Sediment as a dynamic natural resource from catchment to open sea

1. Sediment management concept and sediment policy

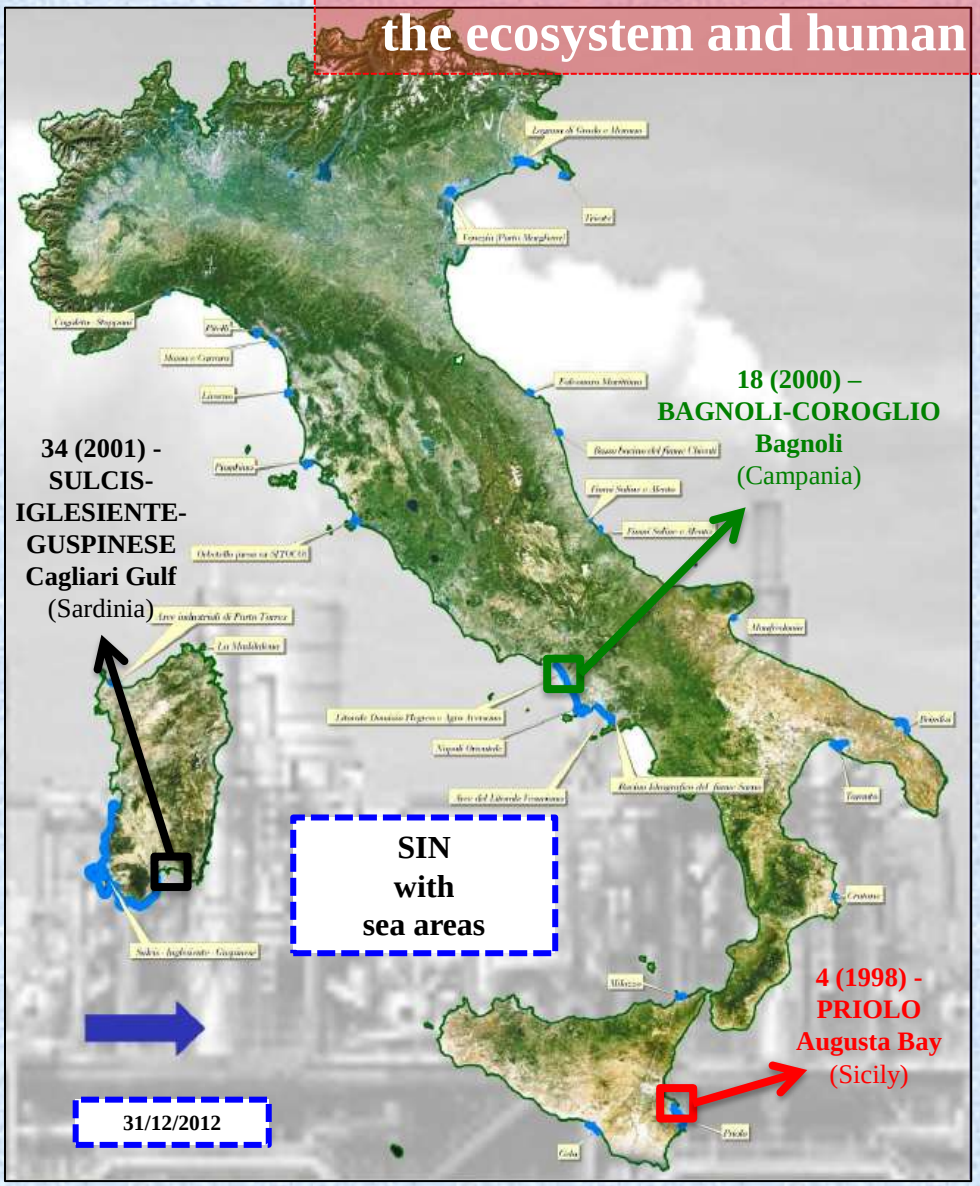
3-5 April 2019

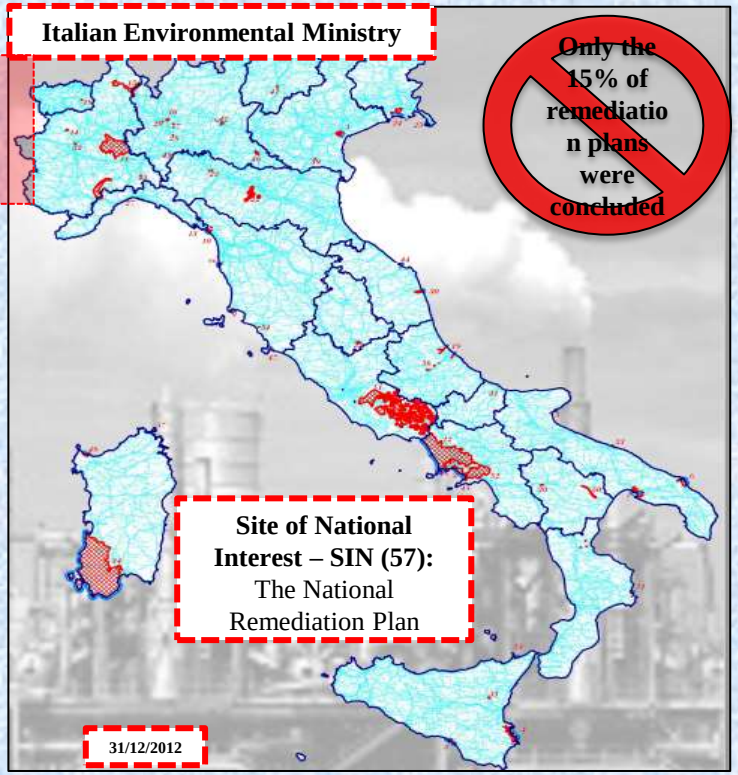
Contaminated sediment as hot-spots of wide-scale marine pollution: a need to re-think sediment management and policy

Mario Sprovieri[1], Maria Bonsignore[1], Salvatore Passaro[2], Daniela Salvagio Manta[1] and Stella Tamburrino[2]

[1] CNR-IAS, Campobello di Mazara (TP) Italy
[2] CNR-ISMAR Napoli, Italy

SIN → impact on the environment, the ecosystem and human health

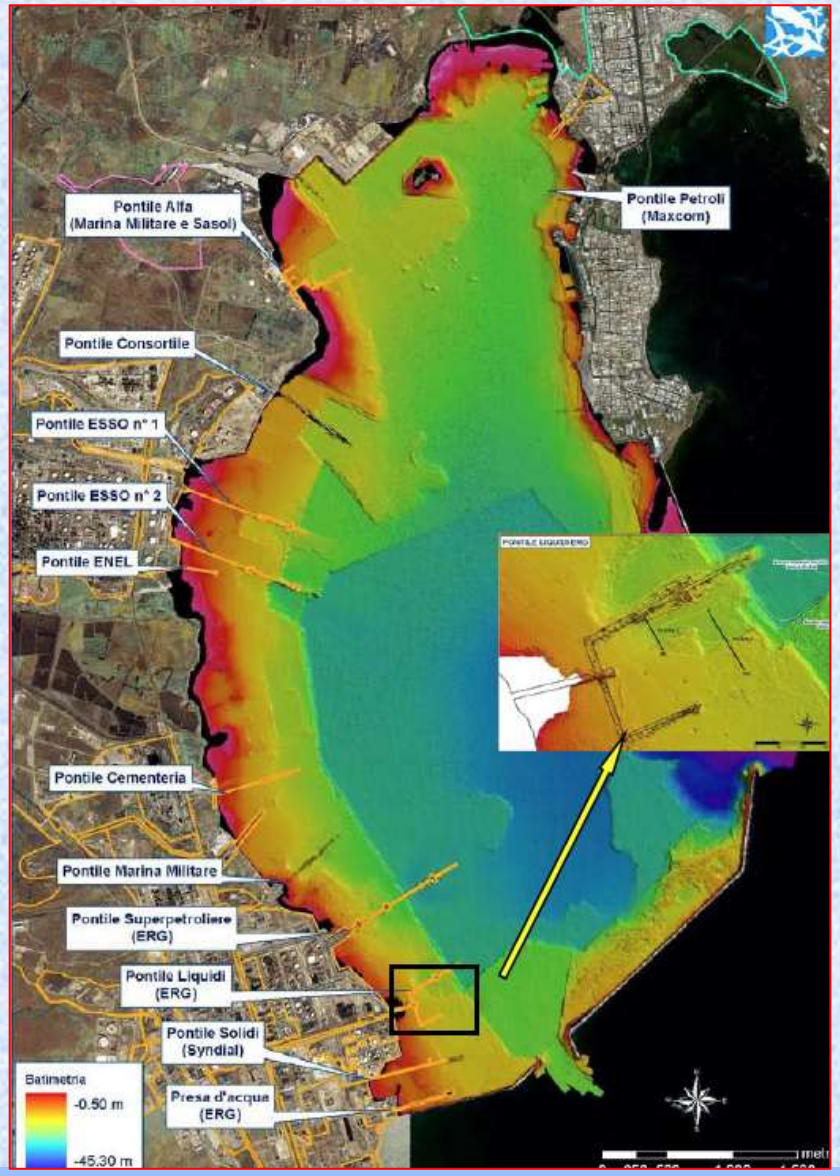




We have selected three SIN as pilot cases mainly because:

1. They are located in three different ***geological setting***;
2. They are sites with an ***huge "historical" contamination*** of sediment recognised in marine environment;
3. For one of these was recognised ***impact to ecosystem and human health***;
4. In one case is also detected ***dumping activities*** on the sea;
5. In all three there is a very articulated sub-marine canyons systems that acts as primary ***control of contaminants transport*** from coast to the deep sea.

