Modernity and the Environment: pollution case histories in lagoons and coastal areas.

Luca Giorgio Bellucci and Silvia Giuliani

Rabat, 23 April 2019

National Research Council of Italy
Institute of Marine Sciences
Via Gobetti 101, 40129 Bologna, Italy.

Accreting aquatic sediments can be extremely important in that they behave as natural archives through the retention of significant information about environmental conditions at the time of particle deposition and strata formation.

Coupling of scientific evidence from sediment cores with historical information represents an effective way to reconstruct and evaluate anthropogenic impacts and changes in transitional and marine-coastal environments.

Sampling sites and techniques should be carefully chosen to avoid that expensive, high-quality analyses are preceded by inaccurate sample collection and preparation.

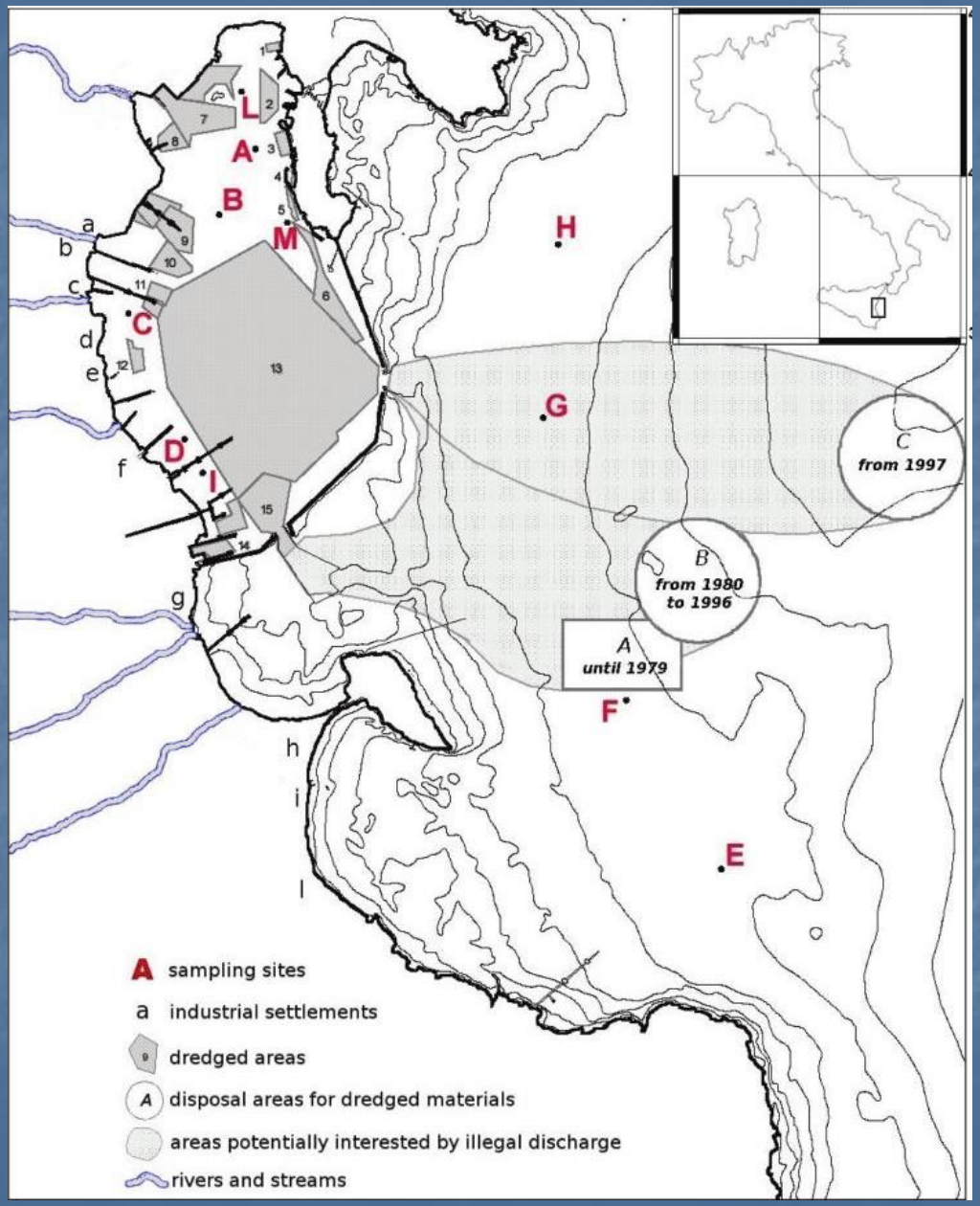
Case Study: The Augusta Bay

Main question: history and sources of Hg pollution

First step: System definition

The collection of available information should always be the first step. It is fundamental to gather all the relevant information:

- characteristics of the study area
- contamination levels
- history of industrial productions
- waste management and public works.


L
A
B
M
H
C
D
I
G
F
E
a
b
c
d
e
f
g
h
i
l
C
from 1997
B
from 1980
to 1996
A
until 1979
A sampling sites
a industrial settlements
dredged areas
A disposal areas for dredged materials
areas potentially interested by illegal discharge
rivers and streams

Where to take the cores?

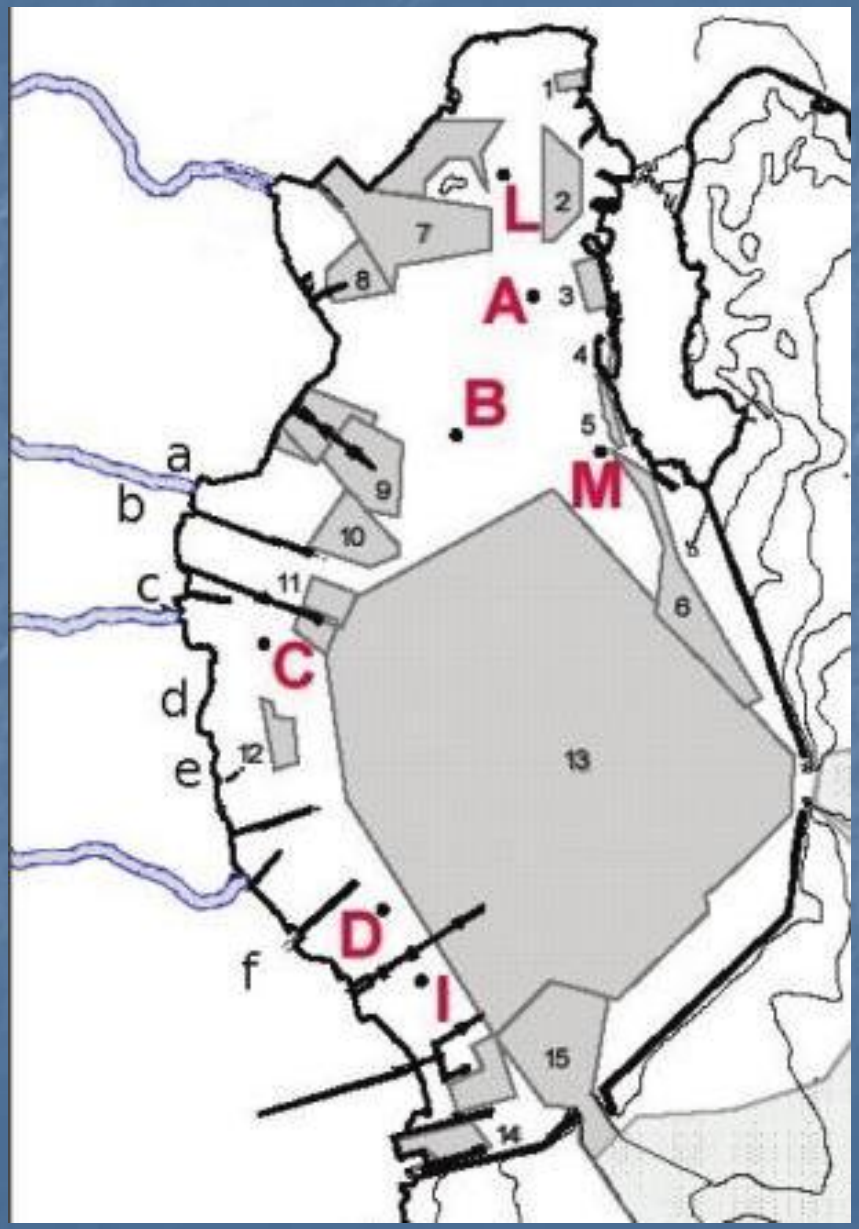
Second step: Bathymetry and high resolution seismic

