

Symposium on March 30-31, 2023

Transdisciplinary research for a healthy planet

Campus Croix Rouge - Amphitheater 10, Building 9 - 57 rue Pierre Taittinger 51096 Reims Cedex



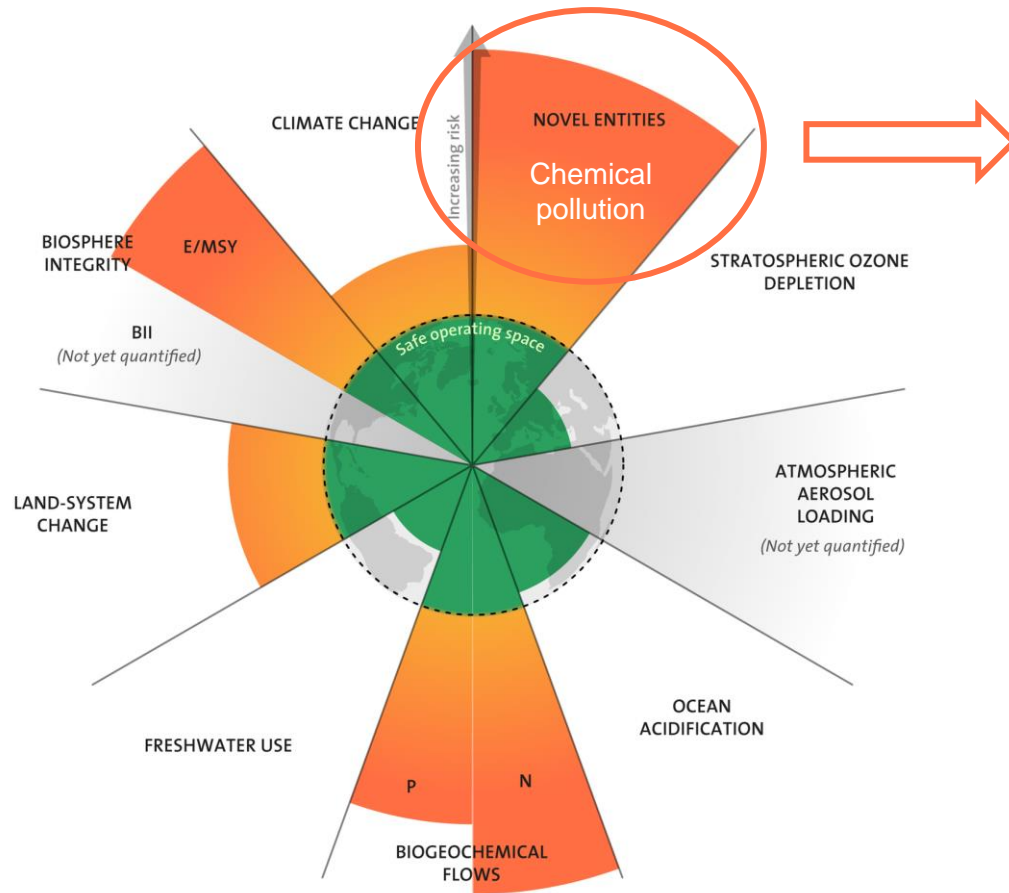
From research to operations: development of *in situ* bioassays by caging crustaceans for the assessment of chemical contamination and toxicity of aquatic environments

Guillaume JUBEAUX (Biomae), Mickael NICOLAS (Groupe CARSO) et Olivier GEFFARD (INRAE)

