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The ports of the Gulf of Aigues-Mortes from Palavas to Port Camargue: Status of water quality and impact of dredging activities

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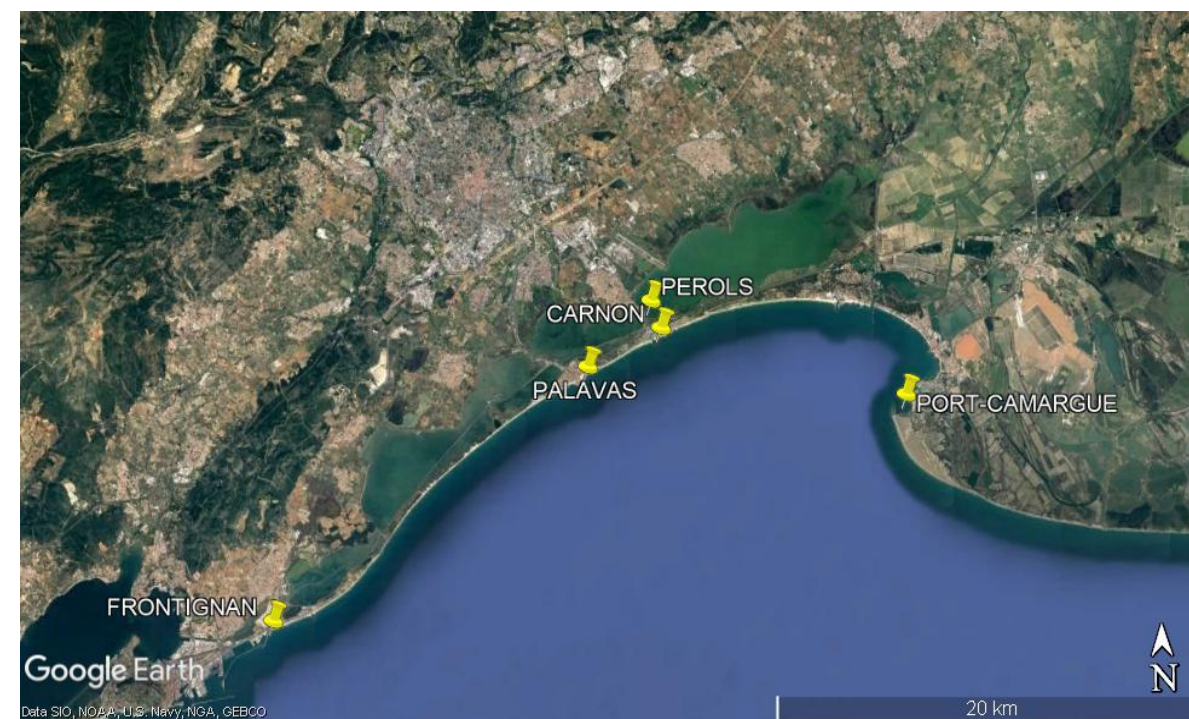
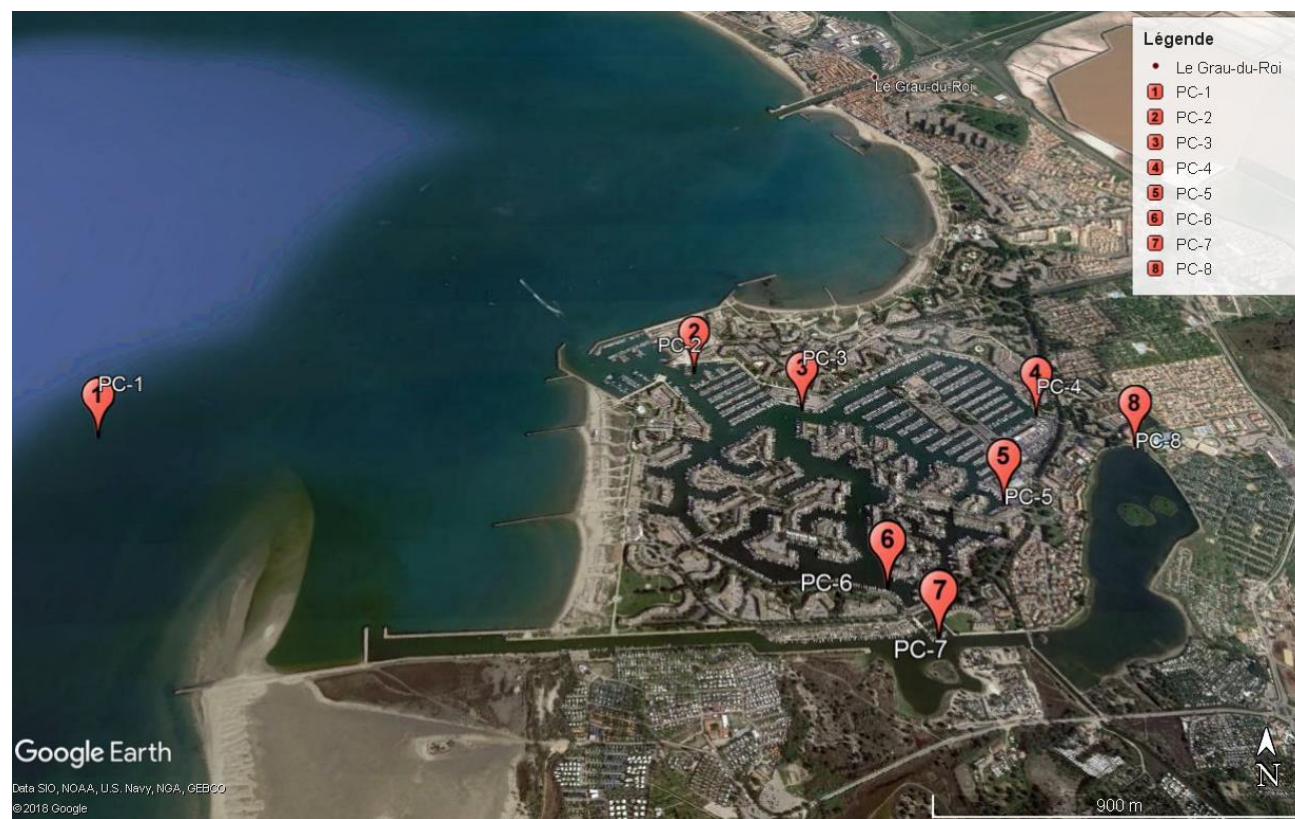
CONTEXT : The Mediterranean coastal zone represents an important socio-economic and ecological space undergoing strong pressures. The ports represent both areas of heavy pollution related to the density of activity but also areas of refuge for many biological species.

