

Assessment of PCB trajectories along the French river corridors between 1945 and 2018



OFB – INTERPOL Consortium Members :

André-Marie Dendievel¹, Brice Mourier¹, Alexandra Coynel², Olivier Evrard³, Pierre Labadie², Sophie Ayrault³, Maxime Debret⁴, Quentin Faivre⁵, Thomas Gardes⁴, Sophia Vauclin¹, Hélène Budzinski², Cécile Grosbois⁵, Marc Desmet⁵ & Thierry Winiarski¹



Contact: andre-marie.dendievel@entpe.fr



Online abstract: <https://meetingorganizer.copernicus.org/EGU2020/EGU2020-2205.html>

Related Paper: <https://www.earth-syst-sci-data-discuss.net/essd-2019-167/>

Assessment of PCB trajectories along the French river corridors between 1945 and 2018

Presentation Outline:

I. Introduction

What are PCBs / Brief History / The PCB Legacy / Objectives

II. Material and Methods

Analyses Material / Quality Control / Socio-Hydrological drivers

III. Results and Discussion

Solid Matrices Comparison

Longitudinal trends of socio-hydrological drivers

$\sum \text{PCBi}$ Spatio-Temporal trends / $\sum \text{PCBi}$ fluxes to W. European Seas

IV. Synthesis / Further reading

I. Introduction

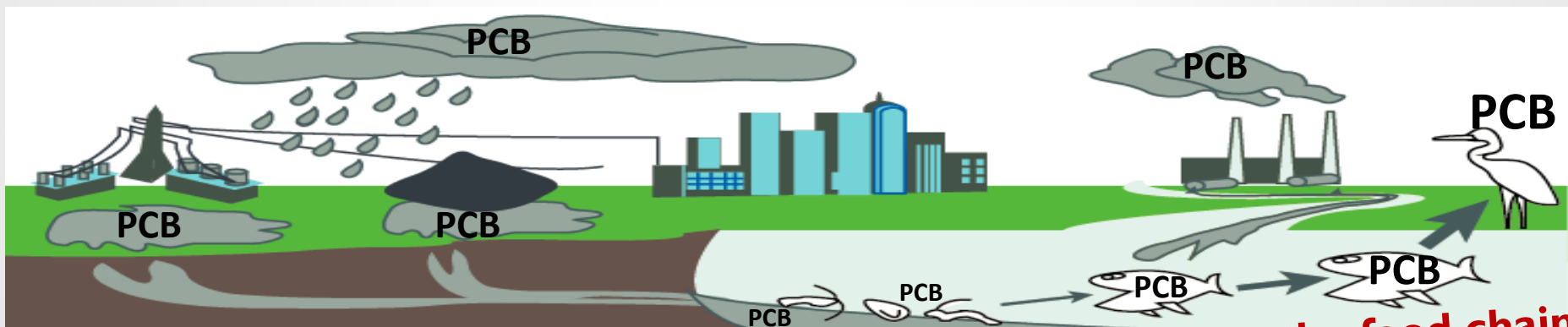
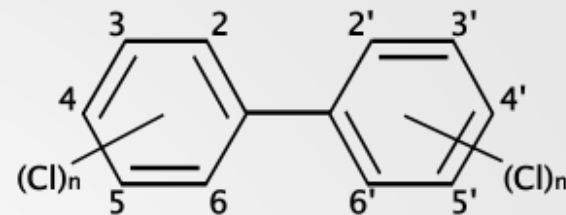
What are PCBs?

- Polychlorobiphenyls = **Persistent Organic Pollutants**

209 congeners; 80% of the toxicity due to 7 PCB indicators (PCBi):

PCB-28 + PCB-52 + PCB-101 + PCB-118 + PCB-138 + PCB-153 + PCB-180

- **Low degradation rates:** Half-life in sediments = 2.4 – 13 years ([Desmet et al., 2012](#))
- **Bioaccumulation and biomagnification** from low to high food chain levels
- **High toxicity:** carcinogenic effects, endocrine disruptors
- Hydrophobic properties: **excellent storage in sediments**

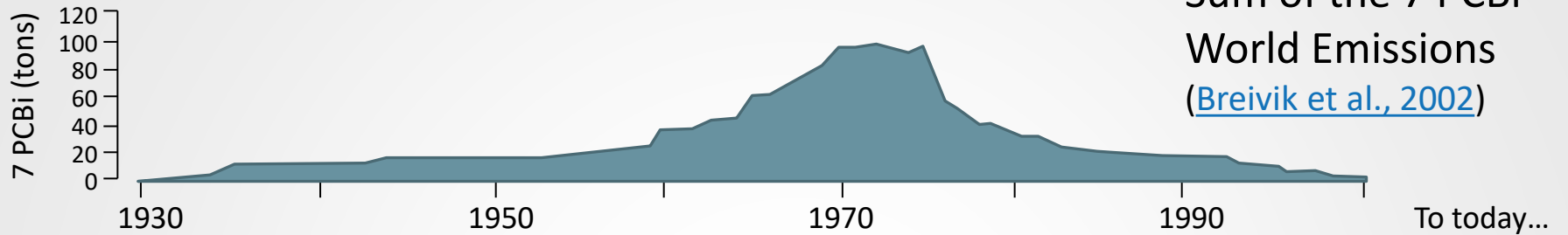


Adapted from [Desforges et al. \(2018\)](#)

From sediment to the food chain

I. Introduction

Brief Historical Overview



■ 1930s: Production / Use (USA, Germany, France, UK)

- In open environments: as paper, wood products, inks and plastics additive
- In closed environments: oil-based electric heaters in transformers and capacitors

■ 1930s–1970s: Increasing use and production

■ 1970s–1980s: International Awareness

- Prohibition in open environments (OECD: 1973, France: 1975; USA: 1976)
- Sale and production bans regarding closed environments (OECD: 1987)