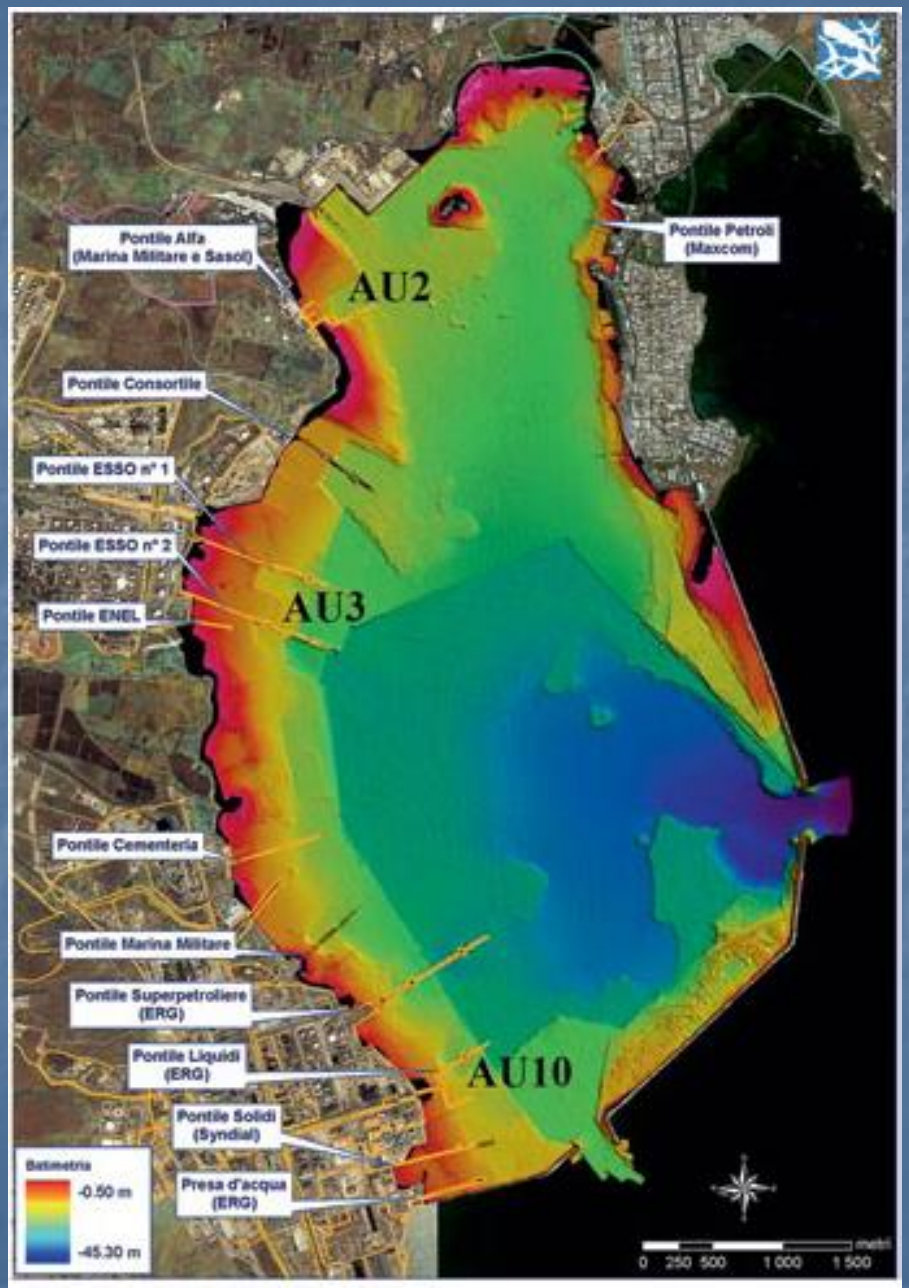
- overall picture of the basin characteristics and sediment distribution (selection of sampling sites that have likely preserved a high degree of information)
- the CHIRP Sub Bottom Profiler is able to generate calibrated frequency-modulated acoustic signals that permit:
  - very high resolution even with limited penetration
  - to reveal areas where sediment accumulation is more regular
  - to distinguish where bottom morphology is affected by phenomena such as slumping, mass accumulation, presence of gas, etc.
  - any change in the sediment reflection coefficient is due to grain size variations, making it possible to recognize silt/clay sediments (more suitable for chronology and contamination studies) from sandy bottoms.

SWAP (Shallow-WAter Prospector), is a highly flexible instrument that can be easily adapted to various monitoring conditions or prescriptions. It can be equipped with geophysical sensors such as vertical and lateral echo sounders, magnetometers, sub-bottom profilers, as well as chemical-physical sensors and current meters for a comprehensive characterization of the water column.

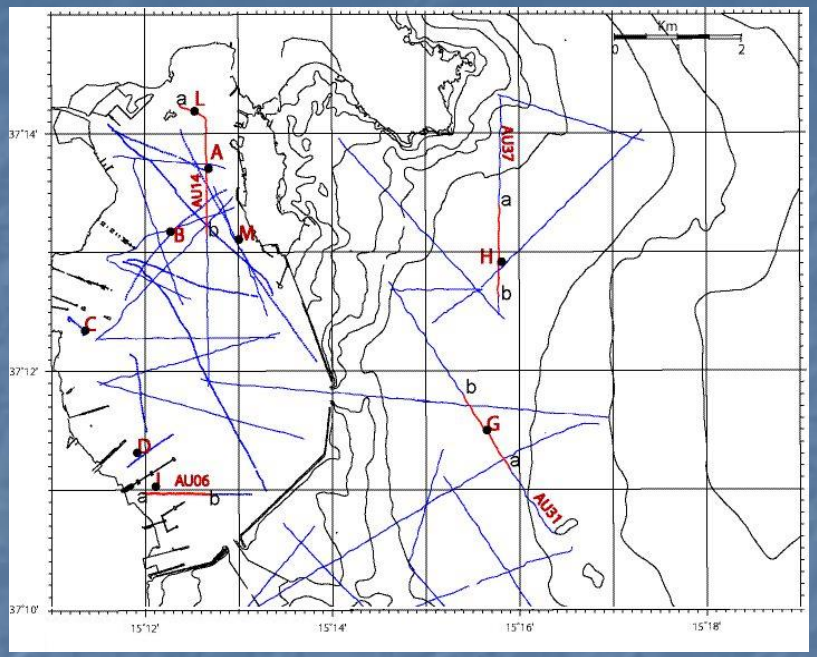
The vehicle is equipped with a multitasking computer that controls engines, positioning and data-logger.

Bathimetry

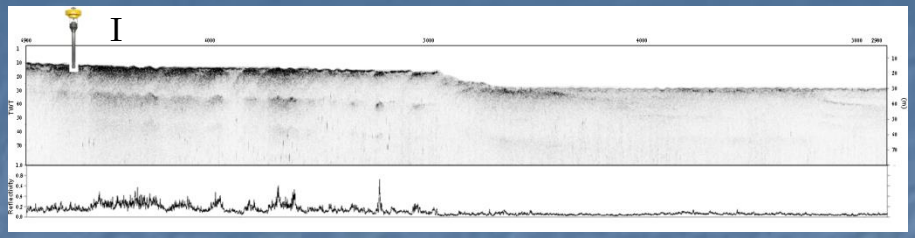

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
L
A
B
M
C
D
I
a
b
c
d
e
f


Pontile Alfa (Marina Militare e Sasol)
Pontile Petroli (Maxcom)
AU2
Pontile Consortile
Pontile ESSO n° 1
Pontile ESSO n° 2
AU3
Pontile ENEL
Pontile Cementeria
Pontile Marina Militare
Pontile Superpetroliere (ERG)
Pontile Liquidi (ERG)
AU10
Pontile Solidi (Syndial)
Presa d'acqua (ERG)
Batimetria
-0.50 m
-45.30 m
0 250 500 1 000 1 500
metri