Study sites of the OHM Littoral Méditerranéen: **port areas of the Gulf of Aigues Mortes:** marina and fishing ports with the supports of the captaincies. The monitoring of the chemical and microbiological quality of the port waters before, during and after the dredging operations allowed us to determine the state of the water quality of the four ports and the impact of these operations on the resuspension of contaminants and the possible disturbances induced.

2018-23: State of water quality =83 sampling campaigns

Sources and transfer of contaminants in a port ecosystem: the case of the marina of **Port-Camargue (PC)**

Determination of the origin of the contamination of the waters of **PC:** help for the management of the contamination



2019-2023 : State of water quality and impact of dredging activities

4 Ports : **Palavas (PA)-Carnon (C)-Pérols (P)-Port Camargue (PC)**
Monitoring before, during and after dredging operations



Monthly database for Port Camargue since March 2018 & monitoring during dredging operations

Physicochemical parameters

- pH
- Temperature
- Dissolved O2
- Salinity
- Turbidity

Turbidity probe by nephelometry, (Infra optical technology) (Ijusus®)

Portable multiparameter HACH® (Hq40d)
Probes LDO101, pH301 & CDC40101

Inorganic compounds

- Trace metals
- Rare earths

Q-ICP-MS, ICAP-TQ, Thermo Scientific

GC-Q-ICP-MS, ICAP Q, Thermo Scientific

GC-ICP-MS (Focus GC Thermo Fisher Scientific-ICP-MS X Series II-Thermo Fisher Scientific®)

Organic compounds

- Compounds used in antifouling paints =organotin
- TBT

GC-Q-ICP-MS, ICAP Q, Thermo Scientific

Microbiological parameters

- Fecal Contamination
- Indicator Bacteria
- FCIB
- Thermo-tolerant coliforms including Escherichia coli
- Intestinal Enterococci