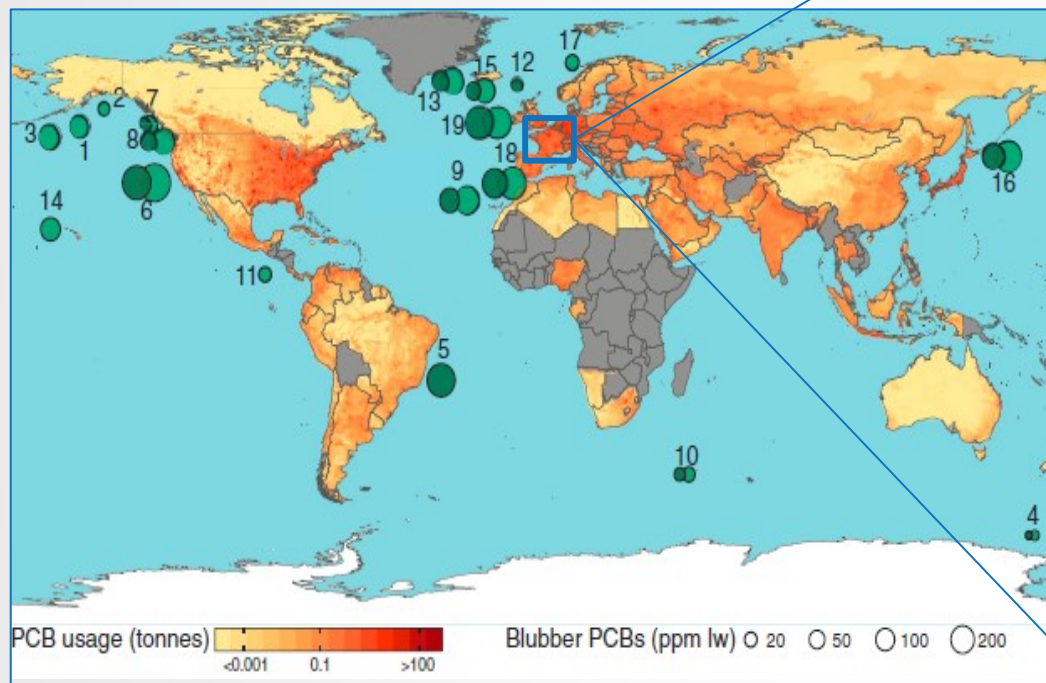
■ 1990s–2010s: Systematic monitoring and device disposal

- Fluvial sediment monitoring since 1991 in France
- Water framework directive (European Union) in 2000
- Gradual device disposal (by 2025) and National Plan *versus* PCBs (2008–2013)

I. Introduction

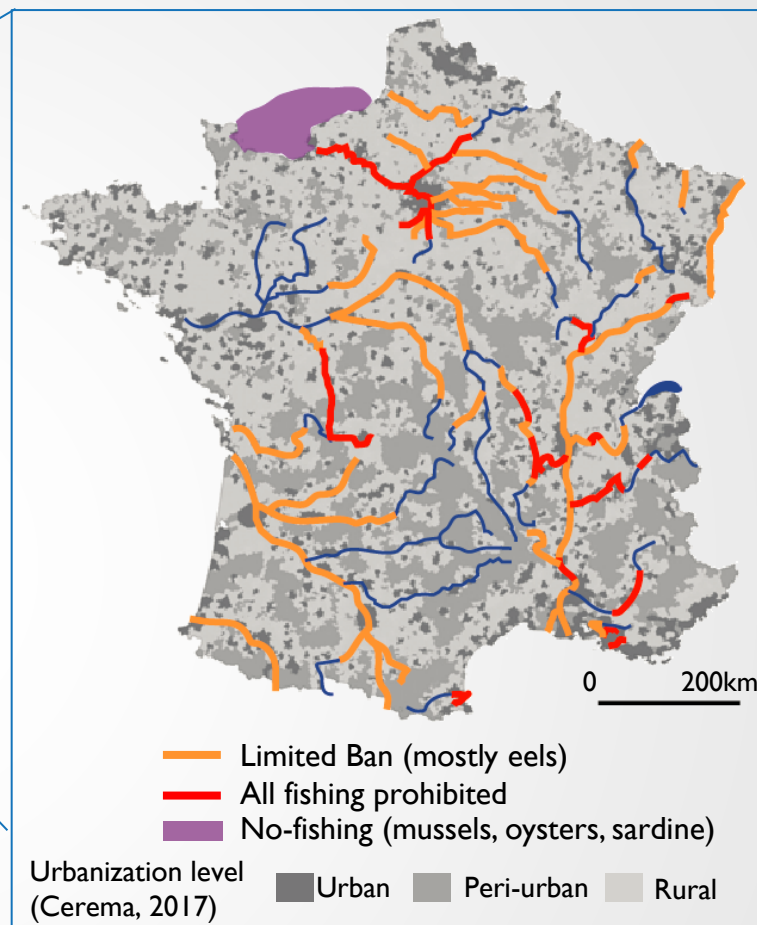
And now: the true PCB Legacy...

Worldwide Seas



PCBs are still a problem:
e.g. Worldwide contamination of Orcas
([Desforges et al., 2018](#))

French Rivers Status



Fishing prohibition due to high
PCB levels in river fishes
(Adapted from Robins des Bois, 2013)

I. Introduction

Our Objectives

1) Reconstruction of spatio-temporal trends of PCB contamination along the main French rivers since 1945

- Collection of research and monitoring data on the 7 PCB indicators along the Garonne, Loire, Rhône and Seine Rivers
- Comparison of measurements on solid sediment matrices: river cores, bed and flood deposits, dredged sediments, suspended particulate matter (SPM)
- Modelling of the spatio-temporal trends (nationwide scale)

2) Integration of social and hydrological drivers to assess the main factors and sources implied in the PCB spatio-temporal patterns

