Anthropogenic Radionuclides: distribution, mass-balance and future trends in the Mediterranean Sea

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Outline

- The Mediterranean Sea
- Sources of radioactivity
- Distribution and time trend in seawater and sediment
- Inventories and budgets in the basin
- Exchanges at the Straits
- Future trends
- Examples on the use of ^{137}Cs as tracer

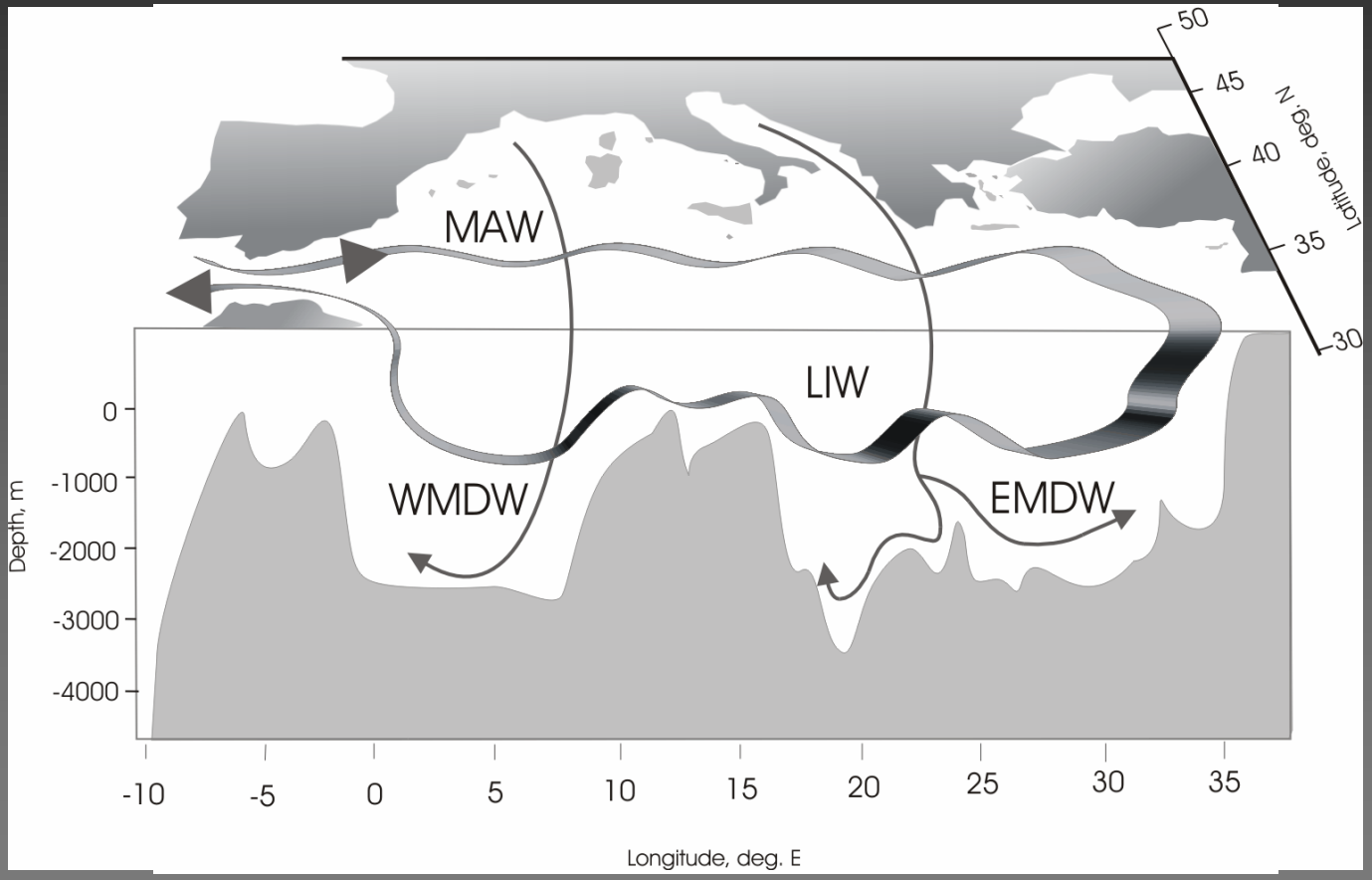
The Mediterranean Sea

Deep Sea, shelf < 10% of surface area, concentration basin, E > R+P

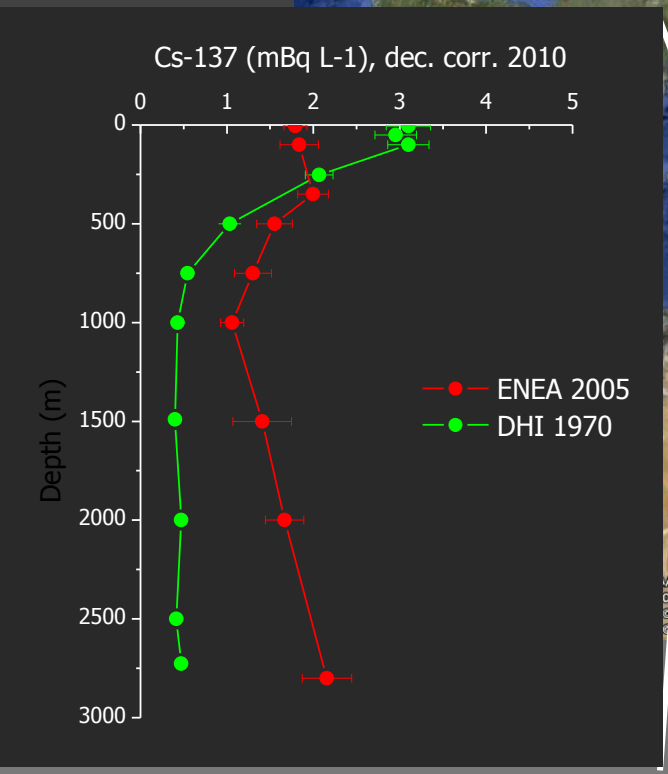
Anthropogenic radionuclides delivered to the Mediterranean Sea from different sources (reference time: 2010)

