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Port sediment quality monitoring network (REPOM) and microplastics

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REPOM : MARINE ENVIRONMENT STRATEGY FRAMEWORK DIRECTIVE (MSFD) MONITORING NETWORK

REPOM is a national port sediment quality monitoring network.
This network is led by the Ministry of Ecological Transition and implemented by the services in charge of the littoral waters control.

Cerema assists the Ministry of Ecology as a technical expert and is in charge of data banking and processing.

- 1997 : creation of REPOM
- 2010 : WFD and Ospar Priority Substances Monitoring: pesticides, flame retardants, phthalates, perfluorinated...
- 2014 : integration into the MSFD surveillance network
- 2021 : monitoring of new substances: chlordecone, cybutrin, microplastics (MP).

Objectives:
- measure the evolution of the seaport sediments contamination
- acquire knowledge ti adapt regulations
- evaluate public environmental policies

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REPOM : MICROPLASTIC ANALYSIS TEST CAMPAIGNS

Context :

- ***The OSPAR convention*** is currently working on the development of a microplastics indicator in sediments. A protocol for sampling and analysis of microplastics in sediments will be recommended by this convention.

- ***The IMO, the London and Barcelona conventions,*** recommend characterizing the presence of macro-waste and microplastics in dredged sediments via the immersion protocol.

REPOM Test Campaigns :
- Monitoring of microplastics in port sediments was initiated in 2021 in the ports of Brest and Douarnenez.

- In 2022, 15 additional points have been sampled and analyzed.

- All the samples were analyzed by the same method by LABOCEA Laboratory.

- ***Among these 19 samples, 3 were analyzed using other methods, in order to compare them and identify the most suitable method(s) for monitoring port sediments.***

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PROJECT TEAM

- **Cerema : A reference public agency in France**
  - In support of public policies for land use planning, mobility, adaptation to climate change and transitions
  - Under the supervision of the Ministry of Ecological Transition
  - Over 2,500 agents across 26 sites in mainland and overseas France (West Indies and Indian Ocean)

→ REPOM coordination & Synthesis of results

- **Cedre : A non-for-profit organisation with a public service mission**
  - Missions for french authorities :
    - Assistance in case of accidental water pollutions
    - Support for the implementation of public policies relating to aquatic litter reduction (incl. MP)
  - 1 site un Brest, a team of 50 people

- **IFPEN : A public sector R&I body , a training center, and an industrial group**
  - An international scope in the fields of energy, transport and the environment
  - 1,635 people with 1,190 engineers and technicians dedicated to research
  - Over 50 job fields, from geologists to engine technicians

- **Labocea : A public laboratory**
  - Missions for Public service , local authorities, professionals and private individuals
  - An actor for the challenges of public health and economic development.

→ Analysis of MP with different methods & Adaptation of methods to port sediments

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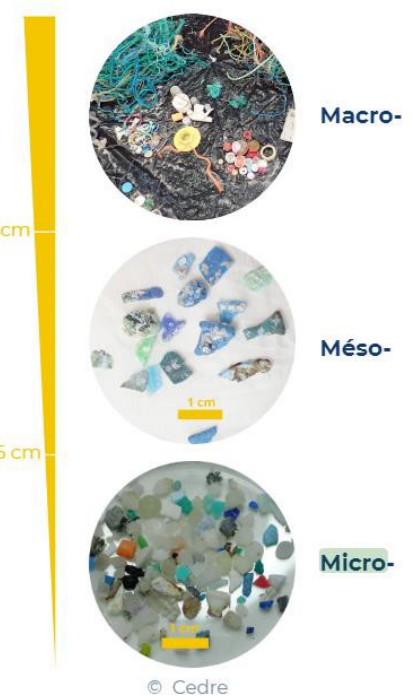
WHAT IS A MICROPLASTIC ?

A plastic particle less than 5 mm



Primary microplastics

Pellets-GPI

tires

Synthetic fibers

Road paint, antifouling

Secondary microplastics

waste, packaging, bottles..

cigarette butts

fishing nets

Different methods to analyse them in sediments were tested and compared :

- Fourier Transform Infra Red (µFTIR)
- Pyrolysis GCMS (Pyr-GCMS)
- Rock-Eval @ (Pyrolysis / IFPEN)

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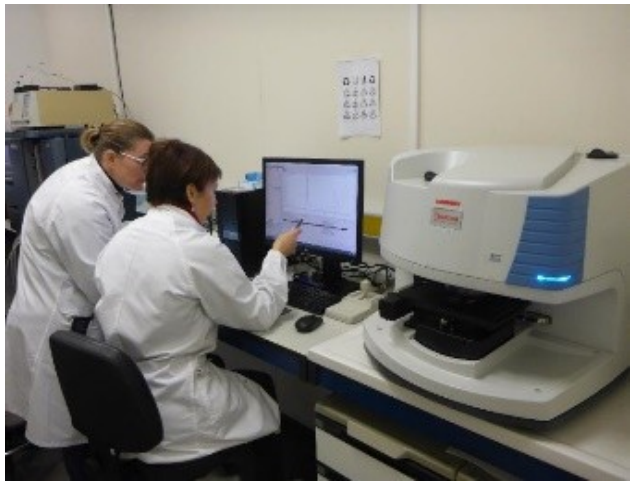
ANALYSIS EQUIPMENT : FOURIER TRANSFORM INFRA RED (FTIR)