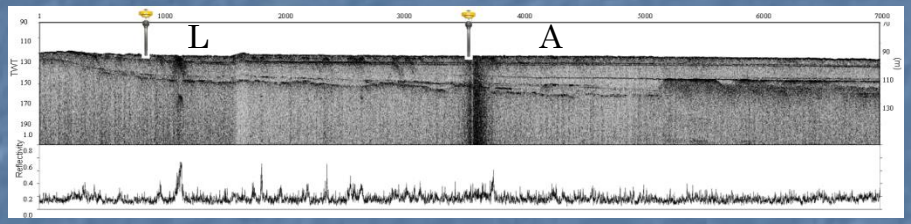
Sub-bottom profiles



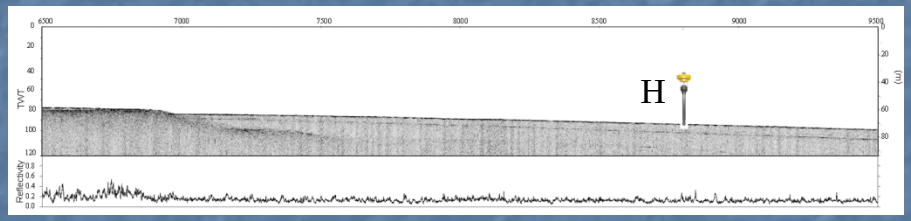
a b



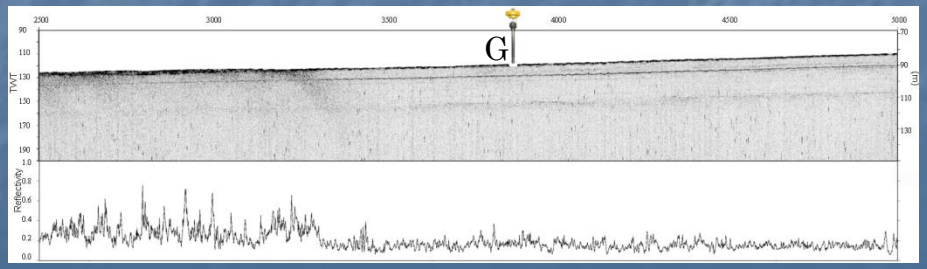
AU06



AU14



AU37



AU31

How to take the right samples?

Third step: Sediment core collection

Once sampling sites have been selected, one or more sediment cores need to be collected for each location. using a device able to preserve the sediment water interface. This is particularly important for those studies that deal with historic reconstructions of events and recent changes in the dynamics of the environment.

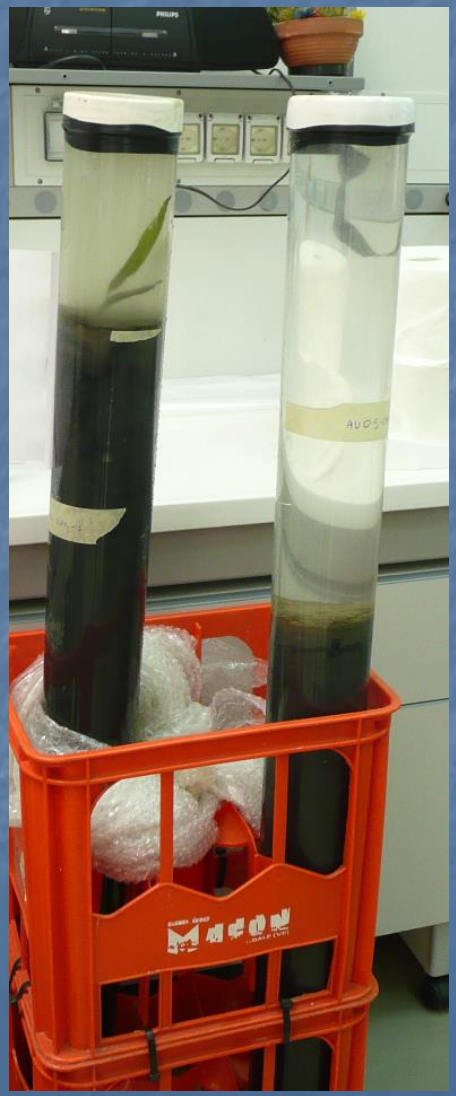
SW-104 is a light corer, 100 Kg maximum, designed with the purpose of recovering cores of clayey or slightly sandy sediments, ideal for sediment monitoring in marine and lacustrine environments, mainly for the study of fluxes at the sediment-water interface. SW-104 corer that is able to collected short (1-1.2 m) cores with an undisturbed water-sediment interface and the overlying bottom water.

It contains a transparent liner (110 mm diameter, 3 mm thick) that holds the sediment core and the bottom water. The load-bearing part, with arming, closure and recovery mechanisms, hosts the dead weight made up of masses from 17 Kg to 100 Kg

The main qualifying properties of this device are:

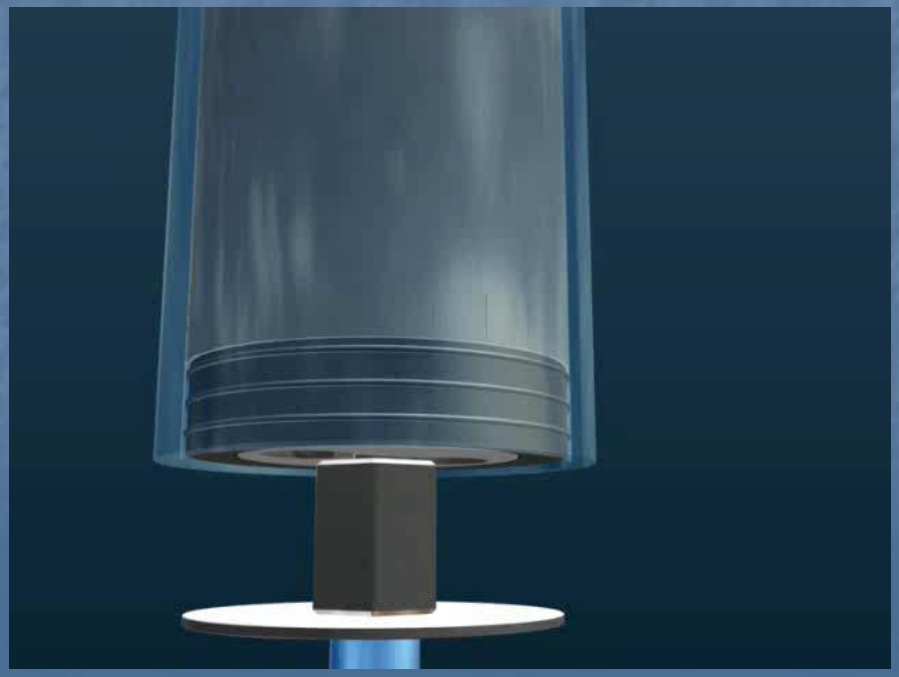
- maximum reduction of disturbance of the core, in particular at the top
- large core diameter of 104 mm (surface area of 85 cm^2) that allows detailed sub-sampling

- easily changeable mass
- recovery ratio of the penetration close to 100%;
- bottom closure mechanism that allows the undisturbed vertical extraction of the core sample



Subsampling

We generally use a high resolution subsampling: 0.5-4 cm thick slices, with smaller thicknesses close to the sediment-water interface. This permits to obtain detailed information about the most recent times, where variations might be very significant. Usually, the core is kept vertical until the sediment is extruded from the plastic tube.

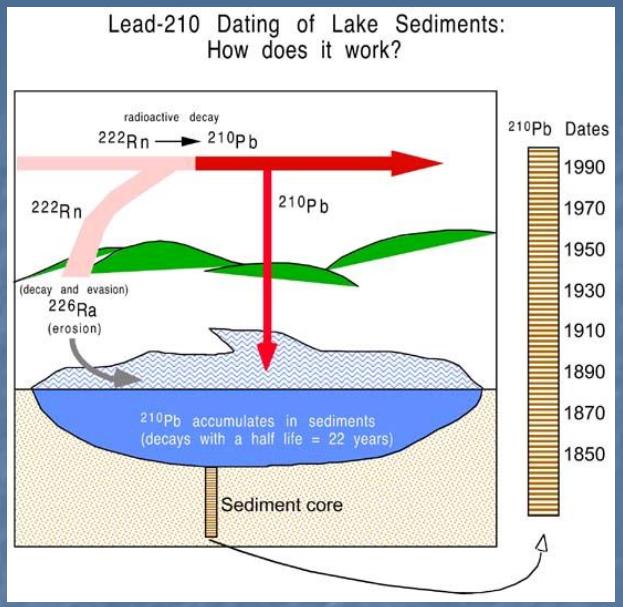


Chronologies

100-year time scale chronologies are usually obtained through activity-depth profiles of radiotracers such as ^{210}Pb and ^{137}Cs in cores not significantly affected by physical mixing and/or bioturbation. The assessment of sediment accumulation rates (cm y^{-1}) and mass accumulation rates (g cm^{-2} y^{-1}) allows not only the dating of both environmental changes and contaminating events, but also the calculation of fluxes of both sedimentary materials and contaminants.

