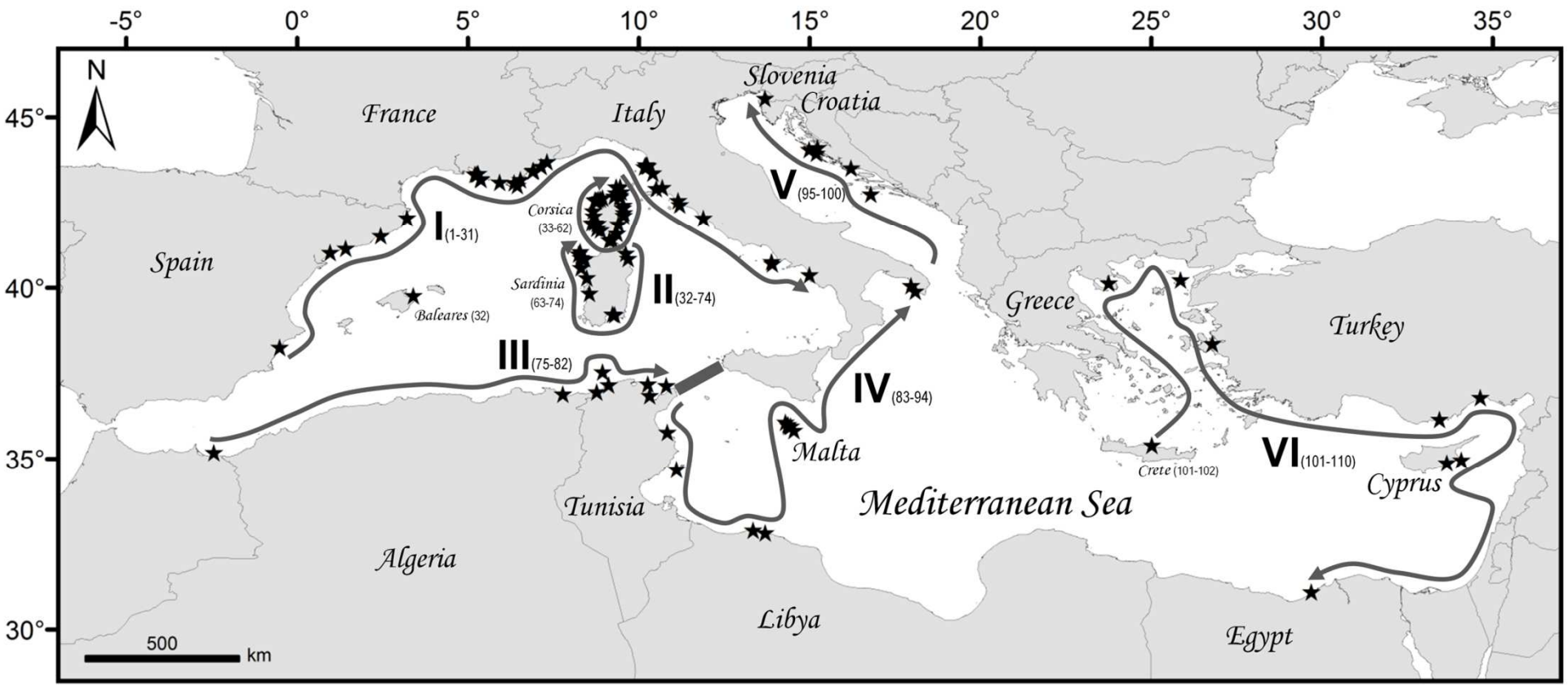






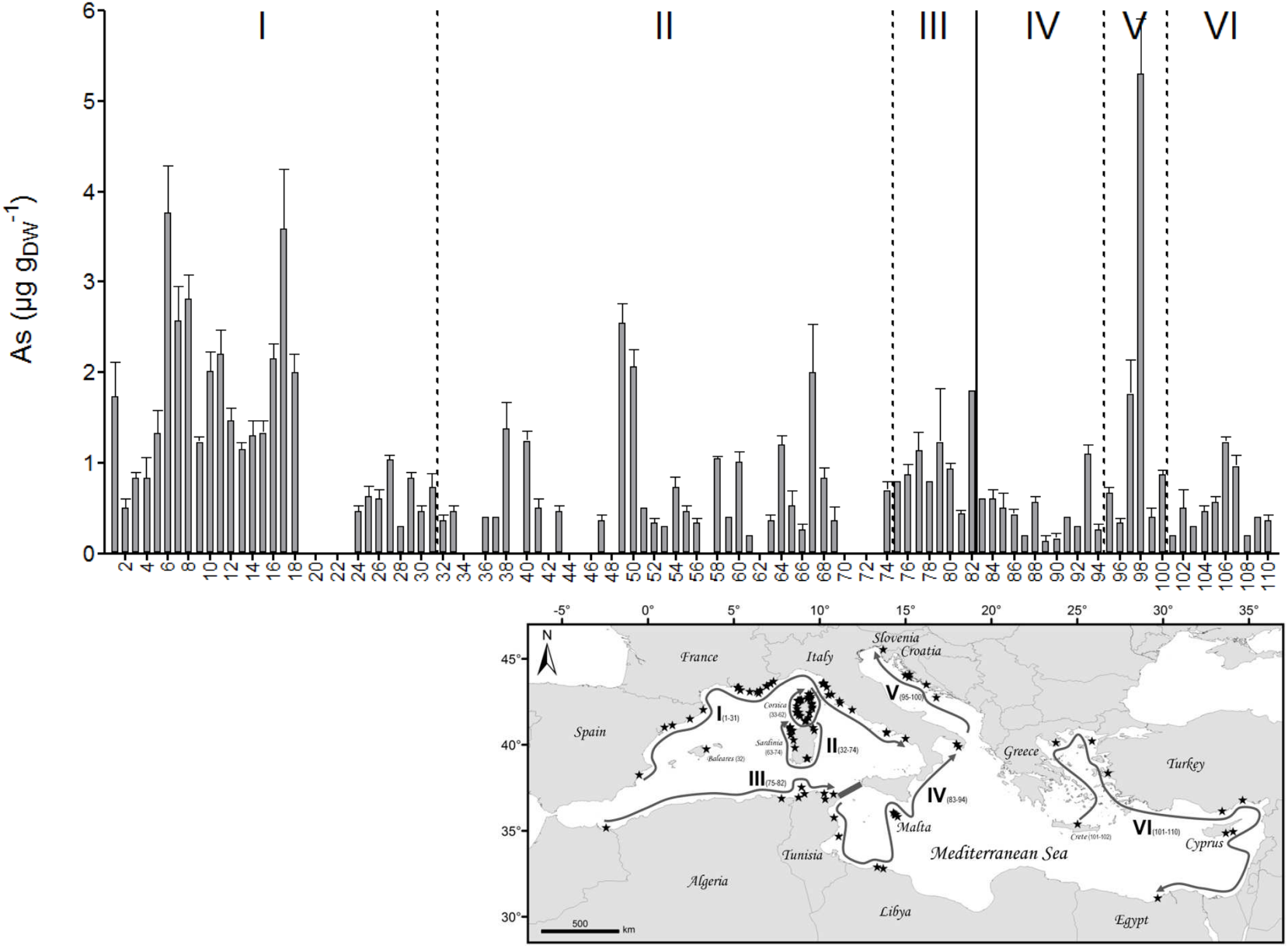


Global monitoring: Mediterranean



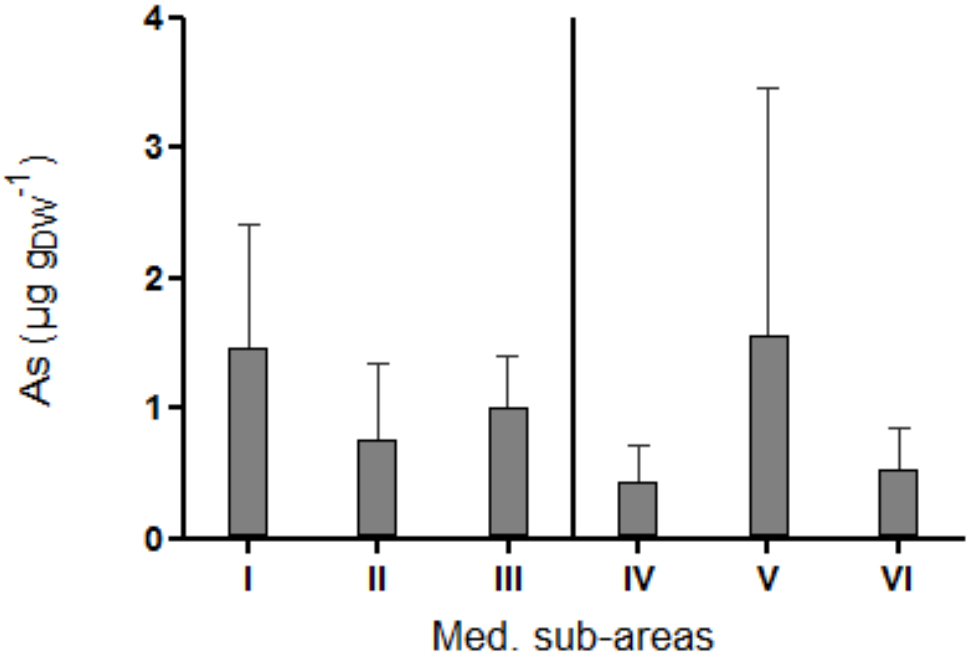
Global monitoring: Mediterranean

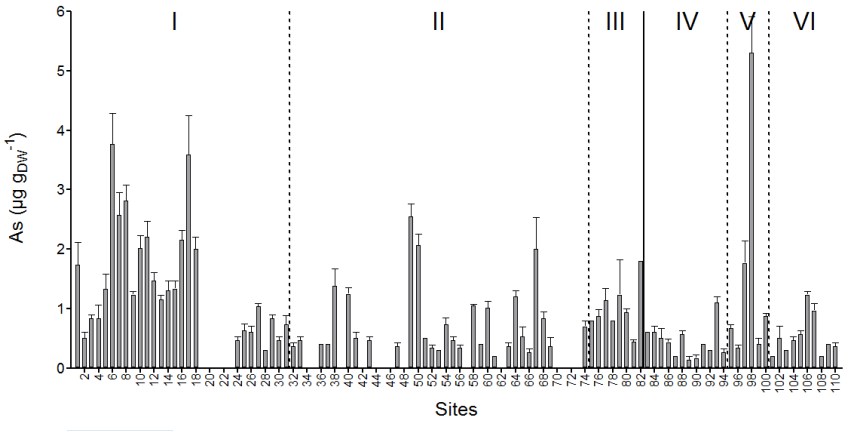