Augusta Bay (SE Sicily), *"closed" site*



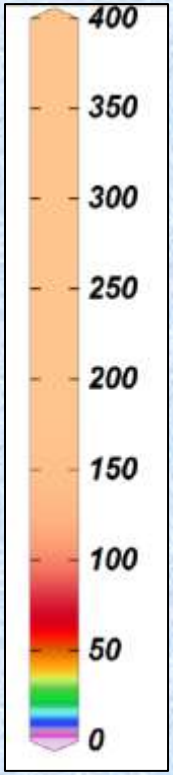
- **1950:** industrial development
- **1960s**: relevant dredging activities and breakwater building
- **1960s-1970s:** chlor-alkali plant *(Montedison-Syndial)* discharges without treatments about ***260 kg y^{-1} of mercury***
- **1980**: waste treatments became operative
- **2003:** Augusta Bay was included in "The National Remediation Plan" by Italian Environmental Ministry (SIN)
- **2005:** cholr-alkali plant production stops

Augusta Bay

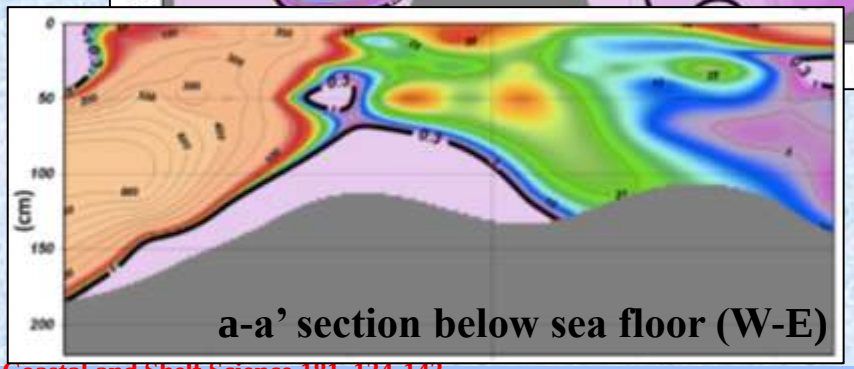
530 sediment cores + 39 superficial sediments

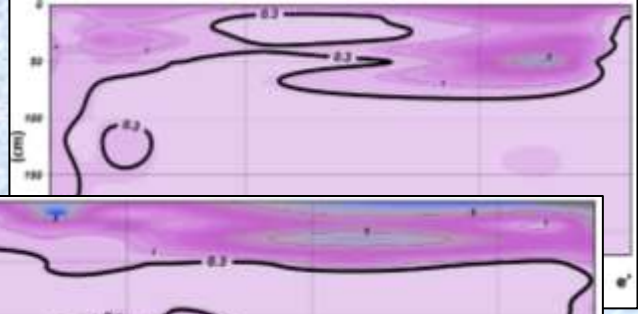
Contaminated Sediment Volume = 30.000 m^3

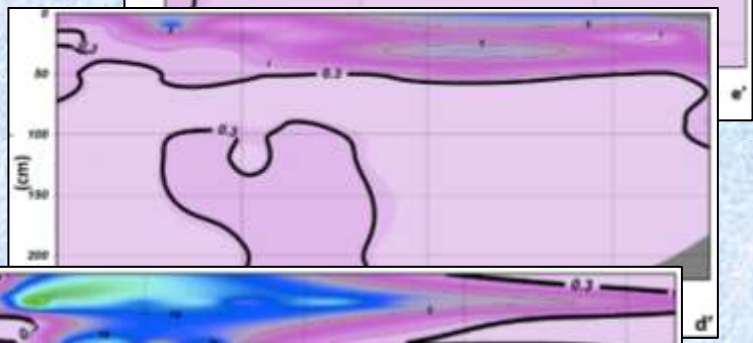
Hg background (Strait of Sicily) 0.04 mg Kg^{-1}
Hg Legal limit 0.3 mg Kg^{-1}

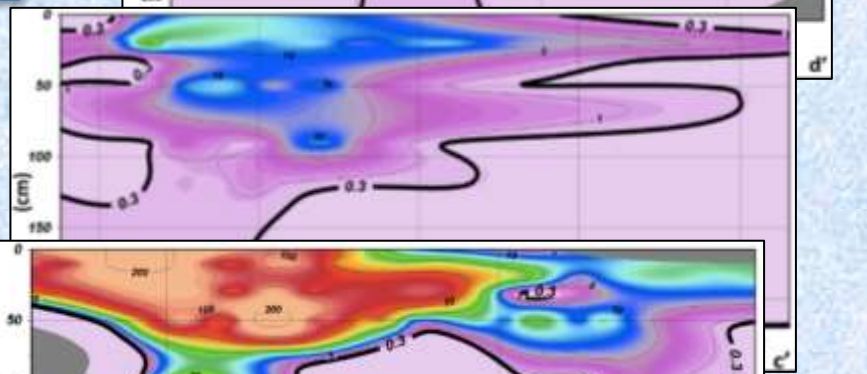


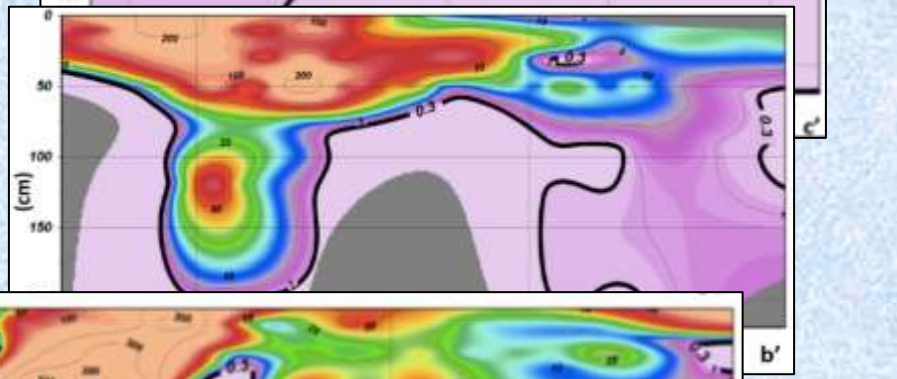
Hg mg Kg^{-1}









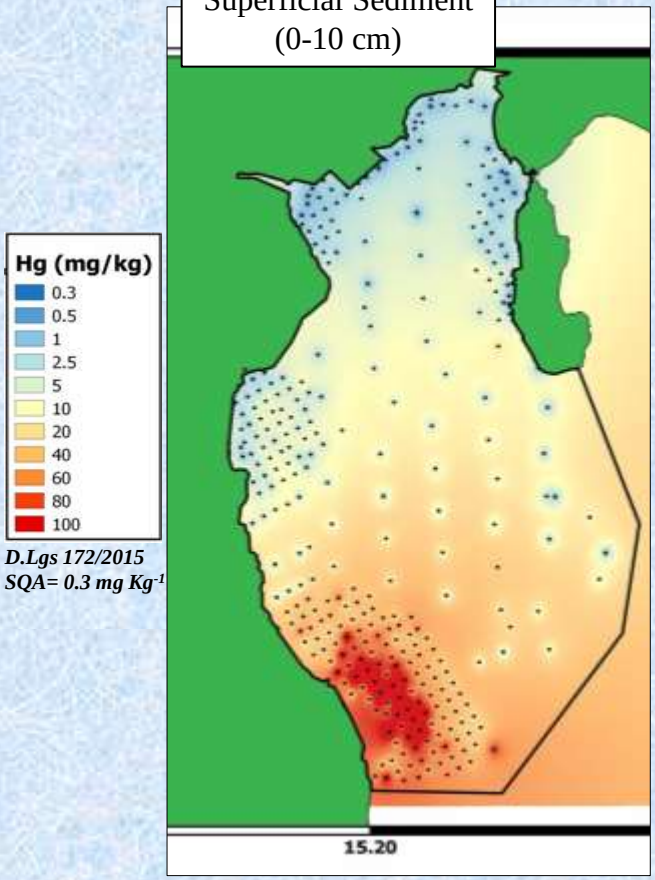


Salvagio Manta et al., 2016. Estuarine, Coastal and Shelf Science 181, 134-143
Bonsignore et al., 2015. Environmental Pollution 205, 178-185