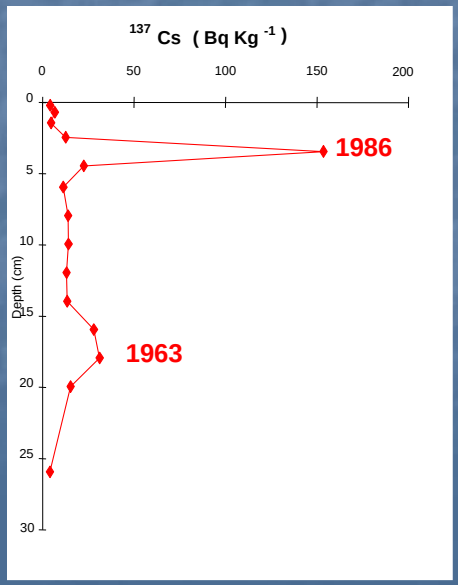
^{210}Pb dating method is based on the depth distribution of the fraction in excess with respect to the sediment natural background ($^{210}Pbex$). This is the fraction of the radiotracer that is supplied from the aquatic environment and decays as a function of time, and depth.

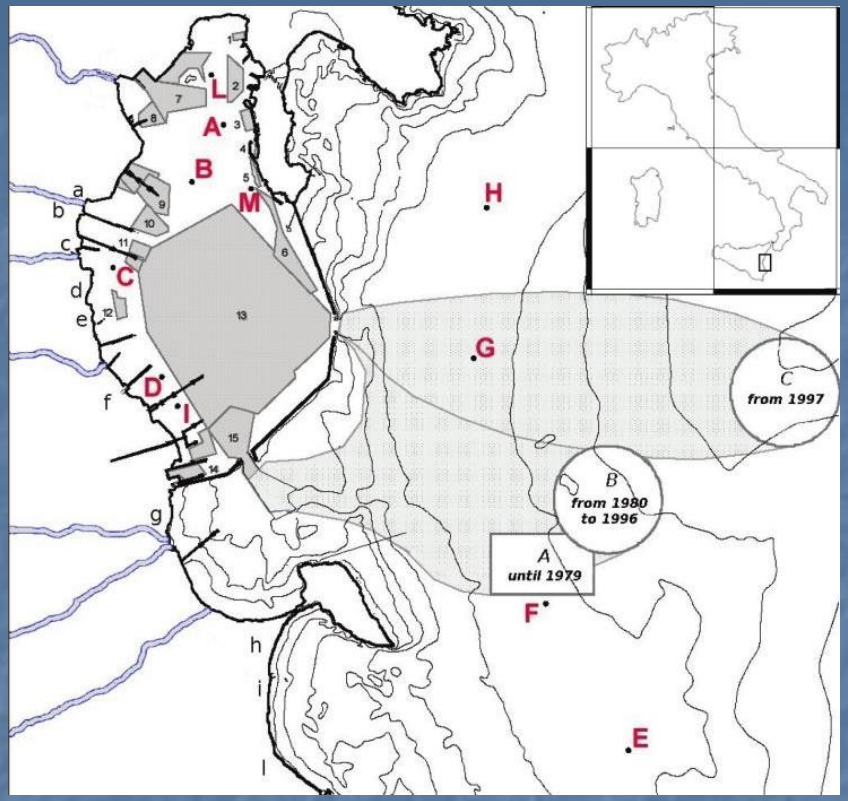
^{210}Pb

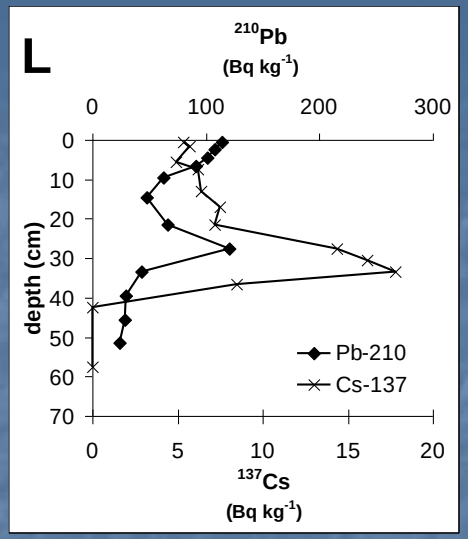


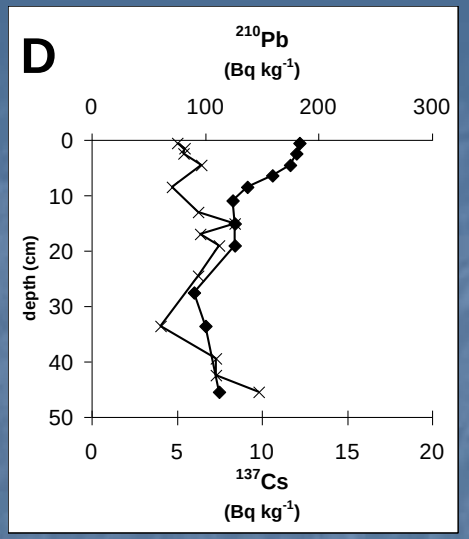
The peak caused by the Chernobyl accident (1986) is a useful time marker in Europe, and permits to calculate average rates after the year of deposition. In addition, the peak due to bomb testing should identify the level deposited in 1963.

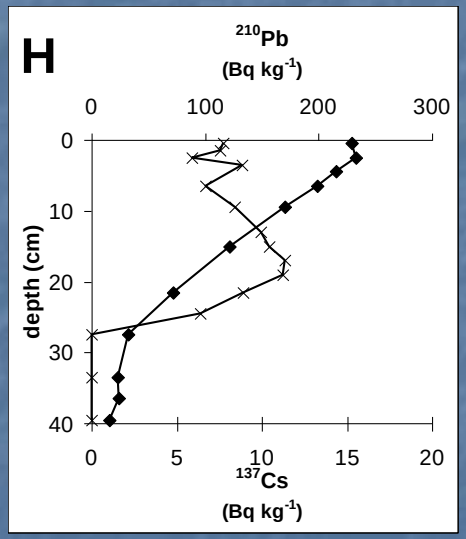
^{137}Cs

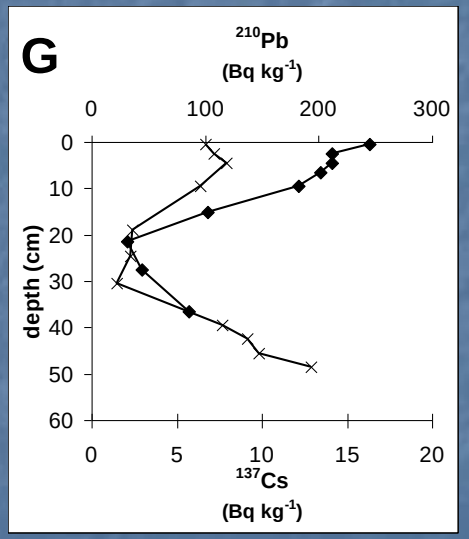



L
A
B
M
H
C
D
I
G
F
E
a
b
c
d
e
f
g
h
i
l
C
from 1997
B
from 1980
to 1996
A
until 1979

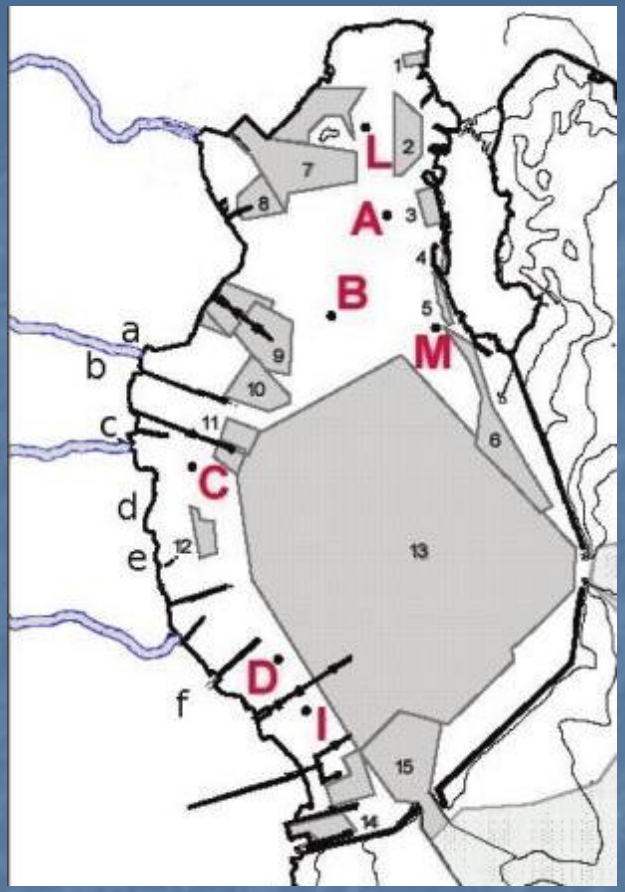

L
^{210}Pb
(Bq kg^{-1})
0
100
200
300
depth (cm)
0
10
20
30
40
50
60
70
Pb-210
Cs-137
0
5
10
15
20
^{137}Cs
(Bq kg^{-1})