CASE STUDY

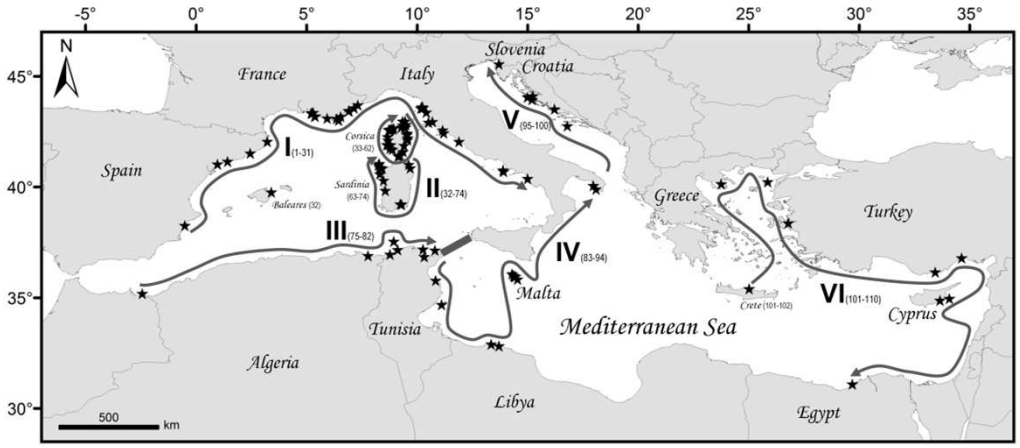


Global monitoring: Mediterranean

CASE STUDY

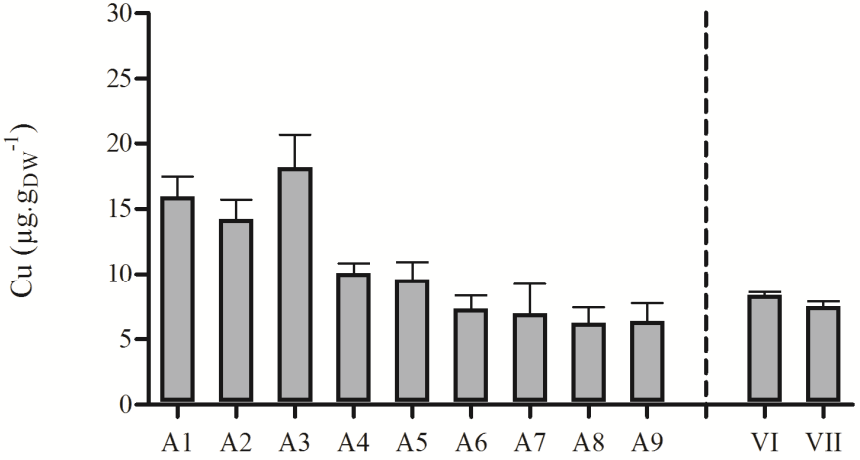




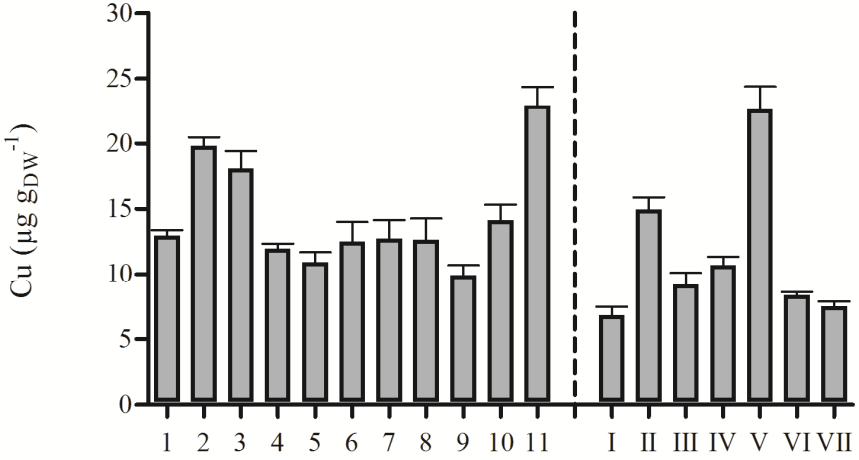


Scale ? Sampling effort ?