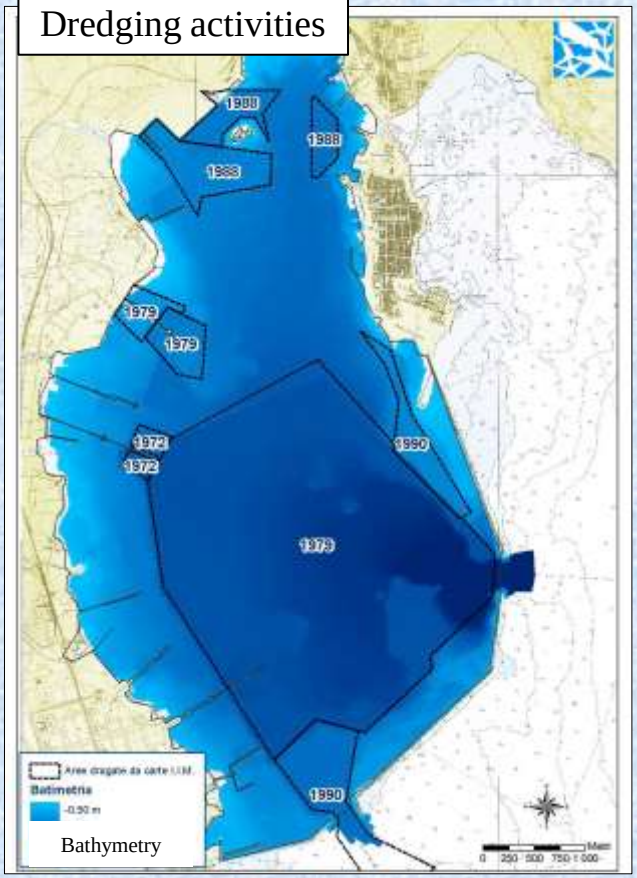
Augusta Bay

- Superficial contamination in spite of cholr-alkali plant production stop

Superficial Sediment (0-10 cm)

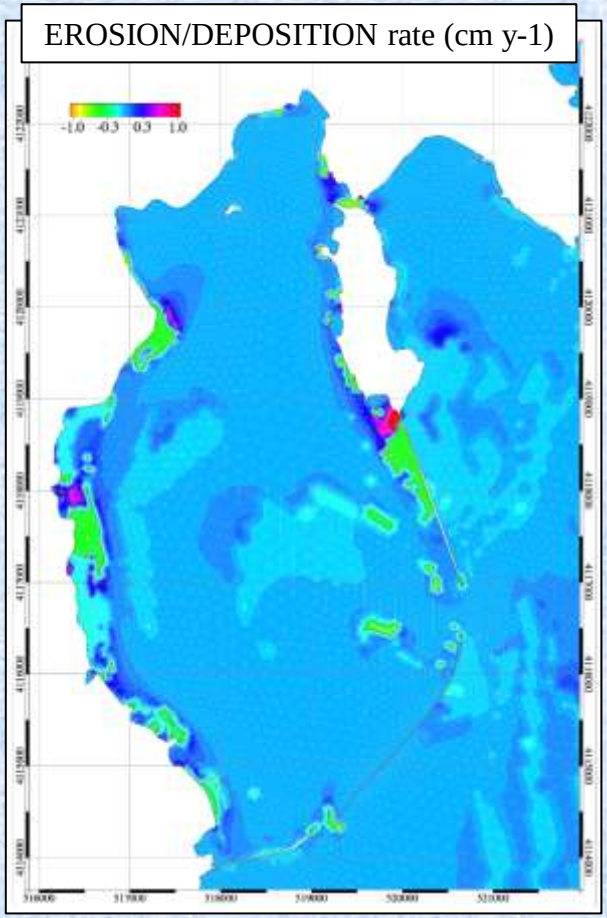


Dredging activities



- Relevant activities of dredging caused remobilization and diffusion of pollutants in the water column

EROSION/DEPOSITION rate (cm y-1)

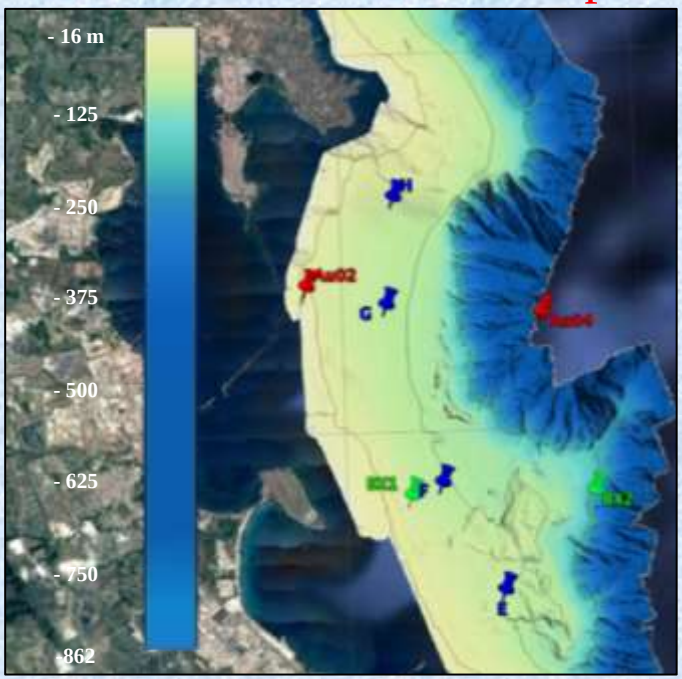


- Scarce active erosion processes

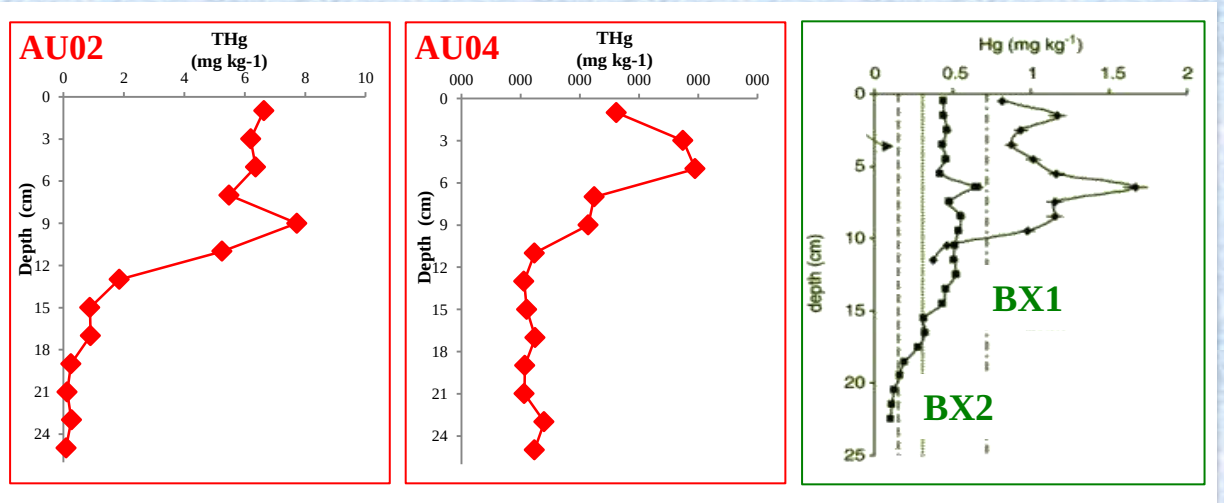
Salvagio Manta et al., 2016. Estuarine, Coastal and Shelf Science 181, 134-143
Bonsignore et al., 2015. Environmental Pollution 205, 178-185