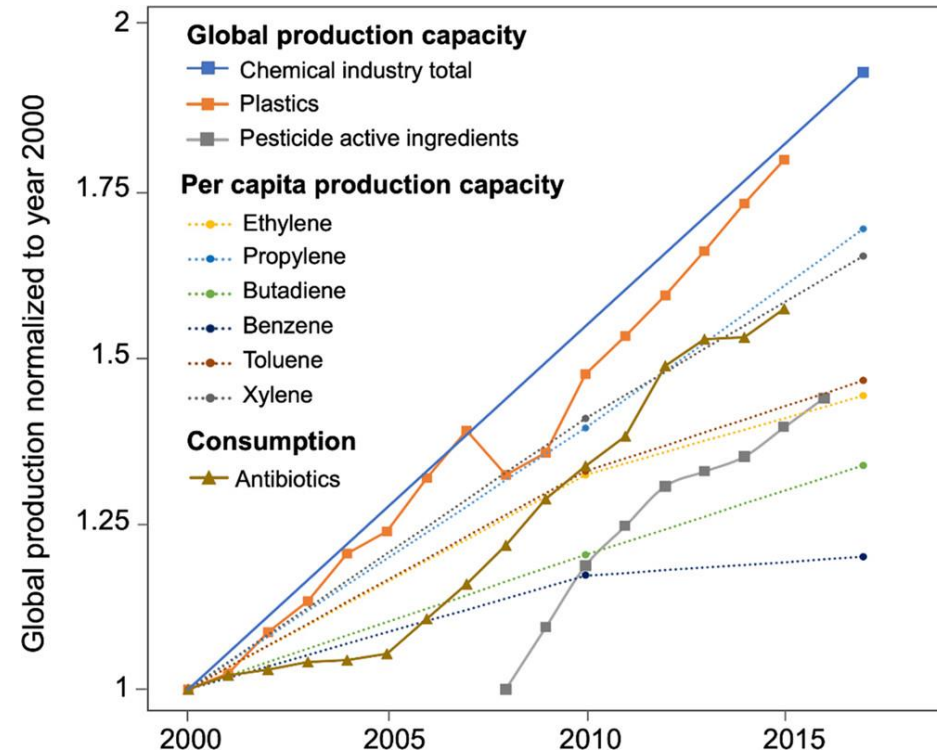


Chemical pollution

Planetary boundaries



Global trends of chemical industry production between 2000 and 2017



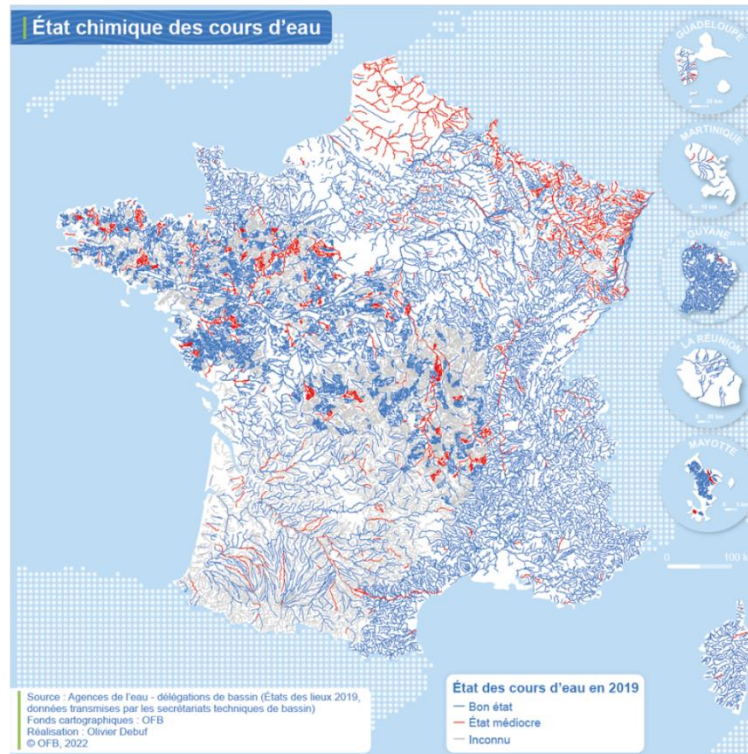
Water Framework Directive



Application of WFD obligations in France since 2000

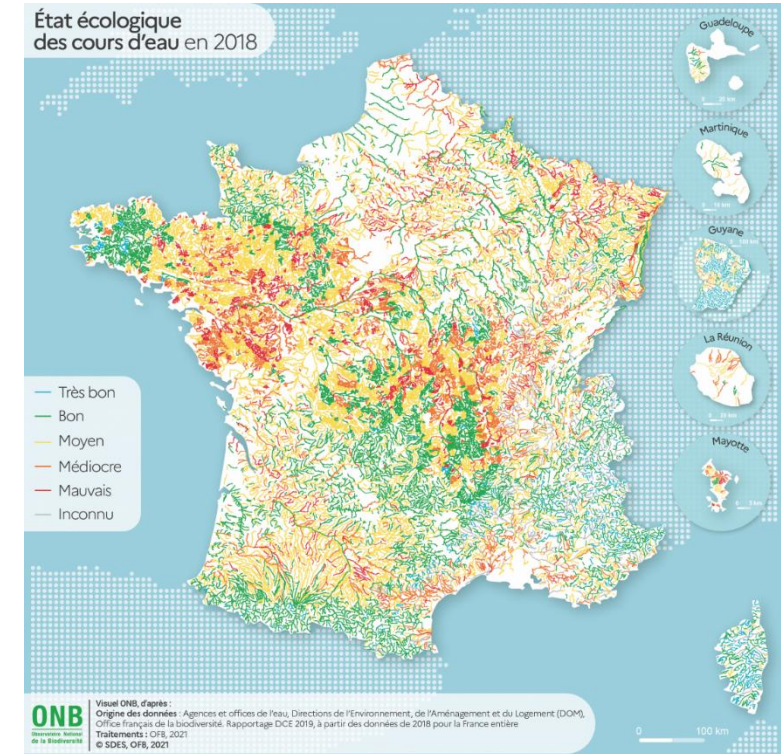
Chemical status

Goal → Reduce / remove priority hazardous substances



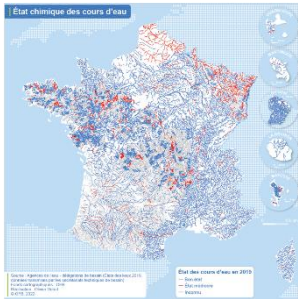
Ecological status

Goal → Preserve / restore aquatic biodiversity



Monitoring strategy

Application of WFD obligations in France since 2000



Chemical status
priority hazardous substances



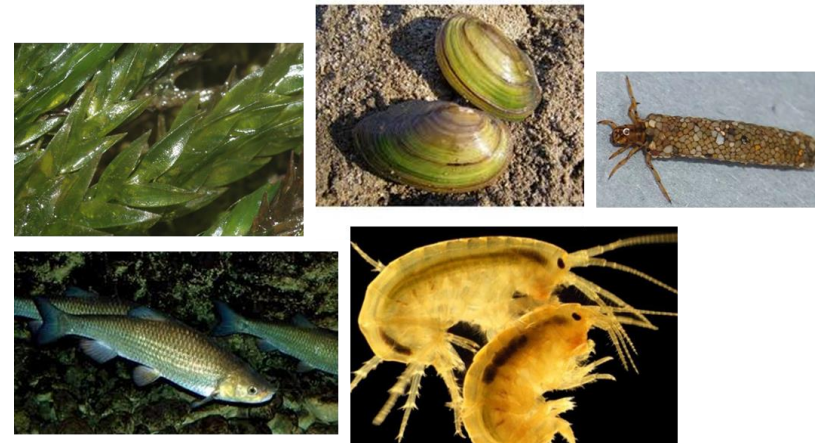
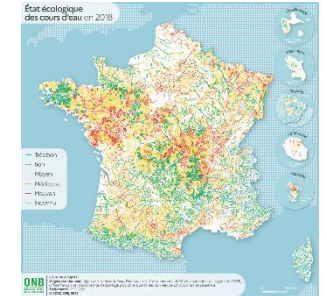
Monitoring of water



Ecological status
aquatic biodiversity

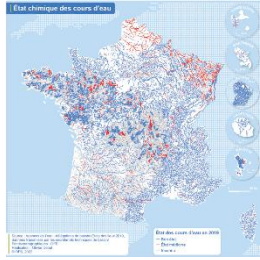


Monitoring the presence and abundance of species in communities (fauna and flora)



Needs

Application of WFD obligations in France since 2000



Chemical status
priority hazardous substances

↓
Monitoring of water

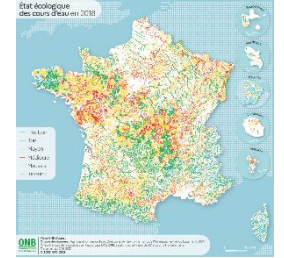
↓
Representativity of punctual samples
Biodisponibility
Hydrophobic substances



Ecological status
aquatic biodiversity

↓
Monitoring of communities

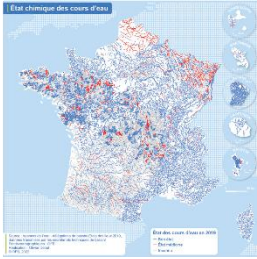
↓
Habitat effect
Predation / competition
Availability of food resources



?

Needs

Application of WFD obligations in France since 2000



Chemical status
priority hazardous substances

Monitoring of water

Representativity of punctual samples

Biodisponibility

Hydrophobic substances

Ecological status
aquatic biodiversity

Monitoring of communities

Habitat effect

Predation / competition

Availability of food resources



No direct link

Link with ecotoxicology

Understanding the fate and impact of chemicals on biota

Biomonitoring approaches for ecotoxicology

WHICH APPROACH?

Passive monitoring



sampling native
organisms



Active monitoring



caging of controlled
organisms



Biomonitoring approaches for ecotoxicology

Active monitoring



caging of controlled organisms



Advantages

- **Active** = Applicable everywhere **VS** **Passive** = only if species is present
- **Active** = Using same reference population = spatial comparison
- **Active** = easy calibration (size, gender,...)

Precaution

- Using **non-invasive species**

Ecotoxicology model

WHICH SPECIES ?



Gammarus fossarum



Non invasive species in Europe / largely present

Well adapted to caging

Easy to handle

Etc.