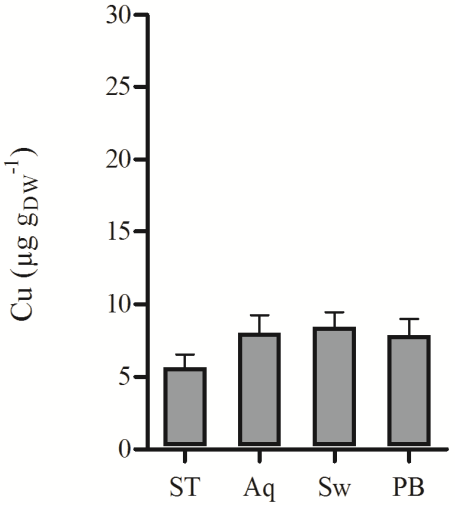
1. Along a radial (100 m)



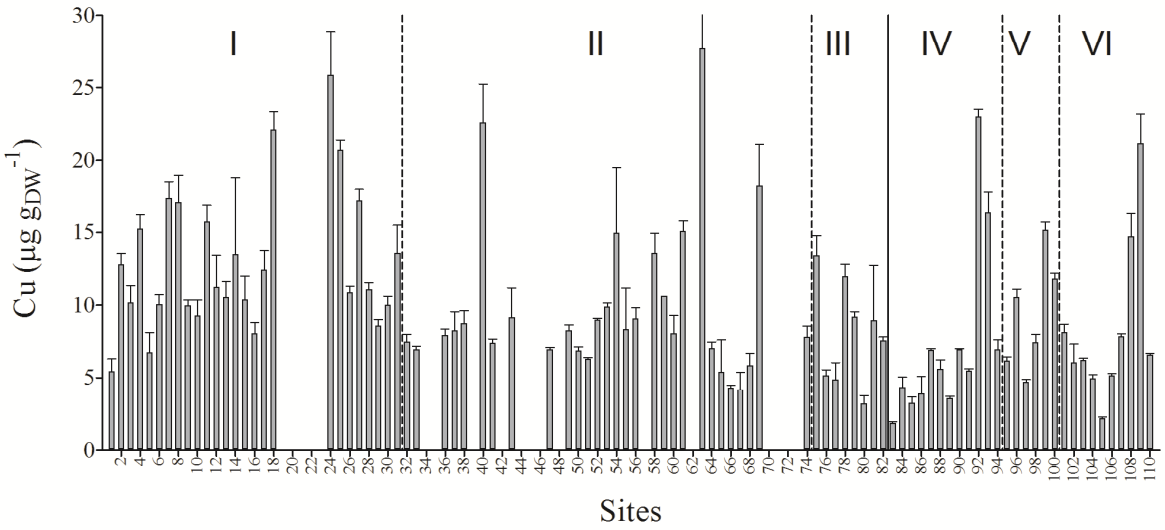
3. Along the French littoral (10-100 km)



2. In a bay (1 km)

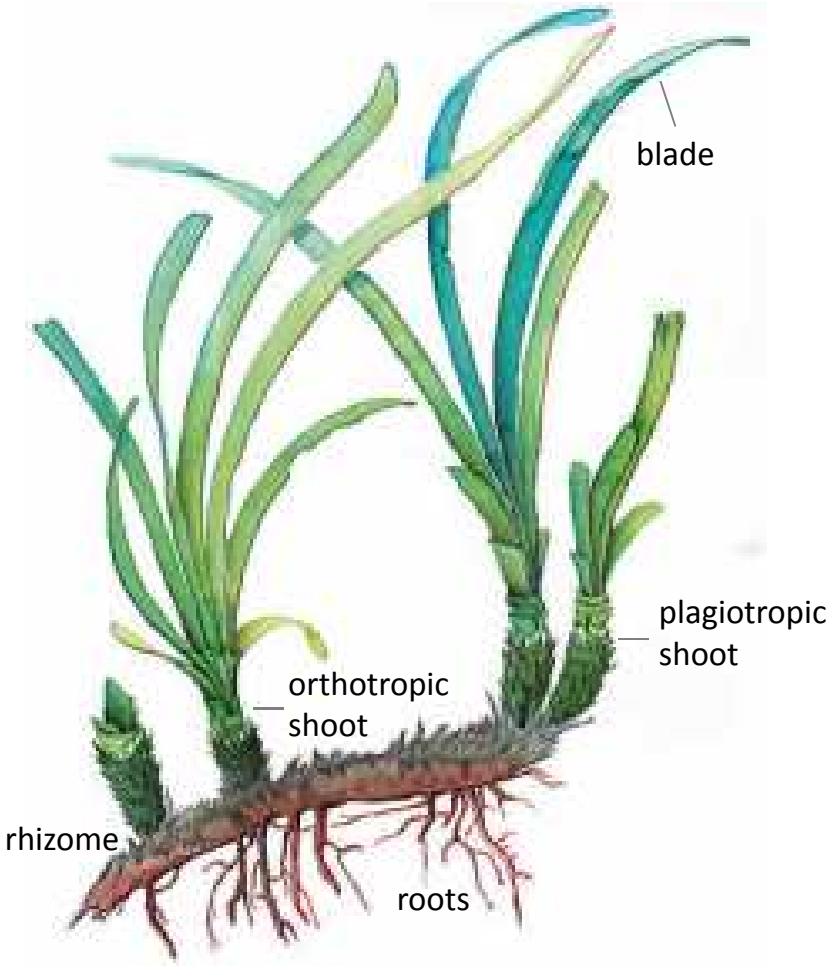


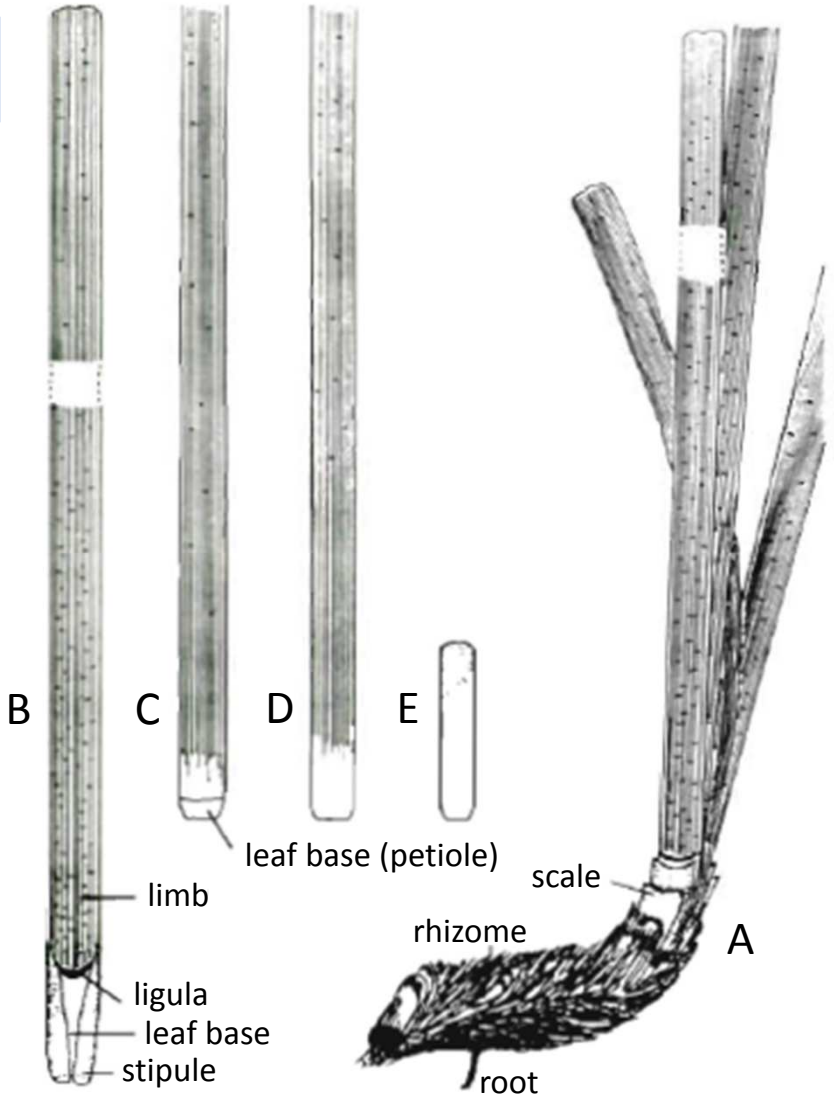
4. Along the Mediterranean coastline (100-1000 km)