Augusta Bay - *OFFSHORE*

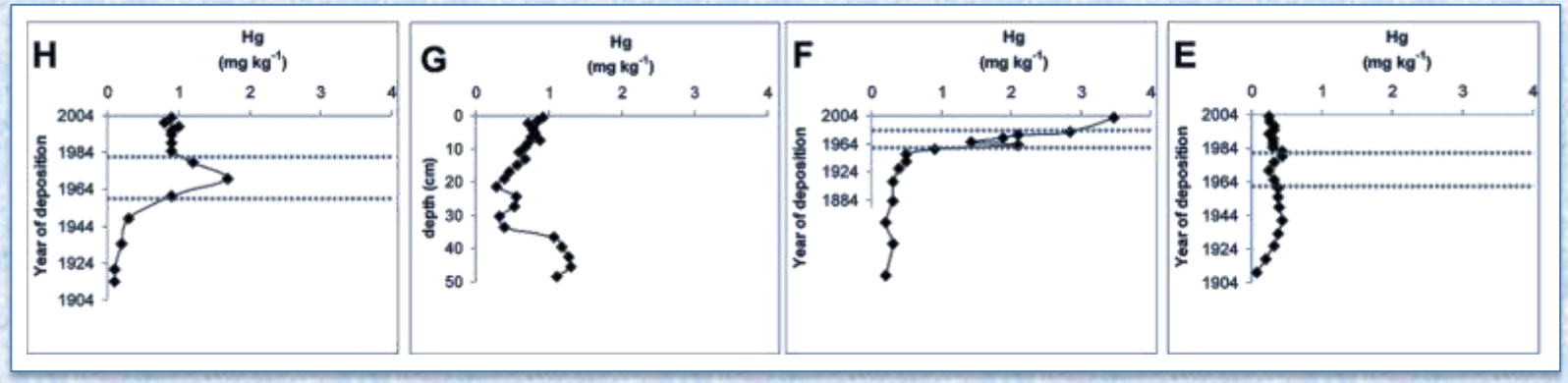
- Pollution transfer to the open sea



W-E box cores



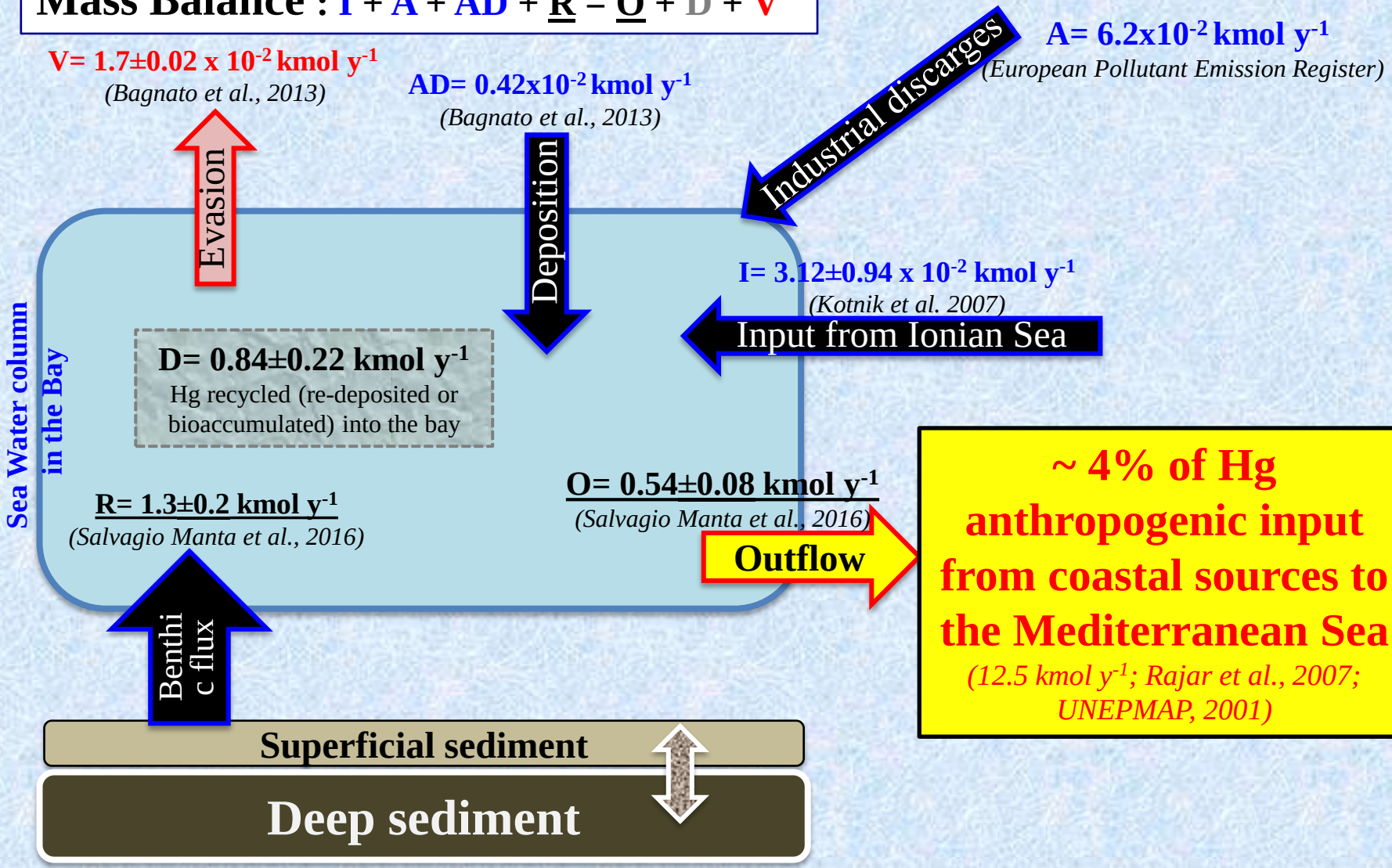
N-S box cores



Salvagio Manta et al., 2016. Estuarine, Coastal and Shelf Science 181, 134-143
Bonsignore et al., 2015. Environmental Pollution 205, 178-185
Di Leonardo et al., 2014. Journal of Sea Research 85, 428-442
Bellucci et al., 2012. Environmental Science and Technology 46, 2040-2046

Augusta Bay

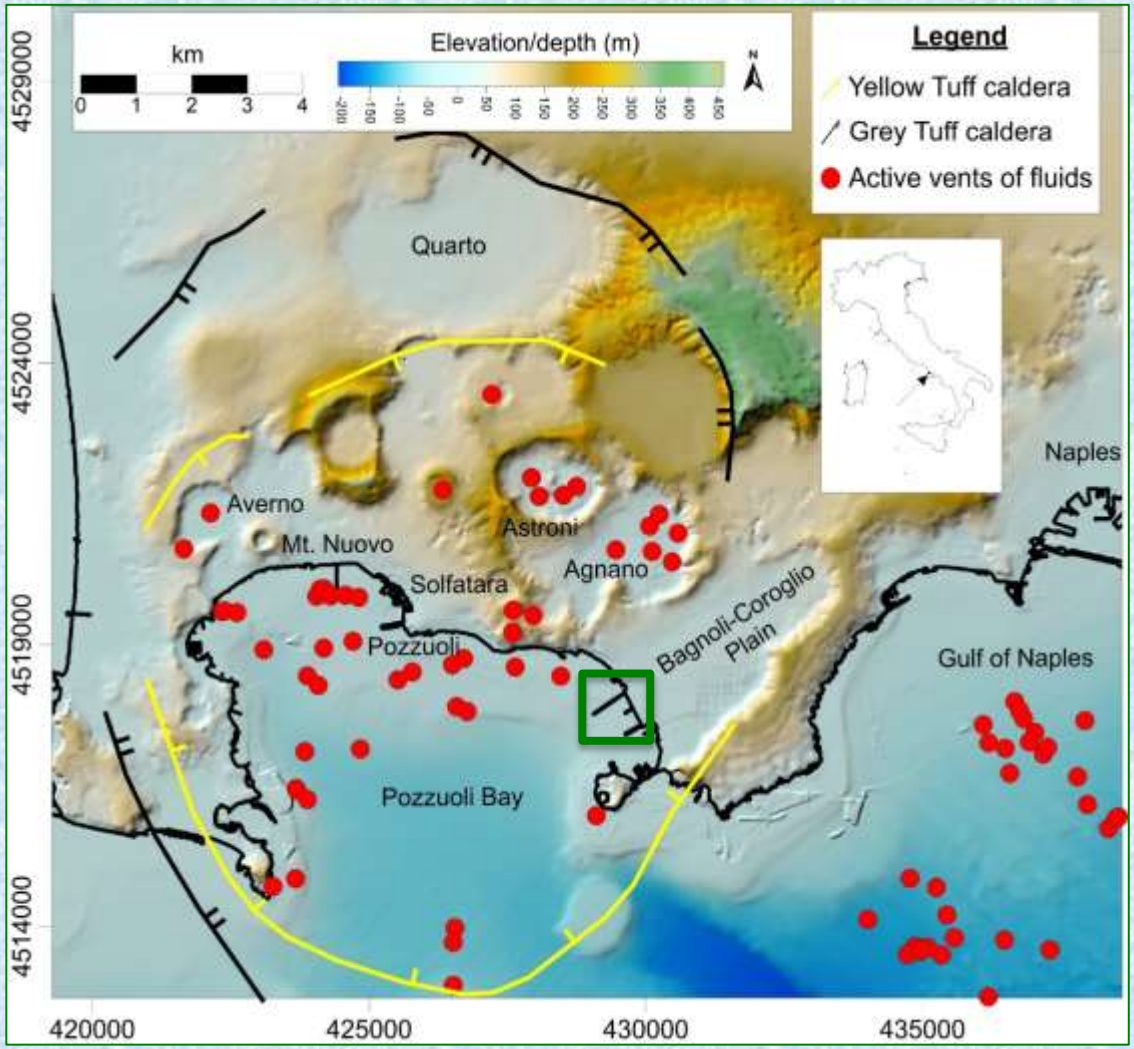
Mass Balance : I + A + AD + R = O + D + V

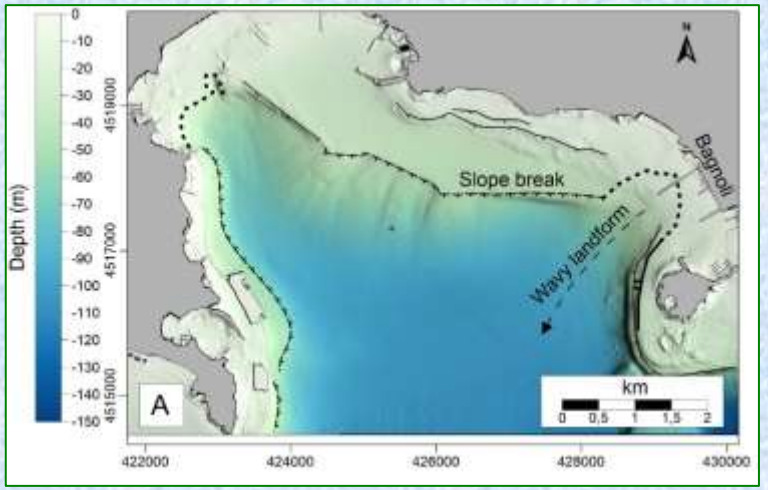


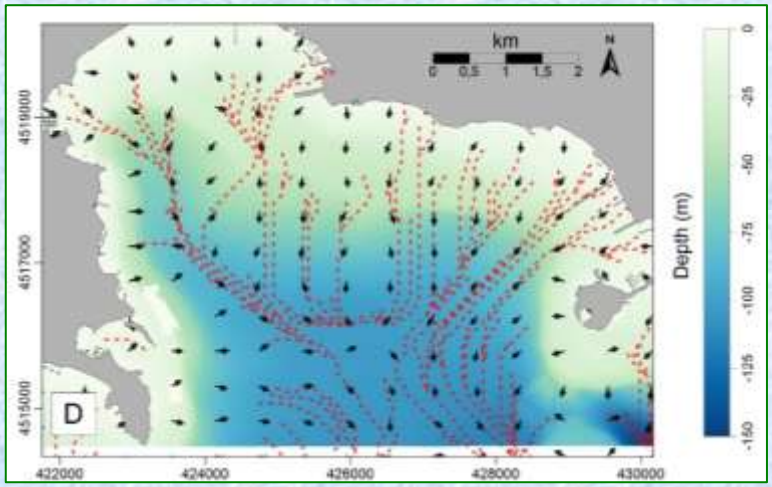
~ 4% of Hg anthropogenic input from coastal sources to the Mediterranean Sea
(12.5 kmol y-1; Rajar et al., 2007; UNEPMAP, 2001)

