Origine et composition de la matière organique littorale à l'échelle de la Métropole en lien avec les apports telluriques

N. Savoye

université de BORDEAUX EPOC cnrs

MOP : matière organique particulaire
= matière particulaire vivante ou d'origine vivante

Diversité des sources et flux de MOP en zone côtière

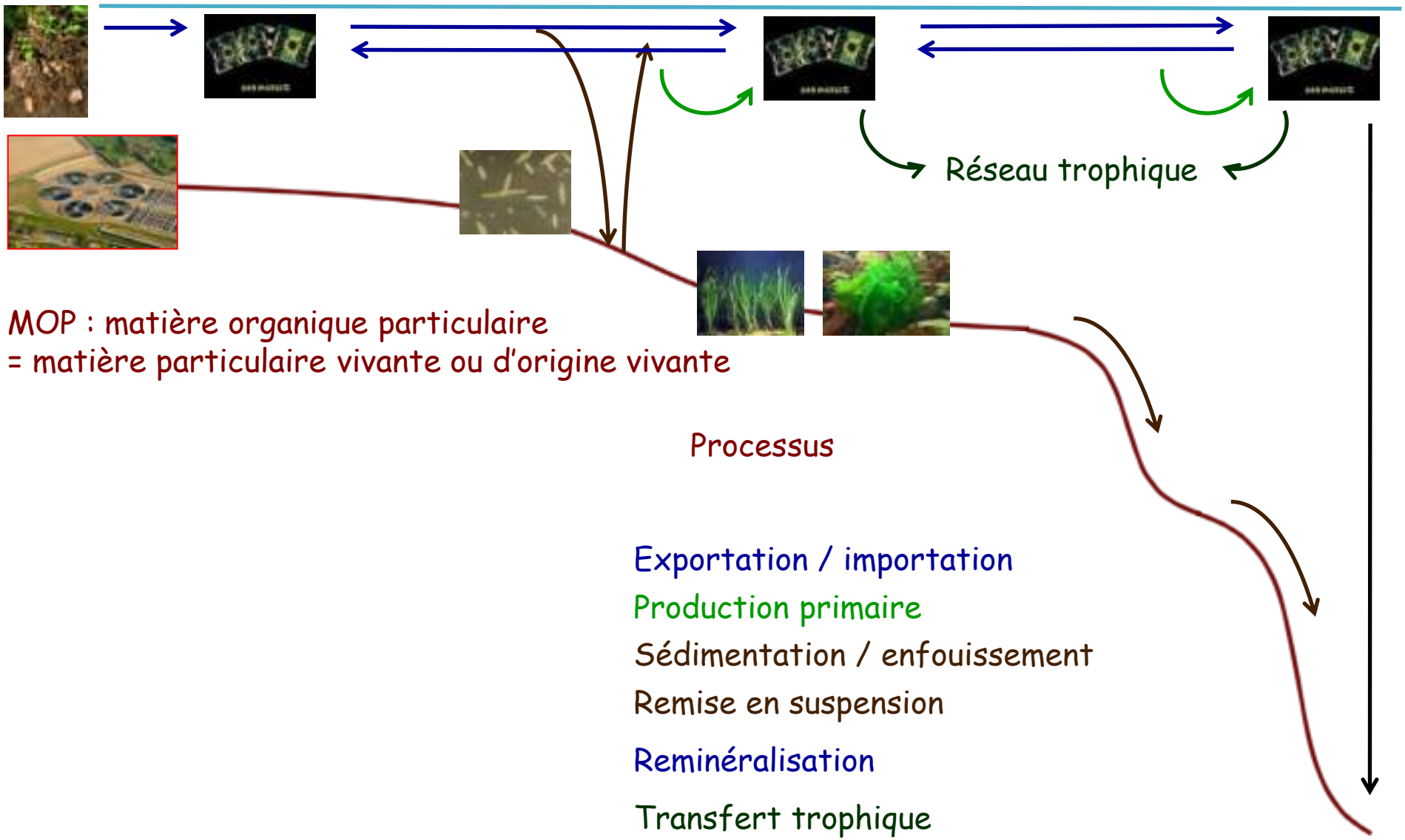
Fleuve

Zone côtière

Océan

MOP : matière organique particulaire
= matière particulaire vivante ou d'origine vivante

Diversité des sources et flux de MOP en zone côtière



MOP : matière organique particulaire
= matière particulaire vivante ou d'origine vivante

Processus

Exportation / importation

Production primaire

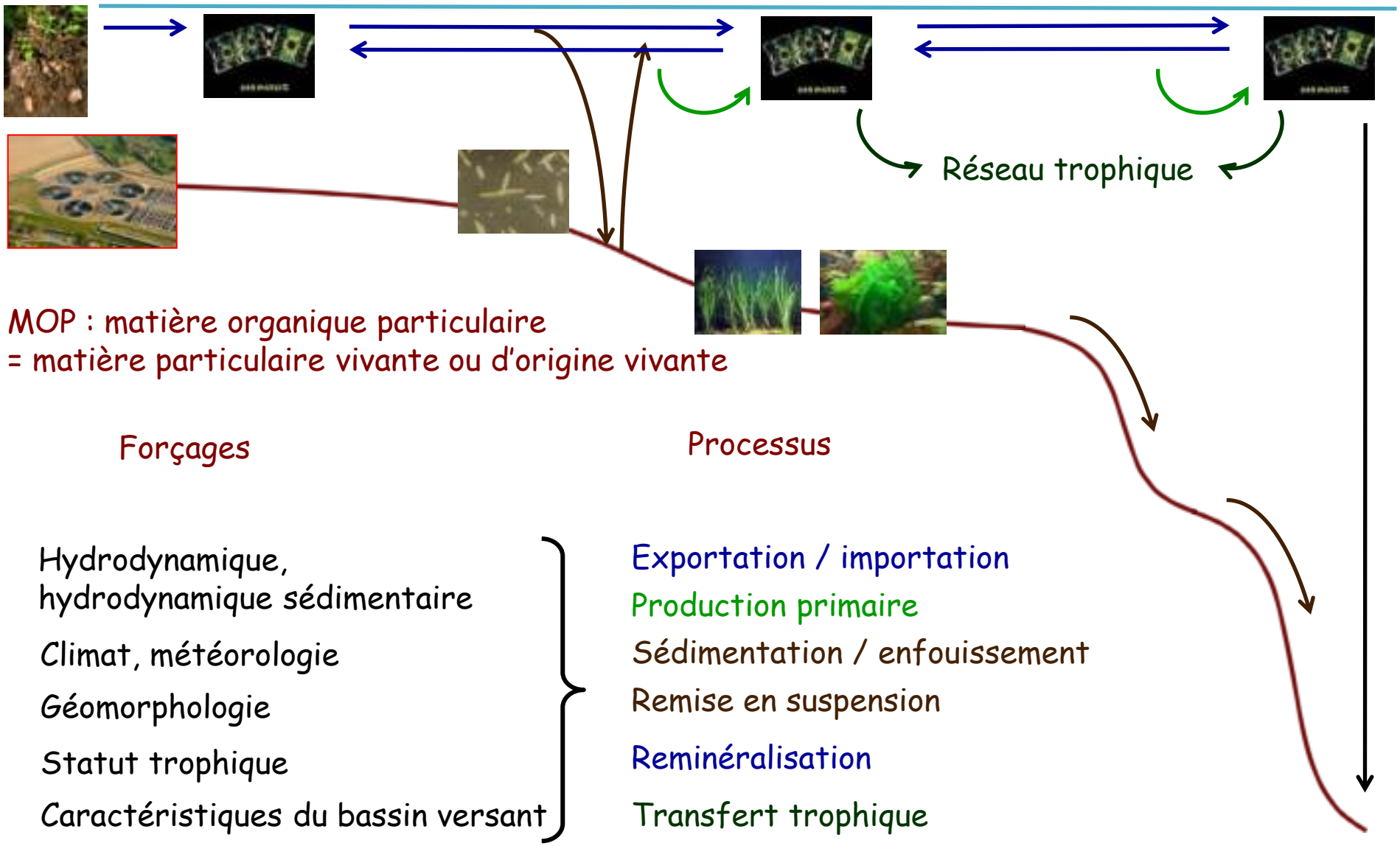
Sédimentation / enfouissement

Remise en suspension

Reminéralisation

Transfert trophique

Diversité des sources et flux de MOP en zone côtière



MOP : matière organique particulaire
= matière particulaire vivante ou d'origine vivante

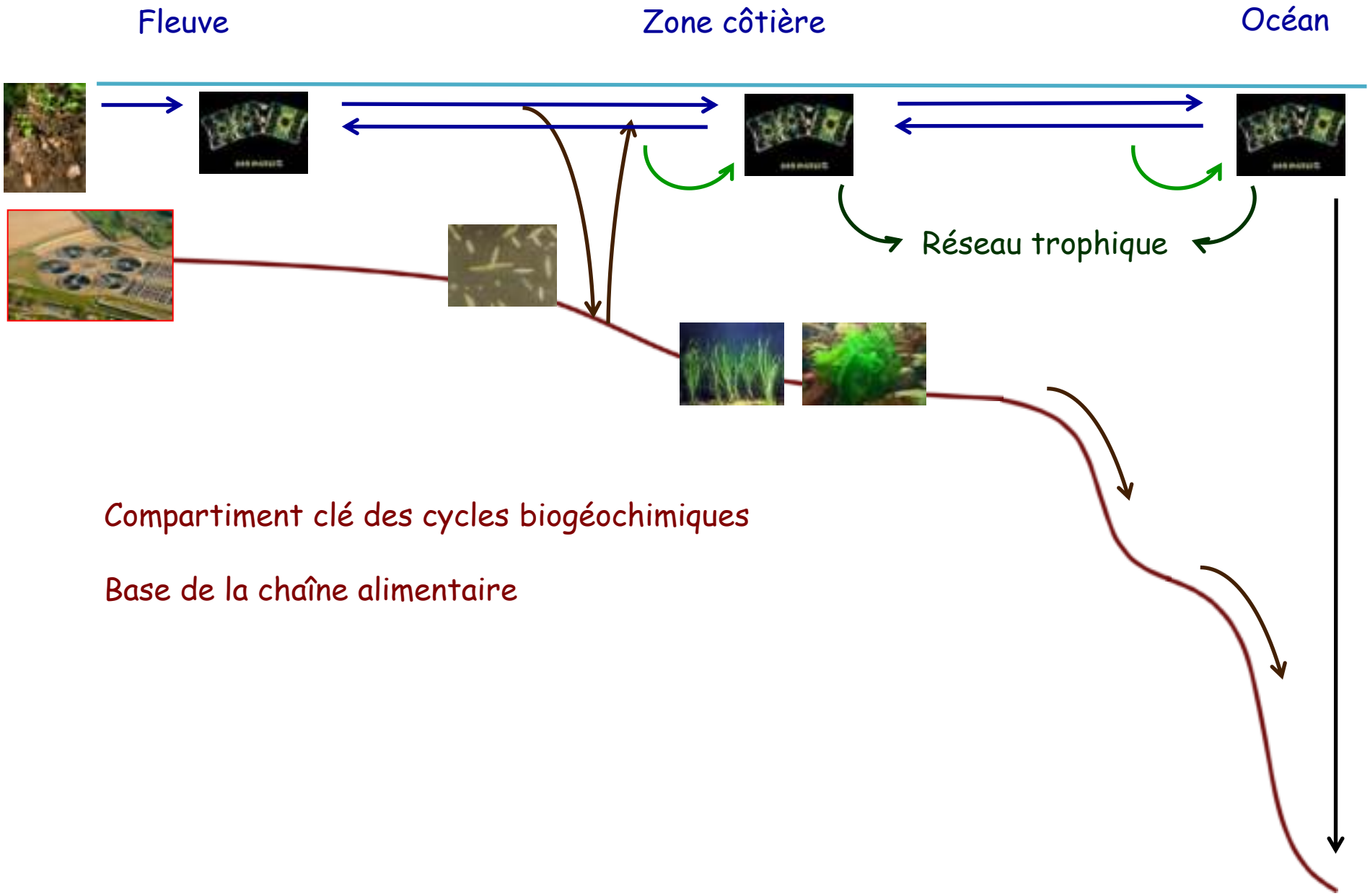
Forçages

- Hydrodynamique, hydrodynamique sédimentaire
- Climat, météorologie
- Géomorphologie
- Statut trophique
- Caractéristiques du bassin versant

Processus

- Exportation / importation
- Production primaire
- Sédimentation / enfouissement
- Remise en suspension
- Reminéralisation
- Transfert trophique

Rôle de la MOP dans les écosystèmes aquatiques



Compartiment clé des cycles biogéochimiques

Base de la chaîne alimentaire

Objectifs

Quantifier les contributions des différentes sources à la composition de la MOP

Mettre en évidence les forçages environnementaux pouvant expliquer les variations spatio-temporelles de cette composition

Echelle intra-écosystémique

Echelle multi-écosystémique

Mettre en évidence une typologie d'écosystèmes

Approche et études

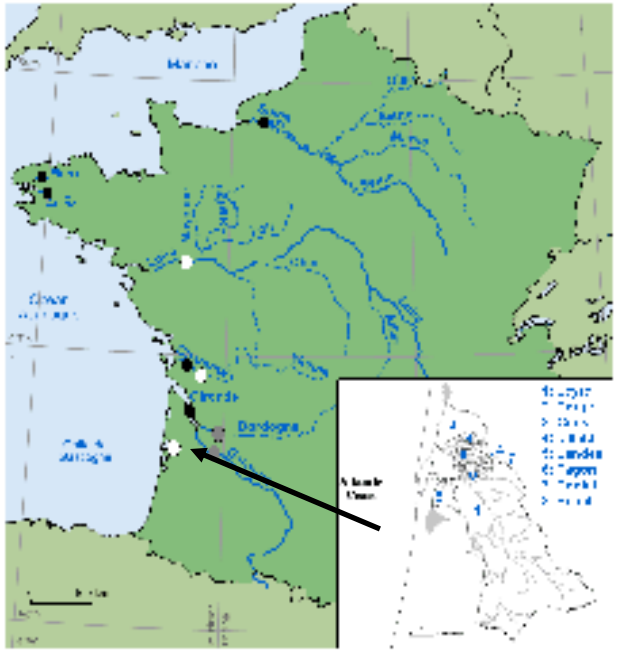
Approche isotopique ($\delta^{13}C$, $\delta^{15}N$) et élémentaire (C/N) + modèle de mélange

Zones côtières

Thèse C. Liénart (2017)

Liénart et al. (2016, 2017, 2018)