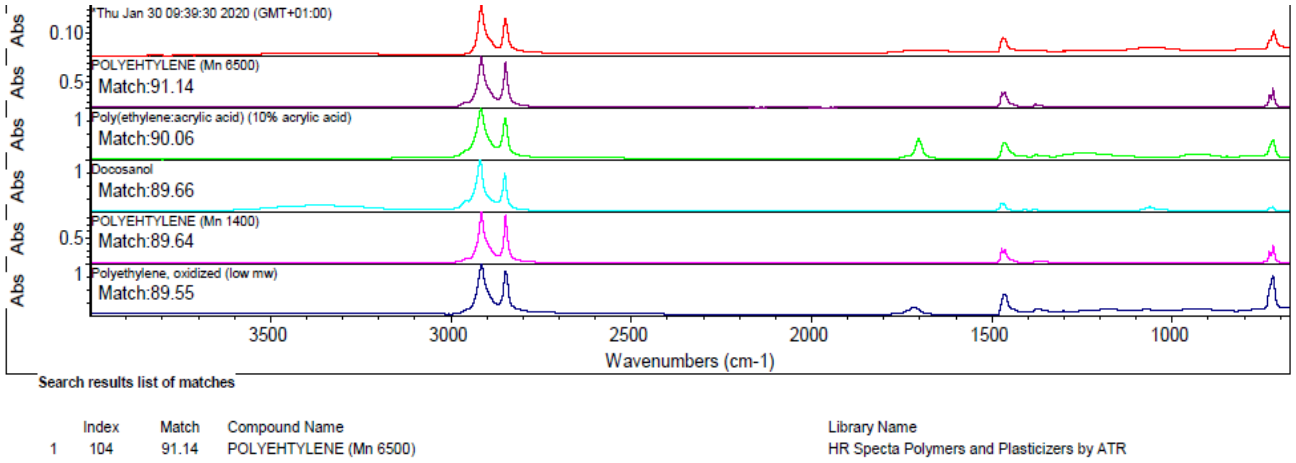
Sample preparation

- **Density separation:** with dense solution of **tungstate**, NaI or **ZnCl2**
- **Organic digestion:** to eliminate organic matter (necessary fort port sediments)
- **filtration**: sample filtered in an adequate filter for FTIR analysis

Microplastic identification

- **Microspectroscopy FTIR :** infrared source
- **Spectrum bibliotheque**: database of spectrum to identify polymers
- **Results:** polymer type (PE, PP, PS…), dimension, number of particles > 80µm

This method was used to analyze all of the samples (19) in 2021 and 2022.



Search results list of matches

	Index	Match	Compound Name	Library Name
1	104	91.14	POLYEHTYLENE (Mn 6500)	HR Specta Polymers and Plasticizers by ATR

ANALYSIS EQUIPMENT : PYROLYSIS – GCMS
(GAS CHROMATOGRAPHY AND MASS SPECTROMETRY)

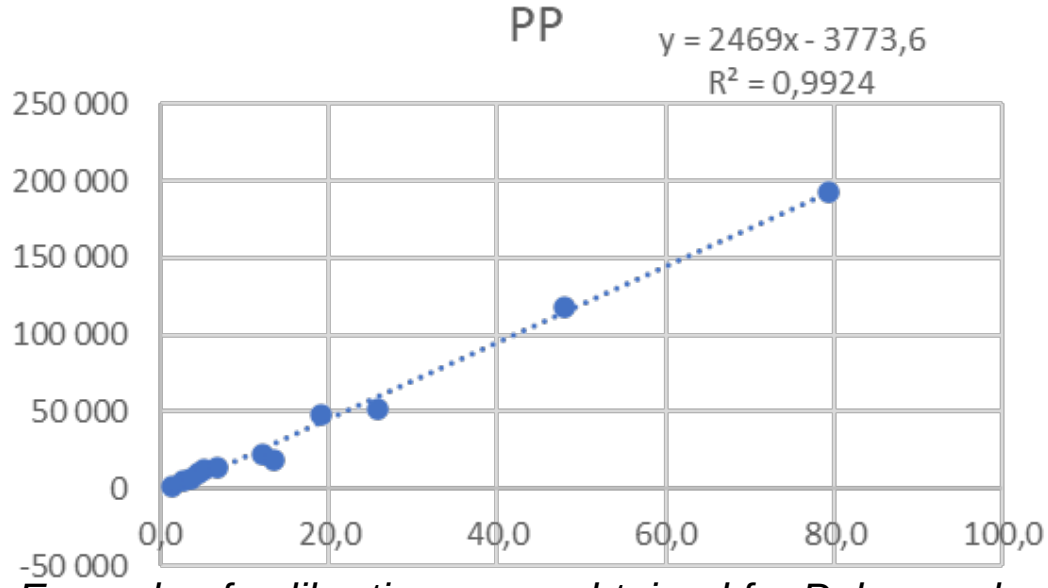
Sample preparation

- **Density separation** with calcium chloride (d=1,4)
- **Digestion of organic matter** with H2O2
- **Supernatant filtration** to recover plastic particles
- **Filter grinding**

Microplastic identification

- **Analysis by Pyr-GCMS**
- **Quantification of 12 polymers** using a calibration solution
- **Results:** polymers type (PE, PP, PS…), mass of particles > 100µm

This method was used to analyze 3 of the samples taken in 2022.



Example of calibration curve obtained for Polypropylene

This method was used to analyze 3 of the samples taken in 2022.

ANALYSIS EQUIPMENT : ROCK-EVAL®

Sample Preparation (1)

1 Raw sample (untreated) → Drying @ 40°C → Griding for homogenization → Dried & crushed sample

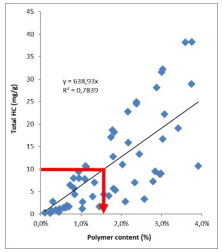
Microplastic Identification (2 & 3)

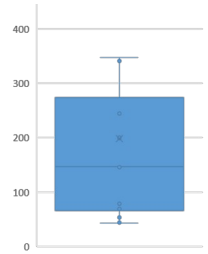
Dried & crushed sample → 3 Treatment 48h, H_2O_2 → Filtration @ 70 µm → Drying @ 50°C

2 → Rock-Eval® duplicate analysis (60mg) = « Bulk »

Study of results

Microplastic Quantification (4)





mass of MP particles > 70µm

4 → Rock-Eval® duplicate analysis (60mg) = « Treated »

Study of results

RESULTS OF REPOM 2021 AND 2022 (FTIR)

Sampling

- 19 points in 14 harbour

Results

- **Highly variable :** between **468** (Port en Bessin) and **34 637 MP/kg** (Arcachon Marina)
- **Very high values compared to those found in the literature :**