Source	^{137}Cs (PBq)	$^{239,240}Pu$ (TBq)
Global fallout, up to 2000	4.1	200
Chernobyl fallout	1.4	0.02
Global fallout, 2000 - 2010	0.03	1.2
Marcoule reprocessing plant	0.03	0.37
Black Sea, up to 1986	0.06	3
Black Sea, 1986-2010	0.3	0.4
Exchanges with Atlantic Ocean, up to 1986	0.9	- 40
Exchanges with Atlantic Ocean, 1990-2010	=	-6.8
Input from rivers	0.005	-
Total	**6.8**	**158.2**

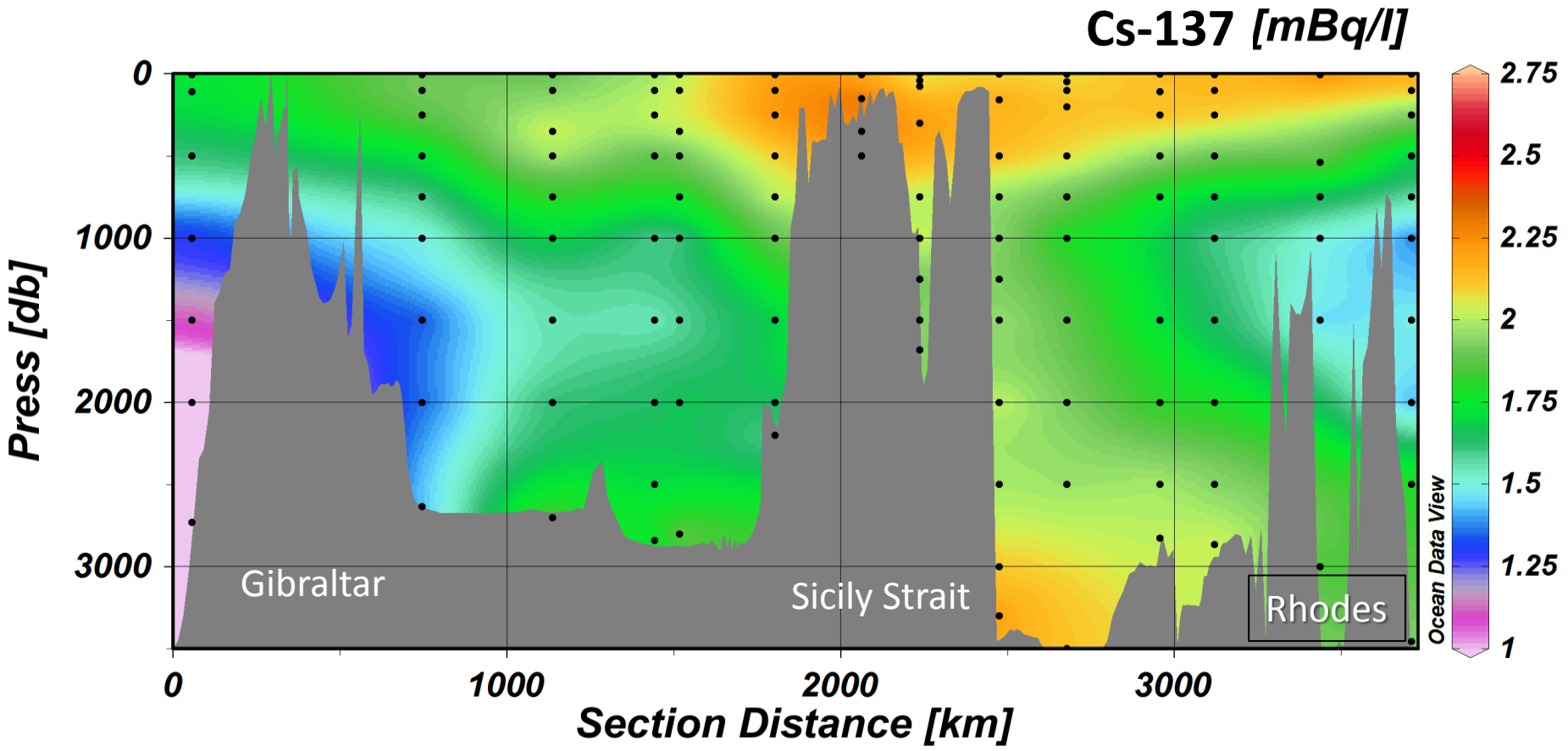
Time trend of ^{137}Cs concentration in surface seawater