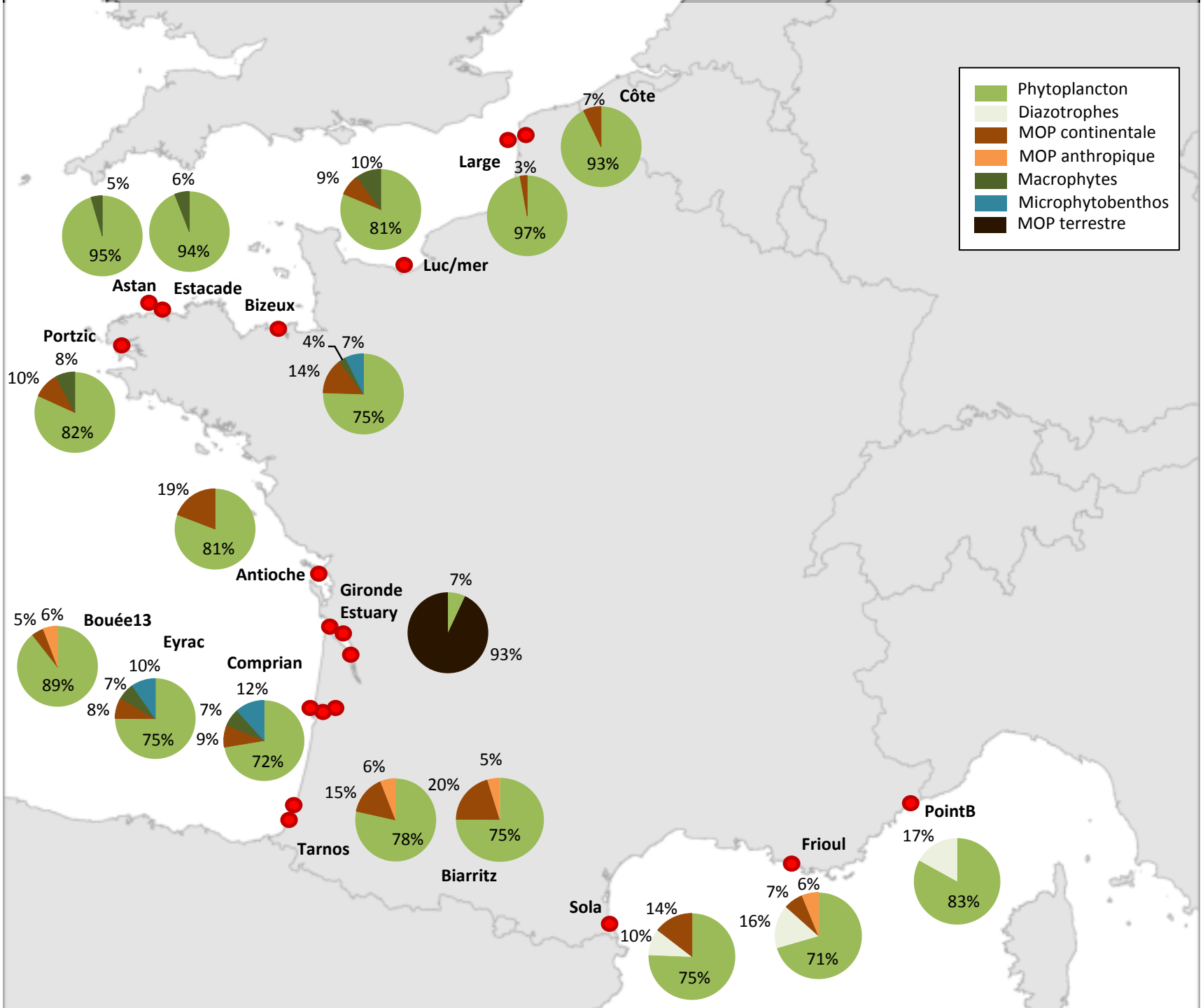
Estuaires

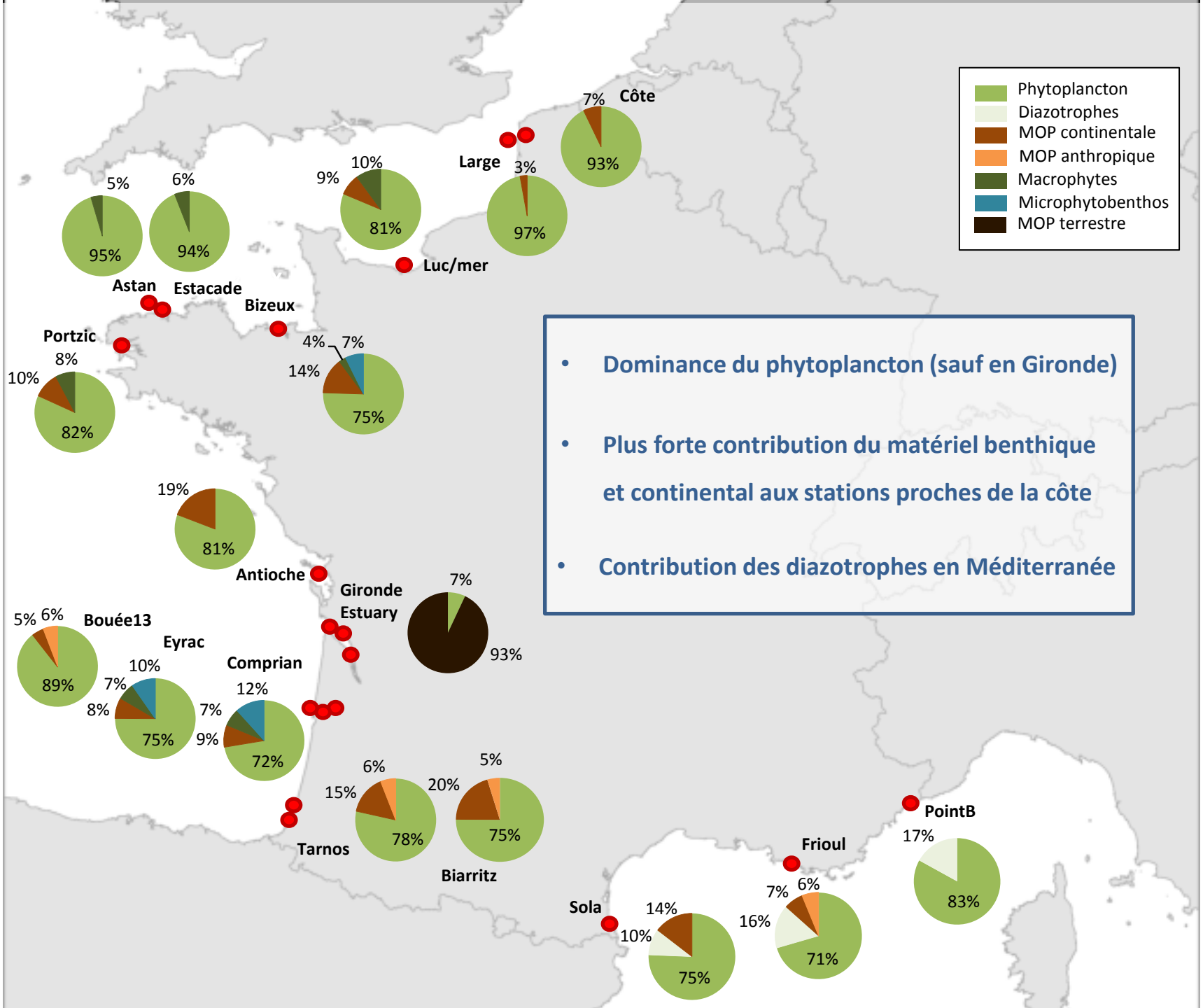


M2 H. de Lary de Latour (2014)

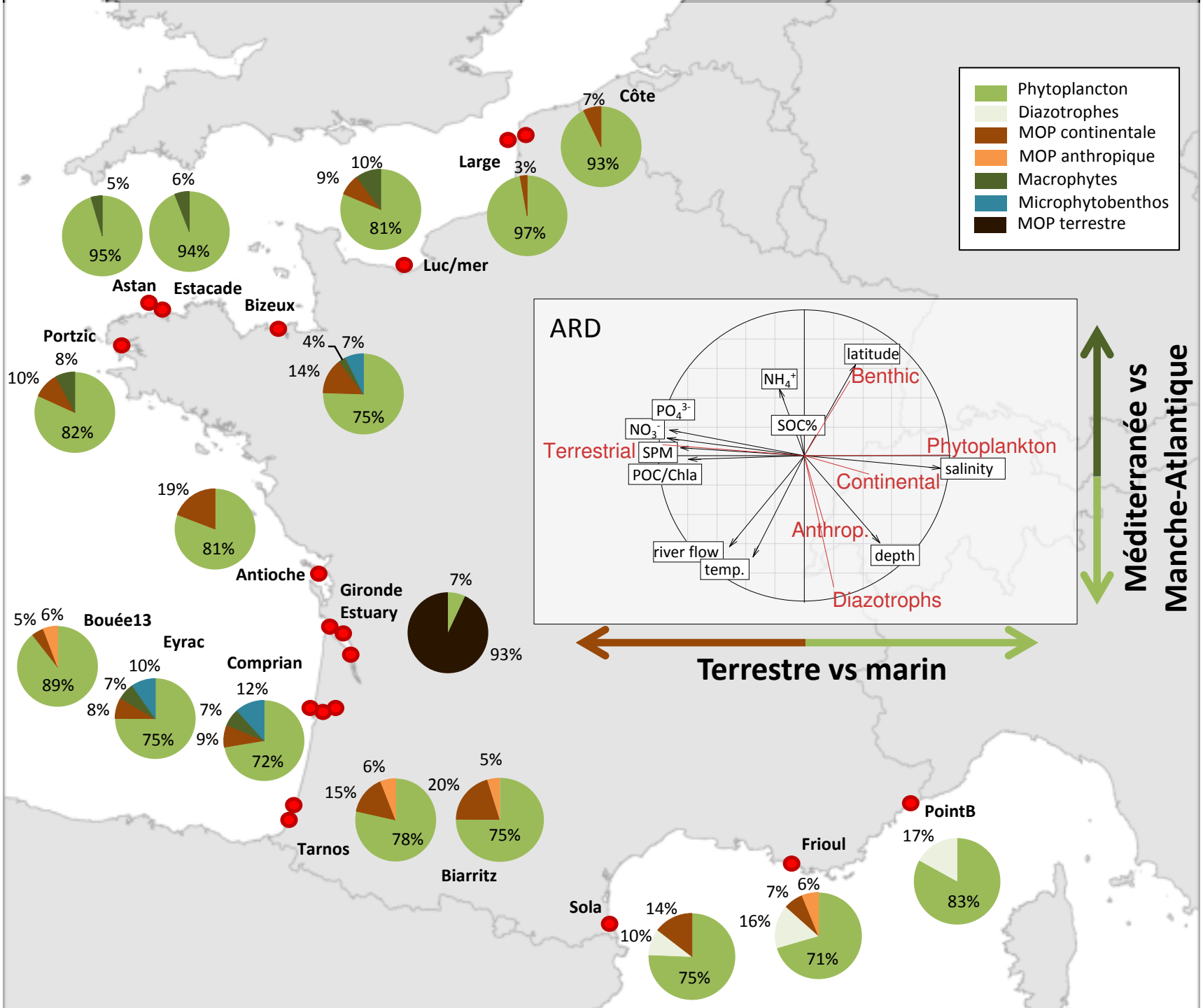
Données issues des thèses de S. Dubois, P. Polsenaere, F. Dindinaud, J. Modéran, N. Savoye

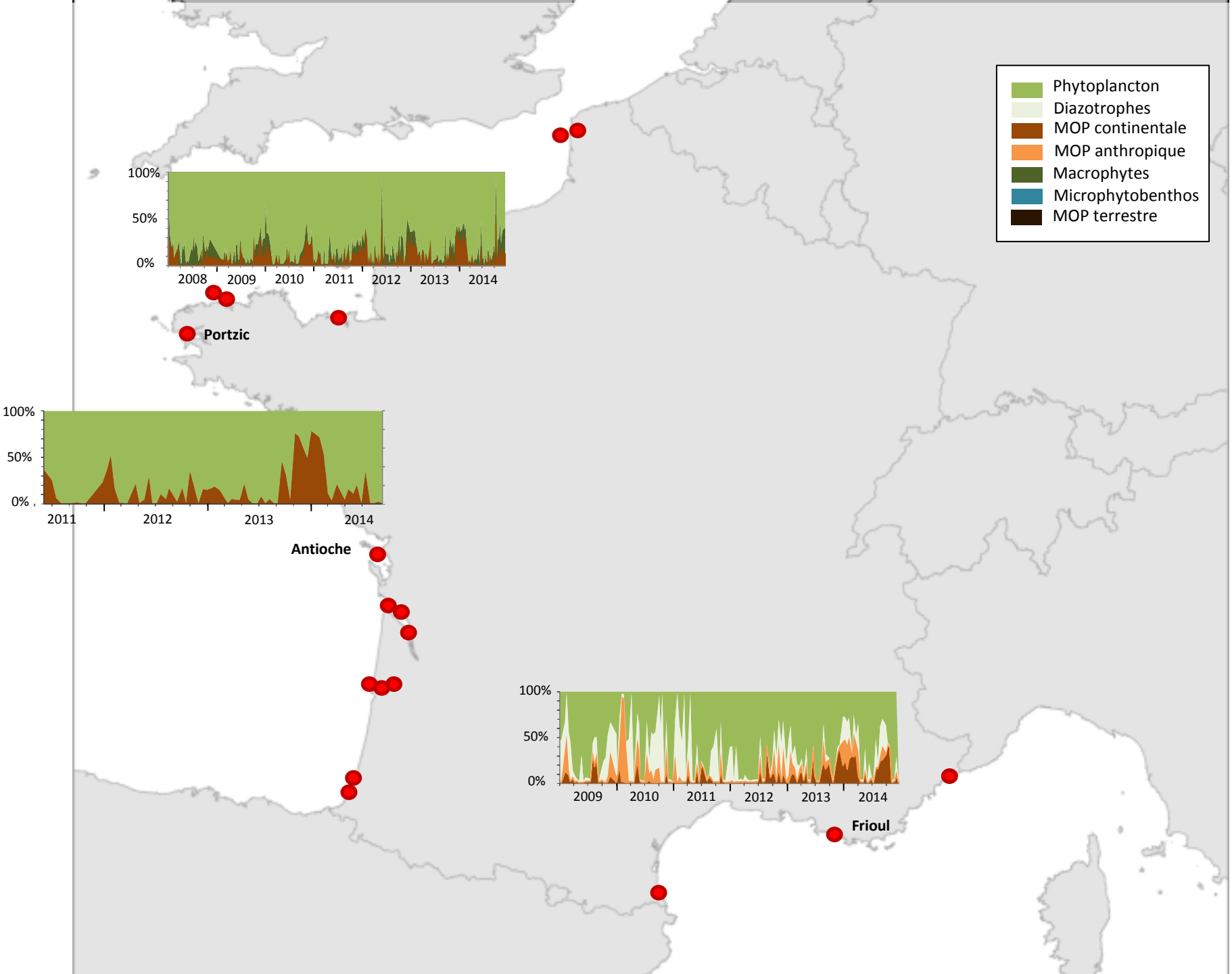
Large diversité d'écosystèmes et de forçages potentiels

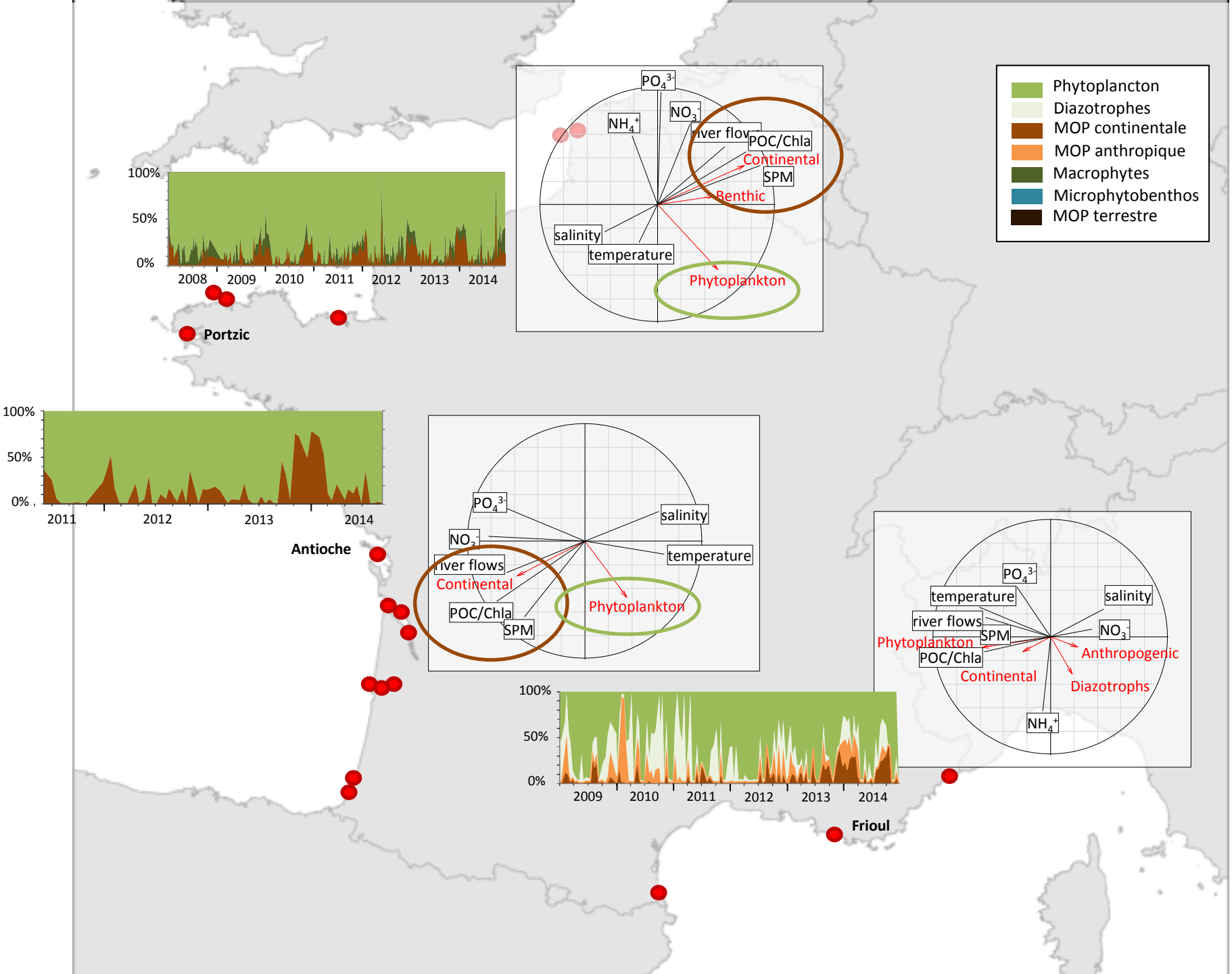

Phytoplancton
Diazotrophes
MOP continentale
MOP anthropique
Macrophytes
Microphytobenthos
MOP terrestre
Côte
7%
93%
Large
3%
97%
10%
9%
81%
Luc/mer
5%
95%
6%
94%
Astan
Estacade
Bizeux
Portzic
8%
10%
82%
4%
7%
14%
75%
19%
81%
Antioche
Gironde
Estuary
7%
93%
5%
6%
Bouée13
89%
Eyrac
10%
7%
8%
75%
Comprian
12%
7%
9%
72%
6%
15%
78%
Tarnos
5%
20%
75%
Biarritz
PointB
17%
83%
Frioul
7%
6%
16%
71%
Sola
14%
10%
75%