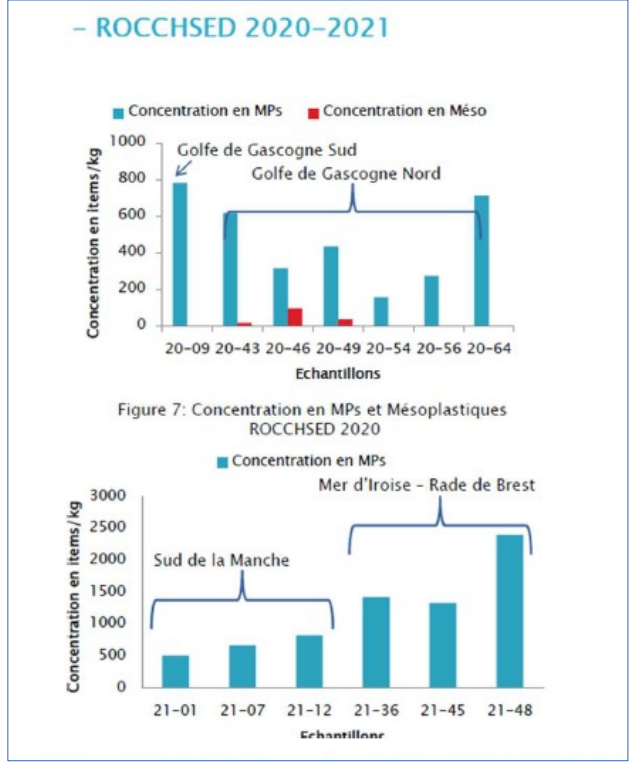
	beaches	Shallow coastal environments	Estuarine environments	Continental shelf environments	Deep sea environments	REPOM 2021-2022
mean MP/kg	1 328	2 809	2 411	1 509	2 352	8 998

From Peter T. Harris, 2020: The fate of microplastic in marine sedimentary environments: A review and synthesis

- ***or measured by other monitoring networks :***

MP/kg	Channel / North Sea 2021	REPOM 2021 (Brest / DZ)
Mean	1 198	2 064

Ifremer ROCCHSED results (quantification limit 300µm)



RESULTS OF REPOM 2021 AND 2022 (FTIR)

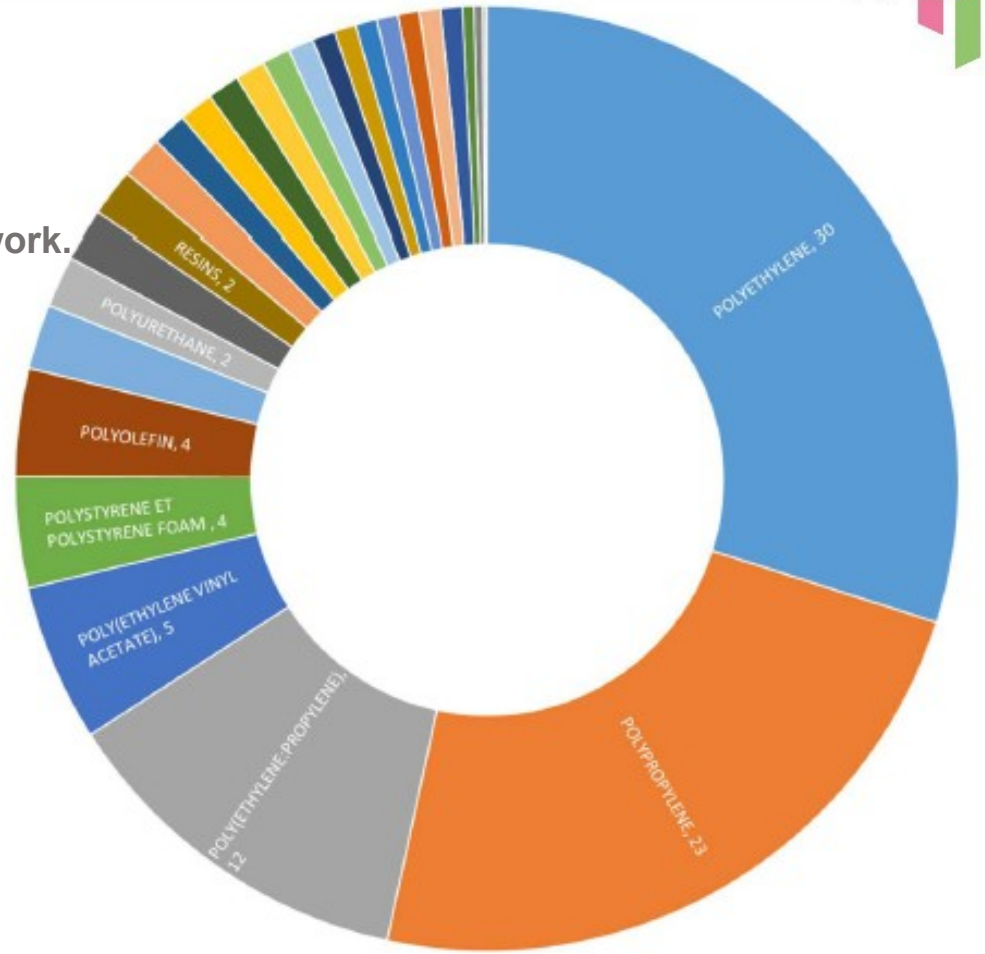
Particle size

- Majority of MP (66%) is in the 80 - 300 µm class.
  This partly explains the superior results to those of the Rocchsed network.