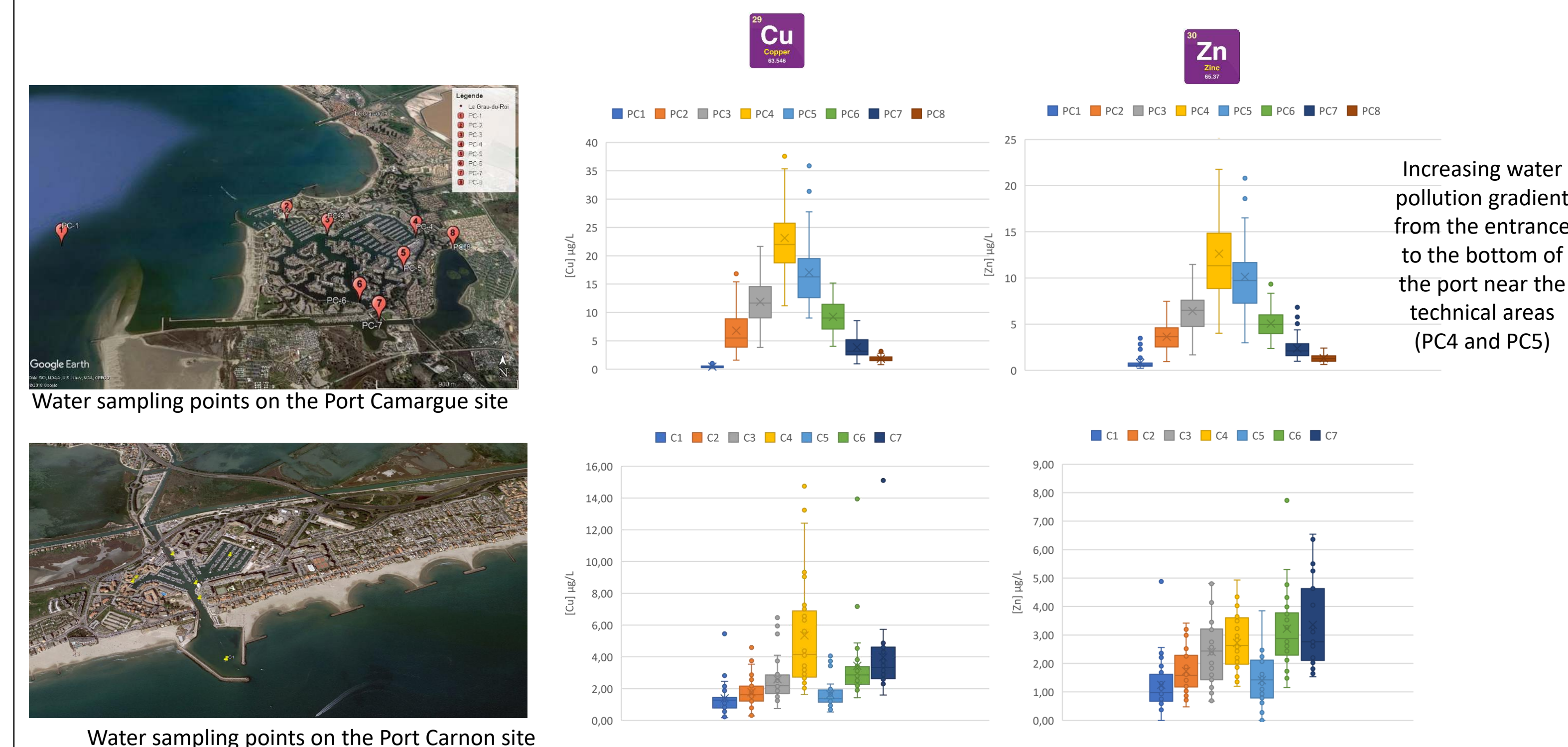
Origin of fecal microbial contamination (gene quantification)