Research and development of solution (2000 – 2013)

In situ bioassays by caging (gammarids) to assess contamination and toxicity in aquatic environments

INRAE

Public Research Institute



In situ feeding assay with *Gammarus fossarum* (Crustacea): Modelling the influence of confounding factors to improve water quality biomonitoring

Romain Coulaud^{a,b}, Olivier Geffard^{a,*}, Benoît Xuereb^{a,1}, Emilie Lacaze^a, Hervé Quéau^a, Jeanne Garric^a, Sandrine Charles^b, Arnaud Chaumot^{a,2}

^aCemagref, UR MALLY, 3 bis quai Chauveau-CP 220, F-69336 Lyon, France
^bUniversité de Lyon, F-69000, Lyon, Université Lyon 1, CNRS, UMR5558, Laboratoire de Biométrie et Biologie Evolutive, F-69622 Villeurbanne, France



Linking genotoxic responses in *Gammarus fossarum* germ cells with reproduction impairment, using the Comet assay

Emilie Lacaze^{a,b}, Olivier Geffard^b, Delphine Goyet^a, Sylvie Bony^a, Alain Devaux^{a,b*}

^aUniversité de Lyon, INRA-ENVTE, Laboratoire des Sciences de l'Environnement, rue Maurice Audin, Visud en Vélizy, F-69518, France
^bCemagref, MALT, Laboratoire d'Écotoxicologie, 3 bis quai Chauveau, 69336 Lyon, Cedex 9, France

Environmental Toxicology and Chemistry—Volume 00, Number 00—pp. 1–14, 2020
Received: 26 July 2019 | Revised: 30 September 2019 | Accepted: 24 December 2019

Environmental Toxicology

In Situ Reproductive Bioassay with Caged *Gammarus fossarum* (Crustacea): Part 2—Evaluating the Relevance of Using a Molt Cycle Temperature-Dependent Model as a Reference to Assess Toxicity in Freshwater Monitoring

Christelle Lopes^{a,b}, Arnaud Chaumot^{a,*}, Benoît Xuereb^a, Romain Coulaud^a, Guillaume Jubeaux^a, Hervé Quéau^a, Adeline François^a, and Olivier Geffard^{a,2}

^aINRAE, UR Riverly, Laboratoire d'Écotoxicologie, Villeurbanne, France
^bLaboratoire de Biométrie et Biologie Evolutive, Université Lyon 1, Université de Lyon, Centre National de la Recherche Scientifique, Villeurbanne, France



Cholinesterase activity in *Gammarus pulex* (Crustacea Amphipoda): Characterization and effects of chlorpyrifos

Benoît Xuereb, Patrice Noury, Vincent Felten, Jeanne Garric, Olivier Geffard^a

Laboratoire d'écotoxicologie, Cemagref, 3 bis quai Chauveau, CP 220, 69336 Lyon Cedex 09, France
Received 27 March 2007; received in revised form 6 April 2007; accepted 10 April 2007
Available online 24 April 2007



OVARIAN CYCLE AND EMBRYONIC DEVELOPMENT IN *GAMMARUS FOSSARUM*: APPLICATION FOR REPRODUCTIVE TOXICITY ASSESSMENT

OLIVIER GEFFARD,^a BENOÎT XUEREBS,^a ARNAUD CHAUMOT,^a ALAIN GEFFARD,^a SYLVIE BIAGANTI,^a CLAIRE NOËL,^a KHEDDIDA ABRACI,^a JEANNE GARRIC,^a GUY CHARMANTIER,^a and MIREILLE CHARMANTIER-DAURES^b

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(Submitted 25 October 2009; Returned for Revision 1 February 2010; Accepted 30 April 2010)

Trends in Analytical Chemistry, Vol. 36, 2012

Relevance and applicability of active biomonitoring in continental waters under the Water Framework Directive

Jean-Philippe Besse, Olivier Geffard, Marina Coquery



Vitellogenin-like proteins in the freshwater amphipod *Gammarus fossarum* (Koch, 1835): Functional characterization throughout reproductive process, potential for use as an indicator of oocyte quality and endocrine disruption biomarker in males

Guillaume Jubeaux^a, Romain Simon^b, Arnaud Salvador^b, Hervé Quéau^a, Arnaud Chaumot^a, Olivier Geffard^{a,2}

^aINRAE, Unité de Recherche Milieux Aquatiques (UR MALLY), 3 bis quai Chauveau—CP 220, F-69336 Lyon, France
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Caged *Gammarus fossarum* (Crustacea) as a robust tool for the characterization of bioavailable contamination levels in continental waters: Towards the determination of threshold values

Jean-Philippe Besse^{a,1}, Marina Coquery^{a,1}, Christelle Lopes^{a,1}, Arnaud Chaumot^{a,1}, Hélène Budzinski^a, Pierre Labadie^a, Olivier Geffard^{a,1,2}

^aINRAE, UR MALLY (Freshwater Systems, Ecology and Pollution), 5 rue de la Doua, CS70077, 69626 VILLEURBANNE Cedex, France
^bUniversité Bordeaux I, Environnements et Paléoenvironnements Océaniques et Continentaux (EPOC), UMR 5805 CNRS, Laboratoire de Physico- et Toxico-Chimie de l'Environnement (LPTC), 351 cours de la Libération, 33405 Talence, France

ENVIRONMENTAL
Science & Technology

Cite This: Environ. Sci. Technol. 2016, 53, 5906–5915

Article
pubs.acs.org/est

Multisubstance Indicators Based on Caged *Gammarus* Bioaccumulation Reveal the Influence of Chemical Contamination on Stream Macroinvertebrate Abundances across France

Benjamin Alric^a, Olivier Geffard^a, André Chandresis^a, Martial Ferréol^a, Adeline François^a, Olivier Perceval^b, Jérémy Piffady^b, Bertrand Villeneuve^c, and Arnaud Chaumot^{a,1}

^aINRAE, UR Riverly, Laboratoire d'Écotoxicologie and ^bINRAE, UR Riverly, Laboratoire d'Hydrobiologie Quantitative, Centre Lyon-Villeurbanne, 5 rue de la Doua CS 20244, F-69625 Villeurbanne, France

^cAgence Française Pour La Biodiversité, site de Vincennes, 5 Square Felix Nadar, 94300 Vincennes, France

Solution transfer for large scale deployment (2014)

In situ bioassays by caging (gammarids) to assess contamination and toxicity in aquatic environments

INRAE
Public Research Institute



BIOMÆ
Biomonitoring Aquatic Environment



More than 7.000 assays achieved since creation



2014 : creation of the **spin-off**

2015 : **Fund raising** (1,5 M€) → large scale pilots + **industrialization to scale up**

2018 : **Regulatory deployment** in France (WFD, )

2019 : First **standard** publication (AFNOR NF T90-721)

2022 : **2 M€ turnover / 30 collaborators**

afnor

normalisation
française

ISSN 0335-3931

NF T90-721

MARS 2023

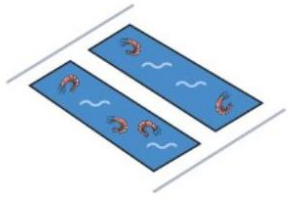
Indice de classement : **T 90-721**

ICS : 13.060.50 ; 13.060.70

Qualité de l'eau — Engagement *in situ* de gammarès pour la mesure de la bioaccumulation de substances chimiques

E : Water quality – In situ gammarus caging for measuring bioaccumulation of chemical substances
D : Wasserbeschaffenheit – In situ in einen Käfig Einsperung von Bachflöhkrebsen zur Messung der Bioakkumulation von chemischen Substanzen