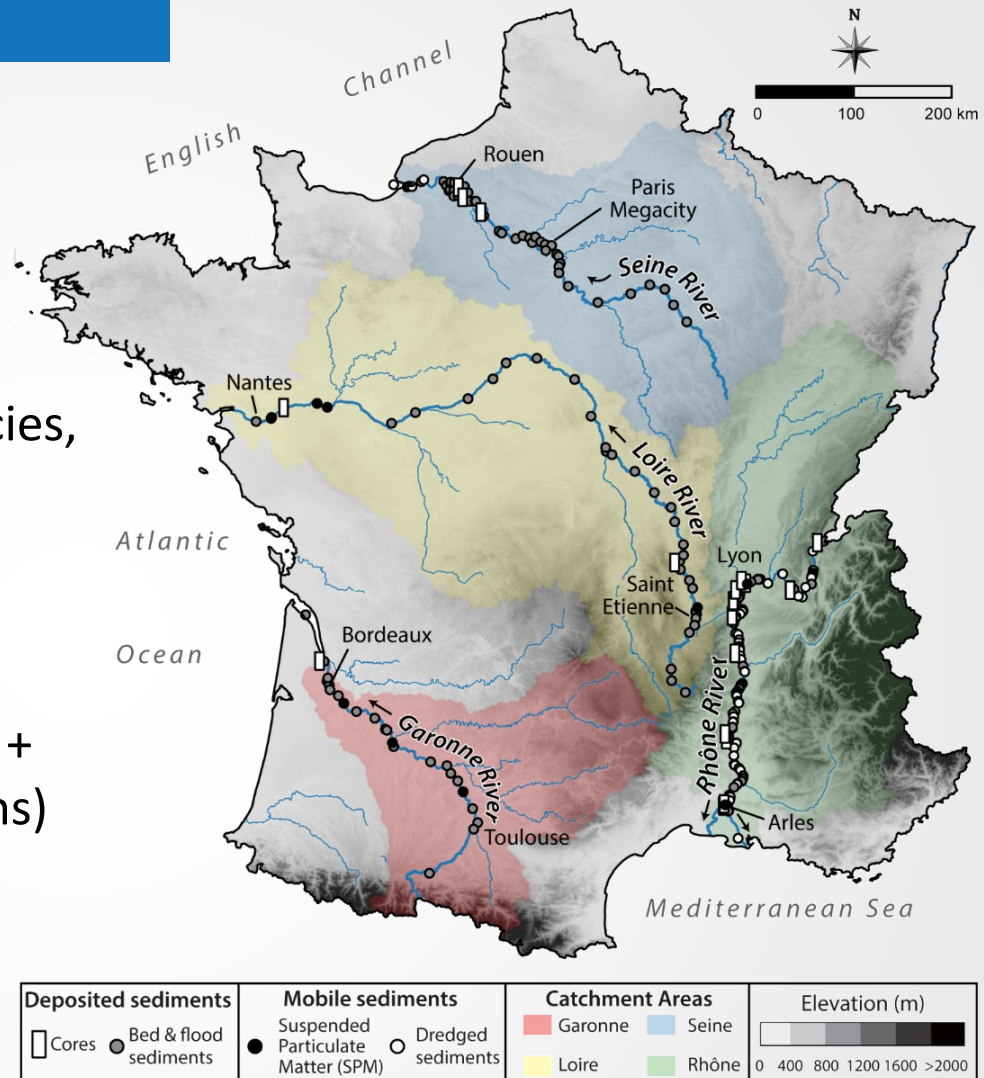
- Population and land use cover (urban and industrial sources)
- PCB polluted sites (underground waters, soils)
- Flow rates and bedload

3) Estimation of the PCB_i fluxes (bedload and specific fluxes) at each river mouth over time & international comparison

II. Material and Methods

- ✓ **Four river corridors:** Garonne, Loire, Rhône and Seine rivers
- ✓ Collection of **research and monitoring data** from:
 - 5 Research labs, 4 Water Agencies, 2 Harbor Authorities
- ✓ **7894 PCBi-congeners analyses**
- ✓ **Two categories of data:**
 - Deposited sediments (19 cores + 135 bed & flood deposit stations)
 - Mobile sediments (9 SPM stations + 81 points of dredging)

Open access data



[Dendievel et al., 2020](#)

II. Material and Methods

Quality control of the data

- ✓ Checking of sampling methods:
Ekman grab, fluvial decanters, sediment corers (Cobra TT and UWITEC)
- ✓ Verification of analyses protocols:
Freeze-dried samples, extraction, purification with sorbents, GC-MS quantification
- ✓ Chronological control: *date of sampling / published age-depth models for cores*
- ✓ For data validation, 2 cases considered according to Quantification Limits (LOQ) / concentrations:

**All 7 PCB_i congeners
> LOQ
= accepted**



**1416 validated
 Σ PCB_i**

**Highly-Chlorinated PCBs (PCB-HC) > LOQ
Low-chlorinated PCBs < LOQ
= reconstruction of the 7 PCB_i Sum (Σ PCB_i)**



**Imputation method based on
PCB-HC > LOQ and inter-annual mean
proportion of PCB-HC on the same river section**



II. Material and Methods

Socio-Hydrological Drivers

- ✓ Demographics: *INSEE population census 2016 integrated in IGN GIS product GEOFLA®*
- ✓ Land cover: *Corine Land Cover Maps from 1990 to 2016*
<https://land.copernicus.eu/pan-european/corine-land-cover>
- ✓ PCB polluted sites computed from
 - French BASOL and BASIAS Databases
- ✓ Flow rates: <http://www.hydro.eaufrance.fr/indexd.php>
- ✓ SPM fluxes according to specific rating curves for each river

Garonne River	Loire River	Rhône River	Seine River
Coynel et al., 2004	Moatar et al., 2006	Poulier et al., 2019	GIP Seine Aval, 2008

- ✓ GIS treatment with QGIS (v.2.18): *merging, buffering, computation*
- ✓ Spatio-temporal modelling with gam ([Wood, 2019](#)) within R (v.3.5.1)