Time trend of ^{137}Cs concentration in the water column

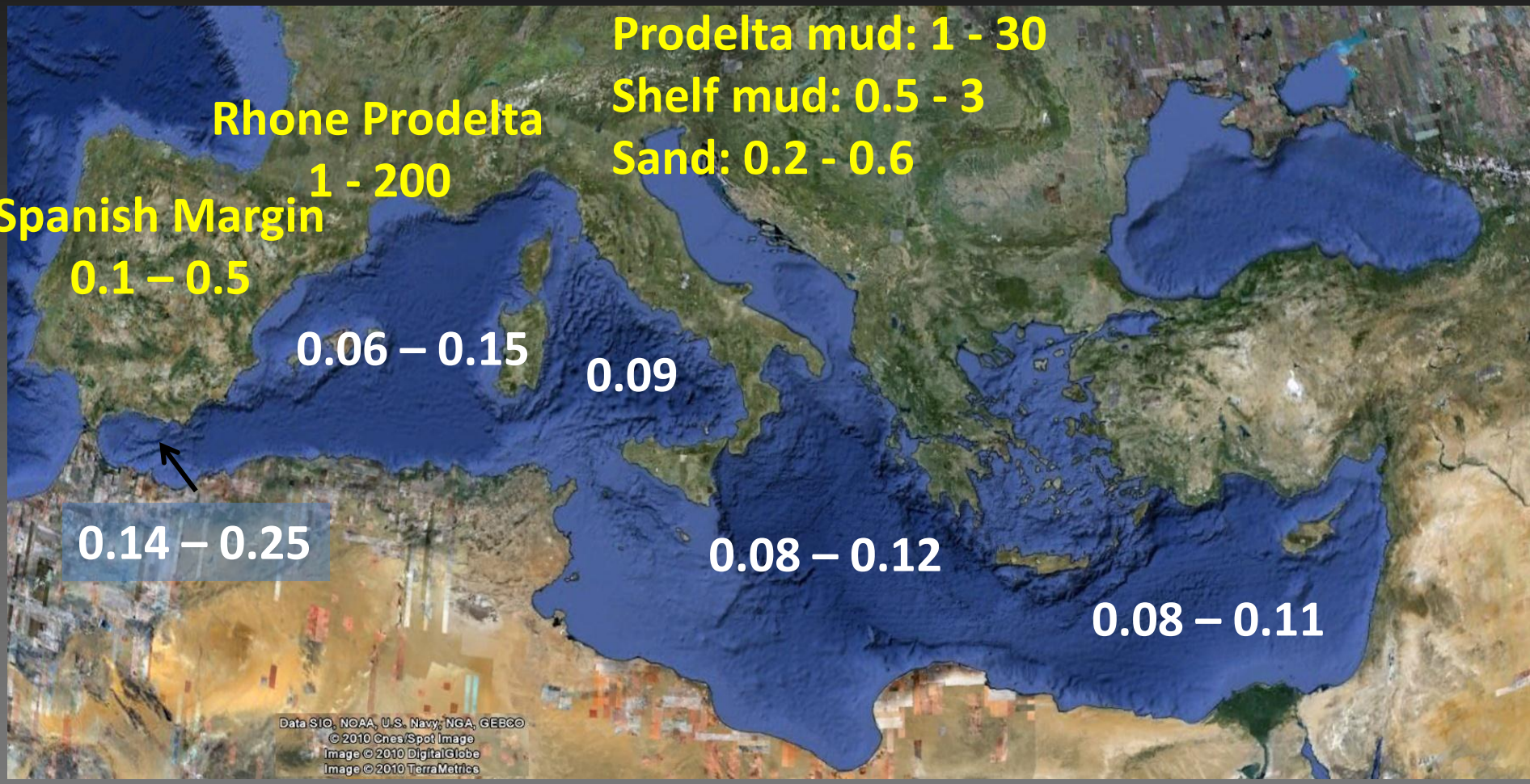


^{137}Cs section in the S-Mediterranean water column, 2005 - 2008



Whole Med Inventory: 6.1 PBq

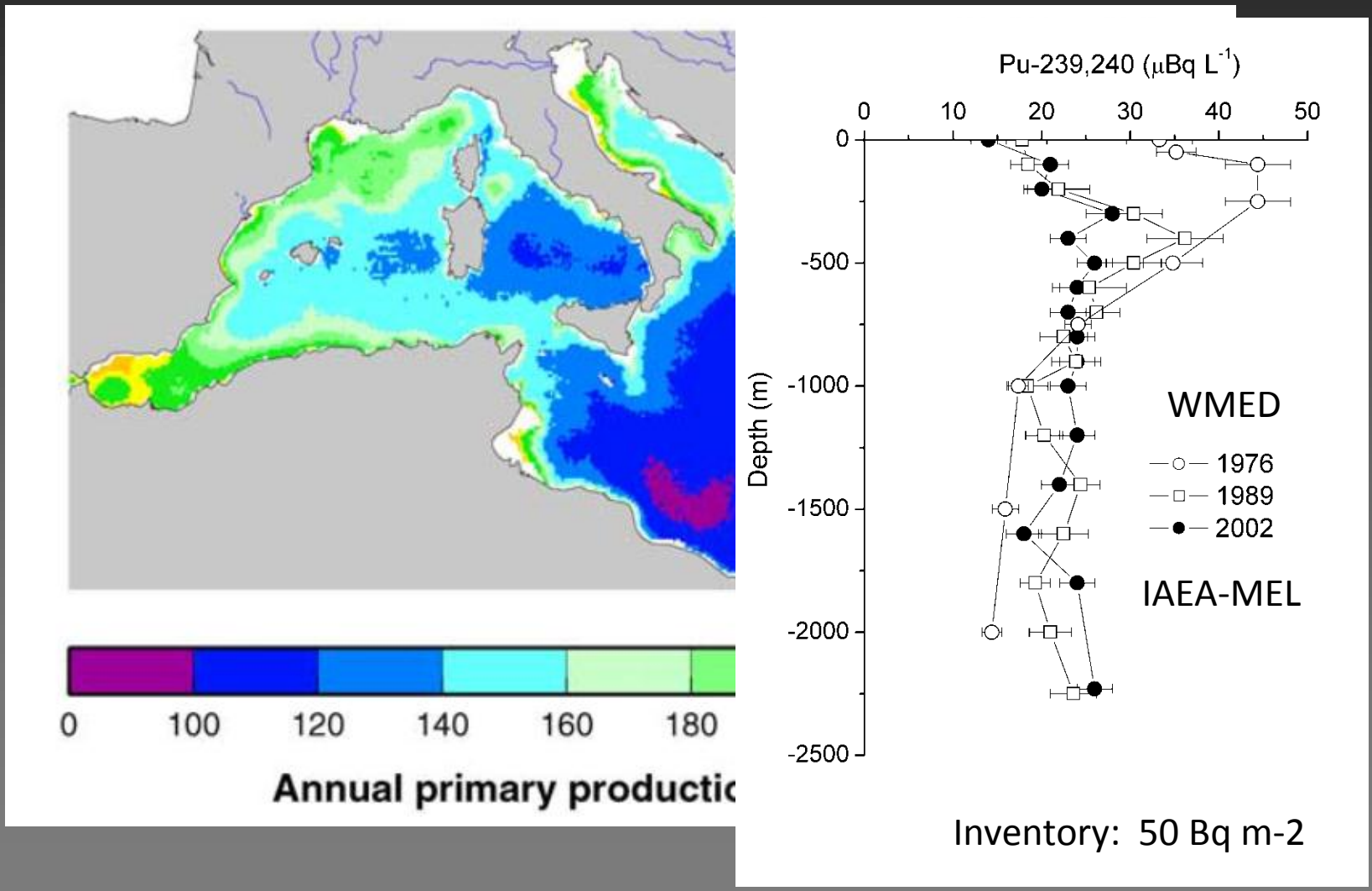
Inventories of ^{137}Cs (kBq m^{-2}) in sediments, 2010



Data from:

Delfanti et al., 1997.
Gascò et al., 2002.
Garcia-Orellana et al., 2009.
Charmasson, 2003.
Noureddine et al., 2008
Barsanti et al., submitted.