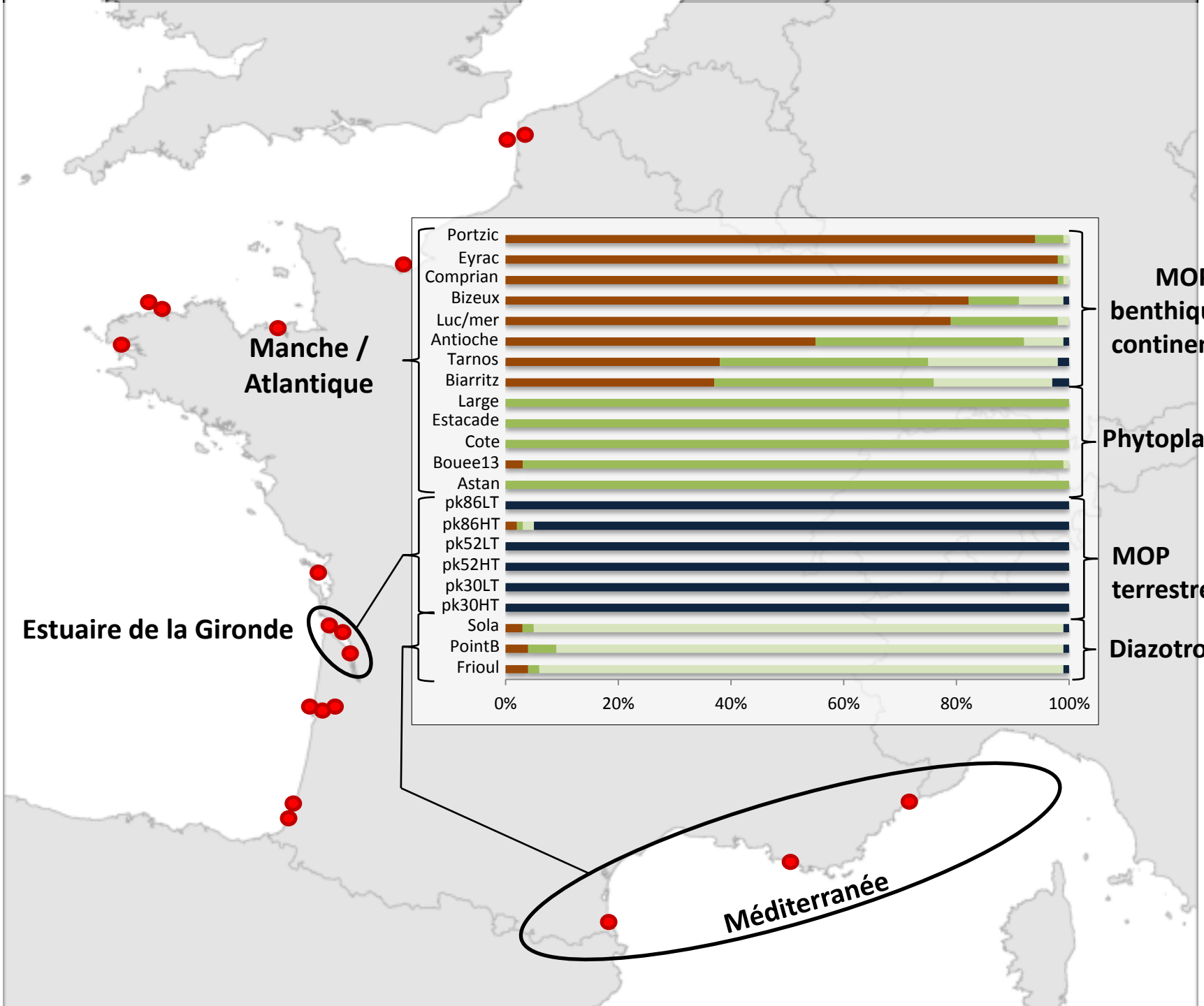


- Dominance du phytoplancton (sauf en Gironde)
- Plus forte contribution du matériel benthique et continental aux stations proches de la côte
- Contribution des diazotrophes en Méditerranée


Phytoplancton
Diazotrophes
MOP continentale
MOP anthropique
Macrophytes
Microphytobenthos
MOP terrestre
Côte
7%
93%
Large
3%
97%
10%
9%
81%
Luc/mer
5%
95%
6%
94%
Astan
Estacade
Bizeux
Portzic
8%
10%
82%
4%
7%
14%
75%
19%
81%
Antioche
Gironde
Estuary
7%
93%
5%
6%
Bouée13
89%
Eyrac
10%
7%
8%
75%
Comprian
12%
7%
9%
72%
6%
15%
78%
Tarnos
5%
20%
75%
Biarritz
Sola
14%
10%
75%
Frioul
7%
6%
16%
71%
PointB
17%
83%
ARD
latitude
Benthic
NH_4^+
PO_4^{3-}
NO_3^-
SOC%
Terrestrial
SPM
Phytoplankton
salinity
POC/Chla
Continental
Anthrop.
river flow
depth
temp.
Diazotrophs
Méditerranée vs Manche-Atlantique
Terrestre vs marin


Phytoplancton
Diazotrophes
MOP continentale
MOP anthropique
Macrophytes
Microphytobenthos
MOP terrestre
100%
50%
0%
2008
2009
2010
2011
2012
2013
2014
Portzic
100%
50%
0%
2011
2012
2013
2014
Antioche
100%
50%
0%
2009
2010
2011
2012
2013
2014
Frioul


Phytoplancton
Diazotrophes
MOP continentale
MOP anthropique
Macrophytes
Microphytobenthos
MOP terrestre
100%
50%
0%
2008
2009
2010
2011
2012
2013
2014
Portzic
PO_4^{3-}
NO_3^-
NH_4^+
river flows
POC/Chla
Continental
SPM
Benthic
salinity
temperature
Phytoplankton
Antioche
Continental
Frioul
Anthropogenic
Diazotrophs

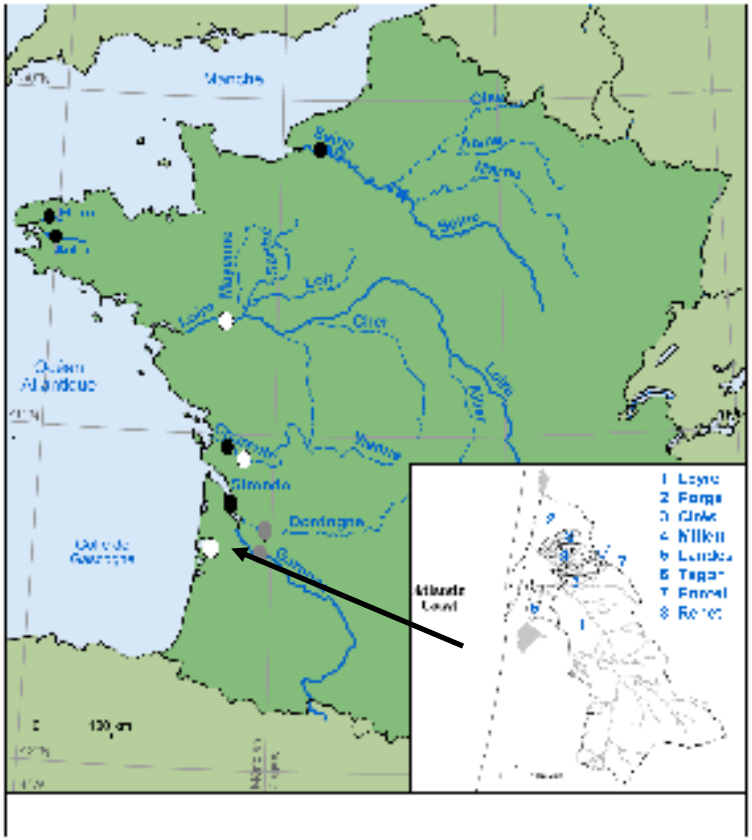

Manche / Atlantique
Estuaire de la Gironde
Méditerranée
Portzic
Eyrac
Comprian
Bizeux
Luc/mer
Antioche
Tarnos
Biarritz
Large
Estacade
Cote
Bouee13
Astan
pk86LT
pk86HT
pk52LT
pk52HT
pk30LT
pk30HT
Sola
PointB
Frioul
0%
20%
40%
60%
80%
100%
MOP benthique et continentale
Phytoplancton
MOP terrestre
Diazotrophes

MOP estuarienne

Estuaires salins

Seine
Elorn
Aulne
Charente
Gironde

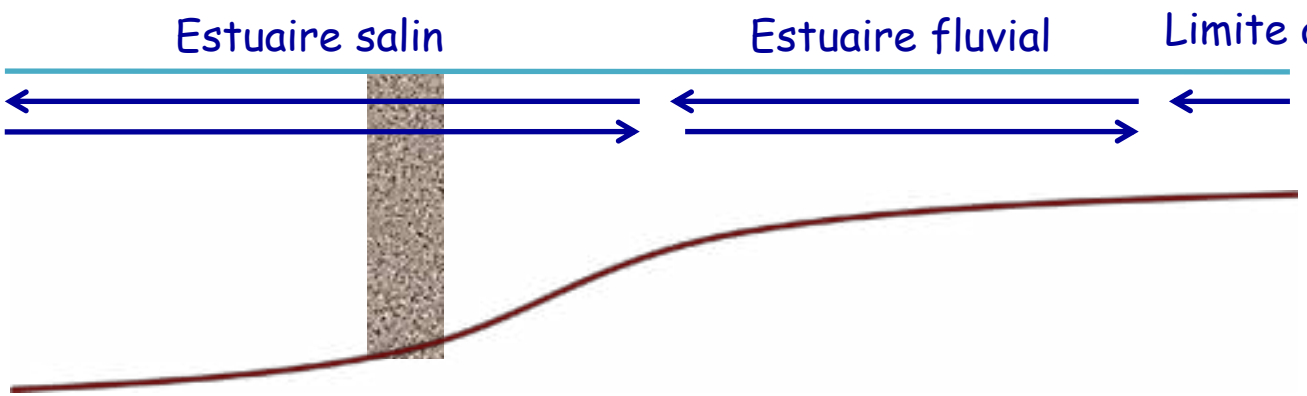
Gradient salin
Echantillonnage mensuel à saisonnier



Estuaires Fluviaux

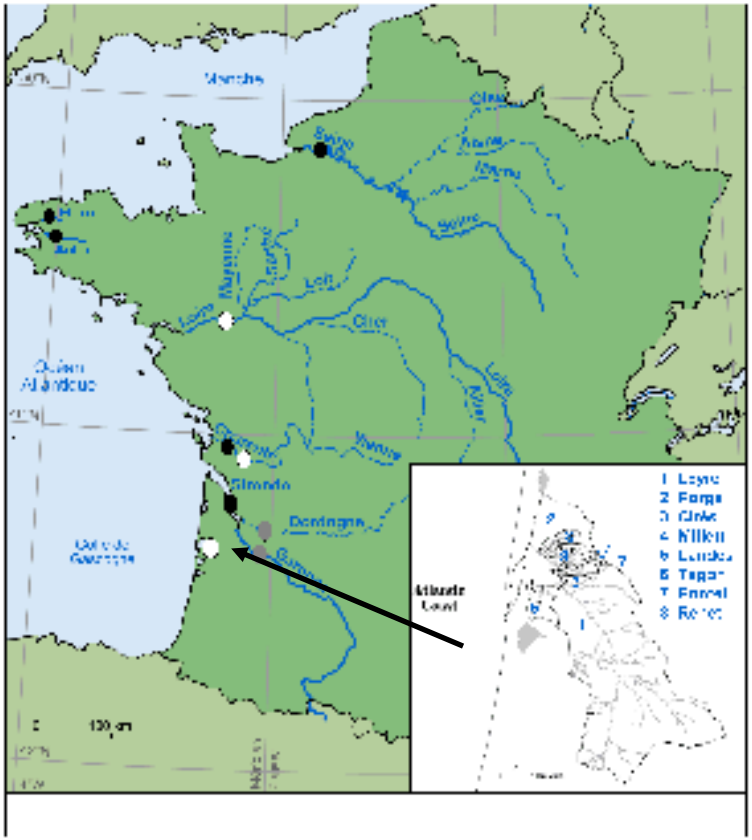
Loire, Charente, Dordogne, Garonne Leyre, Porge, Lanton, Milieu, Canal des Landes, Cirès, Tagon, Ponteil, Renet