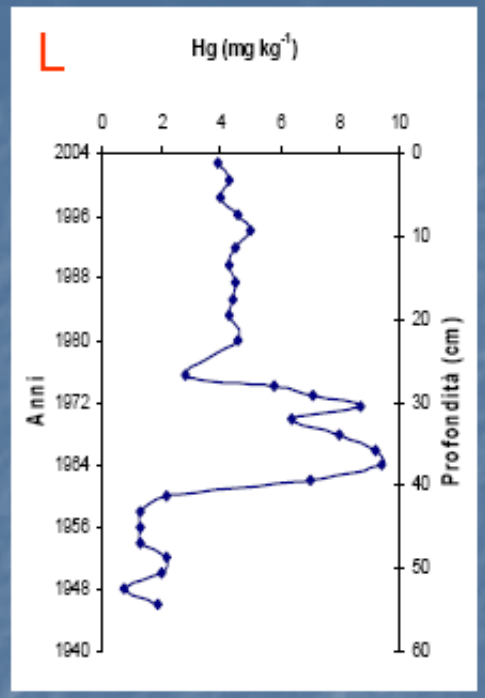

D
^{210}Pb
(Bq kg^{-1})
0
100
200
300
depth (cm)
0
10
20
30
40
50
0
5
10
15
20
^{137}Cs
(Bq kg^{-1})

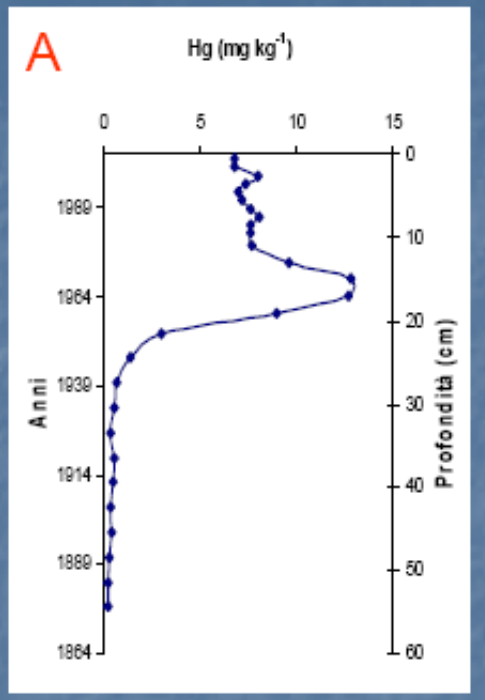

H
^{210}Pb
(Bq kg^{-1})
0
100
200
300
depth (cm)
0
10
20
30
40
0
5
10
15
20
^{137}Cs
(Bq kg^{-1})

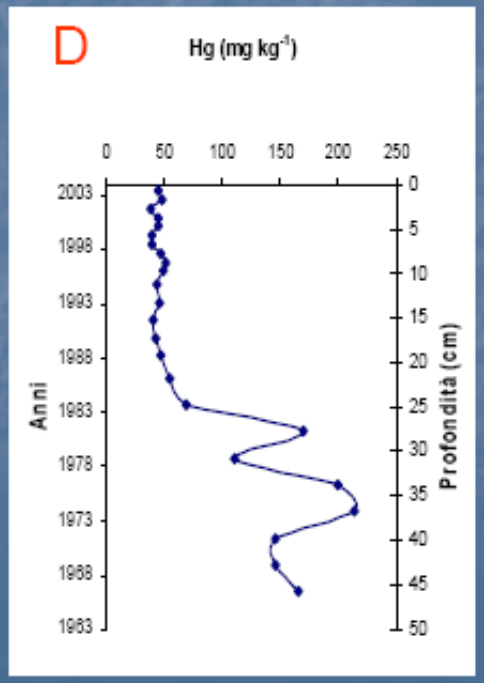

G
^{210}Pb
(Bq kg^{-1})
0
100
200
300
depth (cm)
0
10
20
30
40
50
60
0
5
10
15
20
^{137}Cs
(Bq kg^{-1})

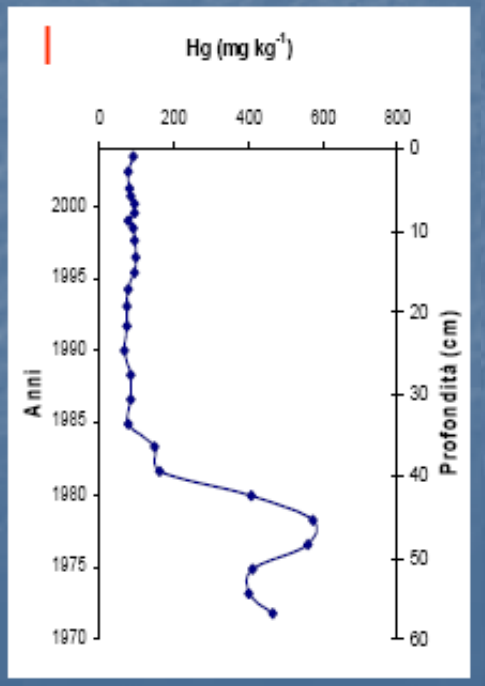
Hg dated profiles





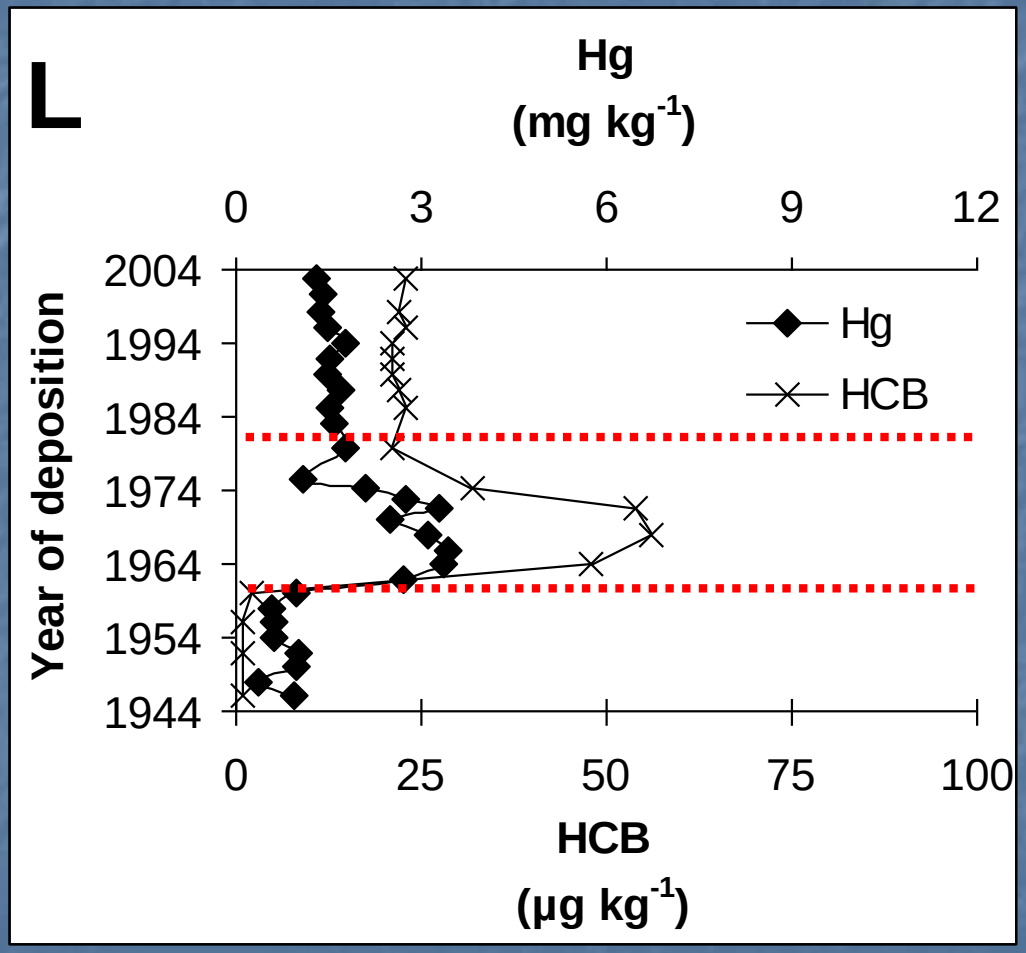






The peak of Hg pollution occurred in the 1970s, after which the trend fell sharply, thanks to the treatment of industrial wastewater.
However, high levels of Hg are still present in surficial sediments.