Salvagio Manta et al., 2016. Estuarine, Coastal and Shelf Science 181, 134-143
Bonsignore et al., 2015. Environmental Pollution 205, 178-185
Bagnato et al., 2013. Chemosphere 93, 2024-2032

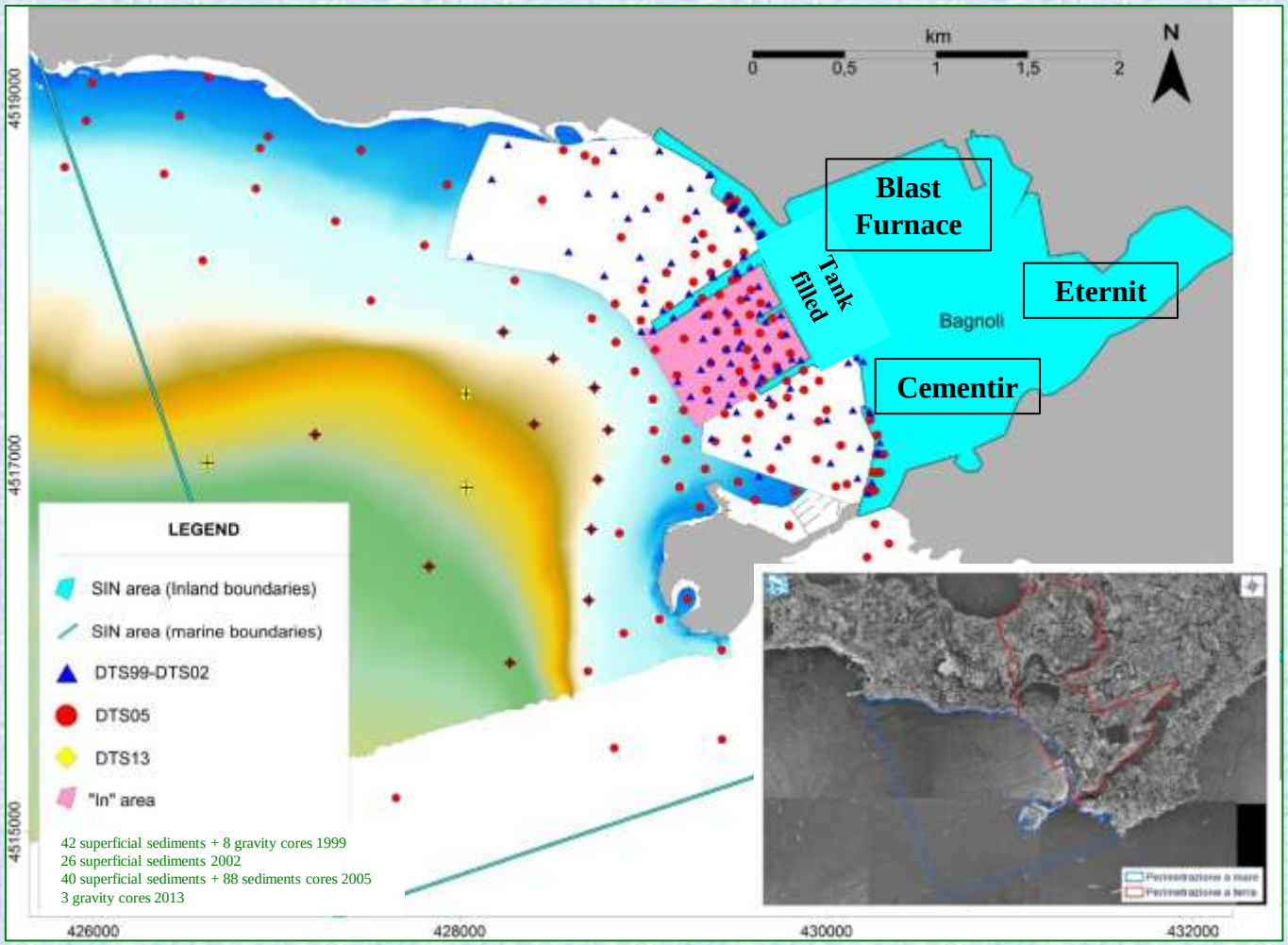
Bagnoli (S Italy), *semi-closed site*







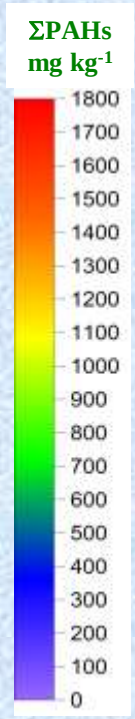
Bagnoli



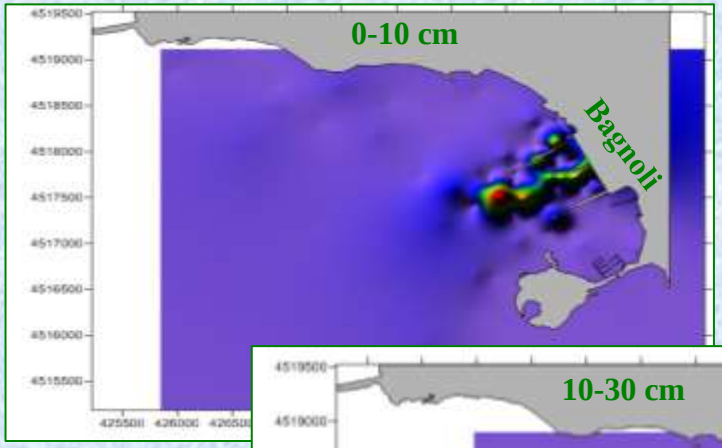
- **1853:** industrial development
- **1908**: chemical plant (MONTECATINI)
- **1910**: steel production plant (ILVA)
- **1938:** cement-asbestos production plant (ETERNIT)
- **1954:** blast furnace slag for cement production (CEMENTIR)
- **1962**: tank filled
- **1985-1993**: Eternit and ILVA stop
- **2000**: Bagnoli was included in "The National Remediation Plan" by Italian Environmental Ministry (SIN, restricted in 2014)

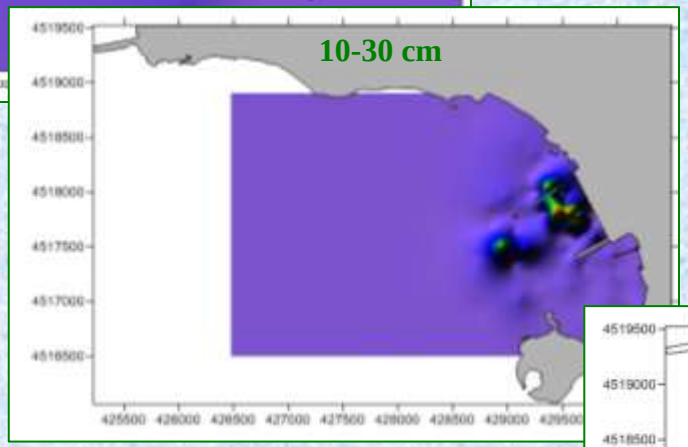
Bagnoli

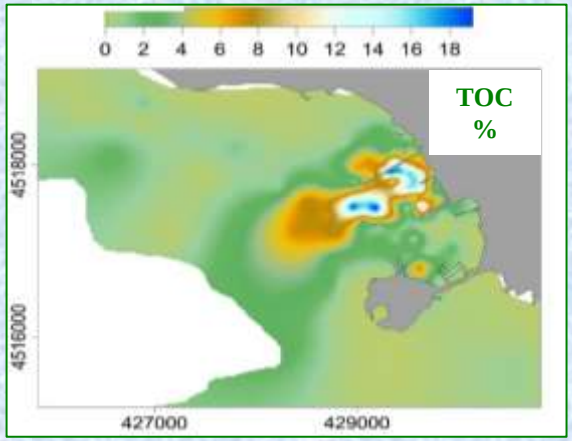
- Geochemistry (organic compounds and heavy metals) testifies huge pollution