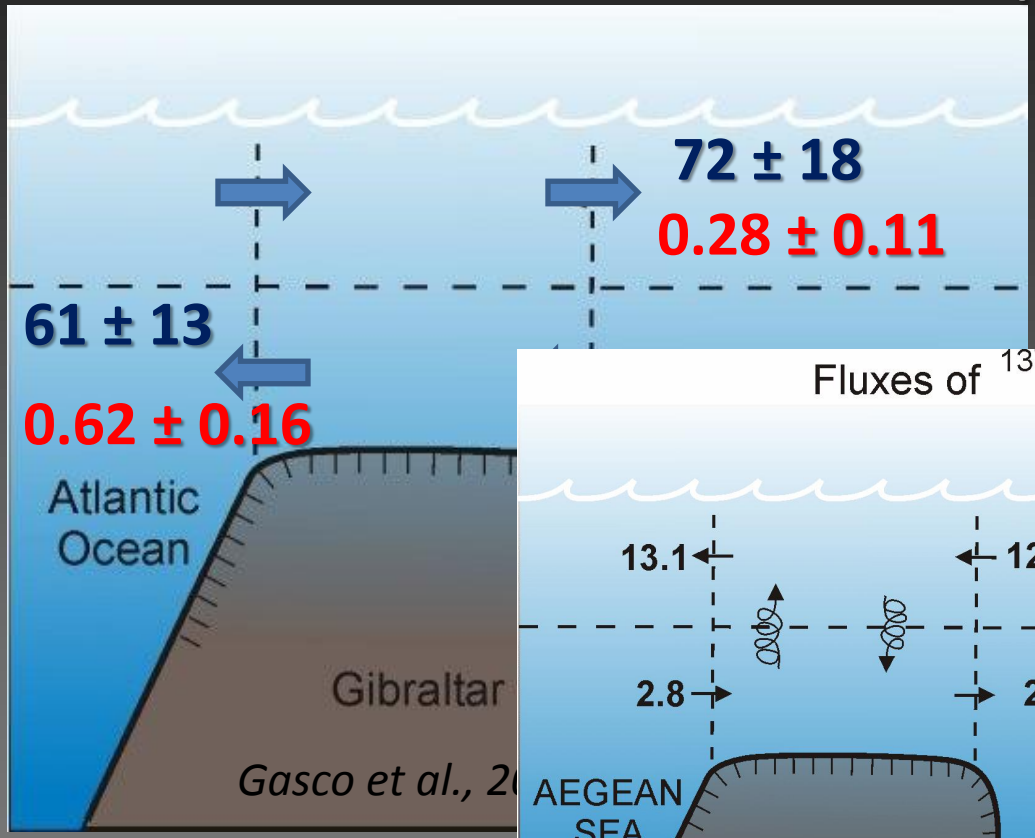
Time trend of ^{239,240}Pu concentration in the water column

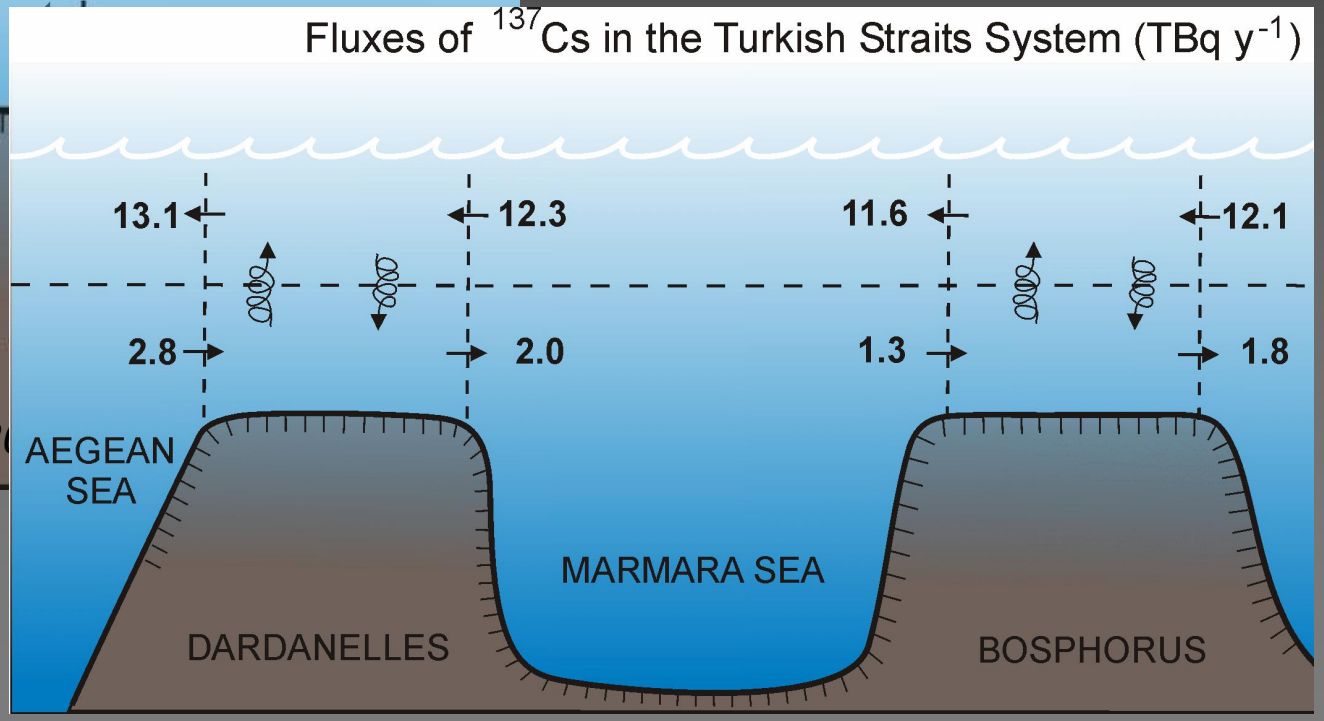


Inventory of ^{137}Cs and $^{239,240}Pu$ in the Mediterranean Sea, 2010

Compartment	137Cs PBq	% delivery	239,240Pu TBq	% delivery
Water column 0-4000 m	6.1	90	75	47
Shelf Sediment	0.2	3	40	25
Deep sea sediment	0.2	3	7	4
Total	6.5	96	122	76

Fluxes of ^{137}Cs and $^{239,240}Pu$ at the Straits (TBq y^{-1})