The answer

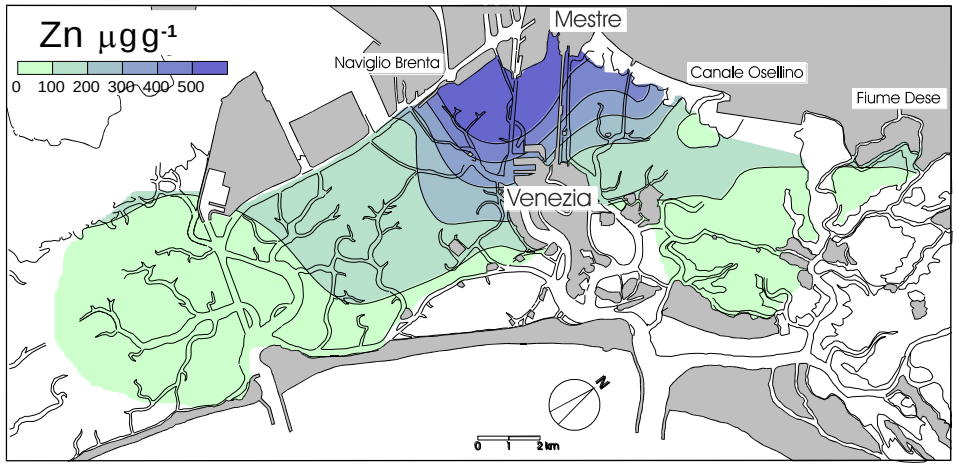


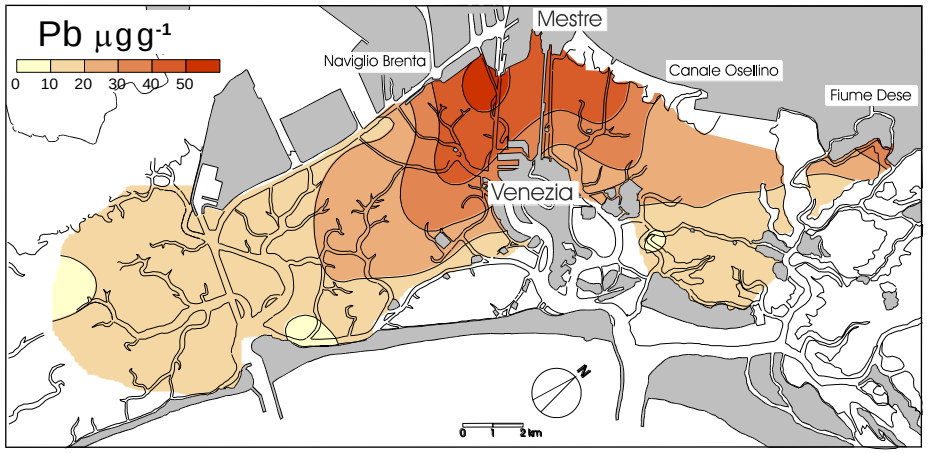
To understand if Hg pollutants were still active, we used hexachlorobenzene (HCB) as an independent tracer, as the history of its production in the area was well known.

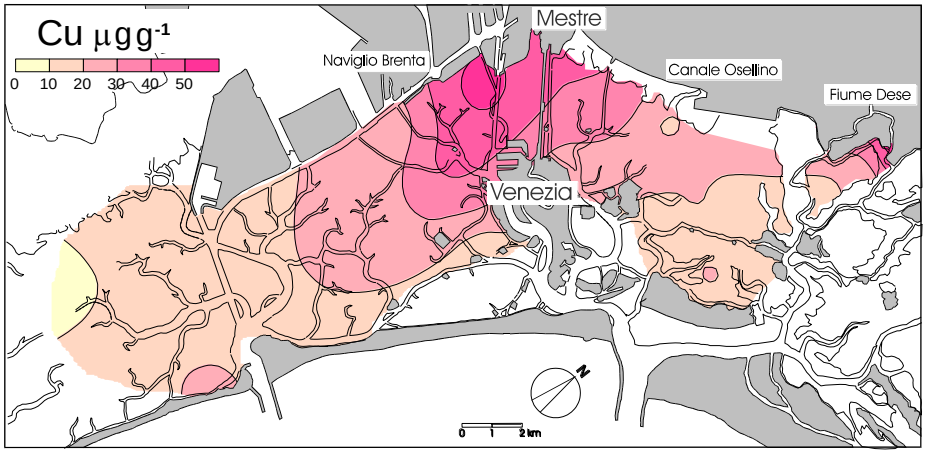
The strong correlation between the Hg and HCB profiles suggests that the high levels of Hg measured in superficial sediments are probably attributable to phenomena of resuspension and redistribution of deep sediments caused by dredging and maritime traffic.