Posidonia oceanica

ECOPHYSIOLOGY

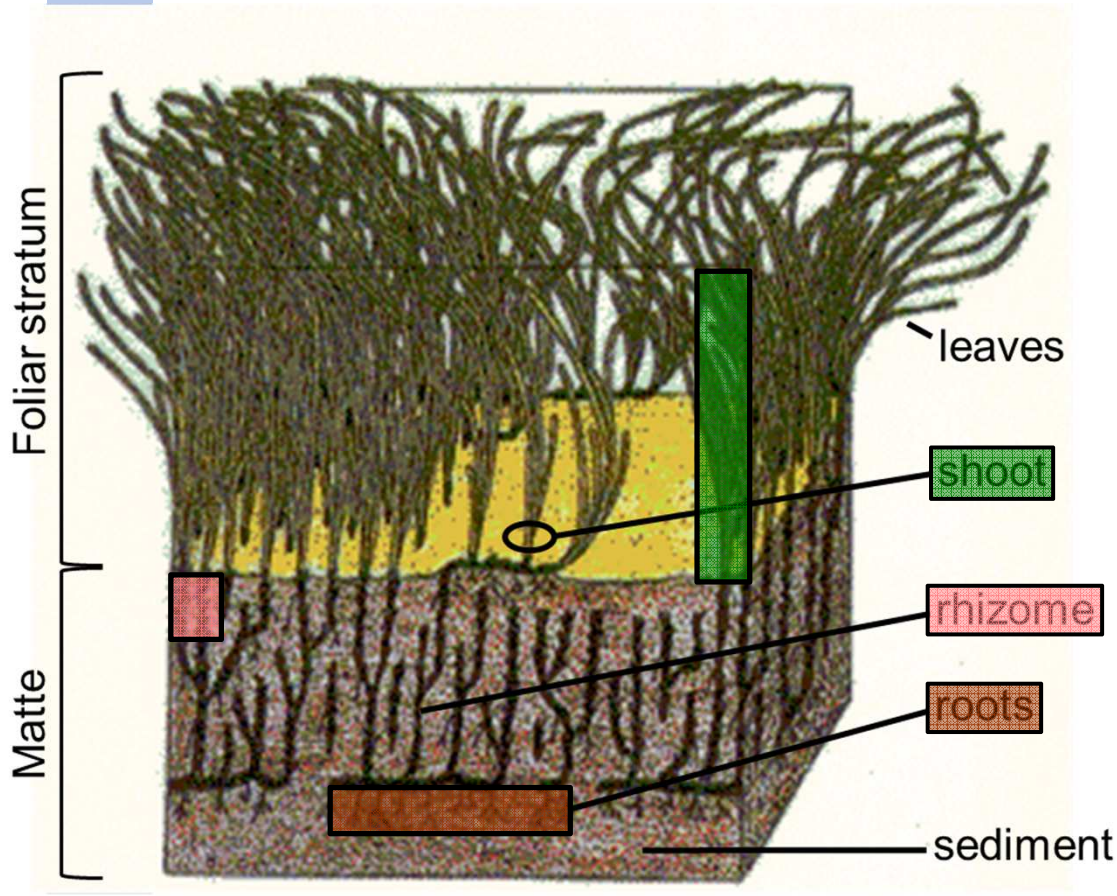




Left: *P. oceanica* shoots fixed on a plagiotropic rhizome. Right: (A) shoot of leaves on a plagiotropic rhizome; (B, C) adult leaves; (D) intermediate leaf; (E) juvenile leaf (modified after Libes and Boudouresque 1987).

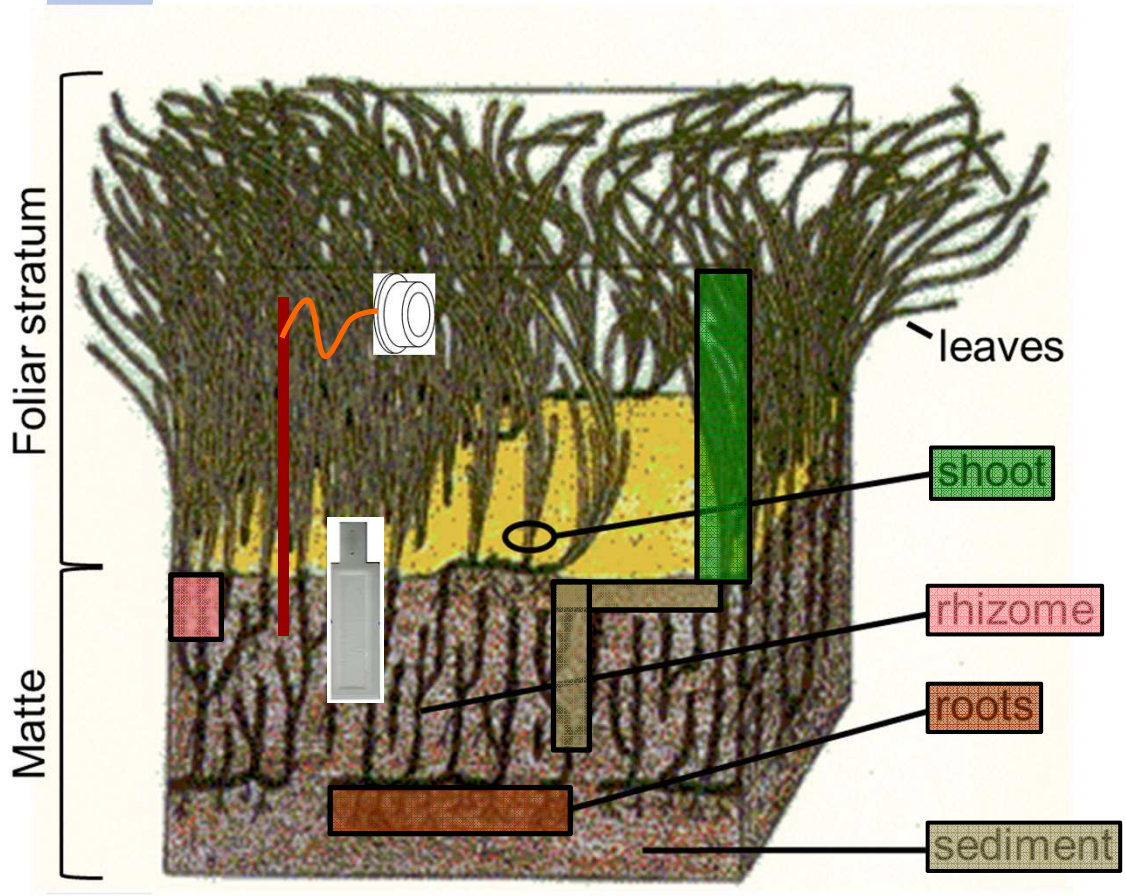
Posidonia oceanica

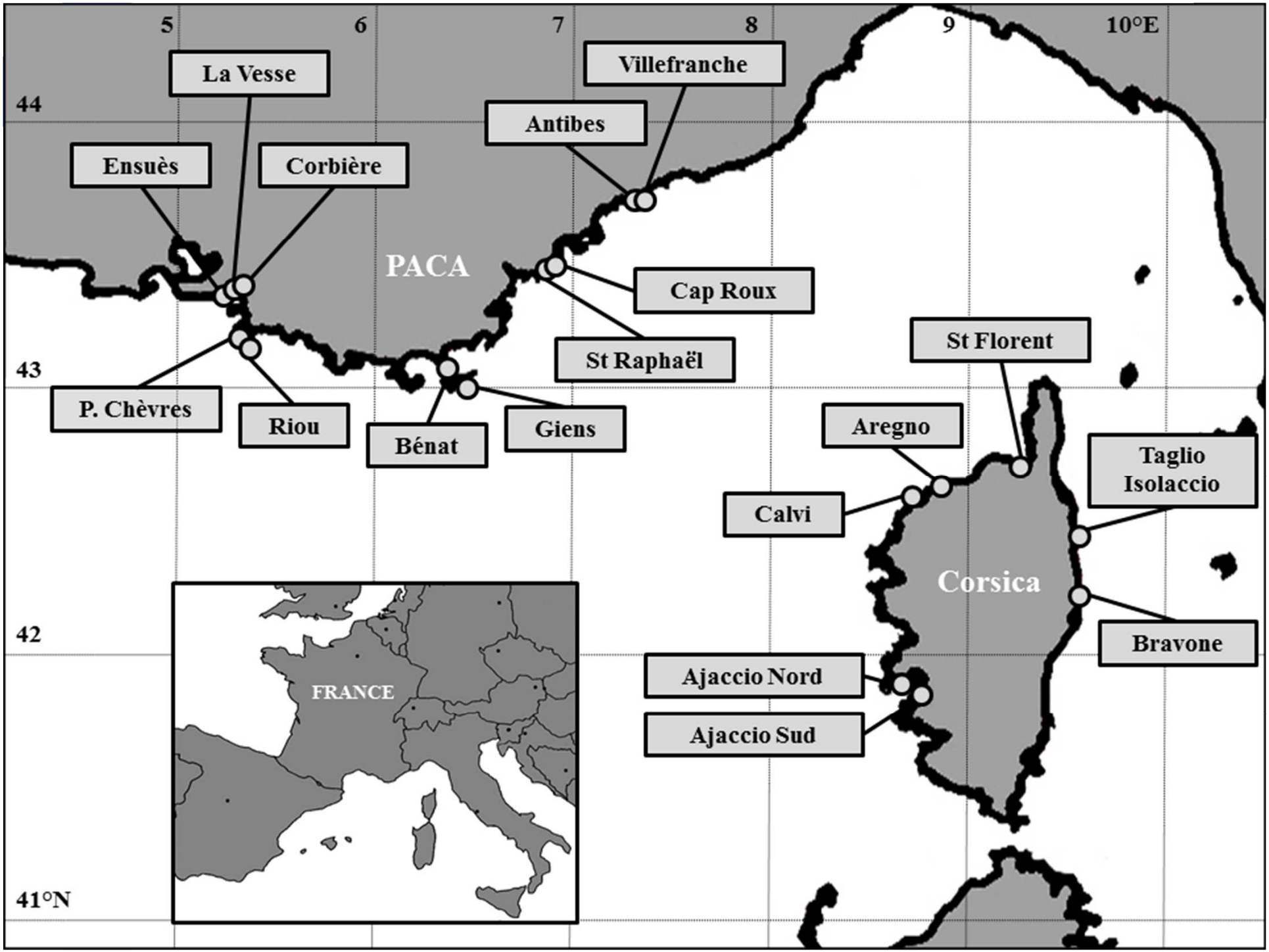
- *Posidonia oceanica*: shoots, rhizomes and roots;
  - Foliar stratum;
  - Matte.