Une station
Echantillonnage mensuel à di-mensuel

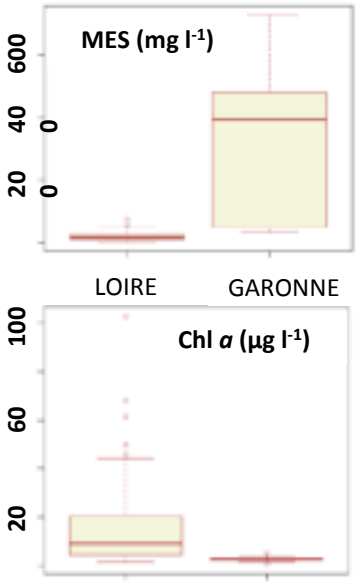


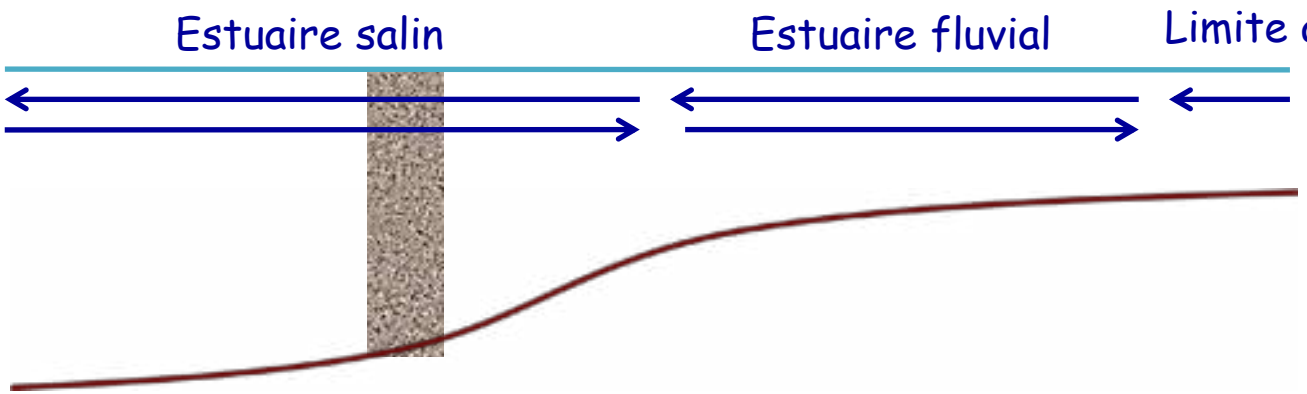
MOP estuarienne

Estuaires salins

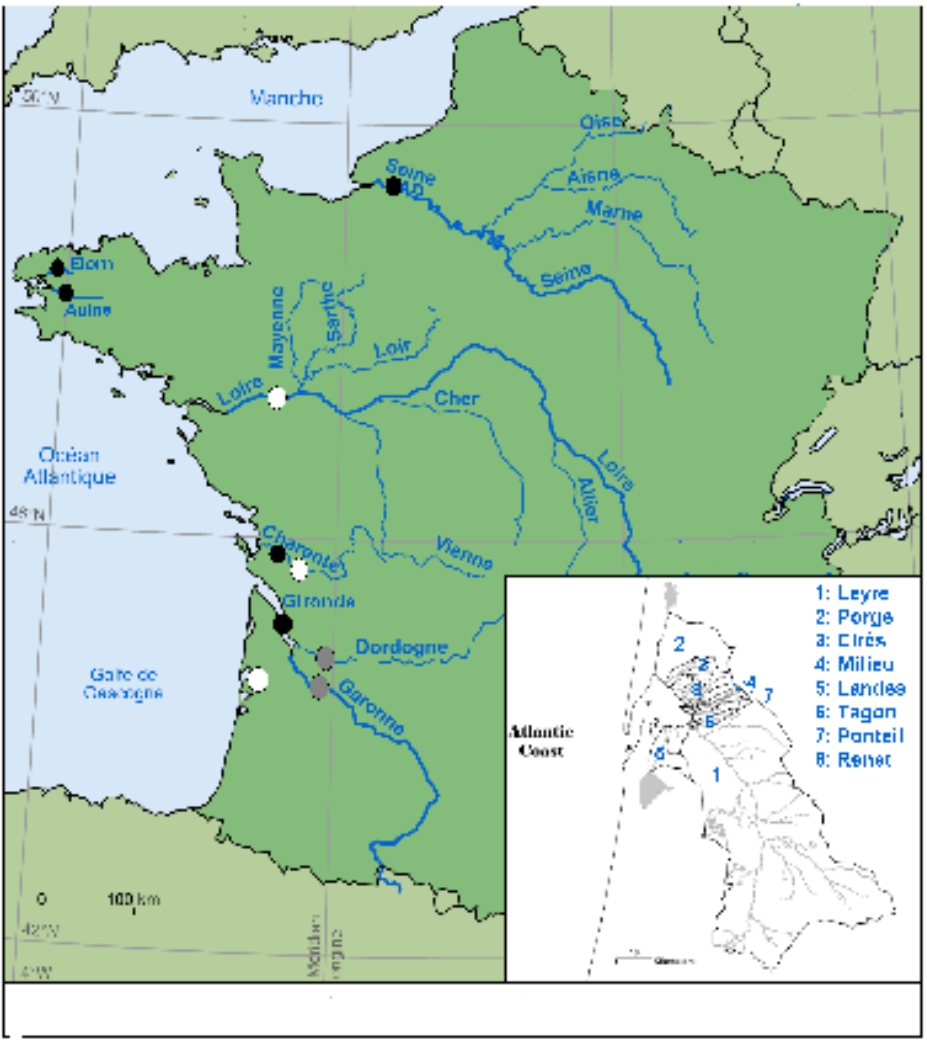


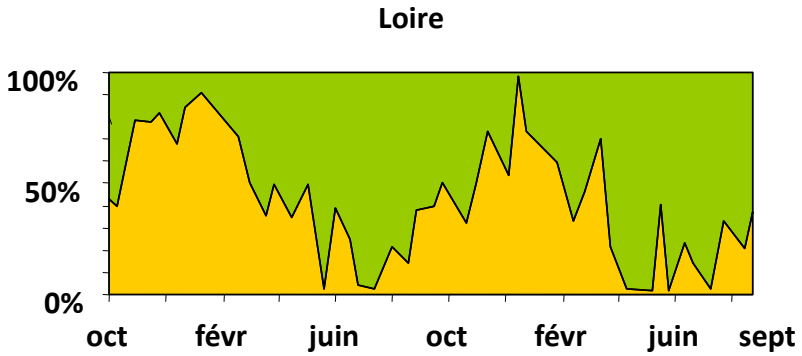
Estuaires Fluviaux

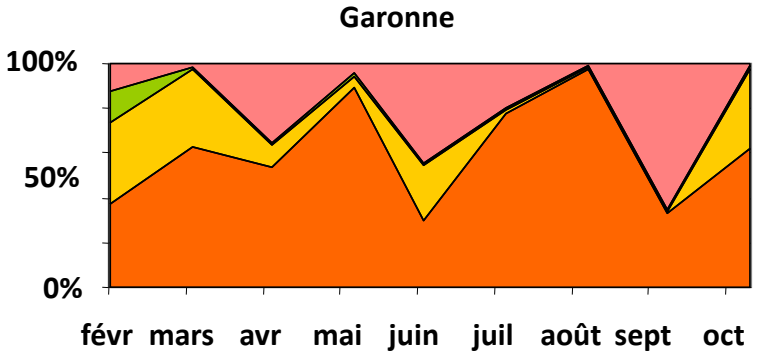


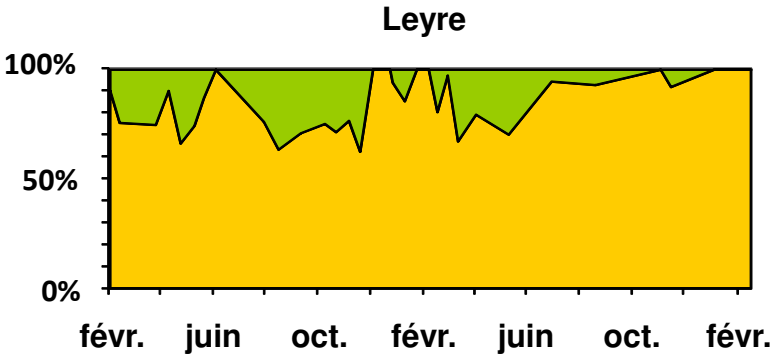


Estuaires fluviaux : composition de la MOP – échelle intra-systémique



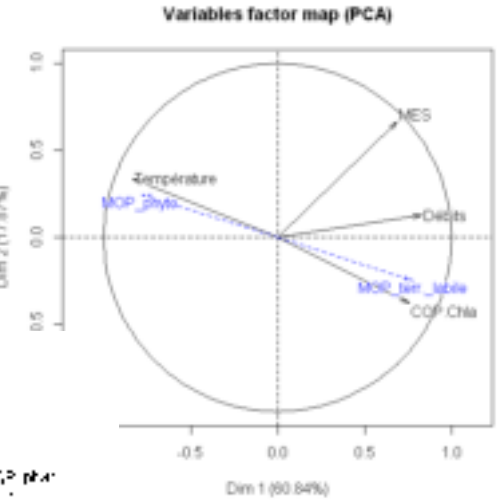


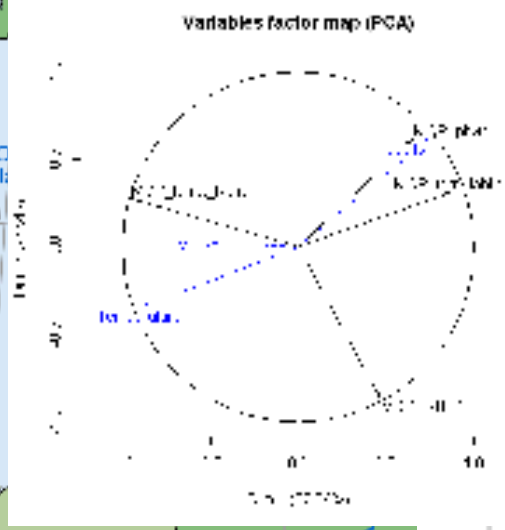


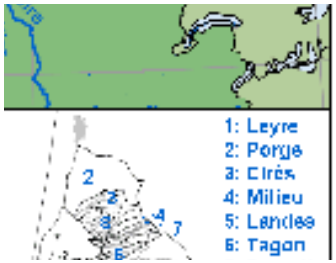


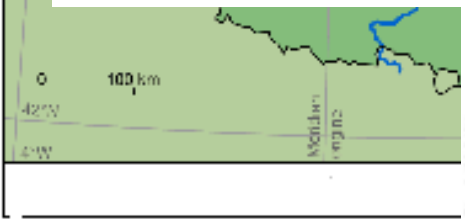
Phytoplancton | MOP terr. labile | MOP terr. réfractaire | MOP anthropique

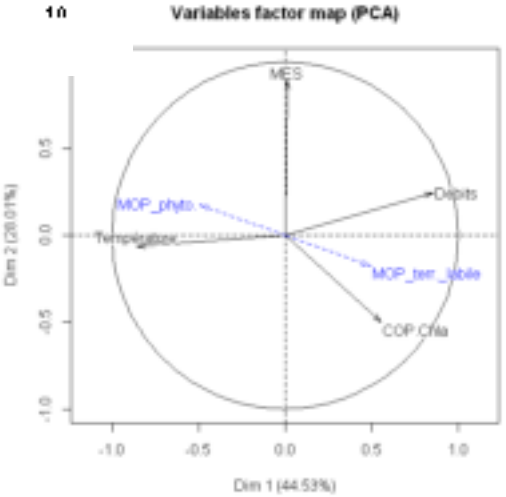
Estuaires fluviaux : composition de la MOP – échelle intra-systémique