Case Study: Pollution in the canals of the Industrial Area of Porto Marghera

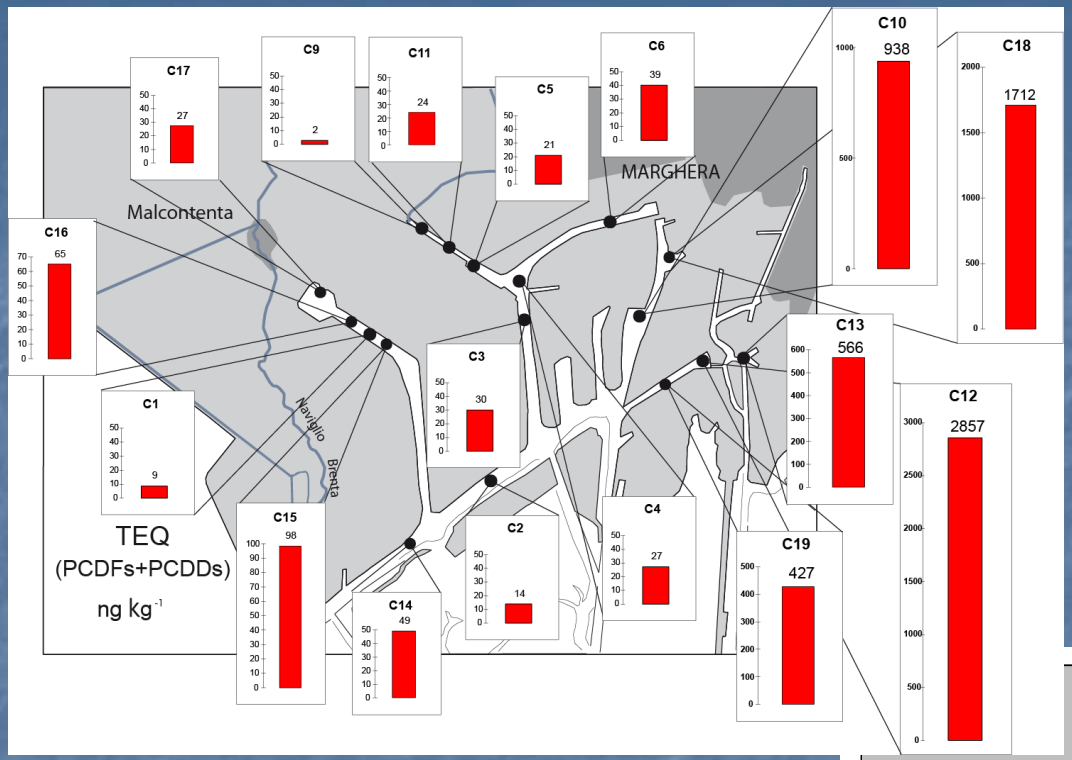
Video

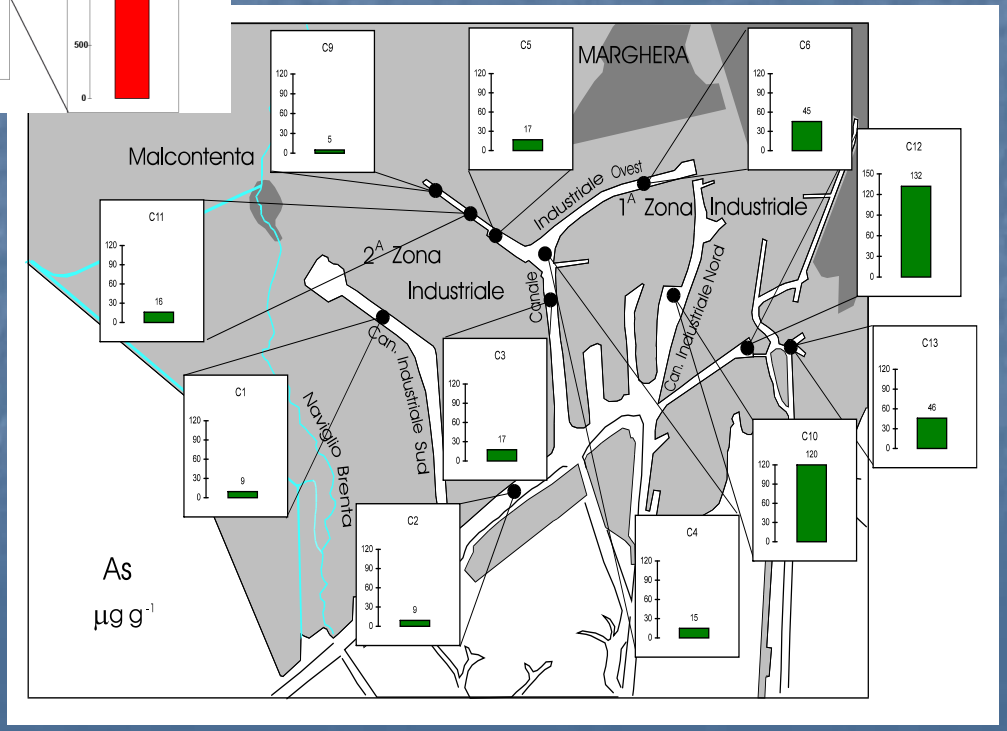

Zn µgg-1
0 100 200 300 400 500
Mestre
Naviglio Brenta
Canale Osellino
Fiume Dese
Venezia
N
0 1 2km

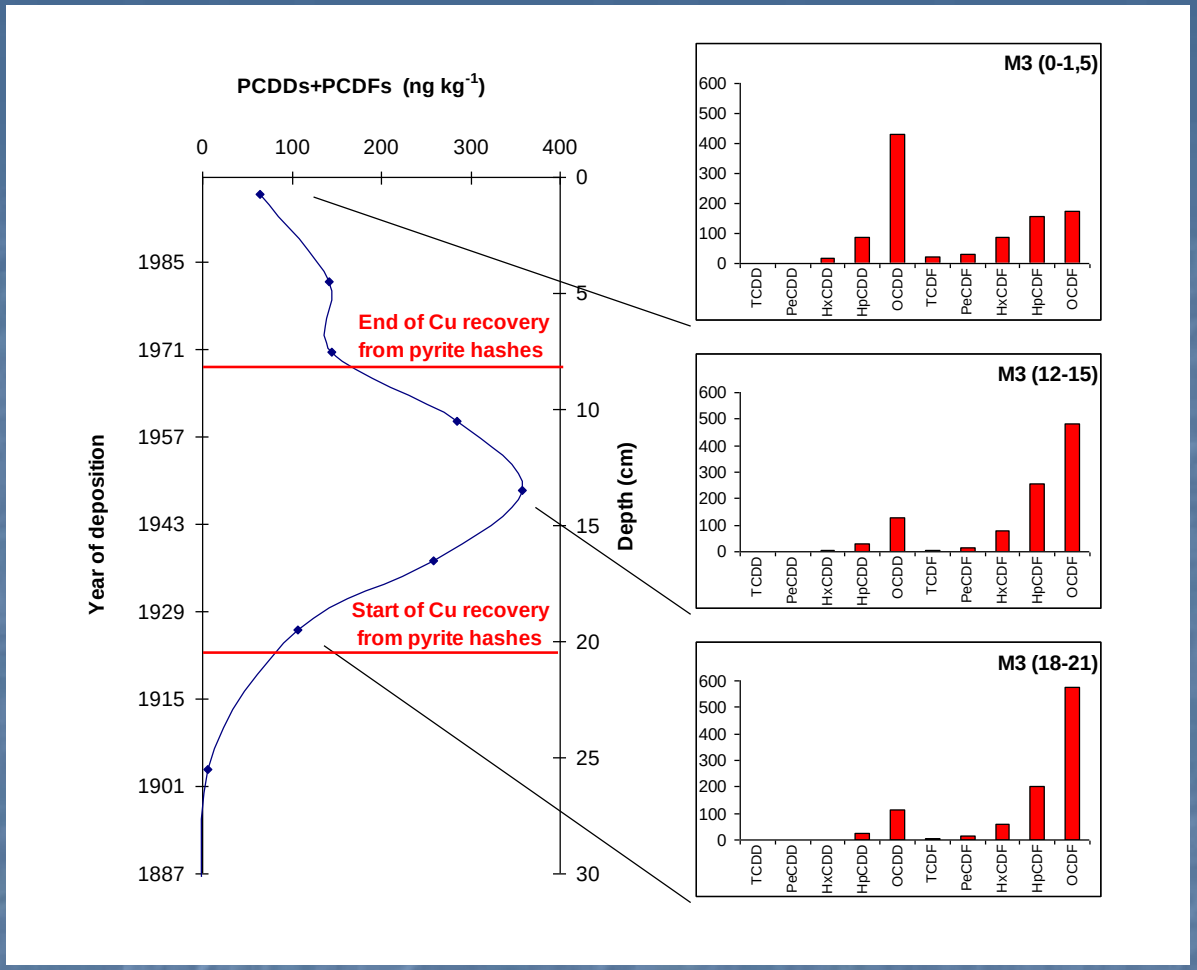

Pb µgg-1
0 10 20 30 40 50
Mestre
Naviglio Brenta
Canale Osellino
Fiume Dese
Venezia
N
0 1 2km


Cu µgg-1
0 10 20 30 40 50
Mestre
Naviglio Brenta
Canale Osellino
Fiume Dese
Venezia
N
0 1 2km