- There are very few MP over 1mm (5-7%)

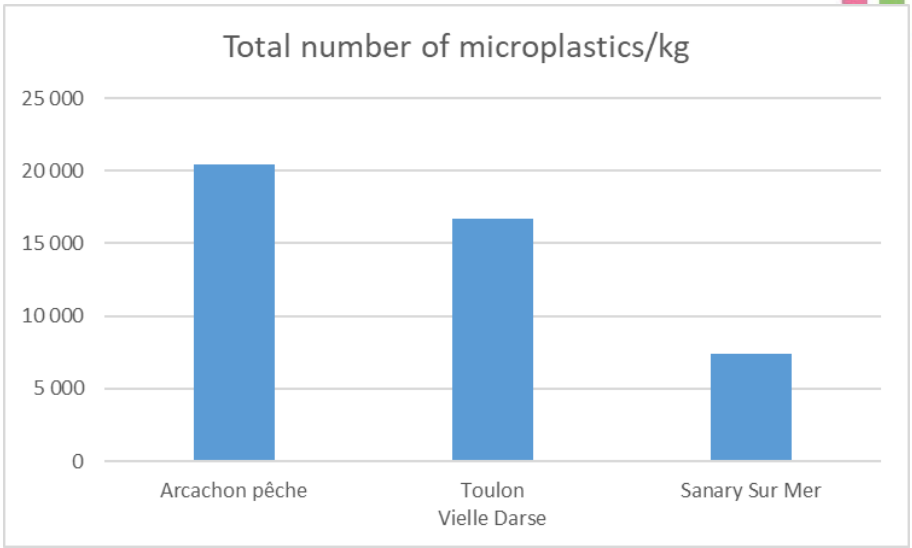
Polymer type

- The main polymers encountered in the port's sediments are Polyethylen (30%), Polypropylen (23%), and Polyethylen:propylen (12%)



RESULTS OF REPOM 2022 – 3 PORTS (FTIR)

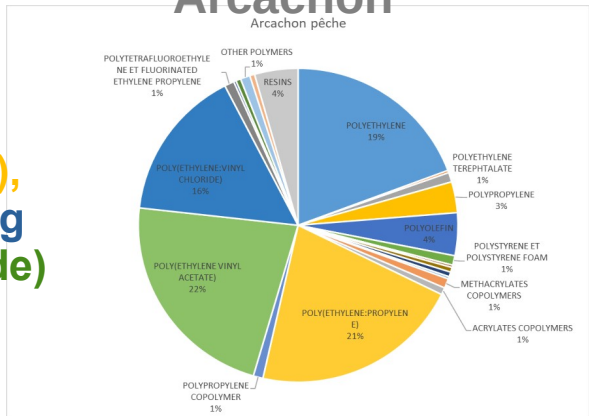
	Arcachon pêche	Toulon Vielle Darse	Sanary Sur Mer
main polymers	PE/PP, EVA, PE	PP, PE, PA	PP, PE/PP, PE
Total number of microplastics/kg	**20 403**	**16 717**	**7 436**



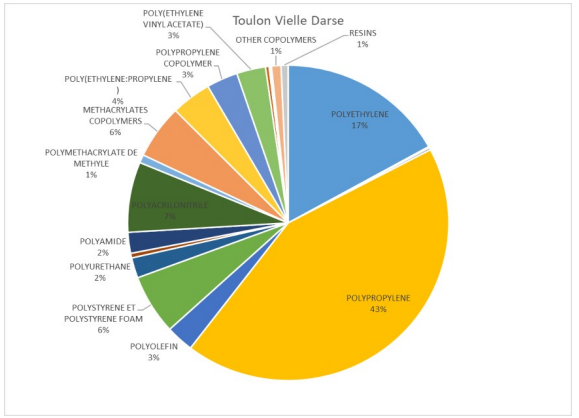
Polymer composition :
Majority of :

- **PP (Polypropylene),**
- **PE (Polyethylene),**
- **PE/PP (Poly (ethylene:propylene),**
- **and PVC derivatives in the fishing port of Arcachon (Polyvinylchloride)**

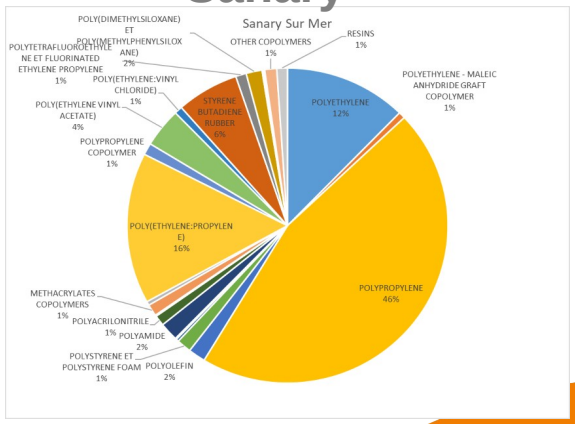
Arcachon



Toulon



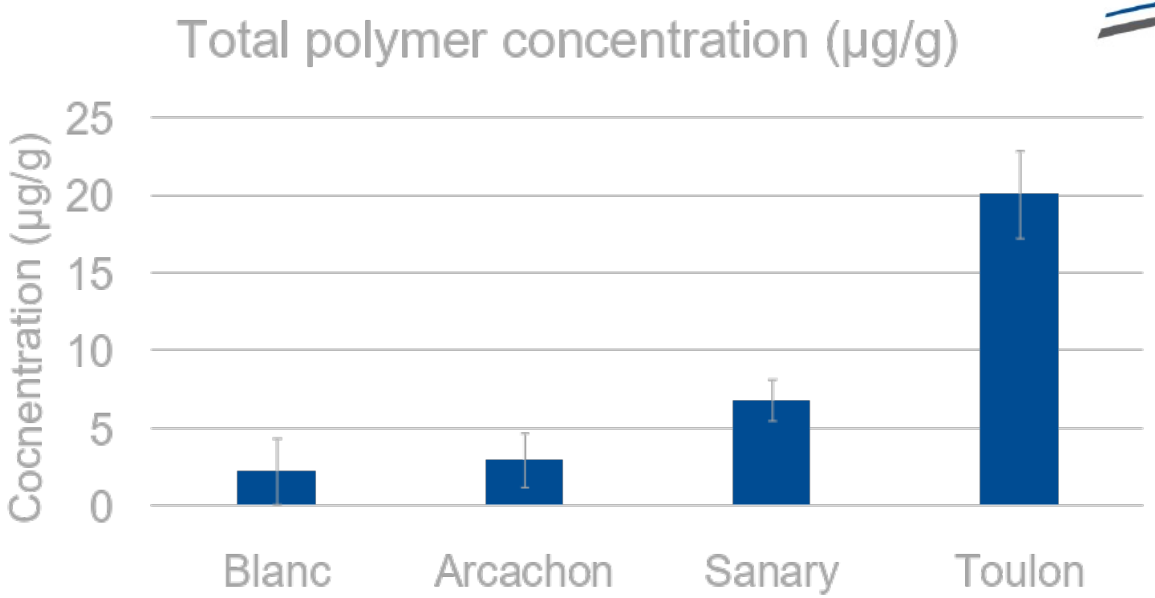
Sanary



RESULTS OF REPOM 2022 – 3 PORTS (PYR-GCMS)