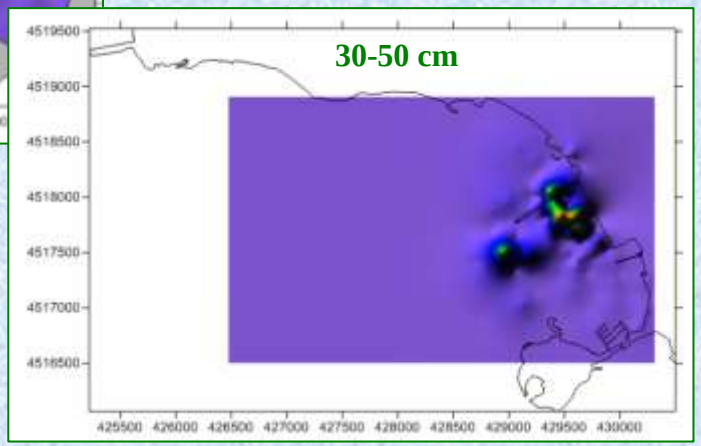


16 Priority PAH congeners (EPA)



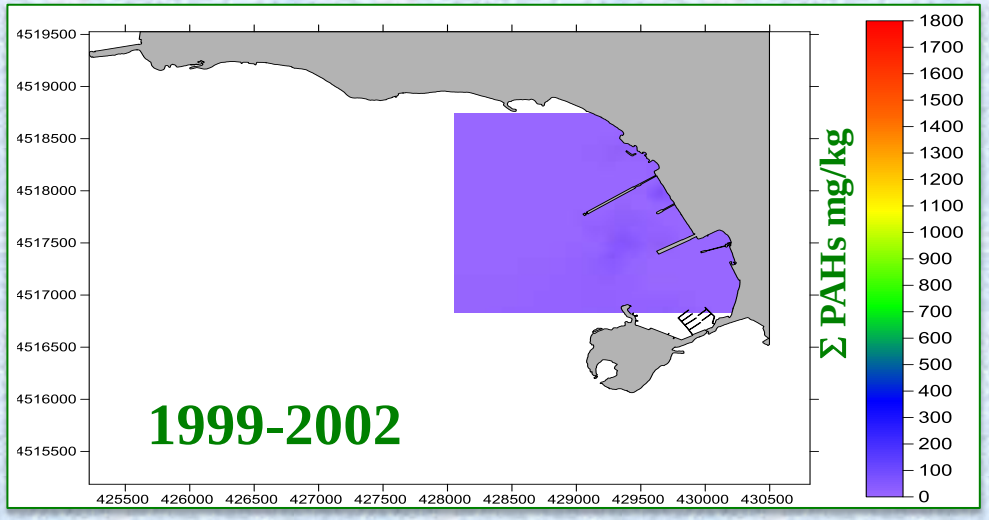




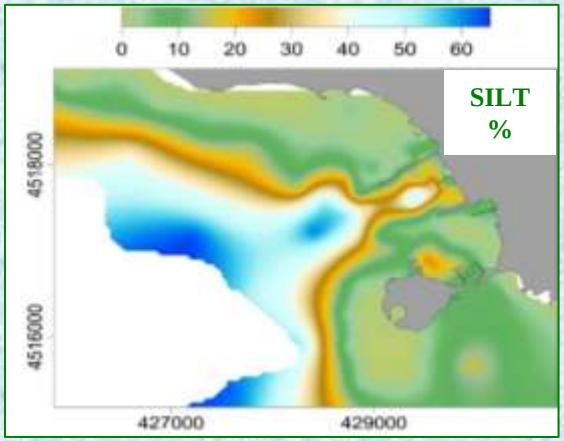


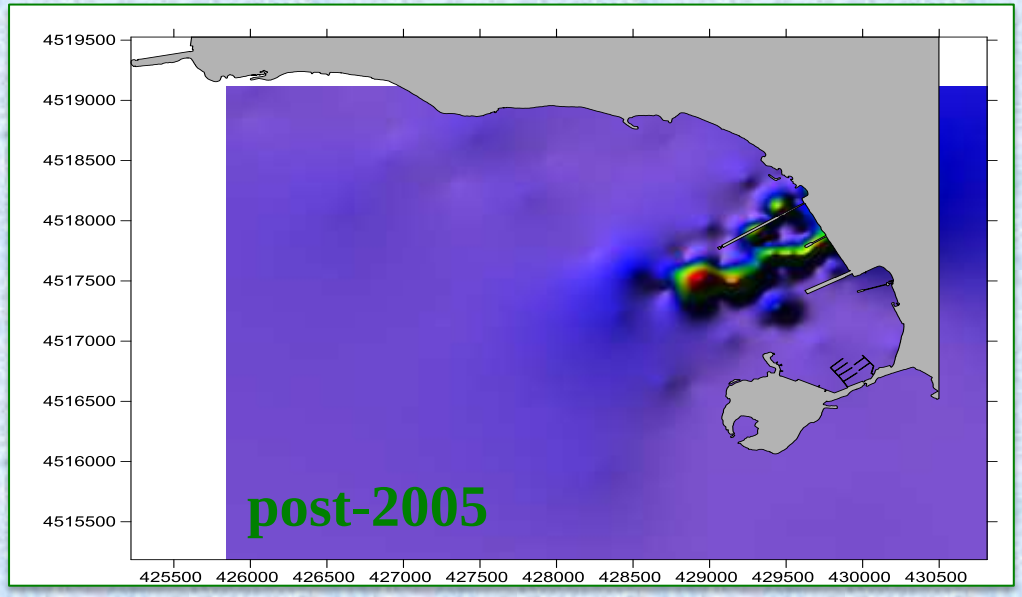
PAH "single congener" Legal limit 10 mg Kg-1

Bagnoli

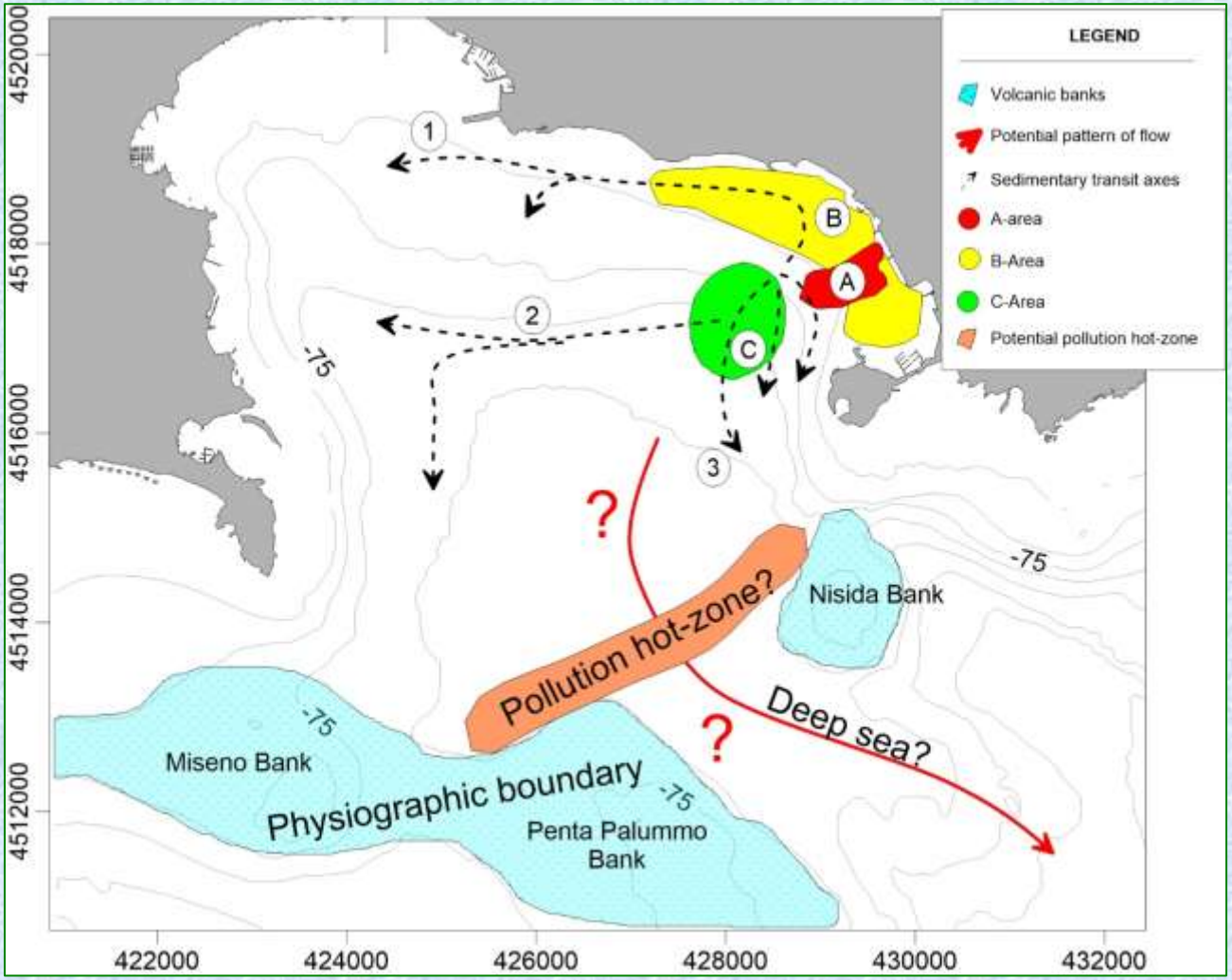


- Multiphase succession of events of dumping detected in the superficial sediments