Posidonia oceanica

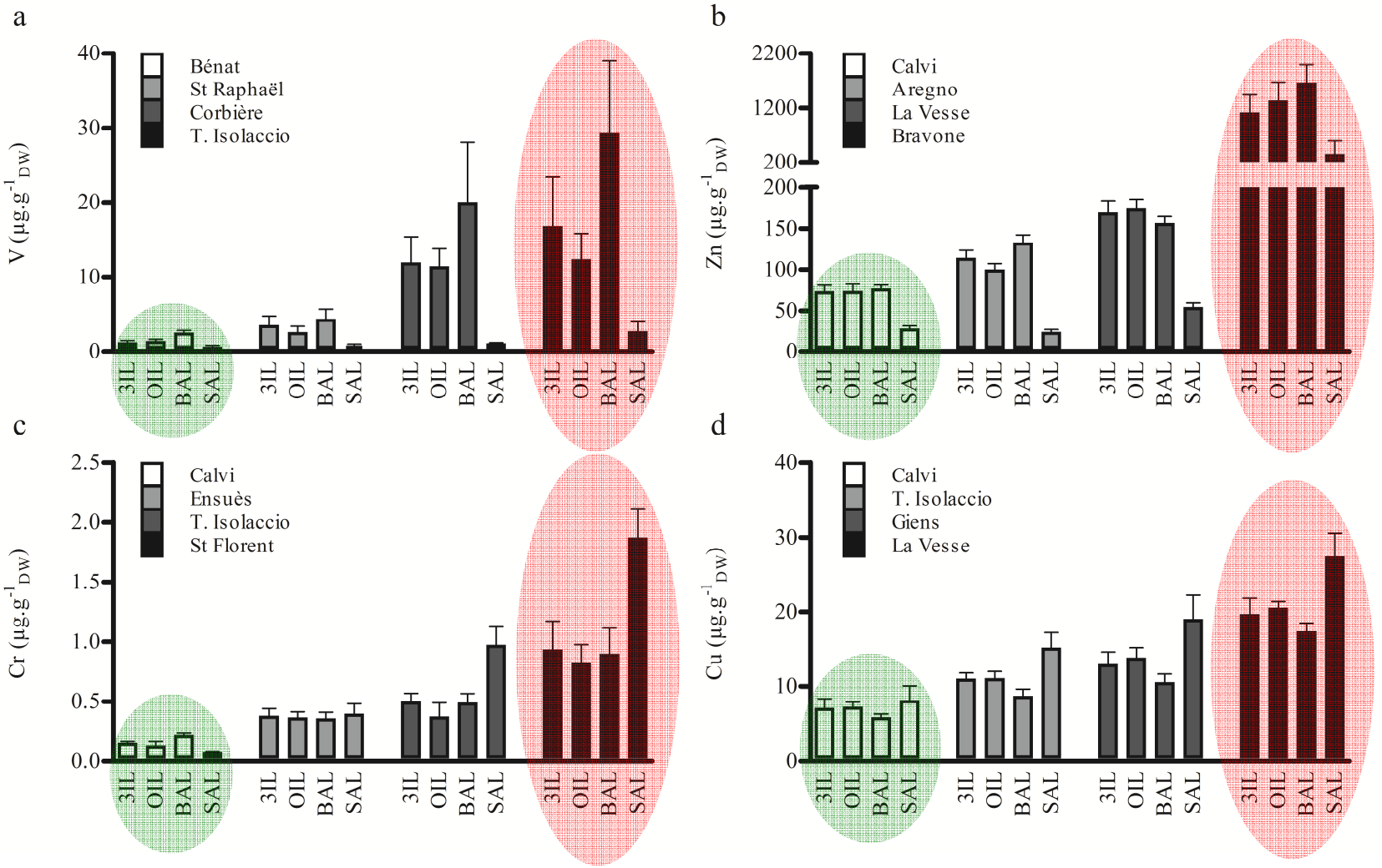
- *Posidonia oceanica*: shoots, rhizomes and roots;
  - Foliar stratum ◄ water;
  - Matte ◄ sediments.




5
6
7
8
9
10°E
44
43
42
41°N
La Vesse
Villefranche
Antibes
Ensuès
Corbière
PACA
Cap Roux
St Raphaël
St Florent
P. Chèvres
Riou
Bénat
Giens
Aregno
Taglio Isolaccio
Calvi
Corsica
Bravone
Ajaccio Nord
Ajaccio Sud
FRANCE