Particle mass

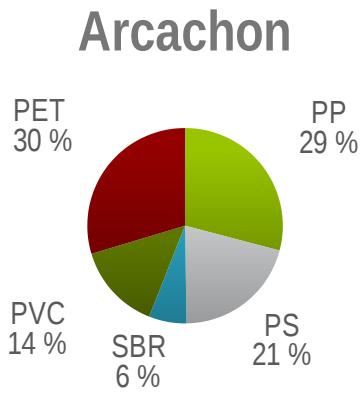
From 2,5 to 20 mg/kg

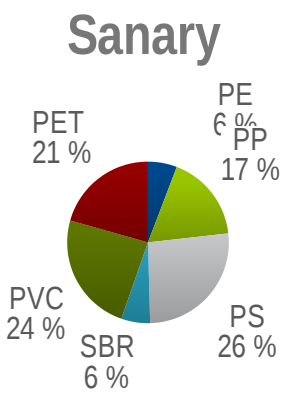


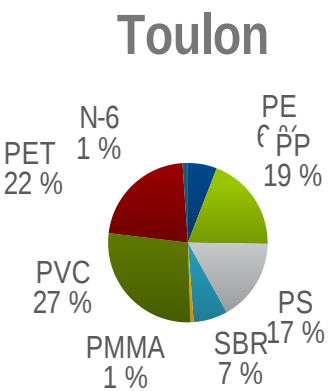
Polymer composition

Majority of :

- **PET (Polyethylene terephthalate),**
- **PP (Polypropylene),**
- **PS (Polystyrene),**
- **and PVC (Polyvinylchloride).**

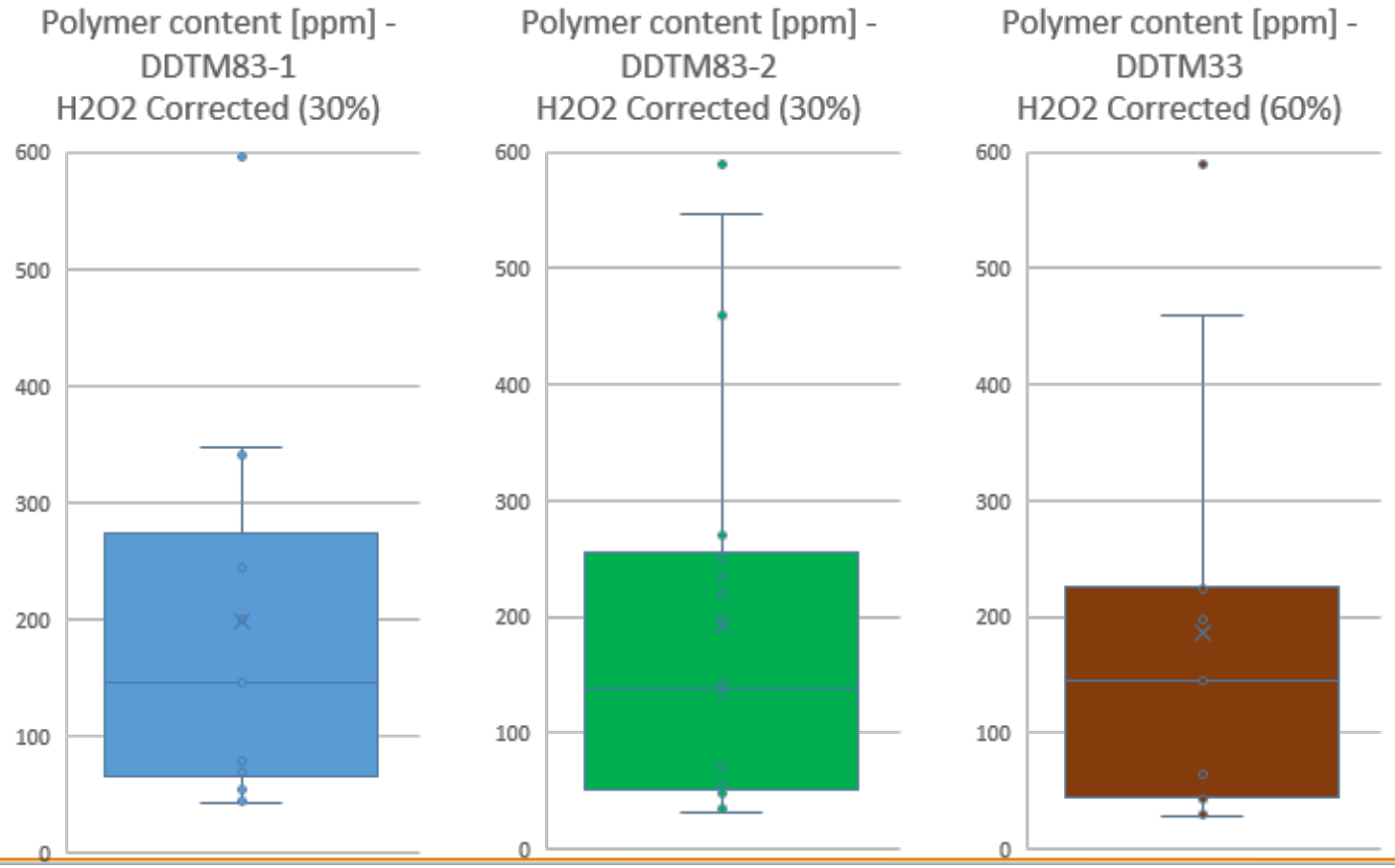






RESULTS OF REPOM 2022 (ROCK EVAL @)