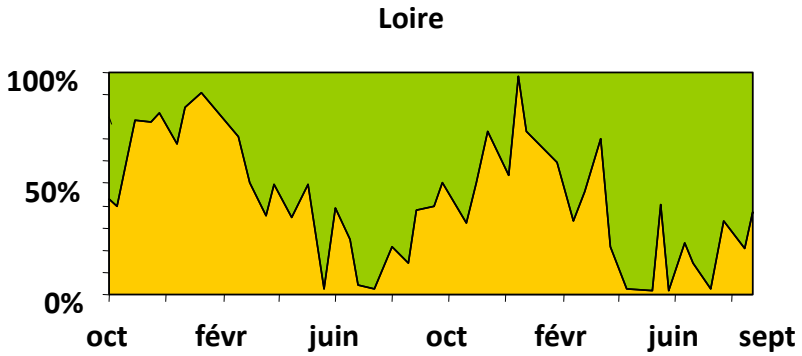


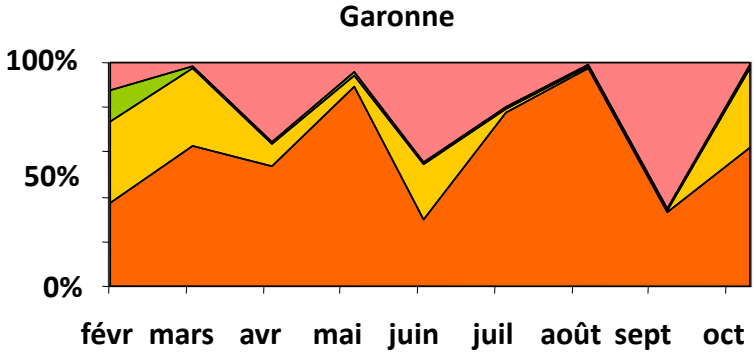


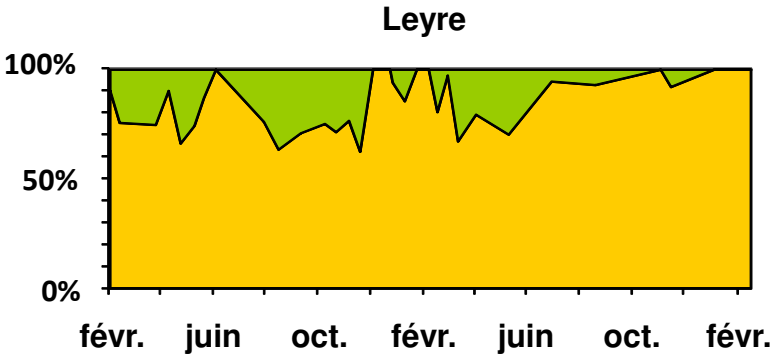






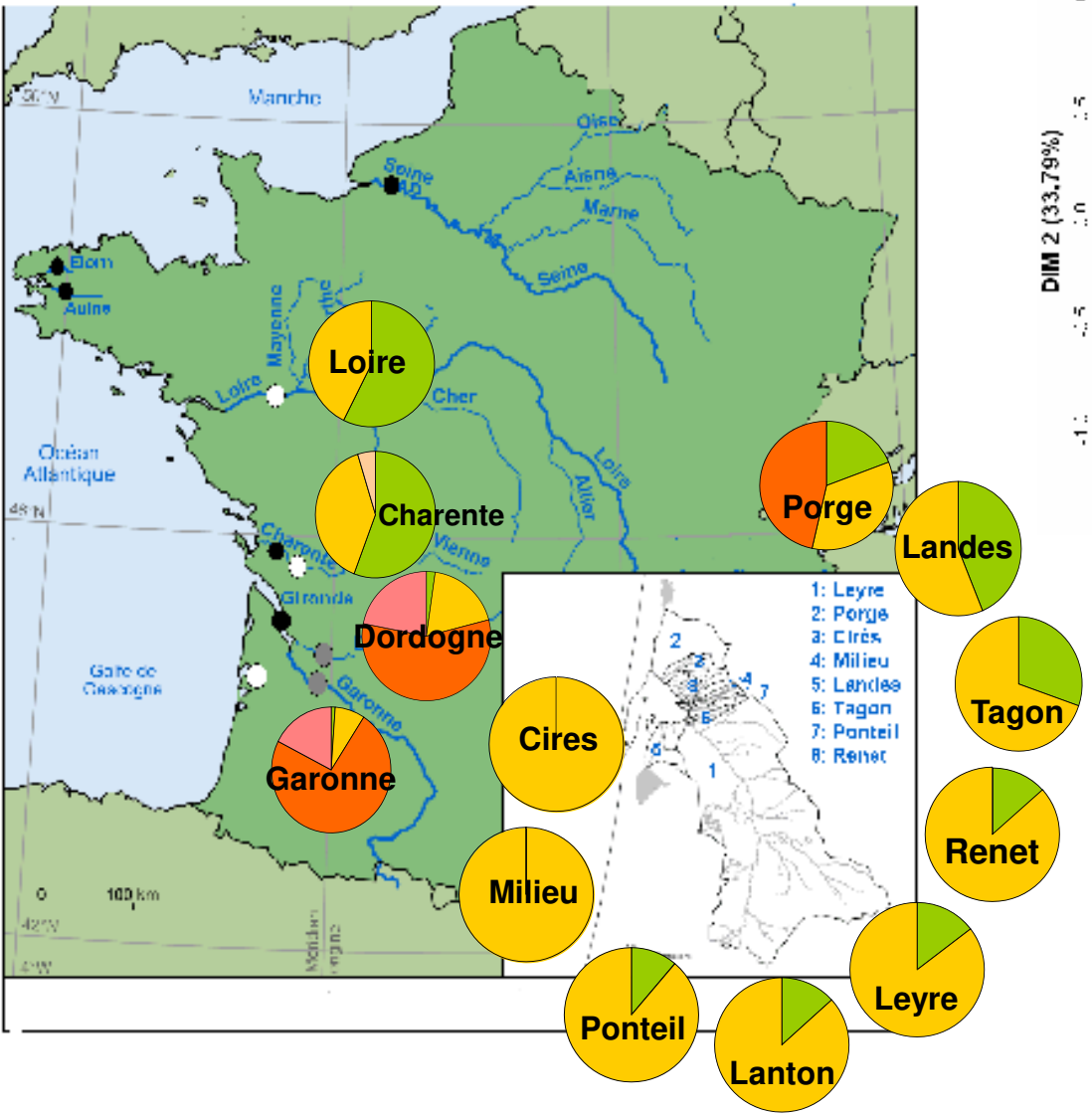


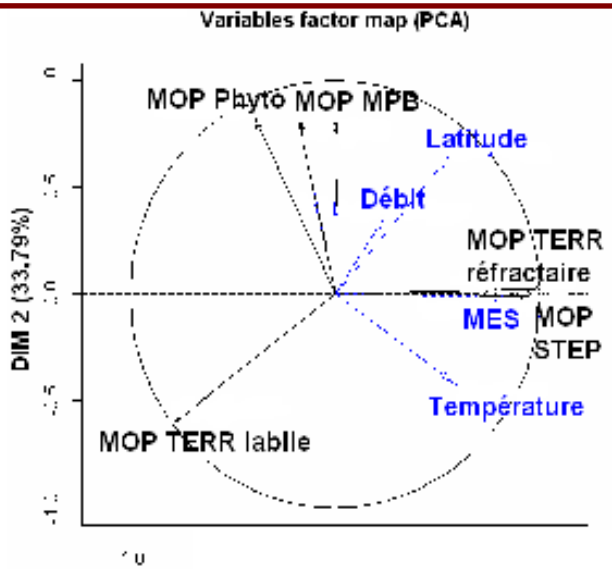


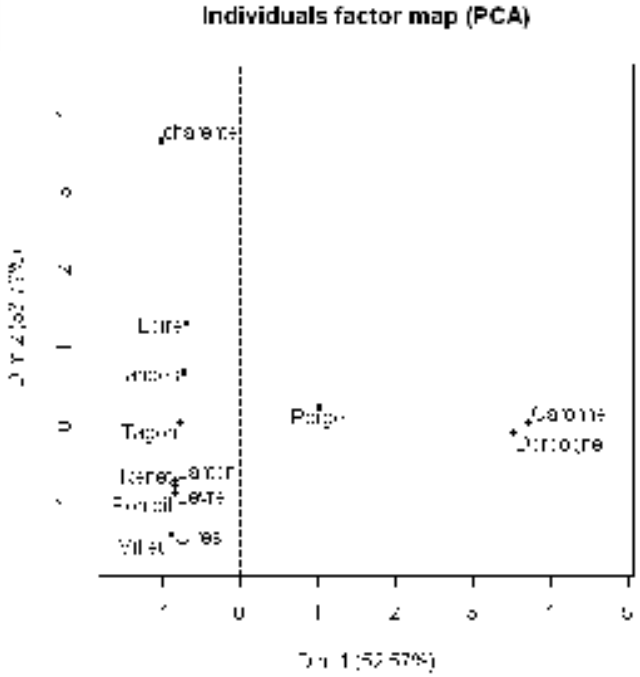


Phytoplancton | M… | …ctaire | MOP anthropique

Estuaires fluviaux : composition de la MOP – échelle multi-systémique

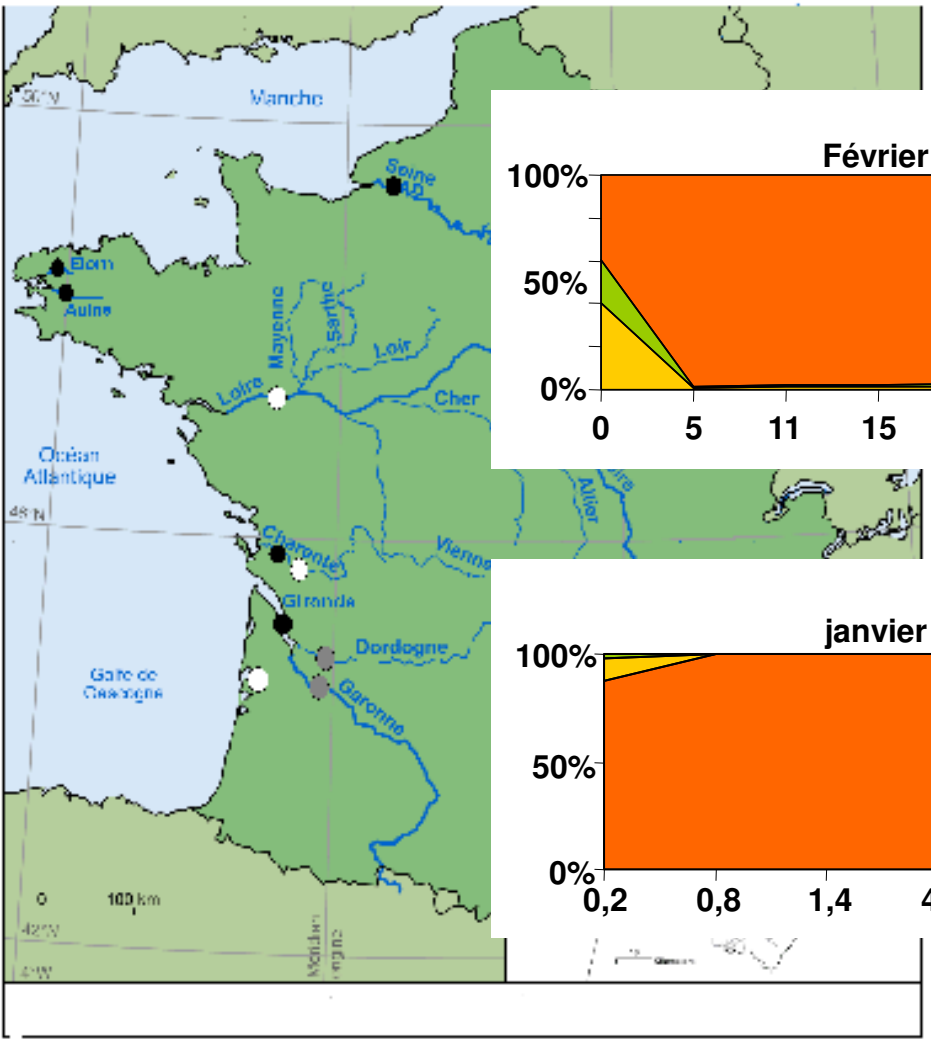


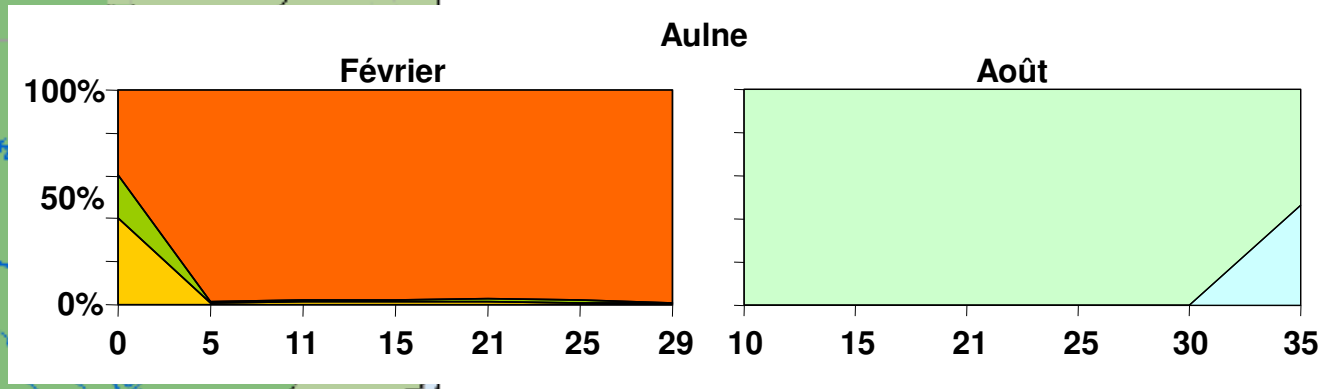


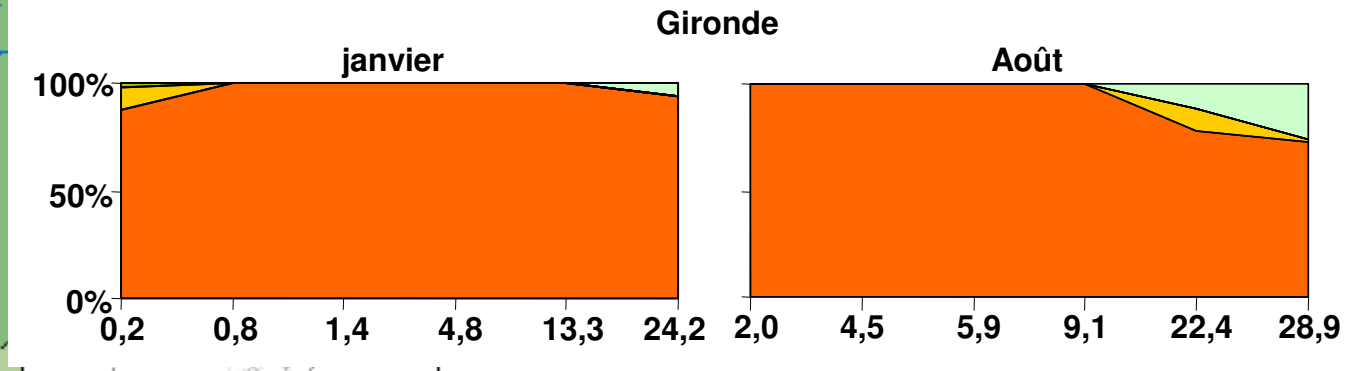


Phytoplancton | MOP terr. labile | MOP terr. réfractaire | MOP anthropique | Microphytobenthos

Estuaires halins : composition de la MOP – échelle intra-systémique



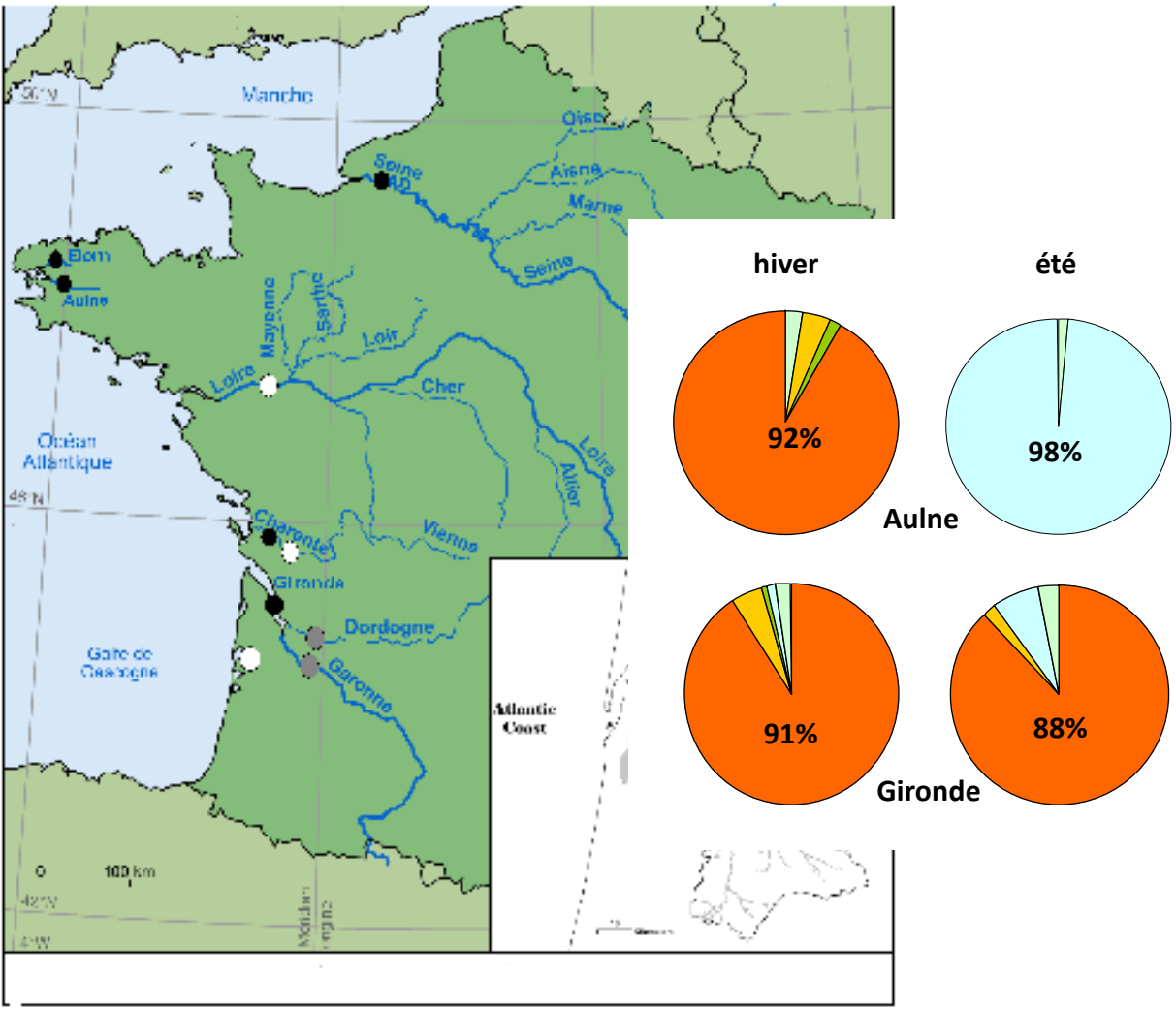




Phyto estuarien | Phyto marin

Phyto eau douce | MOP terr. labile | MOP terr. réfractaire | MOP anthropique | Microphytobenthos

Estuaires halins : composition de la MOP – échelle intra-systémique



Phyto estuarien

Phyto marin

Phyto eau douce

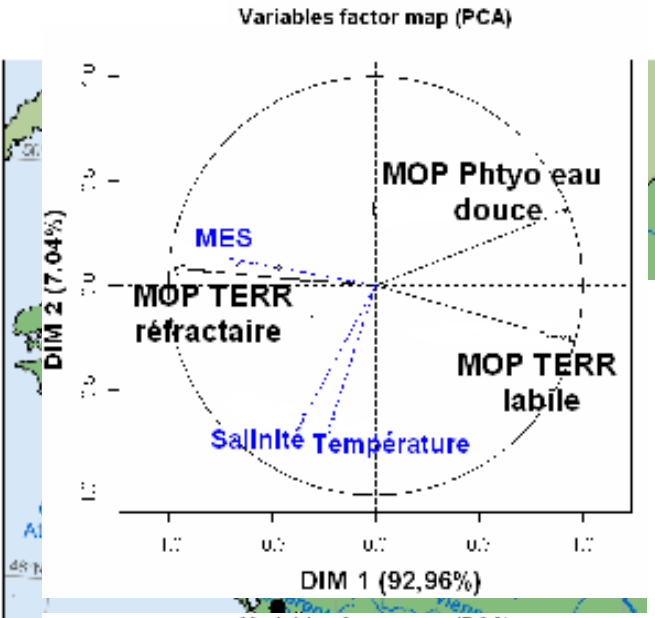
MOP terr. labile

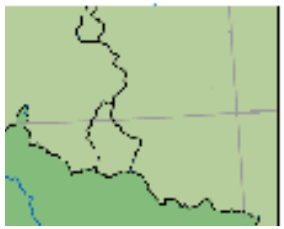
MOP terr. réfractaire

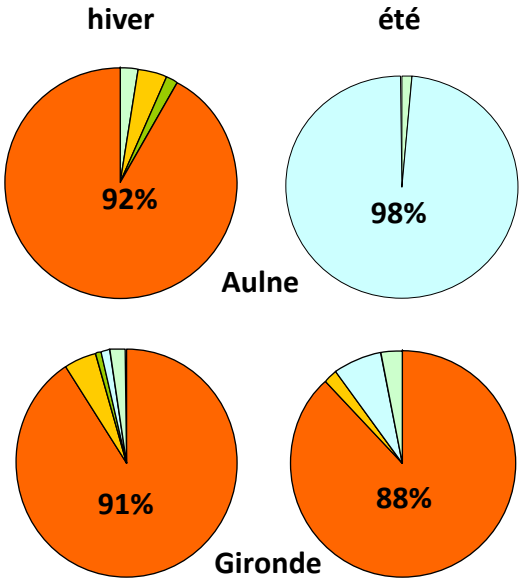
MOP anthropique

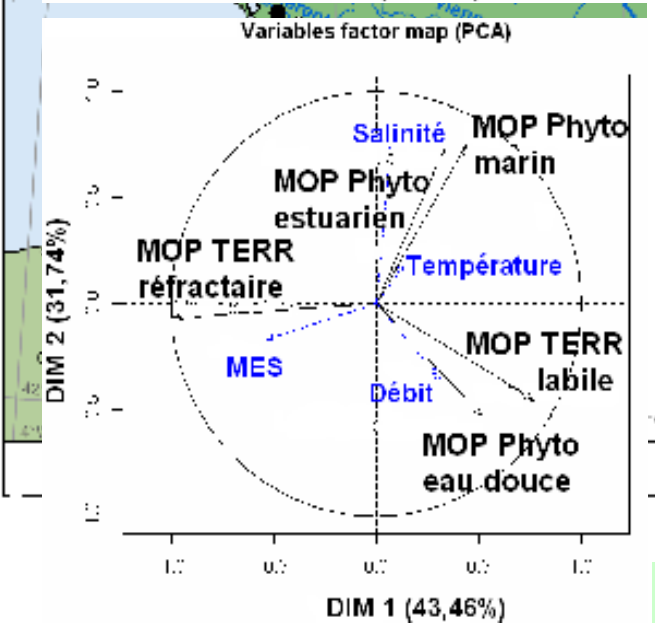
Microphytobenthos

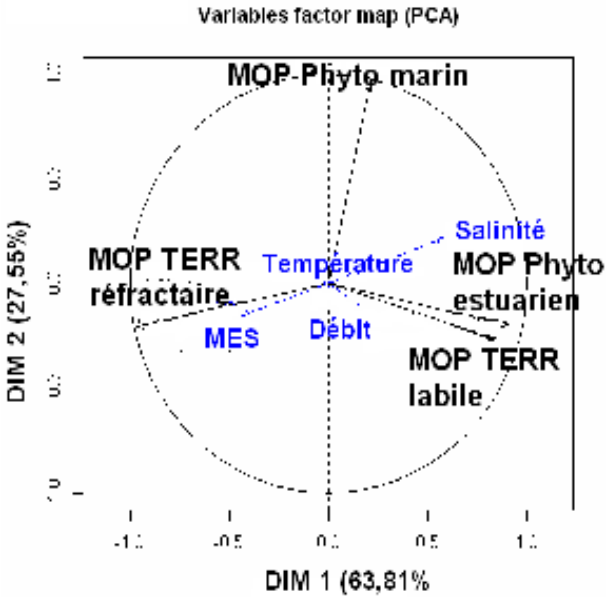
Estuaires halins : composition de la MOP – échelle intra-systémique