Dioxins and As in sediments of the canals



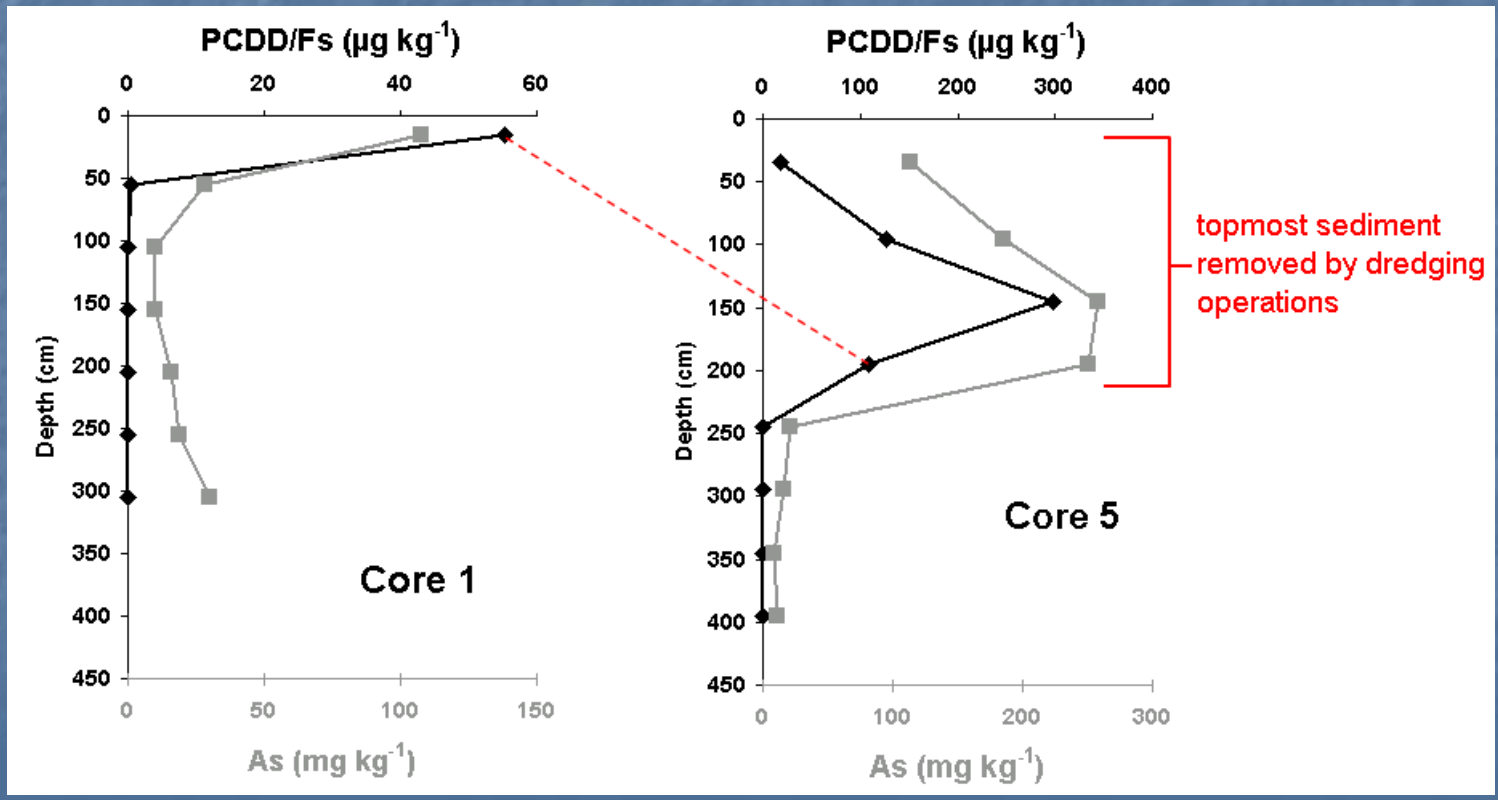




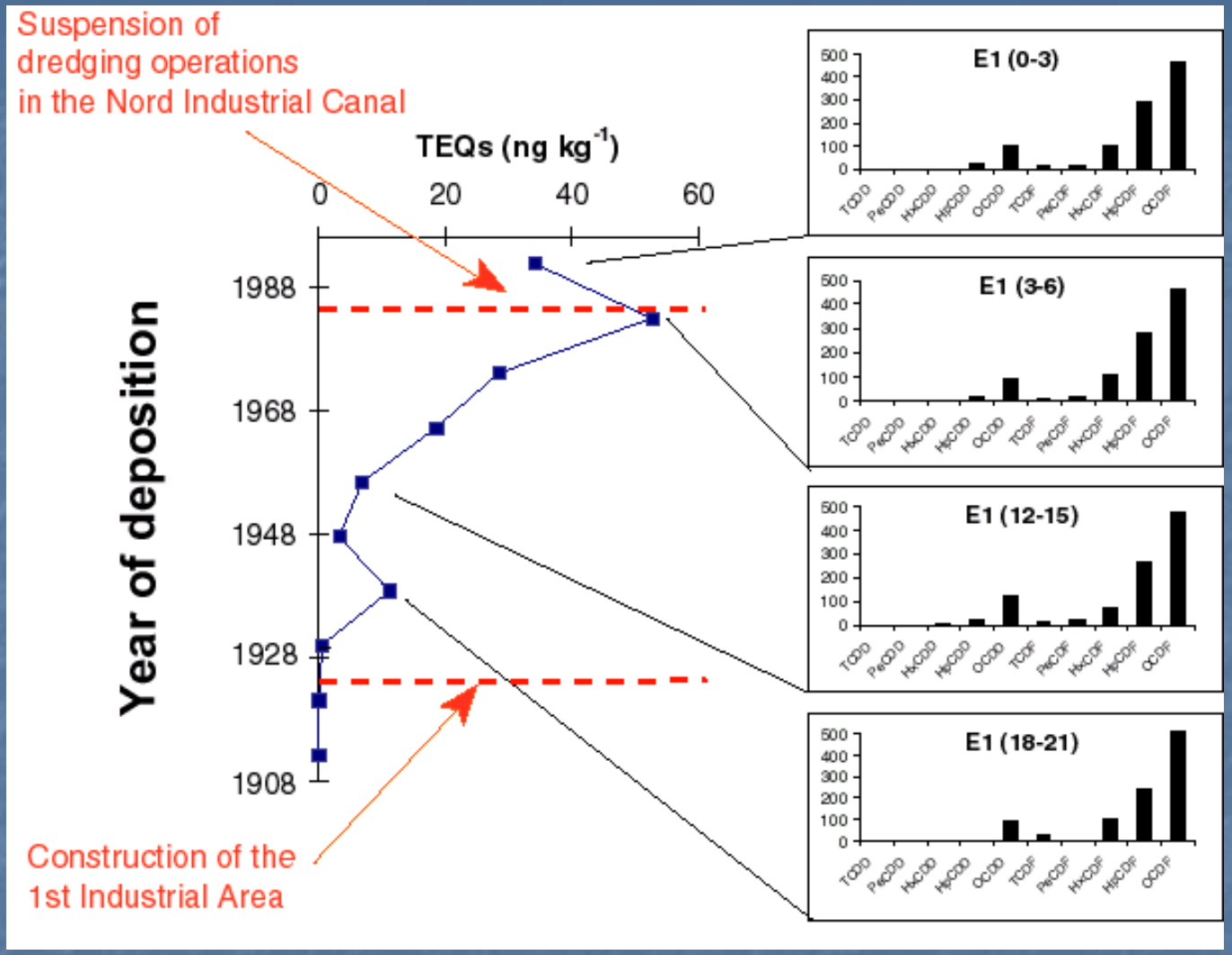
The main industrial source of PCDD/Fs in the Venice Area was identified in the recovery of Cu from pyrite hashes. The plants have been in operation since 1927, were still working in 1968 and have been definitively closed in the early 1970s, in perfect agreement with PCDD/F chronologies recorded by salt marsh core.

Dredging in the polluted canals

The terminal part of the canal (darsena Fincantieri) was dredged in 1997, to allow the launch of a large ship

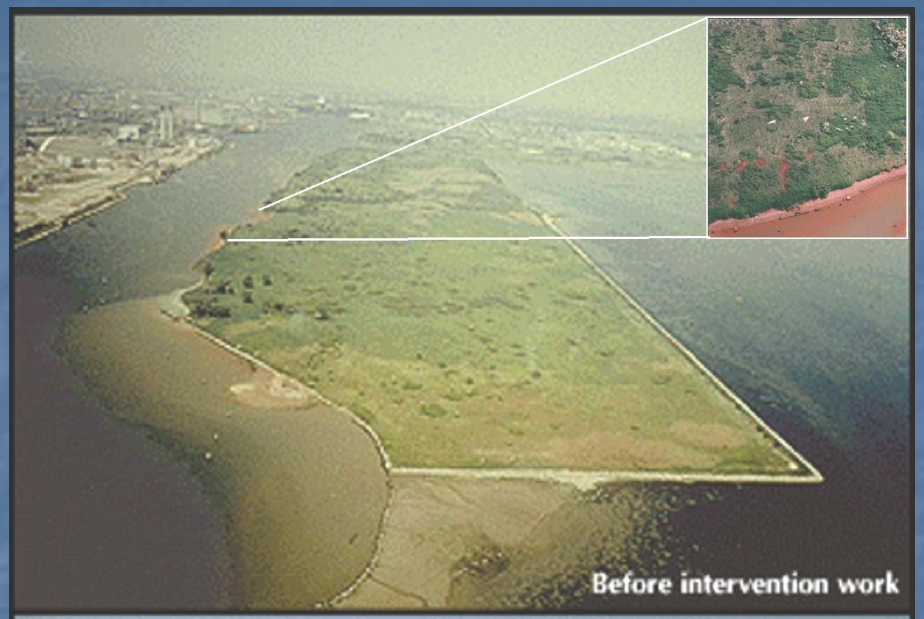


The record shown by core 5 is complete, whereas that of core 1 appears truncated because of the removal of the topmost sediment



The PCDD/F profile at site E1, which is easily influenced by the accumulation of material resuspended within the Nord Industrial Canal, provided evidence that the decrease of contamination began only after the suspension of dredging operations

The Regione Veneto in 2000 adopted a plan for the complete confinement of the erodible banks and the Tresse Islet has been completely secured in 1992



Go ahead, but look back to see the wake of your boat, so you will understand if you're going straight.

Thank You