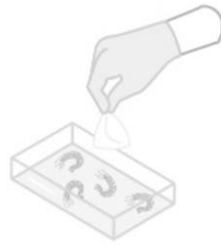
PROTOCOL



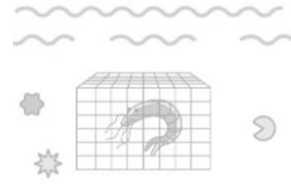
1 Breeding



2 Acclimatization



3 Sorting



4 Exposition



5 Analysis



Thresholds

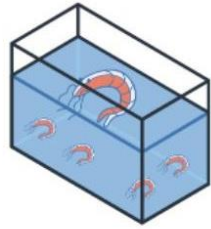
6 Assessment



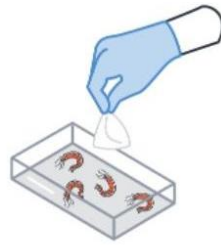
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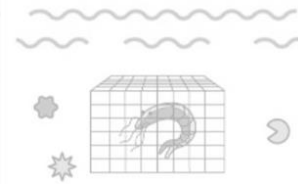
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4



5



Thresholds

6



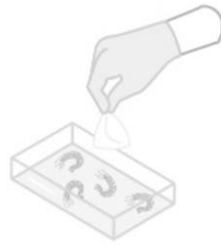
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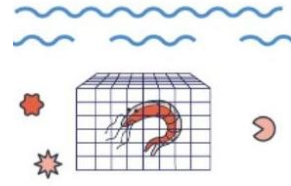
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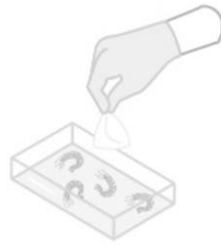
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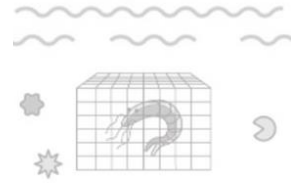
1 Breeding



2 Acclimatization



3 Sorting



4 Exposition



5 Analysis



Thresholds

6 Assessment



Applications with some examples

Check the compliance
with environmental quality
standards in biota (EQS)
For 15 priority hazardous
substances

WFD



Assess the levels of
bioavailable contamination
for a hundred substances

metals, PAHs, PCBs, chlorinated,
brominated and perfluorinated
compounds, drugs, pesticides,
cosmetics, ...

Assess the toxic impacts
(cocktail effects)
of micropollutants in
aquatic environments

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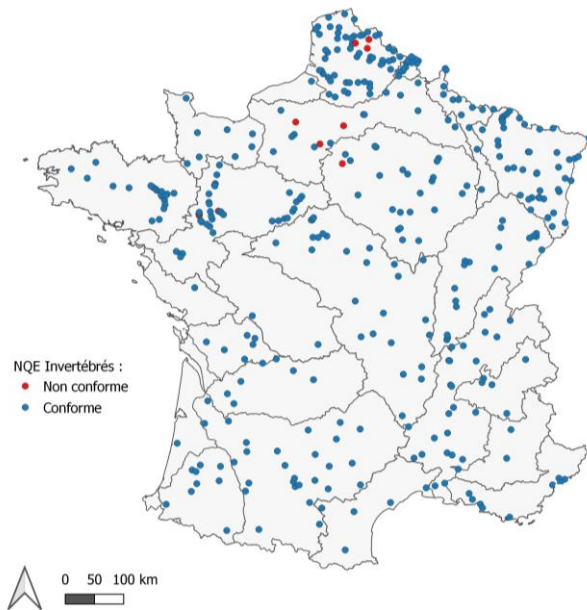
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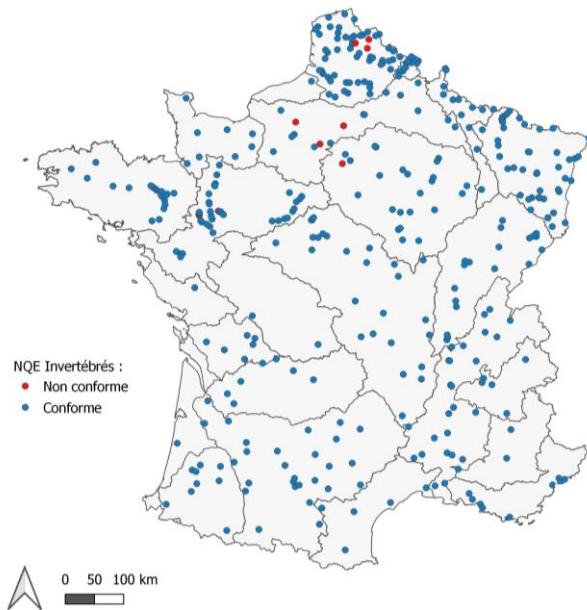
EQS invertebrate Benzo(a)Pyrène



Applications with some examples

Check the compliance with environmental quality standards in biota (EQS)
For 15 priority hazardous substances

EQS invertebrate Benzo(a)Pyrène



Transalte « gammarid » concentration
in « fish » concentration



Babut et al. *Environ Sci Eur* (2020) 32:131
<https://doi.org/10.1186/s12302-020-00416-4>

Environmental Sciences Europe

RESEARCH

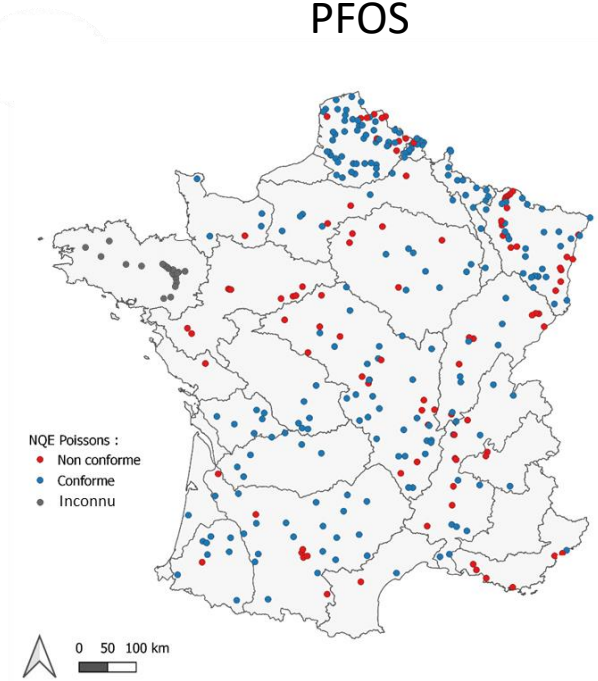
Open Access



Monitoring priority substances in biota under the Water Framework Directive: how effective is a tiered approach based on caged invertebrates? A proof-of-concept study targeting PFOS in French rivers

Marc Babut^{1*}, Benoit J. D. Ferrari², Patrick Jame³, Azziz Assoumani⁴, François Lestremiau⁴, Nicolas Hette-Tronquart⁵, Cécile Miegé¹ and Olivier Perceval⁵

EQS fish PFOS



Applications with some examples

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Applications with some examples

Assess the levels of bioavailable contamination

BBAC (Background Bioavailable Assessment Concentration)



Caged *Gammarus fossarum* (Crustacea) as a robust tool for the characterization of bioavailable contamination levels in continental waters: Towards the determination of threshold values