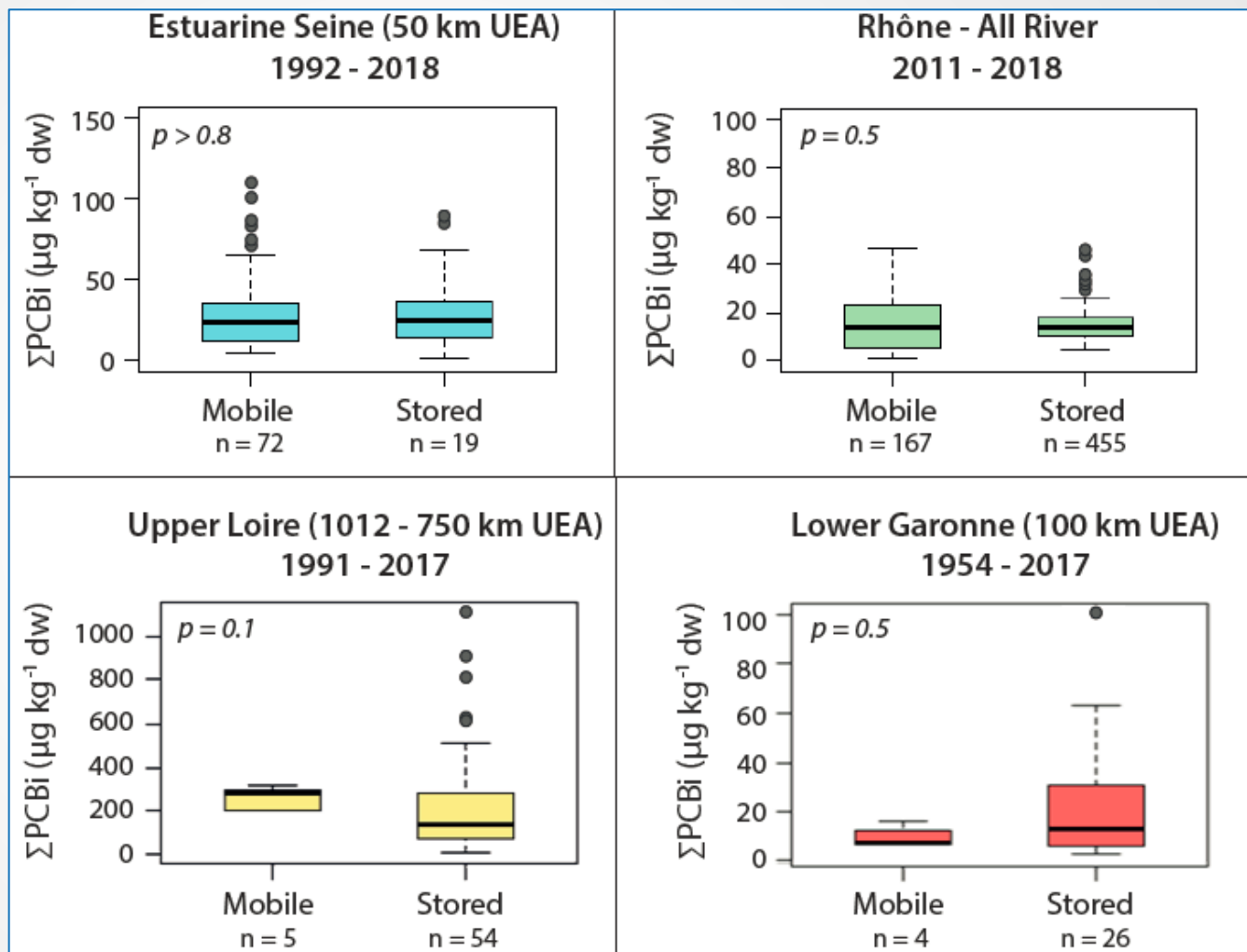
III. Results and Discussion

Solid Matrices Comparison

Despite the data heterogeneity

Contamination levels in the different solid matrices are similarly distributed

(Wilcoxon test, $p \geq 0.5$)



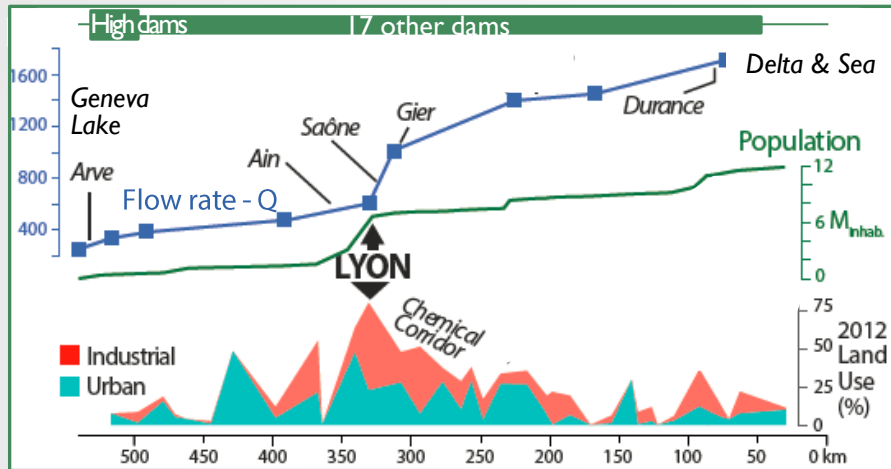
[Dendievel et al., 2020](#)

III. Results and Discussion

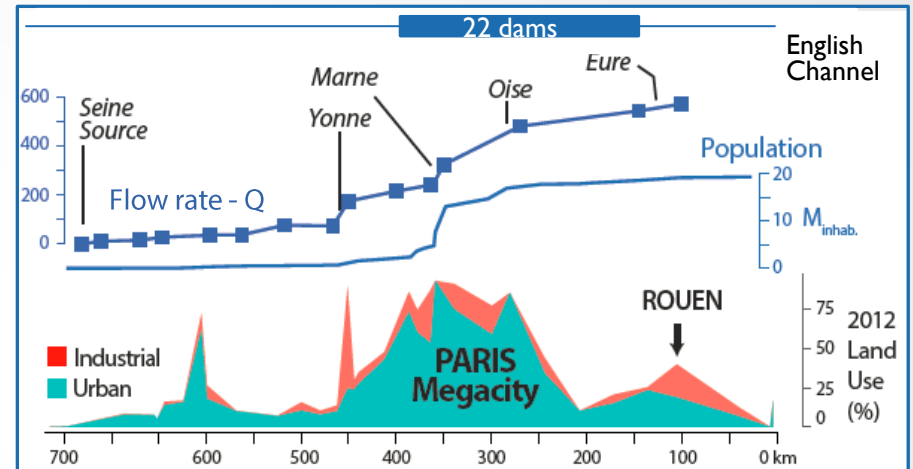
Longitudinal trends of socio-hydrological drivers

❖ **Group 1:** Heavily engineered rivers with one major Megacity (Lyon/Paris)