Particle mass (ppm or mg/kg)



Toulon Port (83), « Vieille darse »
Average concentration :198ppm (median : 146ppm)

Sanary Port (83)
Average concentration : 192ppm (median : 139ppm)

Arcachon (33), Fisching Port
Average concentration : 186ppm (median : 145ppm)

COMPARISON OF RESULTS

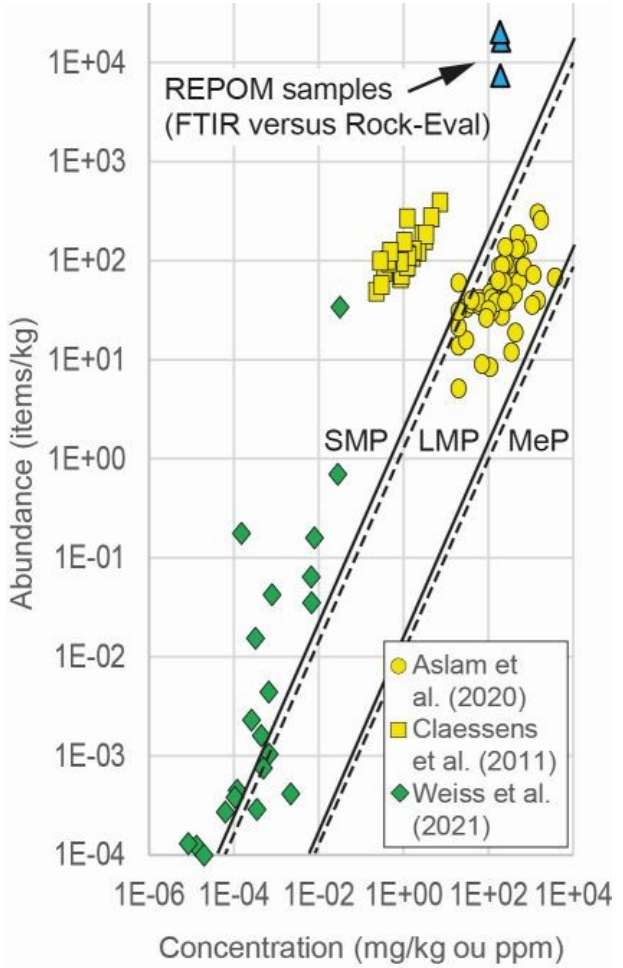
Mass of particles : The masses obtained by Pyrolysis GCMS and by Rock Eval are comparable.

Number versus Mass of particles : The masses obtained by the Rock Eval were compared to the abundances measured by FTIR and appear consistent with the correspondences noted in the literature for small MPs.

Types of polymers : Differences are observed between FTIR and Pyrolysis GCMS.

Parameters that may explain the differences in results :

- Sample preparation method (filter mesh...)
- Sample homogeneity
- Quantities analyzed…



Modified from Rohais et al. (under review)

CONCLUSIONS AND TAKE-HOME MESSAGES

Shortcomings

- **Continuation of tests and comparisons of methods for quantifying microplastics to identify the most suitable method(s) for monitoring port sediments.**

- **Need for Standards for :**
  - Sampling
  - microplastic preparation (digestion/density separation)
  - analysis

- **Integrate microplastics monitoring into the REPOM**

- **Acquire data to implement regulation**

Ubiquitous presence of microplastics in sediment and significant contamination of ports.

- What about the impacts of dredging and dumping operations ?

- What about the pollutants adsorbed to microplastics?