Jean-Philippe Besse^{a,1}, Marina Coquery^{a,1}, Christelle Lopes^{a,1}, Arnaud Chaumot^{a,1}, H el ene Budzinski^b, Pierre Labadie^b, Olivier Geffard^{a,*,1}

^aIrstea, UR MALY (Freshwater Systems, Ecology and Pollution), 5 rue de la Doua, CS70077, 69626 VILLEURBANNE Cedex, France
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IBC (Indicator of bioavailable contamination)

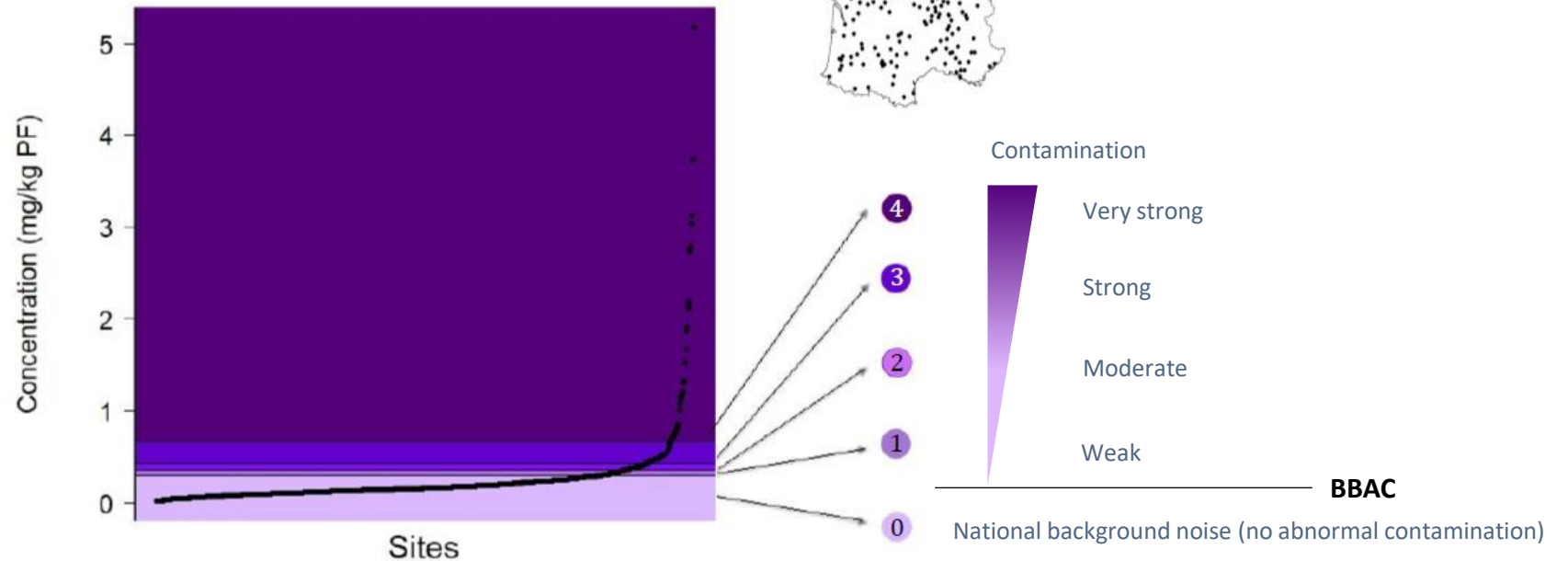


Multisubstance Indicators Based on Caged *Gammarus* Bioaccumulation Reveal the Influence of Chemical Contamination on Stream Macroinvertebrate Abundances across France

Benjamin Alric,¹ Olivier Geffard,¹ Andr e Chandesis,¹ Martial Ferr eol,¹ Adeline Fran ois,¹ Olivier Perceval,¹ J r emy Piffady,¹ Bertrand Villeneuve,¹ and Arnaud Chaumot^{*,1}

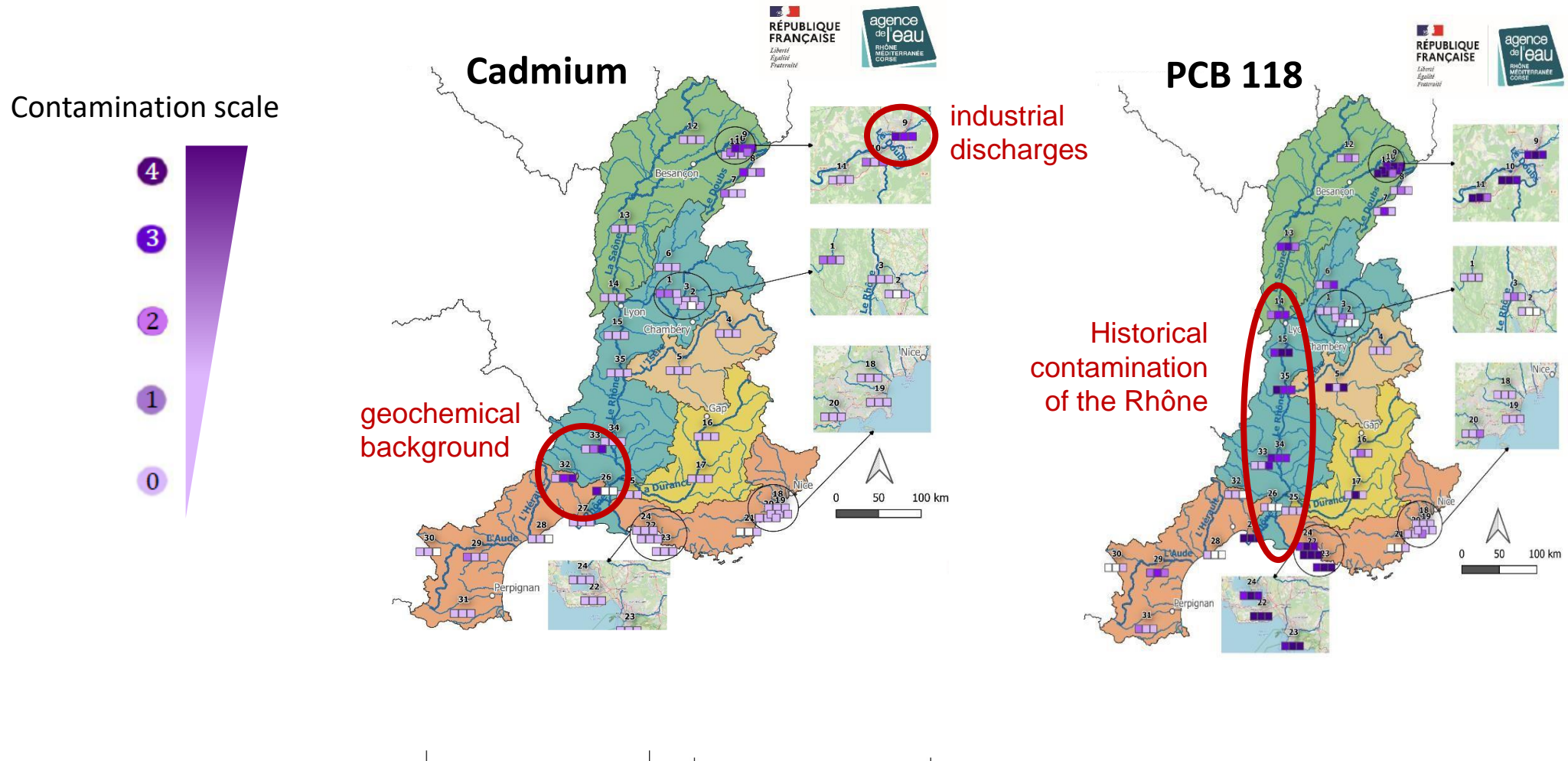
¹Irstea, UR RiverLy, Laboratoire d' cotoxicologie and ²Irstea, UR RiverLy, Laboratoire d'Hydrobiologie Quantitative, Centre Lyon-Villeurbanne, 5 rue de la Doua CS 20244, F-69625 Villeurbanne, France