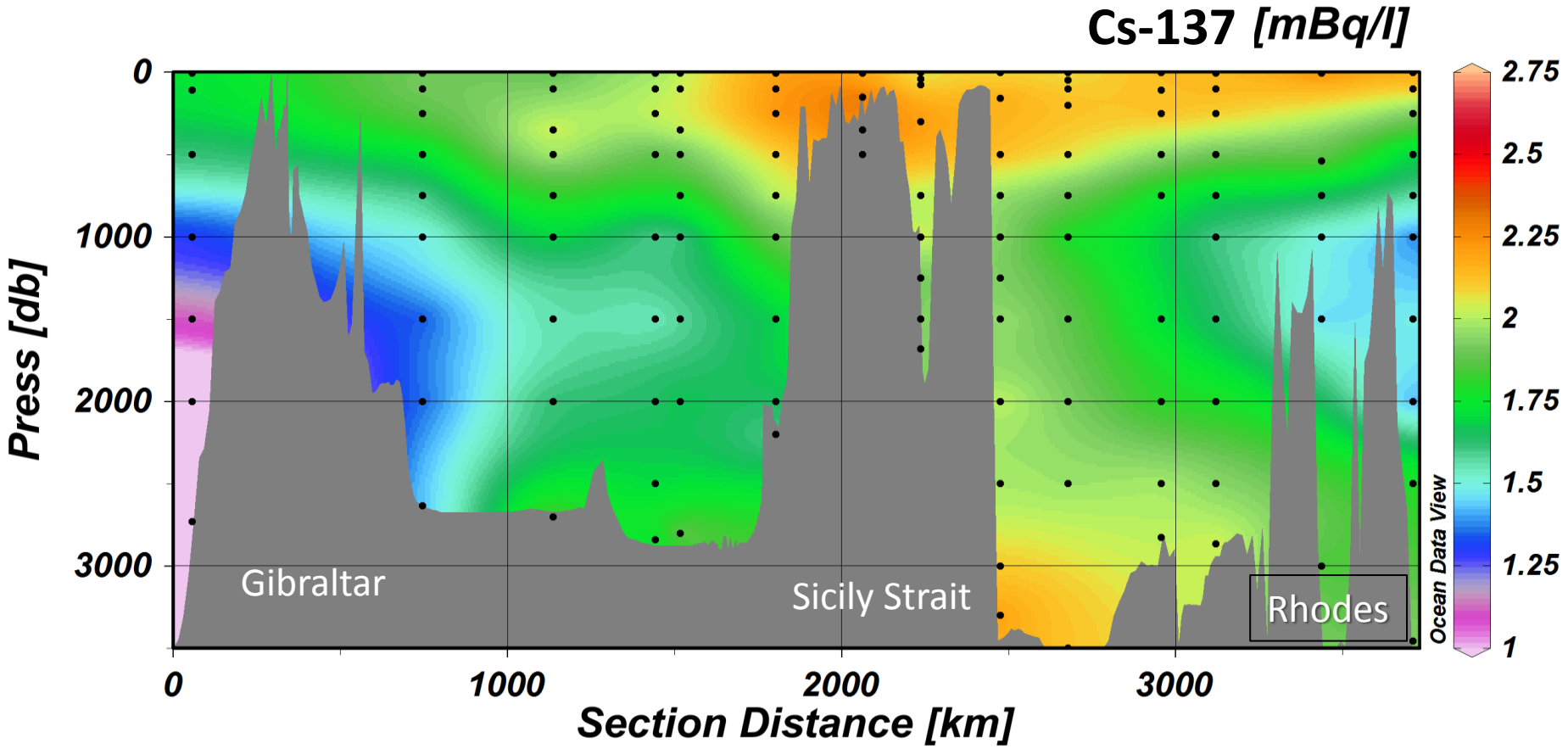


Conclusions (1)

In the Mediterranean Sea:

- Most anthropogenic radionuclides are still in the water column.
- For ^{239,240}Pu important reservoirs are shelf sediments.
- Rad levels in biota low – no concern
- Inventories will decrease in future:
  - No significant sources
  - Pu export at Gibraltar
  - Cs decrease by decay not balanced by input from Black Sea

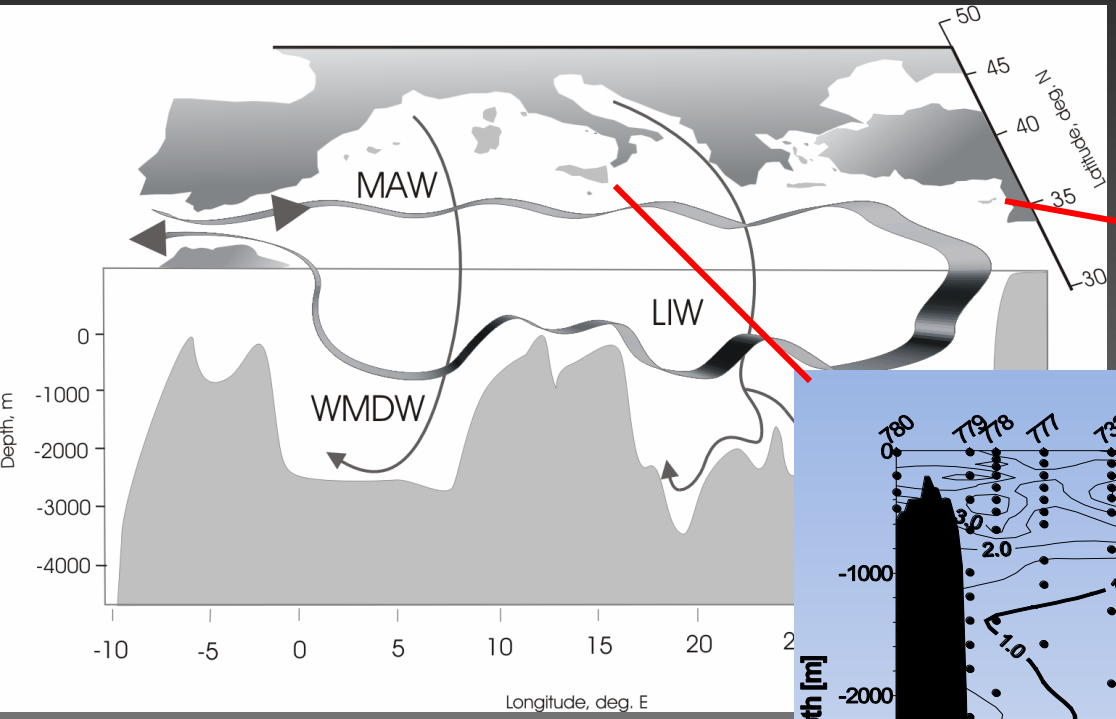
^{137}Cs in the water column of the Mediterranean Sea, 2005 - 2008