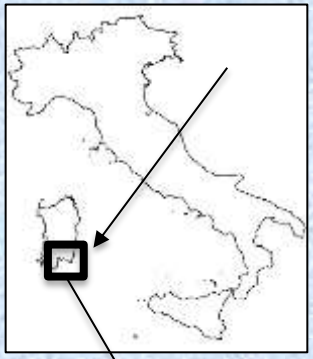
Bagnoli

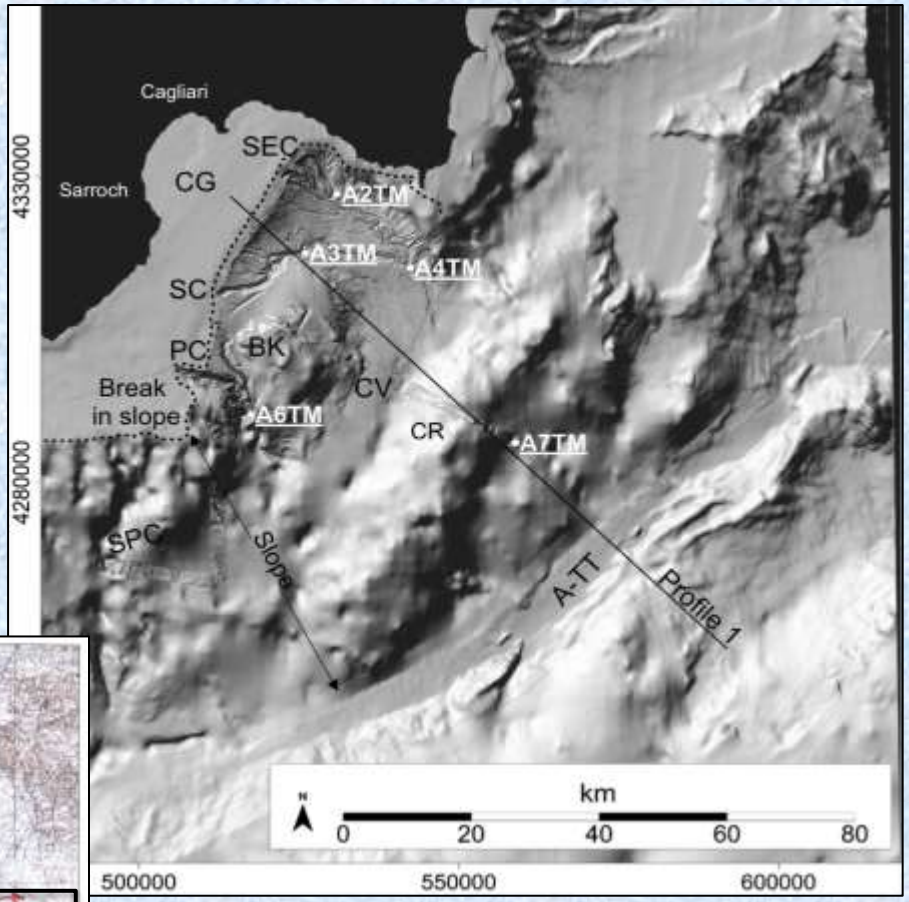


- Three different polluted sector identified (A, B, C)
- ***Re-distribution from point source to a much larger region*** through three transit axis
- Physiographic barrier and potential ***accumulation zone***

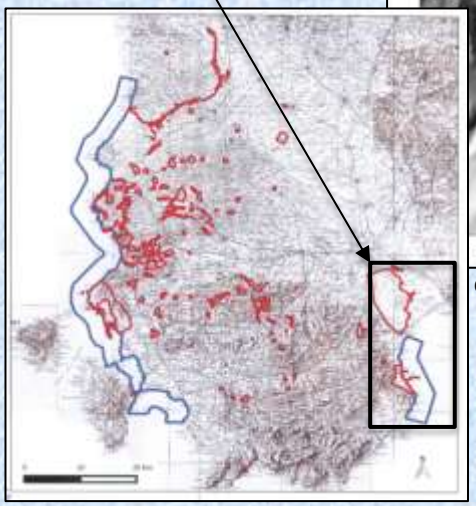
Cagliari (SE Sardinia), *open site*

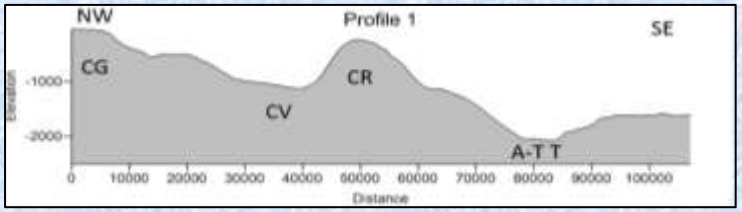
- 5 sediment cores (600-1100 m below sea level)





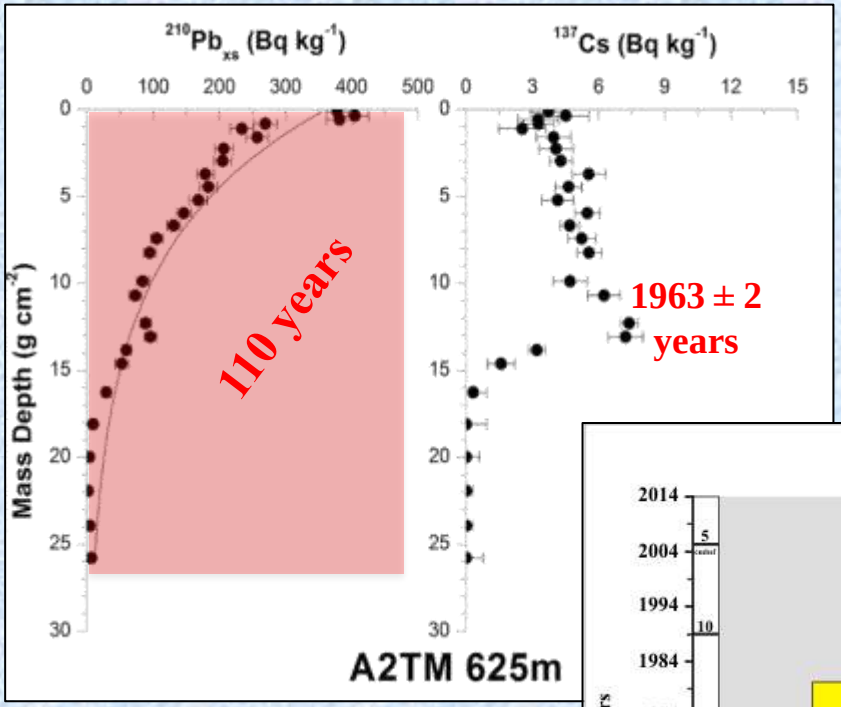
Cagliari Gulf (CG), Carbonara Valley (CV) Carbonara Ridge (CR), Algerian-Tyrrhenian Trough (A-TT)





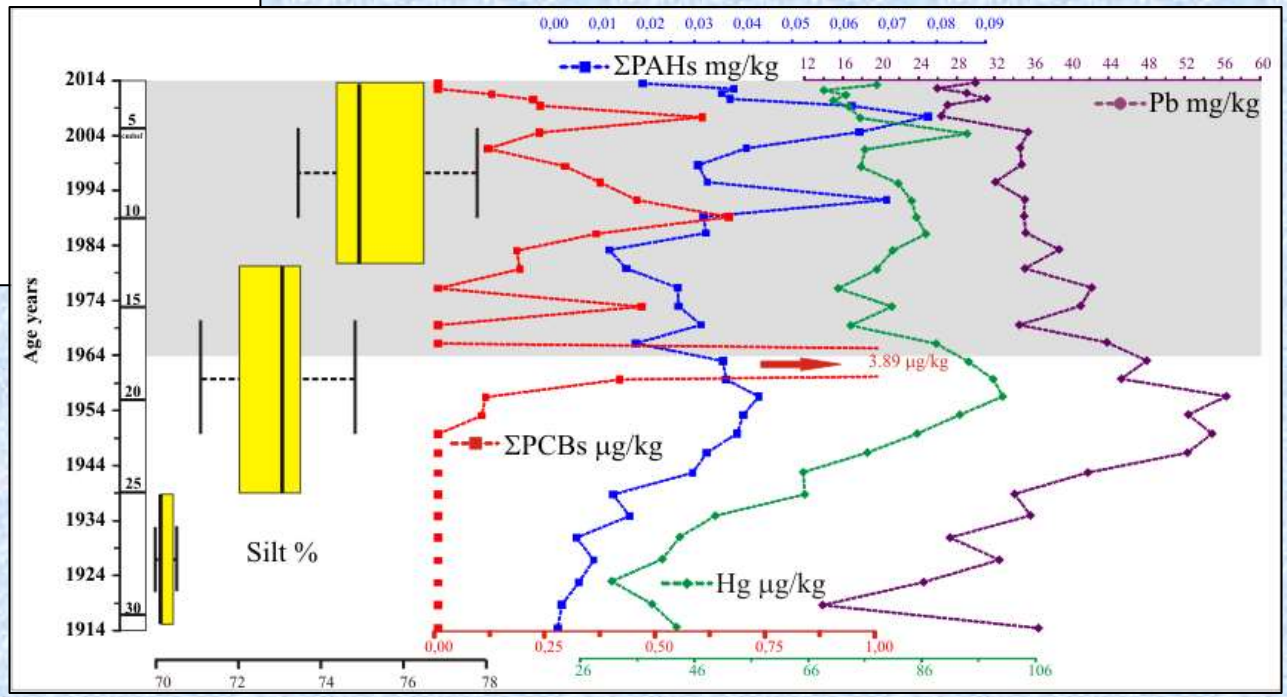
- **1960s**: industrial development of *Macchiereddu-Grogastu* conglomerate behind the Cagliari town (fluorine treatment, generation and distribution of propane, petrochemical plant)
- **1965**: refinery industrial development (*Sarlux-Saras S.p.A.*)
- **1980s**: building of Porto Canale (1.5 mln m^3 of sediment)
- **1990s**: building of Flumini Mannu dam
- **1992**: termo electric plant development (Cagliari)
- **2003**: Cagliari was included in "The National Remediation Plan" by Italian Environmental Ministry (SIN)