³Agence Fran aise Pour La Biodiversit , site de Vincennes, 5 Square Felix Nadar, 94300 Vincennes, France



Applications with some examples

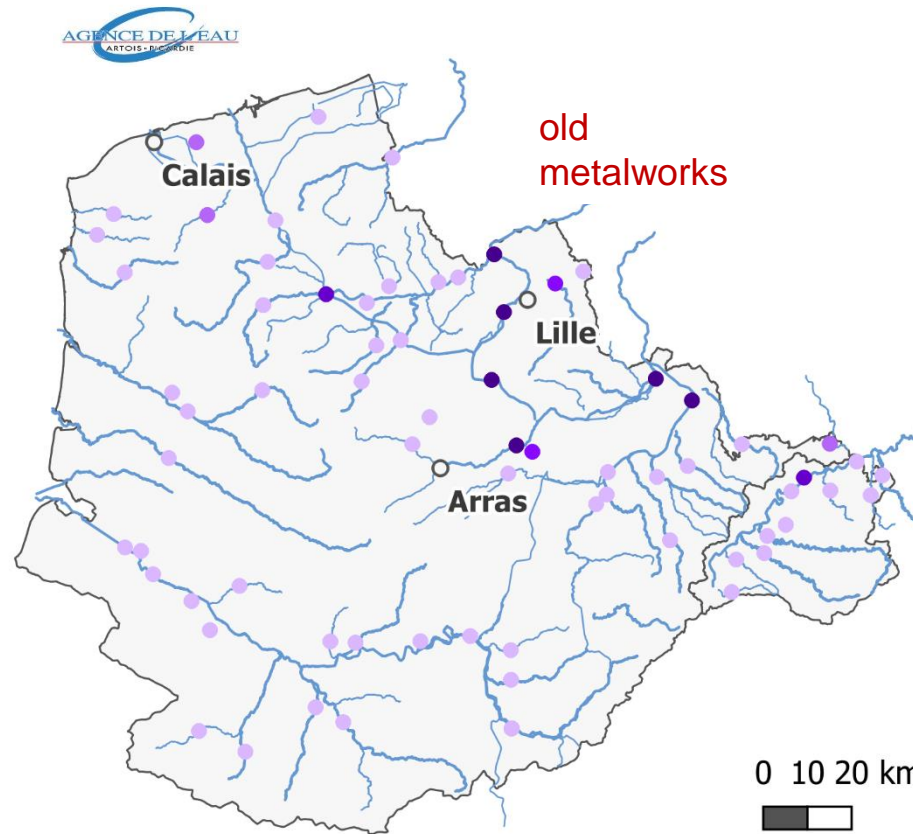
Assess the levels of bioavailable contamination in south of France



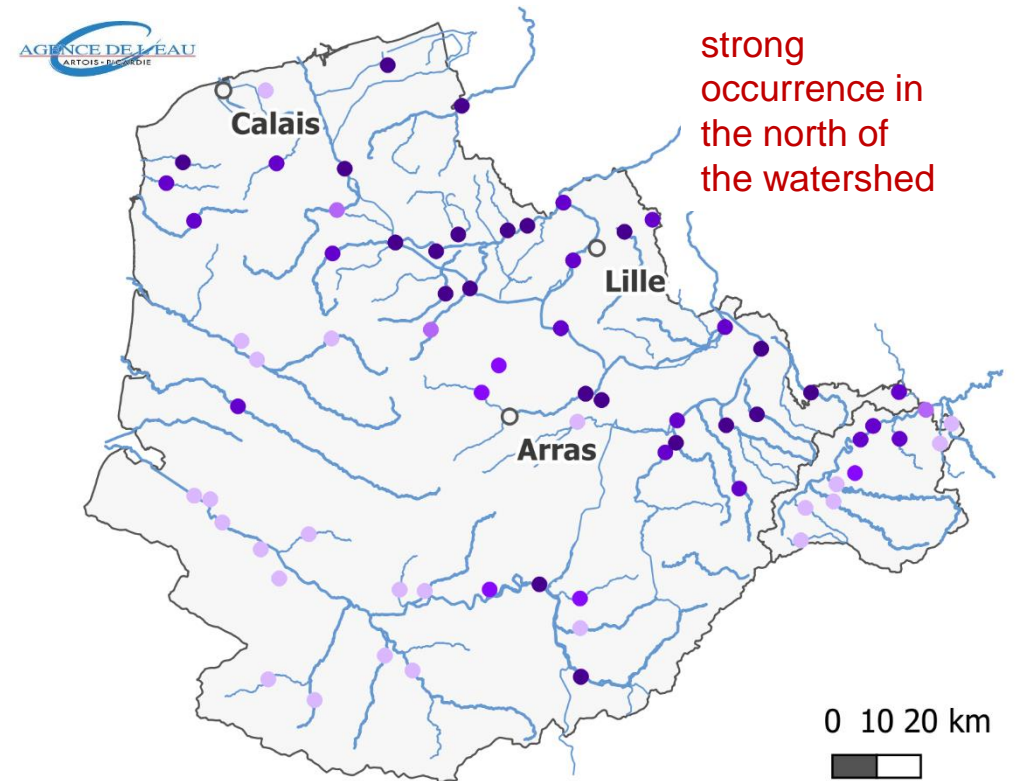
Applications with some examples

Assess the levels of bioavailable contamination in north of France

Contamination scale



Lead



Diflufenican (herbicide)