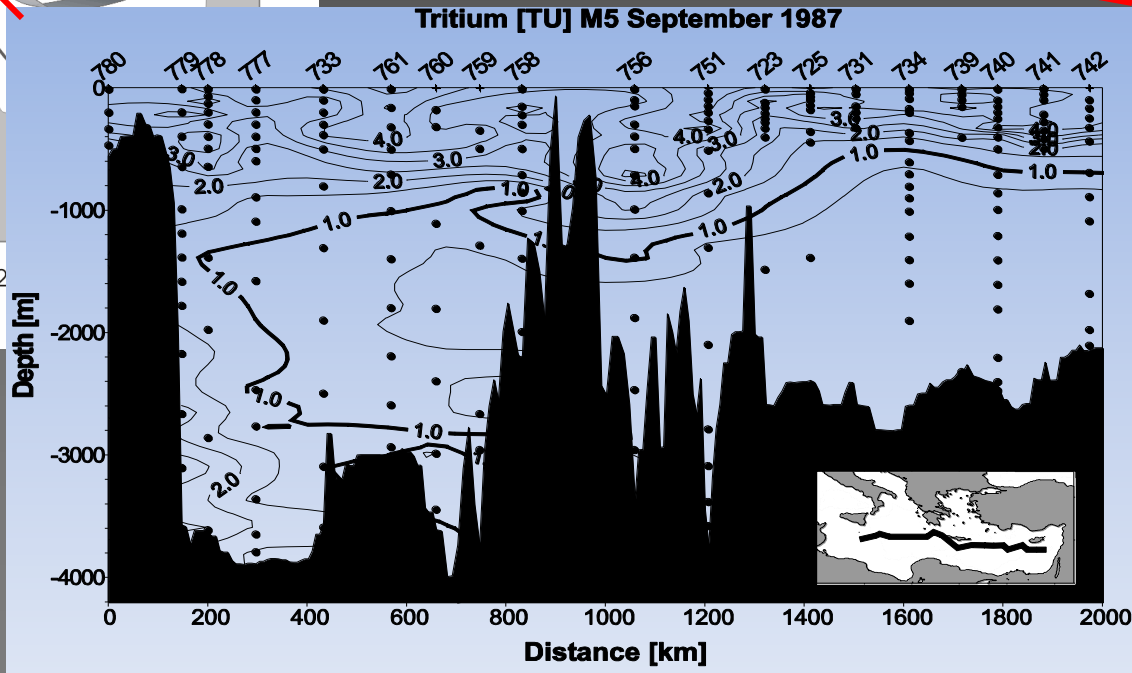
Small concentration range: 1.2 – 3.2 Bq m^{-3}