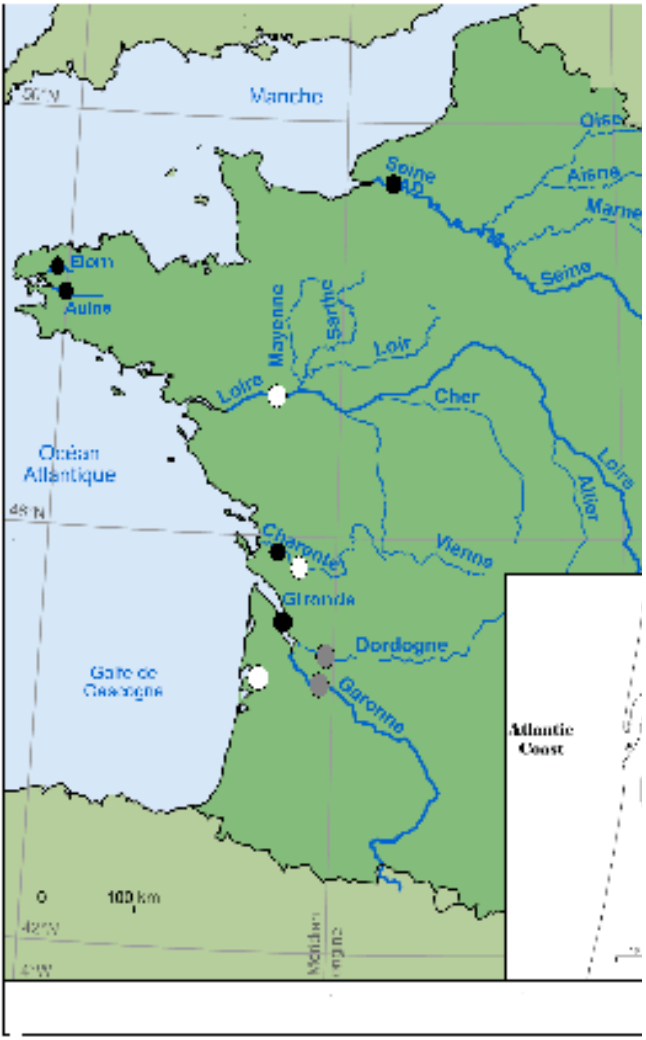


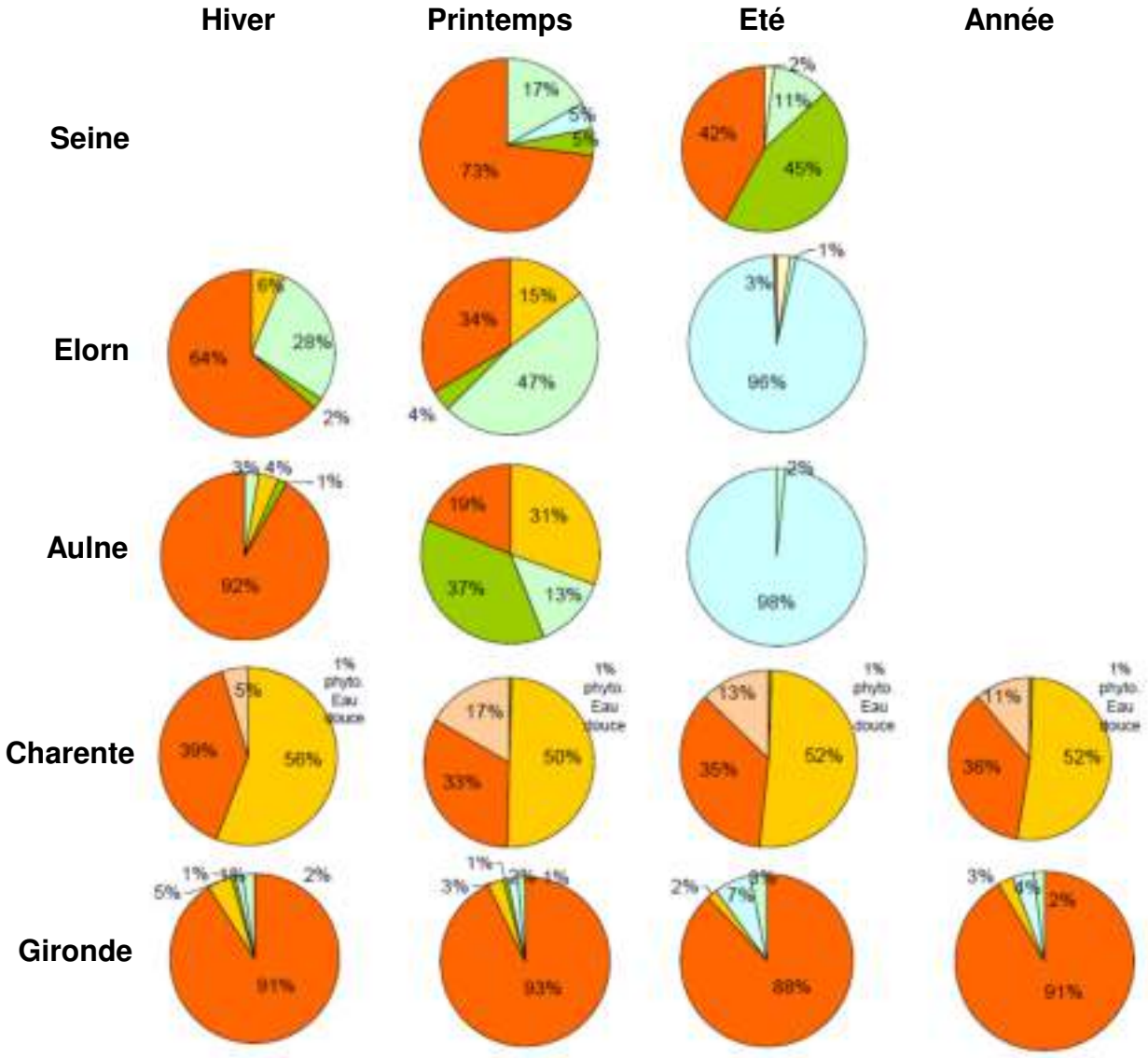


Phyto estuarien | Phyto marin

Phyto eau douce | MOP terr. labile | MOP terr. réfractaire | MOP anthropique | Microphytobenthos

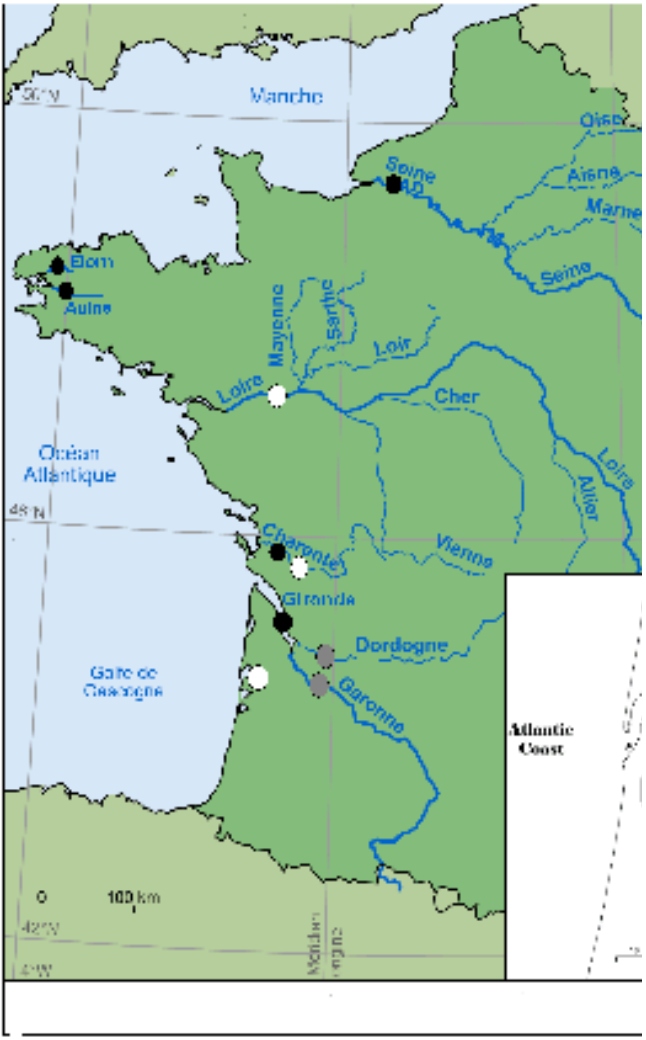
Estuaires halins : composition de la MOP – échelle intra-systémique





Phyto estuarien | Phyto marin | Phyto eau douce | MOP terr. labile | MOP terr. réfractaire | MOP anthropique | Microphytobenthos

Estuaires halins : composition de la MOP – échelle intra-systémique



Seine

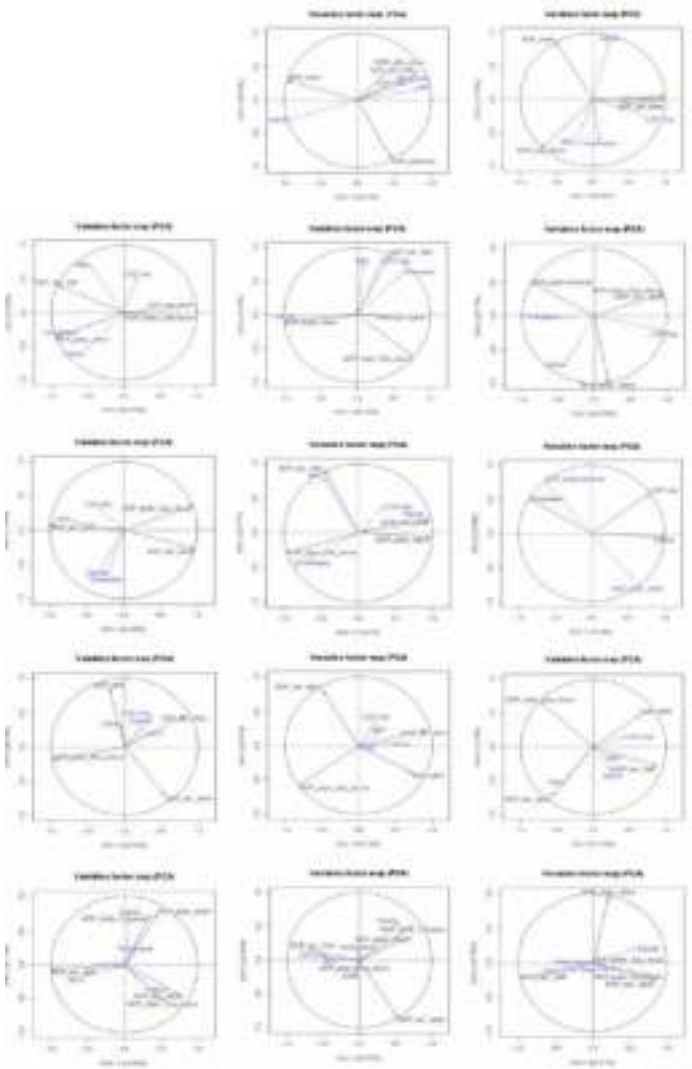
Elorn

Aulne

Charente

Gironde

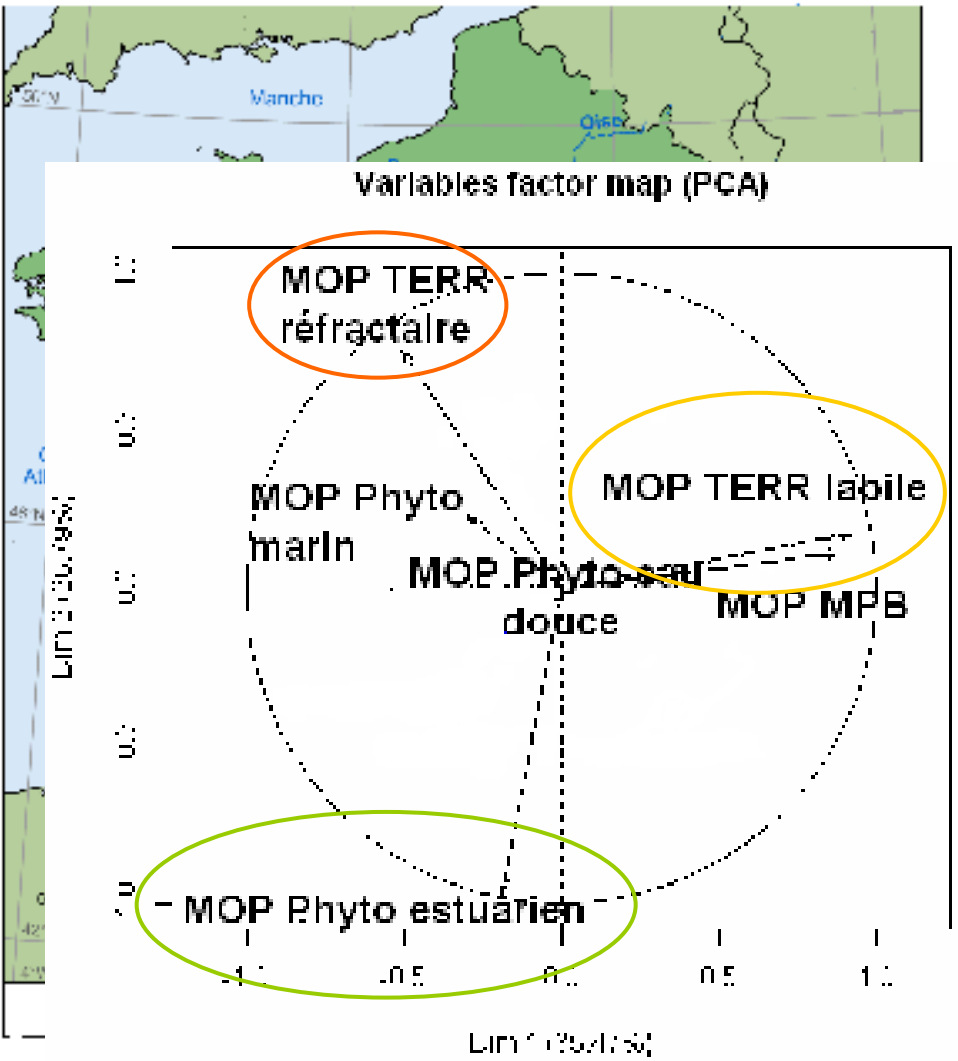
Hiver | Printemps | Eté

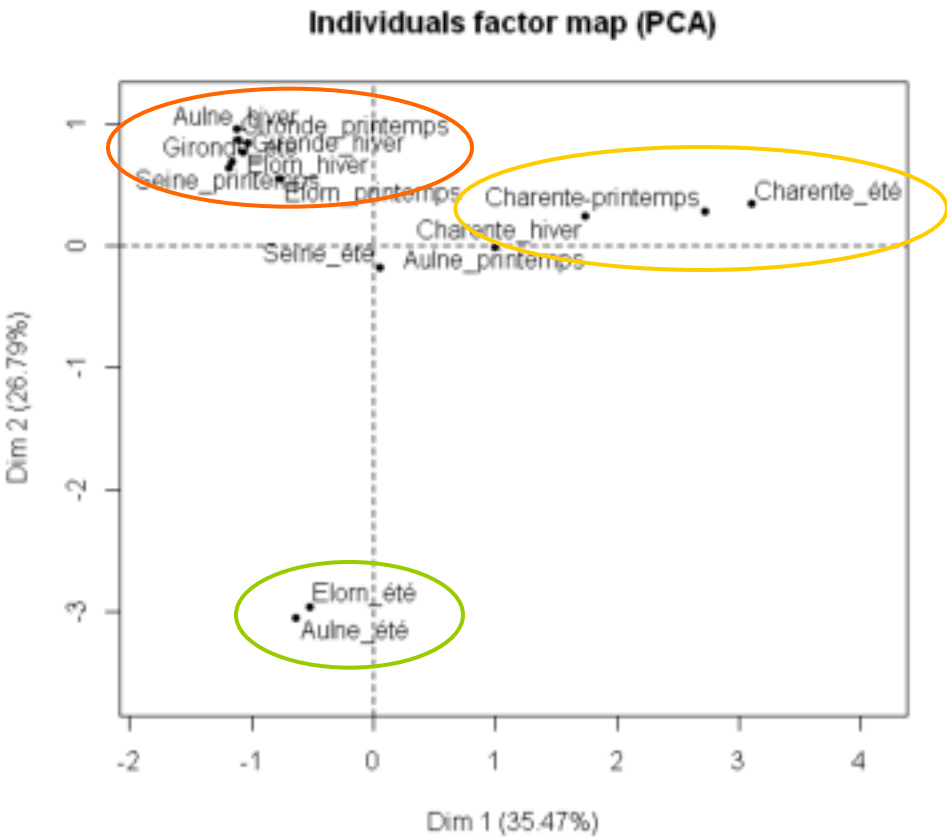


Phyto estuarien | Phyto marin

Phyto eau douce | MOP terr. labile | MOP terr. réfractaire | MOP anthropique | Microphytobenthos