Applications with some examples

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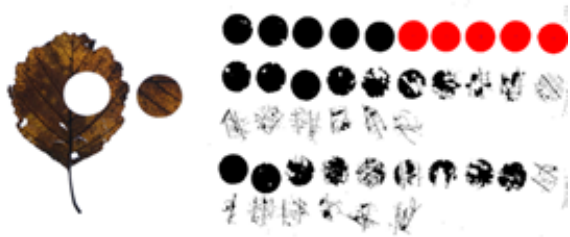
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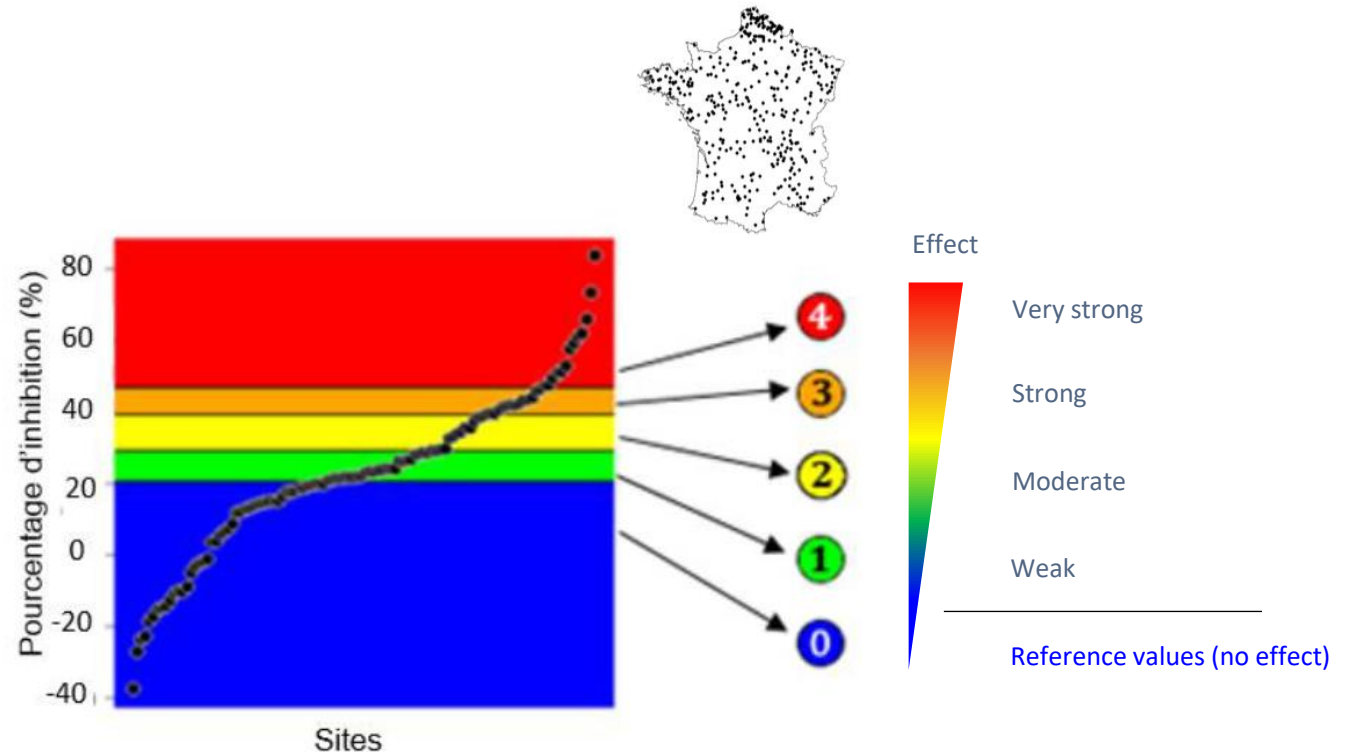
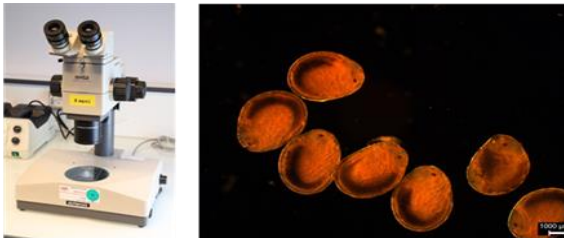
Applications with some examples

Assess the toxic impacts (cocktail effects) of micropollutants in aquatic environments