Still significant differences in different water masses

The evolution of the Eastern Mediterranean Transient through tracer data



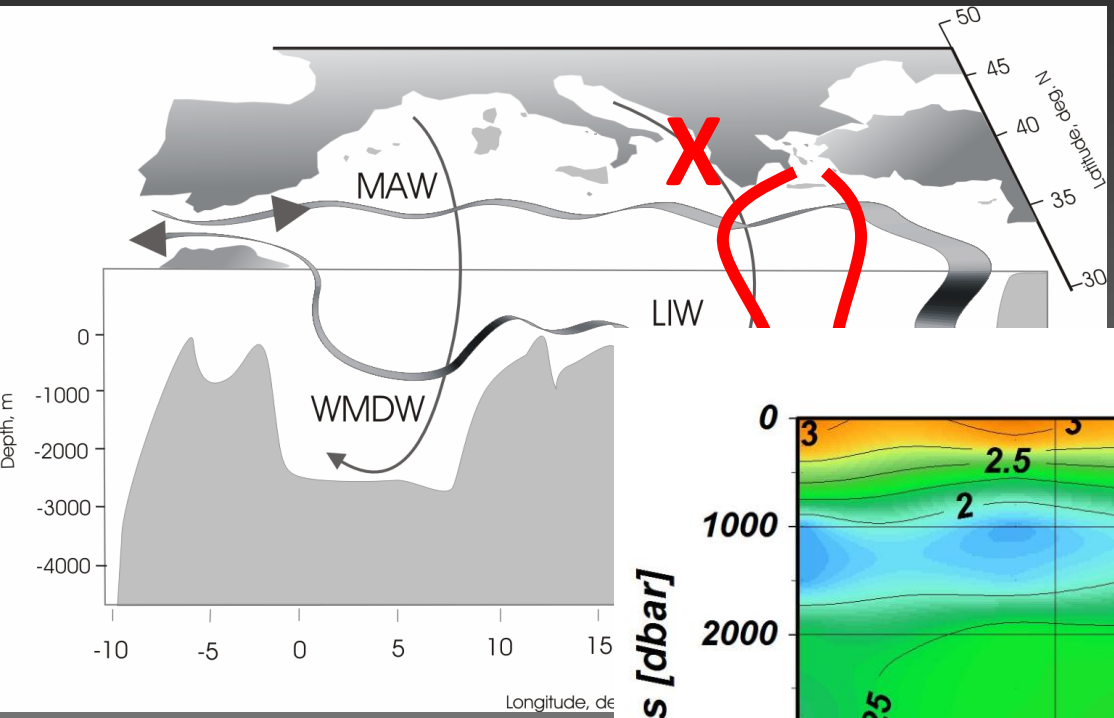
Tritium Section, 1987



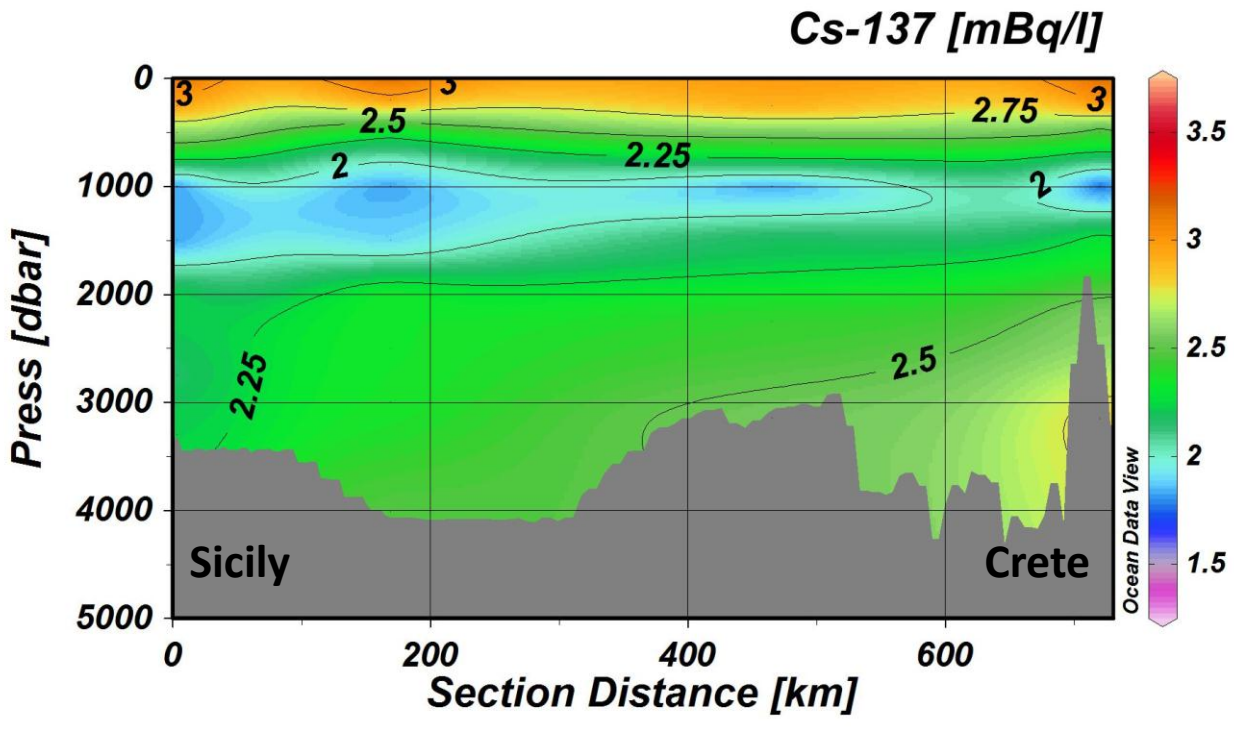
Until 1987

Roether et al., 1999

The evolution of the Eastern Mediterranean Transient through tracer data



In the 1990s



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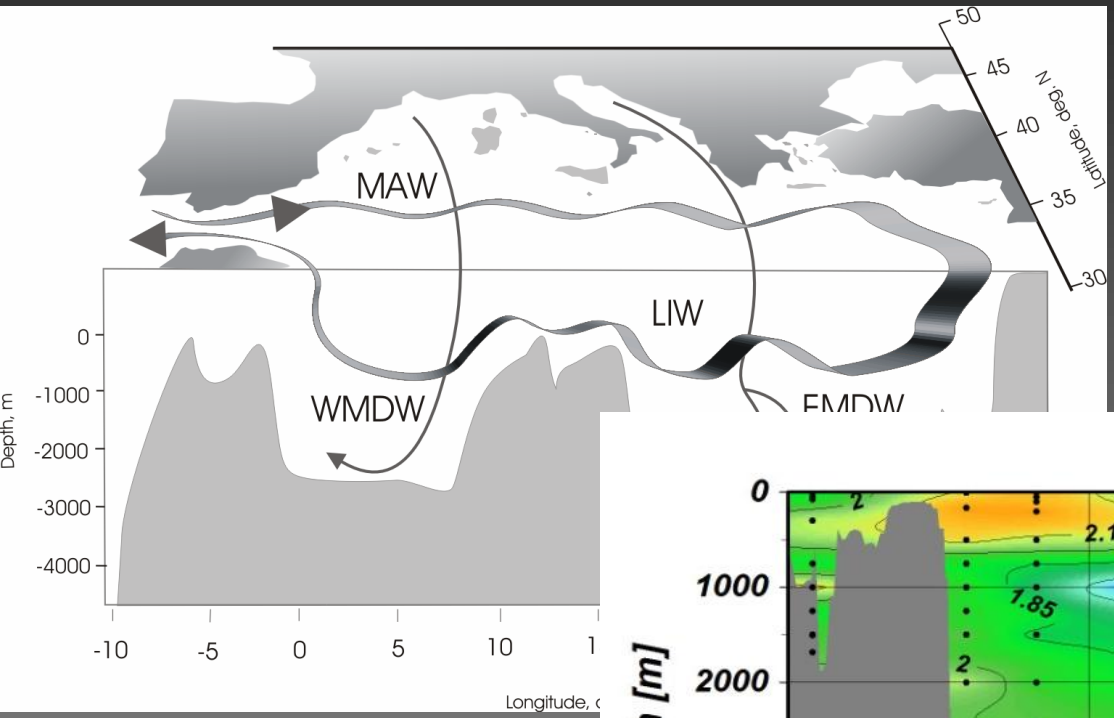