Rhône River

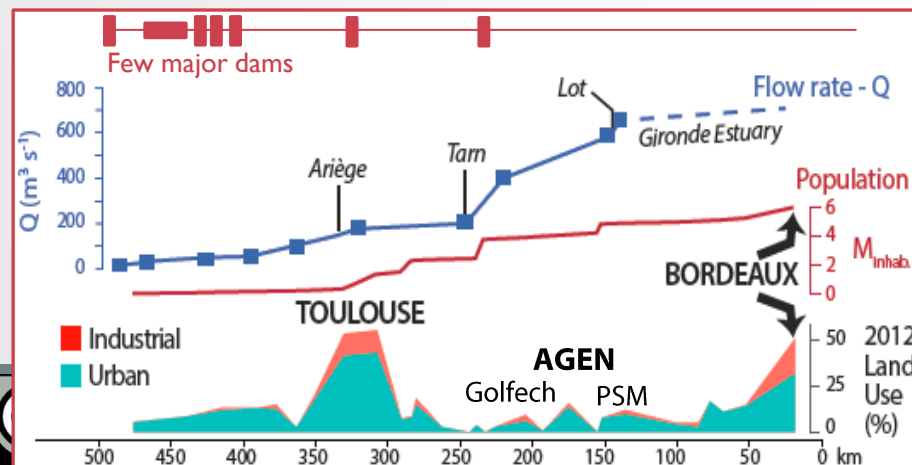


Seine River

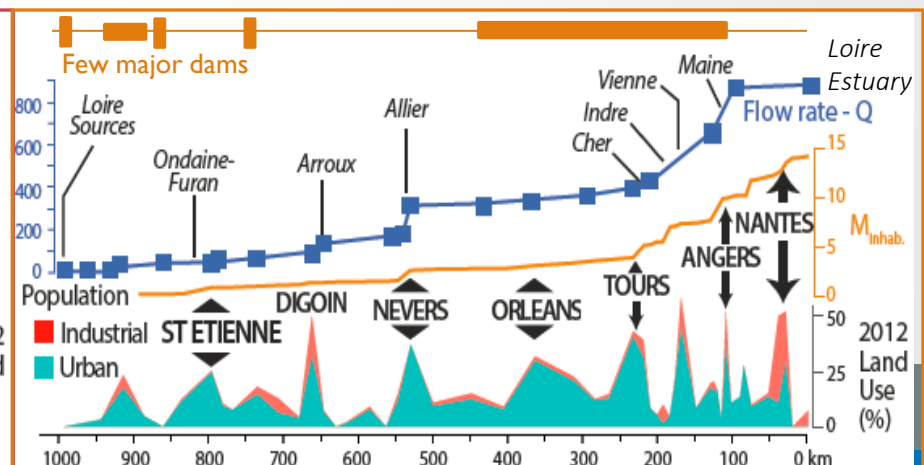


❖ **Group 2:** Limited river equipment–Widespread urban and industrial centres

Garonne River



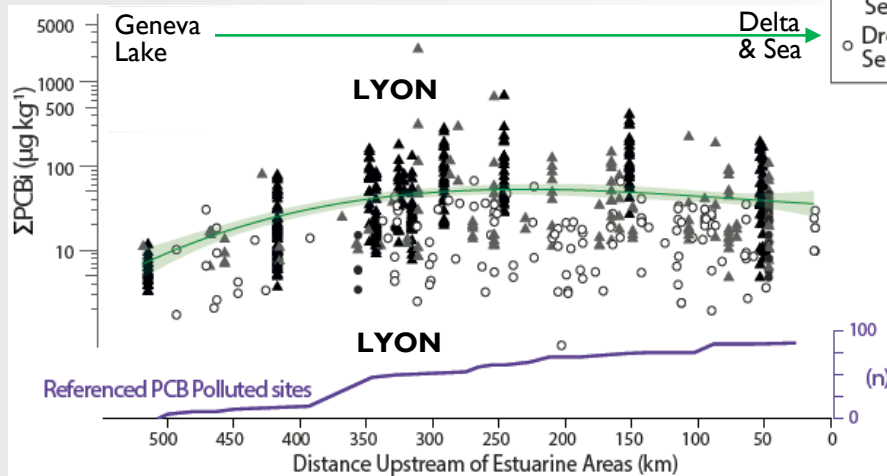
Loire River



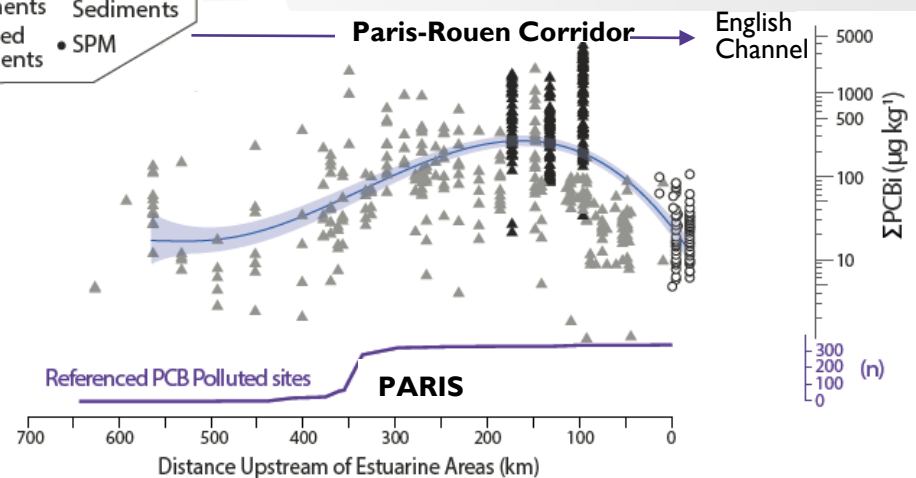
III. Results and Discussion

❖ Group 1: Increasing PCBi pollution from the Megacities to downstream

Rhône River

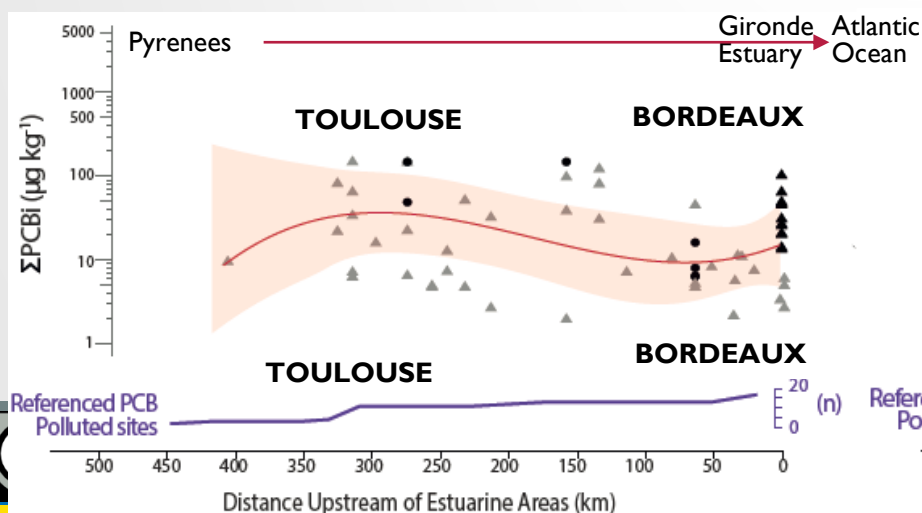


Seine River

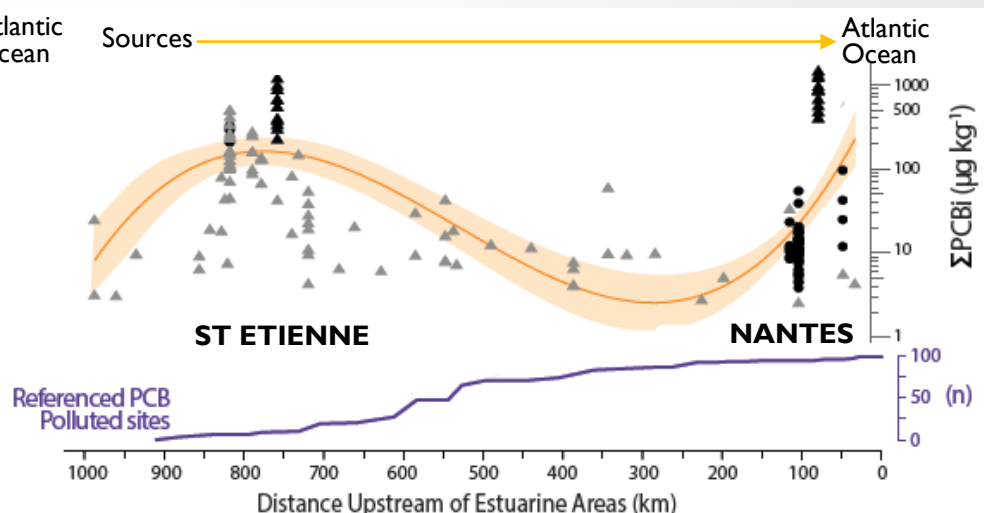


❖ Group 2: Two local sources of PCBis (urban/industrial basins)