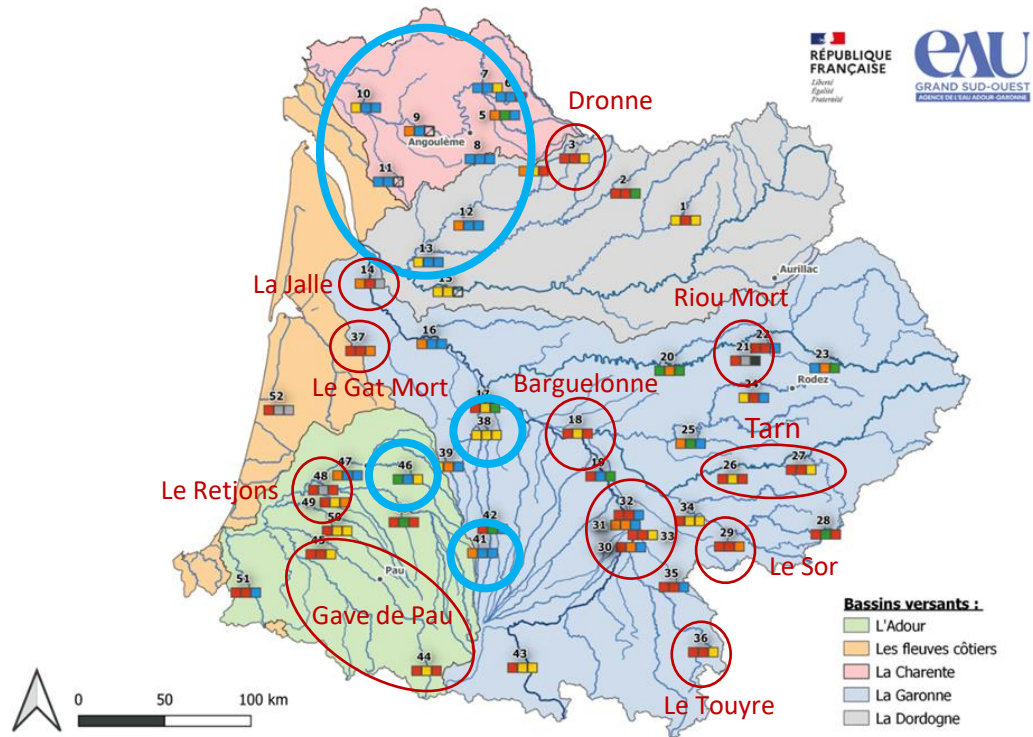
Feeding inhibition



Reprotoxicity



Applications with some examples



Reference stations

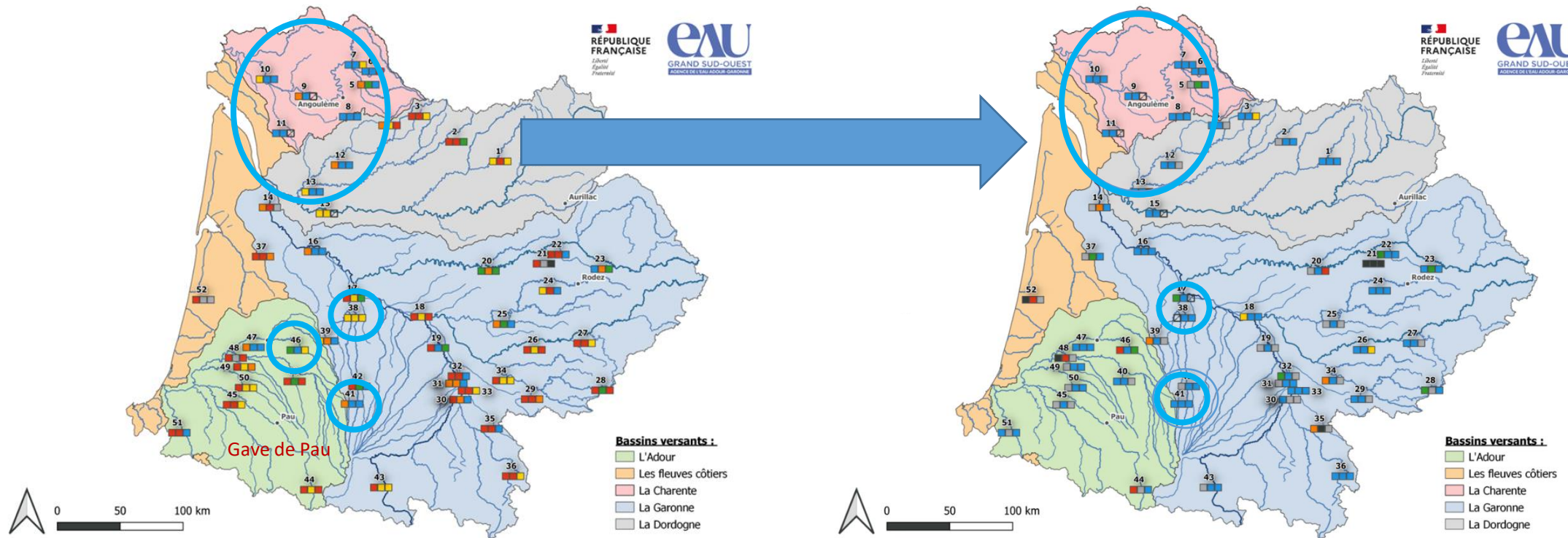
Ranking of stations

Hot spots

Feeding inhibition

Applications with some examples

Weight of evidence → Confirm the **reference stations**

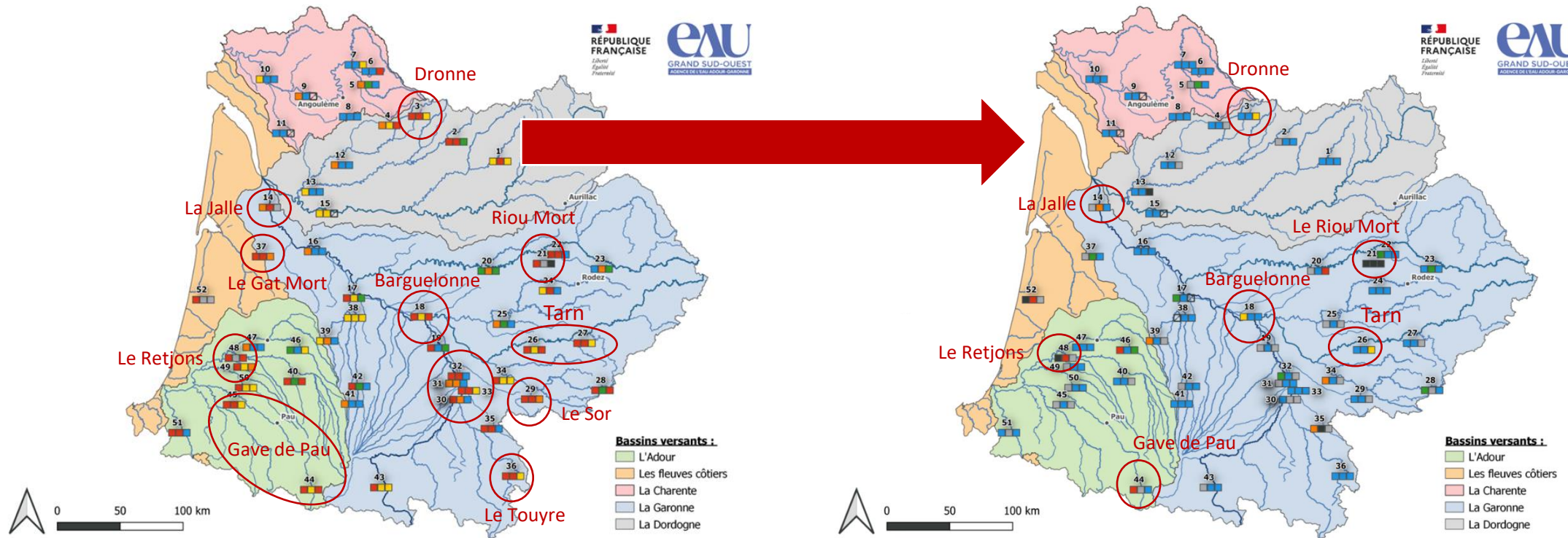


Feeding inhibition

Reprotoxicity

Applications with some examples

Weight of evidence → Identify the **main hot spots**



Feeding inhibition

Reprotoxicity

Conclusion

Gammarid caging = available, standardized and routinely deployable method

⇒ International standardization in progress



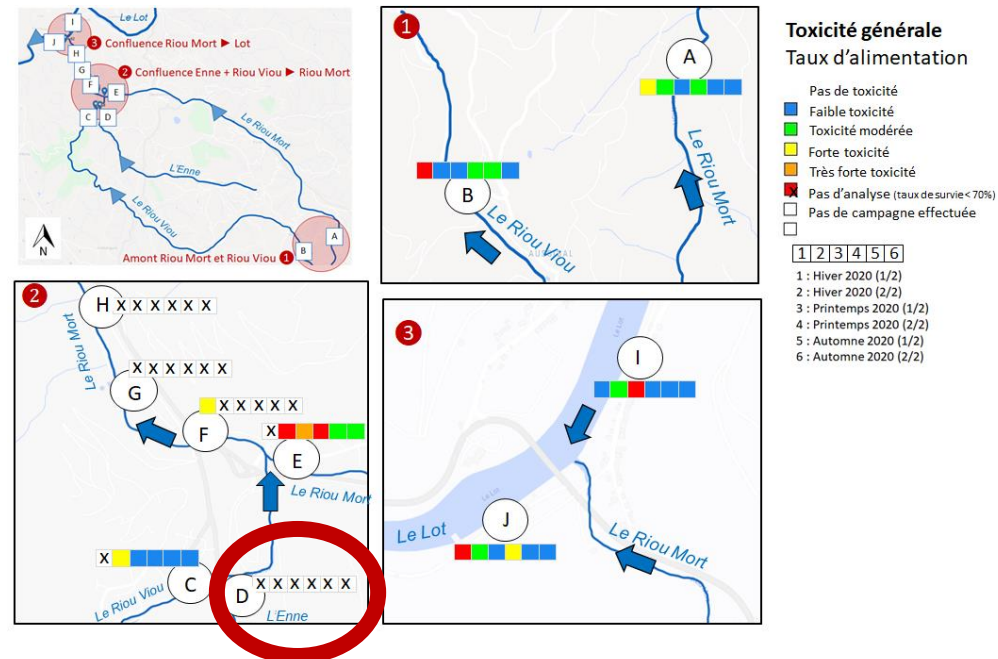
Applicable on a large scale **but also for more localized studies (impact studies)**

Industrial discharges

Urban waste

Wastewater treatment plant

Watershed survey





Aknowledgments



Thank you for your attention



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Filiale of *Groupe CARSO*
BU Water & Environment