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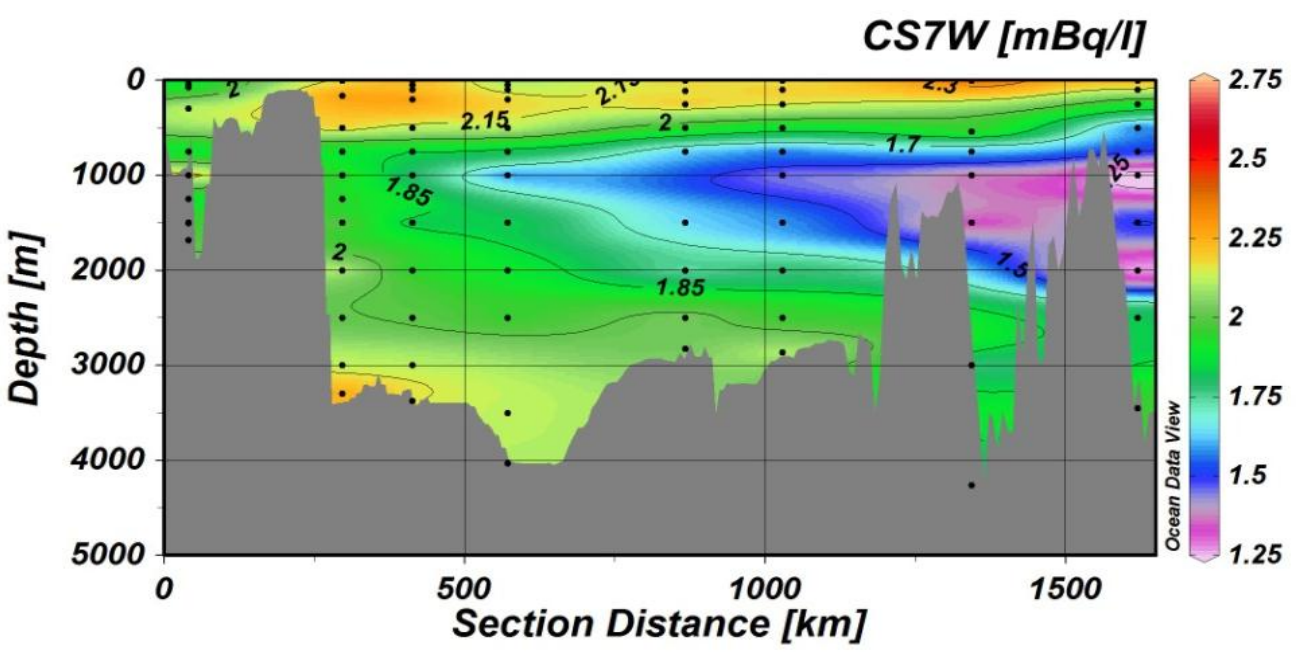
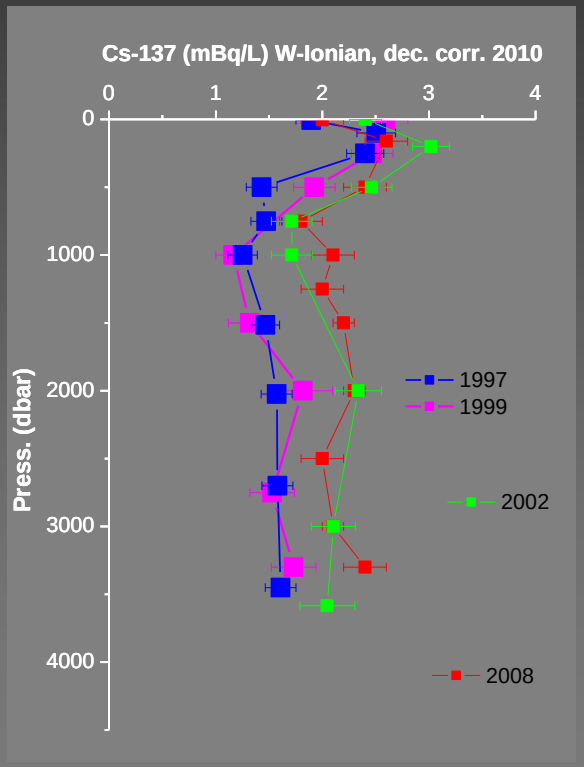
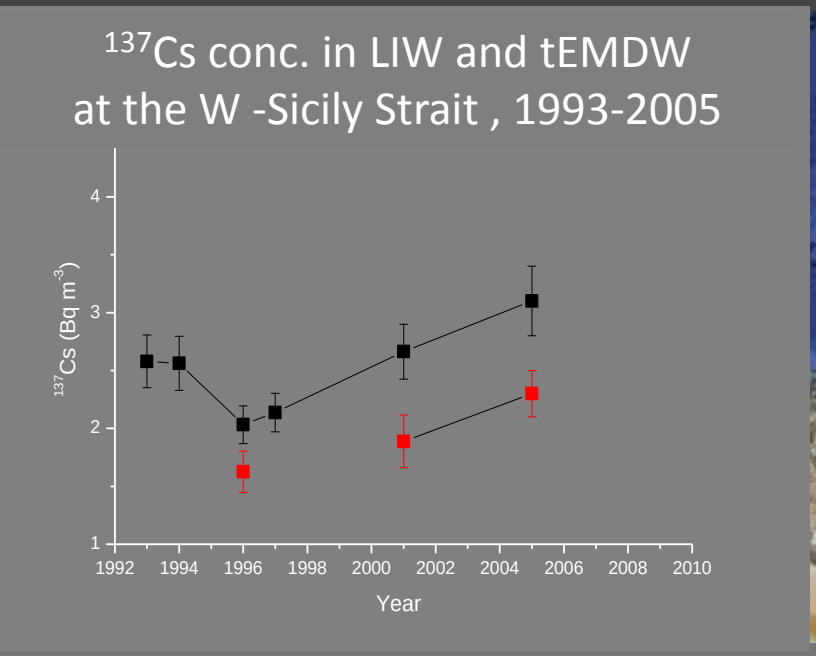
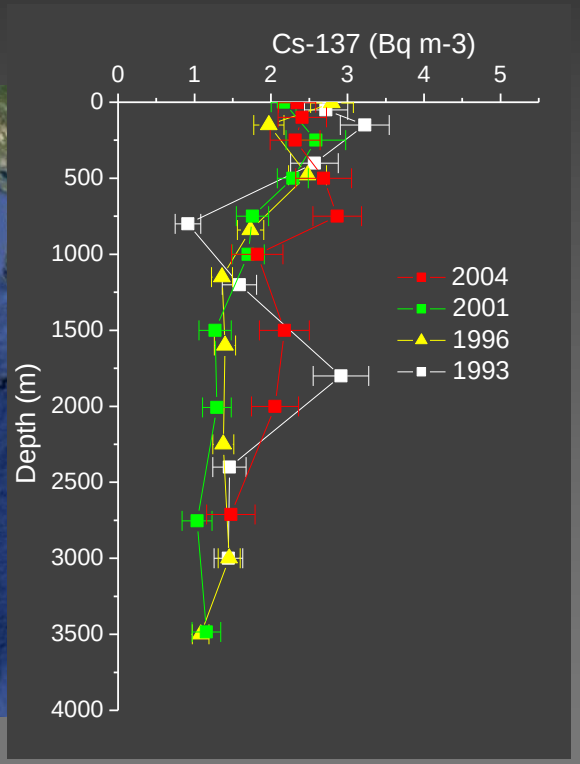


Time trend of ^{137}Cs concentration in the water column Ionian Sea, 1975 - 2008



Time trend of ^{137}Cs concentration in the water column Tyrrhenian Sea, 1975 - 2008





Conclusion (2)

- ^{137}Cs distribution can still complement other studies and give indipendent evidence of changes in the thermohaline circulation of the Mediterranean Sea.

- Key-stations identified in the different basins:

  here time series measurements will be continued, to elucidate mechanisms of water mass transport and transformation.

Thanks for your attention!