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Thanks for your attention

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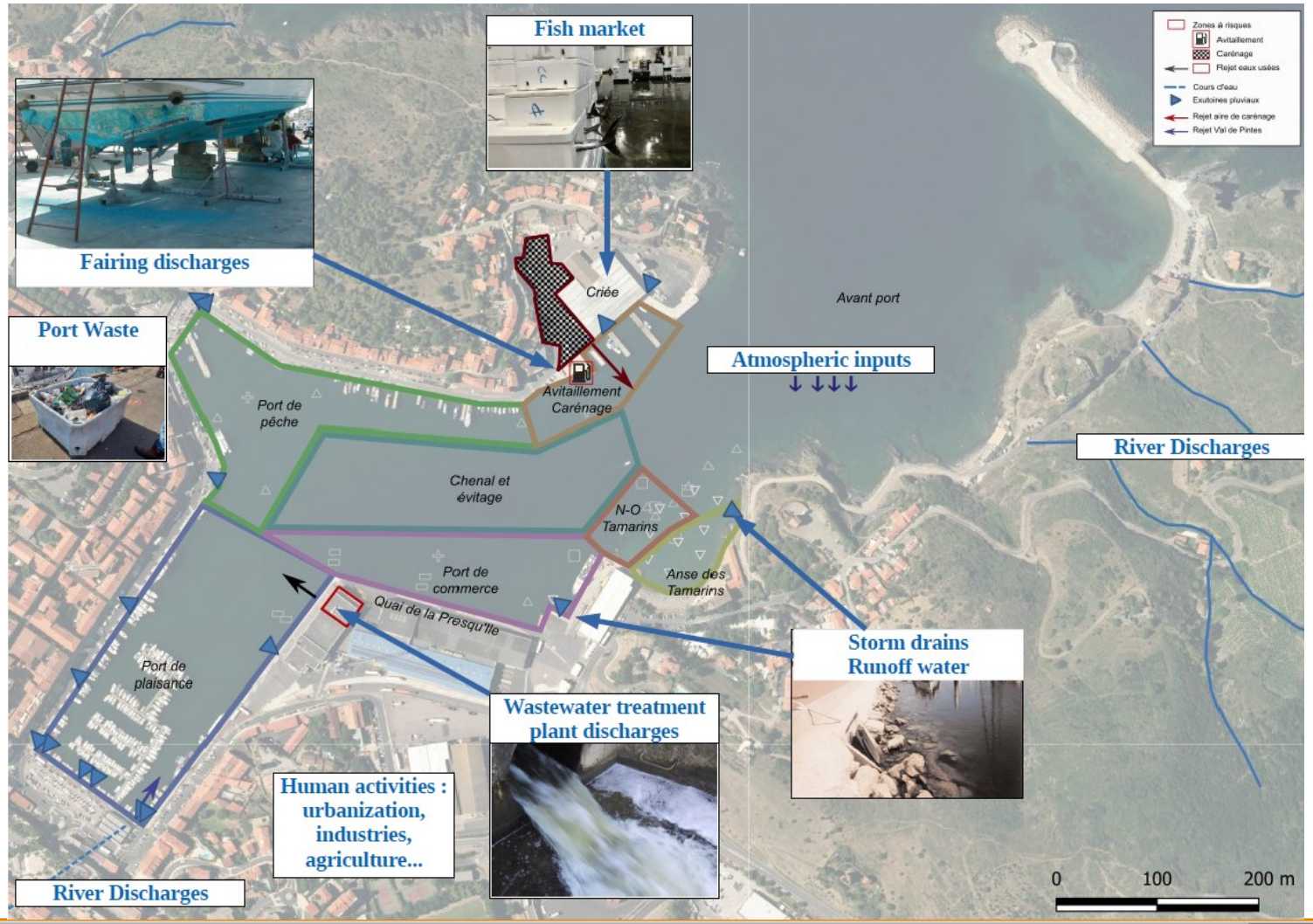
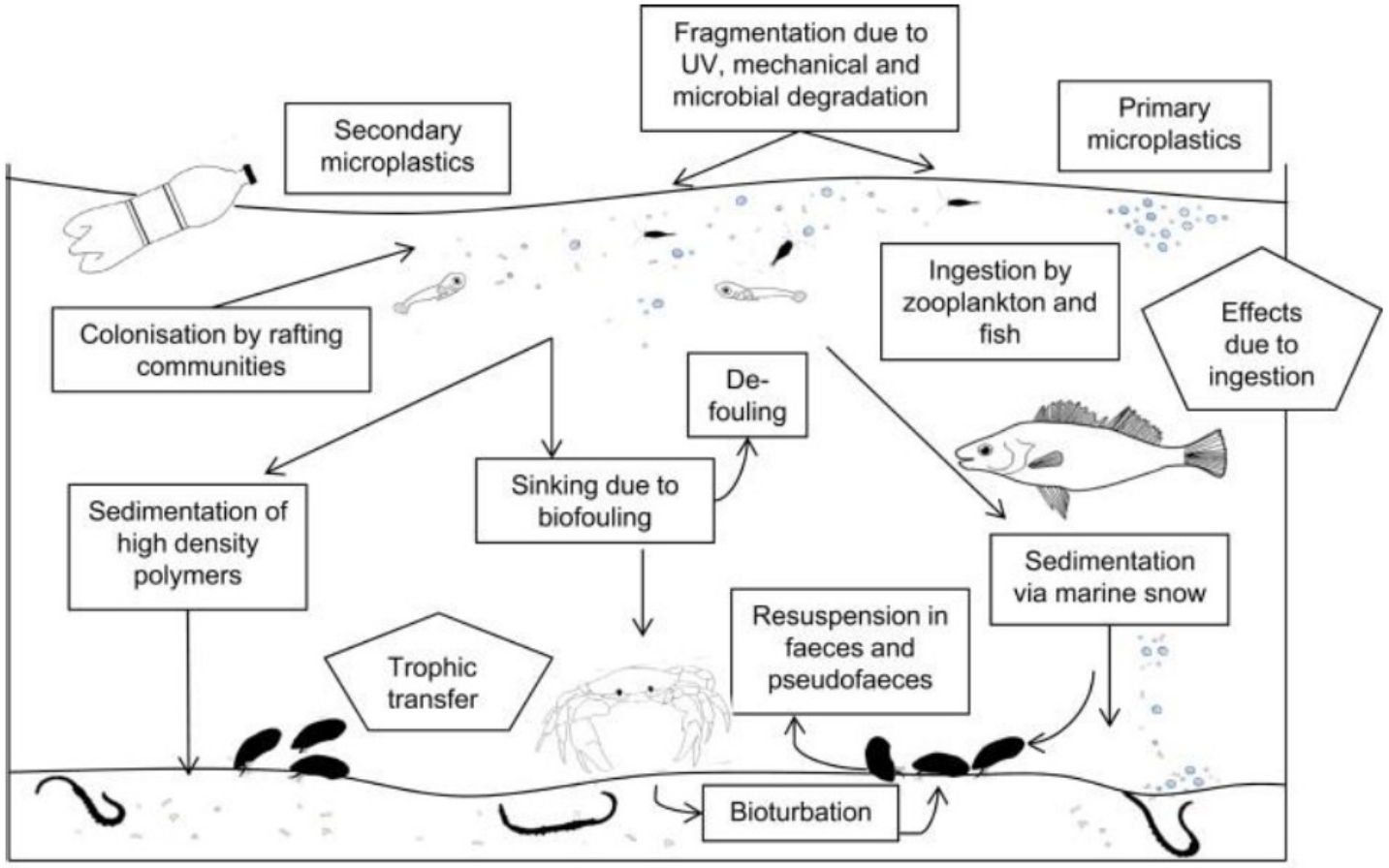
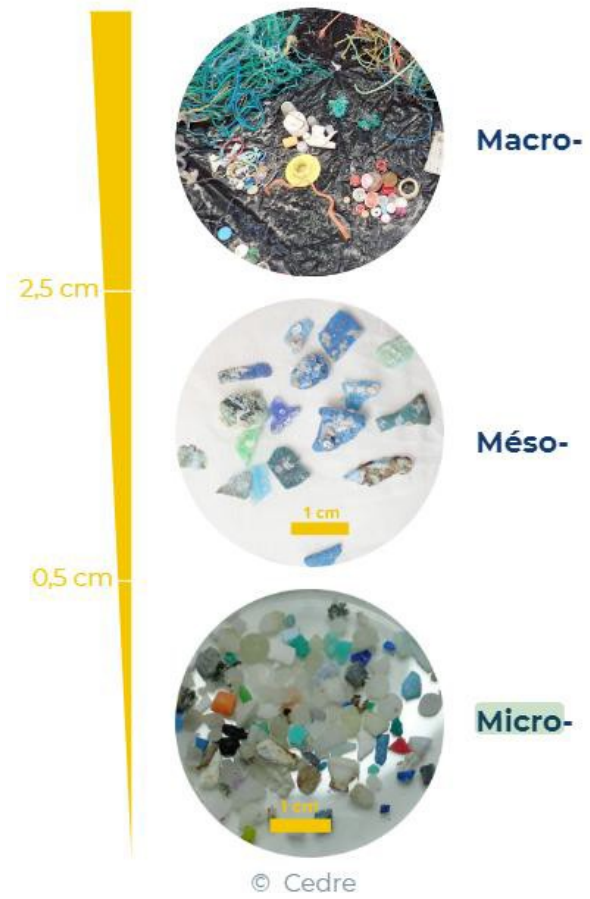
SOURCES OF MICROPLASTICS IN THE PORT ENVIRONMENT