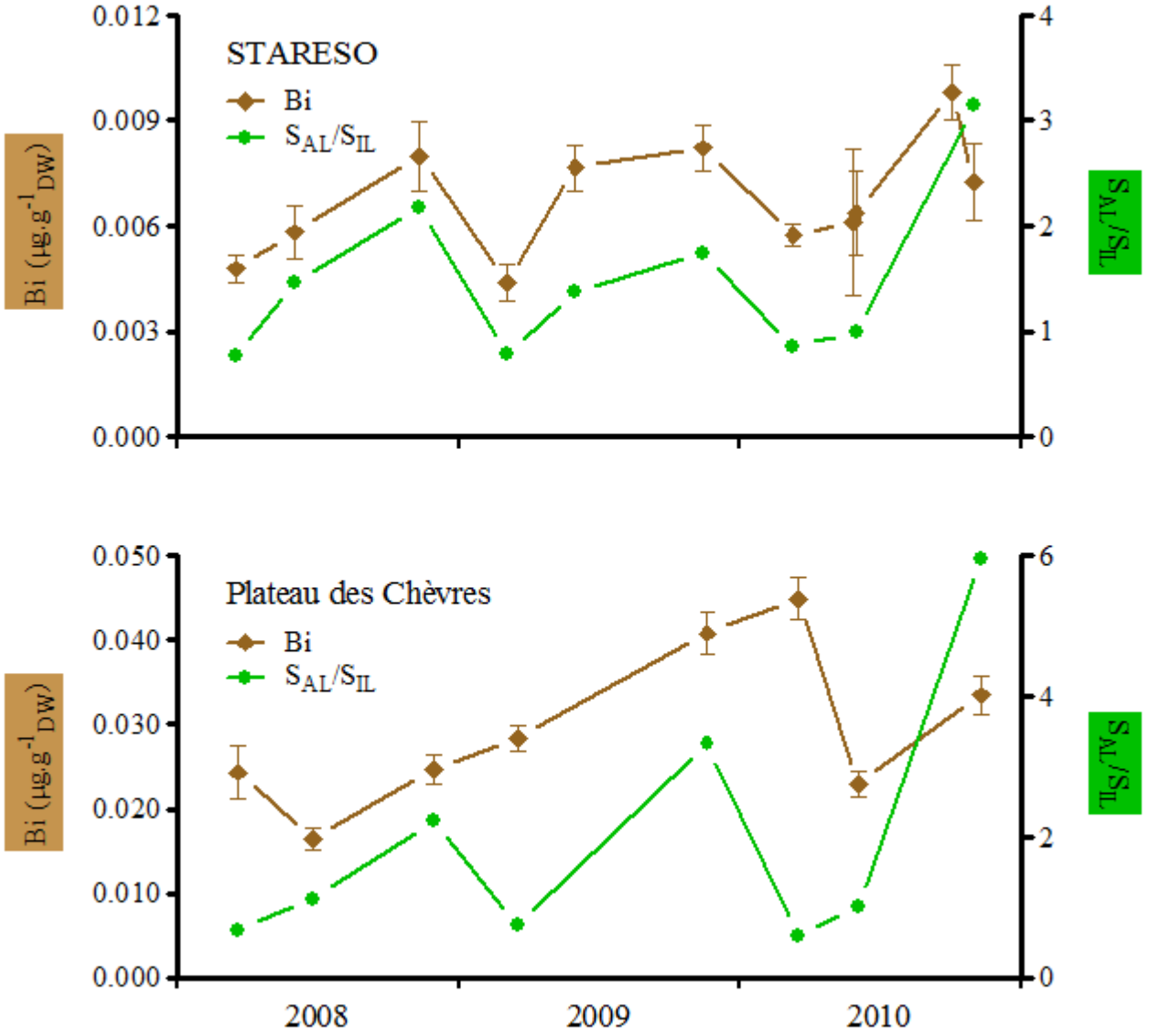
P. oceanica compartmentalization

ECOPHYSIOLOGY



Environment vs. biological cycle

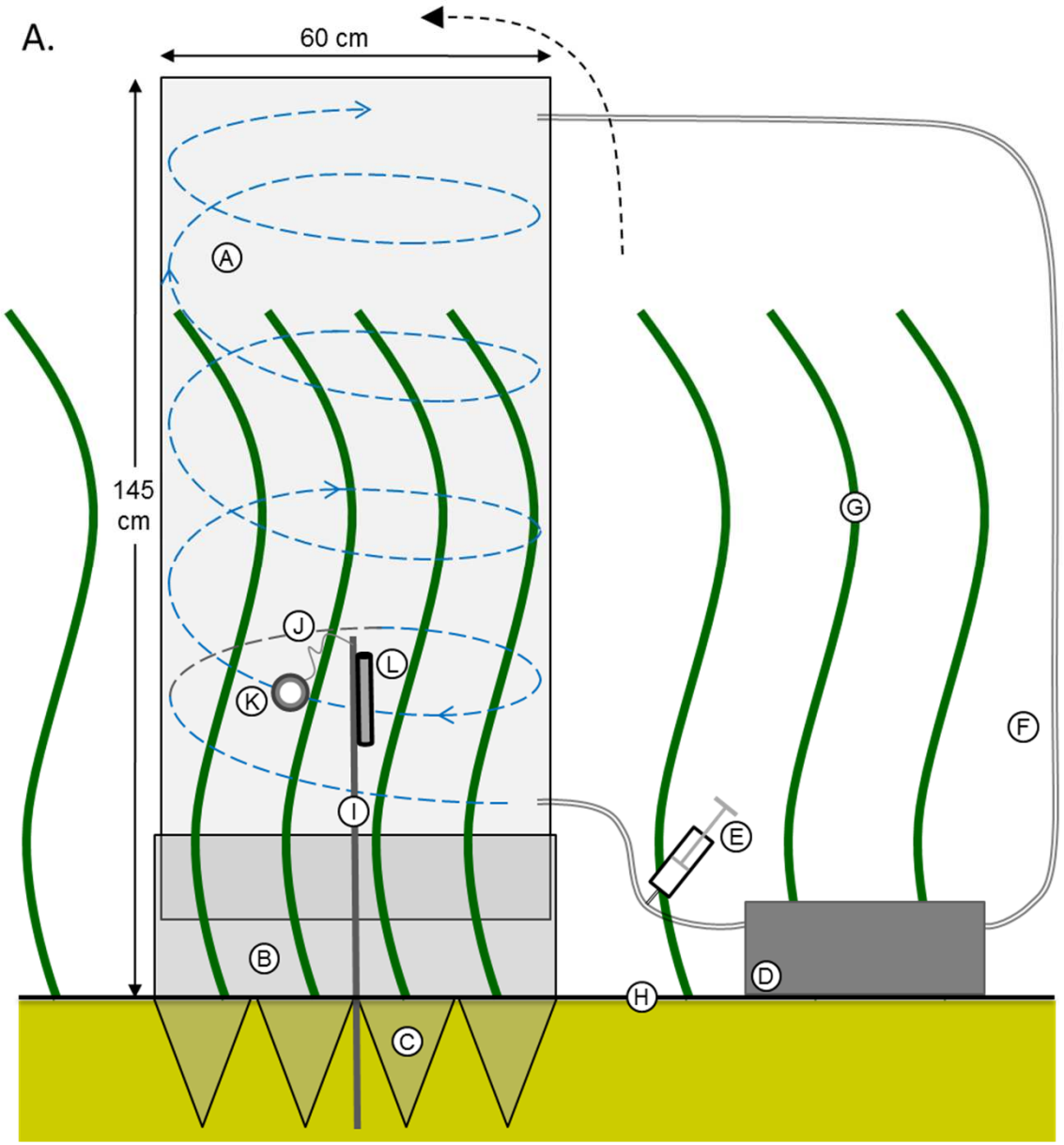
ECOPHYSIOLOGY



Moderate contamination experiment

MESOCOSM

- 5 days of contamination in June 2009;
- 410L bell-shaped mesocosm;
- Contamination every 12 hours (9am-9pm);
- 15 days of decontamination.