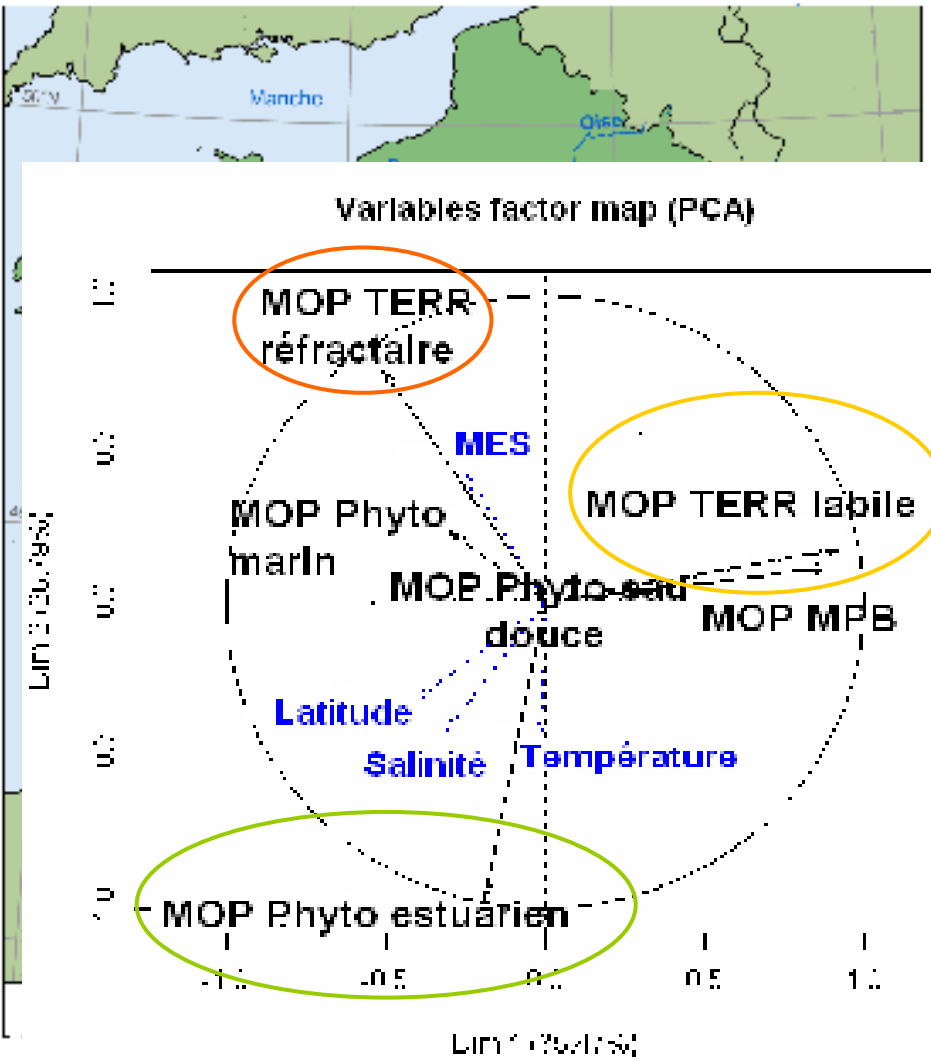
Estuaires halins : composition de la MOP – échelle multi-systémique

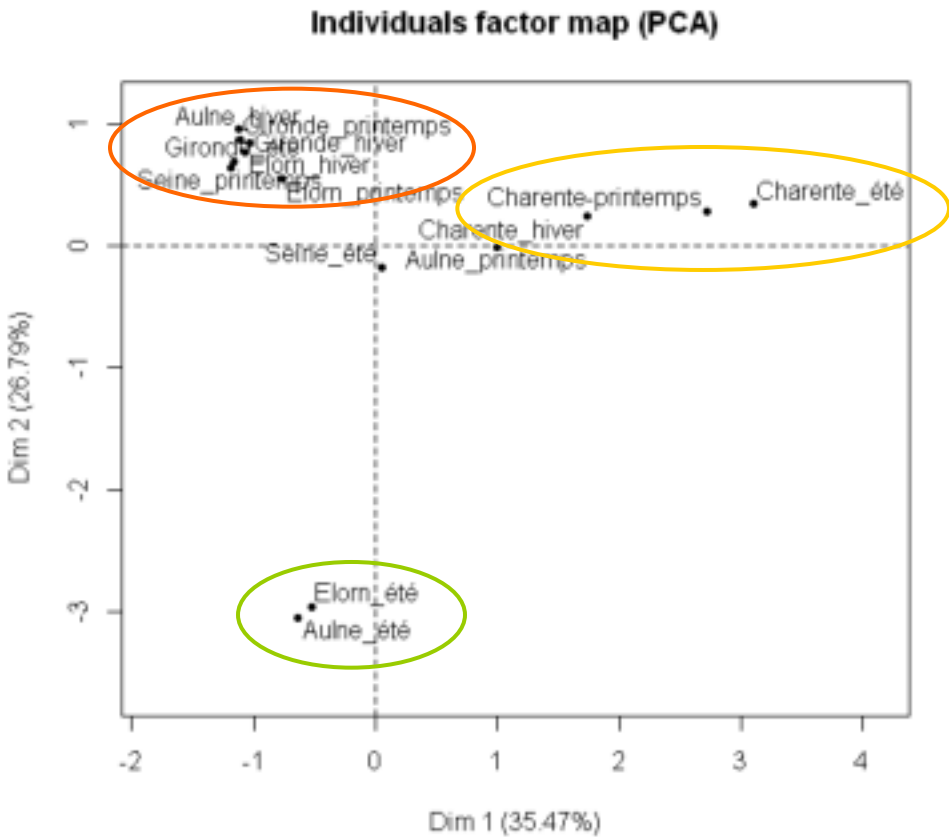




Typologies

Forçages à la composition de la MOP – échelle multi-systémique





Données hétérogènes

Composition et forçage de la MOP dans les estuaires : une typologie

Estuaires peu turbides.
Seine, Aulne, Elorn,
Loire, tributaires bassin d'Arcachon, Charente

FORTE SAISONALITE

- phytoplancton en été ← Température
- MOP terrestre labile en hiver ← Hydrodynamique (Débits)

mélange des masses d'eaux (estuaires halins)

Estuaires turbides.
Gironde, Charente,
Garonne, Dordogne,

FAIBLE SAISONALITE

- MOP terrestre labile ← Hydrodynamique (Débits)
- MOP terrestre réfractaire ← Hydrodynamique sédimentaire

mélange des masses d'eaux négligeable

Figure 2: Summary diagram of the steps of the regionalization method (from Souissi et al. 2000) from contingency tables (station x sources) of each month to the final global cluster. In the present study, 10 cut off levels were considered.

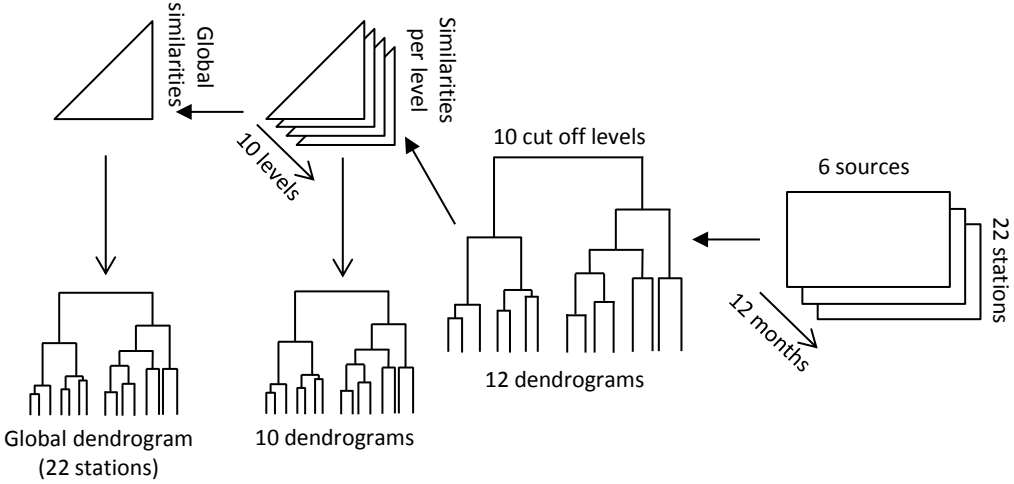
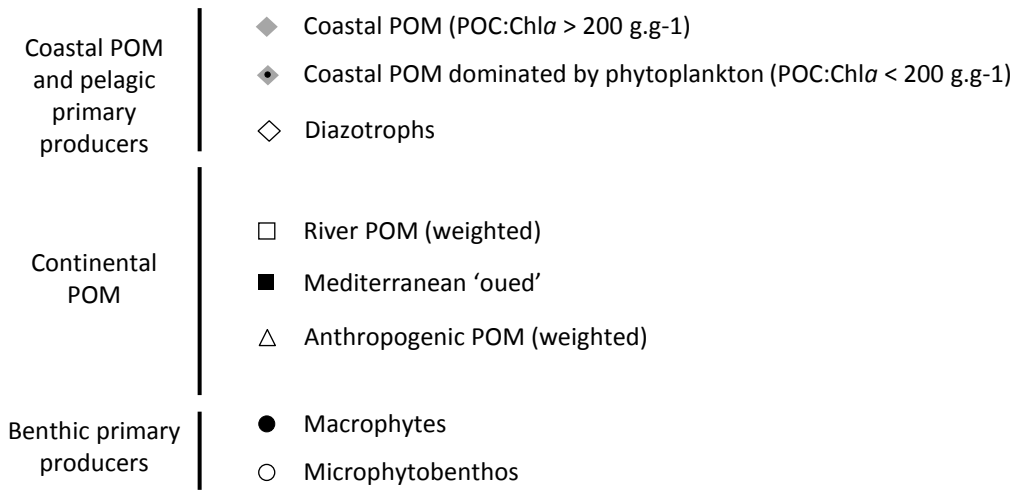
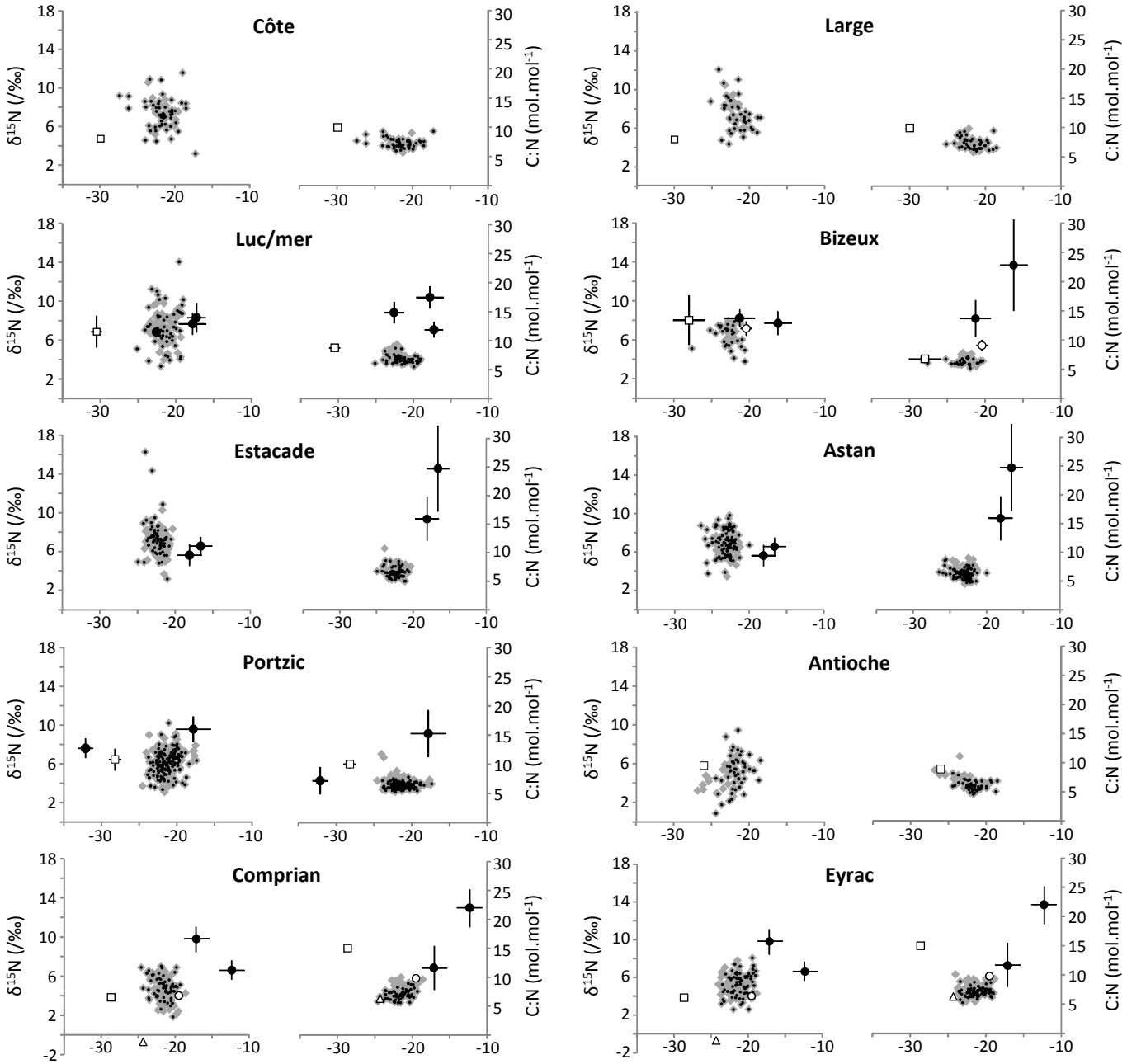


Figure 3: Biplots of elemental (C:N) and isotopic ($\delta^{13}C$ and $\delta^{15}N$) ratios of coastal particulate organic matter (POM) and organic matter sources at the studied stations of the littoral systems and embayments.
Due to it large temporal variability and for clearer reading, phytoplankton values estimated by models iare not presented but only phytoplankton-dominated POM (POC:Chl*a* < 200 $g.g^{-1}$) are presented.
Grey diamonds: POM of high POC:Chla ratio (> 200$g.g^{-1}$; raw data). Grey diamonds with black dots: phytoplankton-dominated POM (POC:Chla < 200$g.g^{-1}$; raw data). White diamonds: diazotrophs (mean±standard deviation). White squares: river POM (mean±standard deviation of raw data, modelled data and/or weighted data; see section 2.6.2 or Table S3). Black square: POM of Mediterranean oued (mean±standard deviation of raw data). White triangles: anthropogenic POM (mean±standard deviation of raw data at Frioul and of weighted data at Bouée13, Eyrac and Comprian). Withe circles: microphytobenthos (mean±standard deviation of raw data). Black circles: macrophytes (mean±standard deviation of raw data).




Côte
Large
Luc/mer
Bizeux
Estacade
Astan
Portzic
Antioche
Comprian
Eyrac
δ15N (/‰)
C:N (mol.mol-1)

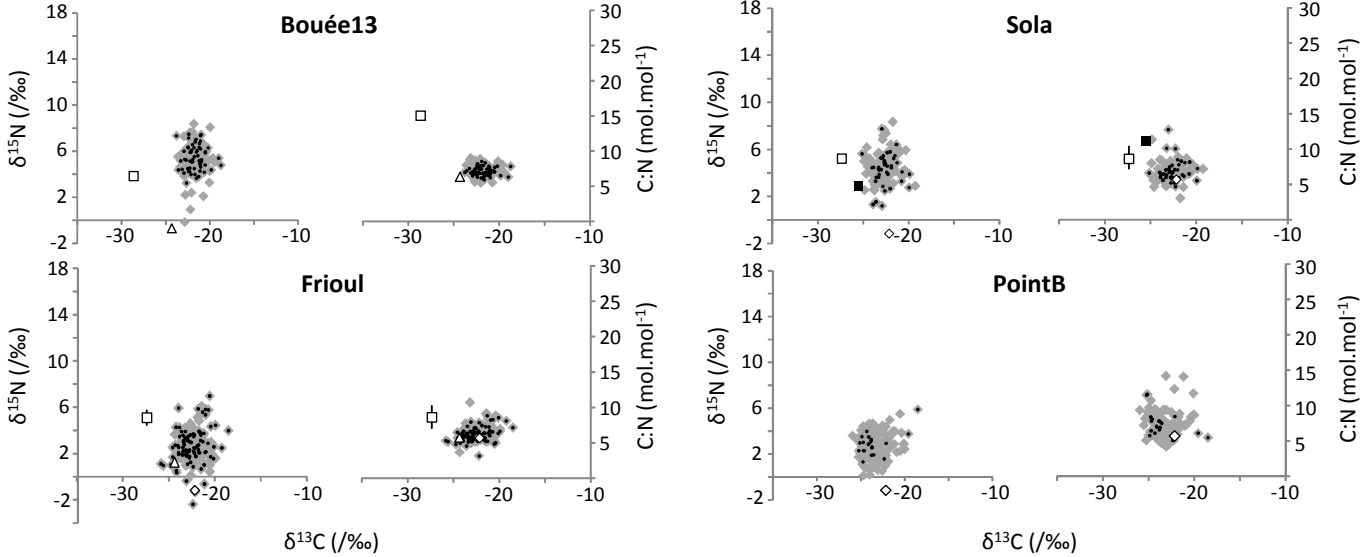
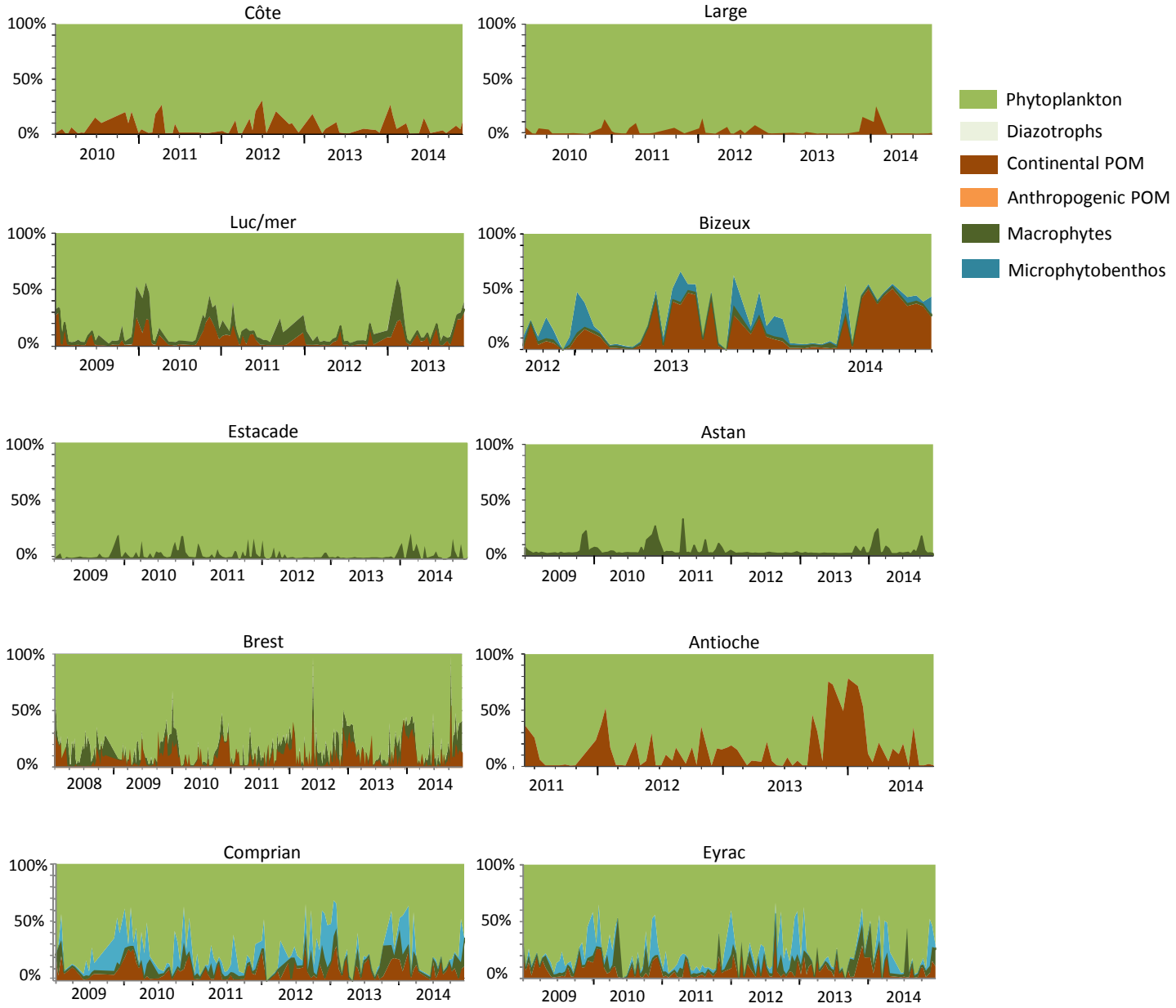