DISPERSION OF MICROPLASTICS IN THE ENVIRONMENT



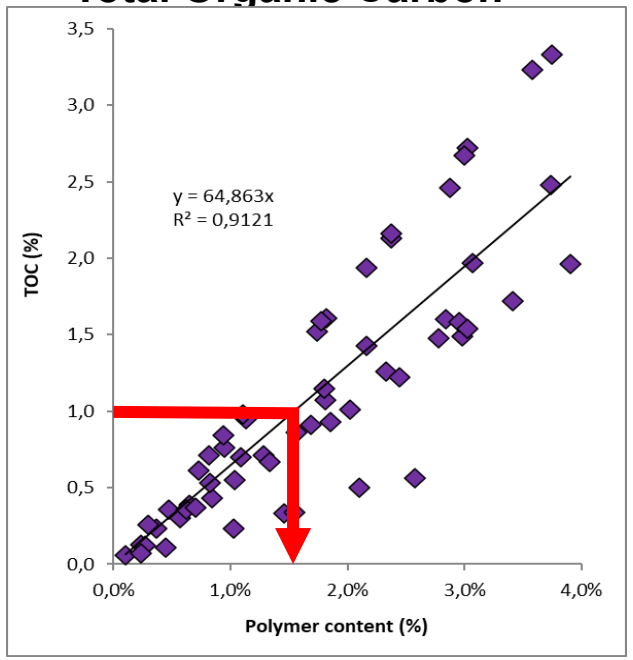
Wright and al., 2013



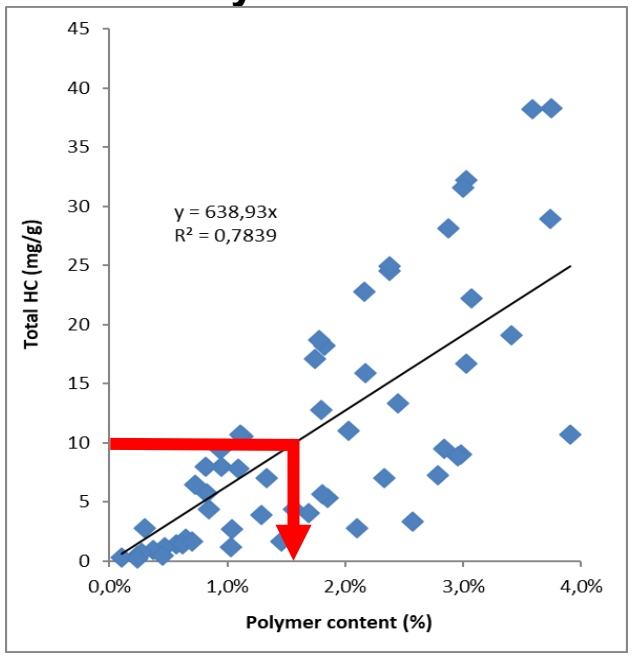
ANALYSIS EQUIPMENT : ROCK EVAL

Study of results : Database of available polymers @ IFPEN

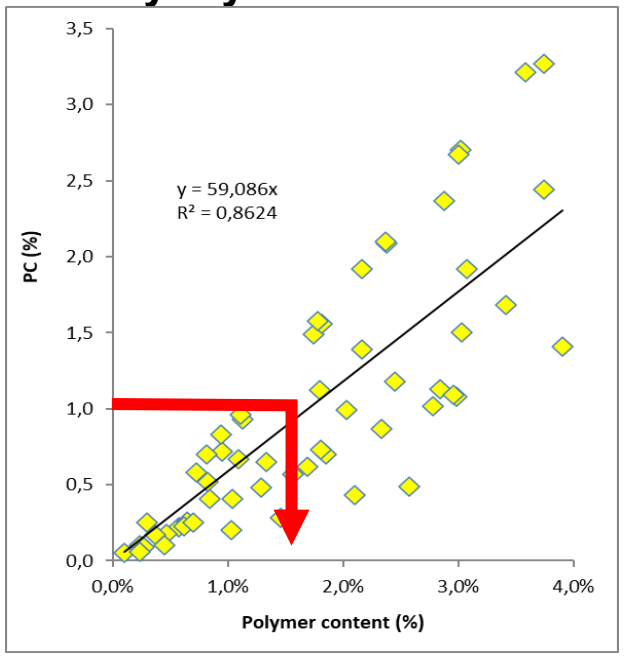
Total Organic Carbon



Total hydrocarbons



Pyrolysable Carbon



1 hypothesis = all residual carbon in the processed sample is polymer/plastic

(Pfeiffer & Fischer 2020, Correc. Fac 25-35%, Prata et al. 2019, Correc. Fac 30-40%)

~~1 analysis = 3 parameters x 3 regressions (max, average, min) = 9 estimates of % mass~~

SAMPLING MATERIAL

Sampling

- **Sieve Grab:** same method than chemicals sampling (surface sample 5 cm ?)
- **Sampling blank:** to determine an eventual atmosphere or any other pollution
- **Sampling collection**: put marine sediment in a glass bottle (weather 450°C)
- **Laboratory:** send at positive cold