HUMAN DOG
HORSE BIRD

| PORTS | Geographical contexts | Capacités | Volumes dredged | Sedimentary facies | Levels GEODE [1] | Dates |
|---------------|--|-----------------------------|-----------------------|---|------------------|-----------------------|
| PÉROLS | <ul style="list-style-type: none"> bordered by 2 ponds: Pérols to the west and Or to the east - Natura 2000 sites) including a main pond and a canal | 130 boat places ≤ 7 m | 2500 m ³ | 70 % limons | <N1 | nov-dec 2020 |
| PORT CAMARGUE | <ul style="list-style-type: none"> Europe's leading yachting harbour, bordering the Petite Camargue Natura 2000 site | 5000 boat places ≤50 m | 5 000 m ³ | sand | <N1 | jan-feb 2021 |
| PALAVAS | <ul style="list-style-type: none"> located at the mouth of the River Lez subject to 2 phenomena: inflow from the River Lez + silting up of the entrance channel coastal sediment transit | 1100 boat places ≤ 20 m | 5 000 m ³ | sand | <N1 | april 2021 |
| CARNON [2] | <ul style="list-style-type: none"> Natural channel between a pond (Or) and the sea, zone NATURA 2000 sedimentary input: silt from ponds + sand from the sea | 850 boat places ≤ 16 metres | 20 000 m ³ | 15000 m ³ silt 5000 m ³ sand | >N1 <N2 | oct 2022- feb 2023 |

PRINCIPAL RESULTS: WATER QUALITY

[Cu] > Environmental Quality Standard EQS (Water Directive Framework) for all harbour waters



- [Cu] > Environmental Quality Standard EQS (Water Directive Framework) for all harbour waters
- [TBT] > EQS especially in the waters of the Technical Areas of the port
- FCIB : Harbour waters of good quality in general, BUT significant contamination at times mostly from animal's origin / Significant positive correlation of concentrations with rainfall (soil leaching) - Water quality often insufficient compared to that of bathing waters
- Necessity to control the discharge of rainwater into the harbour

PRINCIPAL RESULTS: DREDGING OPERATIONS

Two scenarios were observed, depending on the compounds and ports studied: **Resuspension or re-adsorption** of As, Cu, Zn and TBT from the beginning of the dredging operations varies according to the ports considered

- ⇒ PEROLS : Arsenic released into the water column, Cu initially present and/or released from the sediment is sorbed onto the fine particles that are put back into suspension. After dredging, the copper concentrations measured in the water column are lower than the concentrations taken as a reference.
- ⇒ PORT CAMARGUE: significant increase of As, Cu, Zn and Ni water concentrations.
- ⇒ PALAVAS : clear resuspension of arsenic observed from the start of dredging operations. Unlike arsenic, which is released into the water column, Cu and Zn initially present and/or released from the sediments are sorbed onto the fine particles that are resuspended.
- ⇒ CARNON : Cu and Zn concentrations are highly variable from one campaign to the next, both before and during the dredging operation. The port's activities and the meteorology are certainly responsible for the sharp increases at the end of spring and during the summer of 2022. Peaks in contamination were also observed during the dredging operation.

CONCLUSION & PERSPECTIVES

The monitoring of all chemical and microbiological contamination of port waters provides information on the spatial and temporal evolution of water contamination.

The results provide a better understanding of the very different situations in these 4 ports, both in normal conditions and during dredging operations. These data will be a valuable aid for the managers of these ports.

BIBLIOGRAPHY

[1] Arrêté du 30 juin 2020 modifiant l'arrêté du 9 août 2006 relatif aux niveaux à prendre en compte lors d'une analyse de rejets dans les eaux de surface ou de sédiments marins, estuariens ou extraits de cours d'eau ou canaux relevant respectivement des rubriques 2.2.3.0, 3.2.1.0 et 4.1.3.0 de la nomenclature annexée à l'article R. 214-1 du code de l'environnement
NOR : TREL2011758A -JORF n°0162 du 2 juillet 2020

[2] C. Chouba, S. Delpoux, L. Causse, M. Marie, R. Freyrier, et al.. Status of water quality and impact of dredging activities in four ports of the gulf of Aigues Mortes (France). 9th International Symposium "Monitoring of Mediterranean coastal areas: problems and measurement techniques", Institute of BioEconomy (IBE) of the National Council Research (CNR); Italian Society of Silviculture and Forest Ecology (SISEF), Jun 2022, LIVORNO, Italy. pp.416-425, (10.36253/979-12-215-0030-1.37). (hal-04039957)