Bouée13
Sola
Frioul
PointB
δ15N (/‰)
C:N (mol.mol-1)
δ13C (/‰)
18
14
10
6
2
-2
30
25
20
15
10
5
-30
-20
-10

Figure 7: Time series of the contribution of organic matter sources to the coastal POM pool in the littoral systems and embayments.



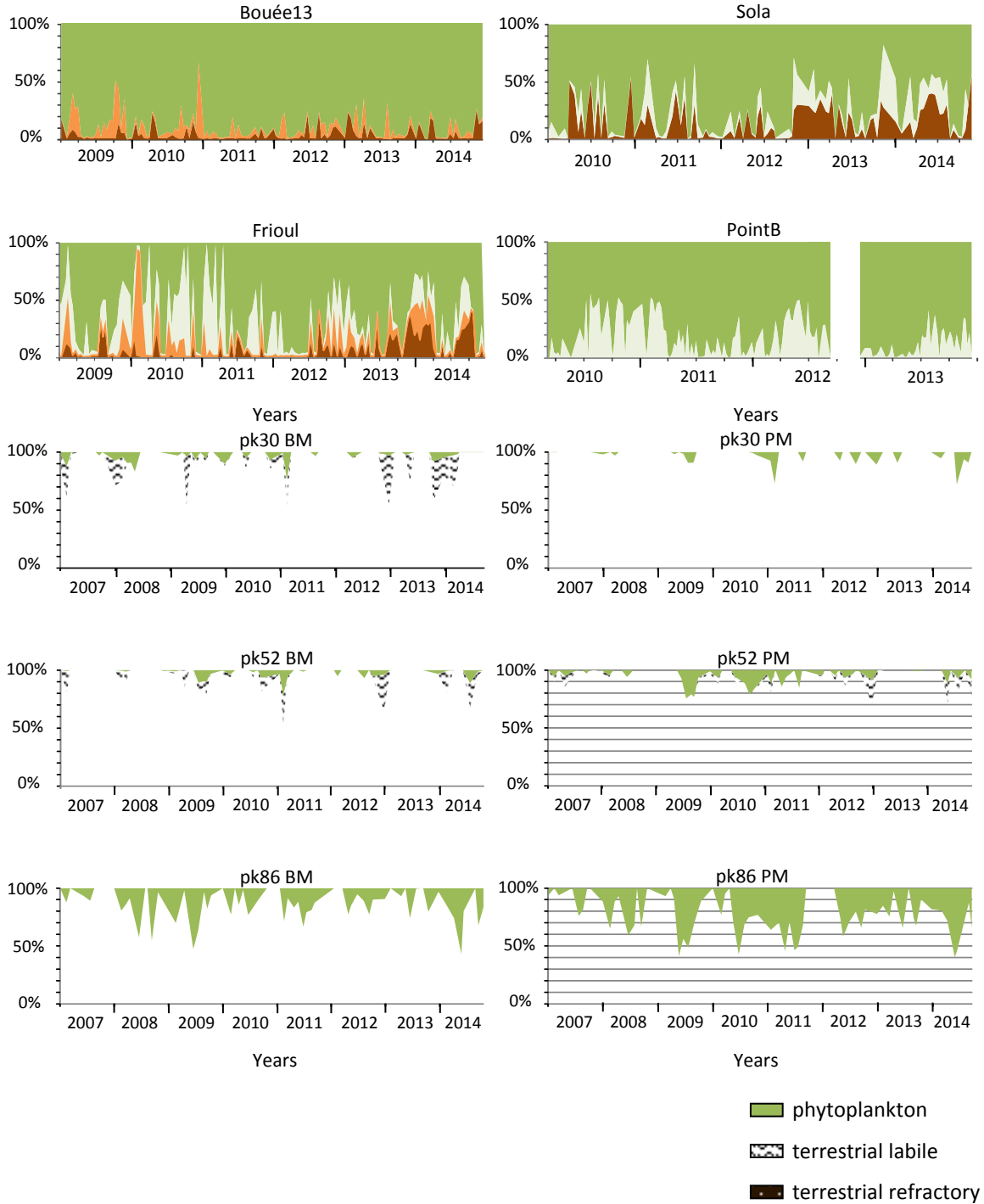
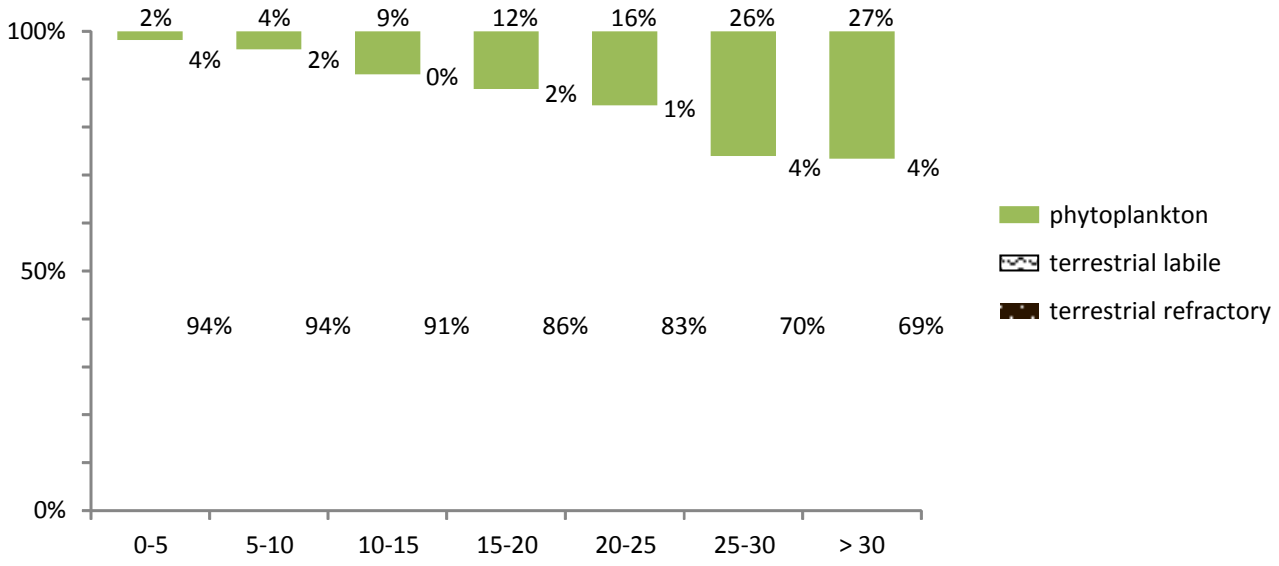


Figure 7: Time series of the contribution of organic matter sources to the coastal POM pool in the Gironde estuary.

Figure 6: Contribution of phytoplankton and labile and refractory terrestrial POM over the salinity gradient of the Gironde estuary.



Tools : elemental and isotopic ratios of C and N (C/N, $\delta^{13}C$, $\delta^{15}N$)

Tools : elemental and isotopic ratios of C and N (C/N, $\delta^{13}C$, $\delta^{15}N$)

1) **Signature of sources** considered depending on station

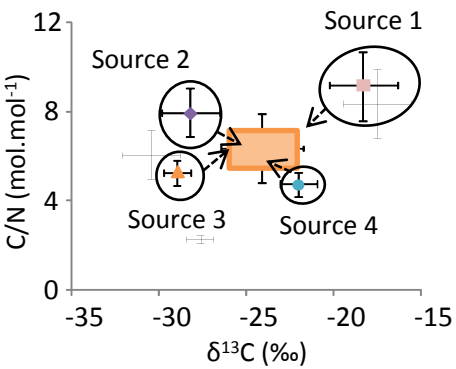
Selected sources	
Phytoplankton	Pelagic primary producers
Diazotrophs	
Macrophytes	Benthic primary producers
Microphytobenthos	
Continental	Continental
Terrestrial	
Anthropogenic	

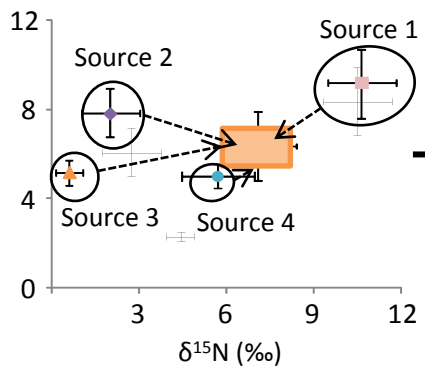
Tools : elemental and isotopic ratios of C and N (C/N, $\delta^{13}C$, $\delta^{15}N$)

1) **Signature of sources** considered depending on station

2) **Quantify the contribution of each source** to the POM pool

Selected sources	
Phytoplankton	Pelagic primary producers
Diazotrophs	
Macrophytes	Benthic primary producers
Microphytobenthos	
Continental	Continental
Terrestrial	
Anthropogenic	

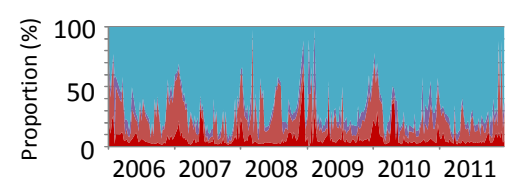


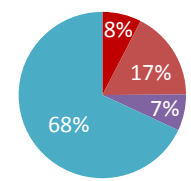


Mixing model (SIAR)

Model outputs :
in **%** and recalculated in **[POC]**

- **date to date**
- **mean annual values**



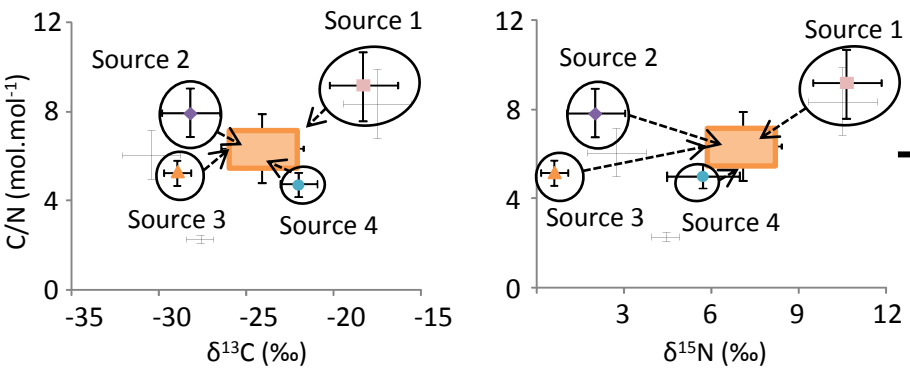


Tools : elemental and isotopic ratios of C and N (C/N, $\delta^{13}C$, $\delta^{15}N$)

Selected sources	
Phytoplankton	Pelagic primary producers
Diazotrophs	
Macrophytes	Benthic primary producers
Microphytobenthos	
Continental	Continental
Terrestrial	
Anthropogenic	

1) **Signature of sources** considered depending on station

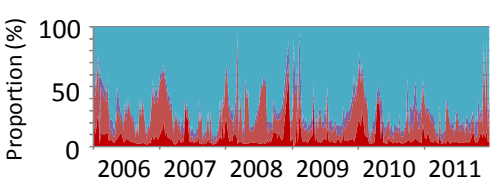
2) **Quantify the contribution of each source** to the POM pool

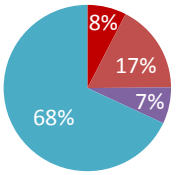


Mixing model (SIAR)

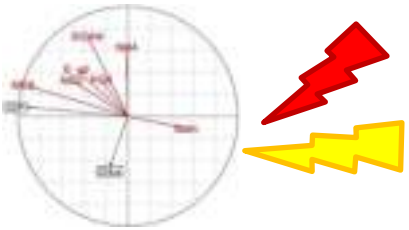
Model outputs :
in **%** and recalculated in **[POC]**

- **date to date**
- **mean annual values**





3) **Forcings to POM composition** → Multivariate analysis (RDA)

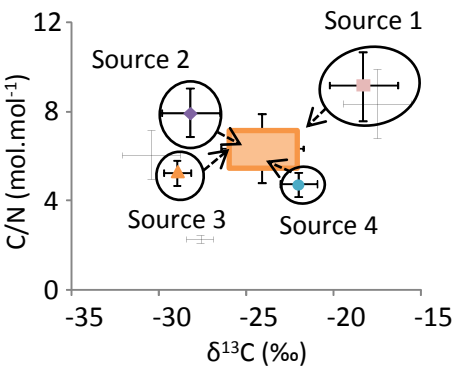


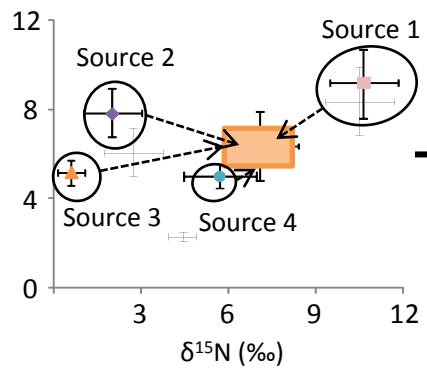
Tools : elemental and isotopic ratios of C and N (C/N, $\delta^{13}C$, $\delta^{15}N$)

Selected sources	
Phytoplankton	Pelagic primary producers
Diazotrophs	
Macrophytes	Benthic primary producers
Microphytobenthos	
Continental	Continental
Terrestrial	
Anthropogenic	

1) **Signature of sources** considered depending on station

2) **Quantify the contribution of each source** to the POM pool

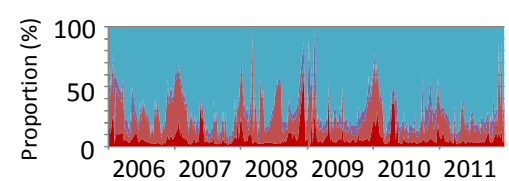


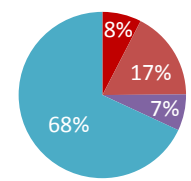


→ **Mixing model (SIAR)** →

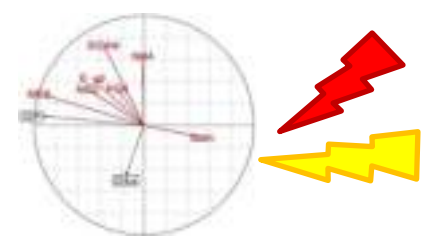
Model outputs :
in **%** and recalculated in **[POC]**

- **date to date**
- **mean annual values**





3) **Forcings to POM composition** → Multivariate analysis (RDA)



4) **Typology based on spatial and temporal variability of POM composition**
using a regionalization method (*Souissi et al 2000*)