Garonne River



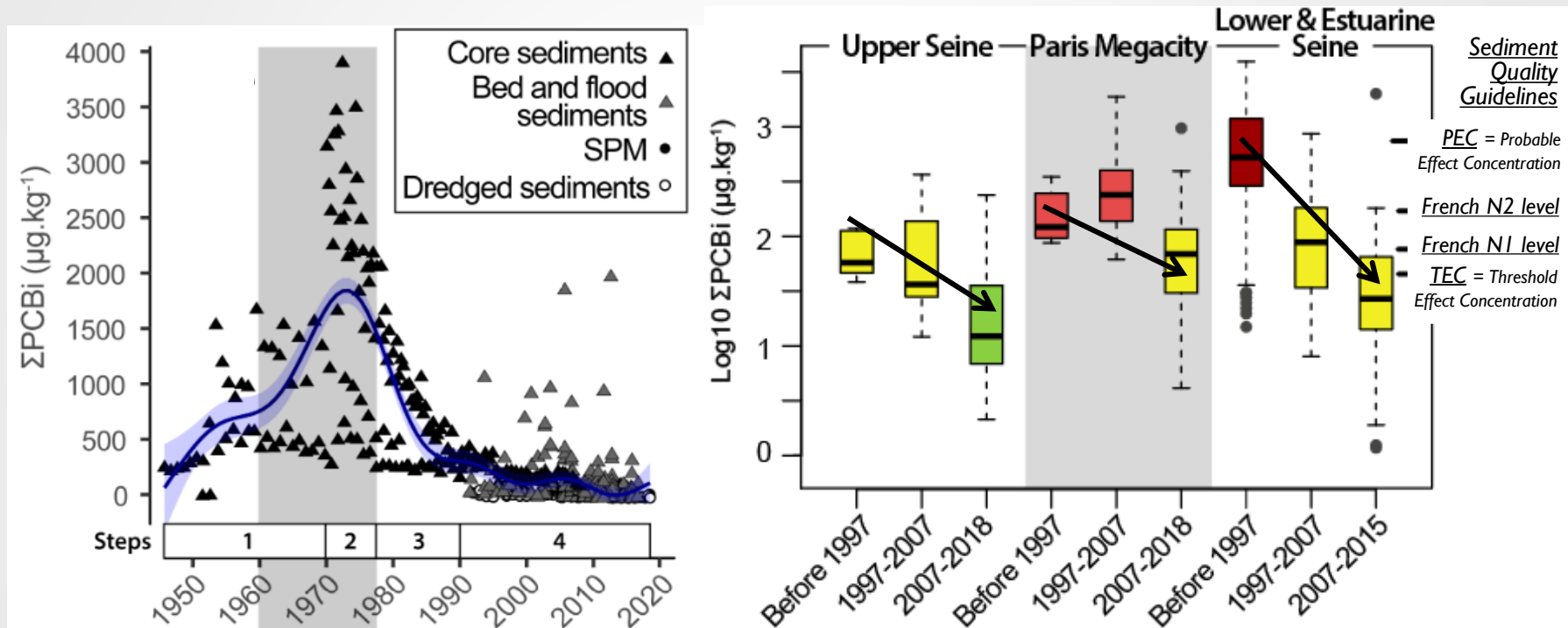
Loire River



III. Results and Discussion

Spatio-temporal trends of the PCB contamination in French Rivers

The Seine River

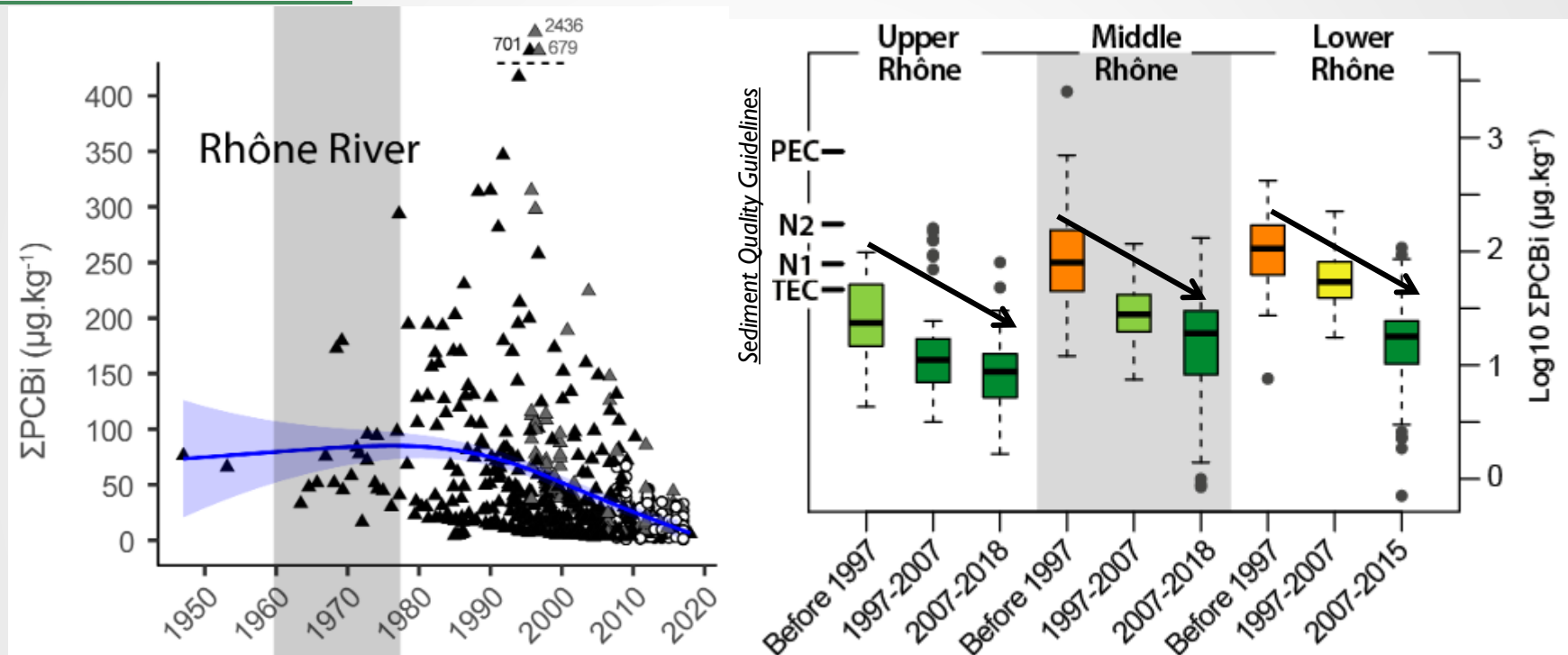


- Major Σ PCBi concentrations **from 1955 to 1980** (> 500 mg/kg; max ca. 4 g/kg)
- **Increasing trend from Paris Megacity to Rouen**, in the Lower and Estuarine section of the Seine River (urban and industrial releases)