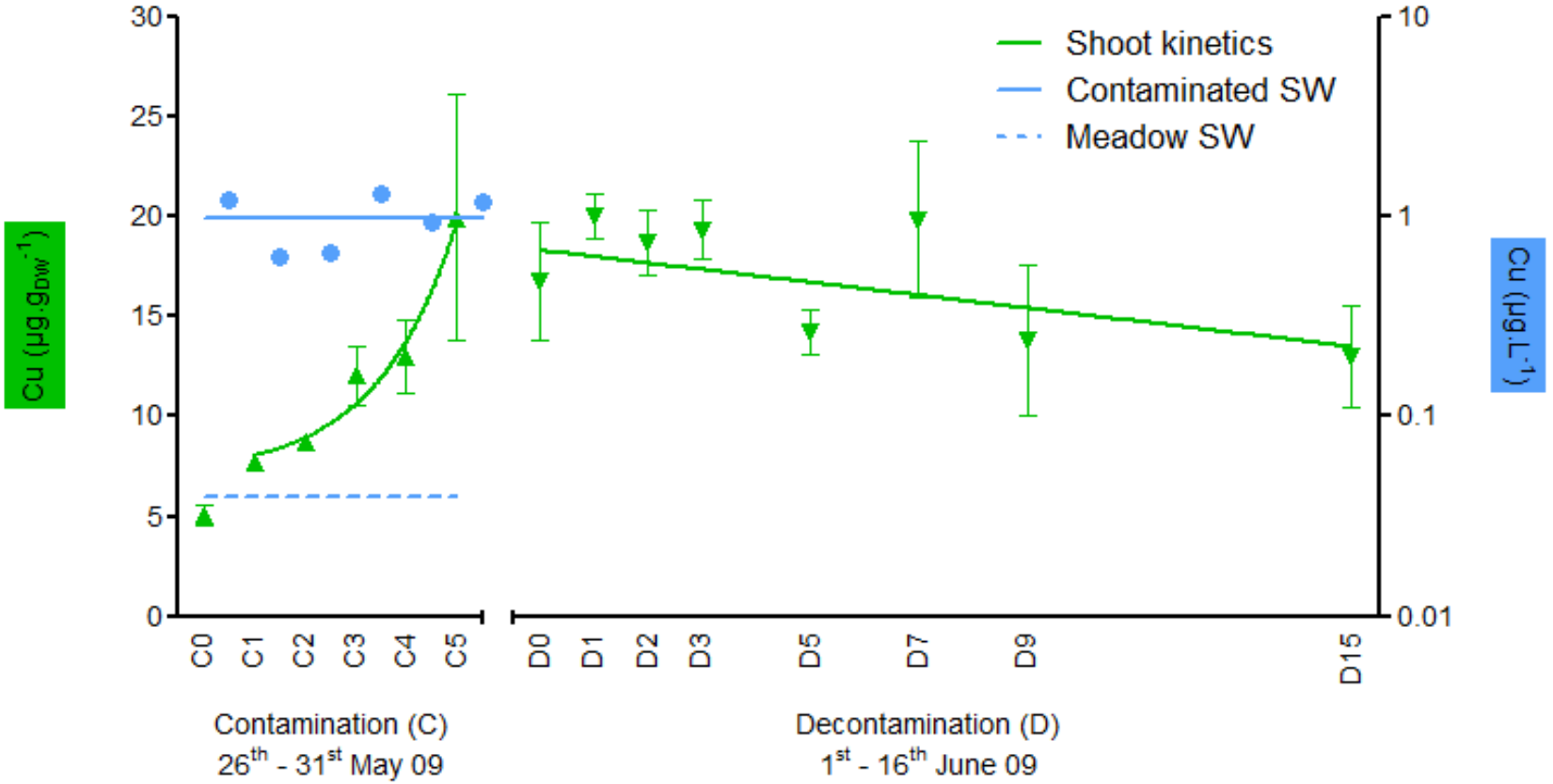


Moderate mesocosm

MESOCOSM

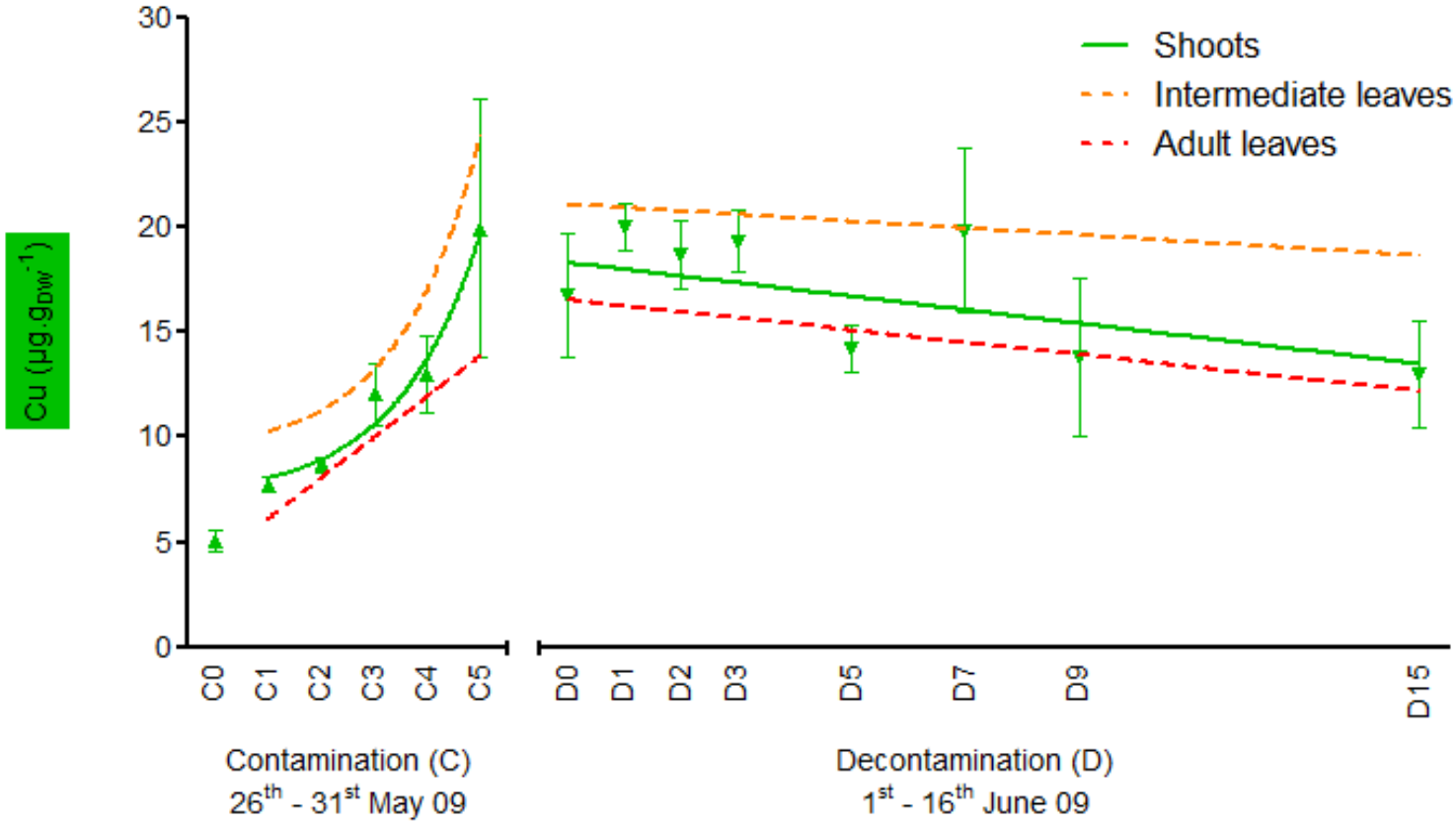
Cu: moderate - shoots and water

MESOCOSM



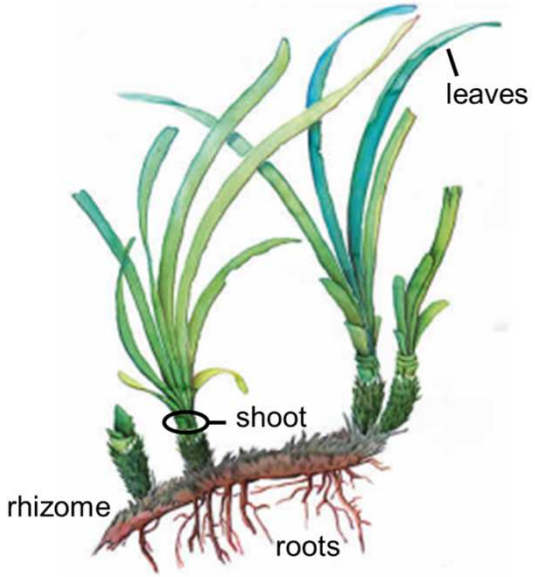
Cu: moderate - shoots and leaves

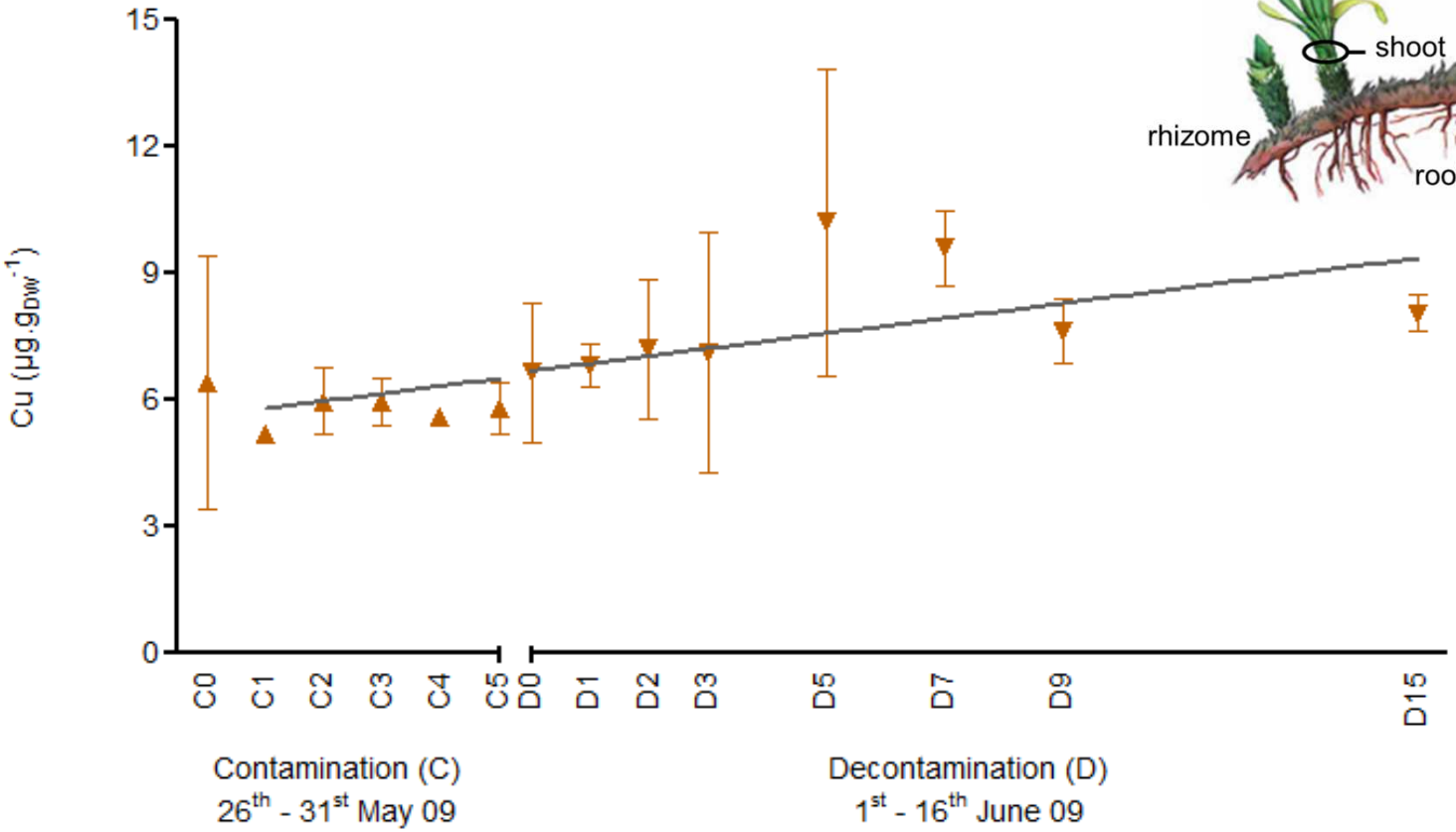
MESOCOSM



Cu: moderate - rhizomes

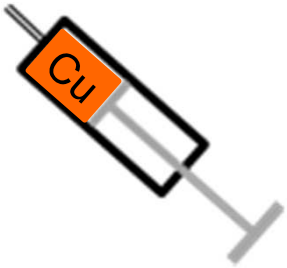
MESOCOSM

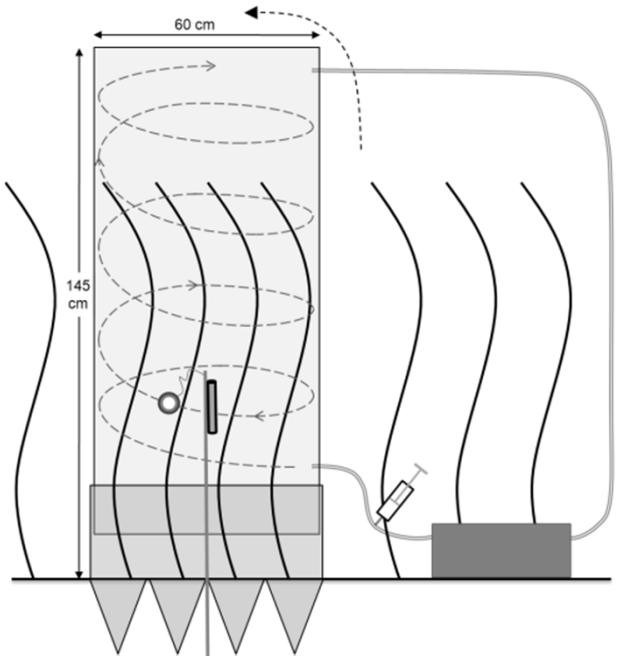




MESOCOSM

acropetal translocation





You said biomonitoring … ??

CONCLUSIONS

1. Spatial monitoring of pollution:

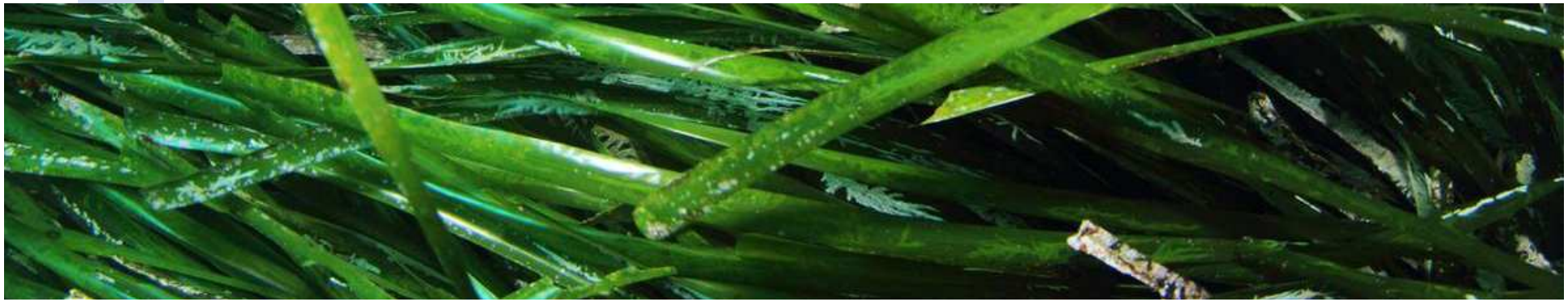
   Sampling strategy will depend of the aims of your study;

2. Compartmentalization and seasonality:

   Bioaccumulated TE levels evolve according to the compartment considered and the species biological cycle;

3. Experimental vs. field monitoring:

   2 complementary approaches.



More information

CONCLUSIONS

http://orbi.ulg.ac.be/

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

Chemical contamination along the Mediterranean French coast using *Posidonia oceanica* (L.) Delile above-ground tissues: a multiple trace element study