Cagliari

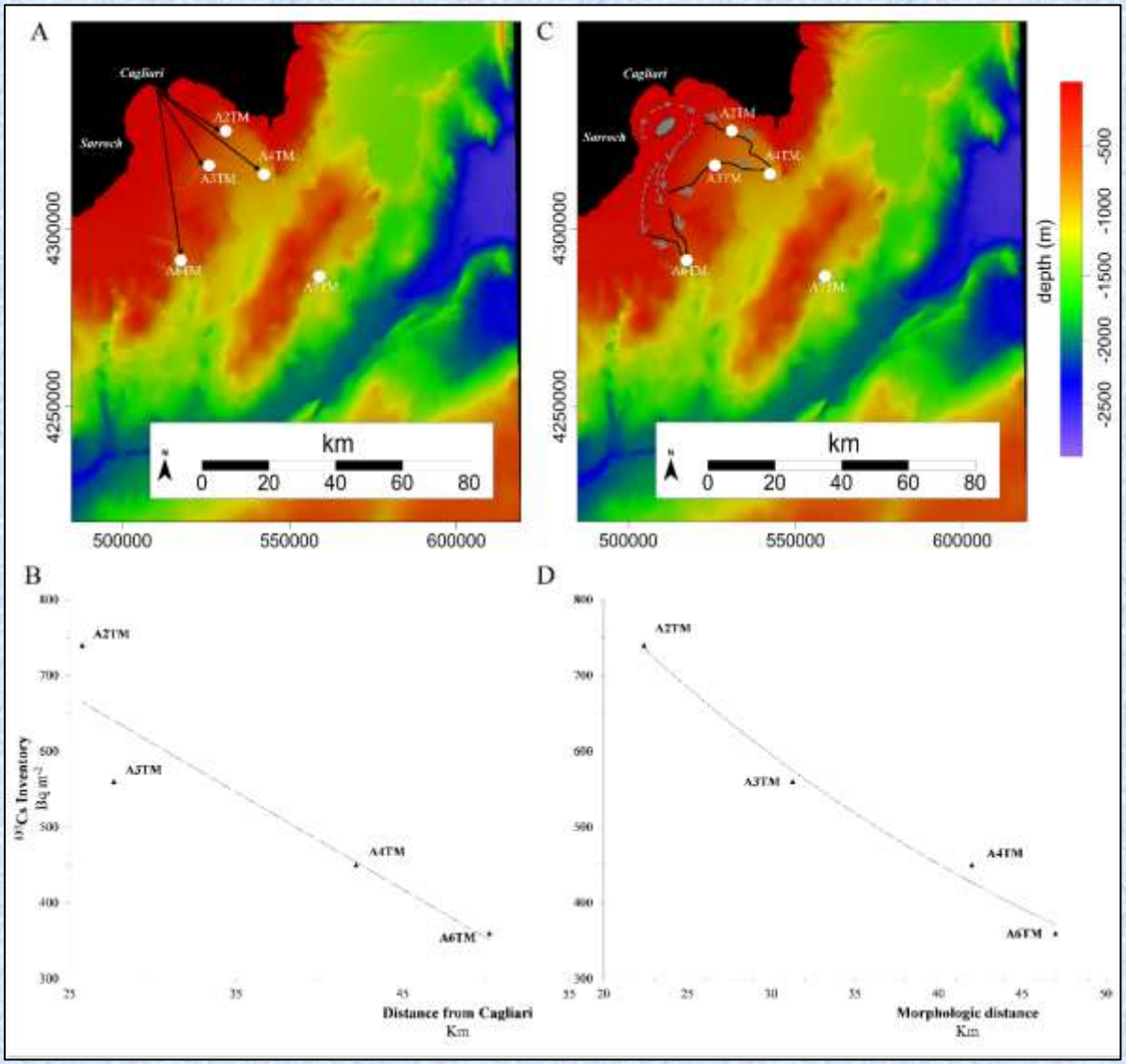


- *Natural* **^{210}Pbxs** T1/2 = 22.23 yrs
- *Artificial* **^{137}Cs** T1/2 = 30.05 yrs

- **^{210}Pbxs** (continuously produced) **and ^{137}Cs** (time dependent) **radionuclides** allowed to obtain reliable and accurate dating of the cores
- **Geochemistry** documents in great detail some important historically anthropogenic impact during the last 110 years

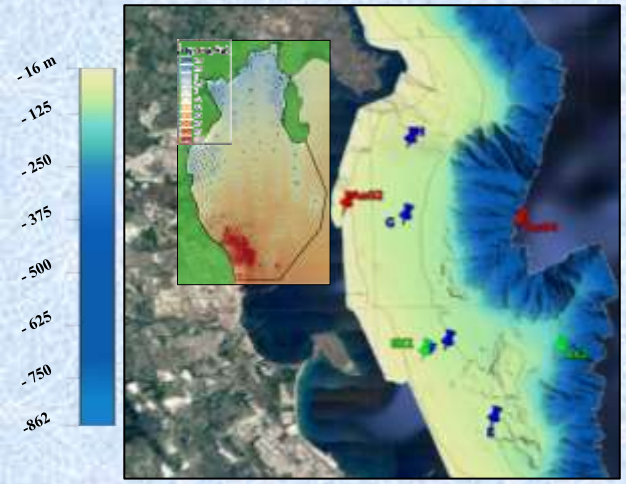


Cagliari

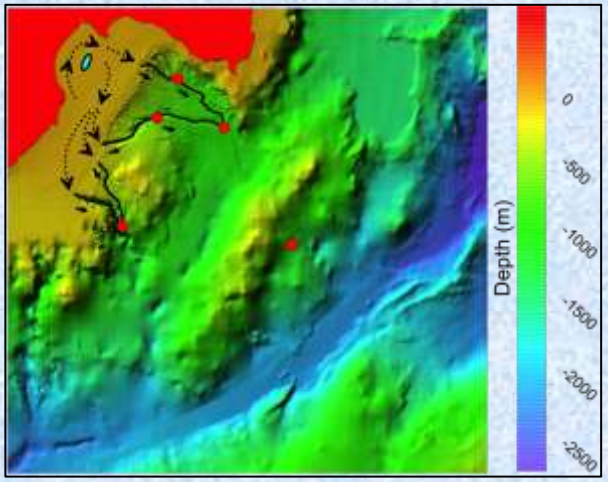


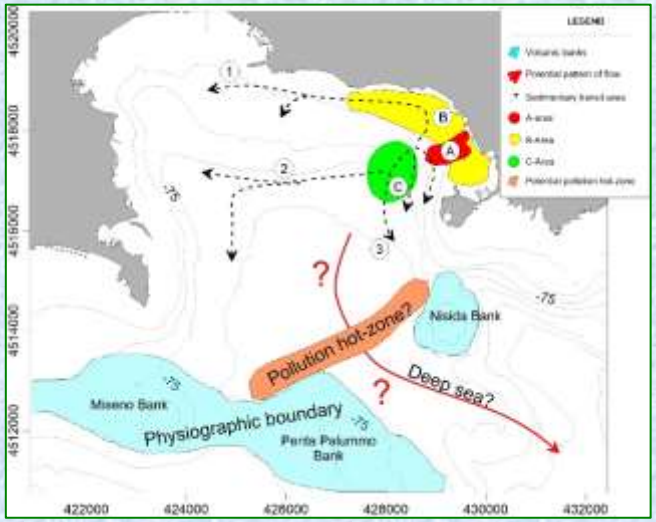
- **^{137}Cs** can be reliably considered as ***tracer*** of terrigenous fine sediment fraction in coastal areas thus we inferred a ***potential relationship*** between the distance of each sampling sites from Cagliari and ^{137}Cs inventories
- Submarine ***canyons act as preferential pathway*** for transport of sediment from the shelf to adjacent basins producing a ***focusing*** action of contaminants in pristine areas

...summarising



- Three different geological setting
- Three different sources
- Three different impacts





- **One common effect: pollution transfer from local to regional/global scale**

TAKE HOME MESSAGE

TIME AND SPACE MONITORING

★ A complete ***understanding of the real impact*** of contaminated sediments on the marine environment and the resulting potential effects on the ecosystem, demands ***more accurate modelling and reconstruction*** of the biogeochemical dynamics of contaminants at ***different time and spatial scale***

OVERCOME THE STATIC VISION

★ Specific and dense connections, in the coast to deep sea framework, challenge a static view on the potential impact of polluted sediments on the marine system. Thus, the ***traditional monitoring*** of marine sediments confined to analysis of space distribution of relatively polluted areas, ***reduces the real understanding of the effective impact on the environment***

SEDIMENT BECOME SOURCE

- Sediments, to be considered time and space modulated ***active sources*** of pollutants for the ecosystem and marine environment, must be considered in all their ***highly dynamic biogeochemistry***

CONSIDER DUMPING ACTIONS

- Events of specific "secondary" deposition of highly polluted sediments in historical contaminated marine areas calls for specific revision of ***dumping regulation*** in coastal marine areas

This approach needs for modern view on an holistic and suitable management of polluted marine sediments that must ***take into account the biogeochemical dynamic of contaminants in variable environmental setting***

Thank you!

stella.tamburrino@cnr.it