- General decreasing trend until nowadays (median = 60 mg/kg, i.e. < PEC)

III. Results and Discussion

Spatio-temporal trends of the PCB contamination in French Rivers

The Rhône River



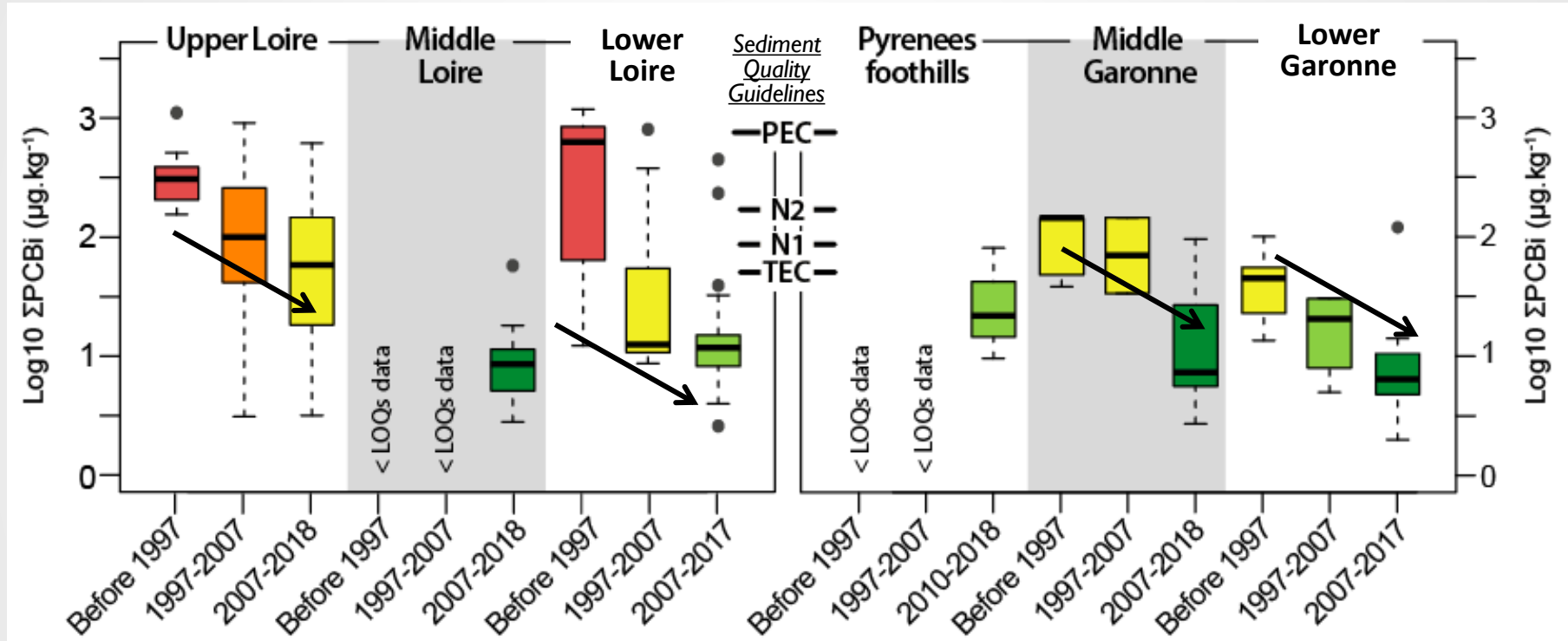
- High [ΣPCBi] from 1970 to 1990 (max = 2.4 g/kg) but lower than in the Seine
- **Hotspot downstream of the Middle Rhône** (Lyon–Chemical Corridor–Gier Valley)
- **General decreasing trend** since the late 1990s (median = 18 mg/kg)