Nicolas Luy[a,*], Sylvie Gobert[a], Stéphane Sartoretto[b], Renzo Biondo[a], Jean-Marie Bouquegneau[a], Jonathan Richir[a]

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Marine Pollution Bulletin

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A reassessment of the use of *Posidonia oceanica* and *Mytilus galloprovincialis* to biomonitor the coastal pollution of trace elements: New tools and tips

J. Richir*, S. Gobert

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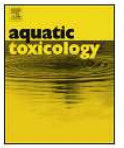

Experimental *in situ* exposure of the seagrass *Posidonia oceanica* (L.) Delile to 15 trace elements

J. Richir[a,*], N. Luy[a], G. Lepoint[a], E. Rozet[b], A. Alvera Azcarate[c], S. Gobert[a]

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Bioassessment of trace element contamination of Mediterranean coastal waters using the seagrass *Posidonia oceanica*

J. Richir[a,b,*], M. Salivas-Decaux[c], C. Lafabrie[c,d], C. Lopez y Royo[c], S. Gobert[a], G. Pergent[c], C. Pergent-Martini[c]

Thank you for your attention

5th Annual World Congress of
Marine Biotechnology-2015

J. Richir, P. Lejeune,
G. Lepoint, K. Das,
S. Gobert

Qingdao,
11-07-15