III. Results and Discussion

Spatio-temporal trends of the PCB contamination in French Rivers

The Loire River

The Garonne River

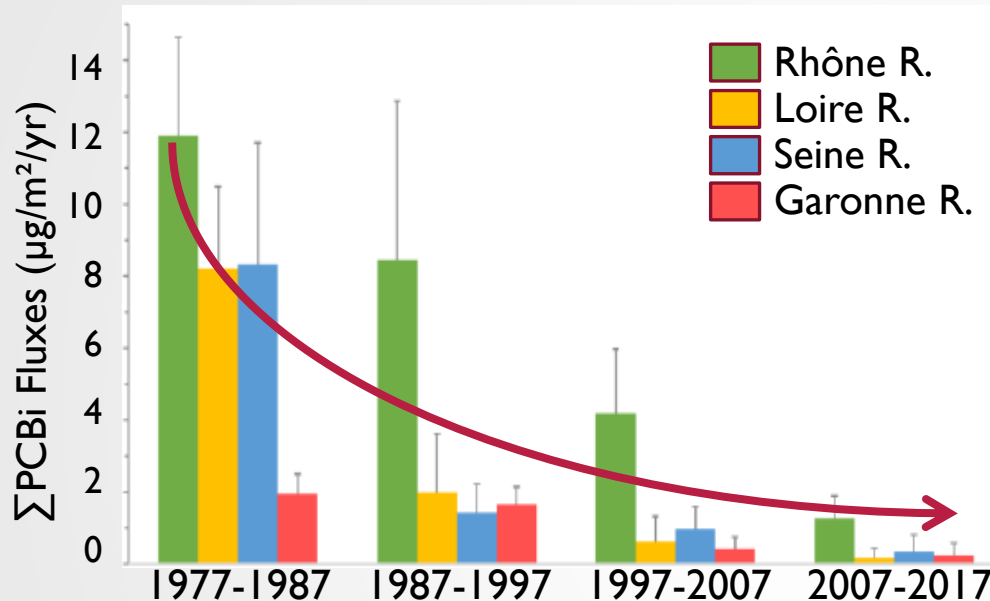


- **Decreasing trend since 1997** also on the Loire and Garonne Rivers
- **Hotspot of PCBi pollution** in Upper and Lower Loire (St-Etienne, Nantes)
- **Lack of data** in the Middle Loire & Pyrenees foothills: **efforts should be made**

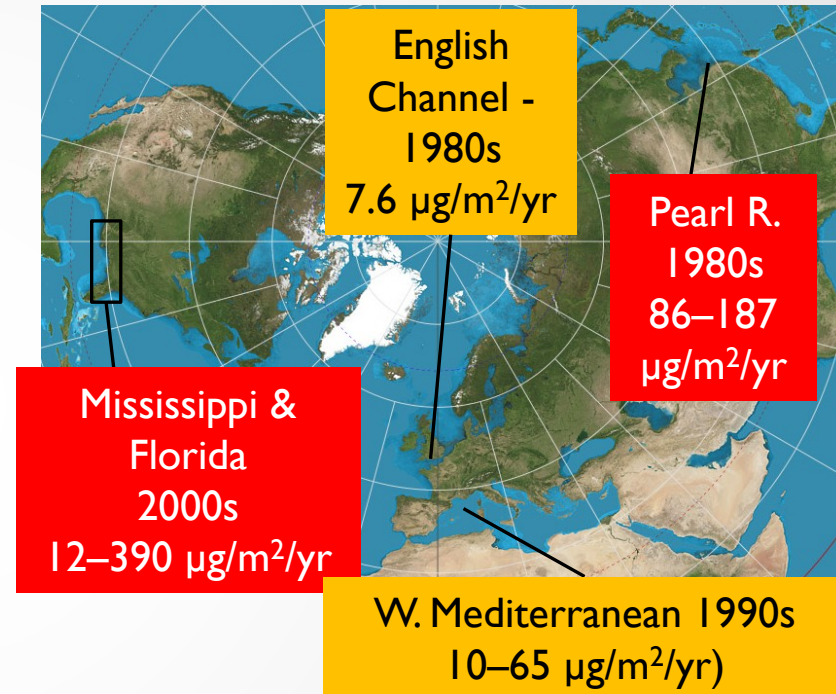
III. Results and Discussion

ΣPCBi specific fluxes

French Rivers



Worldwide



- Order of pollution magnitude: 1) Rhône R.; 2-3) Loire R.≈Seine R.; 4) Garonne R.
- ΣPCBi in French Rivers << **American and Asian Rivers**
- High contribution of French Rivers to the **pollution of W. European Seas**

Synthesis

- ✓ Combination of PCB analyses from research and monitoring programmes at a nationwide scale (France)
- ✓ Comparison with socio-hydrological data
- ✓ Reconstruction of spatio-temporal trends for four river corridors:

Rhône R.	Seine R. / Loire R.	Garonne R.
↗ 1997 ↘	↗ 1975 ↘	↗ 1990-2000 ↘
Highest specific PCB _i fluxes and load	Similar fluxes & load	Rare data & Low pollution

- Significant effect of regulation worldwide (national application of international guidelines)
- Long-term inputs and emissions from urban and industrial zones
- In the coming months: development of a synthesis on **metal and POPs pollution and toxicity risks** along the French river corridors + **recommendations** for monitoring agencies

Related Paper: <https://www.earth-syst-sci-data-discuss.net/essd-2019-167/>

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